Title and sub-title:
Influence of chronic Illness on crash involvement of motor vehicle drivers: 3rd edition

Project Lead Author(s):
Judith L. Charlton, Marilyn Di Stefano, Jamie Dow, Mark J. Rapoport, Desmond O'Neill, Morris Odell, Peteris Darzins, & Sjaan Koppel

Sponsoring Organisations:
This project was funded as contract research by the following organisations:
- Road Safety Victoria, Department of Transport/VicRoads, Victoria.
- Road Safety Authority of Ireland.
- Canadian Council of Motor Transportation Administrators with the participation of the Société de l’assurance automobile du Québec, the Ontario Ministry of Transportation and the Canadian Medical Association Journal.

Abstract:
This report addresses the influence of chronic illnesses and their associated functional impairments on the risk of motor vehicle crash (MVC) involvement. The review assesses the current state of knowledge in regard to specific medical conditions and crash involvement and other measures of driver risk. The evidence reviewed includes eleven systematic literature reviews examining a specific medical condition(s), as well as one rapid review on multiple medical conditions, and MVC risk and/or impacts on on-road driving performance. A number of conclusions are presented which may contribute to the formulation of a set of recommendations for medical fitness to drive decisions and managing MVC risk among drivers with medical conditions.

Key Words: Chronic Illness; Medical Conditions; Fitness-to-Drive; Motor Vehicle Crash; On-Road Test Outcome; Road Safety;

Disclaimer
This report is disseminated in the interest of information exchange. The views expressed here are those of the authors, and not necessarily those of Monash University, or Road Safety Victoria, Department of Transport, Victoria, Australia.
3. PREFACE

Project Manager / Team Leader:
- Judith Charlton

Research Team:
- Marilyn Di Stefano
- Jamie Dow
- Mark J. Rapoport
- Desmond O’Neill
- Morris Odell
- Peteris Darzins
- Sjaan Koppel

Affiliations:
- 1Monash University Accident Research Centre, Monash University, Victoria, Australia
- 2Road Safety Victoria, Department of Transport, Victoria, Australia
- 3Société de l’assurance automobile du Québec, Québec City, Québec, Canada
- 4Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Ontario, Canada
- 5National Office for Traffic Medicine, Royal College of Physicians of Ireland, Dublin, Ireland
- 6Monash University, Victoria, Australia
- 7Monash University Eastern Health Clinical School, Victoria, Australia
<table>
<thead>
<tr>
<th>Compendium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contributorship Statement:</strong></td>
</tr>
<tr>
<td>Funding procurement</td>
</tr>
<tr>
<td>Funding body management &amp; governance</td>
</tr>
<tr>
<td><strong>Systematic Literature Reviews</strong></td>
</tr>
<tr>
<td>Chapter 2: Alcohol use disorders</td>
</tr>
</tbody>
</table>

**Ethics Statement:**
Ethics approval was not required for this project.

**Legitimate use of this work:**
© Copyright Monash University Accident Research Centre.
This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part of this document may be reproduced by any process without the prior written permission of Monash University Accident Research Centre.

This work should be referenced as follows:
## CONTENTS

2. MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE REPORT
   DOCUMENTATION PAGE ................................................................. II

3. PREFACE .................................................................................. III

LIST OF TABLES ............................................................................ XII

LIST OF FIGURES .......................................................................... XII

LIST OF ABBREVIATIONS .............................................................. XIII

1 EXECUTIVE SUMMARY ............................................................. XVI

1.1 AIM OF THE REVIEW ............................................................ XVI

1.2 INTERNATIONAL RESEARCH CONSORTIUM ......................... XVI

1.3 METHODS .............................................................................. XVI

1.4 REVIEW CONTENT .................................................................... XVII

1.5 CRASH RISK AND POLICY .................................................... XVIII

1.6 METHODOLOGICAL ISSUES .................................................. XVIII

1.7 INFLUENCE OF MEDICAL CONDITIONS ON CRASH INVOLVEMENT .. XVIII

1.8 ASSESSING FITNESS TO DRIVE ........................................... XXII

1.9 CHANGES TO THE DRIVING TASK WITH VEHICLE AND COMMUNICATION TECHNOLOGY ........................................... XXII

1.10 RECOMMENDATIONS ........................................................... XXIII

1.11 FUTURE RESEARCH ............................................................. XXIV

2. INTRODUCTION ........................................................................ 1

2.1 AIM OF THE REPORT ............................................................. 1

2.2 BACKGROUND ....................................................................... 1

2.3 SAFE SYSTEM APPROACH ................................................... 1

2.4 THE AGEING POPULATION AND CHRONIC ILLNESS ............... 1

2.5 HEALTH, CHRONIC ILLNESS AND FUNCTIONAL IMPAIRMENT ........ 2

2.6 EVIDENCE-BASED DECISION-MAKING .................................. 3

2.7 FITNESS TO DRIVE GUIDELINES ........................................... 3

2.8 CHANGES TO THE DRIVING TASK WITH VEHICLE AND COMMUNICATION TECHNOLOGY ........................................... 4

2.9 OVERVIEW OF THE REVIEW METHODOLOGY ...................... 5

2.10 REFERENCES ......................................................................... 7

3. INFLUENCE OF ALCOHOL USE DISORDERS ON MVC RISK ........... 11

3.1 OVERVIEW AND KEY RECOMMENDATIONS ............................ 11

3.2 BACKGROUND ....................................................................... 12

3.2.1 Scope .............................................................................. 12

3.2.2 Protocol and registration .................................................... 12

3.2.3 Definition ......................................................................... 12

3.3 METHOD ................................................................................ 13

3.3.1 Eligibility criteria .............................................................. 13

3.3.2 Information sources .......................................................... 13

3.3.3 Search ............................................................................. 13

3.3.4 Study selection ................................................................. 13

3.3.5 Data extraction process .................................................... 14
9.4.3 Cataract ................................................................. 86
9.4.4 Age-related macular degeneration (AMD) ..................... 87
9.4.5 Glaucoma .............................................................. 88
9.4.6 Homonymous hemianopia and quadrantanopia .............. 90
9.4.7 Diabetic retinopathy .............................................. 90
9.4.8 Genetic retinal diseases ........................................... 90
9.4.9 Combined eye disease ............................................ 91
9.4.10 Visual acuity (VA) impairment ................................ 92
9.4.11 Visual field (VF) impairment .................................. 93
9.4.12 Reduced visual acuity and/or visual field loss ............. 95
9.5 CONCLUSIONS .......................................................... 96
9.5.1 Cataract ................................................................. 96
9.5.2 Age-related macular degeneration (AMD) ..................... 97
9.5.3 Glaucoma .............................................................. 97
9.5.4 Homonymous hemianopia and quadrantanopia .............. 97
9.5.5 Genetic retinal diseases ........................................... 97
9.5.6 Combined eye diseases .......................................... 97
9.5.7 Visual acuity impairment ........................................ 97
9.5.8 Visual field impairment .......................................... 98
9.5.9 Study limitations .................................................. 98
9.5.10 Current fitness-to-drive guidelines ........................... 99
9.5.11 Recommendations ............................................... 99
9.6 REFERENCES ........................................................... 100

10. MULTIPLE MEDICAL CONDITIONS AND MVC RISK ......................... 107
10.1 OVERVIEW AND KEY RECOMMENDATIONS ...................... 107
10.2 BACKGROUND .......................................................... 107
10.2.1 Scope .................................................................. 108
10.2.2 Definition ............................................................ 108
10.3 RESULTS .................................................................. 110
10.3.1 Included studies .................................................... 110
10.3.2 Study descriptions ................................................ 110
10.3.3 Studies reporting evidence for MVC risk in drivers with diabetes, its complications and other medical comorbidities (n=4) .......... 119
10.3.4 Studies reporting evidence for MVC risk in drivers with sleep disorders and other medical comorbidities (n=3) ............. 120
10.3.5 Studies reporting evidence for MVC risk in drivers with alcohol dependence and other medical comorbidities (n=3) ............. 120
10.3.6 Studies reporting evidence for MVC risk in drivers with dual sensory impairment (n=1) ............................................. 121
10.3.7 Studies reporting evidence for driving performance in drivers with glaucoma and other medical comorbidities (n=1) ............. 121
10.3.8 Studies reporting evidence for MVC risk in drivers with two or more (unspeciﬁed) medical comorbidities (n=4) ................. 121
10.4 CONCLUSIONS .......................................................... 122
10.4.1 Overall level of risk ............................................... 122
10.4.2 Study limitations .................................................. 122
10.4.3 Current fitness-to-drive guidelines ................................................. 123
10.4.4 Recommendations ........................................................................ 123
10.5 REFERENCES ...................................................................................... 123

11. INFLUENCE OF DEMENTIA ON MVC RISK ...................................... 125
   11.1 OVERVIEW AND KEY RECOMMENDATIONS ................................... 125
   11.2 SUMMARY OF RESULTS .................................................................. 127
   11.3 REFERENCES .................................................................................. 131

12. INFLUENCE OF STROKE / TIA ON MVC RISK .................................. 132
   12.1 OVERVIEW AND KEY RECOMMENDATIONS ................................... 132
   12.2 SUMMARY OF RESULTS .................................................................. 134
   12.3 REFERENCES .................................................................................. 138

13. INFLUENCE OF SYNCOPE ON MVC RISK ........................................ 139
   13.1 OVERVIEW AND KEY RECOMMENDATIONS ................................... 139
   13.2 SUMMARY OF RESULTS .................................................................. 141
   13.3 REFERENCES .................................................................................. 146

14. INFLUENCE OF TBI ON MVC RISK ................................................... 147
   14.1 OVERVIEW AND KEY RECOMMENDATIONS ................................... 147
   14.2 SUMMARY OF RESULTS .................................................................. 149
   14.3 REFERENCES .................................................................................. 152

15. SUMMARY OF MOTOR VEHICLE CRASH RISK ASSOCIATED WITH MEDICAL CONDITIONS AND RECOMMENDATIONS .................................................. 153
   15.1 SUMMARY OF RISK ASSOCIATED WITH MEDICAL CONDITIONS ........ 153
   15.2 PREVALENCE AND RISK STATUS .................................................... 157
   15.3 MANAGEMENT OF DRIVERS WITH MEDICAL CONDITIONS .............. 158
   15.4 LIMITATIONS ................................................................................ 160
   15.5 CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH .... 162
   15.6 REFERENCES ................................................................................ 164

16. APPENDIX A: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF ALCOHOL USE DISORDERS ON MVC RISK .................................................. 166
   SEARCH STRATEGY ............................................................................. 166
   CURRENT FITNESS-TO-DRIVE GUIDELINES ....................................... 168

17. APPENDIX B: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF DIABETES ON MVC RISK ................................................................. 171
   SEARCH STRATEGY ............................................................................. 171
   CURRENT FITNESS-TO-DRIVE GUIDELINES ....................................... 173

18. APPENDIX C: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF EPILEPSY AND/OR SEIZURE DISORDERS ON MVC RISK .................................. 174
   SEARCH STRATEGY ............................................................................. 174
   CURRENT FITNESS-TO-DRIVE GUIDELINES ....................................... 176

19. APPENDIX D: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF HEARING LOSS ON MVC RISK .............................................................. 183
   SEARCH STRATEGY ............................................................................. 183
   CURRENT FITNESS-TO-DRIVE GUIDELINES ....................................... 185
<table>
<thead>
<tr>
<th>Appendix</th>
<th>Supplementary Information for Influence of Chronic Illness on MVC Risk</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.</td>
<td>APPENDIX E: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF PSYCHIATRIC DISORDERS ON MVC RISK</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>SEARCH STRATEGY</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>CURRENT FITNESS-TO-DRIVE GUIDELINES</td>
<td>190</td>
</tr>
<tr>
<td>21.</td>
<td>APPENDIX F: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF SLEEP DISORDERS ON MVC RISK</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>SEARCH STRATEGY</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>CURRENT FITNESS-TO-DRIVE GUIDELINES</td>
<td>200</td>
</tr>
<tr>
<td>22.</td>
<td>APPENDIX G: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF VISION DISORDERS &amp; VISION IMPAIRMENT ON MVC RISK</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>SEARCH STRATEGY</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>CURRENT FITNESS-TO-DRIVE GUIDELINES</td>
<td>204</td>
</tr>
<tr>
<td>23.</td>
<td>APPENDIX H: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF MULTIPLE MEDICAL CONDITIONS ON MVC RISK</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>ONLINE SURVEY – PRIORITISATION OF SIGNIFICANT AND EMERGING MEDICAL AND DISABILITY-RELATED CONDITIONS THAT MAY BE ASSOCIATED WITH INCREASED MOTOR VEHICLE CRASH RISK</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>SUMMARY OF EXPERT PANEL ONLINE SURVEY RESULTS</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>KEY SEARCH TERMS AND PHRASES</td>
<td>209</td>
</tr>
</tbody>
</table>
LIST OF TABLES

TABLE 1: SUMMARY OF MVC RISK ASSOCIATED WITH MEDICAL CONDITIONS AND IMPAIRMENTS .......................................................... XX
TABLE 2: SUMMARY CHARACTERISTICS AND QUALITY ASSESSMENTS OF INCLUDED STUDIES FOR MULTIPLE MEDICAL CONDITIONS (N=16) ................................................................................................................. 111
TABLE 3: SUMMARY CHARACTERISTICS AND QUALITY ASSESSMENTS OF INCLUDED STUDIES FOR DEMENTIA (N=4) ............................................................................................................................................. 127
TABLE 4: SUMMARY CHARACTERISTICS AND QUALITY ASSESSMENTS OF INCLUDED STUDIES FOR STROKE AND TRANSIENT ISCHAEMIC ATTACK (N=8) .......................................................................................................... 134
TABLE 5: SUMMARY CHARACTERISTICS AND QUALITY ASSESSMENTS OF INCLUDED STUDIES FOR SYNCOPE (N=11) ........................................................................................................................................ 141
TABLE 6: SUMMARY CHARACTERISTICS AND QUALITY ASSESSMENTS OF INCLUDED STUDIES FOR TRAUMATIC BRAIN INJURY (N=6) ................................................................................................................... 149
TABLE 7: SUMMARY OF MVC RISK ASSOCIATED WITH MEDICAL CONDITIONS AND IMPAIRMENTS ............................................. 155

LIST OF FIGURES

FIGURE 1: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR ALCOHOL USE DISORDERS ........................................................................................................ 15
FIGURE 2: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR DIABETES ............................................................................................................. 24
FIGURE 3: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR EPILEPSY AND SEIZURE DISORDERS ........................................................................... 32
FIGURE 4: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR HEARING LOSS .................................................................................................. 47
FIGURE 5: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR PSYCHIATRIC DISORDERS .................................................................................... 55
FIGURE 6: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR SLEEP DISORDERS .................................................................................... 68
FIGURE 7: PRISMA GUIDANCE FLOW DIAGRAM OF IDENTIFICATION, SCREENING, AND INCLUSION OF ELIGIBLE STUDIES FOR VISION DISORDERS .................................................................................... 85
FIGURE 8: RISK MANAGEMENT APPROACH FOR TWO MEDICAL CONDITIONS ...................................................................................... 159
LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAMVA</td>
<td>American Association of Motor Vehicle Administrators</td>
</tr>
<tr>
<td>AD</td>
<td>Alzheimer’s Disease</td>
</tr>
<tr>
<td>ADHD</td>
<td>Attention Deficit Hyperactivity Disorder</td>
</tr>
<tr>
<td>AED</td>
<td>Antiepileptic Drug</td>
</tr>
<tr>
<td>AFTD</td>
<td>Assessing Fitness-to-Drive</td>
</tr>
<tr>
<td>AMA</td>
<td>American Medical Association</td>
</tr>
<tr>
<td>AMD</td>
<td>Age-related Macular Degeneration</td>
</tr>
<tr>
<td>APAP</td>
<td>Automatic Positive Airway Pressure</td>
</tr>
<tr>
<td>AS</td>
<td>Arrhythmic Syncope</td>
</tr>
<tr>
<td>ASD</td>
<td>Autism Spectrum Disorder</td>
</tr>
<tr>
<td>AT</td>
<td>Articulated Truck</td>
</tr>
<tr>
<td>AUD</td>
<td>Alcohol Use Disorder</td>
</tr>
<tr>
<td>AUDADIS</td>
<td>Alcohol Use Disorder and Associated Disabilities Interview Schedule</td>
</tr>
<tr>
<td>AUDIT</td>
<td>Alcohol Use Disorders Identification Test</td>
</tr>
<tr>
<td>BAC</td>
<td>Blood Alcohol Concentration</td>
</tr>
<tr>
<td>BMA</td>
<td>British Medical Association</td>
</tr>
<tr>
<td>BPD</td>
<td>Borderline Personality Disorder</td>
</tr>
<tr>
<td>CAGE</td>
<td>CAGE Questionnaire (Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers)</td>
</tr>
<tr>
<td>CCMTA</td>
<td>Canadian Council of Motor Transport Administrators</td>
</tr>
<tr>
<td>CDR</td>
<td>Clinical Dementia Rating scale</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>CIHR</td>
<td>Canadian Institutes of Health Research</td>
</tr>
<tr>
<td>CINAHL</td>
<td>Cumulative Index to Nursing and Allied Health Literature</td>
</tr>
<tr>
<td>CMA</td>
<td>Canadian Medical Association</td>
</tr>
<tr>
<td>CMV</td>
<td>Commercial Motor Vehicle</td>
</tr>
<tr>
<td>CNS</td>
<td>Central Nervous System</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>CPAP</td>
<td>Continuous Positive Airway Pressure</td>
</tr>
<tr>
<td>CSS</td>
<td>Calgary Syncope Score</td>
</tr>
<tr>
<td>CVA</td>
<td>Cerebrovascular Accident</td>
</tr>
<tr>
<td>CVD</td>
<td>Cerebrovascular Disease</td>
</tr>
<tr>
<td>dB</td>
<td>Decibels</td>
</tr>
<tr>
<td>DMV</td>
<td>Department of Motor Vehicles</td>
</tr>
<tr>
<td>DoT</td>
<td>Department of Transport</td>
</tr>
<tr>
<td>DPS</td>
<td>Department of Public Safety</td>
</tr>
<tr>
<td>DSM</td>
<td>Diagnostic and Statistical Manual of Mental Disorders</td>
</tr>
<tr>
<td>DUI</td>
<td>Driving under the influence</td>
</tr>
<tr>
<td>DVLA</td>
<td>Driver and Vehicle Licensing Agency</td>
</tr>
<tr>
<td>DWI</td>
<td>Driving while intoxicated</td>
</tr>
<tr>
<td>ED</td>
<td>Emergency Department</td>
</tr>
<tr>
<td>EEG</td>
<td>Electroencephalogram</td>
</tr>
<tr>
<td>EMBASE</td>
<td>Excerpta Medica database</td>
</tr>
<tr>
<td>ER</td>
<td>Emergency Room</td>
</tr>
<tr>
<td>ESS</td>
<td>Epworth Sleepiness Scale</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FMCSA</td>
<td>Federal Motor Carrier Safety Administration</td>
</tr>
<tr>
<td>FTD</td>
<td>Fitness-to-drive</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
</tbody>
</table>
H* Mildly higher
H** Moderately higher
H*** Considerably higher
HR Hazard Ratio
HS High School
I Inconclusive
ICD International Classification of Diseases
IDF International Diabetes Federation
ILAE International League Against Epilepsy
IRR Incident Rate Ratio
ITRD International Transport Research Documentation
L Lower
LOC Loss of Consciousness
M Mean
MDD Major Depressive Disorder
MHSS Ministry of Health and Social Services
MMC Multiple Medical Conditions
MMSE Mini-Mental State Examination
MSLT Multiple Sleep Latency Test
MTO Ministry of Transportation of Ontario
MUARC Monash University Accident Research Centre
MVC Motor Vehicle Crash
ND Not Different
NHLBI National Heart Lung and Blood Institute
NHTSA National Highway Traffic Safety Administration
NMS Neuromediated Syncope
NNDA Nottingham Neurological Driving Assessment
NR Not Reported
NTC National Transport Commission
NYD Not Yet Diagnosed
NZTA New Zealand Transport Agency
OCD Obsessive-Compulsive Disorder
OEF/OIF Operation Enduring Freedom/Operation Iraqi Freedom
OR Odds Ratio
OSA Obstructive Sleep Apnoea
PPD Persistent Depressive Disorder
PR Prevalance Ratio
PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO International Prospective Register of Systematic Reviews
PS Primary School
PSG Polysomnography
PTSD Post-Traumatic Stress Disorder
RAMQ Régie d’assurance médicale du Québec
REM Rapid Eye Movement
RIRT Rhode Island Road Test
RP Retinitis Pigmentos
RR Relative Risk
RSA Road Safety Authority
RSRPP Road Safety Research Partnership Program
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAAQ</td>
<td>Société d’assurance automobile du Québec</td>
</tr>
<tr>
<td>SAD</td>
<td>Seasonal Affective Disorder</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SE</td>
<td>Standard Error</td>
</tr>
<tr>
<td>SFI</td>
<td>Seizure Free Interval</td>
</tr>
<tr>
<td>SIR</td>
<td>Standardised Incidence Ratio</td>
</tr>
<tr>
<td>SLR</td>
<td>Systematic Literature Review</td>
</tr>
<tr>
<td>SMR</td>
<td>Standardised Mishap Ratio</td>
</tr>
<tr>
<td>SR</td>
<td>Systematic Review</td>
</tr>
<tr>
<td>ST</td>
<td>Single Unit Truck</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>TIA</td>
<td>Transient Ischaemic Attack</td>
</tr>
<tr>
<td>TRID</td>
<td>Transport Research International Documentation</td>
</tr>
<tr>
<td>UPPP</td>
<td>Uvulopalatopharyngoplasty</td>
</tr>
<tr>
<td>VA</td>
<td>Visual Acuity</td>
</tr>
<tr>
<td>VF</td>
<td>Visual Field</td>
</tr>
<tr>
<td>VVS</td>
<td>Vasovagal Syncope</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

1.1 AIM OF THE REVIEW

This report addresses the influence of chronic illnesses and their associated functional impairments on the risk of motor vehicle crash (MVC) involvement. The review assesses the current state of knowledge in regard to specific medical conditions and crash involvement and other measures of driver risk. The evidence reviewed includes eleven systematic literature reviews examining a specific medical condition(s), as well as one rapid review on multiple medical conditions (MMC), and MVC risk and/or impacts on on-road driving performance. A number of conclusions are presented which may contribute to the formulation of a set of recommendations for medical fitness to drive decisions and managing MVC risk among drivers with medical conditions.

1.2 INTERNATIONAL RESEARCH CONSORTIUM

This report is the third edition of Charlton et al. (2004; 2010)\(^1\), providing a review of evidence on selected medical conditions and MVC risk. The body of work presented in the first and second edition reports underpins recommendations for driver licensing and has been widely cited in national guidelines, including in Australia (Austroads, 2017)\(^2\), Canada (Canadian Medical Association, 2017)\(^3\), Ireland (National Office for Traffic Medicine and Road Safety Authority, 2020)\(^4\), New Zealand (New Zealand Transport Agency, 2014)\(^5\), and the United States (National Highway Safety Transport Safety, 2010)\(^6\).

The report was initiated by Road Safety Victoria (Victorian Department of Transport) and led by the Monash University Accident Research Centre, and comprises contributions from an international research consortium from Monash University affiliated researchers in Australia, the Société de l’assurance automobile du Québec, Canada; Sunnybrook Health Sciences Centre, University of Toronto, Canada; and the National Office for Traffic Medicine, Royal College of Physicians of Ireland, Ireland, among other centres.

1.3 METHODS

An electronic search of databases from the disciplines of public health, psychology and transport safety was conducted for each of the selected medical conditions. MVC risk for drivers with selected medical conditions or disorders (identified by self-report or clinically diagnosed) were assessed by the frequency of crashes involving drivers with the disorder(s) that resulted in property damage, or MVC-related injury or fatality (World Health Organization, 2018)\(^7\), as identified by self-report or official MVC records. On-road test outcome was assessed by the frequency of drivers with or without the specified condition who pass or do not pass an on-road driving test administered by a driver licensing authority.

---


or an occupational therapy driving assessor. Details of the search strategy are reported in Appendices A-F.

Key details extracted from papers included in each systematic review included: study design, methods (sample characteristics), outcome measures, and key results relating to MVC risk (e.g., Odds Ratios, Relative Risk). In addition, each study was evaluated for risk of bias using a standardised tool, including: potential for selection bias, information bias, measurement bias or confounding factors, and an overall quality rating (‘good’, ‘fair’ or ‘poor’) was assigned, where the greater the risk of bias, the lower the quality rating of the study.

Guidelines on fitness-to-drive from selected jurisdictions were also reviewed where available for the purpose of comparison with evidence for MVC risk.

The selection of conditions included in the third edition of the report was determined by the project consortium in consultation with the Victorian Department of Transport (DoT), based on the following considerations:

- Included as one of eight higher risk conditions identified in the Charlton et al. (2010) report: Alcohol use disorder, Epilepsy and seizure disorders, Psychiatric disorders [including schizophrenia], Sleep disorders, and Vision impairments and disorders [including cataract]; and
- Identified by the international consortium members as of key interest to their jurisdictions: Diabetes; Hearing impairment; and
- Significant and emerging condition, based on DoT stakeholder survey (MMC); and
- Conditions with recently published systematic reviews led by members of the international consortium: Dementia, Stroke and Transient Ischemic Attack, Syncope, and Traumatic Brain Injury.

1.4 REVIEW CONTENT

Chapters 3-9 document evidence for the relationship between seven medical conditions and safety outcome measures (crashes, on-road driving test outcome). Included in this section were the following conditions: Alcohol use disorder, Diabetes, Epilepsy and seizure disorders, Hearing loss, Psychiatric disorders (including schizophrenia), Sleep disorders, and Vision impairments and disorders (including cataract).

Chapter 10 summarises evidence for MMC. Selection of this topic followed feedback solicited by the Victorian DoT, from Victorian-based external and internal (medical review) stakeholders on potential significant and emerging priorities not included in previous reviews or guidelines. Several significant and emerging medical and disability-related conditions were identified and subsequently, were shortlisted by an expert panel by consensus (including the international consortium) by an independent ranking process. The panel identified MMC as having the highest priority for inclusion in a rapid review.

Chapter 10 provides a high-level summary of the key findings and recommendations from the rapid review that evaluated the available evidence regarding the influence of multiple medical conditions on MVC risk and on on-road driving performance. Inclusion criteria for the review of MMC were: studies identified in Chapters 3-9 which provided evidence on MVC and/or on-road driving test outcomes for:

- Designated ‘primary disorder’ - Alcohol use disorder, Diabetes, Epilepsy and seizure disorders, Hearing loss, Psychiatric conditions (including schizophrenia), Sleep disorders, or Vision impairments and disorders (including cataract); and
- A comorbid medical condition or impairment.

Data extraction for studies addressing MMC and MVC risk was similar to that described above, and the same risk of bias and quality ratings were used as those assigned to the ‘primary disorder’ described in Chapters 3-9.
Chapters 11-14 summarise evidence from four recently published systematic literature reviews on the MVC risk for drivers with: dementia, stroke/transient ischemic attacks (TIA), Syncope, and Traumatic Brain Injury (TBI). Methods for each of these systematic reviews were similar to those described for the new reviews described above, albeit using different risk of bias and quality ratings. Methods are detailed in the relevant chapters.

1.5 CRASH RISK AND POLICY

Licensing authorities need to formulate policy to manage road safety within their jurisdictions. The challenge for licensing policy is to accommodate acceptable risk while balancing the societal and individual need for driving mobility. In particular, decisions must be made about the extent to which safety might be compromised for individuals with a specific medical condition, their passengers and others sharing the road network. This is a fundamental issue for policy development. At what point does the risk outweigh the need for mobility and other social and employment opportunities that are dependent on motor vehicle driving? The review provides authoritative, evidence-based guidance to enable policy development in the area of medical fitness-to-drive.

1.6 METHODOLOGICAL ISSUES

Overall, there were 160 included studies across the 11 systematic reviews. Of the 160 studies, most were cross-sectional/cohort designs (n=35 case-control studies; n=113 cross-sectional/cohort studies); seven were before-after studies and the methodology was not reported in five studies. In terms of quality, only around one third of studies were rated ‘good’ with the remainder being rated ‘fair’ or ‘poor’. For MMC, there were 16 studies included (n=7 case-control studies and n=9 cross-sectional/cohort studies). In terms of quality, only five were rated as ‘good’. Most studies were found to have some level of bias, such as recruitment of non-representative cases (including severity of condition, time since onset), and a lack of control of confounding variables such as age, sex, comorbidities and driving exposure.

1.7 INFLUENCE OF MEDICAL CONDITIONS ON CRASH INVOLVEMENT

Overall risk was evaluated for all medical conditions of interest, based on the quality, consistency and weight of evidence from studies rated ‘good’ or ‘fair’. Studies rated ‘poor’ were documented in the relevant Chapter, but not included in the determination of crash risk. This provided a means of identifying those conditions that presented the greatest risk. As outlined in Charlton et al. (2010), the overall risk for each condition compared with relevant control groups was rated based on available Relative Risk (RR), Odds Ratios (OR), Standardised Mishap Rates, or other available statistical test results:

- ‘Higher’ (H) (* RR mildly higher 1.1-2.0; **moderately higher 2.1-5.0; ***considerably higher >5.0)
- ‘Not Different’ (ND) (nominally, RRs ~ 1.0);
- ‘Lower’ (L); or
- ‘Inconclusive’ (I) (evidence highly equivocal, indeterminable, or no statistical test reported).

Based on the evidence from studies reviewed, seven of the 12 conditions were found to have at least one ‘good’ rated study with at least moderately higher risk (H**) of crash involvement compared with their relevant control group (see...
Table 1). Specifically, these were Alcohol use disorder, Epilepsy, Sleep, Vision, Multiple Medical Conditions (Diabetes with Neuropathy), Dementia, and Stroke.

