Original Article
http://mjiri.iums.ac.ir

Medical Journal of the Islamic Republic of Iran (MJIRI)
Iran University of Medical Sciences

Assessment of neurobehavioral disorders in workers exposed to organic solvents in a publication house

Yasser Labbafinejad[1], Saber Mohammadi[2], Elham Mirzamohammadi[3]
Mostafa Ghaffari[4], Mirsaeed Attarchi[5], Azadeh Amiri[6]

Received: 12 Mar 2013 Accepted: 11 June 2013 Published: 12 Feb 2014

Abstract

Background: Organic solvents are known as a group of organic compounds, widely used in industry and to which many workers are exposed. Neurotoxicity is one of the most important complications of the chronic exposure to the solvents and may causes neurobehavioral disorders in workers. We have studied the frequency of neurobehavioral disorders in workers exposed to organic solvents in one of the publishing houses in Tehran.

Methods: In this cross-sectional study, 510 workers of a publishing house, having been employed at least a year before the research, were selected to be studied. Among them, 345 workers had been exposed to organic solvents and the other (165 workers) had not. Data were collected using a questionnaire. This questionnaire included demographic and occupational information, and the Swedish Q16 questionnaire. Variables included age, duration of employment, working shift, and smoking. Then we compared both groups in terms of neurobehavioral disorders, using statistical methods.

Results: The mean score of the Swedish Q16 questionnaire in the exposed group (4.8±4.4) was significantly higher than the non-exposed group (3.2±3.1) ($p=0.001$). According to the questionnaire score, the frequency of neurobehavioral disorders in the exposed group was 38% and in the non-exposed group was 22% ($p=0.001$). We estimated that the frequency of neurobehavioral disorders in the exposed group was significantly higher than the non-exposed group ($p<0.05$) using regression analysis and removal of the confounding factors.

Conclusion: This study shows that the frequency of the neurobehavioral disorders in the exposed group is significantly higher than the non-exposed group.

Keywords: Neurobehavioral manifestations, Occupational exposure, Solvents.

Cite this article as: Labbafinejad Y, Mohammadi S, Mirzamohammadi E, Ghaffari M, Attarchi M, Amiri A. Assessment of neurobehavioral disorders in workers exposed to organic solvents in a publication house. *Med J Islam Repub Iran* 2014 (12 Feb). Vol. 28:3.

Introduction

Organic solvents are a group of aliphatic and aromatic organic compounds. Various industrial and chemical processes in industry are correlated with the properties of organic solvents and this correlation leads to the workers' significant exposure to such materials (1).

The National Institute of Occupational Safety and Health (NIOSH) estimated that about 9.8 million workers had been exposed to the solvents in early 1970s in US. (2). A great number of workers, all around the world, are exposed to the solvents due to their working in the plastics factories,

1. Associate Professor of Occupational Medicine, Iran University of Medical Sciences, Department of Occupational Medicine and Occupational Medicine Research Center (OMRC), Tehran, Iran. ylabbafinejad@yahoo.com
2. Associate Professor of Occupational Medicine, Department of Occupational Medicine, Iran University of Medical Sciences Tehran, Iran. sabermohammadi@gmail.com
3. MD, Occupational Medicine Specialist, Brain and Spinal Cord Injury Research Center (BASIR), Iran University of Medical Sciences, Tehran, Iran. elmirzamo@yahoo.com
4. Assistant Professor of Occupational Medicine, Department of Occupational Medicine, Iran University of Medical Sciences, Brain and Spinal Cord Injury Research Center (BASIR), Iran University of Medical Sciences, Tehran, Iran. m_ghafaari@yahoo.com
5. Associate Professor of Occupational Medicine, Department of Occupational Medicine, Iran University of Medical Sciences Tehran, Iran. drmsattarchi@gmail.com
6. (**Corresponding author**) MD, Department of Occupational Medicine, Brain and Spinal Cord Injury Research Center (BASIR), Iran University of Medical Sciences, Tehran, Iran. az.amiri419@yahoo.com

pharmaceutical and agricultural production plants, printing industries and laundries, and also as a result of their continual contact with paints, adhesives and detergents. The volatile and lipophilic properties of solvents make a significant amount of them enter into the body through inhalation of vapors and skin absorption.

The workers' exposure to the organic solvents may cause various symptoms and complications. Such acute effects have been well recognized, and they have been mostly appeared to be in the central nervous system (CNS). The main effect of solvents is the CNS depression, and depending on the severity of exposure, it may cause headache, dizziness, fatigue or even loss of consciousness and death (3).

