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SOLVENT NEUROTOXICITY IN VEHICLE COLLISION REPAIR WORKERS

A thesis by publications presented in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

In

Public Health

Massey University, Wellington

New Zealand

Samuel John Keer

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Abstract

Previous studies have shown that vehicle collision repair workers may be at risk of solvent-induced symptoms of neurotoxicity. Changes in industry practices have likely resulted in reduced exposure, but little research has been conducted to assess whether this has reduced the risk of neurotoxicity. This thesis describes a series of studies, which aimed to assess: i) contemporary airborne solvent exposures in collision repair workers; ii) the determinants of airborne solvent exposures; iii) the prevalence of self-reported symptoms of neurotoxicity and objectively measured neuropsychological performance, compared to an unexposed reference group; iv) dose-response associations; and v) the effect of personal protective equipment (PPE) and good workplace hygiene on symptom prevalence.

In total, 370 vehicle collision repair and 211 construction workers (reference group) were recruited. Personal airborne solvent exposure was assessed in 85 collision repair workers, and information on demographics, work practices and symptoms was collected by questionnaire. A sub-group of 47 collision repair and 51 reference workers also completed a battery of neuropsychological tests.

Full-shift, airborne exposures were well below New Zealand and international occupational exposure limits (range, 0.04 – 16.5 ppm). Job title was the strongest predictor of exposure, and non-spraying tasks (e.g. mixing paint and cleaning equipment) were associated with higher exposures than spray painting itself.

Collision repair workers reported significantly more symptoms of neurotoxicity than the reference group, with odds ratios (ORs) of 2.0, 95% CI 1.3-3.3; 2.4, 1.2-4.8; and
6.4, 1.8-23.0, for reporting ≥5, ≥10 and ≥15 symptoms, respectively. They also performed more poorly on neuropsychological tests, particularly those that measure attention/concentration and motor speed/dexterity (e.g. reference vs. collision repair group score on the RBANS total attention scale, -9.5, 95% CI, -15.9, -2.8). Consistent use of PPE (particularly gloves) and good workplace hygiene practices were strongly protective against symptoms, with reductions in risk of up to 90% for those who most consistently wore PPE.

In conclusion, despite relatively low airborne exposure levels, collision repair workers continue to be at risk of solvent-induced neurotoxicity. These findings provide a strong evidence-base for the development and implementation of intervention programmes to reduce solvent exposures and associated morbidity in this population.
**Authors Declaration**

This thesis was produced according to Massey University’s “thesis-by-paper” requirements i.e. it is based on research that is published. Each individual chapter is set out in the style of the journal in which it has been published. Consequently, some of the chapters are relatively succinct, there is some repetition (particularly in the methods sections) and there are small stylistic differences between chapters.

The published manuscripts include other authors who provided technical expertise and contributed to the writing of the papers, including my PhD supervisors and, in some cases, collaborators in different institutes in New Zealand and the U.K. However, for each chapter, my input was greatest, as reflected by being first author on the paper. I was the lead investigator for the studies described, involved in oversight of study design, recruitment, work co-ordination and data collection, data analysis and preparation of the manuscripts. I was also involved in preparation of the ethics application prior to the conduct of these studies.
Acknowledgements

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- My co-supervisor Dave McLean - particularly for your practical writing guidance and no-nonsense, often ‘pithy’ feedback; it made the whole writing process less arduous. For your encouragement, for all the coffees you bought me and for all the moaning you put up with. You are a pleasure to work with and learn from, and a great friend.

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Table of contents

Abstract ................................................................................................................................. i
Authors Declaration ............................................................................................................. iii
Acknowledgements ............................................................................................................ iv
Table of contents ............................................................................................................... vii
List of figures ...................................................................................................................... viii
List of tables ....................................................................................................................... x
Abbreviations .................................................................................................................... xiii

1 General introduction ........................................................................................................ 1

1.1 Outline of the thesis ..................................................................................................... 5

2 Literature review ............................................................................................................. 8

2.1 Solvents – Uses, properties and classes ....................................................................... 10
  2.1.1 Properties and classes ............................................................................................ 10
  2.1.2 Industrial uses ....................................................................................................... 12

2.2 Occupational solvent exposures .................................................................................. 13
  2.2.1 Exposure assessment methodologies .................................................................... 13
  2.2.2 Solvent exposures in the vehicle collision repair industry ..................................... 25
  2.2.3 Determinants of exposure in the collision repair industry ..................................... 27

2.3 Health effects associated with occupational solvent exposures ............................... 30
  2.3.1 A historical perspective ....................................................................................... 30
  2.3.2 Mechanisms of toxicity ....................................................................................... 34
  2.3.3 Neurochemical/physiological, neurobehavioural and other health effects of solvents ................................................................. 40
  2.3.4 Epidemiology of chronic solvent-induced neurotoxicity ...................................... 46