However, overall, the conclusions were qualified by a lack of studies with high quality prospective study design, biased sampling, failure to account for confounding factors (age, gender, driving exposure and severity of the condition). The other conditions examined were found to have mixed or inconclusive evidence, or evidence for only a slight elevation of risk. Evidence for each condition is detailed within the body of the report.
### Table 1: Summary of MVC risk associated with medical conditions and impairments

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prevalence %</th>
<th>MVC risk and Quality of Evidence</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol Use Disorder (AUD)</td>
<td></td>
<td></td>
<td>AUD should continue to be considered a risk for MVC:physicians urged to increase attention to ensuring accurate diagnosis, treatment and follow-up for drivers with heavy drinking patterns, binge drinking, known AUD, and those involved in traffic violations and MVC.</td>
</tr>
<tr>
<td></td>
<td>*Europe: 14.6% males: 3.5% females The Americas: 11.5% males: 5.1% females Australia: 6.1% males: 2.7% females</td>
<td>MVC: H+ (1 'good', 2 'fair' studies) H** (1 'good', 2 'fair' studies) L (1 'good') ** On-road test: 0 studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>*9.3% (age 20-79 y) 19.3% (aged &gt;65 y)</td>
<td>MVC: H* (2 'good', 1 'fair' studies) ND (2 'good', 1 'fair' study) ** On-road test: 0 studies</td>
<td>No basis for change to current fitness-to-drive standards, except to eliminate differentiation between insulin treated vs. treated with hypoglycaemic agents. Identifying drivers at risk of hypoglycaemia while driving remains a high priority.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epilepsy and seizure disorders</td>
<td>*0.4-1.0%</td>
<td></td>
<td>Overall the weight of evidence suggests a slight elevation of risk. However, available evidence is mixed and not of high quality for MVC risk associated with epilepsy and/or seizure disorders. There may be an elevation of risk with AED non-compliance which justifies a guideline for restrictions of driving; some evidence of lower risk for longer seizure free periods.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MVC: H* (2 'good', 2 'fair' studies) H** (1 'good' study) ND (2 'good', 1 'fair' studies) I (1 'good', 2 'fair' studies) Seizure-free interval (SFI) L (2 'fair' studies) for 6 &amp; 12 mo &amp; 3y ND (1 'good' study) for 12 mo vs. 3 mo Anti-epileptic drugs (AED) H** (1 'good' study) H** (1 'fair' study) for non-adherence L (1 'fair' study) for AED modifications ND (1 'fair' study) ** On-road test: 0 studies</td>
<td></td>
</tr>
<tr>
<td>Hearing loss</td>
<td>*5% have mod.-severe hearing loss (&gt; 40dB) *US: 38% age 80 y+ have mod. bilateral hearing loss</td>
<td>MVC: ND (1 'good, 1 'fair' study) L (1 'good' study) ** On-road test: 0 studies</td>
<td>No evidence warranting restrictions for a full licence (commercial or non-commercial) for drivers with hearing loss. For work-related driving, hearing requirements should be incorporated in regulations governing the activities (e.g., driving school bus; transporting dangerous materials).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychiatric conditions</td>
<td>*DSM-IV disorders 4.3-6.4% Anxiety 2.4-18.2% Mood 0.8-9.6%</td>
<td>MVC: MOOD &amp; ANXIETY DISORDERS H* (2 'good', 1 'fair' study) H** (1 'fair' study) ND (4 'fair' studies) OTHER PSYCHIATRIC H* (2 'good', 2 'fair' studies) H* (2 'fair' studies) ND (1 'fair' study) I (1 'fair' study) **On-road test: 0 studies</td>
<td>Available evidence is mixed and not of high quality, and also does not support a blanket restriction on licence holding. Individualised case-by-case approach is recommended as per international guidelines; recommend practice of looking for red-flags which would raise concern.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep disorders</td>
<td>Up to 6%</td>
<td>MCV: SLEEP APNOEA H* (2 'good', 1 'fair' studies) H** (6 'good', 2 'fair' studies) I*** (2 'good', 1 'fair' studies) ND (2 'good', 4 'fair') I (1 'good', 1 'fair' studies) CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP) TREATMENT L (3 'good', 1 'fair' studies ) UVULOPALATOPHARYNGOPLASTY (UPPP) TREATMENT L (1 'good' study) HYPERSONNOLENCE/NARCOLEPSY H** (3 'good', 2 'fair' studies) INSOMNIA H* (1 'good' study) ND (1 'fair' study)</td>
<td>Most international guidelines do not give permission for drivers with sleep disorders to hold an unrestricted licence. Instead, the guidelines indicate a conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from the treating doctor (or a sleep specialist in the case of commercial drivers) subject to compliance with, and satisfactory response to, treatment. Sleep apnoea: The evidence for increased risk of MVC (and</td>
</tr>
</tbody>
</table>
On-road test: 0 studies  

**INFLUENCE OF CHRONIC ILLNESS ON MOTOR VEHICLE CRASH RISK**

<table>
<thead>
<tr>
<th>Vision impairments and disorders</th>
<th>MVC: GLAUCOMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>H***  (1 'good', 1 'fair' study)</td>
<td>H** with Retinopathy (1 'good' study)</td>
</tr>
<tr>
<td>L (1 'good' study)</td>
<td>H** with Neuropathy (1 'good' study)</td>
</tr>
<tr>
<td>ND (1 'good', 1 'fair' study)</td>
<td>ND with ‘Health complications': cardiovascular, visual or hypertension (1 'fair' study)</td>
</tr>
<tr>
<td>I (1 'fair' study)</td>
<td>SLEEP DISORDER:</td>
</tr>
<tr>
<td>On-road test:</td>
<td>H* Multiple sleep disorders (1 'fair' study')</td>
</tr>
<tr>
<td>H*** Critical error (2 'good', 1 'fair' studies)</td>
<td>ND Apnoea with Diabetes; or Myocardial Infarction; or hypertension; or cardiovascular disease; or stroke (2 'good' study); and psychiatric disorder (1 'good' study)</td>
</tr>
<tr>
<td>MVC: VISUAL FIELD IMPAIRMENT</td>
<td>ALCOHOL USE DISORDER (AUD):</td>
</tr>
<tr>
<td>H*** (4 'good', 1 'fair')</td>
<td>H* AUD with poly drug users (cocaine, methamphetamine, opioids, cannabis, or alcohol cohort groups) (1 'fair' study)</td>
</tr>
<tr>
<td>ND (2 'good', 1 'fair' studies)</td>
<td>SENSORY LOSS:</td>
</tr>
<tr>
<td>On-road test:</td>
<td>The available evidence on MVC risk associated with MMC is limited and does not support blanket restrictions. An individualised case-by-case approach recommended by most international guidelines should continue.</td>
</tr>
<tr>
<td>H*** fail (2 'fair' studies)</td>
<td></td>
</tr>
<tr>
<td><strong>3.95%</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vision impairments and disorders</th>
<th>MVC: HEMIANOPIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>H** (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>On-road test:</td>
<td></td>
</tr>
<tr>
<td>H (1 'fair' study)</td>
<td></td>
</tr>
<tr>
<td>ND (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>MVC: CATARACT</td>
<td></td>
</tr>
<tr>
<td>H** (1 'good')</td>
<td></td>
</tr>
<tr>
<td>ND (2 'good')</td>
<td></td>
</tr>
<tr>
<td>MVC: AGE-RELATED MACULAR DEGENERATION (AMD)</td>
<td></td>
</tr>
<tr>
<td>L (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>ND (3 'good', 1 'fair')</td>
<td></td>
</tr>
<tr>
<td>On-road test:</td>
<td></td>
</tr>
<tr>
<td>H** (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>ND (1 'fair' study)</td>
<td></td>
</tr>
<tr>
<td>MVC: VISUAL ACUITY (VA) IMPAIRMENT</td>
<td></td>
</tr>
<tr>
<td>H* (1 'fair')</td>
<td></td>
</tr>
<tr>
<td>ND (7 'good', 3 'fair' studies)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vision impairments and disorders</th>
<th>MVC: DIABETES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>H* with Retinopathy (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>ND with Retinopathy (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>H** with Neuropathy (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>ND with ‘Health complications': cardiovascular, visual or hypertension (1 'fair' study)</td>
<td></td>
</tr>
<tr>
<td>SLEEP DISORDER:</td>
<td></td>
</tr>
<tr>
<td>H* Multiple sleep disorders (1 'fair' study')</td>
<td></td>
</tr>
<tr>
<td>ND Apnoea with Diabetes; or Myocardial Infarction; or hypertension; or cardiovascular disease; or stroke (2 'good' study); and psychiatric disorder (1 'good' study)</td>
<td></td>
</tr>
<tr>
<td>ALCOHOL USE DISORDER (AUD):</td>
<td></td>
</tr>
<tr>
<td>H** AUD with poly drug users (cocaine, methamphetamine, opioids, cannabis, or alcohol cohort groups) (1 'fair' study)</td>
<td></td>
</tr>
<tr>
<td>SENSORY LOSS:</td>
<td></td>
</tr>
</tbody>
</table>

Higher risk for higher severity; higher risk for untreated; Lower risk with CPAP treatment) is consistent with current Australian (and international) fitness-to-drive guidelines. No change recommended. 

Hypersomnolence and narcolepsy: Evidence, albeit limited is consistent with current Australian (and international) fitness-to-drive guidelines. No change recommended.

Limited numbers of studies and conflicting findings preclude firm conclusions. Good quality evidence for increased MVC risk in binocular visual field impairment.

No clear evidence for a specific cut-off criterion for visual fields.

Evidence is mixed and no conclusions can be drawn on MVC risk for visual acuity impairment, cataract, glaucoma, age-related macular degeneration, and homonymous field loss.

The available evidence on MVC risk associated with MMC is limited and does not support blanket restrictions. An individualised case-by-case approach recommended by most international guidelines should continue.
opportunities for improving

1.8

The evidence for MVC risk and impacts on on-road performance (where available) was compared with guidelines regarding fitness to drive from selected jurisdictions. These comparisons generally confirmed that the evidence emerging from studies with ‘fair’ or ‘good’ quality ratings was in line with current guidelines for the conditions reviewed in this review.

1.9

CHANGES TO THE DRIVING TASK WITH VEHICLE AND COMMUNICATION TECHNOLOGY

In recent years the task of driving has changed. Advances in vehicle technology provide opportunities for improving driver safety (e.g., crash avoidance and lane keeping) and
enhancing the human-machine-interface for drivers with functional impairments (e.g., adapted vehicle controls, reversing cameras). Whilst in-car technologies (including driver assistance systems [ADAS]) and access to communication devices (mobile phones, displays for navigation or work) may place additional attentional, cognitive, and visual/auditory processing loads on the driver. However, impacts of these driving task changes on drivers with physical, sensory and cognitive impairments due to medical impairment and disability are not yet well understood. These issues will remain with us until full vehicle automation (“driverless vehicles”) are consistently available across the transport network.

1.10 RECOMMENDATIONS

In the light of the available information presented in this review, several recommendations can be made to improve safety outcomes associated with medical conditions, disabilities and associated functional impairments:

- Review licensing guidelines for fitness-to-drive in the light of all available evidence regarding MVC risk. For example, studies of coroner’s reports, research examining road trauma and culpability, peak medical group and consensus based medical practice guidelines or position statements;
- Promote public awareness, particularly amongst the driving population, about the known MVC risks and effective management for specific medical conditions or functional impairments. This is important particularly because many licensing jurisdictions are reliant on self-referral or voluntary reporting of medical conditions to the licensing authority, or disclosure of symptoms to a doctor. In addition, there is evidence of low levels of awareness among the general population of guidelines on medical fitness to drive\(^{10}\). Hence the onus is on the driver to be aware whether they have symptoms consistent with a reportable medical condition or disability that could affect their driving;
- Improve knowledge within the health professions about the known MVC risks and effective management for medical conditions or functional impairments. This should emphasise that early intervention with driver rehabilitation or remediation/compensation approaches can enhance and extend driving safety;
- Ensure that the evaluation of a driver with a medical condition or disability (and especially in the case of multiple conditions) is conducted on a case by case basis which includes a review of the underlying condition(s), complications and concomitant conditions that may affect fitness-to-drive, and how this may impact on risks for certain types of driving (e.g., as relevant to private vs. commercial licensing requirements and application of licence conditions such as area restrictions or no night driving);
- Develop reliable methods of identifying and referring drivers who are potentially at risk because of multiple medical condition(s) into the DLA medical review process;
- Investigate the capacity for the use of medical technologies for more effective monitoring of driver risk (e.g., in-vehicle blood glucose monitoring system; in-vehicle distraction and fatigue detection systems);
- Investigate the capacity for the use of adaptive technologies and intelligent transport systems (ITS) to enhance driver safety (e.g., safe following distance devices, rear collision warning and crash avoidance systems, lane departure warning systems);
- Include appropriate licensing conditions/restrictions (e.g., alcohol interlocks for drivers with alcohol use disorders, automatic transmission/use of specified vehicle modifications);
- Investigate driver rehabilitation interventions and their value for overcoming functional impairments for drivers with specific medical conditions/disabilities, and
- Advance scientific knowledge linking medical conditions, impacts on driver performance and MVC risk in order to improve the evidence base for formulating policy about licensing and fitness to drive.

1.11 FUTURE RESEARCH

Based on the findings of this review, it is recommended that a cooperative international approach to future research be adopted. This should take the form of a large scale, prospective study (or group of studies) using a population-based study design, including naturalistic methodology, as well as objective metrics (for both MVC outcomes and medical diagnoses) and appropriate controls, and in multiple licensing jurisdictions to investigate the following:

- Conditions or impairments associated with on-road test performance failure and/or high MVC risk;
- The effectiveness of treatments, rehabilitation and countermeasures, including advanced vehicle technologies, and conditional licences in reducing MVC risk;
- Risk and risk reduction strategies for targeted high-risk sub-groups, particularly with multiple medical conditions prevalent in the ageing population, and
- The social, health, safety, and economic consequences of licensing restrictions in at-risk populations.
2. INTRODUCTION

2.1 AIM OF THE REPORT

The aim of this report is to present a critical review of the available scientific evidence that has explored the relationship between medical conditions, motor vehicle crash (MVC) involvement, and where available, impacts on on-road driving performance. The report considers the influence of medical conditions, as well as other enduring complications of the various illnesses and associated functional impairments, on MVC involvement and other measures of driver risk. The current state of knowledge is assessed regarding the size of the problem as well as the evidence for MVC involvement. A number of conclusions are presented which may contribute to the formulation of a set of best practice recommendations for managing the MVC risk associated with certain medical conditions.

2.2 BACKGROUND

A significant issue for consideration in road safety is the impact of medical conditions on MVC involvement and risk of injury. While much of the research on this topic has focused on specific medical conditions, there have been a relatively small number of reviews that have synthesised these findings. Much of the evidence considered in these previous reviews is now at least a decade old and there is a need to review the evidence again, in the light of significant developments in a range of relevant areas. Indeed, recent advances in the areas of medicine, human factors and applied health sciences have led to a better understanding of the underlying mechanisms of many medical illnesses and associated functional impairments. Significant developments in pharmacological and other treatments are also likely to have had an impact on level of impairment, mobility and quality of life of individuals with chronic illness. Developments in information technology and improved access to educational materials are also likely to have led to greater public awareness about medical illnesses, and functional impairments, and in turn, this may have influenced self-regulatory behaviours of drivers with medical conditions (e.g., Gooden, et al., 2019; Stolwyk, et al., 2015).

2.3 SAFE SYSTEM APPROACH

In Australia, national and state road safety plans are developed within a Safe System approach, a strategy derived from Sweden’s Vision Zero and the Netherlands' Sustainable Safety (Australian Transport Council, 2011). The Safe System approach, accepts that while many crashes can be prevented, some will continue to occur despite efforts to the contrary. A key task of the Safe System therefore is to manage vehicles, the road infrastructure and speeds, and the interactions between these components, to ensure that when crashes do occur, crash energies will remain at levels that minimize the probability of death and serious injury. The Safe System approach does not dismiss individual road user responsibilities and behavioural countermeasures but explicitly points to these aspects as supporting components of the system. Components in this context include compliance with road rules, admittance to the system, including improved assessment of fitness to drive relevant to medical conditions, disabilities and functional declines, and information and education to support driving and travelling.

2.4 THE AGEING POPULATION AND CHRONIC ILLNESS

A particular issue of relevance to the impact of chronic illness on MVC involvement is the predicted pattern of ageing of western society (Koppel, et al., 2020). By the year 2030, it is estimated that in many OECD countries, one in every four persons will be aged 65 years or older. This shift in the population distribution is attributed largely to the ageing of the ‘baby boomer’ cohort. In addition, economists and demographers are anticipating a decline in birth rates throughout the world as a result of the health and economic crisis caused by COVID-19 pandemic (Charles-Edwards et al., 2020) and an overall community prevalence increase in disability associated with ageing. Current estimates for Australia suggest that almost 50 percent (49.6%) of those aged 65 years and older have a disability of some kind (ABS, 2019).
A critical issue relevant to ageing and chronic illness, is the co-existence of multiple conditions, which tends to be more common, but not exclusive, to older age groups (Marshall et al., 2011). While there have been relatively few studies that have considered the effect of comorbidity on MVC risk, intuitively there is a strong likelihood that multiple conditions will carry a higher risk than that associated with any of the individual conditions alone; that is, it is possible that they will have a non-linear, multiplicative negative influence on risk. This is also complicated with general age-related frailty and decline in various cognitive, sensory and physical capacities. While it is theoretically possible to tease apart the independent contributions of age and co-existing medical conditions using appropriate methodological and statistical procedures, it is perhaps of greater interest to understand how these factors might interact in their impact on MVC risk, especially as they frequently co-exist in drivers. In addition, it may well be that the relatively safe record of older drivers despite higher levels of morbidity and co-morbidity will provide an opportunity to tease out strategic and compensatory mechanisms which might prove of benefit to safe mobility at all ages with medical conditions relevant to driving (Feng et al., 2018). Indeed, this will have important implications for policy and practice in guiding decisions in road safety (Medves et al., 2010; Rapoport et al., 2015).

In past decades there have been several papers that have focused on MVC risk and medical conditions of older drivers in particular (e.g., Falkenstein, et al., 2020; Hakamies-Blomqvist, 1993; 1994; 1996; Hu, et al., 2000; Janke, 1994; Dobbs, 2001; 2005; Marshall, 2008; Staplin, et al., 1999). The current review takes a broader view of the driving population, considering the relative risk associated with chronic illness across the age span, including those conditions that are more prevalent in older age groups.

2.5 HEALTH, CHRONIC ILLNESS AND FUNCTIONAL IMPAIRMENT

While there is a view that overall health per se is a poor predictor of driving ability (Janke, 1994; Dobbs, 2001), there is some evidence that draws this into question. Using the Cornell Medical Index, derived from the total number of self-reported medical conditions, Rabbitt and Parker showed that drivers (n=362), aged 49-90 years, reporting a relatively poor health score (95th percentile) had an MVC liability about 1.66 times that of those who reported a relatively good health score (5th percentile) (2002). Notwithstanding the equivocal evidence for a contribution of health status, what is likely to be of more interest to driver licensing authorities is a rigorous analysis of those conditions (and the degree of illness/impairment severity) that is associated with the greatest compromise in driving skill and therefore pose the greatest threat to safety.

Clearly, not all medical conditions affect injury risk on the road system to the same extent and not all individuals with the same condition will be affected in the same way. The severity of the condition and other characteristics of the disorder are likely to be important determinants of MVC risk. Indeed, it is not necessarily the medical condition and/or medical complications per se that affect driving, but rather the functional impairments that may be associated with these conditions. In discussing the merits of focussing on impairments in assessing risk, Marottoli comments that functional impairments are "the common pathway through which … medical conditions affect driving capability" (2001, p.11). Moreover, the extent to which individuals may be able to adapt or compensate for their impairment while driving will undoubtedly have some bearing on their likelihood of crash involvement. More research is needed to better understand the link between MVC risk, medical conditions and specific types and levels of functional impairments and the impact of compensatory strategies in moderating this risk.

There is an urgent need for more reliable ways of assessing functional impairment and MVC risk. The majority of studies identified in this review have addressed the question of risk associated with medical conditions rather than functional impairments. Some notable exceptions can be seen in the review of vision impairment (see Chapter 9), where researchers are endeavouaring to understand underlying mechanisms of impairments and how these impact on driving skill and MVC risk (e.g., Huisingh, et al., 2014; Margolis, et al.,
A potential problem with this approach, however, is that there is generally not one single method for assessing a given functional impairment. This is particularly evident in the case of cognitive impairment, where a very large number of neuropsychological functions may be affected and a profusion of assessments are available (see Chapter 11). More effort should be directed towards identifying a set of sensitive and reliable assessments of impairments that impact on driving risk, or to developing and implementing in-vehicle devices that can detect impairment and can rapidly apply urgent countermeasures.

Another large problem is that while some conditions cause fixed functional impairments (e.g., the visual field loss of glaucoma), other conditions have intermittent functional impairments in people who have completely normal function when not experiencing the transient impairment (e.g., sudden loss of consciousness in epilepsy).

2.6 EVIDENCE-BASED DECISION-MAKING

While the determination of risk may finally lie with the driver licensing authorities, in practical terms, medical and health practitioners are called upon to make recommendations about whether individuals with medical conditions meet the national fitness to drive guidelines; with or without licence restrictions (Koppel, et al., 2019). In some jurisdictions (e.g., the Netherlands), specialist medical practitioners are nominated to undertake such assessments. However, in the majority of countries, this responsibility lies with the general practitioner or medical specialist if specified in the guidelines. However, several studies have noted that physicians’ knowledge regarding fitness to drive guidelines, as well as regarding the potential impact of medical conditions on MVC risk, was generally poor (Alkharboush, et al., 2017; Sims, et al., 2012). Indeed, while many medical and other health practitioners believed that their patients’ fitness to drive should be addressed, many did not routinely assess their patients’ fitness to drive, and few felt qualified to do so (Brooks, et al., 2011; Elgar & Smith, 2018; Jang, et al., 2007); however, national education programmes can increase practitioner knowledge and confidence (Kahvedžić, et al., 2015). A practical example of the effect of a professional development programme on medical fitness to drive for health professionals is the joint SAAQ/Quebec College of Physicians workshop. Over the first six years of the programme reports initiated by health professionals increased by 1000 percent (Dow & Jacques, 2012).

Moreover, general practitioners in some countries have indicated that they need more objective tools to assess potentially at-risk drivers (Bogner, et al., 2004; Chan, et al., 2013; Omer, et al., 2014). Specialists may also consider guidelines to be too restricting in terms of their experience of their patients (Ryan, et al., 2017). In addition, decision-making for their own patients may place clinicians in difficult ethical dilemmas. Health care professionals in some jurisdictions report that they do not wish to make these decisions, which have such potential to impact negatively on the general well-being and mobility of their patients (Jones, et al., 2012; Langford, et al., 2010; Redelmeier, et al., 2008; Sims, et al., 2012). These practical, legal, ethical and emotional challenges highlight the need for guidelines for assessment of risk that are informed by scientific evidence with attention to increased conformity with criteria for quality for other clinical guidelines (Rapoport, et al., 2015).

2.7 FITNESS TO DRIVE GUIDELINES

Fitness to drive guidelines have been developed in many jurisdictions, and are regularly updated, to assist health professionals in determining fitness to drive and include various practices for assessing medical fitness to drive, provisions for issuing conditional and restricted licences, and rehabilitation and driver re-training (Unsworth, et al., 2017). In Australia, the guidelines are both evidence-based where the evidence exists and is robust, and where evidence is lacking, are consensus-based with input from clinicians, allied health, researchers, road safety experts, human factors specialists and jurisdiction policy staff.

In Australia, the guidelines are called “Medical standards for licensing and clinical management guidelines” and are designed for two main end-user groups: health
professionals and driver licensing authorities. These combined guidelines must consider both medical assessment criteria and the broader context of the interactions across the driver, vehicle driven, driving task and driving context as relevant to licensing. In some jurisdictions, there are separate guidelines for physicians and standards for licensing authorities (e.g., Canadian Medical Association [CMA] and Canadian Council of Motor Transport Administrators [CCMTA] in Canada).

In most driver licensing guidelines or standards, a distinction is drawn between licensing criteria for private and commercial licences. Due to the higher danger potential to the public and the environment that driving commercial vehicles carries (e.g., transporting dangerous goods, larger freight loads and passengers for hire, working shifts and the longer periods spent driving as well as the size and weight of the vehicle), drivers of these vehicles are required to undergo more stringent medical review and other assessments prior to licensing. In comparison, the daily driving habits of private licence holders may only involve driving to local shops or to work and, hence, a less rigorous approach is indicated.

In addition, some countries allow scope to apply differing degrees of latitude when licensing both commercial and private drivers, depending on their driving circumstances. For example, a farmer may require a commercial licence to drive heavy vehicles on the farm or small local roads, rather than on the open road. Such a scenario would not present a grave threat to public safety and less strict criteria could be applied. In addition, “grandfather rights” (less stringent test standards) apply to those who have held commercial licences prior to certain dates in the UK and Sweden. Conversely, a more rigorous approach may be appropriate in the case of more onerous responsibilities associated with passenger transportation. For example, in the UK, all individuals seeking a taxi licence need to submit a medical report from their GP if: they are a first-time applicant; they are over the age of 45 years, or if they have a medical condition. Regardless of whether considering decisions for private or commercial drivers, it is essential that guidelines for assessing fitness to drive are in line with legislation relating to disability and human rights and do not unfairly discriminate against individuals with a disability. This underlines the importance of establishing guidelines that are informed by sound scientific evidence.

The current review provides a comparative analysis of several international fitness to drive guidelines and consideration of the extent to which these guidelines are informed by available scientific evidence. This interaction between science and policy is critical for the advancement of evidence-based practice in the road safety arena.

2.8 CHANGES TO THE DRIVING TASK WITH VEHICLE AND COMMUNICATION TECHNOLOGY

In recent years the task of driving has changed. Advances in vehicle technology provide opportunities for improving driver safety (e.g., crash avoidance and lane keeping) and the human-machine-interface for drivers with functional impairments (e.g., adapted vehicle controls, reversing cameras) however there are also other associated risks with some of these technologies that need to be managed.

In-car technologies (including driver assistance systems) and access to communication devices (e.g., mobile phones, displays for navigation or work) may place additional attentional, cognitive, and visual/auditory processing loads on the driver. Such demands are particularly pertinent for commercial vehicle drivers whose exposure and work demands (shift work, in-cabin multi-tasking, long monotonous driving) place them at higher risk of not adequately managing driver distraction and arousal/attention requirements. There is an emerging evidence base for potential negative impacts on driving safety for some driver groups (e.g. novice drivers). However, impacts of these driving task changes on drivers with compromised physical, sensory and cognitive systems due to medical impairment and disability are not yet well understood.

These issues will remain with us until full vehicle automation (“driverless vehicles”) are consistently available across the transport network. Drivers with medical conditions/
disabilities interacting with in-car technologies require consideration on a case by case basis, particularly by health professionals managing in-vehicle assessments and rehabilitation (including disability related vehicle modifications) and for licensing authorities considering licensure impacts such as conditions or restrictions.

2.9 OVERVIEW OF THE REVIEW METHODOLOGY

This report is the third edition of the Charlton et al. (2004; 2010) report which provided a comprehensive review of the available scientific evidence on selected medical conditions and MVC risk. The body of work presented in the first and second edition reports underpins recommendations for driver licensing authorities throughout the world. It has been widely cited in national guidelines, including in Australia (Austroads, 2017), Canada (Canadian Medical Association, 2017), Ireland (National Office for Traffic Medicine and Road Safety Authority, 2020), New Zealand (New Zealand Transport Agency, 2014), and the United States (National Highway Transport Safety Administration, 2010).

The report was initiated by Road Safety Victoria (Victorian Department of Transport) and led by the Monash University Accident Research Centre, and comprises contributions from an international research consortium from Monash University affiliated researchers in Australia, the Société de l’assurance automobile du Québec, Canada; Sunnybrook Health Sciences Centre, University of Toronto, Canada; and the National Office for Traffic Medicine, Royal College of Physicians of Ireland, Ireland, among other centres.

The first task of the international research consortium was to identify which medical conditions should be included in the third edition. Members of the consortium noted four systematic literature reviews that were recently published by the group regarding the MVC risk for drivers with: dementia (Chee, et al., 2017), stroke/transient ischemic attacks (TIA) (Rapoport, et al., 2019), syncope (Chee, et al., 2020), and traumatic brain injury (TBI) (Chee, et al., 2019). It was agreed these provided valuable updated information and were therefore proposed for inclusion in the updated report in summary form.

The selection of medical conditions was based on four broad considerations, summarised here and detailed below:

- Identified as one of the high-risk medical conditions identified in the Charlton et al. (2010) report: Alcohol use disorder, Epilepsy and seizure disorders, Psychiatric disorders, Sleep disorders, and Vision impairments and disorders, and
- Identified by the international research consortium members as of key interest to the jurisdiction: Diabetes, Hearing impairment, and
- Significant and emerging condition, based on DoT stakeholder survey and international consortium consensus: Multiple Medical Conditions (MMC), and
- Conditions with recently published systematic reviews led by members of the international research consortium. Four conditions: Dementia, Stroke/TIA, Syncope, and TBI.

The overall aim of the third edition of the report is to summarise and interpret the key findings from the 11 systematic reviews and the rapid review on MMC, and to provide advice on the relevance of the research findings to: current medical condition and MVC risk/medical review policy, operations and legislation for Victoria, Australia, and the National Australian Fitness-to-Drive guidelines.

Chapters 3-9 document a summary of the systematic literature reviews that evaluated the available scientific evidence for the relationship between seven medical conditions and safety outcome measures (crashes, on-road driving test outcome).

Each of seven systematic literature reviews was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach, which provides a detailed guide on the conduct and reporting requirements for systematic reviews and meta-analyses. In this approach, the searches, article selection and data extraction processed follow a rigorous protocol which were not applied in the previous
editions. The protocol for each systematic review was registered with PROSPERO, following their strict criteria which helps to document the scientific rigour of each study conducted.

A systematic search of public health-, psychology-, and transport-databases was conducted for each of the selected medical conditions. MVC risk for drivers with selected medical conditions or disorders (identified by self-report or clinically diagnosed) were assessed by the frequency of crashes involving drivers with the disorder(s) that resulted in property damage, or MVC-related injury or fatality (World Health Organization, 2016), as identified by self-report or official MVC records. On-road driving performance was defined as the frequency of drivers with selected medical conditions or disorders who pass or do not pass on-road driving tests administered by driver licensing authorities or by occupational therapy driving assessors. Details of the search strategy for each systematic review are reported in the Appendices.

Key details were extracted from the included studies, including: study design, methods (sample characteristics), outcome measures, and key results relating to MVC risk (e.g., Odds Ratios, Relative Risk). In addition, each included study was evaluated, using validated standardised quality assessment tools for risk of bias, including: potential for selection bias, information bias, measurement bias or confounding factors, and an overall quality rating (‘good’, ‘fair’ or ‘poor’) was assigned, where the greater the risk of bias, the lower the quality rating of the study.

Guidelines on fitness to drive from selected licensing jurisdictions were also reviewed where available for the purpose of comparison with evidence for MVC risk.

In addition to the chronic illnesses and conditions identified above for inclusion in the updated review, Road Safety Victoria consulted with key Victorian-based external and internal (medical review) stakeholders to gauge their views on other medical conditions or medical treatments which warranted further attention. Hence, the second aim of this report is to review the evidence for newly identified priority issues.

Several significant and emerging medical and disability-related conditions were identified and subsequently, were shortlisted by the international research consortium by an independent ranking process. The panel consensus identified MMC as the highest priority for inclusion in a rapid review. Chapter 10 provides a high-level summary of the key findings and recommendations from the rapid review that evaluated the available evidence regarding the influence of MMC on MVC risk and on on-road driving performance. Inclusion criteria for this review were: studies included in the systematic literature reviews described in Chapters 3-9 which provided evidence on MVC risk and/or on-road driving test outcomes for:

- Designated ‘primary disorder’ - Alcohol use disorder, Diabetes, Epilepsy and seizure disorders, Hearing loss, Psychiatric conditions (including schizophrenia), Sleep disorders, or Vision impairments and disorders (including cataract); and
- A comorbid medical condition or impairment.

Data extraction for studies addressing MMC and MVC risk was similar to that described above, and the same risk of bias and quality ratings were used as those assigned to the ‘primary disorder’ described in Chapters 3-9.

Chapters 11-14 summarise the evidence from the four recently published systematic literature reviews on the MVC risk for drivers with: dementia, stroke/TIA, syncope, and TBI. It is important to note that these reviews were conducted prior to the commencement of this edition of the report, and while they share similar methodologies to the systematic literature reviews described in Chapters 3-9 they have included studies with some different outcome measures (i.e., driving simulator performance) and have used different risk of bias ratings. Consequently, these summaries only focus on the key outcomes and recommendations.
2.10 REFERENCES


3. INFLUENCE OF ALCOHOL USE DISORDERS ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of alcohol use disorders (AUD) on MVC risk and on on-road driving performance. For the full systematic literature review, please refer to:
Perazzolo et al. (In preparation).

3.1 OVERVIEW AND KEY RECOMMENDATIONS

- Driving under the influence of alcohol is a significant risk factor for fatal and injurious MVCs, and AUD are common among the general population: nonetheless the relationship between AUD and the risk of MVC is poorly understood.
- The World Health Organization (2018a) has estimated that 237 million men and 46 million women worldwide have AUDs with the highest prevalence in the Europe (14.8% men and 3.5% women) and the Americas (11.5% men and 5.1% women). AUDs are more prevalent in high-income countries. In Australia, the 12-month prevalence of AUDs in 2016 was 6.1% for men, and 2.7% for women (World Health Organization, 2018a). Alcohol dependence had a prevalence of 2.2% for men, and 0.8% for women.
- This study was registered with PROSPERO (CRD42020154252).
- A systematic search of public health, psychology and transport databases was conducted in October 2019.
- The quality of evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools.
- A total of 8,223 studies were identified, with one study added from bibliographic review; 3,252 duplicates were removed via the software algorithm. Following title and abstract screening, 41 studies were identified for full-text review, of which 33 studies were excluded.
- Of eight included studies, the quality of evidence was variable; three studies were rated ‘good’, four studies rated ‘fair’, and one study rated ‘poor’.
- Six studies reported MVC risk to be elevated for drivers with AUD, with odds ratios ranging from 1.10 to 4.60 - but in each case qualified by factors such as the proportion of those involved as drivers, those with violations, and a graduation of risk with AUD severity. One study reported a reduced MVC risk for drivers with AUD.
- No studies were identified that examined on-road driving performance.
- Key recommendations:
  - AUD should continue to be considered a risk for MVC, with increased attention to ensuring accurate diagnosis of AUD, treatment and follow-up for drivers with heavy drinking patterns, binge drinking, known AUD, and those involved in traffic violations and MVC.
  - Further research should be pursued linking health records (including treatment outcomes) with a diagnosis of AUD, treatment outcomes and MVC involvement.
  - More formal recommendations for detection, assessment and management of binge drinking need to be developed in the context of medical fitness-to-drive.

Authors:
Monica Perazzolo¹, Morris Odell², Margaret Ryan¹, John D. Sheehan³, William Flannery³, Eilish Gilvary⁴, Colin Drummond⁵, Jamie Dow⁶, Mark J. Rapoport⁷, Sjaan Koppel⁸, Judith L. Charlton⁸, Desmond O’Neill¹,⁹

Affiliations:
¹National Traffic Medicine Programme, Royal College of Physicians of Ireland, Dublin, Ireland, ²Department of Forensic Medicine, Monash University, Victoria, Australia, ³Mater Misericordiae University Hospital, Dublin, Ireland, ⁴Newcastle Addictions Services Northumberland, Tyne and Wear Foundation Trust, Newcastle, United Kingdom, ⁵National
Addiction Centre Institute of Psychiatry, Psychology and Neuroscience, King's College London, United Kingdom, Society de l'assurance automobile du Quebec, Quebec City, Quebec, Canada, Department of Psychiatry, Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Ontario, Canada, Monash University Accident Research Centre, Monash University, Victoria, Australia, Trinity College Dublin and Tallaght Hospital, Dublin, Ireland.

Sponsoring organisations:

This project was funded as a grant by the following organisations: Road Safety Authority of Ireland.

