Neurobehavioural testing in workers occupationally exposed to solvents in the manufacturing of paints, glues and varnishes in Oran.

Testing neuropsychologique chez des travailleurs exposés aux solvants dans les manufactures de fabrication de peintures et vernis à Oran.

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Abstract
Objectives - This study evaluated the risk for neuropsychological deficits among workers with long term occupational exposure to solvents.

Methods - This cross-sectional study evaluated 137 workers, exposed for on average 10.2 years (SD 7.9) to low level occupational exposure to organic solvents three plants producing paints, varnishes and glues). They were compared with 132 non-exposed workers recruited from a milk producing plant. A cumulative exposure index was calculated to evaluate the exposure of the workers to organic solvents. The prevalence of neurasthenic symptoms was assessed by Subjective Symptom Questionnaire recommended by WHO (Q16). Trained examiners (physicians) administered the WHO–Recommended Neurobehavioral Core Test Battery (OMS-NIOSH) and the data were adjusted for potential confounding factors using multiple logistic regression analysis (backward elimination technique).

Results - The exposed workers reported (more than once a week) significantly more neurasthenic symptoms (impaired memory, concentration difficulties and being easily irritated without reason) than the referents exposed group. Neurobehavioral performance levels of the exposed workers were lower than in the referents. However, after controlling for potential confounding variables (age, sex, education, tobacco, alcohol and drug consumption), an association between exposure to solvents and the Simple Reaction Time test scores of borderline significance was observed (OR 1.56; 95% CI 0.89-2.73). No association was found between estimated cumulative exposure and either psychometric performance or neurasthenic symptoms.

Conclusion - These findings suggest that workers in paint, varnish and glue producing plants in Algeria may be at risk for neurotoxic injury. In Algeria, much of the morbidity and mortality associated with neurotoxic agents remains hidden as a result of lack of skilled personnel and equipment for diagnosis.

Résumé
Objectif - Rechercher une relation entre l’exposition au long cours aux mélanges de solvants et des dysfonctionnements du système nerveux central.

Matérielle et méthodes - 137 employés de l’industrie des peintures exposés aux solvants en moyenne depuis 10.2 ans (DS 7.9) ont été comparés à 132 salariés de l’industrie laitière. Chaque participant a répondu à un questionnaire (caractéristiques socio-démographiques, habitudes de vie, éléments objectifs des conditions de travail, recherche de facteurs de risques de la pathologie neurocomportementale, et Q16: questionnaire sur les symptômes neuropsychiques subjectifs).
L’exposition a été estimé à partir d’un index d’exposition validé. Les performances psychomotrices ont été évalué à l’aide de la Batterie NCTB (Neurobehavioral Core Test Batterie) O.M.S / NIOSH. Modélisation selon la technique pas à pas descendante (Sys-Stat .8) et avec un seuil de signification 5%.

Résultats - Les personnes exposées aux solvants déclaraient souffrir plus fréquemment (au moins une fois par semaine) de symptômes que les exposés (troubles de la mémoire, difficultés de concentration, irritabilité sans raison). Les exposés étaient moins performants aux tests. Après ajustement sur les principaux facteurs de confusion (âge, sexe, niveau d’instruction et consommation de cannabis, alcool, tabac) une association entre exposition aux solvants et les résultats au test Simple Reaction Time est observée, mais avec un seuil de signification borderline (OR 1.56; 95% CI 0.89-2.73). Aucune association n’est observée entre l’estimation de l’exposition cumulée et la performance psychomotrice ni avec les symptômes neurasthéniques

Conclusion - Ces résultats suggèrent que les ouvriers des manufactures de peintures et vernis sont probablement exposés à un risque neurotoxique. En Algérie, la morbidité et la mortalité associées aux agents neurotoxiques est méconnue. Cette méconnaissance est liée au manque de qualification du personnel et à la faiblesse des moyens diagnostiques.

Key words: Neuropsychological tests, chronic occupational exposure, solvents.

Mots clé : Tests neuro-comportementaux, exposition chronique au travail, solvants

Introduction

Long term occupational exposure to solvents is now widely accepted to be a risk factor for neurotoxic disease in workers. Many studies have found large deficits in tests of psychomotor function. Also more neuropsychiatric symptoms among exposed workers such as fatigue, irritability, memory impairment, affective changes in personality, lack of concentration and depressed mood have been reported

1-2-3-4-5-6-7-8

In Algeria, the potential toxic effects of solvent exposure are little known among workers as well as among employers. No studies have been published so far on the subject in Algeria.

In occupational health services, surveillance of workers at risk is realized by doctors (most of them are general practitioners) who neither have the training nor the tools to screen for neurotoxic diseases in occupational settings. Considering the increase in the production of paints in Algeria, the number of exposed workers has increased in the last 20 years. In general the paint producing plants are of small or medium size, typically employing between 50 and 200 workers. Figure1 shows the amount of organic solvents used for the production of paint in the largest of the plants included in this study.