Researchers specified the chronic or delayed neurotoxic effects of solvent exposure in the second half of the twentieth century (1). Workers exposed to the organic solvents complained of fatigue, amnesia, attention deficit and anxiety more than the non-exposed ones; it would be inferred that the long-term exposure to low doses of organic solvents might impose some chronic effects on the central nervous system (4).Various terms have been used to express those chronic effects such as chronic toxic encephalopathy, early dementia and painters' syndrome. The disorder is usually diagnosed through the patient's complains, the results of the neurobehavioral tests, and also the duration of solvent exposure at work. Epidemiologic studies in workers exposed to the solvents revealed high incidence of neurobehavioral effects in them. These effects include changes in their personality, temperament or their intelligence function (5). Morrow proved that the anxiety and the mood disorders or depression increased in those painters exposed to the solvents (6). A number of studies showed that marginal atrophic disorders in brain or nerve conduction velocity deficit increase in workers exposed to organic solvents (3). The number of solvent exposed workers in industrial countries increases day by day and they deserve to receive employment compensation due to their neuropsychiatric disorders (5).

With regards to the above mentioned studies, it is clear that exposure to the organic solvents is one of the most important factors threatening the workers' health. Accordingly, the workers' health assessment and screening them in terms of neurological symptoms is deemed essential. The Swedish Q16 questionnaire is a screening tool for neurotoxicity symptoms related to organic solvents in workers, prepared by Hoqstedt and colleagues (7). The questionnaire is commonly used in various researches for studying neurotoxic effects of solvent exposure. It is considered as a valid questionnaire, consisting of 16 short yes/no questions and dealing with the symptoms widely expressed by the solvent-exposed workers. Those respondents, who give positive answers to more than 6 questions, have to be referred to a physicians or psychiatrists for further examinations to exclude the possibility of organic brain damages. Most of the studies are based upon the comparison between solvent-exposed workers and non-exposed ones, and they revealed that the average scores of the solvent-exposed workers in the Swedish Q16 questionnaires were higher than the rest (4).

This study evaluates the neurological disorders in a group of solvent-exposed workers using Swedish Q16 questionnaire in a publishing house in Tehran.

Methods

The following research is a cross-sectional study, and the studied population here is the workers of a publishing house in Tehran. They have been working in different parts of the institute, some of whom have been exposed to the solvents and others have not. Variables included age, medication, occupation duration, smoking, shift working, exposure or non-exposure to the solvents and also the scores of Swedish Q16 questionnaire. Census is applied as the sampling method and the whole workers of the printing house became engaged in the research voluntarily and with full consent.

We studied 510 cases. Since they worked in different parts of the institute, 345 workers had been exposed to the solvents (the exposed group) and the remaining 165 had not (the non-exposed group).We considered office workers as non-exposed and the other workers as exposed group. The inclusion criterion included at least one year of working experience in the publication company. The average of working hours in one working shift for workers in this publication house was 11 hours. The workers who suffered from previously diagnosed neurobehavioral diseases and dementia, those who were exposed to the organic solvents in their previous career, and the workers who took other medications affecting the nervous system were excluded from the research. Workers' exposure to the solvents was measured quantitatively; however in this survey only qualitative data was available. According to the manufacture HSE team results, solvent concentrations were higher than occupational permissible limit in all parts of production units.

By medication we meant those drugs which did not affect the nervous system, and the workers who took medications affecting the nervous system were excluded from the research.

Data collection tools included demographic information such as age, sex, duration of employment, and the Swedish Q16 questionnaire. This questionnaire is a screening tool for the neurotoxicity symptoms and includes 16 questions about the neurotoxicity symptoms like fatigue, difficulty in concentration, decreased sexual desire, impaired short-term memory and at least once a week headaches, etc. The questionnaire is presented as the primary and sensitive screening tool to detect the neurobehavioral disorders of the continual exposure to the organic solvents (8). The validity and durability of the questionnaire had been previously studied and proved (4).

Table 1. Mean and standard deviation comparison of studied variable in exposed and non-exposed group.