Keywords:

Automobile Driving; Alcohol Use Disorders; Motor Vehicle Crashes; On-Road Driving; Fitness-to-Drive; Road Safety

3.2 BACKGROUND

A significant proportion of fatal and injurious motor vehicle crashes (MVC) are associated with alcohol ingestion and intoxication but the degree to which MVC risk is related to alcohol use disorders (AUD) has not been quantified. The wide spectrum of AUD, their variety of manifestations and confounding factors challenge definition of risk of AUDs for MVC. At the very least, the overall relationship between alcohol, driving and MVC can be established for the following reasons: alcohol is clearly associated with the outcome (MVC or MVC-related injury); the dose-response relationship (the higher the blood alcohol concentration, the higher the risk of MVC-related injuries); and the existence of a biological explanation based on mediating effect of alcohol on cognitive and psychomotor performance (Rehm et al., 2003). Data about driving under the influence of alcohol (Lapham et al., 2001), biological markers of alcohol abuse (Tokko et al., 2019), binge drinking patterns (Hingson, Zha, & White, 2017) and recidivism (Simpson, Beirness, Robertson, Mayhew, & Hedlund, 2004) provides circumstantial rather than direct evidence about the relationship between drivers with a diagnosis of AUD and crashes.

3.2.1 Scope

The aim of this systematic review was to determine the MVC risk for drivers with AUD (misuse/abuse, dependence) with inclusion in the relevant studies where there is or is not confirmation of driving under the influence of alcohol (DUI). The separation of the question into two parts depending whether inclusion in the study was related to DUI or not is of importance as most people with AUD will not have experience of a DUI detection, and it is important that clinicians, public health bodies and driver licencing agencies can access estimates of the MVC risk of these populations of drivers. Conversely, many studies arising from populations selected from DUI detection will not have a diagnostic formulation of AUD. In addition, the aim of this systematic review was to determine the impact of AUD on on-road driving test performance (pass/fail).

3.2.2 Protocol and registration

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). PRISMA provides a detailed guide on the conduct and reporting requirements for systematic reviews and meta-analyses. The protocol for this systematic review was submitted to PROSPERO (CRD42020154252).

3.2.3 Definition

For the purpose of this review, MVC risk was assessed by the frequency of crashes involving motor vehicles for drivers with AUD that resulted in property damage, or MVC-related injury or a fatality (World Health Organization, 2018b), as identified by self-report or official crash records.
On-road driving performance was defined as the frequency of drivers with AUD who pass or do not pass on-road driving tests administered by driver licensing authorities or by occupational therapy driving assessors.

3.3 METHOD

3.3.1 Eligibility criteria

3.3.1.1 Inclusion criteria

Studies were included in the systematic review according to the following a priori criteria:

1. Original research in a peer-reviewed journal;
2. Full-text available;
3. English language and human studies;
4. Studies which include driving real vehicles;
5. Studies which examine the relationship between AUD related variables (misuse/abuse, dependence) and MVC risk and/or on-road driving performance, and;

3.3.1.2 Exclusion criteria

Studies were excluded from the systematic review according to the following criteria:

1. Commentary articles;
2. Dissertations;
3. Abstracts;
4. Reviews;
5. Studies using qualitative methods for data collection and analysis, and;
6. Correspondence.

3.3.2 Information sources

Relevant studies were identified before the development of a search strategy and were defined as ‘goldset’ studies. These goldset studies were then used to help identify relevant search terms. An electronic search of databases from the disciplines of public health, psychology and transport safety (Ovid Cochrane Library, Ovid Medline, Ovid PsycINFO, Ovid EMBASE, CINAHL PLUS via EbscoHost, Ovid TRANSPORT and TRID: TRIS and ITRD database) was conducted on October 15th 2019 to locate studies from the first available year to October 15th 2019.

3.3.3 Search

Two concepts were derived: Concept 1A: Population=Drivers; Concept 1B: Population=Drivers with diagnosis of AUD (misuse/abuse, dependence); Concept 2A Outcome=Crash Risk; 2B Outcome=On-road Driving Test. Search terms (both indexed [e.g., Medical Subject Headings] and key words) associated with all concepts were derived independently from each author and in consultation with a subject matter expert librarian. See Appendix A (Section 15.2) for the search strategy.

3.3.4 Study selection

Search results were exported into Endnote X8 software and then imported into Covidence (Cochrane technology platform). Duplicates were removed from the total number of identified records using a standard function. For each title/abstract, two reviewers independently completed an initial screen for eligibility and a priori inclusion and exclusion criteria were applied. Any conflicts between the two reviewers were resolved by a third reviewer. Following title and abstract screening, two reviewers independently applied inclusion and exclusion criteria to the full-texts of the remaining records to select studies for this review. Any conflicts between the two reviewers were resolved by a third reviewer. A
bibliographic review of included studies, as well as a review of goldset studies, was conducted to identify additional relevant studies.

3.3.5 Data extraction process

A full-text review of each included study was conducted by two reviewers and the data items were extracted into a pretested data extraction sheet: authors; date of publication; study aim; research design; study period; study location, study population definition; participant demographics (i.e., age range and mean); data sources; MVC outcome; on-road driving performance outcome; main research findings, and risk of bias assessment. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.

3.3.6 Risk of bias

The risk of bias was assessed independently by two reviewers using the National Heart, Lung and Blood Institute Quality Assessment tools (National Institutes of Health, 2014a, 2014b). Each reviewer assessed each study for: risk of potential for selection bias, information bias, measurement bias or confounding factors. Based on this assessment, the two reviewers independently provided an overall quality rating (‘good’, ‘fair’ or ‘poor’), where the greater the risk of bias, the lower the quality rating of the study. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.
3.4 RESULTS

3.4.1 Included studies

The combined searches identified 8,223 studies with one study added from bibliographic review: 3,252 duplicates were removed via the software algorithm. Following title and abstract screening, 41 studies were identified for full-text review, of which 33 studies were excluded. Reasons for exclusion are noted in Figure 1. A significant issue was lack of clarity that the study participant was a driver, or even in a vehicle when the MVC occurred. Altogether, eight studies met the inclusion criteria and were assessed: only one study included drivers following DUI, and given the heterogeneity of the samples, this was included in the overall analysis.

3.4.2 Study descriptions

Included studies were reported between 1994 and 2017, with data collection spanning 1987 to 2010. Of the eight studies, most were case-control studies (n=4 case-control studies; n=2 cross-sectional studies; n=2 cohort studies). Study sample sizes (among the studies that reported sample size) ranged from 234 to 592,406. The mean age of participants was only noted in one study (55.2 ± 5.9 years). Gender distribution was reported in seven studies,
with an average of 60.8% males among the AUD populations. Most studies were conducted in the United States (n=5), with one each in Canada, Spain and Slovenia.

3.4.3 Evidence for risk of MVCs

3.4.3.1 Studies reporting evidence of increased risk (N=6)

**Case-Control**

**Fair quality:**

- Callaghan et al. (2013) reported that drivers with International Classifications of Disease (ICD)-9 diagnosis of 303 (Alcohol dependence syndrome), 305.0 (Nondependent alcohol abuse), 980.0 (Toxic effect of ethyl alcohol) AUD had a higher standardized mortality ratio for MVC fatalities (ICD-9 Codes E810-825 and related ICD-10 codes from state health records (Anderson, Miniño, Hoyert, & Rosenberg, 2001)) compared to the California general population (SMR=4.50, 95% CI 4.10–4.90): the MVC death was noted to be the driver in 53% of MVC fatalities

- Sestan, Dodic Fikfak, and Balantisc (2017) reported that drivers referred for a driver medical assessment who had an alcohol abuse or dependence diagnosis had a higher MVC rate (from police records) in retrospective analysis compared to controls from the population of drivers in Slovenia with a record of crashes or violations (OR=1.70, 95% CI 1.01–2.89, p=0.047).

**Poor quality:**

- Koepsell et al. (1994), in a univariate analyses of medical conditions including ‘alcohol abuse’ found an OR of 2.10 (95% CI 0.80-6.00) where the driver was treated medically after an MVC which was not significant compared to controls.

**Cross-sectional/Cohort**

**Good quality:**

- Hingson et al. (2017) reported a statistically significant increase in the OR of drivers across the gradient of each category of DSM V AUD and self-reported crashes while driving compared across severity compared to controls with no AUD, using the Alcohol Use Disorders and Associated Disabilities Interview Schedule (AUDADIS) which combines elements of alcohol abuse and dependence criteria from DSM-III, DSM-III-R, DSM-IV and ICD-10. When comparing drivers with severe vs. mild AUD (OR=4.60, 95% CI 3.00-7.30); severe vs. moderate AUD (OR=2.50, 95% CI 1.60-3.80) and moderate vs. mild AUD (OR=1.90, 95% CI 1.20-3.20). Binge drinking corrected for AUD was not statistically correlated with MVCs.

- Mann et al. (2010) reported that those with self-reported MVCs in the last 12 months were likely to have higher scores on the Alcohol Use Disorders Identification Tool (AUDIT) measures of Consumption, Dependence and Problems (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). Positive AUDIT Dependence and AUDIT Problems subscales were significantly related to MVC risk (ORs=1.13 and 1.10, respectively, 95% CI NR).

**Fair quality:**

- Del Rio, Gonzalez-Luque, and Alvarez (2001) found that drivers with DSM-IV abuse, dependence and alcohol-induced disorder assessed medically during licence renewal (every driver in Spain has a medical, psychological and vision check at licence application and renewal) had a statistically significant increase in self-reported motor vehicle crashes (23.2% vs 12.1%) over the previous three years compared to those without the diagnosis - a calculated OR is 2.2 (95% CI 1.51-3.21): similar ORs were calculated for the alcohol screening measures of an AUDIT score greater or equal to 8 (2.08; 95% CI 1.68-2.56) and CAGE (Ewing, 1984) score greater or equal to 2 (2.05; 95% CI 1.31-3.21).
• Wieczorek (1995) reported that 96% of those referred for treatment after being found to be driving with impairment with two or more self-reported crashes were alcohol dependent compared to 77% of those with DUI but no crashes (p=0.001).

3.4.3.2 Studies reporting evidence of decreased risk (N=1)

Case-control

Good quality:

• Yao, Voas, and Lacey (2018), in a prospective study of police-reported crashes, reported that heavy (defined using AUDIT), abusive and dependent AUD (defined using AUDADIS) patterns were associated with lower daytime crashes (OR=0.50, 95% CI 0.27-0.49), (OR=0.52, 95% CI 0.41-0.66) and (OR=0.36, 95% CI 0.27-0.49) respectively. Dependent AUD was associated with lower night-time crashes (OR=0.37, 95% CI 0.18-0.77) while risk for heavy and abusive AUD was comparable to normative drinkers. If, in a crash, the risk for elevated BAC >0.05 was greater for dependent (OR=3.45, 95% CI 1.22-9.73), abusive (OR=13.98, 95% CI 6.01-32.51) and heavy AUD (OR=2.94, 95% CI 1.30-6.65) for night-time crashes, and for dependent AUD (OR=10.06, 95% CI 4.88-23.03) and abusive AUD (OR=10.05, 95% CI 5.20-19.42) for daytime crashes.

3.4.4 Evidence for impacts on on-road driving performance

None of the studies that met the inclusion criteria included on-road driving evaluations as an outcome measure.

3.5 CONCLUSIONS

3.5.1 Overall level of risk

Six of seven identified studies reported an increased MVC risk for drivers with AUD, with evidence of increasing risk with severity of grading of the diagnosis in one study. Interpretation is rendered challenging by the paucity and quality of studies, variety of diagnostic schedules, and reliance on historical self-reporting of MVC. Linkage of heavy and binge drinking with AUD would appear to offer an important avenue for diagnosis, treatment and follow-up.

None of the identified studies specifically reviewed the topic of AUD and level of impact on on-road driving performance.

3.5.2 Study limitations

The limitations of the systematic review arise from the small numbers of studies which met the criteria for inclusion, which contrasts with the large number of studies in the biomedical and transport literature on DUI and driving but which do not link with a diagnosis of AUD. In part this may be explained by a reluctance of healthcare professionals to engage with encounters with AUD as an opportunity for opportunistic screening and intervention (Dale et al., 1997).

In terms of the studies included, limitations included reliance on self-report of crashes in half of the studies (Hingson et al., 2017; Mann et al., 2010; Rio et al., 2001; Wieczorek, 1995), as well as variations in the classification of AUD among studies: these included AUDADIS (n=1) (Hingson et al., 2017), AUDIT (n=1) (Mann et al., 2010), AUDIT and AUDADIS (n=1) (Yao et al., 2018), ICD 10 (n=1) (Sestan et al., 2017), ICD 9 and 10 (n=1) (Callaghan et al., 2013), DSM III-R (n=1) (Wieczorek, 1995), DSM IV (n=1) (Del Rio et al., 2001), and unspecified (n=1) (Koepsell et al., 1994). In addition, some of the studies had restricted recruitment to specific populations, including older drivers (Koepsell et al., 1994), drivers referred for further assessment by a DMV (Sestan et al., 2017), crash-involved drivers (Yao et al., 2018).
3.5.3 Current fitness-to-drive guidelines

All reviewed jurisdictions emphasise the importance of abstinence or control when determining fitness-to-drive.

There are significant differences in the period of time mandated for driving cessation until abstinence or control, not stated in some (USA, New Zealand) to specific time intervals (Australia, Canada, and Ireland).

In some jurisdictions, non-adherence to substance misuse treatment is required to be reported by physicians. In addition, there is inconsistency across the guidelines reviewed in the operational definition of key terms such as remission and non-adherence.

Most jurisdictions emphasise the importance of the individual’s compliance with abstinence or control, including clinical and biological monitoring, and consideration of interlocks in some jurisdictions.

See Appendix A (Section 15.3) for licensing restrictions for non-commercial drivers with AUD in various jurisdictions.

3.5.4 Recommendations

Compared to some other medical conditions, the evidence base for advice on assessment, management and prognosis of AUD in the context of medical fitness-to-drive there were relatively few studies. It is a matter of priority that further research is undertaken linking medically diagnosed AUD with MVC risk, as well as more routine referral of those detected as driving with impairment with alcohol for diagnosis and follow-up (as occurs in Quebec) in audited studies. More formal recommendations for detection, assessment and management of binge drinking need to be developed (Turner, 2009) in terms of emphasising to practitioners of high levels of AUD associated with heavy and binge drinking as well as MVC risk (Grant et al., 2017; Valencia-Martín, Galán, & Rodríguez-Artalejo, 2008). The guidelines also depend to a significant extent on the availability and integration of treatment programmes and addiction specialists with doctors assessing medical fitness-to-drive. In the Australian context, it is likely that no immediate change, apart from highlighting physician vigilance for presence of AUD in drivers with heavy or binge drinking, will be recommended pending further research.

3.6 REFERENCES


4. INFLUENCE OF DIABETES ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of diabetes on MVC risk and on on-road driving performance. For the full systematic literature review, please refer to:


4.1 OVERVIEW AND KEY RECOMMENDATIONS

- The worldwide prevalence of diabetes in the general population is estimated at 9.3 percent for adults aged between 20 and 79 years, with a rise to 19.3 percent for those aged over 65 years. It is predicted that the prevalence will continue to increase by 50 percent over the next 20 to 25 years.
- The major concern for drivers with diabetes treated with insulin or sulphonylureas is hypoglycaemia which can cause confusion and slower reaction times and may progress to loss of consciousness leading to an increased MVC risk.
- The systematic review was registered with PROSPERO (see CRD42020158294).
- A search of public health, psychology and transport databases was conducted in November 2019.
- The quality of evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools.
- The initial literature search identified 12,596 articles, of which six met the criteria for inclusion. In terms of their quality of evidence, four studies were rated ‘good’ and two studies were rated ‘fair’.
- All of the included studies used objective methods for diagnosing diabetes and evaluating its effects on MVC risk through comparisons with a control group without diabetes or DMV statistics of the general population of drivers in the jurisdiction.
- Three of the six studies reported a small increase in MVC risk when drivers with diabetes without complications are compared to drivers without diabetes. The remaining three studies reported no difference in MVC risk.
- The small number of studies that met the inclusion criteria is a limitation of the review.
- Key recommendations:
  - There is no basis for recommending changes to current fitness-to-drive standards for diabetes beyond suggesting that the historic differentiation between drivers treated with insulin and those treated with hypoglycaemic agents may be eliminated.
  - Identifying drivers who are at risk of hypoglycaemia while driving remains a priority.
  - Further research on the effects of complications of diabetes on MVC risk, particularly the cognitive effects during periods with frequent hyperglycaemic episodes, is required.

Authors:

Jamie Dow⁷, David Carr², Judith Charlton³, Linda Hill⁴, Sjaan Koppel⁸, Roy Lilley⁵, Richard Marotolli⁶, Desmond O’Neill⁷, Mark J. Rapoport⁸, Christine Roy¹, Neil Swirsky⁹, Vincent Woo¹⁰, Emmanuelle Gagné¹, Claude Giroux¹, & Tamara Rader¹¹

Affiliations:

¹Société de l’assurance automobile du Québec, Québec City, Québec, Canada, ²Washington University in St. Louis, Missouri, United States, ³Monash University Accident Research Centre, Monash University, Victoria, Australia, ⁴University of California San Diego, California, United States, ⁵Health Sciences Complex, St-John’s, Newfoundland and
4.2 BACKGROUND

The prevalence of diabetes in the general population is about 9.3% for adults aged between 20 to 79 years with a rise to 19.3% for those aged over 65 years (International Diabetes Federation, 2019). It should be noted that the prevalence of diabetes has increased steadily in recent years and is estimated to increase 50% over the next 20 to 25 years, principally due to the increase in an aging population, obesity and sedentary lifestyles. Beyond the long-term complications of diabetes such as cardiovascular and renal disease, peripheral neuropathy, and visual complications, the major concern for drivers with diabetes on insulin or sulphonylureas is hypoglycaemia which can cause confusion and slower reaction times and may progress to loss of consciousness leading to increased MVC risk (Cox et al., 2009).

Most licensing jurisdictions throughout the world have criteria for establishing whether individuals with diabetes are fit to drive (see Appendix B, Section 16.3).

4.2.1 Scope

The overarching aim of this systematic review was to synthesise evidence on the risk of MVC for drivers with diabetes and to understand and quantify any effects of these conditions on on-road driving performance as determined by a real-world driving test or comparison to MVC statistics.

4.2.2 Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) which provides a detailed guide on the conduct and reporting requirements for systematic reviews and meta-analyses. The protocol for this systematic review was registered with PROSPERO (see CRD42020158294).

4.2.3 Definition

For the purpose of this review, MVC risk was assessed by the frequency of crashes involving motor vehicles for drivers with diabetes that resulted in property damage, or MVC-related injury or a fatality (World Health Organization, 2018), as identified by self-report or official crash records.

For the purposes of this review, on-road test outcome was assessed by the frequency of drivers with diabetes who pass or do not pass an on-road driving test administered by a driving licensing authority or an occupational therapy driving assessor.

4.3 METHOD

4.3.1 Eligibility criteria

4.3.1.1 Inclusion criteria

Studies were included in the systematic review according to the following a priori criteria:
1. Original research in a peer-reviewed journal;
2. Full-text available;
3. Published in English language and human studies;
4. Used quantitative methods for data collection and analysis, and
5. Specifically reported MVC risk and/or driving test outcome results for drivers with diabetes.

4.3.1.2 Exclusion criteria
Studies were excluded from the systematic review according to the following a priori criteria:
1. Commentary manuscripts;
2. Literature or systematic reviews;
3. Case studies;
4. Dissertations, and
5. Studies which only use qualitative methods for data collection and analysis.

4.3.2 Information Sources
An electronic search of databases from the disciplines of public health, psychology and transport safety (Ovid Cochrane Library, Ovid Medline, Ovid PsycINFO, Ovid EMBASE, CINAHL PLUS via EbcoHost, Ovid TRANSPORT and TRID: TRIS and ITRD database) was conducted on 11 November 2019 to locate studies from the first available year to 11 November 2019. In addition, a bibliographic review of included studies and a review of gold set studies was conducted to locate additional studies.

4.3.3 Search
Two concepts were derived: Concept 1A Population=Drivers; Concept 1B Population=Diabetes; Concept 2A Outcome=Crash Risk; Concept 2B Outcome=On-road Driving Test. Search terms (both indexed [e.g., Medical Subject Headings] and key words) associated with all concepts were derived independently from each author and in consultation with a subject matter expert librarian. See Appendix B (Section 16.2) for search strategy.

4.3.4 Study selection
Search results were exported into Endnote X8 software and then imported into Covidence (Cochrane technology platform). Duplicates were then removed from the total number of identified records using a standard function. For each title/abstract, two reviewers independently completed an initial screen for eligibility and a priori inclusion and exclusion criteria were applied. Any conflicts between the two reviewers were resolved by a third reviewer. The selected abstracts were then distributed to the expert panel members who submitted yes/no recommendations for retention for the full-text review. Abstracts receiving a majority of favourable votes were then distributed to the panel as full texts for review and twelve articles were selected by majority vote.

4.3.5 Data collection process
A full-text review of each included study was conducted by two reviewers and the data items were extracted by reviewers into a pretested data extraction sheet: authors; date of publication; study aim; research design; study period; study location, study population size and definition; participant demographics (i.e., age range and mean); data sources; motor vehicle crash outcome; on-road driving test type, administered by whom and outcome; main research findings, and risk of bias assessment. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer. The data extraction sheets were reviewed and finalised by the expert panel during a series of videoconferences.
4.3.6 Risk of bias

The risk of bias was assessed using the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute [NHLBI], 2014a, 2014b). The expert panel assessed all the articles selected for retention for the final review. Any conflicts between the independent reviewer and the expert panel were resolved by an independent third reviewer.

4.4 RESULTS

4.4.1 Included studies

**Figure 2: PRISMA guidance flow diagram of identification, screening, and inclusion of eligible studies for Diabetes**

The combined searches identified 12,596 studies of which 12,564 were identified through the initial database search and an additional two from a bibliographic review of the included studies. 3,398 duplicates were removed via the software algorithm. Following title and abstract screening, 22 studies were identified for full-text review, of which 16 studies were excluded. Reasons for exclusion are noted in Figure 2. Altogether, six studies met the inclusion criteria and were assessed.
4.4.2 Study descriptions

Included studies were conducted between 1961 and 2019. Of the six studies, most were cohort studies (n=2 case-control studies; n=4 cohort studies). Study sample sizes ranged from 33-406,364 participants. The sample size of participants with diabetes ranged from 14 to 71,412. The mean age of participants across studies was 52.3 years (Range of mean=32.5-60.4 years) among those with diabetes, and 45.7 years among comparison populations (Range of mean=32.3-59.5 years). Gender distribution was reported in the majority of the studies, with an average of 68.1% males among the diabetes populations and 54.0% males among the comparison populations. Three studies were conducted in the United States, two were conducted in Canada and one in Norway.

4.4.3 Evidence for risk of MVCs

4.4.3.1 Studies reporting evidence of increased risk (N=3)

Cross-sectional/Cohort

Good quality:
- Skurtveit et al. (2009) observed an increased MVC risk (Standardised incidence ration [SIR]=1.40, 95% CI 1.20-1.60) for drivers using insulin but a control group using peptic ulcer and gastroesophageal drugs had a similar MVC risk (SIR=1.30, 95% CI 1.20-1.40) when compared to national crash statistics. Those using oral hypoglycemic medication had a MVC risk of SIR=1.2 (95% CI 1.00-1.30). Data for this study covered the period 2004-2006.
- Hansotia and Broste (1991) observed a higher MVC risk of Standardised mishap ratio=1.32 (95% CI 1.06-1.63) for drivers with diabetes in the period 1985-1988 when compared to drivers without diabetes.

Fair quality:
- Crancer and McMurray (1968) observed an increase of 13% in MVC risk for drivers with diabetes compared to the general population although the study did not distinguish between drivers using different drug therapies.

4.4.3.2 Studies reporting evidence of decreased risk (N=0)

4.4.3.3 Studies reporting evidence no difference in risk (N=3)

Case-control

Good quality:
- Dow, Gaudet and Turmel (2013) reported a non-significant difference in MVC risk (OR=1.03, 95% CI 0.97-1.10) with data from 2003-2006 when compared to drivers without diabetes.
- McGwin, Sims, Pulley, and Roseman (1999) concluded that there was no evidence of increased MVC risk using DPS crash data for a large group of drivers in Alabama. The ORs for diabetes were 0.80 (95% CI 0.50-1.40) and 1.00 (95% CI 0.60-1.50) when compared to not-at-fault and non-MVC-involved control groups, respectively.

Cross-sectional/Cohort

Fair quality:
- Laberge-Nadeau et al. (2000), using data from 1987-1990, identified a relative risk of MVC of 1.76 (95% CI 1.06-2.91) for professional drivers with complications (i.e., comorbidities) from diabetes but those without complications did not have increased MVC risk (RR=0.96, 95% CI 0.48-1.91).

4.4.4 Evidence for impacts on on-road driving performance

None of the studies that met the inclusion criteria included on-road driving evaluations as an outcome measure.
4.5 CONCLUSIONS

4.5.1 Overall level of risk

Six studies were reviewed of which four were rated as ‘good’ and two were ‘fair’. Three of the six studies reported a small increase in MVC risk for drivers with diabetes, while the studies that evaluated driving performance concluded that active hypoglycaemia results in impaired driving performance without evaluating the effect upon MVC risk.

The included studies all compared the cohort of affected drivers to the general population of drivers in their jurisdiction. The statistical analysis was robust in all the studies, permitting valid comparisons between the MVC risk of the group or groups being studied and the road safety statistics for the jurisdiction.

None of the studies that met the inclusion criteria included on-road driving evaluations as an outcome measure.

4.5.2 Study limitations

The small number of studies that met the inclusion criteria is a limitation.

4.5.3 Current fitness-to-drive guidelines

As shown in Appendix B (Section 16.3), the fitness-to-drive guidelines in Australia, New Zealand, the United States, and the European Union all have standards for drivers with diabetes that seek to distinguish between drivers with well-controlled diabetes and those whose control is unstable. The aim of these standards is to identify drivers who may be susceptible to hypoglycaemia and restricting their exposure by either suspending their licence or by imposing conditions that limit their driving activities.

Traditionally DMVs had different standards for drivers with diabetes who were treated with insulin and those who used other therapeutic regimens since people with diabetes treated with insulin are considered to be more susceptible to hypoglycaemic episodes. In recent years there is a movement to consolidate these standards as the MVC risk for drivers whose diabetes is treated with insulin has decreased. However, we acknowledge there are very few high-quality studies in the literature.

The introduction of self-monitoring glucose devices revolutionised the management of diabetes and has led to improved control. Newer types of insulin with lower rates of hypoglycaemia, insulin pumps, and improvements in insulin delivery have lowered the risks associated with the older insulin products. As well, improved understanding of the principles of treatment and management by the newer drugs for type 2 diabetes with very low rates of hypoglycaemia have all contributed to the lesser use of insulin and sulphonylureas in a person with type 2 diabetes.

We did not find any studies examining the effects of the new categories of drugs available for treating diabetes or the new methods that can monitor blood glucose levels constantly using, for instance, a smartphone app although these have resulted in less individuals with type 2 diabetes going on insulin. Newer glucose measuring devices offer continuous or near continuous glucose monitoring and alarm with impending hypoglycaemia. There are no current studies evaluating their effects on crash rates due to hypoglycaemia.

A major concern to driving for a driver with diabetes on insulin is hypoglycaemic unawareness: the incapacity for a person with diabetes to recognise an impending hypoglycaemic episode or an onset of an episode that evolves too rapidly for the person affected to react and take remedial action to avoid the episode. All standards reviewed cover this eventuality.

All the reviewed standards also proscribe driving for a period, usually three to six months, after a severe hypoglycaemic episode (defined as an episode requiring third-party intervention due to the incapacity of the person with diabetes to take the appropriate action
themself) requiring an adjustment or a revaluation of the therapeutic regimen. The prescribed period may be reduced upon the recommendation of the treating physician.

All the jurisdictions included in the sample of medical standards for drivers with diabetes have similar standards. All differentiate between diabetes treated with insulin and diabetes treated with other drug regimens. This merits reconsideration in the light of this review.

4.5.4 Recommendations

Three of the six studies in this review reported a small increase in MVC risk when drivers with diabetes without complications are compared to drivers without diabetes. The remaining three studies reported no difference in MVC risk.

There is no basis for recommending major changes to the current medical standards for drivers with diabetes beyond noting that the traditional discrimination between drivers with diabetes using insulin and those using other therapeutic regimens merits re-examination since both groups now demonstrate similar MVC risks of an MVC.

Identifying drivers susceptible to experiencing hypoglycaemia at the wheel must continue to be a priority and hypoglycaemic unawareness must continue to be a contraindication to the maintenance of driving privileges unless an exception is supported by the treating physician. The importance of educating drivers with diabetes to react appropriately to signs of impending hypoglycaemia cannot be overemphasised.

However, the evaluation of a driver with diabetes must always include the evaluation of the effects of diabetic complications and concomitant conditions that may affect fitness-to-drive.

4.6 REFERENCES


5. INFLUENCE OF EPILEPSY AND/OR SEIZURE DISORDERS ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of epilepsy and/or seizure disorders on MVC risk and on on-road driving performance. For the full systematic literature review, please refer to:


5.1 OVERVIEW AND KEY RECOMMENDATIONS

- The World Health Organization (2019) estimates that the prevalence of epilepsy is approximately 50 million worldwide.
- The systematic review was registered with PROSPERO (see CRD42019129664).
- A search of public health, psychology and transport databases was conducted in August 2019.
- The quality of evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools.
- An initial search identified 3,349 studies, with a further 11 studies identified through goldset study and bibliographic review.
- Twenty-three studies published between 1961 and 2017 met the inclusion criteria (n=8 case-control; n=15 cohort/cross-sectional; n=1 before-after).
- In terms of their quality of evidence, 18 studies were rated ‘good’ or ‘fair’.
- Eleven studies specifically investigated MVC risk, with five reporting evidence for increased risk, three reporting evidence for similar risk relative to controls, and three reporting inconclusive evidence. One quarter of the identified studies used self-reported MVCs as their outcome measure.
- Seven studies investigated either: MVC severity and responsibility, antiepileptic medication, impact of different seizure-free intervals, and influence of auras in drivers with epilepsy.
- No studies investigated the impact of epilepsy on on-road driving performance.
- Overall, while findings were mixed, the weight of evidence pointed to a slight increase in MVC risk for drivers with epilepsy. However, the generalisability of these findings is limited as the identified studies were conducted: across a wide period, in numerous licensing jurisdictions with different requirements, and across a diverse range of participant populations.
- Key recommendations:
  - Available evidence aligns with current fitness-to-drive guidelines for eligibility for a conditional licence for drivers with epilepsy. Specifically, the evidence on MVC risk, as well as seizure-free intervals and antiepileptic medication compliance, supports the international guidelines; including recommendation by specialists for eligibility for a conditional licence for those with a six-month or three-month seizure-free interval.
  - Further research should include objective measures of epilepsy and MVC risk, as well as measurement of confounding factors including driving exposure, antiepileptic medication use/compliance, comorbidities and disorder severity.
  - Development of consensus based medical and licensing standards taking these findings into account and encouraging case by case application should be considered.
  - A large-scale, population-based study, necessarily in multiple licensing jurisdictions so as to achieve adequate sample sizes, with well-defined licensing and fitness-to-drive requirements, is warranted to rigorously investigate the MVC risk associated with medically diagnosed epilepsy.
Authors:
Sjaan Koppel¹, Marilyn Di Stefano², Bleydy Dimech-Betancourt¹, Mohammed Aburumman¹, Rachel Osborne¹, Sujanie Peiris¹, Gabrielle Williams¹, Aaron McInnes¹, Amanda Stephens¹, Morris Odell², Peteris Darzins⁴,³, Patrick Carney⁵, Mark Cook⁶, Sam Berkovic⁷, Mark J. Rapoport⁸, Jamie Dow⁹, Desmond O'Neill¹⁰, & Judith L. Charlton¹

Affiliations:
¹Monash University Accident Research Centre, Monash University, Victoria, Australia, ²Road Safety Victoria, Department of Transport, Victoria, Australia, ³Monash University, Victoria, Australia, ⁴Monash University Eastern Health Clinical School, Victoria, Australia, ⁵Eastern Health, Victoria, Australia, ⁶Departments of Medicine and Neurology, University of Melbourne, St. Vincent's Hospital, Victoria, Australia, ⁷Epilepsy Research Centre, University of Melbourne (Austin Health), Victoria, Australia, ⁸Sunnybrook Hospital, Toronto, Ontario, Canada, ⁹Société de l’assurance automobile du Québec, Québec City, Québec, Canada, ¹⁰National Office for Traffic Medicine, Royal College of Physicians of Ireland, Dublin, Ireland.

Sponsoring organisation:
This project was funded by Road Safety Victoria, Department of Transport/VicRoads, Victoria.

Keywords:
Epilepsy; Seizure disorder; Motor vehicle crashes; Fitness-to-drive; Road safety

5.2 BACKGROUND
The issue of MVC risk associated with epilepsy is of considerable interest for medical and licensing authority fitness-to-drive decision-making. Seizures are defined by the transient occurrence of "symptoms or signs" commonly including loss of awareness and motor behaviours (Fisher et al., 2017). Operating a vehicle requires constant awareness to process sensory information, judgment and motor skill execution to generate appropriate and timely responses (Groeger, 2000). These abilities can be severely compromised in the moments leading up to, during, and after a seizure (Chen et al., 2014). Even in cases of seizures with subtle changes in awareness, individuals’ cognitive or motor skills can be impaired, which may affect their ability to drive safely. Furthermore, antiepileptic medicine use may impair driving due to their side effects, including impairment of concentration, fatigue and drowsiness (Drazkowski, 2007). It is noteworthy that the criteria for establishing whether individuals with epilepsy are fit to drive differ considerably across licensing jurisdictions (see Appendix C, Section 17.3).

