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Prevalence of Neuropsychiatric and Mucous Membrane Irritation Complaints Among Palestinian Shoe Factory Workers Exposed to Organic Solvents and Plastic Compounds

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Fahed Takrori, PhD,³ and Espen Bjertness, PhD⁴

Background Long-term exposure to organic solvents is associated with neuropsychiatric and mucus membrane irritation. In developing countries, efforts to secure a good working environment are inadequate and protection against chemical exposures is often neglected.

Methods In a cross-sectional survey, the prevalence of self-reported health complaints and the association with long-term exposure to solvents and plastic materials in the work environment was studied among 167 shoe-factory workers. Prevalences and adjusted prevalence ratios (PR) were calculated in Cox regression. 95% confidence intervals were estimated for PRs of adverse health effects.

Results Overall, the workers reported high prevalences of neuropsychiatric and mucus membrane complaints: headache (65%), mental irritability (53%), tingling of limbs (46%), and sore eyes (43%). Cleaning work was associated with tingling of limbs (PR = 1.8, 1.0-3.2), sore eyes (PR = 1.9, 1.1-3.3), and breathing difficulty (PR = 2.0, 1.0-3.9); plastic work was associated with tingling of limbs (PR = 1.8, 1.2-2.9) and sore eyes (PR = 1.7, 1.1-2.7); and varnishing was associated with breathing difficulty (PR = 1.9, 1.1-3.5).

Conclusions The high prevalence of self-reported health complaints and the exposure-outcome association could be due to volatile organic solvents (dichloromethane, n-hexane) and plastic compounds (isocyanates and polyvinyl chloride). Absence of a satisfactory work environment is likely to contribute to high exposure levels. *Am. J. Ind. Med.* 40:192-198, 2001. © 2001 Wiley-Liss, Inc.

KEY WORDS: organic solvents; plastic compounds; neuropsychiatric symptoms; mucous membrane irritation; shoe industry; cross sectional epidemiological study; interview

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INTRODUCTION

Exposure to organic solvents has been associated with acute symptoms such as headache, palpitation, and chest tightness, in addition to chronic symptoms of dizziness, fatigue, and depression [Wang and Chen, 1993]. It has been suggested that exposure to organic solvents could cause mental and cognitive impairment that may become chronic and disabling [WHO, 1985; Mikkelsen, 1997]. The nature of the possible connection between long term exposure and the

development of clinically evident encephalopathy among exposed workers has not been clearly established [Daniell et al., 1999].

Based on epidemiological studies on shoe manufacturing, organic solvents are considered to be the main risk factor for occupational diseases among the workers [Scarpelli et al., 1993]. Chronic neurological signs and symptoms as well as neurophysiological abnormalities attributed to exposure to industrial solvents have been found among shoe workers [Passero et al., 1983]. A high prevalence of polyneuropathy was observed in shoe and leather workers in Florence [Buiatti et al., 1978]. Toxic polyneuropathy observed among groups of shoe-industry workers in Italy was clinically characterized as distal motor deficit, and *n*-hexane found in solvents and glues was suggested as the causative agent [Abbritti et al., 1976; Cianchetti et al., 1976; Rizzuto et al., 1980; Passero et al., 1983]. Also a neurasthenic syndrome including tiredness, concentration difficulty, impaired memory, and mental irritability have also been reported among shoe workers [Johnson, 1987]. Exposure to glue solvents in shoe factories has been found to cause chronic airway impairment with non-specific bronchial hyper-responsiveness [Paggiaro et al., 1985]. Workers exposed to polyvinyl chloride in Nigerian shoe factories developed restrictive lung diseases [Oleru and Onyekwere, 1992]. Workers with long job duration in the shoe industry had a higher prevalence of chronic phlegm (15%), and attacks of shortness of breath and dyspnea (39%) than workers with shorter job duration [Paggiaro et al., 1993]. Mironov et al. [1994] indicated that diseases of locomotion and nervous system were prevalent among shoe-factory workers.