	Exposed group (n=345)	Non-exposed group (n=165)	p value
Age (year)	38.1±9	34.2±1.2	<0.001
Working hours	11.4±1.7	11.2±2.7	0.231
Working experience (year)	14.8±8.8	12.4±8.7	0.008
BMI (kg/m²)	26.15±3.65	25.98±4.00	0.058
Swedish Q16 questionnaire score	4.8±4.4	3.2±3.1	<0.001

Table 2. Comparison of positive answers (percent) to each of Swedish Q16 questions in two studied groups

	Questions	Exposed group	Non-exposed group	p-Value
1	Are you abnormally tired?	39	20	<0.001
2	Do you often have a painful tingling in some part of your body?	41	17	<0.001
3	Do you have heart palpitation even when you don't exert yourself?	23	13	0.009
4	Do you often feel irritated without any particular reason?	25	11	<0.001
5	Do you often feel depressed without any particular reason?	30	18	0.004
6	Do you have problems with concentration?	22	13	0.028
7	Do you forget easily?	19	7	<0.001
8	Do you perspire without any particular reason?	26	14	0.003
9	Do you often have problems with open and close buttons on your dress?	31	13	<0.001
10	Do you generally find it hard to get the meaning from reading newspapers and books?	35	20	<0.001
11	Have your relatives told you have a short memory?	42	46	0.416
12	Do you feel pressure in your chest?	29	23	0.146
13	Do you often have to make notes about what you must remember?	48	39	0.051
14	Do you often have to go back and check things you have done (locked the door ,etc)	47	42	0.288
15	Do you have headache at least once a week?	8	9	0.846
16	Are you less interested in sex than what you think is normal?	25	9	<0.001
	Abnormal test	38	22	<0.001

Table 3. Comparison the percent of persons with smoking, shift work and drug use in two groups

	Exposed group	Non-exposed group	p-value	Odds ratio	95%CI
Smoker N (%)	21 (6.1)	8 (4.8)	<0.001	2.96	1.58-5.54
Shift worker N (%)	45 (13.0)	21 (12.7)	<0.001	2.98	1.95-4.56
Drug user N (%)	25 (7.2)	38 (23.1)	0.006	0.54	0.34-0.84

Table 4. Correlation of studied variables with frequency of neurobehavioral disorders according to regression analysis

		beta	p value	Adjusted odds ratio	95%CI
Age		0.01	0.45	0.98	0.94-1.02
smoking		0.37	0.18	1.45	0.83-2.53
Working experience		0.04	0.06	1.04	0.99-1.1
Shift working		0.29	0.19	1.34	0.85-2.11
Education	Illiterate and sixth grade [a]	-	-	1	-
	Guidance and high school Without Diploma [b]	0.3	0.41	0.73	0.35-1.53
	Diploma [c]	0.6	0.06	0.54	0.28-1.04
	Associate degree [d]	0.52	0.19	1.69	0.76-3.76
	BA[e] and higher	0.3	0.59	0.73	0.23-2.3
Exposure to solvents		0.58	0.02	1.79	1.07-3.02

a: up to 6 years of education in school, b: Between 6-11 years of education in school, c: At least 12 years of education in school, d: An educational level between High school graduate and Bachelor of Science (at least 2 years of education in university), e Bachelor of Science.

According to this questionnaire, if it contained 4 positive answers or more for the workers younger than 28-year old and 6 positive answers or more for the 28-year old workers or older, then the respondent was supposed to be suffering from neurobehavioral disorders (8). The information obtained by interviewing the workers completed the questionnaires. We fill out the questionnaires in early shift for all of the employees.

The study was approved by the ethics committee of the Tehran University of Medical Sciences.

Statistical Analysis

Mean, standard deviation (SD) and range of quantitative variables were calculated. The quantitative variables were analyzed using t-test and correlation, and the qualitative variables were analyzed using chi-square. The logistic regression analysis was applied to remove the effect of confounding factors. The data were analyzed using the SPSS software.

Results

A total of 510 workers of a publishing house included in this study; 345 of whom were exposed to the organic solvents and were considered as the exposed group and 165 ones were working in other parts of the company where there was no exposure to the solvents and they were considered as the non-exposed group. The studied workers' average age was 36±10 years with a working experience of 14±8 years. Comparison between the two groups in terms of age, sex, BMI (Body Mass Index), working experience, working hours and their Swedish Q16 questionnaire score is shown in Table 1.

As can be seen, the average age and working experience of the exposed group is significantly higher than the non-exposed group ($p<0.05$). The average Swedish Q16 questionnaire score in the exposed group (4.8±4.4) is also significantly higher than the non-exposed group (3.2±3.1) ($p=0.001$). There was no significant difference between the two groups in terms of other variables (weight and working hours). Table 2 shows the percentage of positive answers to each question in the Swedish Q16 questionnaire for both groups. As shown here, in most of the questions like depression, fatigue, anger, difficulty in concentration, feeling of amnesia, decreased sexual desire, and difficulty in comprehension, a significant relationship is recognized in the organic solvent-exposed group. There was no significant difference between the exposed

and non-exposed groups for some questions of the questionnaire including amnesia in others' opinions, feeling of chest pressure, note-taking due to paramnesia, frequent review, and once a week headaches. The frequency of neurobehavioral disorders in the exposed group was 38% (according to the questionnaire scores) and that in the non-exposed group was 22% (p=0.001).