5.2.1 Scope
This study aimed to establish the motor vehicle MVC risk for drivers with epilepsy and quantify any impacts on on-road driving performance.

5.2.2 Protocol and registration
This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) which provides a detailed guide on the conduct and reporting requirements for systematic reviews and meta-analyses. The protocol for this systematic review was registered with PROSPERO (see CRD42019129664).

5.2.3 Definition
For the purpose of this review, MVC risk was assessed by the frequency of crashes involving drivers with epilepsy and/or seizures that resulted in property damage, or MVC-related injury or death (World Health Organization, 2018), as identified by self-report or official MVC records.
On-road driving performance was defined as the frequency of drivers with epilepsy and/or seizure disorders who pass or do not pass an on-road driving test administered by driver licensing authorities or by occupational therapy driving assessors.

5.3 METHOD

5.3.1 Eligibility criteria

5.3.1.1 Inclusion criteria

Studies were included in the systematic review according to the following a priori criteria:

1. Original research published in peer-review journal;
2. Full-text available;
3. English language and human studies;
4. Studies including drivers with epilepsy and/or seizures and MVC risk, and/or on-road driving test outcome, and
5. Studies which use quantitative methods for data collection and analysis.

5.3.1.2 Exclusion criteria

Studies were excluded from the systematic review according to the following a priori criteria:

1. Commentary manuscripts;
2. Literature or systematic reviews;
3. Case studies;
4. Dissertations, and
5. Studies which use qualitative methods for data collection and analysis.

5.3.2 Information sources

Relevant studies were identified before the development of a search strategy and search terms, and were defined as ‘goldset studies’. These studies were identified by leading researchers in the field of epilepsy and/or seizure disorders, MVC, on-road driving performance, and road safety. An electronic search of databases from the disciplines of public health, psychology and transport safety (Ovid Cochrane Library, Ovid Medline, Ovid PsycINFO, Ovid EMBASE, CINAHL PLUS via EbscoHost, Ovid TRANSPORT and TRID: TRIS and ITRD database) was conducted on August 22nd 2019 to locate studies from the first available year to August 22nd 2019 (i.e., no date limit was applied).

5.3.3 Search

Two concepts were derived: Concept 1A Population=Drivers; Concept 1B Population=Epilepsy; Concept 2A Outcome=Crash Risk; Concept 2B Outcome=On-road Driving Test. Search terms (both indexed [e.g., Medical Subject Headings] and key words) associated with all concepts were derived independently from each author and in consultation with a subject matter expert librarian. See Appendix C (Section 17.2) for the search strategy.

5.3.4 Study selection

Search results were exported into Endnote X8 software and imported into Covidence (Cochrane technology platform). Duplicates were removed from the total number of identified records using a standard function. For each title/abstract, two reviewers independently completed an initial screen for eligibility and a priori inclusion and exclusion criteria were applied. Any conflicts between the two reviewers were resolved by a third reviewer. Following title and abstract screening, two reviewers independently applied the inclusion and exclusion criteria to each full-text. Any conflicts between the two reviewers...
were resolved by a third reviewer. A bibliographic review of included studies, as well as a review of goldset studies, was conducted to identify additional relevant studies.

5.3.5 Data collection process

Data extraction for each included study was conducted by two reviewers and the following information was extracted into a pretested data extraction sheet: authors; date of publication; study aim; research design; study period; study location, study population definition; participant demographics (i.e., age range and mean); data sources; MVC outcome; on-road driving test outcome; main research findings, and risk of bias assessment. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.

5.3.6 Risk of bias

The risk of bias for each included study was assessed independently by two reviewers using the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute, 2014a, 2014b, 2014c). Each reviewer assessed each study (based on 12 criteria for case-control or before-after studies, or 14 criteria for observational cohort and cross-sectional studies) for: risk of potential for selection bias, information bias, measurement bias or confounding factors. Based on this assessment, the reviewers independently provided an overall quality rating (‘good’, ‘fair’ or ‘poor’), where the greater the risk of bias, the lower the quality rating of the study. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.

5.4 RESULTS

5.4.1 Included studies

![Figure 3: PRISMA guidance flow diagram of identification, screening, and inclusion of eligible studies for Epilepsy and Seizure disorders](image)

The combined searches identified 3,360 studies (of which 3,349 were identified through the initial database search and an additional 11 from a bibliographic review of the included studies identified), and 1,045 duplicates were removed via the software algorithm. Following
title and abstract screening, 293 studies were identified for full-text review, of which 270 studies were excluded for the following reasons: 91 studies were not a primary study (reports, dissertations, commentaries) or did not contain original quantitative data; 79 studies were not available in English language; 48 studies were duplicates; 44 studies did not have outcomes that included: a) MVC risk, or b) on-road driving test outcome; seven studies did not include drivers with epilepsy and/or seizure disorders, and one study did not have a full-text available. Reasons for exclusion are noted in Figure 3. Altogether, 23 studies met the inclusion criteria and were assessed.

5.4.2 Study descriptions

Included studies were published between 1961 and 2017, with only five published in the last decade. Of the 23 studies, most were cross-sectional/cohoot studies (n=8 case-control studies; n=4 cross-sectional studies; n=10 cohort studies; n=1 before-after study).

Study sample sizes (among the 22 studies that reported sample size) for drivers with epilepsy ranged from 50 to 34,896. The mean age of drivers was reported in nine studies; The mean age of drivers with epilepsy across studies was 42.2 years (Range of mean=37.4–55.8 years) and was 41.6 years for comparison populations (Range of mean=37.0–48.6 years). The gender distribution was reported in 18 studies. The average proportion of male drivers with epilepsy was 64.1 and the average proportion of male drivers in the comparison groups was 53.0. Most studies were conducted in the United States of America (n=10). Two studies reported inclusion of drivers with commercial as well as private driver licences, however neither of these studies provided separate results for these different licence groups. Motor vehicle crashes were ascertained via various data sources (official records: n=13 studies; self-report, interviews or questionnaires: n=6, and medical records: n=4). Several studies provided insights on one or more specific factors including: crash responsibility (n=3), antiepileptic medicine (n=5), seizure-free intervals (n=3), and/or auras (n=3).

No studies were located which investigated any effects of epilepsy/seizures, or related treatments, on on-road driving performance.

5.4.3 Evidence for risk of MVCs

Of the 23 studies, 16 studies specifically investigated MVC risk for drivers with epilepsy. The remaining seven studies reported on evidence related to MVC responsibility, the effects of antiepileptic drugs (AED), the impact of different seizure-free intervals, and the influence of auras in drivers with epilepsy rather than the risk of the MVC per se.

In terms of the quality of evidence, 11 studies were rated ‘good’, seven studies were rated ‘fair’, and five studies rated ‘poor’ (see section 3.3.1). Studies with a ‘poor’ rating did not contribute to the overall conclusions regarding the MVC risk associated with epilepsy.

5.4.3.1 Studies reporting evidence of increased risk (N=5)

Case-Control

Good quality:

- Vernon et al. (2002) reported that both drivers with epilepsy with restricted- and with unrestricted-licence11 had significantly higher MVC rates (per 10,000 licence days) compared to matched controls (drivers with restricted licences: 2.67 vs. 1.81; Relative Risk [RR]=1.47, 95% CI 1.06-2.03; drivers with unrestricted licences: 2.69 vs. 1.55, RR=1.73, 95% CI 1.58-1.90). Similar findings were reported for at-fault MVC rates compared to matched controls, for both restricted- and unrestricted-licence groups.

Fair quality:

---

11 Restrictions broadly include various levels of driving limitations such as restrictions to area, time of day, and speed of driving; use of assistive aids; periodic reviews/shorter renewal periods; or denial/exclusion from driver’s licence.
Taylor et al. (1996) reported that, once adjusted for age, gender, and driving exposure, drivers with a history of single seizures or epilepsy had a significantly increased risk of MVC-related serious injury compared to drivers without epilepsy (OR=1.33, 95% CI 1.01-1.76), however no differences were found across other MVC severity types.

**Poor quality:**

Hormia (1961) reported drivers with epilepsy were significantly more likely to be involved in an MVC (42.1%) compared to drivers without epilepsy (30.6%; x/σ=2.05, p<0.05).

**Cross-sectional/Cohort**

**Good quality:**

Hansotia and Broste (1991) reported that drivers with epilepsy had a significantly higher overall MVC rate (Standardised Mishap Ratio [SMR]=1.33, 95% CI 1.00-1.73, p<0.05), and a significantly higher rate of MVC-related injuries (SMR=1.63, 95% CI 0.95-2.60, p<0.05), compared to the general driving population.

Lings (2001) reported that drivers with epilepsy were seven times more likely to be involved in an MVC (OR=7.01, 95% CI 2.18-26.13) compared to drivers without epilepsy.

**Fair quality:**

Popkin and Stewart (1992) reported drivers with seizures/narcolepsy had a significantly higher MVC rate compared to the general driving population (t=2.60, p<0.01). There was no significant difference in the MVC rates for drivers with seizures/narcolepsy across those with a restricted licence and those with an unrestricted licence.

**Poor quality:**

Crancer and McMurray (1968) reported that drivers with epilepsy with a restricted licence had a significantly higher MVC rate (41.4/100 drivers) compared to the general driving population (31.1/100 drivers, p<0.05).

5.4.3.2 Studies reporting evidence of decreased risk (N=0)

5.4.3.3 Studies reporting evidence for no difference in risk (N=3)

**Case-Control:**

**Fair quality:**

McLachlan et al. (2007) reported that lifetime and one-year MVC rates for drivers with epilepsy were not significantly different compared to drivers without epilepsy (respectively, RR=1.00, 95% CI 0.95-1.06; RR=0.99, 95% CI 0.82-1.19).

**Cross-Sectional/Cohort:**

**Good quality:**

Kwon et al. (2011) reported that, once important medical and psychiatric comorbidities were adjusted for, drivers with epilepsy were not more likely to be involved in an MVC compared to the general population, (OR=1.62, 95% CI 0.95-2.76).

---

12 Restrictions broadly include various levels of driving limitations such as restrictions to area, time of day, and speed of driving; use of assistive aids; periodic reviews/shorter renewal periods; or denial/exclusion from driver’s licence.

13 Restrictions broadly include various levels of driving limitations such as restrictions to area, time of day, and speed of driving; use of assistive aids; periodic reviews/shorter renewal periods; or denial/exclusion from driver’s licence.
• Taylor et al. (1995) reported that MVC rates for drivers with epilepsy were not significantly different compared to the general population ($\chi^2=2.6$, df=2, p>0.10).

**Poor quality:**
- Bener et al. (1996) reported that ‘property damage’ MVCs for drivers with epilepsy were not significantly different compared to drivers without epilepsy (RR=1.85, 95% CI 0.64-5.14).

5.4.3.4 Studies reporting inconclusive evidence (N=4)

**Cross-Sectional/Cohort:**

**Good quality:**
- Sillanpää and Shinnar (2005) reported no MVCs across a 12-month period for both drivers with epilepsy and a control group.

**Fair quality:**
- Beaussart et al. (1997) reported that, compared with the general driving population, drivers with epilepsy were more likely to be involved in an MVC (epilepsy: 23.4% vs. general driving population: 10.6%), but less likely to be involved in an MVC that resulted in serious injury (epilepsy: 0.6% vs. general driving population: 3.3%). There was no difference across the two groups in terms of MVCs that resulted in a death (epilepsy: 0.4% vs. general driving population: 0.5%). However, no tests of statistical analyses were reported.
- Davis and Wehling (1972) reported that drivers with epilepsy had a higher MVC rate (18.2/100) compared to the general driving population (7.1/100). However, no statistical analyses were reported.

**Poor quality:**
- Sheth et al. (2004) reported that the rates for fatal MVCs for drivers with epilepsy (8.6/100,000 population) was 2.6 times lower than rate for the general driving population. However, no statistical analyses were reported.

5.4.4 Other relevant risk factors

5.4.4.1 Risk of MVC-related serious injury (N=3)

**Cross-Sectional/Cohort:**

**Good quality:**
- van der Lugt (1975) reported a significantly lower proportion of seizure-related MVCs resulted in serious injury compared with ‘average’ MVCs for Dutch drivers (1.9% vs. 7.8%, respectively; $\chi^2=24.47$, df=3, p<0.001).
- Lings (2001) reported that drivers with epilepsy had significantly higher rates of MVCs that resulted in treatment in the emergency department (9.4/1000 person-years) compared to matched controls (1.3/1,000 person-years; OR=7.01, 95% CI 2.18-26.13, p<0.01).

**Fair quality:**
- Taylor et al. (1996), also reported above, reported that drivers with a history of single seizures or epilepsy had a significantly increased risk of MVC-related serious injury compared to drivers without epilepsy (adjusted OR=1.33, 95% CI 1.01-1.76; p=NR).

5.4.4.2 Risk of MVC responsibility (N=4)

**Case-Control:**

**Good quality:**
- Sestan et al. (2017) reported that drivers with epilepsy were twice as likely to have
been involved in at-fault MVCs compared to matched controls (OR=1.99, 95% CI 1.01–3.92).

- Orriols et al. (2014) reported that drivers with severe epilepsy had an increased risk of being responsible for an MVC compared to controls (OR=2.53, 95% CI 1.53-4.20).
- Orriols et al. (2013) reported that drivers with epilepsy who were prescribed AEDs had an increased risk of being responsible for an MVC (OR=1.74, 95% CI 1.29-2.34) compared to those not exposed to AEDs. Higher odds were reported for drivers with severe epilepsy and prescribed AEDs (ICD-10: long term) (OR=2.20, 95% CI 1.31-3.69).
- Vernon et al. (2002) reported that drivers with epilepsy had an increased risk of at-fault MVCs compared to matched controls, including both restricted-14 (OR=2.39, 95% CI 1.70-3.36, p<0.05) and unrestricted-licence groups (OR=2.02, 95% CI 1.80-2.27, p<0.05).

5.4.4.3 MVC risk associated with seizure-free intervals (SFI) (N=3)

Case-Control:

Fair quality:

- Krauss et al. (1999) reported that drivers with at least a 12-month SFI were significantly less likely to be involved in an MVC compared to drivers with shorter SFIs (OR=0.08, 95% CI 0.01-0.47). In addition, drivers with at least a six-month SFI were significantly less likely to be involved in an MVC compared to drivers with shorter SFIs (OR=0.15, 95% CI 0.03-0.69).

Cross-Sectional/Cohort:

Fair quality:

- Taylor et al. (1996) reported that drivers with SFIs of 3 years or more were significantly less likely to be involved in: all MVC types (OR=0.74, 95% CI 0.62-0.87), MVCs that resulted in injuries (OR=0.66, 95% CI 0.46-0.93), and MVCs that resulted in serious injuries (OR=0.56, 95% CI 0.32-0.96).

Retrospective before and after:

Good quality:

- Drazkowski et al. (2003) reported that the risk of seizure-related MVCs did not increase after state-wide legislation reduced SFIs from 12 to three months (Incidence rate difference: -0.03/109 miles, 95% CI -0.30-0.24; RR=0.98, 95% CI 0.77-1.24).

5.4.4.4 MVC risk associated with AED therapy (N=5)

Case-Control:

Good quality:

- Orriols et al. (2013) reported that drivers with epilepsy who were prescribed AEDs were significantly more likely to be responsible for an MVC compared to those not taking prescription medications (OR=1.74, 95% CI 1.29-2.34). Evidence also suggested that the risk is linked to seizures and not medicines: odds ratios observed in drivers with severe epilepsy who were not exposed to AEDs on the day of the MVC (OR=2.91, 95% CI 1.25-6.77), were similar to odds for exposed drivers (OR=2.02, 95% CI 1.01-4.04).

Fair quality:

---

14 Restrictions broadly include various levels of driving limitations such as restrictions to area, time of day, and speed of driving; use of assistive aids; periodic reviews/shorter renewal periods; or denial/exclusion from driver’s licence.
• Krauss et al. (1999) reported significantly reduced likelihood of MVC involvement associated with AED therapy modifications, including drivers whose medications were reduced, stopped or switched by their physician (OR=0.11, 95% CI NR).

Cross-Sectional/Cohort:  
**Fair quality:**

• Faught et al. (2008) reported that for drivers with epilepsy, after adjusting for age, sex and comorbidities, periods of AED non-adherence were associated with significantly higher MVC-related injuries (IRR=2.08, 95% CI 1.81-2.39) relative to periods of AED adherence.

• Taylor et al. (1996) reported that likelihood of MVC involvement (across all MVC severity types) was significantly higher for drivers with epilepsy who were using AEDs compared to those not using AEDs (OR=1.10, 95% CI 1.01-1.20). However, when considering MVCs with any injury or serious injury, there were no significant association with AEDs (MVC with any injury: OR=0.75, 95% CI 0.54-1.04; MVC with serious injury: OR=0.75, 95% CI 0.54-1.04).

5.4.4.5 MVC risk associated with reliable auras (N=3)  
**Case-Control:**  
**Fair quality:**

• Krauss et al. (1999) reported that having reliable auras (i.e., where drivers reported always having auras at the start of seizures) was one of the significant factors associated with reduced likelihood of being involved in a seizure-related MVC (OR=0.08, 95% CI NR).

**Poor quality:**

• Punia et al. (2015) reported that the presence of an aura was not significantly different across those who were involved in an MVC compared to those that were not involved in an MVC (OR=0.89, 95% CI 0.49–1.61, p=0.76).

Cross-Sectional/Cohort:  
**Fair quality:**

• Taylor et al. (1996) reported non-significant findings for the association between auras and involvement in all MVC types (OR=1.08, 95% CI 0.99-1.17) and for MVCs that resulted in injuries (OR=1.16, 95% CI 0.95-1.41).

5.4.5 Evidence for impacts on on-road driving performance  
None of the studies that met the inclusion criteria included on-road driving evaluations as an outcome measure.

5.5 CONCLUSIONS  
5.5.1 Overall level of risk  
Twenty-three studies were identified, with the majority being retrospective cohort and case-control studies. Of the studies that provided direct evidence on the MVC risk associated with epilepsy, 11 were rated ‘good’ (n=6) or ‘fair’ (n=5) in terms of the quality of their evidence. The remaining studies provided supplementary evidence on the risk of crash-related serious injuries, at-fault MVCs, or the role of AEDs, SFIs or auras. No studies included on-road driving evaluations as an outcome measure.

Of the six studies addressing MVC risk that were rated ‘good’ quality, three reported an increased MVC risk: two indicating 30-70 percent higher than general population risk (Hansotia & Broste, 1991; Vernon et al., 2002), and one reporting a seven times higher risk compared with matched controls, albeit with a small sample and a wide confidence interval (Lings, 2001). Two studies reported no difference compared to the general population.
Of the five studies rated ‘fair’ quality, two reported significantly increased MVC risk: one reporting an approximately 45 percent higher MVC rate compared with the general driving population (0.092 vs 0.063) (Popkin & Stewart, 1992), while the other reported a 30 percent higher risk for MVCs that resulted in serious injury only (Taylor et al., 1996). One study reported no significant differences (McLachlan et al., 2007) and two studies were inconclusive with only descriptive results presented (Beaussart et al., 1997; Davis & Wehling, 1972).

Evidence relating to other relevant MVC factors was also considered. One study, rated ‘fair’ quality, reported that seizure-related MVCs were more likely to result in serious injuries compared with the ‘average’ MVC derived from the general driving population (van der Lugt, 1975).

Three studies provided evidence on length of SFI and MVC risk. At a population level, Drazkowski et al. (2003) provided ‘good’ evidence that there is no deleterious effect on safety when SFI requirements are reduced from 12 months to three months; however, at an individual level, there was ‘fair’ evidence from two studies reporting lower risks with longer duration SFI, albeit with different SFIs studied (Krauss et al., 1999; Taylor et al., 1996).

Five studies, with ‘good’ or ‘fair’ evidence, provided evidence on the role of AEDs and MVC risk. Findings were mixed, although the studies addressed a range of different questions relating to medication use. One study rated ‘fair’ quality (Taylor, et al., 1996), reported a significant influence on MVC risk of taking AEDs compared with no AED medication. Another study reported ‘good’ evidence that drivers with epilepsy who were exposed to AEDs were significantly more likely to be responsible for their MVC compared to those who were not exposed to AEDs (Orriols et al., 2013). On the important question of adherence to medication, the evidence suggests that non-compliance may pose a threat to safety. One study reported ‘fair’ evidence that non-adherent drivers with epilepsy have a two-times higher risk compared to adherent drivers (Faught et al., 2008). Also relevant to medication regimes, ‘fair’ evidence reported a decreased likelihood of MVC involvement associated with prescribed changes in medications (Krauss et al., 1999). This could be attributed to closer monitoring and/or more cautious driving as drivers self-regulate when treatments are changed.

This review revealed inconsistent findings on the association between MVC involvement and auras. Two studies rated ‘fair’ in terms of their quality of evidence were identified; one reporting a significantly lower likelihood of MVC involvement associated with auras (Krauss et al., 1999), the other reporting no relationship between auras and MVC involvement, and this effect held across all MVC severities (Taylor et al., 1996). Given the mixed findings, the small sample sizes and the potential self-report biases inherent in both studies, it is difficult to draw reliable conclusions about MVC risk associated with auras.

5.5.2 Study limitations

The main limitation of this systematic review is the paucity of data. Despite studies being conducted across several decades, there are still few studies of ‘good’ quality. Moreover, there were no studies identified that explored on-road performance of drivers with epilepsy. Due to a lack of consistent diagnosis of epilepsy groups (e.g., inclusion of other disorders of loss of consciousness, varied disease severity), several studies may not be entirely generalisable to the entire epilepsy population. Furthermore, there were studies that only sampled drivers that sought medical attention or were hospitalised following MVCs, which fails to account for all MVCs or minor ones.

From the evidence, there is little to glean in terms of epilepsy types, seizure burden and/or
time since diagnosis, and their association with MVCs. One quarter of the identified studies used self-reported MVCs as their outcome measure. However, self-reported data may be biased due to recall bias or a deliberate concealment of the true nature of one’s condition or MVC history due to a fear of loss of licence. Several studies did not adequately control driving exposure (at least n=10), medication use and/or compliance (at least n=7), and other comorbidities (at least n=9). We cannot discount the possibility that these factors may contribute to driving impairment in drivers with epilepsy and/or seizure disorders. Three studies also had short periods of observation (i.e., 12 months) which may not adequately sample the occurrence of MVCs within the cohorts studied. Lack of clarity surrounding mandatory periods of non-driving post-epilepsy event/seizure or self-regulation of driving may also impact upon exposure and complicates assessment of MVC risk. Moreover, several studies are over 20 years old (n=11), which may mean changes in the way epilepsy is treated and managed, and may not apply in the present-day era. Four studies failed to provide any information about statistical tests and there was inconsistent use of risk analyses across studies (e.g., relative risk, hazard ratio, odds ratio and standardised mishap ratios). This has precluded meta-analysis of results from included studies.

5.5.3 Current fitness-to-drive guidelines

As summarised in Appendix C (Section 17.3), all reviewed licensing restrictions / considerations for private licences specified that a diagnosis of epilepsy should be taken into account when determining a driver’s fitness-to-drive. The weight of evidence within this review suggests a significantly higher risk, albeit with the majority of studies indicating slight elevation. Further, all jurisdictions emphasised the importance of SFIs when determining fitness-to-drive (Australia, NZ, UK, and EU all specify 12 months SFI; Canada and USA specify six months). This is consistent with the reviewed literature that suggests that one of the most useful and practical predictors of safe driving is the interval of time since the previous seizure (see Krauss et al., 1999; Taylor et al., 1996). Interestingly, the guidelines for New Zealand, Canada and the United States indicated reduced SFIs (<12 months) were permissible upon recommendation by a treating specialist. The albeit limited evidence on SFIs (n=3 studies) suggests that, at least at a population level, there is no deleterious effect on safety for reducing minimum SFI that prevent driving from 12 months to three months. However, at an individual level, reduced risks were evident with reduced SFI, albeit with different seizure-free periods studied.

Most jurisdictions also emphasise the importance of the individuals’ medication compliance. For example, the driver should be considered conscientious and reliable with respect to adherence to the prescribed medication. On the issue of compliance, the evidence within our review was clear that non-adherence is a threat to safety, with evidence from one study of a two-fold increase in MVC risk.

While there were no studies in the current review that reported specifically on commercial licences and drivers with epilepsy, some evidence was provided that may have relevance to fitness-to-drive decisions for commercial licensing, which are much more stringent compared on private licences (e.g., seizure free for five to 10 years). For example, where guidelines indicate that authorities or clinicians may take into account individual circumstances (e.g., NZ, EU and Canadian guidelines refer to discretion by licensing authorities), evidence on SFIs and AEDs derived from private motor vehicle drivers may be informative.

5.5.4 Recommendations

On the primary question of MVC risk associated with epilepsy and/or seizure disorders, the available evidence is mixed and not of high quality. Based on these findings, a large-scale population-based controlled study in multiple licensing jurisdictions so as to achieve adequate sample sizes of MVC risk and epilepsy is warranted. Notwithstanding study limitations, there is some evidence for a low to moderate elevation of risk associated with epilepsy, and heightened risk with AED non-compliance which justifies the presence of guidelines regarding restrictions of driving in those with epilepsy. Some evidence was found
for reduced risk with longer seizure free periods; however evidence from one strong study showed that lowering the seizure-free requirement from 12 months to three months did not significantly affect MVC rates (Drazkowski et al., 2003).

While there were no studies in the current review that reported specifically on commercial licences and drivers with epilepsy, where guidelines indicate that authorities or clinicians may take into account individual circumstances (e.g., NZ, EU and Canadian guidelines refer to discretion by licensing authorities), evidence on SFIs and AEDs derived from private motor vehicle drivers may be informative. Furthermore, consideration of individual driver comorbidities and driver insight, such as are relevant to drivers experiencing seizures associated with traumatic or acquired brain injury and neurological diseases (like multiple sclerosis, parkinsons) are very important.

In the absence of a body of homogeneous rigorous peer-reviewed scientific research, medical peak bodies and disability advocacy groups together with driver licensing authorities are required to explore other data and methods of establishing clearly articulated medical standards and licensing provisions. These are required to maintain objective and defensible criteria that must be met for drivers with epilepsy that optimise the safety of drivers, passengers and other road users. Although lower down the scale of the evidence hierarchy, the development, and regular review, of consensus-based medical standards for licensing and clinical management guidelines is one approach adopted by many countries which fills this gap.

5.6 References


6. INFLUENCE OF HEARING LOSS ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of hearing loss on MVC risk and on on-road driving performance. For the full systematic literature review, please refer to:


6.1 OVERVIEW AND KEY RECOMMENDATIONS

- The global prevalence of moderate to severe hearing loss (i.e., a loss of more than 40dB) is at least five percent for the general population, and increases with age (World Health Organization, 2020). In the United States, 38 percent of those over the age of 80 have moderate, bilateral hearing impairment (Goman & Lin, 2016).
- Hearing standards for drivers, when they exist, only apply to commercial drivers. In many jurisdictions with hearing standards, they only apply to certain categories of commercial vehicles rather than to all drivers of commercial vehicles.
- The effect of hearing loss on MVC risk is controversial and hearing standards are being subjected to legal challenges.
- The systematic review was registered with PROSPERO (see CRD42020158300).
- A search of public health, psychology and transport databases was conducted in October 2019.
- The quality of evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools.
- The initial literature search identified 1,717 articles, of which four met all the criteria for inclusion. In terms of the quality of evidence, two studies were rated ‘good’ and two studies rated ‘fair’.
- All of the included studies used objective methods of establishing hearing loss and evaluated its effects on MVC risk through comparisons with a control group with normal hearing or DMV statistics of the general population of drivers in the jurisdiction.
- One study (rated ‘good’) identified an overall decreased MVC risk associated with hearing loss, and the remaining studies reported no difference.
- The small number of studies that met the inclusion criteria is a limitation.
- Key recommendations:
  - There is no evidence warranting restrictions for holding a full licence (commercial and non-commercial) for drivers with hearing impairment.
  - Where it is judged that a standard of hearing is required to perform the ancillary tasks associated with employment that includes driving certain types of commercial vehicles, those requirements should be incorporated in the regulations governing those particular activities (e.g., driving a school bus or transporting dangerous materials).

Authors:
Jamie Dow1, David Carr2, Judith Charlton3, Linda Hill4, Sjaan Koppel3, Roy Lilly5, Richard Marotolli6, Desmond O’Neill7, Mark J. Rapoport8, Christine Roy9, Bernard Sévigny9, Neil Swirsky10, Emmanuelle Gagné1, Claude Giroux1, & Tamara Rader11

Affiliations:
1Société de l’assurance automobile du Québec, Québec City, Québec, Canada, 2Washington University in St. Louis, Missouri, United States, 3Monash University Accident Research Centre, Monash University, Victoria, Australia, 4University of California San Diego, California, United States, 5Health Sciences Complex, St-John’s, Newfoundland and
Sponsoring organisations:

This project was funded by the Canadian Council of Motor Transportation Administrators with the participation of the Société de l’assurance automobile du Québec, The Ontario Ministry of Transportation and the Canadian Medical Association Journal.

Keywords:

Hearing loss; Motor vehicle crashes; Fitness-to-drive; Road safety

6.2 BACKGROUND

Worldwide, the prevalence of moderate to severe hearing loss (i.e., a loss of more than 40dB) is at least five percent for the general population aged 12 years or older (World Health Organization, 2020) and increases with age. In the US, 38 percent of those over the age of 80 have moderate, bilateral hearing impairment (Goman & Lin, 2016).

In most licensing jurisdictions, hearing standards for drivers relate to commercial drivers with no standards for drivers of private vehicles (see Appendix D, Section 18.3). Thus, the majority of drivers are not affected by the hearing standards, although most drivers, including legislators, believe that hearing is essential when driving. The effect of hearing loss on MVC risk is controversial.

6.2.1 Scope

The overarching aim of this systematic review was to synthesise evidence on the risk of motor vehicle crashes for drivers with hearing loss and to understand and quantify any effects of these conditions on on-road driving performance as determined by a real-world driving test or comparison to crash statistics.

6.2.2 Protocol and registration

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The protocol for this systematic review was registered with PROSPERO (CRD42020158300).

6.2.3 Definition

For the purpose of this review, MVC risk was assessed by the frequency of crashes involving motor vehicles for drivers with hearing loss and to understand and quantify any effects of these conditions on on-road driving performance as determined by a real-world driving test or comparison to crash statistics.

For the purpose of this review, on-road test outcome was assessed by the frequency of drivers with hearing loss who pass or do not pass an on-road driving test administered by driver licensing authorities or by occupational therapy driving assessors.

6.3 METHOD

6.3.1 Eligibility criteria

6.3.1.1 Inclusion criteria

Studies were included in the systematic review according to the following a priori criteria:

1. Original research in a peer-reviewed journal;
2. Full-text available;
3. Published in English language and human studies;
4. Used quantitative methods for data collection and analysis, and
5. Specifically reported MVC risk and/or driving test outcome results for drivers with hearing loss.

6.3.1.2 Exclusion criteria

Studies were excluded from the systematic review according to the following a priori criteria:
1. Commentary manuscripts;
2. Literature or systematic reviews;
3. Case studies;
4. Dissertations, and
5. Studies which only use qualitative methods for data collection and analysis.

6.3.2 Information sources

An electronic search of databases from the disciplines of public health, psychology and transport safety (Ovid Cochrane Library, Ovid Medline, Ovid PsycINFO, Ovid EMBASE, CINAHL PLUS via EbscoHost, Ovid TRANSPORT and TRID: TRIS and ITRD database) was conducted on 18 October 2019 to locate studies from the first available year to 18 October 2019. In addition, a bibliographic review of included studies and a review of goldset studies was conducted to locate additional studies.

6.3.3 Search

Two concepts were derived: Concept 1A Population=Drivers; Concept 1B Population=Hearing loss; Concept 2A Outcome=Crash Risk; Concept 2B Outcome=On-road Driving Test. Search terms (both indexed [e.g., Medical Subject Headings] and key words) associated with all concepts were derived independently from each author and in consultation with a subject matter expert librarian. See Appendix D (Section 18.2) for search strategy.

6.3.4 Study selection

Search results were exported into Endnote X8 software and then imported into Covidence (Cochrane technology platform). Duplicates were then removed from the total number of identified records using a standard function. For each title/abstract, two reviewers independently completed an initial screen for eligibility and a priori inclusion and exclusion criteria were applied. Any conflicts between the two reviewers were resolved by a third reviewer. The selected abstracts were then distributed to the expert panel members who submitted yes/no recommendations for retention for the full-text review. Abstracts receiving a majority of favourable votes were then distributed to the panel as full texts for review and six articles were selected by majority vote. During the expert panel discussions two more articles were eliminated when more detailed analysis revealed non-conformity with the inclusion criteria.