Studies from industrialized countries indicate that organic solvent exposure is common and constitutes a potential health hazard to workers [Anshelm, 1985; Iregren, 1986]. There are reasons to believe that the situation in the developing countries, including the Palestinian Authority, is worse [Nijem et al., 2000]. However, this has not been comprehensively studied.

Manual shoe production (in homes) has a long history and is considered to be an important industrial sector in the West Bank and Gaza Strip. During the last few years, shoes have been produced in factories using organic solvents and modern plastics technology. It is likely that exposure reducing efforts have not been taken in order to reduce negative health effects.

The objectives of the present study were to estimate the prevalences of nervous system and mucous membrane irritation complaints among shoe-factory workers in Hebron City, and to investigate the associations between these health complaints, and exposure to organic solvents and plastic compounds.

MATERIALS AND METHODS

Study Population

Hebron City is one of the largest cities in the West Bank with a total population of 200,000 inhabitants. It is located in the southern part of the West Bank, 40 km from Jerusalem. Hebron is a trade center manufacturing glass and leather. Over the past 10 years, many industrial activities started to develop, including the leather industry (Hebron Chamber of Commerce, personal communication). The leather industry represents 40% of Hebron's industrial sector. An important sector of the leather industry is manual shoe manufacturing (shoe-factory and workshops). Twenty-seven small factories with modern technology are found in the city (Chamber of Commerce, personal communication), the factories usually employ 15–100 workers. The factories lack minimum standards, e.g., an effective ventilation system, barriers between factory tasks, and enough space for the workers. The workers rarely use personal protective equipments such as respiratory protective equipments, gloves, and special working clothes [Nijem et al., unpublished data].

Sampling Procedure

This study was conducted during 1996–97 by sending an invitation and information letter to the owners of 27 factories. Owners from 20 factories accepted to participate in the study. Workers who had worked less than 1 year in these factories were excluded from the study. The owners of the 20 factories allowed us to interview personally a total of 167 workers (all male). However, the owners refused to provide us with names and total number of workers in their factories, so as to choose a random sample, instead the owners agreed to send the workers (from working site) one by one to a separate room at the administration building where the team was waiting. Two trained interviewers from Hebron University performed the interviews, one was asking the questions and the other was writing down the answers. Sociodemographic and life style indicators of the study population are provided in Table I.

Questionnaire

Health complaints among the workers were measured by using questions from a validated Swedish neuropsychiatric symptom questionnaire (Q16) [Hane and Hogstedt, 1980], with slight modification. The questions were related to symptoms representing neuropsychiatric and mucous membrane irritations outcomes such as headache, mental irritability, painful tingling of limbs, sore eyes, and breathing difficulties. We considered headache, sore eye, and breathing difficulty as acute effects and mental

TABLE I. Sociodemographic and Life Style Factors of Shoe-Factory Workers (n = 167) in Hebron City, 1996–1997

Factors	Median	Percentiles	
		25	75
Age (years)	29	24	36
Years of education	9	7	12
Number of people in household	8	5	10
Smoking (years)	4	0	10
Cigarettes/day	7	0	7

irritability and tingling of limbs as subchronic or chronic effects. For each health complaint it was asked if the workers considered it to be work related. To our knowledge the Q16 was used for the first time in an Arabic-speaking population. Other questions related to exposure, age, socio-demographic characteristics (smoking, marital status, and education), life style (number of people in household that eating and sleeping in the same house), and the use of personal protective equipment (respiratory protective equipment, gloves, goggles, head cover, special shoes, and working clothes) were also included.

Exposure

The workers were exposed to different chemical compounds depending on the work task and the type of production: Dichloromethane (cleaning), *n*-hexane (adhesive), toluene (varnishing), and diisocyanate and PVC in plastic sole curing and molding, respectively.

The total months of work in different tasks (plastic molding, cleaning, gluing, and varnishing) was calculated

and used as an estimate of cumulative exposure. Adhesive work was categorized into four subgroups (0, 1–12, 13–72, > 72 months), cleaning into three subgroups (0, 1–24, > 24 months), varnishing and plastics were dichotomized (0, ≥ 1 month).

