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Full Length Article

Solvent neurotoxicity in vehicle collision repair workers in New Zealand

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ABSTRACT

Objectives: To assess whether solvent use and workplace practices in the vehicle collision repair industry are associated with symptoms of neurotoxicity in spray painters and panel beaters (auto body repair workers).
Methods: Neurobehavioural symptoms were assessed using a cross-sectional study design in 370 vehicle collision repair and 211 reference workers using the EUROQUEST questionnaire. Full-shift airborne solvent levels were measured in a subset (n = 92) of collision repair workers.
Results: Solvent exposures were higher in spray painters than in panel beaters, but levels were below current international exposure standards. Collision repair workers were more likely to report symptoms of neurotoxicity than reference workers with ORs of 2.0, 2.4 and 6.4 (all $p < 0.05$) for reporting ≥ 5, ≥ 10 and ≥ 15 symptoms respectively. This trend was generally strongest for panel beaters (ORs of 2.1, 3.3 and 8.2 for ≥ 5, ≥ 10 and ≥ 15 symptoms respectively). Associations with specific symptom domains showed increased risks for neurological (OR 4.2), psychosomatic (OR 3.2), mood (OR 2.1), memory (OR 2.9) and memory and concentration symptoms combined (OR 2.4; all $p < 0.05$). Workers who had worked for 10–19 years or 20+ years in the collision repair industry reported consistently more symptoms than those who had only worked less than 10 years even after adjusting for age. However, those who worked more than 20 years generally reported fewer symptoms than those who worked 10–19 years, suggesting a possible healthy worker survivor bias.
Conclusions: Despite low airborne solvent exposures, vehicle collision repair spray painters and panel beaters continue to be at risk of symptoms of neurotoxicity.

What this paper adds

- Previous research has shown that vehicle collision repair workers exposed to mixed solvents have an increased risk of symptoms of neurotoxicity.
- Changes in industry practices over the past two decades have likely resulted in reduced solvent exposure, but little research has been conducted to confirm this, and the current risk of symptoms of neurotoxicity in vehicle collision repair workers is therefore unknown.
- The current study has shown that despite current airborne exposures being below international exposure standards, collision repair workers continue to have a significantly elevated risk of symptoms of neurotoxicity.
- Further preventive measures are required to reduce the burden of neurotoxicity in this group, which represent a sizable proportion of the global workforce.

1. Introduction

Acute health effects of occupational exposure to solvents (e.g. headaches, nausea and light-headedness) have long been recognised, with high exposures associated with intoxication,

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unconsciousness and in some cases death (Dick, 2006). Chronic effects such as sustained changes in mood, memory, concentration and cognitive deficits have also been documented, in some cases leading to a diagnosis of Chronic Solvent Neurotoxicity (CSN) or Chronic Toxic Encephalopathy (CTE) (Dick, 2006; Baker and Fine, 1986; Dryson, 1998; Dryson and Ogden, 1998; van Valen et al., 2012). Among those with CSN, industrial and automotive repair spray painters are consistently over-represented (Keski-Santti et al., 2010). Spray painting involves the use of large quantities of solvent mixes for preparation work, cleaning of refurbished panels, and thinning of paint. This and the subsequent spraying of solvent-containing paints may result in elevated solvent exposure through both inhalation and dermal absorption (Dick, 2006).

Several cross-sectional studies since the 1970s have shown symptoms of neurotoxicity in spray painters and other solvent-exposed workers (Hanninen et al., 1976, 1991; Elofsson et al., 1980; Husman, 1980; Daniell et al., 1993), but findings have not always been consistent (Triebig et al., 1992a, 1992b; Maizlish et al., 1985). Dose-response associations have been reported (Chen et al., 2001) but are often weak, possibly due to the 'healthy worker survivor bias' (Meyer-Baron et al., 2008). Also, previous studies have often been conducted in larger enterprises where workplace hygiene and hazards are likely to be managed more effectively (Daniell et al., 1993; Hasle et al., 2006) and studies were not always adequately controlled for potential confounders (Meyer-Baron et al., 2008; Mikkelsen, 1997; Gamble, 2000).

Significant changes in paint formulations, solvent use and workplace practices have occurred in this industry in the past few decades which, as suggested recently (Kauppinen et al., 2013), may have resulted in a significant decline in workplace solvent exposures. However, little research has been conducted to confirm this and it is also unclear whether this has contributed to a significantly reduced risk of neurotoxicity in collision repair workers. In the current study, collision repair industry workers (n = 370) from small to medium workshops, and a reference group of construction industry workers (n = 211) in New Zealand were recruited to assess contemporary solvent exposures and associated neurotoxicity risks.