6.3.5 Data collection process

A full-text review of each included study was conducted by two reviewers and the data items were extracted into a pretested data extraction sheet: authors; date of publication; study aim; research design; study period; study location, study population size and definition; participant demographics (i.e., age range and mean); data sources; MVC outcome; on-road driving test type, administered by whom and outcome; main research findings, and risk of bias assessment. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.
6.3.6 Risk of bias

The risk of bias was assessed independently by two reviewers using the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute [NHLBI], 2014a, 2014b). Each reviewer assessed each study for: risk of potential for selection bias, information bias, measurement bias or confounding factors. Based on this assessment, the two reviewers independently gave each study a total score (out of 12) and provided an overall quality rating (‘good’, ‘fair’ or ‘poor’), where the greater the risk of bias, the lower the quality rating of the study. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer. It should be noted that reviewers did not rate any study that they had co-authored.

6.4 RESULTS
6.4.1 Included studies

![PRISMA diagram](image)

The combined searches identified 1,722 studies, of which 1,717 were identified through the initial database search and an additional five from a bibliographic review of the included studies. A total of 583 duplicates were removed via the software algorithm. Following title and abstract screening, 12 studies were identified for full-text review, of which eight studies were excluded. Reasons for exclusion are noted in Figure 4. Altogether, four studies met all the inclusion criteria and were assessed.
6.4.2 Study descriptions

Included studies were conducted between 1994 and 2013. All four studies used a cross-sectional or cohort study design (case-control: n=3; cohort: n=1). Study sample sizes ranged from 80-635,114 participants. The sample size of participants with hearing loss ranged from 40 to 11,683. The mean age of participants across studies was 44.3 years (Range of mean=32.3-60.4 years) among those with hearing loss, and 51.7 years among comparison populations (Range of mean=47.2-99 years). Gender distribution was reported in all four studies, with an average of 94% males among the hearing loss populations and 53.9% males among the comparison populations, principally due to a large all-male cohort in one study. Studies were conducted in the United States (n=2) and in Canada (n=2).

6.4.3 Evidence for risk of MVCs

6.4.3.1 Studies reporting evidence of increased risk (N=0)

6.4.3.2 Studies reporting evidence of decreased risk (N=1)

Case-control

**Good quality:**

- Picard et al. (2008) noted that the drivers with hearing loss had a decreased MVC risk compared to the general driving population (PR=0.80, 95% CI 0.79-0.81). Notwithstanding this overall decreased MVC risk, there was an increasing MVC risk associated with increased level of hearing loss severity (Mild hearing loss: PR=1.13, 95% CI 1.05-1.21; Moderate hearing loss PR=1.18, 95% CI 1.08-1.27; Severe hearing loss PR=1.31, 95% CI 1.20-1.42).

6.4.3.3 Studies reporting evidence for no difference in risk (N=3)

Case-control

**Good quality:**

- Dow et al. (2013) reported no significant difference in the MVC risk for drivers with hearing loss (OR=1.03, 95% CI 0.97-1.10).

**Fair quality:**

- McCloskey et al. (1994) reported no significant difference in the MVC risk for drivers with a hearing loss between 1 and 40 dB (1.0, 95% CI 0.36-1.8) and (0.6, 95% CI 0.2-1.5) for those with a loss of 40 dB or greater. Drivers who used a hearing aid while driving were found to be at increased risk of an MVC with injury (2.1, 95% CI 1.2-3.8).

Cross-sectional/Cohort

**Fair quality:**

- Green et al. (2013) reported no significant difference in the MVC risk for drivers with hearing loss (RR=1.05, 95% CI 0.87-1.26).

6.4.4 Evidence for impacts on on-road driving performance

None of the studies that met the inclusion criteria included on-road driving evaluations as an outcome measure.
6.5 CONCLUSIONS

6.5.1 Overall level of risk

Four studies were included in this review, of which three studies were rated ‘good’ and one study rated ‘fair’.

All studies compared the cohort of affected drivers to the general population of drivers in their jurisdiction. The statistical analysis was robust in all the studies, permitting valid comparisons between the MVC risk of the group or groups being studied and the road safety statistics for the jurisdiction. One study (rated ‘good’) identified an overall decreased MVC risk associated with hearing loss, and the remaining studies reported no difference.

Despite the small number of studies, their quality permits the reviewers to state that there is no scientific evidence supporting the inclusion of hearing loss in medical fitness-to-drive standards; hearing loss has no effect on MVC risk.

None of the studies that met the inclusion criteria included on-road driving evaluations as an outcome measure.

6.5.2 Study limitations

The small number of studies that met the inclusion criteria is a limitation. However, the included studies featured large cohorts that partially compensate for this limitation.

6.5.3 Current fitness-to-drive guidelines

All but one of the reviewed licensing jurisdictions have hearing standards for commercial drivers (see Appendix D, Section 18.3). One jurisdiction has no hearing standards for any class of driver while none have standards for non-commercial drivers.

The justification for the standards for commercial drivers is based on the necessity to communicate with passengers or with police and other authorities, especially in the event of an emergency; laws that state that busses must stop at level-crossings to listen for train whistles; the requirement for school bus drivers to control their passengers or for delivery-vehicle drivers to talk to their clients. These justifications are not related to medical fitness-to-drive or MVC risk but are predicated on the capacity to carry out the ancillary tasks associated with the type of commercial vehicle they are employed to drive.

These standards have become the subject of legal contestations related to commercial drivers. In Canada, since DMVs have been unable to present credible medical or legal justifications for driver fitness hearing standards, there have been instances of human rights tribunals directing DMVs to accommodate commercial drivers with below-standard hearing loss, putting into question the maintenance of the current CCMTA hearing standard. In the US, FMCSA, the organisation governing interstate commercial driving, has indicated officially its intention to eventually abolish its hearing standard while instituting a programme for exemptions to the current standard.

Overall, it should be noted that the hearing standards for commercial drivers currently applied in Australia, New Zealand, Canada, and the US are not supported by findings of this review.

6.5.4 Recommendations

Based upon the studies in this review, there is no evidence supporting a requirement for fitness-to-drive hearing standards for non-commercial drivers. Although none of the studies address the specific question of the effects of hearing loss on MVC risk for commercial drivers, two studies did not exclude commercial drivers (Dow et al., 2013; Picard et al., 2008) and neither demonstrated a statistically significant increase in MVC risk.

Furthermore, since there is no evidence for elevation of MVC risk associated with hearing loss, the justifications for hearing standards for commercial drivers are not supported as a medical fitness-to-drive issue and it is unlikely that their continued application cannot be
defended when there is a legal challenge. If it is determined that the critical tasks associated
with driving certain types of commercial vehicles require a given level of hearing, this
requirement should be incorporated in the appropriate regulations governing that aspect of
the transportation industry.

6.6 REFERENCES

Dow, J., Gaudet, M., & Turmel, E. (2013). Crash rates of Quebec drivers with medical
conditions. *Annals of advances in automotive medicine, 57*, 57-66.


and dual sensory impairments and history of motor vehicle collision involvement of older


National Heart Lung and Blood Institute (2014a). *Quality assessment of case-control
studies*. Bethesda, MD: National Institutes of Health, Department of Health and Human

National Heart Lung and Blood Institute (2014b). *Quality assessment tool for observational
cohort and cross-sectional studies*. Bethesda, MD: National Institutes of Health, Department

Picard, M., Girard, S. A., Courteau, M., Leroux, T., Larocque, R., Turcotte, F., ... & Simard,
M. (2008). Could driving safety be compromised by noise exposure at work and noise-


7. INFLUENCE OF PSYCHIATRIC DISORDERS ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of psychiatric disorders on MVC risk and on on-road driving performance. For the full systematic literature review, please refer to:


7.1 OVERVIEW AND KEY RECOMMENDATIONS

- Prevalence rates of any DSM-IV disorder in the prior year vary widely in the general population, from 4.3 to 26.4 percent, depending on the disorder, nationality and study (Demyttenaere et al., 2004). Anxiety disorders and mood disorders have been reported as the most common psychiatric disorders, with prevalence in the range of 2.4% to 18.2%, and 0.8% to 9.6%, respectively.
- The systematic review was registered with PROSPERO (see CRD42020157675).
- A search of public health, psychology and transport databases was conducted in November 2019.
- The quality of evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools.
- An initial search identified 27,855 studies, and 24 studies met the inclusion criteria (n=10 case-control; n=6 cross-sectional; n=8 cohort).
- Of the included studies, 13 avoided use of subjective measures to ascertain psychiatric disorder and MVC, 4 used subjective measures for both psychiatric disorder and MVC, and 7 used a subjective measure for one of these (5 for psychiatric disorder, 2 for MVC).
- Only seven studies adjusted for driving exposure, and only three studies adjusted for drugs or alcohol (and one additional study excluded those with drugs or alcohol).
- In terms of the quality of evidence, four studies were rated ‘good’, ten studies were rated ‘fair’, and ten studies were rated ‘poor’. Sixteen studies reported an increased MVC risk associated with psychiatric disorders, and nine did not. No studies showed a reduced MVC risk with psychiatric disorders. The negative studies, i.e. those finding no association between psychiatric disorders and MVC risk, were more often rated ‘Poor’ (55.6%) than the studies finding an increased risk (33.3%) evidence for risk of motor vehicle crashes.
- There was no category of disorder that was consistently associated with increased MVC risk.
- Key recommendations:
  - Most international guidelines do not suggest a blanket restriction on driving for drivers with a psychiatric disorder.
  - The available evidence is mixed and not of high quality, and also does not support such a blanket restriction.
  - Instead, the individualised case-by-case approach recommended by international guidelines, including looking for red-flags which would raise concern, should continue.
  - Further research should include objective assessments of psychiatric disorders and MVC risk, measurement of driving exposure as a confound and consideration of impacts of long-term psychiatric illness and its’ treatments on on-road driving performance.

Authors:
Psychiatric disorders encompass a wide-range of conditions characterized in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013). According to the World Health Organization, prevalence rates of disorders in the general population range from 4.3-26.4 percent - depending on the disorder, nationality and study (Demyttenaere et al., 2004), with a more recent Canadian estimate of 19.8 percent annual prevalence of mental disorder (Mental Health Commission of Canada, 2016). Previous reviews suggest that drivers with psychiatric disorders are at a higher risk of crash causation and other adverse driving outcomes (Ménard & Korner-Bitensky, 2008; Hill et al., 2017), though there is conflicting evidence and relatively few investigations into on-road driving fitness (Unsworth, 2017).

7.2.1 Scope

The aim of this systematic review was to determine the MVC risk for drivers with psychiatric disorders and to establish evidence for any impacts of the conditions on on-road driving performance. We conducted a systematic review of primary research pertaining to MVC risks with psychiatric disorders (including mood disorders, anxiety disorders, psychotic disorders, personality disorders and combined “mental disorders”). Given the abundance of reviews already on Attention Deficit Hyperactivity Disorder (ADHD) and MVC risk, we conducted an umbrella review (i.e., a systematic review of systematic reviews) on ADHD which we’ve summarised in a separate paper.

7.2.2 Protocol and registration

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). PRISMA provides a detailed guide on the conduct and reporting requirements for systematic reviews and meta-analyses. The protocol for this systematic review was registered with PROSPERO (CRD42020157675).

7.2.3 Definition

For the purpose of this review, MVC risk was assessed by the frequency of crashes involving motor vehicles for drivers with psychiatric disorder as identified by official crash records, self-reported data, or crashes occurring on on-road driving tests.
7.3 METHOD
7.3.1 Eligibility criteria
7.3.1.1 Inclusion criteria
Studies were included in the systematic review according to the following a priori criteria:
1. Original research in a peer-reviewed journal;
2. Full-text available;
3. Published in English language and human studies;
4. Specifically reported MVC risk for drivers with psychiatric disorders and had a comparison group;
5. Use of quantitative methods for data collection and analysis, and
6. For studies on ADHD, only systematic reviews (reported in a separate paper).

7.3.1.2 Exclusion criteria
Studies were excluded from the systematic review according to the following criteria:
1. Commentary articles;
2. Dissertations;
3. Abstracts only;
4. Reviews;
5. Case studies and case series;
6. Systematic reviews on all topics (except for those on ADHD), and
7. Use of only qualitative methods for data collection and analysis.
Additionally, studies on the effects of psychotropic medications that did not include groups of cases with a psychiatric disorder and controls without a psychiatric disorder were excluded.

7.3.2 Information sources
Electronic database searches from the disciplines of medical, health sciences and transport safety (Cochrane Library, Medline, PsycINFO, EMBASE, CINAHL, TRANSPORT and TRID) were conducted between November 13th and 15th 2019 to identify studies from the first available year until the search date. No time limits were applied. A bibliographic review of identified reviews and included studies was conducted to identify additional studies.

7.3.3 Search
Concepts pertaining to psychiatric disorders and MVC risk were derived, using a limited search with MEDLINE and Google Scholar to identify keywords, MeSH headings and descriptor terms. We also compiled a ‘goldset’ list with which to verify our search strategy in MEDLINE, prior to the full search of all databases. See Appendix E (Section 19.2) for search strategy.

7.3.4 Study selection
Results of the search were exported into EndNote X8 software, and duplicates were removed using a standard function. Following this, the final list of studies were exported into Covidence (Cochrane technology platform) for: 1) title review, 2) title and abstract review, and 3) full text review. The software randomly assigned each citation to pairs of reviewers. For each title, two reviewers independently completed an initial screen for eligibility and a priori inclusion and exclusion criteria were applied. Any conflicts between the two reviewers were resolved by a third reviewer. The same process was followed for title and abstract screening. Two reviewers independently applied inclusion and exclusion criteria to the full-texts of the remaining records to select studies for this review. Any conflicts between the two reviewers were resolved by a third reviewer.

7.3.5 Data extraction
Full-text review of each included study was conducted by two reviewers. Data items were extracted into a pre-tested data extraction sheet including details of each study and the risk
of bias assessment. The completed data extraction sheets were reviewed and finalized by the expert panel during a series of videoconferences. Discrepancies between the two reviewers were resolved by consensus, or by a third reviewer. At the data extraction phase, the primary psychiatric disorders were divided into two categories: ‘mood and anxiety disorders’ and ‘other mental/psychiatric disorders’ in order to organize the broad array of studies identified.

7.3.6 Risk of bias

The risk of bias was assessed independently by two reviewers using the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute [NHLBI], 2014a, 2014b). Discrepancies between the two reviewers were resolved by discussion and agreement by the expert panel during the videoconferences, or by a third reviewer.

7.4 RESULTS
7.4.1 Included studies

Literature Search

Unique records identified through other sources
- From searching reference lists of included studies and relevant reviews (n = 18)

Records identified through database searching (n = 37,837)

Records screened on the basis of titles (n = 23,457)

Records screened on the basis of abstracts (n = 1,669)

Full-text studies assessed for eligibility (n = 130)

Studies available for data extraction (n = 47)

Studies included in quantitative synthesis (n = 24)

Excluded through format Screening (n = 14,380)
- Duplicate records (n = 7,405)
- Missing abstracts (n = 1,596)
- Wrong publication type (n = 1,820)
- Irrelevant reviews (n = 3,113)
- Nonhuman studies (n = 446)

Excluded (n = 21,788)
- Does not meet study criteria (n = 21,788)

Excluded (n = 1,557)
- Does not meet study criteria (n = 1,557)

Excluded (n = 83)
- Wrong Publication Type (n = 40)
- ADHD Reviews (n = 11)
- Psychiatric Illness Reviews (n = 11)
- Other (n = 18)
- No collision measure (n = 22)
- No psychiatric illness group (n = 5)
- No/wrong control group (n = 5)
- Does not meet study criteria (n = 9)
- Duplicates (n = 2)

Late Exclusions (n = 23)
- No extractable crash data (n = 21)
- Simulator studies (n = 2)

Figure 5: PRISMA guidance flow diagram of identification, screening, and inclusion of eligible studies for Psychiatric Disorders

7.4.2 Study descriptions

Psychiatric disorder was ascertained using self-report or questionnaires/scales in eight studies, records or databases in nine studies, interviews in five studies, and the method of ascertainment of psychiatric disorder was not stated in one study.

MVCs were ascertained using records in 14 studies, self-report or questionnaires in five studies, interviews in two studies, instrumented vehicles in one study and method of ascertainment was not specified in one study.
Only eight of the studies adjusted for driving exposure, and only three adjusted for drugs or alcohol (and one additional excluded those with drugs or alcohol).

On quality assessment, three were rated ‘good’, ten as ‘fair’, and ten as ‘poor’. The negative studies were more often rated poor than the positive studies (57.1% vs 31.3%).

7.4.3 Evidence for risk of MVCs

7.4.3.1 Studies reporting evidence of increased risk (N=16)

7.4.3.1.1 Mood and anxiety disorders

Case-control

Poor quality:

- Sagberg et al. (2006) reported that drivers involved in an at-fault MVC were more than twice as likely to have reported feeling anxious (OR=3.15, 95% CI 0.66-2.55, p=0.03) or depressed (OR=2.43, 95% CI 0.98-3.48, p=0.03) than those with a not-at-fault MVC in the prior six months.

Cross-Sectional

Fair quality:

- Wickens et al. (2012) reported that drivers with probable anxiety/mood disorder were 78% more likely to be involved in an MVC compared to the general population without probable anxiety/mood disorder (OR=1.78, 95% CI 1.37-2.31, p<0.001).

Poor quality:

- Dula et al. (2010) reported that drivers with high anxiety (0.42 ± 0.93) had almost double the at-fault MVCs compared to drivers with low anxiety (0.22 ± 0.53; p=0.01).
- Duric et al (2007) reported that approximately one third of examinees at an Institute of Public Health who had caused an MVC in the last six months had no neurosis (31.25%) while almost two thirds of drivers who had caused MVCs had neurotic disorders (71.43%).

Cohort

Good quality:

- Aduen et al. (2018) found that drivers with depression had a 34% increased risk of MVC compared to the general population (IRR=1.34, 95% CI 1.05-1.71, p=0.02).
- Foley et al. (1995) found that drivers ages 65 years and over with increased depressive symptoms had a 50% increased risk of MVC compared to those without depression (RR=1.50, 95% CI 1.10-2.10, p<0.05).

Fair quality:

- Alavi et al. (2017) reported that amongst heavy vehicle drivers who were involved in an MVC, drivers with depression (OR=2.40, 95% CI 1.20-6.60, p=0.04) and obsessions (OR=2.70, 95% CI 2.70-19.40, p=0.004), but not other psychiatric disorders, had more than double the risk of MVC over two years compared to those without any medical conditions.

7.4.3.1.2 Other Psychiatric Disorders

Case-control

Good quality:

- Dow et al. (2013) found that drivers with psychiatric conditions had a 32% increased MVC risk compared to drivers without psychiatric conditions (OR=1.32, 95% CI 1.29-1.35).
• Orriols et al. (2014) reported that drivers with personality disorders had a 35% increased risk of being responsible for an injurious crash compared to drivers with other chronic conditions (OR=1.35, 95% CI 1.05-1.74), although the risk for other long-term psychiatric disorders was not stated.

*Fair quality:*

• Dumais et al. (2005) reported that young male drivers who died in an MVC were more than three times as likely to have borderline and/or antisocial personality disorder (OR=3.54; 95% CI 1.38-16.01).

*Poor quality:*

• Brenner et al. (1969) reported that drivers found to be at-fault in a fatal MVC were four times more likely to have signs of various psychopathologies (suicidal proclivity, clinical depression, violence, or paranoia) than drivers not found to be at-fault in a fatal MVC (RR=4.00, 95% CI NR).
• Selzer et al. (1968) reported that drivers responsible for a fatal MVC had significantly more psychopathology including paranoid ideation (23% vs. 5%), clinical depression (21% vs. 8%) and suicidal proclivity (21% vs. 8%) than those not responsible (p<0.01 for all).

*Cross-Sectional*

*Poor quality:*

• Yates et al. (1987) reported that drivers with alcoholism with antisocial personality disorder (45.5%) were almost twice as likely to report a personal-injury MVC than drivers with alcoholism without antisocial personality disorders (25.7%; χ²=5.40, df=1, p<0.05).

*Cohort*

*Fair quality:*

• Eekelma et al. (1970) found that while drivers with psychotic, “psychoneurotic” and personality disorders had a greater MVC rates than the general population before discharge from a state hospital (Ratios ranged from 1.35-1.72 between experimental and control), after discharge they were safer drivers compared to the general population, but this was true only for women (Ratios of 2.69 vs. 0.33, before vs. after discharge).
• Crancer and Quiring (1969) found that drivers with personality and psychoneurotic disorders had significantly higher MVC rates (114% and 49% higher, respectively) compared to the general population.
• Waller et al. (1965) found that drivers with mental illness, largely schizophrenia and manic depression (15.3), averaged twice as many MVCs per 1,000,000 miles driven compared to the general population (7.2) over 10 years.

7.4.3.2 Studies reporting evidence of decreased risk (N=0)

7.4.3.3 Studies reporting evidence no difference (N=5)

7.4.3.3.1 Mood and Anxiety Disorders

*Case-control*

*Fair quality:*

• Dumais et al (2005) found no increased risk of fatal MVC in males with mood (OR=0.51, 95% CI 0.19-1.32) or anxiety (OR=0.69, 95% CI 0.16-2.71) disorders.
• Koepesell et al. (1994) reported that older drivers who were involved in an MVC were not more likely to have had a history of depression compared to the control group of drivers with other medical conditions (OR=1.70, 95% CI 0.90-3.10).
Cohort

Fair quality:

- Cross et al. (2009) reported no significant association between drivers with depression and any MVC (RR=1.23, 95% CI 0.85-1.77), injurious MVC (RR=1.39, 95% CI 0.64-3.02) or at-fault MVC (RR=1.26, 95% CI 0.73-2.17) compared to drivers with other medical conditions.

Cross-Sectional

Fair quality:

- Margolis et al. (2002) reported that older female drivers with higher depressive symptoms were not more likely than those with lower depressive symptoms to have an MVC (HR=1.41, 95% CI 0.86-2.29, p=0.17).

Poor quality:

- Aduen et al. (2015) reported that drivers who reported depression on a questionnaire did not have an increased risk of multiple MVCs (RR=1.55, 95% CI 0.85-2.82), single vehicle MVC (RR=1.24, 95% CI 0.86-1.79), or at-fault MVC (RR=1.47, 95% CI 0.84-2.60), although they did double the risk of injury from MVC (RR=2.25, 95% CI 1.05-4.82).

7.4.3.3.2 Other Mental/Psychiatric Disorders

7.4.3.4 Studies reporting evidence no difference (N=3)

Case-control

Poor quality:

- Buttigleri et al. (1969) reported that the MVC records did not differ statistically between drivers admitted to a neuropsychiatric ward and the Californian driving population.

- Buttigleri et al (1967) reported that 81.44% of drivers admitted to neuropsychiatric wards had no MVCs in three years preceding hospitalization, which was similar to the general driving population (78.66%) at the time of the study (p>0.05).

Cross-Sectional

Fair quality:

- Edlund et al. (1989) reported that drivers with schizophrenia (10%) had no increased risk of MVC compared with a control group (9%; p>0.05), but also noted that the controls drove at twice the frequency of the cases.

7.4.3.5 Studies reporting inconclusive evidence of risk (N=2)

7.4.3.5.1 Other Mental/Psychiatric Disorders

Case-control

Fair quality:

- Dumais et al. (2005) found no increased risk of fatal MVC in males with cluster A personality disorders (p=NR).

Poor quality:

- Armstrong et al. (1969) reported that there was no increase in MVC rates of drivers admitted to a private psychiatric hospital compared to drivers with physical illness.
Evidence for impacts on on-road driving performance

None of the studies that met the inclusion criteria included MVCs occurring during on-road driving evaluations, although this was anticipated to occur quite rarely.

CONCLUSIONS

Overall level of risk

This systematic review identified 24 studies that investigated the MVC risk for drivers with a psychiatric disorder. However, only four of these studies were rated as having a 'good' quality of evidence.

In terms of the studies with 'good' ratings, they reported a 34% increased risk of MVC among drivers with depression compared to the general population (Aduen et al., 2018), a 50% increased risk of MVC among drivers aged 65 years and over compared to those without depression (Foley et al., 1995), a 32% increased risk of MVC among those with a psychiatric disorder (Dow et al., 2013), and a 35% increased likelihood of having a personality disorder among those found responsible (vs. not responsible) for an MVC (Orriols et al., 2014).

In three other studies with quality of evidence ratings of 'fair', strong associations were found between depression and MVC (Alavi et al., 2017, Wickens et al., 2012, Koepsell et al., 1994), whereas there were also three studies with quality of evidence ratings of 'fair' in which depression was not found to be associated with an increased risk of MVC (Margolis et al., 2002; Cross et al., 2009; Dumais et al., 2005).

On the topic of anxiety, one study found obsessions to be associated with almost double the risk of involvement in MVC (Alavi et al., 2017), one found almost double the risk of at-fault MVC among those with probable mood and anxiety disorders (Wickens et al., 2012), and one found no increased risk of MVC fatalities associated with anxiety disorders (Dumais et al., 2005), but no studies were rated to be 'good' quality. There were no studies identified that claimed a neutral or reduced risk of MVC involvement on this topic.

Mixed 'psychiatric disorders' were found to pose an increased MVC risk in two studies with quality of evidence ratings of 'fair' (Eelkema et al., 1970; Waller, 1965), and one study with a quality rating of 'fair' found that males who died of an MVC were three times more likely to have a diagnosis of borderline or antisocial personality disorder (but not Cluster A personality disorders) (Dumais et al., 2005).

Only one study with a quality rating of 'fair' looked at schizophrenia as distinct from other 'psychiatric disorders' and found no relationship with MVC involvement (Edlund et al., 1989).

No disorder was consistently linked to either driving risk or safety.

Study limitations

We identified a very narrow number of studies that examined the risk of MVC associated with drivers with psychiatric disorder, of very limited quality, including ten studies rated 'poor', ten studies rated ‘fair’, and only four studies rated ‘good’. Each study took a different approach to this research topic, more than half of the studies used a subjective measure of either psychiatric disorder or MVC, and few adjusted for important confounding factors such as alcohol or distance travelled.

Current fitness-to-drive guidelines

Most of the reviewed international guidelines (see Appendix E, Section 19.3) do not suggest a blanket restriction on driving for individuals with psychiatric disorders, and recommendations are made for an individualized approach, considering factors such as adherence to treatment, absence of cognitive impairment or sedating medications, sufficient periods of stability after acute episode of illness, lack of impact on daily functioning, and insight as pre-requisites for safe driving.
7.5.4 Recommendations

The available study evidence is limited in number, of heterogenous study design and not of high quality. However, there is some evidence for increased risk, which justifies the presence of guidelines which encourage non-driving periods (in cases of acute symptoms and periods of adjustment to treatments), licence conditions and requirements for regular medical review for those with longer term psychiatric disorder. The current research evidence makes it difficult to quantify the magnitude of this increased risk on either a general, or specific diagnosis basis and therefore does not support blanket restrictions. The characteristics of people with psychiatric disorder most at risk of MVC have not been clearly identified. However, as with any condition that may impact cognition, judgement and insight, the individualised case-by-case approach recommended by international guidelines should continue.

Further research should include objective assessments of psychiatric disorder and MVC risk considering measurement of exposure as a confound, identification of risk factors for MVC among those with psychiatric disorder, delineation of the role of treatment and consideration of impacts of long-term psychiatric disorders and its' treatments on on-road driving performance. Given the limitations of evidence, a consensus-based approach to reassessing the recommendations of Fitness-to-Drive Guidelines would be warranted for psychiatric disorder, such as one recently completed on the topic of driving and dementia (Rapoport et al., 2018).

7.6 REFERENCES


8. INFLUENCE OF SLEEP DISORDERS ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of sleep disorders on MVC risk and on on-road driving performance. For the full systematic literature review, please refer to:


8.1 OVERVIEW AND KEY RECOMMENDATIONS

- In Australia, it is believed that up to six percent of the population suffers from some form of chronic sleep disorder, with an estimated total financial cost associated with sleep disorders at AUD$7.5B in 2004, roughly amounting to 0.8 percent of the Australian GDP in that period (Hillman, Murphy, Antic, & Pezzullo, 2006). Furthermore, it is estimated that sleep disorders account for 1.4 percent of the total burden of disease in Australia (Hillman et al., 2006).

- This review was registered with PROSPERO (see CRD42019144643). A systematic search of public health, psychology and transport databases was conducted in on 8th November 2019. The quality of evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools.

- An initial database search identified 4,363 studies, with a further four studies identified through bibliographic and goldset review.

- Thirty-seven studies published between 1976 and 2015 met the inclusion criteria (n=7 case-control; n=24 cohort/cross-sectional; n=6 before-after). Overall, the quality of evidence for 20 studies was rated ‘good’, nine studies rated ‘fair’, and eight studies rated ‘poor’. Included studies addressed: sleep apnoea and sleep-related breathing disorders (n=33, including n=13 sleep apnoea severity, and n=11 sleep apnoea treatment); central disorders of hypersomnolence and narcolepsy (n=5), and insomnia (n=2), with some studies covering multiple sleep disorders.

- Of the thirty-three studies specifically investigating MVC risk associated with sleep apnoea, seventeen studies reported an increased risk (10 ‘good’ and 4 ‘fair’, 3 ‘poor’), six reported no difference in risk (2 ‘good’, 4 ‘fair’), and two provided inconclusive findings (1 ‘good’ , 1 ‘fair’). Thirteen studies specifically reported the effects of sleep apnoea severity on MVC risk, with seven suggesting increased risk with increased severity (5 ‘good’, 2 ‘fair’), four reporting no difference in risk (2 ‘good, 1 ‘fair’, 1 ‘poor’), and two providing inconclusive evidence (1 ‘good’, 1 ‘poor’).

- Eleven studies specifically reported evidence for the effects of treatment of sleep apnoea on MVC risk, with five (4 ‘good’, 1 ‘fair’) suggesting increased risk for untreated sleep apnoea. Six studies (3 ‘good’, 1 ‘fair’, 2 ‘poor’) reported evidence of decreased risk associated with Continuous Positive Airway pressure (CPAP) treatment, one study (‘poor’) indicated no difference in risk associated with CPAP, and two studies (both ‘poor’) provided inconclusive evidence. One study (‘good’) reported evidence of decreased risk associated with uvulopalatopropharyngoplasty (UPPP) treatment.

- Five studies (3 ‘good’, 2 ‘fair’) investigated MVC risk associated with disorders of hypersomnolence and narcolepsy, with all suggesting increased risk.

- Only two studies investigated MVC risk associated with insomnia, with inconsistent findings: one reporting increased risk of MVC (‘good’) and one no difference (‘fair’).

- No studies investigated the impact of sleep disorders on on-road driving performance.

- Evidence for at least a moderately elevated MVC risk for drivers with sleep disorders (sleep apnoea; hypersomnia and narcolepsy) with the majority reporting around 2-3 times higher risk. However, the identified studies were conducted in numerous
licensing jurisdictions, with different licensing requirements, and across a diverse range of participant populations, which may limit the generalisability of the findings.

- Key recommendations:
  - Most international guidelines do not give blanket permission for drivers with sleep disorders to hold an unrestricted licence; specifically, Australian guidelines specify an unrestricted licence may not be held if there is a diagnosis of moderate to severe sleep apnoea (or a diagnosis of narcolepsy), frequent self-reported episodes of sleepiness or drowsiness while driving, involvement in MVC, or doctor deems driver to be at significant driving risk.
  - Instead, the guidelines indicate a conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from the treating doctor (or a sleep specialist in the case of commercial drivers) subject to compliance with, and satisfactory response to, treatment. Several specify specific levels of severity of apnoea must be met. Canada and EU guidelines specify annual medical review for commercial licence drivers.
  - For sleep apnoea: The evidence for increased risk of MVC (and higher risk for higher severity; higher risk for untreated; Lower risk with CPAP treatment) is consistent with current Australian (and international) fitness-to-drive guidelines. No change recommended.
  - For hypersomnolence and narcolepsy: Evidence, albeit limited is consistent with current Australian (and international) fitness-to-drive guidelines. No change recommended.
  - For insomnia, there is limited, inconsistent evidence which precludes definitive recommendations for fitness-to-drive decisions. Current Australian guidelines do not specify licensing requirements for drivers with insomnia. No change recommended.
  - Further research should include objective measures of sleep disorders and MVC risk, as well as measurement of confounds including driving exposure, medication use/compliance, comorbidities and disorder severity. Consideration of on-road driving performance is also warranted. A population-based controlled study in multiple licensing jurisdictions that investigates the MVC risk for drivers with sleep disorders is recommended.

Authors:
Judith L. Charlton¹, Marilyn Di Stefano², Bleydy Dimech-Betancourt¹, Mohammed Aburumman¹, Rachel Osborne¹, Sujanie Peiris¹, Suzanne L. Cross¹, Gabrielle Williams¹, Amanda Stephens¹, Aaron McInnes¹, Morris Odell³, Peteris Darzins⁴, Clare Anderson⁵, Mark J. Rapoport⁷, Jamie Dow⁷, Desmond O’Neill⁸, & Sjaan Koppel¹.