Data and Statistical Analyses

SPSS software (SPSSWIN, release 8.0) was used to calculate the prevalences of self-reported health complaints (sore eye, headache, tingling of limbs, mental irritability, and breathing difficulty) in relation to exposure in different categorized working tasks (plastics, cleaning, adhesive, and varnishing). The reference group was recognized as workers who did not take part in a specific task, and were considered unexposed.

Prevalence ratio (PR), which was used as an estimate of relative risk, was computed to describe exposure-outcomes associations [Skov et al., 1998]. Cox regression was used to estimate PR that was adjusted for categories of age (16–24, 25–29, 30–36, > 36 years), education (< 9, 9, > 9 years), marital status (single or married), and ever smoking (yes, no). 95% CI were calculated for PRs, CIs that did not include the null value were considered statistically significant.

RESULTS

Overall prevalences were high for most symptoms ranging from 28% (breathing difficulty) to 65% (headache) (Table II). Prevalences over strata of age, education, marital status, and smoking were also mostly high. The prevalence of sore eye (50%) and breathing difficulty (33%) were higher among smokers than nonsmokers. The associations between exposure and neurological symptoms (headache,

TABLE II. Percentages of Self-Reported Health Outcomes by Categories of Age, Education, Marital Status, and Smoking Habits Among Shoe Factory Workers in Hebron City, 1996–1997

Health outcome	Age (years)				Education (years) ^a			Marital status ^b		Smoking (ever)		Total N = 167
	16–24 (N = 44)	25–29 (N = 43)	30–36 (N = 39)	> 36 (N = 41)	< 9 (N = 22)	9 (N = 66)	> 9 (N = 78)	Single (N = 60)	Married (N = 105)	No (N = 68)	Yes (N = 99)	
Sore eyes	46	42	44	39	45	41	41	40	44	32	50	43
Headache	68	61	72	59	60	64	70	68	62	65	65	65
Breathing difficulty	27	35	33	17	24	36	29	27	29	21	33	28
Mental irritability	46	54	54	61	55	50	52	50	56	50	56	53
Tingling of limbs	46	30	49	59	53	50	36	37	51	40	50	46

^aMissing information from one worker.

^bMissing information from two workers.

tingling of limbs, and mental irritability) are provided in Table III. Tingling of limbs showed a significant association with cleaning compounds. The risk of tingling of limbs significantly increased among the workers who were using organic solvents in cleaning tasks for 1–24 months (PR = 1.7; CI = 1.0–3.0), or more than 24 months (PR = 1.8; CI = 1.0–3.2). Moderate, nonsignificant associations were found between cleaning, headache, and mental irritability.

The associations between exposure and mucous membrane irritation (sore eyes and breathing difficulty) are given in Table IV. There was a significant association between sore eyes and exposure to organic solvents for more than 24 months in cleaning processes, (PR = 1.9; CI = 1.1–3.3). Working with plastic molding also showed a significant association with sore eyes (PR = 1.7; CI = 1.1–2.7). Cumulative uses of varnishes or adhesive compounds were not associated with sore eyes. Breathing difficulty was significantly associated with the cleaning task (Table IV): working with cleaning compounds for 1–24 months doubled the risk of breathing difficulty among the workers (PR = 2.0, 1.0–3.9). Varnishing also showed an association with breathing difficulty (PR = 1.9, 1.1–3.5). Working in adhesive application or plastic molding did not show a significant association with breathing difficulty.

DISCUSSION

The overall prevalences of the self-reported health complaints were high among the shoe-factory workers. This could be due to exposure to highly volatile solvents and plasticizer compounds that are known to cause mucus membrane irritation [Oleru and Onyekwere, 1992] and induce neurotoxic effects [Kyrklund, 1992; Wang and Chen, 1993] as well as mental and cognitive impairment [Mikkelsen, 1997; Morrow et al., 1998]. The absence of mechanical ventilation and suitable protective equipment [Nijem et al, unpublished data] could cause persistence of these compounds at the work site for a long period of time, thus increasing the exposure time and level. The absence of barriers between different work departments could enable substances from different sites to diffuse freely and result in bystander's exposure.

