

Evaluation of Occupational Combined Exposure to Organic Solvents and Noise in Printing Industry

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Abstract: In working environments where organic solvents such as toluene, Benzene, xylene, styrene, and trichloroethylene are used, noise is also common. Thus, ototoxicity of an organic solvent has a probable interaction with noise under such environments. The present study aimed to evaluate the occupational combined exposure to organic solvents and noise exposures in printing industry, where several departments were selected as raw material storage, white process, color process, ultraviolet process, and design area as an exposure area. Administrative area was selected as a control. Assessment of occupational exposure to these pollutants was carried out using calibrated instruments. Significant increase in the level of xylene, benzene, VOC'S, and noise during working hours in comparison a control area. However, the only insignificant differences in the level of toluene exposure during work time in comparison with work area and control office. The present study concluded that exposed to organic solvents as: xylene, benzene, toluene, VOC'S, and noise exposure in the printing processing industry can result in measurable health risks to the workers. These findings should be used as a preventive measures for noise and organic solvents exposures control in the workplace environment.

INTRODUCTION

Hearing impairment of workers is often caused by several factors, including age, heredity, and exposure to ototoxic substances in working environments. The exposure to noise is the most common cause of hearing impairment and causes hearing loss among workers exposed to intensive noise. In working environments where organic solvents are used, noise is also common. Thus, ototoxicity of an organic solvent has a probable interaction with noise under such environments.^(1,2) Hearing loss is a leading occupational concern in industrial country among

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workers.⁽³⁻⁶⁾

Occupational noise exposure is a well-known cause of premature hearing loss for workers in industrial processes. Smoking and ototoxic chemicals exposures are believed to cause hearing impairment.^(2,7-11)

Studies have indicated that exposure to some organic solvents such as toluene, xylene, styrene, *n*-hexane and trichloroethylene have ototoxic and neurotoxic impairment affecting hearing.^{(2,7,}

¹¹⁾ In addition, Morata (1989) and Kowalska *et al.*, (2000) also found such effects in workers exposed to carbon disulfide.^(13,14)

The printing industry is very diverse, which is reflected by the multitude of different products e.g., books, daily newspapers, periodicals, packaging, cartons, carrier bags, drink containers, signs, forms, brochures, advertisements, wall paper, textiles, sheeting, metal foil, ...,etc.⁽¹⁵⁾

In the printing industry, the main sources of volatile organic compounds (VOC'S) in commercial offset lithography

are the uses of organic solvent, ink, fountain solution and cleaning agents. Considerable amounts of vaporized toluene, xylene, alcohols, and other airborne organic compounds are emitted to the indoor air.⁽¹⁶⁾

The printing industry uses a lot of solvents and the exposure of printers is mainly dependent on the number of cleaning and plate changing episodes undertaken during their working day which can result in solvent exposure up to 10 times that of other activities.⁽¹⁵⁾

Volatile organic compounds (VOC's) are found in many industrial environments and in certain occupational exposure, solvents can be particularly high.^(16,17). In the printing industry, benzene-containing solvents were used in the ink solution and to clean the printing machines. Press operators and maintenance workers are two examples of trades in the printing industry that risk exposure to benzene.⁽¹⁸⁾

Printing presses are a major source of

high noise levels in the printing industry. Noise is one of the occupational risks with higher expression in industrial environments. Hearing loss is still one of the most prevalent occupational diseases in industry. Overexposure to noise (>85 db) occupational safety and Health Administration (OSHA)) has been known to cause occupational hearing loss. Combined exposure to organic solvent and noise have emerged as a major cause of occupational hearing loss.⁽¹⁹⁾

The present study aimed at evaluating the occupational combined exposure to organic solvents and noise exposures in printing industry.

MATERIAL AND METHODS

The present study was conducted in printing industry located in Dammam City. An inventory of the printing industry where the available departments were selected including: raw material storage, white process, color process, ultraviolet (UV) process, and design area as an exposure

area. Administrative office was selected as control area.

Calibrated MIRAN was used to determined levels of organic solvents as toluene, benzene, and xylene in different printing plant departments ⁽²⁰⁾. Assessment of occupational exposure to noise in different printing plant departments was done using calibrated Sound Pressure Level meter (TES 1352A).⁽²¹⁾ The noise was measured at workers' head level. Volatile organic compounds (VOC'S) were measured using direct reading monitors; the EntryRAE PGM-3000 Multi-Gas Monitor⁽²⁰⁾.