The purpose of the present study was to determine whether workers with long term occupational exposure to organic solvents in three factories of paint and glue in Oran (Algeria) were at risk of having impaired neuropsychological functioning.

Material and methods

Study design

This cross-sectional study took place between october 1997 and march 1999. Elligible workers exposed to organic solvents (aromatic, aliphatic solvents and ketons) were recruited from three different plants, producing paint varnish and glue, each employing between 20 and 150 workers. The main criterion for inclusion was at least one year of employment as an exposed worker and currently
employed in production site. The reference group was recruited from a diary products producing facility localized in the same geographical area as the index plants. In total, 285 workers were invited to the examinations. All invited exposed workers participated in the examinations (participation rate 100%). Among 148 referents who were invited, 16 subjects declined to participate. Thus the participation rate was 89% in the reference group.

Subjects were excluded from participation if any of the following criteria were met: (a) past or current neuropsychiatric disorders that might cause brain injury or affect performance at the study session (e.g. depression, psychosis, neurosis) (b) any chronic disease (c) chronic use of medication (d) regular (daily) consumption of alcohol or drugs (e) exposure to other neurotoxins (f) workers unable to read digit.

**Questionnaire**

Interview of the participants was done by a trained physician. Data about occupational history, health and lifestyle habits were collected. Information was also collected about non-occupational exposure to solvents, other neurotoxins, metal dusts and other chemicals.

Neurasthenic symptoms assessed by the use of the Subjective Symptoms Questionnaire (SSQ) transcribed into the Arabic language. The Arabic version of the SSQ has been validated in a previous neuropsychological study on solvent exposed workers. The participants were required to categorize the subjective symptoms according to how often they had been experienced during the last year. Four categories were used: never, sometimes (less than once a month), regular (less than once a week) or often (more than once a week).

**Neuropsychological tests**

The Neurobehavioral Core Test battery (O.M.S-NIOSH) which has been recommended by WHO, was administered individually by technically trained personnel (certified specialist in occupational medicine). The same test sequence was applied for all subjects. The neurobehavioral examination for each worker was carried out on first day of the week, in the morning before the working shift started. The test battery included the symptom questionnaire Profile of Mood Status (POMS), Simple reaction time, Digit Symbol, Benton retention test, Digit span and Pursuit Aiming II.

**Exposure**

The basic production and work processes did not change significantly during the 10 years before the study was conducted. However, the consumption of solvents increased and toluene was removed for safety reasons in the country. The solvent consumption in the largest of the plants under study is shown in figure 1. The paints contained mainly xylene, white spirit, solvent naphtha, various additives (kaolin, oil, silica, fungicides, catalysts) and pigments. Lead pigments were used infrequently. The glues contained mainly cyclohexanol and acetone. The plants were not equipped with specific ventilation system. Only natural ventilation, such opening hangars with doors and windows, was available. Only 15%-20% of the workers used airways protection devices (dust masks made of paper).

**Exposure assessment**

No industrial hygiene data were available. Thus, air concentrations of cyclohexane, benzene and acetone at the worksites of 12 workers were measured by a Draeger pump (a measured volume of air
is drawn through a tube containing chemicals which change in color in response to the presence of a specific gas present in the sample. Color changes and the duration of the color change indicate the measured concentration (table 1).

Exposure assessment was also conducted by an interview to characterize a painters’ index and solvents’ index. These indices have previously been validated in studies of workers exposed to hydrocarbons and were used to construct a Job-Exposure-matrix. 13, 14

The painter’s Index was calculated for six workers doing painting in the plants. Specific details of exposure at work, such as duration of painting (day/week), use of personal protective equipment, ventilation and exposure to paints outside the work place were collected. Four work situations were considered since there are recognized in literature as important determinants for high solvent exposure 15-16. These were working as painter, using alkyd paints, paint spraying, paint removing. The participants were asked to indicate on a four point-scale how often they were involved in the above mentioned practices (in days/week). The score for each item was 0 or 1 according to the frequency of the particular practice (more or less than once week). Each painter could get a score between 1 and 4. Subsequently this score is weighted by the individual working conditions, which were considered as good (0), middle (1) or bad (2). The final painter’s index was defined on a four point-scale (1-2-3 or 4) weighted by specific criteria according to working conditions. Higher values of this exposure index were considered to indicate higher levels of exposure.

Solvents Index: All respondents were asked about the use of solvents, glues, degreasing agents and paint removers. The solvent score was calculated according to the frequency of the particular work practice (more (1) or less (0) than once week). Further, the working conditions (good (0), middle (1) or bad (2)) and non-occupational exposure (absent (0)-present (1)) were considered as weighting factors. The information was scored. The final Solvent Index was defined on a four point-scale (1-2-3 or 4).

Statistical Methods

The student’s t–test was applied for group comparisons of continuous variables, while the $\chi^2$ test was used to compare outcomes between groups for dichotomous variables. General linear regression models and logistic regression models were used assess multivariate models for continuous and dichotomous variables respectively. Logistic regression models were adjusted for independent variables (age, sex, education, tobacco, alcohol, drugs). Continuous neurobehavioral variables were categorized for the use of logistic regression into two groups, above the mean of all participants and below this level. The level of significance was set at 5%.