Affiliations:
¹Monash University Accident Research Centre, Monash University, Victoria, Australia, ²Road Safety Victoria, Department of Transport, Victoria, Australia, ³Victorian Institute of Forensic Medicine, Victoria, Australia, ⁴Monash University Eastern Health Clinical School, Victoria, Australia, ⁵Turner Institute for Brain and Mental Health, Monash University, Victoria, Australia, ⁶Sunnybrook Hospital, Toronto, Ontario, Canada, ⁷Société de l’assurance automobile du Québec, Québec City, Québec, Canada, ⁸National Office for Traffic Medicine, Royal College of Physicians of Ireland, Dublin, Ireland.

Sponsoring organisations:
This project was funded by Road Safety Victoria, Department of Transport/VicRoads, Victoria.

Keywords:
Sleep disorder; Crash risk; Fitness-to-drive; Road safety

8.2 BACKGROUND
Sleep disorders are relatively common disorders that cause major sleep disruption and fragmentation and, as such present serious health and safety implications to those who are affected by them. Sleep disorders that may result in excessive daytime sleepiness include the sleep apnoea syndromes (obstructive sleep apnoea, central sleep apnoea and nocturnal hypoventilation), periodic limb movement disorder, circadian rhythm disturbances (e.g., advanced or delayed sleep phase syndrome), some forms of insomnia and narcolepsy (Institute of Medicine, 2006; Sateia, 2014). Excessive daytime sleepiness, which manifests itself as a tendency to doze at inappropriate times when intending to stay awake, can arise from many causes and is associated with an increased risk of motor vehicle crashes (MVC; Findley, Fabrizio, & Knight, 1989; Howard, et al., 2004; Masa, Rubio, Findley, & Cooperative Group, 2000; Stutts, Wilkins, & Vaughn, 1999; Turkington, Sircar, Allgar, & Elliott, 2001). In many parts of the world, drivers with sleep disorders are restricted from driving – with the criteria for establishing whether an individual with a sleep disorder is fit to drive varying considerably across licensing jurisdictions (see Appendix F, Section 20.3).

8.2.1 Scope
The aim of this study was to review the literature examining the MVC risk for drivers with a sleep disorder(s) and quantify any impacts on on-road driving performance.

8.2.2 Protocol and registration
The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). PRISMA provides a detailed guide on the conduct and reporting requirements for systematic reviews and meta-analyses. The protocol for this systematic review was registered with PROSPERO (see CRD42019144643).

8.2.3 Definition
For the purpose of this review, MVC risk for drivers with a sleep disorder(s) were assessed by the frequency of crashes involving drivers with a sleep disorder(s) that resulted in property damage, or MVC-related injury or fatality (World Health Organization, 2018), as identified by self-report or official MVC records.

On-road test outcome was assessed by the frequency of drivers with a sleep disorder(s) who pass or do not pass an on-road driving test administered by driver licensing authorities or by occupational therapy driving assessors.

8.3 METHOD
8.3.1 Eligibility criteria
8.3.1.1 Inclusion criteria
Studies were included in the systematic review according to the following a priori criteria:

1. Original research in a peer-reviewed journal;
2. Full-text available;
3. Published in English language and human studies;
4. Studies including drivers with sleep disorders and MVC risk and/or on-road driving test outcome, and
5. Studies which use quantitative methods for data collection and analysis.

8.3.1.2 Exclusion criteria
Studies were excluded from the systematic review according to the following a priori criteria:

1. Commentary articles;
2. Dissertations;
3. Case studies;
4. Abstracts;
5. Review, and
6. Studies which use qualitative methods for data collection and analysis.

8.3.2 Information sources

Relevant studies were identified before the development of a search strategy and search terms, and were defined as ‘goldset studies’. These studies were identified by leading researchers in the field of sleep disorders, MVC, on-road driving performance, and road safety. An electronic, systematic search of the medical, health sciences and transport literature, using a combination of keywords, MeSH terms (and equivalent indexed terms) was conducted in each of the following databases: MEDLINE, Cochrane Library, CINAHL, EMBASE, PsycINFO, TRANSPORT and TRID. The search was conducted on November 8th 2019 to locate studies from the first available year to November 8th 2019 (i.e., no date limit was applied).

8.3.3 Search

The review consisted of a published literature search conducted in the English language in two stages: Step 1: a key word search will be conducted for two concepts: Concept 1A Population=Drivers; Concept 1B Population=Sleep Disorders; Concept 2A Outcome=Crash Risk; Concept 2B=On-road Driving Test Outcome. Search terms (both indexed [e.g., Medical Subject Headings] and key words) associated with all concepts were derived independently from each author and in consultation with a subject matter expert librarian. See Appendix F (Section 20.2) for the search strategy.

8.3.4 Study selection

Search results were exported into Endnote X8 software and imported into Covidence (Cochrane technology platform). Duplicates were removed from the total number of identified records using a standard function. For each title/abstract, two reviewers independently completed an initial screen for eligibility and a priori inclusion and exclusion criteria were applied. Any conflicts between the two reviewers were resolved by a third reviewer. Following title and abstract screening, two reviewers independently applied the inclusion and exclusion criteria to each full-text. Any conflicts between the two reviewers were resolved by a third reviewer. A bibliographic review of included studies, as well as a review of goldset studies, was conducted to identify additional relevant studies.

8.3.5 Data collection process

Data extraction for each included study was conducted by two reviewers and the following information was extracted by into a pretested data extraction sheet: authors; date of publication; study aim; research design; study period; study location, study population definition; participant demographics (i.e., age range and mean); data sources; MVC outcome; on-road driving test outcome; main research findings, and risk of bias assessment. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.

8.3.6 Risk of bias

The risk of bias for each included study was assessed independently by two reviewers using the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute, 2014a, 2014b, 2014c). Each reviewer assessed each study (based on 12 criteria for case-control or before-after studies, or 14 criteria for observational cohort and cross-sectional studies) for: risk of potential for selection bias, information bias, measurement bias or confounding factors. Based on this assessment, the reviewers independently provided an overall quality rating (‘good’, ‘fair’ or ‘poor’), where the greater
the risk of bias, the lower the quality rating of the study. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer.
8.4 RESULTS

8.4.1 Included studies

A total of 4,365 studies were identified. A review of the goldset studies yielded two studies. The combined database searches identified 4,363 studies (of which 4,361 were identified through the initial search and an additional 2 from bibliographic review). 1,556 duplicates were removed via the software algorithm. Following title and abstract screening, 417 studies were identified for full-text review, of which 380 studies were excluded. Reasons for exclusion are noted in Figure 1. Altogether, 37 studies met the inclusion criteria and were assessed.

8.4.2 Study descriptions

Included studies were conducted between 1976 and 2015, with 12 published in the last decade. Of the 37 studies, most were cross-sectional/cohort studies (n=7 case-control studies; n=11 cross-sectional studies; n=13 cohort studies; n=6 ‘before-after’ studies). Study sample sizes ranged from 50–1,750,918 participants. The sample size of participants with sleep disorders ranged from 11 to 9,502. The mean age of drivers with a sleep disorder(s) was 50.2 years (Range of mean=41.5–56.6 years), and 47.0 years for comparison populations (Range of mean = 37.0–60.0 years). Gender distribution was reported in 27 studies; the average proportion of males was 84.4 percent for drivers with a sleep disorder(s), and 74.3 percent for comparison populations. Seven studies provided information specific to drivers with a commercial licence (truck/heavy vehicle drivers). Most studies were conducted in the United States (n = 10).

Confirmation of a sleep disorder was ascertained in studies using: 1) self-report (n=4), 2) administrative data (n=2), and 3) objective measures (e.g., polysomnography, respiratory polygraphy) (n=31). MVCs were ascertained in studies using: 1) official records (n=15), and 2) self-report, interviews or questionnaires (n=22). In terms of controlling for confounding variables, nine studies adjusted for driving exposure, four studies adjusted for alcohol...
consumption, two studies adjusted for comorbidities, and one study adjusted for medication exposure.

No study reported on on-road driving test performance as an outcome measure of risk.

Altogether, 37 studies met the inclusion criteria, and covered three main categories of sleep disorders (not mutually exclusive) including: sleep apnoea and sleep-related breathing disorders (n=33 studies, with n=13 also covering sleep apnoea severity, and n=11 covering sleep apnoea treatment), central disorders of hypersomnolence and narcolepsy (n=5 studies), and insomnia (n=2 studies).

It should be noted that the outcome measure for all included studies was MVC risk; No studies reported on-road driving test outcomes as the outcome measure. The evidence for MVC risk, based on the studies included, is discussed for each of these disorder categories in turn below.

Overall, twenty studies were rated as ‘good’, nine as ‘fair’ and eight as ‘poor’. Studies with a ‘poor’ quality of evidence rating were deemed to not contribute reliably to conclusions about the risk associated with sleep disorders.

8.4.3 Sleep apnoea and sleep-related breathing disorders

8.4.3.1 Studies reporting evidence of increased risk (N=17)

Case-control

Good quality:

- Mulgrew et al. (2008) reported that drivers with mild (RR=2.60, 95% CI 1.70-3.90), moderate (RR=1.90, 95% CI 1.20-2.80), and severe (RR=2.00, 95% CI 1.40-3.00) sleep apnoea had significantly increased rates of MVCs, compared to age- and sex-matched controls. Furthermore, when the impact of sleep apnoea on MVC-related injury was examined, drivers with mild (RR=4.80, 95% CI 1.80-12.40), moderate (RR=3.00, 95% CI 1.30-7.00) & severe (RR=4.30, 95% CI 1.80-8.90) sleep apnoea had significantly higher rates of MVCs than controls.
- Teran-Santos et al. (1999) found that drivers with sleep apnoea (AHI≥10) had a significantly higher MVC rate compared to drivers without sleep apnoea (OR=6.30, 95% CI 2.40-16.20).

Fair quality:

- Horstmann et al. (2000) reported that drivers with sleep apnoea were significantly more likely to have been involved in an MVC (12.4%) compared to age- and sex-matched controls (2.9%; p<0.01).

Poor quality:

- Lloberes et al. (2000) reported that drivers with sleep apnoea had a significantly higher number of MVCs over the previous five years (0.6±0.7) compared with age- and sex-matched controls (0.07±0.03, p<0.05), but not drivers with non-apnoeic snoring (0.3±0.5, p>0.05).

Cross-sectional/Cohort

Good quality:

- Akkoyunlu et al. (2013) reported that highway drivers with sleep apnoea had a significantly higher MVC/year ratio (Md=0.00, Range=0.00-0.07) than highway drivers without sleep apnoea (Md=0.00, Range=0.00-0.00; p<0.05).
- Arita et al. (2015) reported that the MVC rates due to falling asleep while driving for drivers with severe (9.8%) & very severe (16.9%) sleep apnoea were 1.5 and 2.6 times higher than drivers who are ‘simple snorers’ (6.4%; p<0.05, p=0.01, respectively).
- Barbé et al. (1998) reported that drivers with sleep apnoea syndrome had a significantly higher mean number of MVCs (M=0.53, SD=0.10) during the previous
three years compared to the general driving population (M=0.22, SD=0.06; p<0.05). When controlling for the number of kilometres driven, drivers with sleep apnoea were significantly more likely to be involved in an MVC risk MVC compared to the general driving population (OR=2.60, 95% CI 1.06-6.43, p<0.05). Drivers with sleep apnoea were also significantly more likely to have had more than one MVC compared to the general driving population (OR=5.20, 95% CI 1.07-25.29, p<0.05).

- Findley et al. (1988) reported that drivers with sleep apnoea had a sevenfold higher MVC rate (0.41 events per driver over five years) than drivers without sleep apnoea (0.06 events per driver over five years; p<0.01). Furthermore, the proportion of drivers with one or more MVCs was significantly higher for drivers with sleep apnoea (31%) compared to drivers without sleep apnoea (6%, p<0.01). Finally, the at-fault MVC rate was significantly higher for drivers with sleep apnoea (24%) compared to drivers without sleep apnoea (3%; p<0.01).

- George and Smiley (1999) reported that drivers with sleep apnoea had significantly higher MVC rates/year for preceding five years (M=0.09; SD=0.14) compared to drivers without sleep apnoea (M=0.07; SD=0.14, p<0.05).

- Komada et al. (2009) reported that drivers with sleep apnoea were significantly more likely to be involved in an MVC compared to age-matched controls from the general population (OR=2.36, 95% CI 1.62-3.44).

- Karimi et al. (2015a) reported an increased MVC risk ratio of 2.45 for drivers referred for sleep apnoea compared with the general driving population (p<0.01).

- Young et al. (1997) reported that drivers with mild sleep-disordered breathing (AHI=5-15) were significantly more likely to have at least one MVC in the previous five years compared to drivers without sleep-disordered breathing (OR=4.20; 95% CI 1.60-11.30; p<0.05). Furthermore, drivers with moderate sleep-disordered breathing (AHI>15) were significantly more likely to have multiple MVCs in the previous five years compared to drivers without sleep-disordered breathing (OR=7.30, 95% CI 1.8-25; p<0.05).

- Gottlieb et al. (2018) reported that drivers with mild, moderate and severe sleep apnoea had adjusted ORs for any MVC that were respectively 7%, 13% and 123% higher compared to drivers without sleep apnoea, independently of excessive sleepiness (p=NR).

- Wu and Yan-Go (1996) reported that drivers with sleep apnoea were significantly more likely to report at least one MVC (31%) compared to drivers without sleep apnoea (15%; p<0.01). Furthermore, drivers with sleep apnoea had an increased MVC ratio compared to drivers without sleep apnoea (OR=2.58, 95% CI 1.06-6.31, p=0.04).

- Shiomi et al. (2002) reported that drivers with severe sleep apnoea (AHI>30) had a significantly higher rate of MVCs compared to drivers who were ‘simple snorers’ (p<0.05).

- Ward et al. (2013) reported that the mean MVC rate ratio was significantly higher for drivers with sleep apnoea (AHI≥5/h) compared to the general driving population (RR=3.07, 95% CI 2.98-3.17).

Before-after

Fair quality:

- Findley et al. (2000) found that drivers with sleep apnoea had a significantly higher MVC rate than all drivers in the state of Colorado (0.07 vs. 0.01 per driver per year, p=0.02).

8.4.3.2 Studies reporting evidence of no difference in risk (N=6)

Cross-Sectional/Cohort
Good quality:

- Aldrich (1989) reported that the proportion of drivers with sleep apnoea who reported MVCs (19% men, 15% women) was not significantly different to age- and sex-matched drivers without sleep disorders (11% men, 6% women; p>0.05).
- Kim et al. (2018) reported no differences in the drowsy-related MVC rates between drivers with and without moderate-to-severe sleep apnoea (peripheral arterial tonometry respiratory distress index≥15/h; p>0.05).

Fair quality:

- Garbarino et al. (2016) reported no significant differences in the number of MVCs between drivers with no sleep apnoea, mild sleep apnoea, moderate sleep apnoea and severe sleep apnoea groups (p>0.05).
- Howard et al. (2004) reported that self-reported diagnosis of sleep apnoea was not associated with MVC involvement in the previous three years (OR=0.82, 95% CI 0.53–1.26, p=0.36).
- Philip et al. (2010) reported no significant difference in the proportion of drivers reporting an MVC between drivers with sleep apnoea (5.8%) and drivers without a sleep disorder (p>0.05).
- Stoohs et al. (1994) reported no significant difference between MVCs/miles driven for drivers with sleep-disordered breathing (0.09 MVCs/10,000 miles) and drivers without sleep-disordered breathing (0.05 MVCs/10,000 miles; p=0.14).

8.4.3.3 Studies reporting inconclusive evidence of risk (N=2)

Case-Control

Good quality:

- Kingshott et al. (2004) reported no differences between MVC drivers and matched controls in any polysomnography measure of sleep-disordered breathing (i.e., AHI; p=0.89) or differences in the proportion of sleep stages (all p>0.05).

Cross-Sectional/Cohort

Fair quality:

- Karimi et al. (2015b) reported that the proportion of drivers with more severe sleep apnoea (apnoea events ≥5 per hour) was not significantly different between those involved in MVCs (73%) and those not involved in MVCs (78%, p=0.70).

8.4.3.4 Studies reporting evidence of increased risk associated with sleep apnoea severity (N=13; including N=7 specific focus on severity)

Case-Control

Fair quality:

- Horstmann et al. (2000) found that a greater proportion of drivers with a high sleep apnoea severity (i.e., AHI>34/h) reported MVCs than drivers with lower sleep apnoea severity (i.e., AHI=10-34/h; p<0.05). Moreover, drivers with higher sleep apnoea severity had higher average MVC rates per one million km compared to drivers with lower sleep apnoea severity (p<0.05), which was also the case for more serious MVCs (i.e., >$600 &/or personal injury).

Cross-Sectional/Cohort

Good quality:

- Akkoyunlu et al. (2013) found severity of sleep apnoea was associated with an increased risk of MVC. Increasing years spent as a professional driver corresponded with higher severity of sleep apnoea, as measured by AHI scores (r=0.57; p<0.01). Furthermore, a significant relationship was found between the ratio of MVCs per year and arousal index (r=0.33, p<0.05).
Arita et al. (2015) found that the rates of MVCs due to falling asleep while driving in the severe (9.8%) and very severe (16.9%) sleep apnoea groups were 1.5 and 2.6 times higher than the rate for the drivers with simple snoring (6.4%; p<0.05, p=0.01, respectively).

George and Smiley (1999) noted that the higher rates of MVCs per year in those with sleep apnoea could be accounted for by those drivers with severe sleep apnoea (AHI>40), since there were no significant differences in MVC rates among drivers without sleep apnoea and the drivers with mild (AHI=10-25) and moderate sleep apnoea (AHI=26-40).

Gottlieb et al. (2018) reported that AHI (as measured during PSG) was significantly higher among those involved in an MVC (M=5.50 events per hour, 95% CI 1.3-13.79) than those who were not involved in an MVC (M=4.30 events per hour, 95% CI 1.3-10.9; p<0.01). In addition, there was an increased risk of MVC for each additional 10 events per hour (OR=1.15, 95% CI 1.04-1.26, p<0.01). This increased risk remained when those with excessive sleepiness were excluded (OR=1.17, 95% CI 1.02-1.33, p=0.02).

Komada et al. (2009) found that experiencing an MVC, as well as dozing off at the wheel, were significantly associated with increase in AHI (p<0.05 for both). MVC risk significantly associated with increase in AHI score (AHI≥40: OR=1.75, 95% CI 1.03-2.98, p<0.05). As stated above, the study also provided evidence that AHI scores were significantly higher for drivers with multiple MVCs than drivers with a single MVC (p<0.05).

Fair quality:

Garbarino et al. (2016) also reported a significant relationship between sleep apnoea severity and MVCs in their sample of commercial drivers (p<0.05).

8.4.3.5 Studies reporting evidence of no difference in risk associated with sleep apnoea severity (N=4)

Cross-Sectional/Cohort

Good quality:

Karimi et al. (2015a) failed to find an association between sleep apnoea severity (i.e., AHI) and MVC risk (p≥0.80). The authors concluded that apnoea events do not predict MVC risk.

Kingshott et al. (2004) found no significant differences between drivers who were involved in MVCs, compared to those who were not involved in MVCs, in AHI (p=0.89).

Fair quality:

Karimi et al. (2015b) found that sleep apnoea severity poorly predicted MVCs (p>0.20)

Before-after

Poor quality:

Yoshino et al. (2006) reported that severity of sleep apnoea was not predictive of MVCs prior to initiation of CPAP treatment (p>0.05).

8.4.3.6 Studies reporting inconclusive evidence of risk associated with sleep apnoea severity (N=2)

Cross-Sectional/Cohort

Good quality:

Young et al. (1997) reported that odds of MVC did not increase with sleep disordered breathing severity however no statistical tests were conducted.

Poor quality:
• Shiomi et al. (2002) reported that the rate of MVCs increased with the severity of sleep apnoea as classified by AHI, no statistical tests were reported.

8.4.3.7 Studies reporting evidence of increased risk associated with no sleep apnoea treatment (N=5)

Cross-Sectional/Cohort

Good quality:
• Burks et al. (2016) found that commercial drivers with sleep apnoea with no record of adherence to APAP treatment had a higher rate of MVCs (0.07 per 100,000 miles) compared to the matched controls (0.01 per 100,000 miles). The MVC rate in non-adherent drivers with sleep apnoea was five-fold greater (RR=4.97, 95% CI 2.09-10.63, p<0.01) than that of the control group.
• George (2001) reported that untreated drivers with sleep apnoea had a higher rate of MVCs per year (M=0.06 per driver; SD=0.17) compared to the general driving population (M=0.18 per driver; SD=0.29, p<0.01).
• Karimi, Hedner, Häbel, Nerman, and Grote (2015) reported that MVC incidence increased by 54% among drivers with sleep apnoea who were noncompliant with CPAP (i.e., <4 hours/night or off treatment).
• Komada et al. (2009) found that the proportion of drivers who experienced MVCs was significantly higher in untreated drivers with sleep apnoea compared with the control group (p<0.01).

Before-after
Fair quality:
• Findley et al. (2000) found that drivers with sleep apnoea who were not being treated with nasal CPAP continued to have a high at-fault MVC rate before and after diagnosis (for both before and after: 0.07 MVCs per driver per year, 95% CI 0.01-0.25).

8.4.3.8 Studies reporting evidence of decreased risk associated with CPAP treatment (N=6)

Cross-Sectional/Cohort

Good quality:
• George (2001) found, following CPAP treatment, the number of MVCs per year for drivers with sleep apnoea (M=0.06 per driver, SD=0.17) decreased significantly (p<0.01) and was comparable to that of drivers without sleep apnoea.
• Karimi, Hedner, Häbel, et al. (2015a) found that CPAP use greater or equal to four hours per night was associated with a 70% reduction of MVC incidence (7.6 to 2.5 per 1,000 drivers per year).
• Komada et al. (2009) reported that the proportion of drivers with sleep apnoea who experienced MVCs was significantly lower following treatment with CPAP (3.1%), compared with pre-CPAP treatment (16.8%; p<0.01).

Before-after
Fair quality:
• Findley et al. (2000) reported that drivers who were treated with nCPAP had a significantly lower MVC rate while being treated than before treatment (0.07 vs. 0 per driver per year, p=0.03).

Poor quality:
• Cassel et al. (1996) found that, following nasal CPAP, the MVC rate significantly decreased from 0.80 per 100,000 km (untreated) to 0.15 per 100,000 km (nCPAP treatment, p<0.01).
• Krieger et al. (1997) reported a decrease in the average number of MVCs following treatment (p<0.01). Furthermore, the number of drivers and the average number of MVCs per driver significantly decreased following treatment (p<0.01).

8.4.3.9 Studies reporting evidence of decreased risk associated with UPPP treatment (n=1)

Case-control

Good quality:

• Haraldsson et al. (1995) reported that, after correction for driving exposure, drivers with rhonchopathy had a greater reduction in MVC risk compared to controls (i.e., drivers without rhonchopathy with either nasal septum or polyposis) following treatment with UPPP (RR=0.60, 95% CI NR, p<0.01). In addition, this reduction was greater (over 7 times greater) for single-vehicle (at-fault) MVCs (RR=1.30, 95% CI NR, p<0.01). Among drivers with rhonchopathy, the number of single-car MVCs over five years decreased by 83% (p<0.05), while there was a non-significant difference of MVCs for controls. Furthermore, among drivers with rhonchopathy, the number of drivers involved in a single-vehicle MVC decreased by 76.9% (p<0.05), while it did not change among controls.

8.4.3.10 Studies reporting evidence of no difference in risk associated with CPAP treatment (N=1)

Before-after

Poor quality:

• Engleman et al. (1996) reported that mileage- and time-adjusted MVC rates (per 10,000 miles) did not show a significant reduction in the rate of both casualty-free “minor” MVCs and MVCs causing injury (considered “major”) after CPAP therapy (p>0.30, p>0.20, respectively). This was also the case for sleep-related MVC rates (p>0.20, p>0.10 for minor and major MVCs, respectively).

8.4.3.11 Studies reporting inconclusive evidence of risk associated with CPAP treatment (N=2)

Before-after

Poor quality:

• Yoshino et al. (2006) reported 43.4% of drivers with sleep apnoea had experienced MVCs before CPAP therapy, compared to 5.7% after an average of 18 months of therapy. However, the authors did not compare these rates statistically, so these results must be interpreted with caution.

• Yamamoto, Akashiba, Kosaka, Ito, and Horie (2000) reported that there were no MVCs for the drivers during treatment, while 13 of 39 drivers (33.3%) had had MVCs before treatment. Based on this, the authors suggested that long-term nasal CPAP treatment reduces the rate of MVCs, however, the authors did not compare these rates statistically.

8.4.4 HYPERSOMNOLENCE AND NARCOLEPSY

8.4.4.1 Studies reporting evidence of increased risk (n=5)

Cross-Sectional/Cohort

Good quality:

• Aldrich (1989) reported that the proportion of drivers with narcolepsy (52% men, 29% women) reporting sleep related-MVCs was more than four times higher than comparison groups (11% men, 6% women; p<0.01).

• Pizza et al. (2015) reported that the MVC risk was significantly higher for drivers with central disorders of hypersomnia compared to controls after adjustment for gender,
age, marital status & caffeine consumption (p<0.01). In addition, the association between category of central hypersomnia and MVC was highest risk for narcolepsy type 2 (OR=2.82; 95% CI 1.60–4.96) and idiopathic hypersomnia (OR=2.04; 95% CI 1.05–3.95), compared to controls, however there was no difference between narcolepsy type 1 and controls (OR=1.68; 95% CI 0.97–2.91).

**Fair quality:**
- Philip et al. (2010) reported that drivers with narcolepsy/hypersomnia had a significantly higher risk of MVC compared to drivers without a sleep disorder (OR=3.16, 95% CI 1.36–7.33, p<0.01).
- Popkin and Stewart (1992) found that the MVC rates for drivers with seizures/narcolepsy were significantly higher than the expected MVC rates of the general driving population (t=2.60, p<0.01).

**Case-Control**

**Good quality:**
- Vernon et al. (2002) reported that drivers with episodic conditions (including narcolepsy) who had an unrestricted licence had significantly higher total and at-fault MVC rate per 10,000 licence days compared to the comparison group (Total MVC: 2.69 vs. 1.55, RR=1.73, 95% CI 1.58-1.90, p<0.05; At-fault MVC: 1.76 vs. 0.87, RR=2.02, 95% CI 1.80-2.27, p<0.05). In addition, drivers with episodic conditions (including narcolepsy) who had a restricted licence had significantly higher total and at-fault MVC rate per 10,000 licence days compared to controls (Total MVC: 2.67 vs. 1.81; RR=1.47, 95% CI 1.06-2.03, p<0.05; At-fault MVC: 2.40 vs. 1.00, RR=2.39, 95% CI 1.70-3.36, p<0.05).

8.4.5 INSOMNIA

8.4.5.1 Studies reporting evidence of increased risk (N=1)

**Cross-Sectional/Cohort**

**Good quality:**
- Garbarino et al. (2017) reported that drivers with insomnia had a significantly higher MVC rate compared to drivers without insomnia (OR=2.21, 95% CI 1.65–2.99, p<0.05). Moreover, after controlling for presence of sleep apnoea, excessive daytime sleepiness, short sleep duration, & other concurrent diseases, drivers with insomnia had an almost two-fold higher MVC risk compared to drivers without insomnia (OR=1.82, 95% CI 1.33–2.49, p<0.01).

8.4.5.2 Studies reporting evidence of no difference in MVC risk (N=1)

**Cross-Sectional/Cohort**

**Fair quality:**
- Philip et al. (2010) reported no significant difference in the proportion of drivers reporting an MVC between drivers with insomnia (6.2%) and drivers without a sleep disorder (7.0%; p>0.05).

8.5 CONCLUSIONS

8.5.1 Overall level of risk

Thirty-seven studies were identified, with the majority being cohort and cross-sectional studies. In total, quality of evidence was rated 'good' for twenty studies and 'fair' for nine studies. The majority of included studies (n=33) addressed sleep apnoea and sleep-related breathing disorders (including sleep apnoea severity, and sleep apnoea treatment) with only five studies addressing central disorders of hypersomnolence and narcolepsy, and two studies addressing insomnia. No studies included on-road driving evaluations as an outcome measure.
Of the thirty-three studies specifically investigating MVC risk associated with sleep apnoea, seventeen studies reported an increased risk and of these, ten were rated ‘good’ (Mulgrew et al., 2008; Teran-Santos et al., 1999; Akkoyunlu et al. 2013; Arita et al., 2015; Barbé et al., 1998; Findley et al., 1988; George & Smiley, 1999; Komada et al., 2009; Karimi, Hedner, Habel, et al., 2015a; Young et al., 1997) and four were rated ‘fair’ (Horstmann et al., 2000; Gottlieb et al., 2018; Wu & Yan-Go, 1996; Findley et al., 2000). Where ORs and RRs were reported, half indicated around two and a half times elevated risk (Range: 1.5 – 7.3).

Six studies reported no difference in MVC risk associated with sleep apnoea, two ‘good’ studies (Aldrich, 1989; Kim et al., 2018), and four ‘fair’ (Garbarino et al., 2016; Howard et al., 2004; Philip et al., 2010; Stoohs et al., 1994).

With respect to the effects severity of sleep apnoea on MVC risk, seven studies reported an increased risk associated with increased severity; five were rated ‘good’ (Akkoyunlu et al., 2013; Arita et al., 2015; George & Smiley, 1999; Gottlieb et al., 2018; Komada et al., 2009) and two studies were rated ‘fair’ (Horstmann et al., 2000; Garbarino et al., 2016). In contrast two ‘good’ studies (Karimi, Hedner, Häbel, et al., 2015a; Kingshott et al., 2004) and one fair study (Karimi, Hedner, Zou et al., 2015b) reported no difference in risk.

Eleven studies specifically reported evidence for the effects of treatment of sleep apnoea on MVC risk. Five studies reported increased risk for untreated sleep apnoea: four rated ‘good’ (Burks et al., 2016; George, 2001; Karimi, Hedner, Häbel, Nerman & Grote, 2015; Komada et al., 2009) and one rated ‘fair’ (Findley et al., 2000). Three studies rated ‘good’ (George, 2001; Karimi, Hedner, Häbel, et al., 2015a; Komada et al., 2009) and one study rated ‘fair’ (Findley et al., 2000) reported evidence of a significant decrease in risk associated with CPAP treatment, with one noting a 70% decrease and another reported a CPAP-treated rate that was comparable with drivers without sleep apnoea. One study, rated ‘good’ also reported evidence of decreased risk associated with UPPP treatment (Haraldsson et al., 1995).

Five studies investigated MVC risk associated with disorders of hypersomnolence and narcolepsy, with all suggesting increased risk; three studies rated ‘good’ identified increases between two and four times higher than drivers without these conditions (Aldrich, 1989; Pizza et al., 2015; Vernon et al., 2002) and two rated ‘fair’ (Philip et al., 2010; Popkin and Stewart, 1992).

Only two studies investigated MVC risk associated with insomnia, with inconsistent findings: one ‘good’ study reporting increased risk of MVC (Garbarino et al., 2017) and one ‘fair’ study reporting no difference (Philip et al., 2010).

Overall, for sleep apnoea, findings were mixed; however, the weight of evidence from fourteen studies rated ‘good’ or ‘fair’, revealed findings of elevated MVC risk in the moderately elevated range with the majority around two and a half times higher than those without apnoea. This evidence must be tempered by findings from a smaller number of studies reporting no difference in risk.

8.5.2 Study limitations

The principal limitation to this review is the paucity of data. While data from several studies spanned several decades, only half (54%) were of high quality. Many of the studies were published more than forty years ago, with just twelve published in the last decade. This is particularly significant, given that recent advances in screening for OSA and medical treatments are highly relevant for improving functional abilities of drivers, and similarly, improved vehicle technologies and infrastructure have also had a positive impact on lowering MVC risk. Only nine studies adjusted for driving exposure and two adjusted for comorbidities. Studies were conducted in numerous jurisdictions with different requirements for licensing of drivers with sleep disorders, unknown periods of absence from driving (formal or informal), different methods and outcome measurements. This has precluded meta-synthesis of results from included studies. The varied samples, and the methods for estimating risk also limit the generalisability of findings.
8.5.3 Current fitness-to-drive guidelines

The potential for heightened MVC risk with variable alertness associated with excessive daytime sleepiness due to sleep disorders has justifiably prompted careful consideration by licensing jurisdictions on the requisite conditions for determining fitness-to-drive of drivers with these conditions. The current systematic review identified evidence for an increased motor vehicle MVC risk associated with sleep disorders (including sleep apnoea, narcolepsy and insomnia).

As summarised in Appendix F (Section 20.3), all reviewed guidelines for private and commercial licences specified that a diagnosis of sleep disorder should be taken into account when determining a driver’s fitness-to-drive. There is general agreement across international guidelines that drivers with sleep disorders may not hold an unrestricted licence. Specifically, Australian guidelines specify an unrestricted licence may not be held if there is a diagnosis of moderate to severe sleep apnoea (a score from 16 to 24 on the ESS) or a diagnosis of narcolepsy, frequent self-reported episodes of sleepiness or drowsiness while driving, involvement in MVC, or doctor deems driver to be at significant driving risk. Instead, the guidelines indicate a conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from the treating doctor (or a sleep specialist in the case of commercial drivers) subject to compliance with, and satisfactory response to, treatment. US and EU guidelines specify specific levels of severity of apnoea must be met, using AHI criteria rather than ESS. Canada and EU guidelines specify annual medical review for commercial licence drivers. For sleep apnoea, the evidence for increased risk of MVC (and higher risk for higher severity; higher risk for untreated; lower risk with CPAP treatment) is consistent with current Australian (and international) fitness-to-drive guidelines. Hence, no change is recommended. For hypersomnolence and narcolepsy, the evidence, albeit limited, is consistent with current Australian (and international) fitness-to-drive guidelines and no is change recommended. For insomnia, there is very limited, inconsistent evidence which precludes definitive recommendations for fitness-to-drive decisions. Current Australian guidelines do not specify licensing requirements for drivers with insomnia and no change is recommended.