Statistical Analysis

The collected data were subjected to statistical analysis and presented graphically using SPSS software. Descriptive statistics and Student "t test" were carried out to the collected data.

RESULTS and DISCUSSION

Hearing loss is still one of the most prevalent occupational iseases in industry.

Overexposure to noise has been known to cause occupational hearing loss. Such exposure is common in many industrial settings.^(7,8) Recently, however, solvents either alone or interacting with noise have emerged as a major cause of occupational hearing loss. Simultaneous exposure to noise and solvents has worsened hearing loss in occupational settings.⁽²²⁾ Organic solvents, known to be hazardous materials, can induce both central^(22,23.) and peripheral neurotoxicities.⁽²⁴⁾ A few studies focused on the effects of a combined exposure to solvents and noise on hearing suggest a synergistic interaction between noise and solvents^(7, 8,25). Sass-Kortasak *et al.*, (1995) used the cumulative exposure index to evaluate the effect of combined exposure to solvents and noise on hearing loss, but they could not find a consistent, significant relation between styrene exposure and hearing loss.⁽²⁶⁾

Table 1: Descriptive statistics of Xylene, Benzene, Toluene, VOC's, and noise in deferent department in printing industry during working hours.

Department	Xylene (ppm) Mean ± SD	Benzene (ppm) Mean ± SD	Toluene (ppm) Mean ±SD	VOC'S (ppm) Mean ±SD	Noise level (dB) Mean ±SD
Raw Material storage	5.55±2.36	19.83±11.37	1.25±1.15	0.73±0.70	85.23±2.37
White printing process	10.32±6.93	90.44±49.03	3.52±2.41	10.86±0.74	93.72±5.11
Color printing process	9.41±5.64	98.28±75.62	3.21±1.39	9.86±1.45	91.94±4.53
UV process	10.25±3.07	112.76±54.48	3.27±1.54	22.86±0.91	91.41±5.36
Design area	7.94±3.37	45.67±24.31	3.60±1.18	13.86±1.45	81.01±7.63
Control area	6.98±1.92	18.66±6.59	3.08±1.33	0.25±0.41	62.50±5.92

In the present study, the highest levels of xylene exposure during working hours were found in white printing process with mean value of 10.32 ppm and the lowest levels were found in raw material storage area with mean of 5.55 ppm and both levels are lower than TLV of xylene of 100 ppm.⁽¹⁹⁾ Similar study of Morata *et al.*, that found the mean exposure to xylene varied from 12 ppm to 40 ppm which represents concentrations higher than our finding concerning xylene exposure.⁽⁸⁾

The higher level of benzene exposure during working hours was found in UV process with mean of 112.76 ppm and the lower level of benzene was found in control area with mean of 18.66 ppm and both are higher than TLV of benzene 0.5 ppm.⁽¹⁹⁾ Similar studies found that Benzene exposure levels monitored for exposed workers ranged from 0.06 to 122 ppm, respectively.⁽²⁷⁾

The higher level of VOC's exposure during working hours was found in UV

process with mean of 22.86 ppm and the lower levels were found in control area with mean of 0.25 ppm and both are higher than TLV of VOC's 0.24 ppm.⁽¹⁹⁾

In similar exposures, with range of 0.45-4.5 ppm, odours, irritation, and discomfort may appear in response to the presence of total VOC together with thermal comfort factors and stressors. Above about 4.5 ppm, one may expect complaints; above 37.5 ppm, temporary discomfort and respiratory irritation have been demonstrated for a common mix of chemicals in an office building.⁽²⁸⁾

Our study levels of toluene exposure during working hours found in design area with mean of 3.60 ppm and the lower level of toluene exposure were found in raw material storage with mean of 1.25 ppm and the both levels are lower than TLV of toluene of 50 ppm.⁽¹⁹⁾ Similar study of Morata *et al.*, found that the mean level of exposures to toluene varied from 10 to 70 ppm and these represent health hazards to

the exposed workers.⁽⁸⁾

Noise exposure during working hours found in white printing process with mean of 93.72 dB which is higher than noise permissible level of 85 dB of OSHA.⁽²⁹⁾ And the lower level of noise exposure

during working hours found in control area with mean of 62.50 dB which is lower than noise permissible level of 85 dB of OSHA.⁽²⁹⁾ However, Holmberg *et al.*,⁽³⁰⁾ proved similar relation between organic solvents and noise exposure in the level of 85-90 dB.