2. Methods

2.1. Study population

The study population was recruited from collision repair workshops throughout the North Island of New Zealand, with a focus on the main centres (Wellington and Auckland). Workshops were identified from the Yellow Pages and internet searches and approached on an ongoing basis until the desired sample size was reached. This figure (400 collision repair workers, 200 reference workers) was derived from an estimation based on previous studies that around 15–20% of the collision repair workforce was likely to have neurobehavioural symptoms compared with less than 5% of the comparison group. This gave the study a 90–99% power to detect a two to three-fold difference (i.e. 10–15% vs 5%). In total 175 workshops each employing between 2 and 15 staff were recruited. All staff aged between 17 and 70 years were invited to take part, including spray painters, panel beaters (or auto body repair workers) and office staff with a history of work as a spray painter or panel beater. This last group were all ex-tradesmen and were recoded as a spray painter or panel beater accordingly, which more accurately reflected their working life exposure. Exclusion criteria were no history of work involving solvent exposure or any history of major head injury or neurological/neurodegenerative disease, including meningitis, major depression or epilepsy. Collision repair workers who declined participation were invited to complete a short questionnaire assessing key demographic factors. A reference group of construction workers from various trades (scaffolders, carpenters, electricians, builders and building labourers, fire safety system installers, plumbers and associated management staff) with negligible/no exposure to solvents was recruited in the same regions using a similar strategy and exclusion criteria.

2.2. Questionnaire

Information on demographics, work characteristics, use of solvents and solvent-based products and other potential confounders was obtained for all participants by questionnaire. Current (i.e. in the past 3 months) symptoms of neurotoxicity were measured using an adapted version of the EUROQUEST (Carter et al., 2002) questionnaire, administered face-to-face. The questionnaire consists of 59 core items, which cover the following symptom domains: neurological (e.g. numbness and tingling in extremities, balance problems), psychosomatic (e.g. headaches, nausea, tinnitus), mood, memory, concentration, fatigue and sleep quality. EUROQUEST also includes questions on symptoms of acute exposure (irritation of the mucosal membranes and intoxication, 6 items). Symptom frequency for these and the 59 core symptoms in recent months was reported on a 4-point scale, "seldom or never", "sometimes", "often" or "very often". Questions regarding sensitivity to environmental conditions (6 items, e.g., *"Are you sensitive to bright lights?"*) and anxiety (6 items, e.g., *"Are you generally a nervous person?"*) were also included and rated on a different 4-point scale ("strongly disagree", "disagree", "agree" or "strongly agree"). The final section of the EUROQUEST assesses perceived general health (4 items), where participants are asked to rate different aspects of their general health and wellness as "very good" "good", "poor" or "very poor". For the purpose of subsequent analyses we dichotomised symptoms, with "strongly disagree" or "disagree", "seldom or never" or "sometimes", and "poor" or "very poor" constituting a negative response and "agree" or "strongly agree", "often" or "very often", "very good" and "good" constituting a positive response (Kaukiainen et al., 2009a). Anxiety (6 items, e.g., *"Are you generally a nervous person?")* and perceived general health (4 items, e.g., *"how good is your health?")* were included to enable us to control the analyses for individual personality traits which have been found to lead participants to under or over report their symptoms (Kaukiainen et al., 2009a). Responses to these questions were aggregated to produce a total 'score' for each domain.

2.3. Exposure assessment

Full-shift airborne personal exposure measurements were conducted with a random sample of workers from 17 collision repair workshops representative of the 175 involved using a whole-air method (USEPA, 1999); these included 50 spray painters and 36 panel beaters. We also included a small group of office workers (n = 6) with no history of spray painting or panel beating (these workers were not included in the questionnaire survey). Teflon tubing running from the workers breathing zone was connected to a 400 cc stainless steel sampling canister (Restek Corporation, PA, USA) negatively pressurised to near full vacuum (−30 mmHg). A flow controller (Restek Corporation, PA, USA) was used to maintain a flow rate of 0.9 ml/min and sampling was stopped when air pressure in the canisters reached between −5 and −3 mmHg. Samples were analysed using Selected Ion Flow Tube Mass Spectrometry, or SIFT-MS (Syft Technologies, Christchurch, NZ) for toluene, xylene, styrene, acetone, methyl and ethyl-acetates, butanols and propanols, benzenes, hexanes, methyl ethyl ketone and ethanol, the method of which has been described in detail elsewhere (Prince et al., 2010). The limit of detection was 5