8.5.4 Recommendations

Further research should include objective measures of sleep disorders and MVC risk, as well as measurement of confounds including driving exposure, medication use/compliance, comorbidities and disorder severity. Consideration of on-road driving performance is also warranted. A population-based controlled study in multiple licensing jurisdictions that investigates the MVC risk for drivers with sleep disorders is recommended. Furthermore, given the limited evidence identified in this review, a particular research focus is warranted on MVC risk for commercial licenced drivers with sleep disorders.

Notwithstanding study limitations, there is some evidence for a moderate elevation of risk, a heightened risk with non-treatment, and lower risk with treatment which justifies the presence of guidelines regarding restrictions of driving (conditional licence) in those with sleep disorders.

8.6 REFERENCES


commercial vehicle drivers. *American Journal of Respiratory and Critical Care Medicine, 170*(9), 1014-1021.


This chapter provides a high-level summary of the key findings and recommendations from a systematic literature review that evaluated the available evidence regarding the influence of vision disorders on MVC risk and on-road driving performance. For the full systematic literature review, please refer to:


9.1 OVERVIEW AND KEY RECOMMENDATIONS

- Worldwide estimates suggest that the prevalence of visual impairment is around 596 million worldwide (Burton et al., 2021), with cataracts, age-related macular degeneration (AMD), glaucoma and diabetic retinopathy being the leading causes of visual impairment, particularly in older adults (Flaxman et al., 2017). The prevalence of vision disorders also increases with age (Wang et al., 2000).
- The aim of this systematic review was to evaluate and summarise the literature examining the impact of vision disorders and visual impairment on motor vehicle crash (MVC) risk and on-road driving performance.
- The review was registered with PROSPERO (CRD42020180135). A systematic search of seven public health, psychology and transport safety databases was conducted on April 2nd 2020. The quality of the evidence for each study was rated using the National Heart, Lung and Blood Institute Quality Assessment tools (NHLBI, 2014).
- The database searches resulted in the identification of 6,617 articles, with a further two studies identified through bibliographic review.
- Forty-eight studies met the inclusion criteria and were included for evidence synthesis, of which 36 reported MVC risk outcomes only, nine reported on-road performance assessment outcomes only, and three reported both MVC risk and on-road performance outcomes.
- Visual acuity impairment was most frequently studied (n=17), followed by visual field impairment (n=11). Glaucoma was the most frequently studied eye disease, followed by age-related macular degeneration (AMD) and cataract; no studies assessed the impact of diabetic retinopathy on driving outcomes that met review the inclusion criteria.
- Of the 39 studies reporting MVC outcomes, 34 were observational cohort studies and five were case-control studies. In terms of quality, 15 were rated as ‘good’, 17 rated as ‘fair’, and seven rated as ‘poor’ quality. Of the 12 studies reporting on-road performance outcomes, five were rated as ‘good’ and seven were rated as ‘fair’ quality.
- As less than half of the studies were of ‘good’ quality and findings were often conflicting, firm conclusions cannot be drawn for most vision disorders.
- However, there is some evidence from studies rated as ‘good’ quality indicating that there is increased MVC risk in drivers with binocular visual field impairment.
- Evidence is inconclusive regarding the impact of mild visual acuity impairment, cataract, glaucoma, age-related macular degeneration, and homonymous field loss on MVC risk.
- Recommendations: This review highlights the need for future well-designed studies, including larger sample sizes of drivers with a wide range of visual loss, to explore the impact of vision disorders and visual impairment on driving outcomes, in order to inform evidence-based policy and fitness to drive guidelines. Further studies are also required to determine the extent of the binocular VF required to support safe driving. Collectively, these studies would assist in identifying how vision disorders and visual impairment impact on driving ability and safety, to ensure that drivers with
such impairments are not being unnecessarily restricted from driving, with the associated negative impacts on independence and mobility. This is particularly important given the ageing of our population, the prevalence of eye disease/disorders associated with ageing and the role of vision in safe driving.

Authors:
Professor Joanne Wood¹, Dr Alex Black¹, Dr Kaeleen Dingle², Mr Cameron Rutter³, Dr Marilyn Di Stefano⁴, Associate Professor Sjaan Koppel⁵, Professor Judith L. Charlton⁵ and Professor Sharon Bentley¹

Affiliations:
¹Centre for Vision and Eye Research, School of Optometry and Vision Science, Queensland University of Technology, Queensland, Australia, ²School of Public Health and Social Work, Queensland University of Technology, Queensland, Australia, ³Academic Division, Library, Queensland University of Technology, Queensland, Australia, ⁴Road Safety Victoria, Department of Transport, Victoria, Australia, ⁵Monash University Accident Research Centre, Monash University, Victoria, Australia.

Sponsoring organisations:
This project was funded as contract research by the following organisation: Road Safety Victoria, Department of Transport/VicRoads, Victoria.

Keywords:
Vision disorders; Eye disease; Vision impairment; Motor vehicle crashes; On-road driving performance

9.2 BACKGROUND

Driving a motor vehicle requires the ability to observe, interpret and respond appropriately in a highly complex visual environment. Adequate visual function is therefore a key requirement for safe driving. For this reason, most driver licensing jurisdictions around the world have defined visual acuity and visual fields standards for driver licensing. The requirement to meet those standards is usually tested prior to issuing an initial driver licence, however, the requirement to meet visual standards at future licence renewal varies considerably between jurisdictions. Some jurisdictions require evidence of satisfactory vision prior to licence renewal throughout the driving lifespan, whilst others mandate vision testing for older drivers only.

As the population ages, the number of drivers with visual impairment resulting from vision disorders is increasing, given the prevalence of vision disorders increases with age (Foreman et al., 2018; Wang et al., 2000). Estimates suggest that the prevalence of visual impairment worldwide is around 596 million (Burton et al., 2021), with cataracts, age-related macular degeneration (AMD), glaucoma and diabetic retinopathy being the leading causes, particularly in older adults (Flaxman et al., 2017). This increase in prevalence of visual impairment has important implications for driving ability and safety, given the role of vision in driving (Wood & Black, 2016). While most driver licence jurisdictions around the world have defined vision standards for driver licence eligibility, the criteria for meeting these visual standards vary greatly both between and within countries, and are not necessarily evidence-based (Wood, 2019).

9.2.1 Scope

The aim of this systematic review was to determine the impact of common vision disorders and/or visual impairment on MVC risk and on-road driving test outcomes.

9.2.2 Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). PRISMA provides a detailed guide
on the conduct and reporting requirements for systematic reviews and meta-analyses. The protocol for this systematic review was prospectively registered with PROSPERO (CRD42020180135).

9.2.3 Definition

For the purpose of this review, MVC risk was assessed by the frequency of crashes involving motor vehicles as identified by self-report or official crash records.

On-road driving performance outcomes were assessed by driving tests using standardised criteria to assess fitness to drive, and administered by either a driving instructor, driving occupational therapist or driver licensing authority.

9.3 METHOD

9.3.1 Eligibility criteria

9.3.1.1 Inclusion criteria

Studies were included in the systematic review according to the following a priori criteria:

1. Original research published in a peer-reviewed journal;
2. English language and human studies;
3. Full text available;
4. Studies with population including drivers with vision disorders and/or visual impairment (assessed either by eye health professional and/or standardised vision measures);
5. Studies with a comparison/control population of drivers without vision disorders and/or visual impairment;
6. Studies with either MVC risk (self-report or state-recorded) and/or on-road driving test outcomes (standardised criteria to assess fitness-to-drive, administered by driving instructor, driving occupational therapist or driver licensing authority);
7. Studies which used quantitative methods for data collection and analysis.

9.3.1.2 Exclusion criteria

Studies were excluded from the systematic review according to the following a priori criteria:

1. Commentary manuscripts;
2. Literature or systematic reviews;
3. Case studies;
4. Conference abstracts and proceedings;
5. Dissertations;
6. Studies which use driving simulator methods for data collection;
7. Studies which include participants who are non-drivers, and
8. Studies which only use qualitative methods for data collection and analysis.

9.3.2 Information sources

Relevant studies were identified before the development of a search strategy and were defined as ‘goldset studies’ by three expert vision researchers (n=21). These studies were used to identify and refine the relevant search terms and keywords, particularly keywords and MeSH terms for vision disorders and visual impairment that impact on driving ability and safety.

The search terms included MeSH terms and keywords that incorporated the following three key concepts: drivers of automobiles, vision disorders and visual impairment, and MVC risk and on-road driving performance.

An electronic search of databases from the disciplines of public health, psychology and transport safety (Cochrane Library, Ovid Medline, Ovid PsycINFO, EMBASE, CINAHL PLUS via EbscoHost, Ovid TRANSPORT and TRID: the TRIS and ITRD databases) was conducted on April 2nd 2020, to locate studies from the first available year to April 2nd 2020.
9.3.3 Search

The review of published literature was conducted in the English language in two stages:
Step 1: A key word search was conducted for two concepts:


*Concept 2A* Outcome = Crash Risk, *Concept 2B* Outcome = On-road Driving Test Outcome.

Step 2: Consisted of a systematic search of the included seven databases using a combination of keywords, MeSH terms, and equivalent indexed terms (see Appendix G, Section 21.2). In addition, a bibliographic and citation review of the 48 included articles was also conducted. Limits were applied to the search: English language and human studies only; but no date limits were applied.

9.3.4 Study selection

Results from the search strategy were exported into EndNote X9 software, and duplicates were removed using a standard function, as were articles in the incorrect format (e.g., commentary, case studies, conference abstracts). The studies that remained after removal of duplicates were exported to Covidence (Cochrane technology platform) for title and abstract review. Three reviewers (JW, SB, AB) worked independently and in duplicate to screen the remaining titles and abstracts for inclusion. Any queries raised were resolved by discussion and agreement, or by a third reviewer. The same strategy was used for the full-text screening stage, to include/exclude studies using the study criteria and code the reasons for exclusion.

9.3.5 Data collection process

A full-text review of each included study was conducted by three reviewers (JW, SB, AB) who worked independently and in duplicate; the following data items were extracted into a pretested data extraction sheet: citation; study aim; research design; study period; study location, study population definition; key participant demographics (i.e., age range and mean); data sources; MVC risk outcome; on-road driving test outcome; main research findings, and risk of bias assessment (see section 2.3.6 below). Reviewers did not extract data from their own studies. Any discrepancies between the two reviewers were resolved by discussion and agreement, or by a third reviewer. Where a study did not report any statistical findings relevant to the aims of this systematic review and there was sufficient data reported in the paper, the authors calculated a crude OR and 95% CI using online statistical tools (https://www.medcalc.org/calc/odds_ratio.php).

9.3.6 Risk of bias

The risk of bias was assessed independently by two of four reviewers (either KD, SB, JW, AB) using the National Heart, Lung and Blood Institute (NHLBI) Quality Assessment tools (NHLBI, 2014). Each reviewer completed a table that scored each study against the 12 criteria for case-control studies or 14 criteria for observational cohort and cross-sectional studies. Each study was assessed for risk of potential: selection bias, information bias, measurement bias or confounding factors. Based on this assessment, the two reviewers independently gave each study an overall quality rating of ‘good’, ‘fair’ or ‘poor’, where the greater the risk of bias, the lower the quality rating of the study. Reviewers did not assess the quality of their own studies. Any discrepancies between the two reviewers were resolved by a third reviewer.
In total we screened 6,617 citations, extracted from seven databases, for eligibility (see Figure 1): 3,112 articles were screened in Covidence after duplicate records were removed. Following screening of titles and abstracts, 159 articles remained where full text articles were available. These full text articles were screened on inclusion and exclusion criteria and assessed for eligibility, which resulted in 48 studies included for the evidence synthesis, of which 36 reported MVC risk outcomes only, nine reported on-road performance assessment outcomes only, and three reported both MVC risk and on-road performance outcomes.
9.4.2 Study descriptions

Of the 39 studies reporting MVC risk outcomes, 11 were published in the last 10 years (2010-2020), with a range from 1976 to 2019. Most were conducted in the United States (n=26), with the remaining conducted in Australia, Nigeria, Canada, Japan, South Africa, UK, and multi-national (Canada, Australia, New Zealand). Most studies were retrospective cohort studies (n=29), five were prospective cohort studies and five were case-control studies. Studies included drivers with the following vision disorders: AMD, cataract, glaucoma, genetic retinal diseases, homonymous hemianopia and quadrantanopia, and a combination of vision disorders. Studies also included drivers with the following visual impairments: reduced visual acuity (VA), visual field (VF) loss, and VA and/or (VF) impairment. Note that conditions and disorders resulting in visual field impairments (e.g., VF loss, glaucoma, hemianopia/quadrantanopia) were considered separately, as studies grouped as VF loss considered any type/pattern of field defects, whereas hemianopic and quadrantanopic loss and glaucomatous field loss included participants with specific patterns of field loss. The sample size of drivers with visual impairment across all included studies ranged from 10 to 2,071. The age of the drivers with visual impairment was predominantly older (65 years and older), however, some studies included younger and middle-aged drivers (homonymous hemianopia and quadrantanopia, genetic retinal diseases), while others included a very wide age range. Overall, there was a wide range of gender distributions, from 0% to 100% male.

In terms of the quality of evidence ratings, 15 studies were rated ‘good’, 17 studies rated ‘fair’, and seven studies rated ‘poor’. Studies with a ‘poor’ quality of evidence rating did not contribute to the conclusions regarding the MVC risk associated with vision disorders and/or visual impairment.

Of the 12 studies reporting on-road assessment outcomes, seven were published in the last 10 years (2010-2020), with a range from 1995 to 2018. Most of the studies were conducted in the United States (n=6) and Australia (n=4), with the remaining conducted in Germany and Canada. All studies were cross-sectional in design. Studies included drivers with the following vision disorders: AMD, glaucoma, homonymous hemianopia/quadrantanopia, genetic retinal disease, and a combination of vision disorders. The sample size of drivers with visual impairment ranged from 10 to 75, with a mean sample size of 29 participants. The age of the drivers with visual impairment was predominantly older (65 years and over), with some younger and middle-aged drivers, particularly drivers with homonymous hemianopia and quadrantanopia or those using biotic telescopes. Overall, there was a wide range of gender distribution of participants, ranging from 36% to 100% male.

In terms of the quality of evidence ratings, five studies reporting on-road assessment outcomes were rated ‘good’ and seven studies rated ‘fair’.

9.4.3 Cataract

The impact of cataract on state-recorded and self-reported MVC risk relative to controls has been explored in three studies, with mixed results. All studies were rated ‘good’ quality and included two case control and one cross-sectional/cohort study. All studies were published more than 20 years ago.

9.4.3.1 Studies reporting evidence of increased MVC risk (N=1)

Cross-sectional/Cohort

Good quality:

- Owsley et al. (1999) reported that older drivers with cataract, in one or both eyes, had a higher rate of state-recorded at-fault crash involvement in the previous five years (RR=2.48, 95% CI 1.00-6.14) compared with matched controls. However, there were no differences in the number of self-reported MVCs in the past 12 months between drivers with cataracts and controls (p=0.19).
9.4.3.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.3.3 Studies reporting evidence of no difference in MVC risk (N=2)

Case-control

Good quality:

- McGwin et al. (1998) reported no difference in state-recorded or self-reported MVC risk for older drivers with cataract compared to those without eye disease (statistics not reported in the paper).
- McCloskey et al. (1994) reported no difference in state-recorded injurious MVC risk in older drivers with cataract compared to those without eye disease (RR=1.00, 95% CI 0.70-1.60).

9.4.3.4 Studies reporting evidence for impact on on-road driving outcomes (N=0)

There have been no studies of on-road driving performance in drivers with cataract compared to controls.

9.4.4 Age-related macular degeneration (AMD)

Five studies reported on the MVC risk of drivers with AMD and were rated as ‘good’ (n=4) and ‘fair’ (n=1). There were no studies reporting increased MVC risk in drivers with AMD compared to controls, with one study reporting decreased MVC risk, and four studies reported no difference in MVC risk, when compared to controls.

Two studies assessed the on-road driving performance of drivers with AMD compared to controls, one was rated as ‘good’ quality and one ‘fair’. Overall, these studies report mixed findings, with one study reporting that on-road driving performance was less safe than controls, particularly for those with intermediate AMD, while the other study failed to find a significant between group difference in driving performance.

9.4.4.1 Studies reporting evidence of increased MVC risk (N=0)

9.4.4.2 Studies reporting evidence of decreased MVC risk (N=1)

Cross-sectional/Cohort

Good quality:

- McGwin et al. (2013) reported that older drivers with intermediate AMD had a reduced state-recorded MVC risk compared to controls (RR=0.35, 95% CI 0.13-0.91). However, the study reported similar state-recorded MVC risk compared to controls for older drivers with early (RR=0.73, 95% CI 0.36-1.50) and advanced AMD (RR=1.11, 95% CI 0.38-3.19).

9.4.4.3 Studies reporting evidence of no difference in MVC risk (N=4)

Case-control

Good quality:

- McGwin et al. (1998) reported no difference in state-recorded or self-reported MVC risk for older drivers with AMD compared to those without eye disease (statistics not reported in the paper).
- McCloskey et al. (1994) reported no difference in state-recorded injurious MVC risk in older drivers with AMD compared to those without eye disease (RR=0.90, 95% CI 0.40-2.00).

Cross-sectional/Cohort

Good quality:
• Wood et al. (2018) reported no significant difference in the number of self-reported MVCs in the previous one- or five-year period for older drivers with AMD compared to drivers without eye disease (p>0.23).

Fair quality:
• Szlyk et al. (1995) reported no significant difference in state-recorded or self-reported MVCs in the previous five-year period (p=0.10).

9.4.4.4 Studies reporting evidence for any impact on on-road driving outcomes (N=2)

Cross-sectional/Cohort

Good quality:
• Wood et al. (2018) reported that drivers with early and intermediate AMD were less safe than age-matched controls (p=0.012), with driving instructor interventions being significantly higher than controls, but only for drivers with intermediate AMD (RR=3.05, 95% CI 1.47-6.36).

Fair quality:
• Szlyk et al. (1995) reported a reduction in overall on-road performance scores in drivers with AMD, compared to controls, however, the difference failed to reach significance (p=0.07).

9.4.5 Glaucoma

Nine studies reported on the MVC risk of drivers with glaucoma compared to controls and all were rated as ‘good’ (n=4) or ‘fair’ (n=5). Five studies indicated increased MVC risk (two using state-recorded and three using self-reported data), one study indicated decreased MVC risk (state-recorded data), and three reported no difference in MVC risk (one using state-recorded and one using self-reported data).

Four studies assessed the on-road driving performance of drivers with glaucoma compared to controls and all were rated as ‘fair’ or ‘good’. Three studies suggest inferior on-road performance for drivers with glaucoma compared to controls, while one study demonstrated similar levels of performance. There is some evidence of increased risk of critical errors during driving, even for people with early/mild glaucoma.

9.4.5.1 Studies reporting evidence of increased MVC risk (N=5)

Case-control

Good quality:
• McGwin et al. (1998) reported a significant increase in state-recorded MVC risk for older drivers with glaucoma compared to those without eye disease (OR=2.90, 95% CI NR).

Cross-sectional/Cohort

Good quality:
• Haymes et al. (2007) reported that older drivers with glaucoma had a higher rate of self-reported MVC compared to controls (all MVCs, OR=6.62, 95% CI 1.40-31.23; at-fault MVCs, OR=12.44, 95% CI 1.08-143.99). Older drivers with glaucoma had a non-significant higher rate of state-recorded MVC (all MVCs, OR=3.21, 95% CI 0.72-14.27); at-fault MVCs, OR=7.21, 95% CI 0.46-113.40).

Fair quality:
• Kwon et al. (2016) reported older drivers with glaucoma had a higher state-recorded MVC rate compared with those without glaucoma (RR=1.65, 95% CI 1.20-2.28).
• Tanabe et al. (2011) reported a significant association between self-reported MVC risk and severity of glaucoma (p=0.007). Drivers with severe glaucoma had increased MVC risk compared with the control group (OR=9.30, 95% CI 2.40–35.70).
• Szlyk et al. (2005) reported that older drivers with glaucoma had a significantly higher rate of self-reported MVCs compared to controls (p=0.005).

9.4.5.2 Studies reporting evidence of decreased MVC risk (N=1)

Cross-sectional/Cohort

Good quality:

• McGwin et al. (2004) reported that older drivers with glaucoma had a lower overall state-recorded MVC rate compared to controls (RR=0.51, 95% CI 0.33–0.80). However, there was no significant difference for at-fault state-recorded MVCs (RR=0.99, 95% CI 0.54–1.80).

9.4.5.3 Studies reporting evidence of no difference in MVC risk (N=3)

Case-control

Good quality:

• McCloskey et al. (1994) reported no difference in state-recorded injurious MVC risk in older drivers with glaucoma compared to those without eye disease (RR=1.50, 95% CI 0.80–2.90).

Cross-sectional/Cohort

Fair quality:

• Szlyk et al. (2002) reported no significant difference in the number of self-reported MVCs for the glaucoma group compared to controls (p=0.77).
• Devos et al. (2018) reported no significant difference in self-reported MVCs in the previous five years for drivers with glaucoma compared to controls (p=0.33).

9.4.5.4 Studies reporting evidence for any impact on on-road driving outcomes (N=4)

Cross-sectional/Cohort

Good quality:

• Wood et al. (2016) reported that older drivers with glaucoma with mild to moderate glaucoma demonstrated reduced overall driving performance compared with controls (adjusted p=0.028). Drivers with glaucoma also demonstrated higher rates of critical errors than controls (RR=2.06, 95% CI 1.17–3.62).
• Haymes et al. (2008) reported no significant difference in overall driving performance between older drivers with glaucoma and controls (p=0.60). However, drivers with glaucoma were more likely to demonstrate critical interventions compared to controls (OR=6.00, 95% CI 1.46-24.69), and after adjustment for potential confounders (OR=10.62, 95% CI 1.46-7.35).

Fair quality:

• Bhorade et al. (2016) reported that older drivers with glaucoma were more likely to demonstrate unsafe driving (marginal or fail score; OR=4.13, 95% CI 1.30–13.14) compared to controls, that drivers with glaucoma were more likely to require a wheel intervention (OR=4.70, 95% CI 1.03–21.17), but there was no significant difference in braking interventions (OR=1.94, 95% CI 0.36–10.63).
• Devos et al. (2018) reported no significance difference in driving performance scores between drivers with glaucoma and controls (p=0.16).
9.4.6 Homonymous hemianopia and quadrantanopia

One study reported on the MVC risk of drivers with homonymous hemianopia and quadrantanopia compared to controls, was rated as ‘good’ quality and reported increased state-recorded MVC risk in this group relative to controls.

Two studies also reported on the on-road driving performance of the drivers with homonymous hemianopia and quadrantanopia from this MVC risk study and were rated as being of ‘good’ or ‘fair’ quality. The on-road driving performance in both studies was reported to be poorer in the drivers with homonymous hemianopia and quadrantanopia when compared to the controls.

9.4.6.1 Studies reporting evidence of increased MVC risk (N=1)

Cross-sectional/Cohort

Good quality:

- McGwin et al. (2016) reported that drivers with hemianopia or quadrantanopia had overall higher MVC rates (RR=2.45, 95% CI 0.89–3.95), and elevated at-fault MVC rate (RR=2.64, 95% CI 1.03–6.80), compared to controls. In a subgroup analysis, only the hemianopia group differed significantly from controls.

9.4.6.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.6.3 Studies reporting evidence of no difference in MVC risk (N=0)

9.4.6.4 Studies reporting evidence for impact on on-road driving outcomes (N=2)

Cross-sectional/Cohort

Good quality:

- Wood et al. (2009) reported no significant difference in failure rate between drivers with hemianopia and quadrantanopia and controls (p=0.068). In subgroup analyses, there was a significant different between those with hemianopia compared to controls (p=0.027) for performance outcomes on a five-point scale. However, there were no differences in the driving performance between controls compared to those with hemianopia or quadrantanopia who met the criteria for driving on the interstate (p>0.05).

Fair quality:

- Elgin et al. (2010) reported that drivers with hemianopia and quadrantanopia were more likely to have poorer safety ratings for the non-interstate sections of the drive (p<0.05). Drivers with hemianopia and quadrantanopia were more likely to require verbal interventions (p<0.05). Drivers with hemianopia were more likely to require physical interventions (p<0.001), but no differences were reported between drivers with quadrantanopia and controls. There were no differences in driving performance between controls and those with hemianopic or quadrantanopic field loss who met the criteria for driving on the interstate section (p>0.05).

9.4.7 Diabetic retinopathy

There have been no studies that have investigated the MVC risk or on-road driving performance of drivers with diabetic retinopathy compared to controls that met the inclusion criteria of this systematic review.

9.4.8 Genetic retinal diseases

Three studies reported on the MVC risk of drivers with genetic retinal diseases compared to controls and were all rated as ‘fair’ quality. Two studies indicated increased MVC risk (using state-recorded data), while one study indicated equivalent MVC risk (using self-reported data).
9.4.8.1 Studies reporting evidence of increased MVC risk (N=2)

Cross-sectional/Cohort

Fair quality:
- Fishman et al. (1981) reported that drivers with retinitis pigmentosa were more likely to self-report any MVC in previous five-year period compared to those with normal vision (p=0.02; crude OR 2.48, 95%CI 1.16-5.32)
- Szlyk et al. (1992) reported that drivers with retinitis pigmentosa have higher self-reported MVC risk than control (p=0.005; crude OR 5.07, 95%CI 1.47-17.46).

9.4.8.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.8.3 Studies reporting evidence of no difference in MVC risk (N=1)

Cross-sectional/Cohort

Fair quality:
- Szlyk et al. (1993) reported no significant difference in self-reported MVCs for drivers with central vision loss from Stargardt's disease or cone-rod dystrophy, compared to controls (statistics not reported in the paper).

9.4.8.4 Studies reporting evidence for any impact on on-road driving outcomes (N=0)

There have been no studies of on-road driving performance in drivers with any genetic retinal diseases compared to controls.

9.4.9 Combined eye disease

One study rated as ‘fair’ quality reported on the MVC risk (using both state-recorded and self-reported data) of a group of drivers with a range of eye diseases and demonstrated no difference in risk compared with that of a group of visually normal controls. Two studies assessed the on-road driving performance of drivers with a range of eye diseases compared to controls, the studies were rated as either ‘fair’ or ‘good’ quality and reported that performance for these combined groups of drivers was not significantly different to that of controls.

9.4.9.1 Studies reporting evidence of increased MVC risk (N=0)

9.4.9.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.9.3 Studies reporting evidence of no difference in MVC risk (N=1)

Cross-sectional/Cohort

Fair quality:
- Szlyk et al. (1995) reported no difference in the rate of state-recorded MVCs (p=0.06) in drivers with various eye conditions and visual impairment (N=37 young and N=23 older drivers; conditions included AMD, RP, cone-rod dystrophy, Stargardt's disease, hemianopia; severity or type of vision loss not specified), as compared to age-matched controls. There was also no significant difference in the rate of self-reported MVCs (p=0.60).

9.4.9.4 Studies reporting evidence for any impact on on-road driving outcomes (N=2)

Cross-sectional/Cohort

Good quality:
- Wood et al. (2013) reported no significant differences in overall driving performance of drivers with visual impairment who were experienced users of bioptic telescopes for driving (conditions included optic atrophy, ocular albinism, Stargardt's disease, cone dystrophy, other diseases), compared to age-matched controls (p=0.89).
Fair quality:
- Wood and Mallon (2001) reported no significant difference in overall safety rating between drivers with visual impairment (conditions included cataracts, cataracts and glaucoma, cataracts and AMD, cataracts and other, and AMD) and age-matched controls (p>0.05).

9.4.10 Visual acuity (VA) impairment

Seventeen studies reported on the MVC risk of drivers with VA impairment compared to drivers without VA impairment, including large population-based cohort studies, as well as case control studies, with studies rated as ‘good’ (n=9), ‘fair’ (n=3) or ‘poor’ (n=5). Five studies indicated increased MVC risk (using self-reported or employer-reported data), while twelve studies indicated no difference in MVC risk (eight using state-recorded data, three using self-reported data and one naturalistic driving data). It is important to note that the number of drivers in these studies that had visual acuity worse than driving standards (typically 6/12) is relatively small, which limits the ability to make conclusions about more severe levels of VA impairment on driving safety.

9.4.10.1 Studies reporting evidence of increased MVC risk (N=5)

Case-control

Poor quality:
- Humphriss (1987) reported that the proportion of drivers involved in previous MVCs who failed to meet VA licence criteria (better than 6/12 in each eye separately, or better-eye 6/6 if worse-eye worse than 6/12 or, at least 6/12 binocularly) was significantly higher than drivers with no MVC history who failed to meet VA licence criteria.

Cross-sectional/Cohort

Fair quality:
- Davison (1985) reported that for drivers aged 55 and over, reduced binocular VA (worse than 6/9) significantly increased self-reported MVC risk in the previous three years compared to those with good VA (p<0.025, one-tailed test). In all ages, right eye VA (worse than 6/6.5) was associated with any MVC type (p<0.01, one-tailed test) and left eye VA (worse than 6/6) was associated with MVC involvement in past three years (p<0.05, one-tailed test).
- Ivers et al. (1999) reported that a two-line difference in VA was associated with increased risk of self-reported MVCs (PR=1.6, 95% CI 1.00-2.40), as was VA worse than 6/18 in the right eye (PR=2.00, 95% CI 1.20-3.50). There was no increased MVC risk based on better-eye VA (PR=1.20, 95% CI 0.30-5.00) (data not reported).

Poor quality:
- Hofstetter (1976) found that the proportion of drivers with poor VA (in lowest quartile) who reported three or more MVCs was approximately double the proportion of drivers with good VA who reported three or more MVCs.
- Oladehinde et al. (2007) reported a significant increase in self-reported MVC risk for drivers with impaired VA (worse than 6/18) in the better eye compared to controls (RR=3.50, 95% CI 2.38-5.14).

9.4.10.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.10.3 Studies reporting evidence of no difference in MVC risk (N=12)

Case-control

Good quality:
- Gresset and Meyer (1994) reported no difference in MVC risk between drivers with reduced VA compared to those with normal VA and binocularity (VA 6/12 or 6/15: OR=0.97, 95% CI 0.68-1.38, VA 6/12 or 6/15 and lack of binocularity: OR=1.23, 95% CI 0.88-1.72).
- Owsey, McGwin, et al. (1998) reported no difference in injurious MVC risk for drivers with reduced VA (binocular VA worse than 6/12 compared to controls (OR=1.60, 95% CI 0.60-3.80) and no difference in non-injurious MVC risk for drivers with reduced VA compared to controls (OR=1.60, 95% CI 0.70-3.60).
- McGwin et al. (1998) reported no significant difference in state or self-reported MVC risk for drivers with reduced VA (worse than 6/12) compared to controls (statistics not reported).
- McCloskey et al. (1994) reported no significant difference in injurious MVC risk for those drivers with VA impairment regardless of the definition of impairment (6/7.5 to 6/9; 6/12; 6/15 to 6/18; 6/21 or worse) compared to VA of 6/6 or better; drivers with corrected VA of 6/15-6/18 MVC risk was reduced compared to those with VA of 6/6 or better (RR=0.30, 95% CI 0.10-0.90).

Cross-sectional/Cohort

**Good quality:**
- Margolis et al. (2002) reported that drivers with reduced VA (6/12 or worse) had similar MVC rates compared to a control group (HR=1.14, 95% CI 0.73–1.80).
- Owsey, Ball, et al. (1998) reported no difference in prospective MVC risk in those with reduced VA compared to controls (RR=1.45, 95% CI 0.58-3.64).
- Huisingh et al. (2017) reported that reduced VA (worse than 6/12) was not associated with any type of prospective crash recorded using naturalistic driving data (RR=0.98; 95% CI 0.52-1.84).

**Fair quality:**
- Cross et al. (2009) reported that drivers with any level of reduced binocular VA (worse than 6/6 but better then 6/12; 6/12 or worse) had similar MVC risk (any, injurious and at-fault) to those with VA of 6/6 or better.
- Green et al. (2013) reported no difference in MVC risk for drivers with reduced binocular VA (worse than 6/12) compared to controls, both for all MVCs (RR=1.04, 95% CI 0.74-1.48) and at-fault MVCs (RR=1.08, 95% CI 0.66-1.76).
- Keeffe et al. (2002) reported that drivers with VA (worse than 6/12) were no more likely to have a self-reported MVC than those with better VA (p>0.90).