The number of smokers in the exposed group (21%) was more than the non-exposed (8.3%). This difference was also statistically significant (p<0.001). The working shift in the exposed group (45%) was higher than the non-exposed group (21%), but the non-exposed group took more medications than the exposed group (Table 3).

With regards to the significant difference between the exposed and the non-exposed group in terms of age, number of smokings, education, and working shift, the regression analysis was used to remove the effects of such variables known as the confounding factors. The frequency of the neurobehavioral disorders in the exposed group, due to the Swedish Q16 questionnaire scores, was higher than the non-exposed group (CI: 1.07 – 3.02, OR: 1.79, p=0.02) (Table 4).

Discussion

In this research, we studied the neurobehavioral disorders due to chronic exposure to the organic solvents using the Swedish Q16 questionnaire. This questionnaire has been widely used in various researches to study the neurotoxic effects of solvent exposure. In this research and according to the questionnaire scores, the frequency of neurobehavioral disorders in the exposed group is estimated to be higher than the non-exposed group. This finding is consistent with the results of previous studies having been carried out in this field. Most of the studies showed that the solvent-exposed workers received the average higher scores in the questionnaire related to the symptoms. The results of researches by Ihrig and colleague revealed that slightly increased mental complaints and reduced concentration are associated with chronic solvent exposures (9). Some researchers have warned about the high risk of psychopathy in painters and workers exposed to the solvents, which eventually leads to their early retirement. On the other hand, long-term exposure to high amounts of solvents might affect the aging process and reduce the cognitive symptoms (6); this issue may gain importance by increasing workforce age.

In the present research, the frequency of positive answers in the exposed group for most of the questions in the Swedish Q16 questionnaire (11 out of 16 questions) was more than the non-exposed group and only 5 of the questions showed no significant relationship. Pouryaghoub and colleagues carried out a research and proved such positive relationship for just one question (depression) and found no significant difference between the two groups in terms of other neuropsychiatric symptoms in the exposed group (10). Lundberg in his study applied the Swedish Q16 questionnaire and the psychometric tests to assess the neurological symptoms in the workers exposed to the solvents (painters and carpenters) and found a strong dose-response relationship between the group exposed to the solvents and the number of positive answers to the questions in the Swedish Q16 questionnaire (including the prevalence of more than 6 symptoms) (4). In the Nasterlack's research, those painters exposed to the organic solvents showed higher temperament and behavioral symptoms than the non-exposed group. These symptoms were more associated with their long term exposure to the solvents than their recent exposure (11). In most studies, the average 5 years exposure has been considered enough to assess the neurobehavioral symptoms (12). The average working experience of the studied workers in the present research was 14 years as the indicative of their long term and chronic exposure to the solvents. The results of the researches carried out by Williamson, Winder, White, and Nilson revealed that the prognosis of CNS disorder

depends on the duration and the severity of exposure to the solvents and also to the time past from the last exposure (13, 14, 15).

In some researches no relationship was found between the organic solvent exposure and the neurobehavioral symptoms. Spurgeon and Bleeker did not detect any increase in the symptoms associated with the solvents in those people exposed to the organic solvents (16, 17). In the studies of Beheshti and colleagues, who studied the neurobehavioral symptoms in the workers of an automobile factory exposed to the organic solvents in 2002, no significant difference was detected between the two groups in term of neurobehavioral symptoms (8).

The questionnaire applied here, is presented as a screening tool to find the disorders due to the long term exposure to the organic solvents. Therefore, it was expected to face with several false positive cases. The designers of this questionnaire recommended that the positive cases be confirmed by the physician's examination and the appropriate clinical examinations and psychological and neurophysiologic tests (17), the accomplishment of which were not possible for us due to our limited resources.

The confounding factors such as age, education, drug abuse, alcohol, etc. could affect the results of the research. The studies of Colvin and colleagues on the workers of a paint production plant showed that some factors like age, education and alcohol consumption confound the neurobehavioral test scores (18). In the present research, we minimized the effects of such confounding factors by the use of regression analysis. We asked about medication, but we didn't ask about alcohol consumption. Because of our cultural limitations we had no possibility to collect detailed information about drug and alcohol abuse. It was one of the limitations of our survey. The research design was cross-sectional and that was another limitation. It is suggested that the future studies be prospective. Meanwhile, it is recommended that additional tests for screening the neurobehavioral disorders be applied in future studies.