2.4 Exposure controls to reduce morbidity ........................................................................ 80

2.5 Summary ....................................................................................................................... 84

3 Determinants of airborne solvent exposure in the collision repair industry ................ 86

3.1 Introduction .................................................................................................................. 87

3.2 Methods ....................................................................................................................... 89

3.3 Results ........................................................................................................................ 98

3.4 Discussion .................................................................................................................... 106

3.5 Supplementary material ............................................................................................ 112

4 Solvent neurotoxicity in vehicle collision repair workers in New Zealand ............... 114

4.1 Introduction ................................................................................................................ 115

4.2 Methods ....................................................................................................................... 117
4.3 Results............................................................................................................. 122
4.4 Discussion ....................................................................................................... 132
4.5 Supplementary material.................................................................................. 138

5 Neuropsychological performance in solvent-exposed vehicle collision repair
workers in New Zealand ....................................................................................... 144
5.1 Introduction ..................................................................................................... 145
5.2 Methods .......................................................................................................... 147
5.3 Results ............................................................................................................. 153
5.4 Discussion ........................................................................................................ 160
5.5 Supplementary material .................................................................................. 168

6 Effects of personal protective equipment use and good workplace hygiene on
symptoms of neurotoxicity in solvent-exposed vehicle spray painters........ 183
6.1 Introduction ..................................................................................................... 184
6.2 Methods .......................................................................................................... 186
6.3 Results ............................................................................................................. 193
6.4 Discussion ........................................................................................................ 203
6.5 Supplementary material .................................................................................. 211

7 General discussion ............................................................................................. 215
7.1 Introduction ..................................................................................................... 215
  7.1.1 Summary of main findings ......................................................................... 216
7.2 Discussion of specific results ........................................................................ 218
  7.2.1 Exposures .................................................................................................. 218
  7.2.2 Determinants of exposure ......................................................................... 220
  7.2.3 Health effects ............................................................................................ 223
  7.2.4 Exposure controls ...................................................................................... 230
7.3 Strengths and limitations ............................................................................... 232
7.4 Recommendations and future research ........................................................ 242
7.5 General conclusions ....................................................................................... 249

8 References ........................................................................................................ 251

9 Appendices ....................................................................................................... 269
List of figures

Figure 3.1. Full shift geometric mean airborne specific and total solvent concentrations ............. 98
Figure 3.2. VEM observation 1 – Mixing and decanting paint and thinners and spray-painting in a downdraft spray booth ........................................................................................................ 103
Figure 3.3. VEM observation 2 – Spray painting in a cross-draft booth and cleaning spray equipment in a gun washer with dedicated LEV ........................................................................................................ 104
Figure 3.4. VEM observation 3 – Cleaning spray equipment in an open-sided gun washer with dedicated LEV and performing other miscellaneous tasks in a paint mixing room ........................................... 105
List of tables

Table 2.1. Organic solvent classes and example compounds – industrial applications* ........................................... 11
Table 2.2. Results of solvent exposure monitoring in the vehicle collision repair industry ........................................ 26
Table 2.3. WHO and Raleigh Criteria for classification of solvent-induced effects on the central and peripheral nervous systems (adapted from van der Hoek, Verberk (191)) .......................................................... 43
Table 2.4. IARC carcinogenicity classification of various industrial solvents (adapted from Lynge, Anttila (202)) ........................................................................................................................................................................ 46
Table 2.5. Neuropsychological tests and sub-tests ..................................................................................................... 53
Table 2.6 Studies of subjective and objective neurobehavioural effects in vehicle collision repair and industrial spray painters ...................................................................................................................................................... 69
Table 3.1. Determinants of airborne total solvent exposure .......................................................................................... 100
Table 3.2. Task duration and airborne total solvent exposure ......................................................................................... 101
Table 3.3. Supplementary table. Determinants of airborne total solvent exposure – Additive Limit Value concentrations of all solvents detected ........................................................................................................................................... 112
Table 3.4. Supplementary table - Task duration and airborne total solvent exposure expressed as Additive Limit Values ....................................................................................................................................................... 113
Table 4.1. Demographic and work characteristics of study participants ........................................................................... 124
Table 4.2. Full shift whole-air concentrations of all solvents detected combined (geometric means), including Additive Limit Value (ALV) calculation ........................................................................................................... 126
Table 4.3. Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms between reference workers and collision repair workers ........................................................................................................ 128
Table 4.4. Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms in reference workers and collision repair workers stratified by employment duration (tertiles) ........................................................................................................... 129
Table 4.5. Prevalence odds ratios of dichotomised (yes/no) acute symptom and sensitivity to environmental conditions EUROQUEST questions between reference workers and collision repair workers ........................................................................................................................................... 131
Table 4.6. Supplementary table - Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms in reference workers and collision repair workers stratified by employment duration quartiles ......................................................................................................................................... 138
Table 4.7. Supplementary table - Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms between reference workers and collision repair workers – Alternative EUROQUEST symptom domain cut points (≥2 and ≥4 symptoms per domain) ........................................................................................................................................... 139
Table 4.8. Supplementary table - Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms in reference workers and collision repair workers stratified by employment duration (tertiles) – Age excluded from regression model ........................................................................................................................................... 140
Table 4.9. Supplementary table - Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms between reference workers and collision repair workers – Excluding current office workers ........................................................................................................................................... 141
Table 4.10. Supplementary table - Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms between reference workers and collision repair workers – Excluding 7 panel beaters recoded as spray painters ........................................................................................................................................... 142
Table 4.11. Supplementary table - Prevalence odds ratios of dichotomised (yes/no) EUROQUEST symptoms between reference workers and collision repair workers – Excluding reference workers ‘exposed’ to solvents (n=19) ........................................................................................................................................... 143
Table 5.1. Characteristics of study population ............................................................................................................. 154
Table 5.2. Neuropsychological test scores for comparison and collision repair workers ........................................ 156
Table 5.3. Neuropsychological test scores based on the bottom 5th, 10th and 20th percentiles for Comparison and collision repair workers