Table 2: Distribution of total organic solvents levels and noise during work time in comparison with work area and control office.

variable	Work area Mean \pm SD	Control area Mean \pm SD	P.value
Xylene (ppm)	8.82 \pm 4.94	6.98 \pm 1.87	0.002**
Benzene(ppm)	73.49 \pm 58.86	18.66 \pm 6.41	0.00031**
Toluene (ppm)	3.02 \pm 1.84	3.08 \pm 1.29	0.82
VOC'S(ppm)	11.66 \pm 7.22	0.20 \pm 0.40	0.000419**
Noise (dB)	88.66 \pm 10.75	62.50 \pm 5.76	0.000419**

**P< 0.01

There are significant increase in the level of xylene, benzene, VOC'S and noise during working hours in comparison of control area. However, the only insignificant results were in the level of toluene

exposure during working hours in comparison of control area .Moreover, there is significant increase in the level of noise level during working hours in comparison with control area.

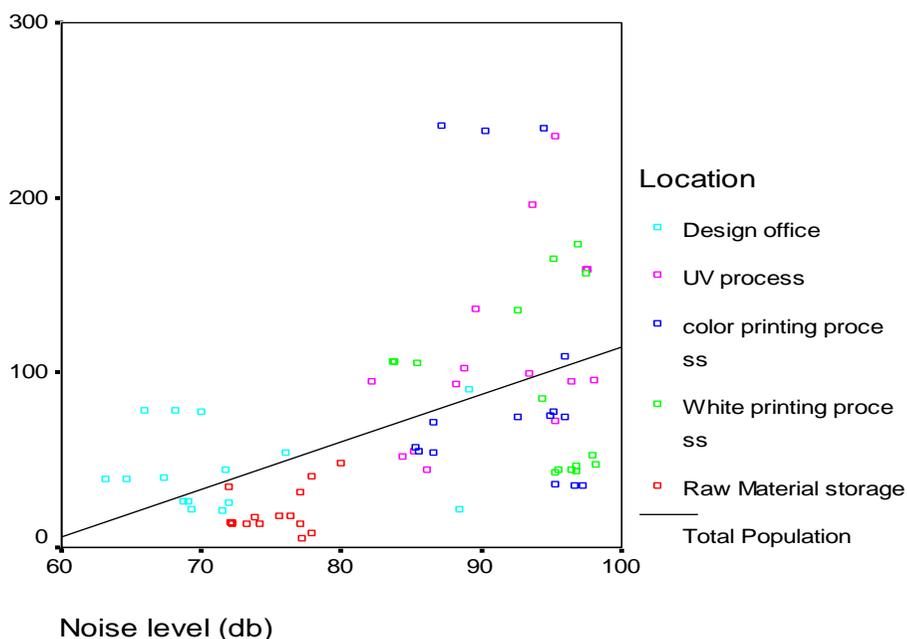


Figure 1: Correlation between benzene and noise in deferent departments in printing industry during work time.

Epidemiological data showed the ototoxic effects of organic solvents in workplaces. In a study done in Poland, 26 workers among 40 workers had hearing loss because of trichloroethylene exposure. In another study, workers exposed to solvents were more likely to have hearing loss than control workers were.^(8,31) It has been hypothesized that organic solvents can injure the sensory cells and peripheral nerve endings of the cochlea, and have

solvents related effects on the brain and a retrocochlear influence. These findings suggest that chronic exposure to the mixed solvents could cause a toxic effects on the auditory system.

CONCLUSION

The present study concluded that exposure to organic solvents as: xylene, benzene, toluene, VOC'S, and noise exposure in the printing processing industry can result in measurable health risks to the workers.

The present study gives a brief idea about the working environment and its impact on printing industrial workers. This study could be used as a guideline for administrators, policy makers and health and safety departments to formulate strategies for the protection of workers from noise and organic solvents exposures hazards. The data will also help us to adopt the best possible measures for noise and organic solvents exposure control in the workplace environment.

Acknowledgement: The authors thank Abudll Azziz Al-Mulla, graduate student from College of Applied Medical Sciences, King Faisal University, who provided support in the field work,

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