Conclusion

The results of our study revealed that the prevalence of neurobehavioral disorders in the organic solvent exposed group was significantly more than the non-exposed group that it was correlated by other previous studies. If the results of the present research can be confirmed by further prospective studies, then the use of Swedish Q16 questionnaire would be helpful in the periodic examinations of the personnel exposed to the organic solvents for screening the neurobehavioral disorders.

References

1. Viaene MK. Overview of the neurotoxic effects in solvent-exposed workers. Arch Public Health 2002, 60, 217-232

2. Rosenstock L, Cullen MR, Brodkin CV, Redlich CA. Clinical occupational and environmental medicine. 2nd edition. Philadelphia: WB Saunders; 2005, 991.

3. Ridgway P, Nixon TE, Leach JP. Occupational exposure to organic solvents and long-term nervous system damage detectable by brain imaging, neurophysiology or histopathology. Food Chem Toxicol. 2003 Feb; 41(2):153-87.

4. Lundberg I, Hogberg M, Michelsen H, Nise G, Hogstedt C. Evaluation of the Q16 questionnaire on neurotoxic symptoms and a review of its use. Occupational and environmental medicine 1997, 54, 343-350.

5. Ladou J. Occupational and environmental medicine. 4th edition. Philadelphia: McGraw-Hill; 2007, 488.

6. Nordling Nilson L, Barregard L, Sallsten G, Hagberg S. Self reported symptoms and their effects on cognitive functioning in workers with past exposure to solvent- based glues: an 18-year follow-up. Int Arch Occup Environ Health (2007), 81: 69-79

7. Hogstedt C, Hane M, Axelson O. Diagnostic and health care aspects of workers exposed to solvents. In: Zenz C, editor. Occupational medicine. 2nd ed. Chicago: Medical Publishers; 1980. 249–58.

8. Beheshti S, Sharifian S.A., Mehrdad R, Hosseininia SH. Solvent exposure can cause neurobehavioral effect. J Gorgan Uni Med Sci. 2002; 4 (2):30-35

9. Ihrig A, Dietz MC, Bader M, Triebig G. Longi-

tudinal study to explore chronic neuropsychologic effects on solvent exposed workers. Industrial Health 2005, 43, 588-596.

10. Pouryaghoub Gh, Sadeghniiat Haghighi Kh, Sarreshtahdar H. Neuropsychological Effects of "Perchloroethylene" on Exposed Dry Cleaning Workers. ZUMS Journal. 2008; 16 (64) :47-56

11. Nasterlack M, Dietz M.C, Frank K-H, Hacke W, Scherg H, Schmittner H, et al. A multidisciplinary cross-sectional study on solvent-related health effects in painters compared with construction workers. Int Arch Occup Environ Health (1999) 72: 205-214

12. Ekberg K, Hane M, Berggrem T. Psychologic effects of exposure to solvents and other neurotoxic agents. In:Zenz C, editor. Occupational Medicine. 3rd edition. St Louis: Mosby-year book; 1994. 779-89.

13. Williamson AM, Winder C. A prospective cohort study of the chronic effects of solvent exposure. Environ Res 1993, 62, 256-71.

14. White RF, Robins TG, Proctor S, Echeverria D, Rockskay AS. Neuropsychological effects of exposure to naphta among automotive workers. Occup Environ Med 1994, 51, 102-12.

15. Nilson LN, Sallsten G, Hagberg S, Backman L, Barregard L. Influence of solvent exposure and aging on cognitive functioning, an 18 year follow up of formerly exposed floor layers and their controls. Occup Environ Med 2002, 59, 49-57.

16. Bleecker ML, Bolla KI, Agnew J, Schwartz BS, Ford DP. Dose related subclinical neurobehavioral effects of chronic exposure to low levels of organic solvents. Am J Ind Med 1991, 19(6): 715-728.

17. Spurgeon A, Gray CN, Sims J, Calvert I, Levy LS, Harvey PG, et al. Neurobehavioral effects of long-term occupational exposure to organic solvents: two comparable studies. Am J Ind Med. 1992; 22(3):325-35.

18. Colvin M, Myers J, Nell V,Rees D, Cronje R. A cross-sectional survey of neurobehavioral effects of chronic solvent exposure on workers in a paint manufacturing plant. Environ Res 1993; 63(1):122-32.