Table 5.4. Neuropsychological test scores for collision repair workers stratified by employment duration

Table 5.5. Supplementary table - Neuropsychological test scores based on the lowest 5th, 10th and 20th percentiles for comparison and collision repair workers – Excluding Māori and Pacific persons

Table 5.6. Supplementary table – Neuropsychological test scores for collision repair workers stratified by employment duration – Excluding age from the regression model

Table 5.7. Supplementary table - Neuropsychological test scores for Comparison and collision repair workers – Adjusted for lifetime alcohol (mean drinks per week) in place of alcohol consumption in the past 48 hours

Table 5.8. Supplementary table - Neuropsychological test scores based on the bottom 5th, 10th and 20th percentiles for Comparison and collision repair workers – Adjusted for lifetime alcohol (mean drinks per week) in place of alcohol consumption in the past 48 hours

Table 5.9. Supplementary table - Neuropsychological test scores for collision repair workers stratified by employment duration. – Adjusted for lifetime alcohol (mean drinks per week) in place of alcohol consumption in the past 48 hours

Table 5.10. Supplementary table - Neuropsychological test scores for Comparison and collision repair workers – Adjusted for lifetime alcohol consumption (frequency) in place of alcohol consumption in the past 48 hours

Table 5.11. Supplementary table - Neuropsychological test scores based on the bottom 5th, 10th and 20th percentiles for Comparison and collision repair workers - Adjusted for lifetime alcohol consumption (frequency) in place of alcohol consumption in the past 48 hours

Table 5.12. Supplementary table - Neuropsychological test scores for collision repair workers stratified by employment duration

Table 5.13. Supplementary table - Neuropsychological test scores based on the lowest 5th, 10th and 20th percentiles for collision repair workers stratified by employment duration

Table 5.14. Supplementary table - Neuropsychological test scores for collision repair workers tested at the start of the week (Monday-Wednesday) and the end of the week (Thursday-Friday)

Table 5.15. Supplementary table – Neuropsychological test scores for Comparison and collision repair workers - Excluding reference workers who reported exposure to solvents (n=7)

Table 5.16. Supplementary table - Neuropsychological test scores for Comparison and collision repair workers – Excluding current office workers (n=4)

Table 5.17. Supplementary table - Neuropsychological test scores for Comparison and collision repair workers - Excluding Māori and Pacific persons

Table 5.18. Supplementary table - Neuropsychological test scores for Comparison and collision repair workers – Adjusted for both alcohol consumption in the past 48 hours and lifetime alcohol (mean drinks per week)

Table 5.19. Supplementary table - Characteristics of study populations – Comparison of demographic characteristics of current study and previous study participants

Table 6.1. Demographic characteristics of workers

Table 6.2. Prevalence of PPE use and particular workplace practices

Table 6.3. Prevalence odds ratios for symptoms of neurotoxicity and PPE use/workplace practices

Table 6.4. Prevalence odds ratios for symptoms of neurotoxicity and combined PPE-use mutually adjusted for other variables in the table.
Table 6.5. Supplementary table – Prevalence odds ratios for symptoms of neurotoxicity by exposure group – exposure variables included in model – Adjusted for both age and duration of employment

Table 6.6. Supplementary table. Prevalence odds ratios for symptoms of neurotoxicity and ‘hygiene’ metric – mutually adjusted with other variables in table – Excluding ex-tradesmen office workers who reported spray painting 0 hours on a typical working day (n=9).