Results

Demographic background

The characteristics of the 137 solvents exposed workers and 132 referents that participated in this study are shown in table 2. The exposed workers and the referents were comparable with respect to age and marital status. However, there were significantly more women in the reference group. The level of education was higher in the reference group. Only 8% of the exposed workers had high level of education (>12 years) in contrast to 17.4 % in the referents. There were also significant differences in smoking habits. The self-reported alcohol consumption was low in both groups. The exposed subjects were more likely to consume cannabis occasionally (less than 5 cigarettes/year) than the referents.
The mean duration of exposure to solvents was 10.2 years (SD 7.9). The subjects were exposed to solvents for 3 to 5 hours daily. Around 2/3 of the exposed workers were highly exposed according to the estimated indices of exposure.

Subjective Symptoms

The exposed workers reported subjective symptoms more frequently (> or = 1 time/week) than the referents. A significantly elevated odds ratio among the exposed workers was shown for impairment of memory (p< 0.04), concentration difficulties (p<0.03) and being easily irritated without reason (p<0.05) (table 3). The POMS symptom questionnaire indicated more hostility (p<0.03) and more confusion (p<0.007) among the exposed workers (table 4).

Neurobehavioral Performance

The arithmetic mean test scores for the Simple Reaction Time test, Digit Symbol test, Benton test and the Pursuit-Aiming test were significantly poorer in the exposed workers when compared to the referents (Table 4). Age, gender, education and the consumption of tobacco, alcohol and drugs were included in regression models together with the variable being exposed or not. When using this approach, no significant association between neuropsychological outcome and exposure was observed. However, an association of borderline significance was found between being exposed to organic solvents and the results on the Simple Reaction Time test (table 5).

Discussion

In this cross-sectional study we examined the association between occupational exposure to organic solvents, self-reporting of symptoms and neurobehavioral test performance. The results showed that the workers exposed to solvents were more likely to report subjective symptoms such as forgetfulness, impaired concentration ability, being easily irritated without reason, difficulties understanding read materials, increased sweating and increased anger and confusion. These results are in agreement with numerous previous cross-sectional studies. However, no consistent relationships were observed between the reporting of subjective symptoms and the estimated cumulative exposure indices.

The solvent-exposed group also had reduced performance in several neurobehavioral tests when compared to the referents. However, after controlling for potential confounding variables, exposure to solvents was not statistically significantly associated with the neurobehavioral outcomes. The odds ratio for an exposed subject to have a poor performance on the Simple Reaction Time was 1.56. Although this increased odds ratio was not of statistical significance, it could suggest that exposure to solvents may have had an impact on this outcome variable. The lack of association between the outcome variables and exposure to solvents could eventually be explained by the relatively short duration of exposure in years and that the exposure in general was less than five hours each day.

It could also be, although no specific ventilation was available in the work rooms, that natural ventilation due to opening of doors and windows may have a beneficial effect on the level of exposure.

The estimated cumulative exposure indices were not related to symptom reporting or neuropsychological performance. This may be due to an overweighting in the calculation of the exposure indices of the reporting by the workers of unpleasant smell, which not necessarily reflects the level of exposure as suggested in some studies. Cross-sectional studies are generally vulnerable to healthy worker effect as suggested by the high turnover rate of workers in the studied plants. This could mean that only less affected workers were
eligible for inclusion into the study, whereas severely affected subjects may have left their jobs. A strength of this study is that alcohol consumption was negligible, in contrast to most studies on this subject. Around 95% of the exposed workers did not consume any alcohol at all.

The educational level in Algeria may be quite variable among workers, and we excluded two workers who were unable to read digits. Our results are in agreement with many studies that have shown slightly worse neuropsychological test performance related to low level occupational exposure, particularly affecting memory, attention, affective changes in personality and perceptual speed 18-19-20-21-22.

However, the exposed workers had a lower level of education than referents, which partly may contribute to the overall group differences in the neurobehavioral tests. As reported by numerous studies 4-23-24-25-26-27, and despite crude and inappropriately calculated exposure measures, Algerian’s workers in these plants are at risk.

Conclusion

These findings could suggest that workers in paint, varnish and glue producing plants in Algeria are at risk of acquiring solvent induced neurotoxic diseases. In Algeria, much of the morbidity and mortality associated with neurotoxic agents remains hidden as a result of lack of skilled personnel and equipment for diagnosis. The knowledge of the neurotoxic properties of organic solvents is very low among workers and managers in these plants, in contrast to the extensive knowledge about other occupational factors causing diseases such as hearing loss and pulmonary diseases. There are also limited resources for research, in particular in the field of occupational medicine. Simple Reaction Time may be helpful for detecting possible early effects of exposure to low levels of organic solvents, and in addition the equipment is easy to use and affordable to buy in many less developed countries.

Competing interest : none

References