A significant association between long-term exposure to cleaning solvents and tingling of limbs was found. This could be due to inhalation of neurotoxic solvents as *n*-hexane and dichloromethane, since both solvents were used as cleaning agents in the factories under study. Cumulative exposure in plastic molding was associated with sore eyes and tingling of limbs. Workers in this task could be exposed to diisocyanates, a strong irritant compound that produces eye and airway inflammation [Akbar-Khanzadeh and Rivas, 1996], and to different solvents such as *n*-hexane that are responsible for

toxic polyneuropathy [Giuliano et al., 1975]. The pyrolysis products of heated polyvinyl chloride (PVC), e.g., hydrochloric acid could also produce airway inflammation [Ng et al., 1991; Oleru and Onyekwere, 1992]. In the varnish application, exposure to organic solvents was associated with breathing difficulty. Cumulative exposure to solvents in adhesives apparently did not increase any of the health outcomes.

Our results could be biased by several factors. To exclude unhealthy workers who leave their jobs is a major source of selection bias in occupational health studies. The factory owners chose workers in this study; this could create selection of healthy workers and a biased underestimation of association in our study. Selection of the workers by the factory owners was problematic but we did not have any other recourse but to accept the owners demand as a prerequisite for participation. However, the absence of medical records for the workers may have reduced the possibility of choosing healthy workers but did not prevent it. Exposed workers could be concerned about their health, and over report symptoms, creating biased overestimates of association. Registration of exposure and outcomes by the same team is likely to produce observer bias, however, the use of a standardized questionnaire (Q 16) with sufficient sensitivity, as well as previous effective training of the team by a specialist, may have minimized the influence of the interviewers.

The fact that unexposed shoe-factory workers reported high prevalences of complaints could be an indication that they are really exposed (bystander's exposure, exposure in other tasks). If so, our association would be biased toward the null value, i.e., towards no association. Using the same questionnaire, we have interviewed dairy workers in Hebron city, unexposed to organic solvents and plastic compounds. Also in this group the prevalence of symptoms was considered high, but it was 32 – 67% lower than in the group of shoe-factory workers. The FAFO-study [FAFO, 1993] reports high prevalences of health complaints in the male Palestinian population: headache, 36%; general tiredness: 47%; and depression, 28%. This may indicate that exposure to solvents and plastic compounds may increase the level of reported health complaints among shoe-factory workers, and that other unobserved factors may explain the high overall symptom prevalences, e.g., the tense political situation in the city and/or cultural factors. It was considered to use dairy workers as a reference group, but not done because they were considerably younger than the shoe-factory workers.

Although we performed both Cox and Logistic regression to estimate relative risk, we believe PR results are quite more conservative than odds ratios (ORs) [Checkoway et al., 1989], i.e., PR of sore eyes and working in cleaning task for >24 months was 1.9 (95% CI = 1.1–3.3), while OR was 3.2 (95% CI = 1.4–7.5). However, the use of Cox

TABLE III. Number of Cases, Prevalences, and Prevalence Ratios (PR) for Selected Neuropsychiatric Symptoms, by Categorized Duration of Exposure in Different Work Tasks, Hebron City, 1996–1997