Table 6.7. Supplementary table. Prevalence odds ratios for symptoms of neurotoxicity and skin exposure (body parts exposed during painting) – Mutually adjusted for other variables in the table.

Table 6.8. Supplementary table. Prevalence odds ratios for symptoms of neurotoxicity and ‘hygiene’ metric – Mutually adjusted with other variables in table.
**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>NIOSH</td>
<td>National Institute of Occupational Safety and Health</td>
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<tr>
<td>CSN</td>
<td>Chronic Solvent-induced Neurotoxicity</td>
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<tr>
<td>CSE</td>
<td>Chronic Solvent-induced Encephalopathy</td>
</tr>
<tr>
<td>CTE</td>
<td>Chronic Toxic Encephalopathy</td>
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<tr>
<td>CNS</td>
<td>Central Nervous System</td>
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<td>PNS</td>
<td>Peripheral Nervous System</td>
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<td>PPE</td>
<td>Personal Protective Equipment</td>
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<tr>
<td>DNA</td>
<td>Deoxyribonucleic Acid</td>
</tr>
<tr>
<td>RNA</td>
<td>Ribonucleic Acid</td>
</tr>
<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer</td>
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<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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<tr>
<td>CAT</td>
<td>Computer Aided Topography</td>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>Q16</td>
<td>Neuropsychological Questionnaire 16</td>
</tr>
<tr>
<td>PNF</td>
<td>Psychologisch-Neurologischer Fragebogen (Questionnaire)</td>
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<tr>
<td>POMS</td>
<td>Profile of Mood States</td>
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<tr>
<td>NCTB</td>
<td>Neurobehavioral Core Test Battery</td>
</tr>
<tr>
<td>NES</td>
<td>Neurobehavioural Evaluation System</td>
</tr>
<tr>
<td>BARS</td>
<td>Behavioural Assessment and Research System</td>
</tr>
<tr>
<td>CANTAB</td>
<td>Cambridge Neuropsychological Performance Test Automated Battery</td>
</tr>
<tr>
<td>BEES</td>
<td>Behavioural Evaluation for Epidemiological Studies</td>
</tr>
<tr>
<td>RBANS</td>
<td>Repeatable Battery for the Assessment of Neurobehavioural Status</td>
</tr>
<tr>
<td>NART</td>
<td>National Adult Reading Test</td>
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<tr>
<td>JEM</td>
<td>Job-Exposure Matrix</td>
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<tr>
<td>TWA</td>
<td>Time-Weighted Average</td>
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<tr>
<td>TLV</td>
<td>Threshold Limit Values</td>
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<tr>
<td>WES</td>
<td>Workplace Exposure Standards</td>
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<tr>
<td>PEL</td>
<td>Permissible Exposure Limit</td>
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<td>OEL</td>
<td>Occupational Exposure Limit</td>
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<tr>
<td>STEL</td>
<td>Short-Term Exposure Limit</td>
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<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>ALV</td>
<td>Additive Limit Value</td>
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<tr>
<td>GCMS</td>
<td>Gas Chromatography Mass Spectroscopy</td>
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<td>VEM</td>
<td>Video Exposure Monitoring</td>
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<tr>
<td>PIMEX</td>
<td>Picture Mixed Exposure</td>
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<tr>
<td>NSC-60</td>
<td>Neurobehavioural Symptom Checklist</td>
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<tr>
<td>LEV</td>
<td>Local Exhaust Ventilation</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>ER</td>
<td>Exposure Ratio</td>
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<tr>
<td>NZ</td>
<td>New Zealand</td>
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<tr>
<td>SIFT-MS</td>
<td>Selected-Ion flow-Tube Mass Spectroscopy</td>
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<tr>
<td>MEK</td>
<td>Methyl Ethyl Ketone</td>
</tr>
<tr>
<td>MIK</td>
<td>Methyl Isobutyl Ketone</td>
</tr>
<tr>
<td>GM</td>
<td>Geometric Mean</td>
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<tr>
<td>PPM</td>
<td>Parts Per Million</td>
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<td>PPB</td>
<td>Parts Per Billion</td>
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<tr>
<td>PPT</td>
<td>Parts Per Trillion</td>
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<tr>
<td>W/W</td>
<td>Weight for Weight (Percentage Mass)</td>
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<tr>
<td>CRA</td>
<td>Collision Repair Association of New Zealand</td>
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<tr>
<td>HRC</td>
<td>Health Research Council of New Zealand</td>
</tr>
<tr>
<td>CR</td>
<td>Collision Repair</td>
</tr>
<tr>
<td>DASS</td>
<td>Depression, Anxiety and Stress Scale</td>
</tr>
<tr>
<td>SME</td>
<td>Small to Medium-sized Enterprise</td>
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