Neuropsychiatric symptom	Exposure (months)	No. of cases	Prevalence	Prevalence ratio (PR) ^a	95% CI		
Headache	Adhesive work	0	35	0.67	1 (reference)		
		1–12	12	0.55	0.8	0.4–1.5	
		13–72	31	0.66	1.0	0.6–1.6	
		> 72	30	0.65	1.0	0.6–1.8	
	Cleaning	0	52	0.57	1 (reference)		
		1–24	28	0.67	1.2	0.7–1.9	
		> 24	28	0.85	1.5	0.9–2.4	
	Plastic work	0	66	0.62	1 (reference)		
		≥1	42	0.69	1.1	0.7–1.6	
	Varnishing	0	66	0.63	1 (reference)		
		≥1	42	0.68	1.1	0.7–1.6	
	Tingling of limbs	Adhesive work	0	25	0.48	1 (reference)	
			1–12	7	0.31	0.7	0.3–1.6
			13–72	18	0.38	0.8	0.4–1.4
> 72			26	0.57	1.0	0.5–1.8	
Cleaning		0	31	0.34	1 (reference)		
		1–24	24	0.57	1.7	1.0–3.0	
		> 24	21	0.64	1.8	1.0–3.2	
Plastic work		0	38	0.36	1 (reference)		
		≥1	38	0.62	1.8	1.2–2.9	
Varnishing		0	50	0.48	1 (reference)		
		≥1	26	0.42	0.8	0.5–1.3	
Mental irritability		Adhesive work	0	28	0.54	1 (reference)	
			1–12	12	0.55	1.0	0.5–2.0
			13–72	21	0.45	0.8	0.5–1.4
	> 72		28	0.61	1.1	0.7–1.9	
	Cleaning	0	46	0.50	1 (reference)		
		1–24	21	0.50	1.0	0.6–1.7	
		> 24	22	0.67	1.4	0.8–2.3	
	Plastic work	0	51	0.48	1 (reference)		
		≥1	38	0.62	1.3	0.8–2.0	
	Varnishing	0	56	0.53	1 (reference)		
		≥1	33	0.53	1.0	0.6–1.5	

^aPR was adjusted for categories of age, education, marital status, and smoking.

TABLE IV. Number of Cases, Prevalences, and Prevalence Ratios (PR) for Self-Reported Symptoms Indicating Mucous Membrane Irritation, by Categorized Duration of Exposure in Different Work Tasks, Hebron City, 1996–1997

Mucus irritant symptoms	Exposure (months)	No. of cases	Prevalence	Prevalence ratio (PR) ^a	95% CI	
Sore eyes	Adhesive work					
	0	22	0.42	1 (reference)		
	1–12	7	0.32	0.7	0.3–1.8	
	13–72	19	0.40	0.9	0.5–1.7	
	> 72	23	0.50	1.2	0.7–2.4	
	Cleaning					
	0	30	0.33	1 (reference)		
	1–24	20	0.48	1.5	0.8–2.6	
	> 24	21	0.64	1.9	1.1–3.3	
	Plastic work					
	0	37	0.35	1 (reference)		
	≥1	31	0.50	1.7	1.1–2.7	
	Varnishing					
0	40	0.38	1 (reference)			
≥1	34	0.56	1.3	0.8–2.0		
Breathing difficulty	Adhesive work					
	0	10	0.19	1 (reference)		
	1–12	7	0.32	1.6	0.6–4.5	
	13–72	17	0.36	1.9	0.9–4.1	
	> 72	13	0.28	1.7	0.7–4.1	
	Cleaning					
	0	19	0.22	1 (reference)		
	1–24	16	0.38	2.0	1.0–3.9	
	> 24	12	0.36	1.7	0.8–3.7	
	Plastic work					
	0	25	0.24	1 (reference)		
	≥1	22	0.36	1.5	0.8–2.7	
	Varnishing					
0	22	0.21	1 (reference)			
≥1	25	0.40	1.9	1.1–3.5		

^aPR was adjusted for categories of age, education, marital status, and smoking.

regression for the calculation of PRs will produce confidence intervals that are slightly too wide [Skov et al., 1998].

In conclusion, this study indicates an association between self-reported health complaints (neuropsychiatric symptoms and mucous membrane irritation), and exposure to organic solvents and plasticizers in cleaning, varnishing, and plastic tasks. The presence of different biases could affect our results in both directions. Illuminating such biases is important, e.g., by applying longitudinal designs as well as the use of objective measures of exposure and outcomes. However, the resource situation in the study area is presently a major obstacle in achieving this.

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