**Poor quality:**
- Adeoti et al. (2007) reported no difference in self-reported MVC risk for drivers with impaired VA (6/9 or worse) in better-eye (p=0.85) or impaired VA in the worse-eye (p=0.54), compared to those with normal VA.
- Adekoya et al. (2009) reported no difference in self-reported MVC risk for drivers with impaired VA in the better-eye (worse than 6/9; OR=1.09, 95% CI 0.43-2.81) or impaired VA in the worse-eye (worse than 6/24; OR=1.30, 95% CI 0.56-3.00), compared to normal VA.

9.4.10.4 Studies reporting evidence for any impact on on-road driving outcomes (N=0)

There have been no studies of on-road driving performance in drivers with VA impairment compared to controls.

9.4.11 Visual field (VF) impairment

Eleven studies examined MVC risk using a range of different methods to measure and classify VF impairment, with studies rated as ‘good’ (n=6), ‘fair’ (n=2) or ‘poor’ (n=3). Five studies reported increased MVC risk for drivers with VF impairment (four reporting state-recorded MVC risk and one naturalistic driving data) and six studies reported no difference...
in MVC risk (two reporting state-recorded data, two reporting self-recorded data, and two reporting both state and self-reported data).

Two studies assessed the on-road driving performance of drivers with VF loss from a variety of eye conditions compared to controls, both were rated as ‘fair’ quality and reported decreased driving performance in those with VF impairment.

9.4.11.1 Studies reporting evidence of increased MVC risk (N=5)

Case-control

Good quality:
- Owsley, McGwin, et al. (1998) reported that older drivers involved in injurious MVCs were more likely to have VF impairment (automated perimetry, central 30° VF: OR=2.60, 95% CI 1.10-6.30, peripheral 30-60° VF: OR=2.40, 95% CI 1.30-4.50). Associations between non-injurious crash involvement and peripheral VF impairment were also observed (OR=1.80, 95% CI 1.00-3.10), but there was no increased non-injurious MVC risk for drivers with central VF impairment (OR=1.80, 95% CI 0.80-4.40). These associations were not significant when adjusted for eye condition and useful field of view.

Cross-sectional/Cohort

Good quality:
- Huisingh et al. (2017) in a study of naturalistic driving data, reported that peripheral VF impairment (confrontation technique) in either eye was associated with a higher rate of major crash involvement (adjusted RR=1.53, 95% CI 1.02–2.29). In addition, peripheral VF impairment in both eyes was associated with an increased rate of crash involvement (adjusted RR=1.74, 95% CI 1.18–2.56), major crash involvement (RR=2.32, 95% CI 1.40–3.83), and at-fault crash involvement (RR=1.73, 95% CI 1.14–2.61).
- Huisingh et al. (2015) reported that drivers with worse VF impairment (automated custom perimetry) had an increased rate of at-fault MVCs compared to those with average sensitivity in the three upper quartiles of sensitivity (RR=1.40, 95% CI 1.07–1.83). Severe binocular VF impairment (7–21 impaired points) increased risk of at-fault MVCs compared those with no VF impairment (0 impaired VF points), (RR=1.51, 95% CI 1.08–2.12).
- Rubin et al. (2007) reported that VF impairment (automated screening perimetry) was a significant predictor of crash involvement, but the association varied with the level of visual field loss. Drivers with very mild field loss had reduced risk of crash involvement compared to those with no field loss (HR=0.59, 95% CI 0.34–1.00), while those with more severe VF loss showed greater MVC risk (HR=1.31, 95% CI 1.13-4.27, p<0.01).

Fair quality:
- Johnson and Keltner (1983) reported that drivers with binocular VF loss (automated screening perimetry) had significantly elevated MVC rates compared to an age and gender-matched control group (p<0.005). However, drivers with monocular VF loss had similar MVC rates compared to an age and gender-matched control group (p>0.20).

9.4.11.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.11.3 Studies reporting evidence of no difference in MVC risk (N=6)

Case-control

Good quality:
• McGwin et al. (1998) reported no significant difference in state or self-reported MVC risk for drivers with reduced sensitivity in either the central 30º VF or peripheral 30-60º VF (automated perimetry) compared to controls (statistics not reported).

Cross-sectional/Cohort

Good quality:
• Owsley, Ball, et al. (1998) reported no difference in prospective MVC risk in those with VF impairment (automated perimetry) compared to controls, including reduced sensitivity in the central 30º VF (RR=0.99, 95% CI 0.36-2.75) and in the 30-60º peripheral VF (RR=0.77, 95% CI 0.42-1.40).

Fair quality:
• Okamura et al. (2019) reported that drivers with monocular field loss in either the better or worse eye (automated perimetry) had similar police-registered (p=0.09) and self-reported MVC (p=0.74) history compared to a control group.

Poor quality:
• Woolnough et al. (2013) reported no difference in MVC risk for older drivers with visual field defects (confrontation technique) compared to controls.
• Adekoya et al. (2009) reported no difference in MVC risk for drivers with impaired VF (confrontation technique) compared to normal fields (p=0.19).
• Oladehinde et al. (2007) reported no difference in MVC risk for drivers with bilateral VF defects (automated perimetry) compared to controls (RR=1.07, 95% CI 0.98-6.73).

9.4.11.4 Studies reporting evidence for impact on on-road driving outcomes (N=2)

Cross-sectional/Cohort

Fair quality:
• Kasneci et al. (2014) reported that drivers with glaucomatous or hemianopic VF loss were more likely to fail an on-road driving assessment compared to controls (statistics not reported in the paper; crude OR=5.67, 95% CI 1.25-25.61)
• Silveira et al. (2007) reported that drivers with visual field defects (vision disorders not reported) were more likely to fail an on-road driving assessment compared to control (statistics not reported in the paper; crude OR=21.90, 95% CI 4.90-97.90)

9.4.12 Reduced visual acuity and/or visual field loss

One study reported on the MVC risk of drivers with VA and/or VF impairment that was rated as ‘poor’ quality and provided inconclusive evidence regarding MVC risk (using state-recorded MVC data).

9.4.12.1 Studies reporting evidence of increased MVC risk (N=0)

9.4.12.2 Studies reporting evidence of decreased MVC risk (N=0)

9.4.12.3 Studies reporting evidence of no difference in MVC risk (N=0)

9.4.12.4 Studies reporting inconclusive evidence of MVC risk (N=1)

Cross-sectional/Cohort

Poor quality:
• Decina and Staplin (1993) reported that drivers who failed vision screening had significantly different MVC risk compared to controls (p<0.001). But this significant difference was a result of increased MVC rates in younger drivers with good vision (compared to those with poor vision), and increased MVC risk in older drivers with poor vision (compared to those with good vision).
9.4.12.5 Studies reporting evidence for impact on on-road driving outcomes (N=0)

There have been no studies of on-road driving performance in drivers with reduced visual acuity and/or visual field impairment compared to controls.

9.5 CONCLUSIONS

This systematic review summarised the evidence provided by studies comparing MVC risk (state-recorded, self-reported or recorded during naturalistic driving) or on-road driving performance for drivers with vision disorders or vision impairment to those without vision disorders and normal vision. A key finding of this review is that there are only a limited number of high-quality studies that provide relevant data, with only 48 studies meeting our inclusion criteria and of these, less than half were rated as being of ‘good’ quality (n=18, 39% across all conditions and impairments). Importantly, many of the studies rated as ‘good’ quality, reported data on only relatively small numbers of drivers with visual impairment.

Most studies reported on MVC risk (n=39), with around half including state-recorded data, and relatively few including at-fault MVC data (n=10), which provides a better understanding of the potential impact of vision disorders or vision impairment on driving safety (Owsley et al., 2015). Other MVC studies included self-reported data which has inherent limitations (McGwin et al., 1998), while one study included data from in-vehicle monitoring which records MVCs as well as near misses.

In terms of the studies that reported the impact of impairment of visual function on MVC risk, VA impairment was most commonly reported (n=17), followed by VF impairment (n=11), which is likely to be because these measures of visual function are most commonly included in driver licensing standards (see Appendix G, Section 21.3), and therefore are the data most widely available to researchers when assessing MVC risk. It is important to note, that the methods for assessing and defining impairment, particularly VF impairment, varied widely between studies, making it difficult to combine the evidence and draw definitive conclusions.

In terms of the studies reporting different vision disorders or specific eye diseases, glaucoma was most common (n=11), followed by AMD (n=5) and cataract (n=3), with only a limited number of studies that reported on drivers with homonymous hemianopia and quadrantanopia field loss, retinitis pigmentosa, Stargardt’s disease and cone-rod dysfunction. In addition, some studies reported data collapsed across a range of different eye diseases (see section “Combined eye diseases”), which is problematic when trying to understand the effect of specific eye diseases on driving outcomes and makes comparison across studies impossible. No studies reporting on MVC risk or on-road driving performance in drivers with diabetic retinopathy met the inclusion criteria for this review, which is of concern given that this condition is a prevalent cause of significant visual impairment (Flaxman et al., 2017). Most studies involved older drivers, which is likely a consequence of the age-related increase in eye disease, vision disorders and associated visual impairment (Wang et al., 2000).

9.5.1 Cataract

Three studies were identified that were all rated as ‘good’ quality but reported conflicting results regarding the MVC risk of drivers with cataracts compared to controls and were all published more than 20 years ago. One cataract-specific study reported increased at-fault MVC risk in drivers with cataracts compared to those without cataracts, conversely, two studies that included a range of different vision disorders, including cataract, failed to find an association between cataract and increased MVC risk. There were no studies of on-road driving performance in drivers with cataracts. More studies of driving outcomes are required given the high prevalence of cataract within older adults, which is a leading cause of visual impairment (Foreman et al., 2018), with an estimated 30 percent of the older population having significant cataract in at least one eye (Rochtchina et al., 2003).
9.5.2 Age-related macular degeneration (AMD)

Five studies reported on the MVC risk of drivers with AMD and were rated as ‘good’ or ‘fair’ quality, with MVC risk in drivers with AMD either reduced or equivalent to that of controls, particularly for those with intermediate AMD. Two studies assessed on-road driving performance in this population, one reporting less safe driving performance than controls, particularly for those with intermediate AMD, while the other reported no significant difference in performance of the drivers with AMD compared to controls. The limited number of studies in this area, together with the increasing prevalence of this age-related condition (Wong et al., 2014), where the prevalence of early and intermediate AMD in adults aged 50 years and older is around 15 and 10 percent respectively (Keel et al., 2017), suggests the need for further studies to fully understand the impact of AMD on driving ability and safety.

9.5.3 Glaucoma

Based on the nine glaucoma MVC studies, all rated as either ‘good’ or ‘fair’ quality, there is mixed evidence regarding MVC risk in people with glaucoma, with one study reporting reduced risk, some equivalent risk and others increased risk. Although there is insufficient evidence of inferior on-road performance in drivers with glaucoma compared to controls from four studies of ‘good’ or ‘fair’ quality, there is some evidence of increased risk of critical errors during on-road driving assessments, even for those with early/mild glaucoma. Further good quality studies with larger sample sizes of cases with glaucoma are warranted, given that the prevalence of glaucoma in people aged 40-80 years is 3.5% (Tham et al., 2014), it is a leading cause of visual impairment and blindness (Flaxman et al., 2017) and because glaucoma tends to go unnoticed and undiagnosed in over half of all cases. (Quigley, 2011)

9.5.4 Homonymous hemianopia and quadrantanopia

Three studies were identified, where MVC risk and on-road driving performance in drivers with homonymous hemianopia and quadrantanopia were compared with drivers with normal fields, which reported data from the same study cohort, with study quality rated as ‘good’ or ‘fair’. The fact that there are so few studies that have assessed the driving ability and safety of this population is important given that most jurisdictions deny drivers with this type of field loss the opportunity to drive (Yan et al., 2019), regardless of the lack of evidence suggesting that all drivers with this condition are unsafe to drive.

9.5.5 Genetic retinal diseases

With only three fair quality, small, older studies of MVC risk and no studies of on-road driving performance in genetic retinal diseases, there is insufficient evidence on which to draw conclusions. Genetic retinal diseases are low in prevalence compared with other eye diseases (Flaxman et al., 2017), and the issue of meeting the visual standards for driver licensing typically arises at a young age, when an individual first considers applying for a driving license.

9.5.6 Combined eye diseases

Three studies, including one of MVC risk and two of on-road driving performance, presented data for drivers with a range of different eye diseases. Study data and results were pooled across diseases, rather than presenting data for individual diseases separately, which makes comparison with other studies challenging and inconclusive.

9.5.7 Visual acuity impairment

Studies exploring the MVC risk of drivers with VA impairment were the most common in this systematic review. Review of this evidence did not suggest increased risk of involvement in state-recorded and self-reported MVC for drivers with VA impairment compared to those with normal levels of VA, with only self-reported MVC studies reporting increased MVC risk in those with VA impairment. However, the cut-points used to define ‘reduced VA’ vary between studies, typically relating to local driving standards, making valid comparisons challenging. In addition, the number of drivers in these studies that have reduced VA worse
than these standards is relatively small, which limits the ability to determine whether alternative cut-points for VA are more appropriate.

9.5.8 Visual field impairment

The evidence from studies of state-recorded and self-reported MVC and those recorded during naturalistic driving, indicate that more severe VF impairment in both eyes is associated with increased MVC risk relative to those with no VF impairment. This is consistent with two small on-road driving studies rated as ‘fair’ quality, which suggest poorer overall driving performance in those with binocular field loss compared to those with no VF impairment. However, the evidence is limited by the inclusion of a wide variety of methods for assessing visual fields and definitions of VF impairment, making comparisons between studies challenging. Most jurisdictions include some form of VF criteria in driver licensing standards, thus additional good quality MVC risk and on-road performance studies are a priority to determine evidence-based VF criteria for licensure, particularly as VF impairment can be caused by common eye conditions (e.g., glaucoma) and visual field loss is more likely to go unnoticed and undetected than VA loss.

9.5.9 Study limitations

While 48 studies were identified that met the inclusion criteria for this systematic review, many had several methodological and reporting limitations that make synthesis and interpretation of the data across studies challenging. Limitations included drivers with varying degrees of impairment which was not consistently measured with standardised tools, relatively small sample sizes (particularly for the studies of on-road driving performance which ranged from 10 to 75 for drivers with visual impairment), inconsistent driving outcome criterion measures, as well as unclear statistical approaches and presentation of results. In addition, many studies are more than a decade old (72% of MVC risk and 42% of on-road driving performance studies were published prior to 2010). This is relevant given that visual standards for licensing have changed in many jurisdictions over this period and the demands of driving have also changed over recent years. A limitation in terms of the data analysis is the lack of consistent adjustment for confounding factors, such as age, gender, or driving exposure, which have a significant impact on driving ability and safety and vary greatly between study populations. There are also additional limitations that are more specific to studies of MVC risk or on-road driving performance which are described separately in the following sections.

An important limitation of the MVC studies is that half included self-reported rather than state-recorded MVC risk. While collecting retrospective self-reported MVC data is easier and more convenient than accessing and interpreting MVC records from state or police authorities, it is limited by driver recall bias, in addition to problems regarding the allocation of blame (McGwin et al., 1998). Some studies of self-reported MVC risk also did not collect information on driving exposure rates in terms of distances travelled and thus present data as absolute numbers of MVCs rather than as MVC rates per distance driven. This is a particular issue for older drivers with visual impairment who often restrict their driving exposure, avoiding more challenging driving situations, such as night-time or peak hour traffic (DeCarlo et al., 2003; Janz et al., 2009; Owsley et al., 1999), which may explain why they do not have high MVC risk, despite having driving performance that is rated as unsafe. In addition, drivers with more severe loss may have their licence revoked because they fail to meet the visual requirements for licensing, and therefore are not well represented in MVC records.

Of the studies that included state-recorded MVC data in this review, only around half included at-fault MVCs, which provide a better understanding of the impact of vision on driving safety, rather than all MVCs which include collisions where the driver is not at-fault, and thus where vision is less likely to be a contributing factor. Whilst ‘at fault’ crashes do convey culpability, they do not necessarily confer direct causality related to the vision disorder or impairment, unless referred to specifically in the MVC record by the record author (usually law enforcement). In this regard, naturalistic driving studies are useful.
because they collect objective data on MVCs and include major, minor, and near miss MVC data. In addition, while a number of the MVC studies reported on large populations of drivers, they included relatively few drivers with specific eye disorders or impairment of VA or VF, limiting the confidence that can be placed on the outcomes. Having only small numbers of drivers with vision disorders in the various studies makes interpretation of the data challenging, and is exacerbated by the fact that the way in which visual impairment was measured and reported varies greatly between studies.

An additional limitation of both self-reported and state-recorded retrospective MVC studies is that while the vision measures are conducted at the time of the study, the MVCs occurred previously, from 1 to 10 years prior to the vision measures in some studies. While extended time frames allow more time to collect MVC data, the longer the period between the MVC event and assessment of vision, the less likely it is that the visual status of the driver at the time of examination reflects the visual status at the time that the MVC occurred.

All of the on-road measures were conducted using standardised evaluation criteria to assess fitness to drive, and almost all were administered by a driving instructor or driver occupational therapist. However, not all assessors were masked to participant characteristics and the driving courses were conducted in different traffic scenarios of different lengths, complexity and situations (non-interstate/interstate), making comparison between studies challenging.

9.5.10 Current fitness-to-drive guidelines

As summarised in Appendix G (Section 21.3), all of the licensing guidelines that were reviewed indicate that VA and VF should be taken into account in order to determine fitness-to-drive for a private vehicle license. Some also had specific comments regarding progressive eye diseases, such as cataract and glaucoma, but typically refer to their impact on VA and VF.

The evidence in the current systematic review regarding VA impairment is generally limited to those drivers whose VA already meets the various standards outlined in the fitness to drive guidelines and there are few drivers in the studies with VA worse than current standards (VA of 6/12), which limits the ability to determine whether alternative cut-points are more appropriate. Thus the evidence derived from this systematic review doesn't indicate that the current standards should be changed.

While many jurisdictions incorporate assessment of VF within their medical fitness to drive licensing standard, these vary greatly between jurisdictions in terms of the definition of VF loss and its severity and the assessment technique recommended. The inclusion of this measure of visual function in driving standards is particularly important given that VF impairment can be caused by common eye conditions (e.g., glaucoma) and VF loss is more likely to go unnoticed and undetected than VA loss. The evidence in the current systematic review also highlights the negative impact of moderate to severe binocular VF impairment on driving ability and safety. However, this review does not provide clear evidence for a specific cut-off level on which standards should be based.

The current systematic review did not identify any studies examining the effect of other conditions listed such as diplopia or sudden monocularity on driving outcomes, thus no recommendations for the guidelines regarding these conditions can be made.

9.5.11 Recommendations

On the primary question of whether increased MVC risk and decreased on-driving performance are associated with vision disorders and/or visual impairment, the available evidence is mixed, both in terms of the quality of studies and the outcomes reported. This review identified some good quality evidence indicating increased MVC risk in drivers with binocular VF impairment. However, evidence is inconclusive regarding the impact of mild VA impairment, cataract, glaucoma, AMD, and homonymous field loss on MVC risk. There
were no studies examining the impact of diabetic retinopathy and either MVC risk or on-road driving performance.

The findings of this review highlight the need for further well-designed studies with larger sample sizes involving drivers with a greater range of visual loss, in order to explore the impact of vision disorders and visual impairment on MVC risk and on-road driving performance, particularly for common eye conditions such as cataract, glaucoma, AMD and diabetic retinopathy. Further studies are also required to determine the extent of the binocular VF required to support safe driving. Collectively, these studies would assist with identifying how visual disorders and visual impairment impact on driving ability and safety, to ensure that drivers with such impairments are not being unnecessarily restricted from driving, with the associated impacts on independence and functional mobility (Chihuri et al., 2016; Shimada et al., 2016). However, such studies require considerable commitment of time and funding, but are necessary to contribute to evidence-based recommendations that can be used by policy makers and clinicians.

This review suggests that different vision disorders impact on driving ability and safety in different ways and it is important that clinicians are aware of this issue when advising individuals with visual impairment. Importantly, people are often unaware that their vision and driving performance is changing. Regular eye examinations serve not only to allow detection of eye diseases and visual impairment early, but also provide the opportunity for clinicians to inform individuals of relevant changes in their vision. This is important to foster awareness, encourage self-regulation, compliance with vision health management protocols to reduce disease progression where possible and to support transitioning to alternative mobility options when driving independently is no longer possible.

9.6 REFERENCES


105 INFLUENCE OF CHRONIC ILLNESS ON MOTOR VEHICLE CRASH RISK

10. MULTIPLE MEDICAL CONDITIONS AND MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from a rapid review that evaluated the available evidence regarding the risk of MVC for drivers with multiple medical conditions (MMC), and quantify any impacts on on-road driving performance.

10.1 OVERVIEW AND KEY RECOMMENDATIONS

- Road Safety Victoria (Department of Transport, Victoria, Australia) recently obtained feedback from key Victorian-based external and internal (medical review) stakeholders regarding medical condition / illness or treatment gaps that were not discussed at all, or only briefly discussed, in the 2010 ‘Influence of chronic Illness on crash involvement of motor vehicle drivers’ report and/or the 2016 AFTD guidelines (Charlton et al., 2010; Austroads, 2017).
- Several significant and emerging medical and disability-related conditions were identified by stakeholders.
- MUARC administered an online survey of an international expert panel, in the field of chronic illness and MVC risk, seeking opinions regarding which emerging and significant medical condition, functional issue or treatment should be addressed in a supplementary literature review conducted by MUARC.
- The results of the online survey identified that MMC were the highest priority.
- The rapid review identified 16 studies that investigated the risk of MVC (n=15), or impacts on on-road driving performance (n=1), for drivers with MMC. However, only six studies were rated as having a ‘good’ quality of evidence.
- The available evidence that has specifically aimed to explore MVC risk associated with MMC is limited, and therefore does not support blanket restrictions.
- Key recommendations:
  - An individualised case-by-case approach recommended by most international guidelines should continue when individuals present with multiple morbidities and/or disability issues.
  - Based on these findings, a large-scale, prospective population-based controlled study of MVC risk and multiple medical conditions is warranted.

10.2 BACKGROUND

Road Safety Victoria (Department of Transport, Victoria, Australia) recently obtained feedback from key Victorian-based external and internal (medical review) stakeholders regarding medical condition / illness or treatment gaps that were not discussed at all, or only briefly discussed, in the 2010 ‘Influence of chronic Illness on crash involvement of motor vehicle drivers’ report and/or the 2016 AFTD guidelines (Charlton et al., 2010; Austroads, 2017). Several significant and emerging medical and disability-related conditions were identified by stakeholders (including some medical treatments/interventions): Autism Spectrum Disorders, interstitial glucose monitoring devices, dialysis treatment for permanent/irreversible renal failure, chronic/irreversible hepatic encephalopathy or chronic liver disease, drug dependency, medicinal cannabis use, congenital limb deficiencies or limb amputation and use of prostheses to drive, the combination of multiple medical and eyesight conditions, and cancer treatment interventions (e.g., chemotherapy, radiation).

MUARC administered an online survey to collect and converge the opinions of an international expert panel in the field of chronic illness and MVC risk. This survey was to determine, by consensus, a ranking of which emerging and significant medical condition, functional issue or treatment should be addressed in a supplementary literature review conducted by MUARC. The expert panel was presented with a 5-item questionnaire (see Appendix H, Section 22.1), comprised of both closed and open-ended questions, with the specific objective of prioritising significant and emerging medical and disability-related
conditions that may be associated with an increased MVC risk. The online survey was created using the online research software Qualtrics. Distribution was conducted via e-mail and the responses were confidential (by following a link as provided by email) in order to facilitate honest and unbiased responses. Findings of the online survey were collated in order to identify which conditions should be addressed in a supplementary literature review. The findings of the survey identified MMC as highest priority for review. More details about the results of the survey are provided in Appendix H (Section 22.2).

This chapter provides a high-level summary of the key findings and recommendations from the rapid review that evaluated the available evidence regarding the influence of MMC on MVC risk and on on-road driving performance.

**Authors:** Judith L. Charlton¹, Marilyn Di Stefano², Bleydy Dimech-Betancourt¹, Suzanne L. Cross¹, Rachel Osborne¹, Morris Odell³, Peteris Darzins⁴, Mark J. Rapoport⁵, Jamie Dow⁶, Desmond O'Neil⁷, & Sjaan Koppel¹

**Affiliations:** ¹Monash University Accident Research Centre, Monash University, Victoria, Australia; ²Road Safety Victoria, Department of Transport, Victoria, Australia; ³Monash University, Victoria, Australia; ⁴Monash University Eastern Health Clinical School, Victoria, Australia; ⁵Sunnybrook Hospital, Toronto, Ontario, Canada; ⁶Société de l’assurance automobile du Québec, Québec City, Québec, Canada; ⁷National Office for Traffic Medicine, Royal College of Physicians of Ireland, Dublin, Ireland.

**Sponsoring organisations:**
This project was funded by Road Safety Victoria, Department of Transport/VicRoads, Victoria.

**Keywords:**
Multiple Medical Conditions; Motor vehicle crashes; Fitness-to-drive; Road safety

10.2.1 Scope

The overarching aim of this rapid review was to provide a high-level summary of the key findings and recommendations from the available evidence regarding the influence of MMC on MVC risk and on on-road driving performance.

10.2.2 Definition

For the purpose of this review, studies were included in this rapid review if they were included in the systematic literature reviews described in Chapters 3-9 which provided evidence on MVC risk and/or on-road driving test outcomes for:

- Designated ‘primary disorder’ - Alcohol use disorder, Diabetes, Epilepsy and seizure disorders, Hearing loss, Psychiatric conditions (including schizophrenia), Sleep disorders, or Vision impairments and disorders (including cataract); and
- A comorbid medical condition or impairment.

For the purpose of this review, MVC risk was assessed by the frequency of crashes involving motor vehicles for drivers with MMC that resulted in property damage, or MVC-related injury or a fatality (World Health Organization, 2018), as identified by self-report or official crash records.

On-road driving performance was defined as the frequency of drivers who pass or do not pass on-road driving tests administered by driver licensing authorities or by occupational therapy driving assessors.
METHOD

10.2.3 Eligibility criteria

10.2.3.1 Inclusion criteria

Studies were included in the systematic review according to the following *a priori* criteria:

1. Original research in a peer-reviewed journal;
2. Full-text available;
3. Published in English language and human studies;
4. Used quantitative methods for data collection and analysis, and
5. Specifically reported crash risk and/or driving test outcome results for drivers with a medical condition.

10.2.3.2 Exclusion criteria

Studies were excluded from the systematic review according to the following a priori criteria:

1. Commentary manuscripts;
2. Literature or systematic reviews;
3. Case studies;
4. Dissertations, and
5. Studies which only use qualitative methods for data collection and analysis.

10.2.4 Information sources

Key comorbidities that may be related to MVC risk were identified, derived from the qualitative data from the expert panel online survey responses. Several comorbidities were already included in the review by MUARC and the international research consortium. Therefore, each of the studies included in the ‘final set of included studies’ for each of the systematic reviews was reviewed. Specifically, the medical conditions that were reviewed included: alcohol abuse disorder, diabetes, epilepsy/seizure disorders, hearing loss, sleep disorders (including sleep apnoea), psychiatric disorders (including schizophrenia), and vision disorders and visual impairments (including cataracts). Note that this review did not include the studies previously published (i.e., Chapters 11-14).

10.2.5 Search

A keyword search of each full-text article for each of the ‘final set of included studies’ was conducted to review the evidence on MVC risk, medical conditions and comorbidities. Appendix H (Section 22.3) provides a list of the terms used in the keyword searches across the medical conditions.

10.2.6 Study selection and data extraction

Having identified articles containing information about comorbidities, a full text review was conducted to extract the relevant findings on MVC risk associated with MMC. Two reviewers independently completed the keyword searches and applied the a priori inclusion and exclusion criteria. Search results were entered into a data collection table (pre-determined criteria including operational definitions within an Excel spreadsheet). Results were then combined to determine agreement. Any conflicts between the two reviewers were resolved by a third reviewer.

10.2.7 Risk of bias

The risk of bias was assessed from the systematic reviews for each high-risk medical condition in the previous chapters. These systematic reviews used the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute
Each study was assessed for risk of potential for selection bias, information bias, measurement bias or confounding factors. Based on this assessment, each study received a total score (out of 12 for case-control or before-after designs and 14 for cross-sectional/cohort designs) and provided an overall quality rating (‘good’, ‘fair’ or ‘poor’), where the greater the risk of bias, the lower the quality rating of the study.

10.3 RESULTS

10.3.1 Included studies

Sixteen studies were identified that met the inclusion criteria (see Table 2). The keyword search identified 14 studies. A review of goldset studies yielded two additional studies.

10.3.2 Study descriptions

Table 2 provides the characteristics of the included studies. Included studies were conducted between 1961 and 2012, with six published in the last decade. Most studies were case-control studies (n=8 case-control studies; n=2 cross-sectional studies; n=6 cohort studies). Age distributions and gender frequencies for specific conditions are provided in Chapters 3-9.

In terms of their focus, four of the 16 studies provided evidence on MVC risk associated with diabetes, its complications or comorbid conditions with diabetes.

Another four studies provided evidence on MVC risk associated with a number of MMC/comorbidities.

Three studies provided evidence on MVC risk associated with sleep disorders and MMC, with two studies focusing on sleep apnoea and other medical co-morbidities, and one study focusing on multiple sleep disorders. Three studies provided evidence on the MVC risk associated with substance and/or alcohol dependence/abuse. Specifically, two studies explored the MVC risk associated with comorbid alcohol dependence and psychiatric illness, and one study explored the risk associated with polydrug/alcohol abuse. One study provided evidence on MVC risk associated with dual sensory impairment (i.e., hearing impairment and vision impairment). Finally, one study reported on on-road driving test performance as an outcome measure of risk, and specifically focused on glaucoma and a number of comorbid conditions. Most studies were conducted in the United States (n=12).

Most of the studies used self-reported measures (i.e., interviews or questionnaires) (n=10) to obtain information on medical history, however, administrative data (n=2), and medical records (n=4) were also reviewed in some studies. MVC data were ascertained in studies using: 1) official records (n=11), and 2) self-report, interviews or questionnaires (n=4).
Table 2: Summary Characteristics and Quality Assessments of Included Studies for Multiple Medical Conditions (N=16)

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
<th>Groups</th>
<th>Measures</th>
<th>Key findings</th>
<th>Quality ratings</th>
</tr>
</thead>
</table>
CLINICAL DATA: Inpatient hospital admission data, including demographic and diagnostic information, using ICD-9 codes | Increased risk of MVC fatalities in polydrug/alcohol abusers compared to the general population (SMR=2.6, 95% CI 2.4-2.9) | FAIR            |
| Koepsell et al. (1994)        | Diabetes and coronary heart disease         | Older adult drivers (aged 65 or older) injured while driving during 1987 or 1988: n=234 Age-, gender- and country-matched controls not injured while driving during 1987 or 1988: n=446 | MVC DATA: Injurious MVC (requiring medical care) obtained from police records  
CLINICAL DATA: Medical conditions active within previous three years, as determined from the medical record | Comorbid diabetes and coronary heart disease were more likely to be involved in MVC compared to those with neither condition (OR=8.0, 95% CI 1.7-37.7) | POOR            |
| McGwin and colleagues (1999)  | Diabetes and vision impairment (specifically diabetic retinopathy) Diabetes and neurological impairment (specifically diabetic neuropathy) | At-fault MVC-involved older drivers (aged 65 or older): n=249  
Not-at-fault MVC-involved older drivers (aged 65 or older): n=198  
Non-MVC involved older drivers (aged 65 or older): n=454 | MVC DATA: At-fault MVC data obtained from Alabama Department of Public Safety police records  
CLINICAL DATA: Demographics, driving habits, diabetes information and treatment, other chronic conditions and visual function obtained via telephone interview | At-fault MVC-involved drivers were more likely to report diabetic retinopathy when compared to not-at-fault crash involved drivers (Crude rate: RR= 1.5, 95% CI 0.3-8.2; adjusted for age, sex, race, annual mileage: RR= 1.9, 95% CI 0.3-10.9)  
At-fault MVC-involved drivers were more likely to report diabetic retinopathy when compared to non-crashed involved drivers (Crude rate: RR= 1.1, 95% CI 0.3-3.8; adjusted for | GOOD            |
Green et al. (2013) | Hearing impairment and vision impairment | Older drivers (aged 70 or older) with both hearing and vision impairment: n=61  
Older drivers (aged 70 or older) with neither visual nor hearing impairment: n=1,248 | MVC DATA:  
- MVCs spanning the five years prior to study enrolment were obtained from the Alabama Department of Public Safety records  
CLINICAL DATA:  
- Visual acuity was measured using the Electronic Visual Acuity test  
- Contrast sensitivity was measured using the Pelli-Robson chart  
- Presence of subjective hearing loss and other health conditions were determined using a general health questionnaire | Drivers with both contrast sensitivity impairment and hearing impairment had elevated MVC rates (Total: adjusted RR=2.41, 95% CI 1.62–3.57; At-fault: adjusted RR=2.06, 95% CI 1.13–3.76) compared to drivers with no visual or hearing impairment  
Drivers with both visual acuity impairment and hearing impairment had a higher total MVC rate compared to drivers with no visual or hearing impairment (adjusted RR=1.52, 95% CI 1.01–2.30)  
Those with dual visual acuity impairment and hearing impairment had a significantly higher unadjusted rate for at-fault MVCs compared to drivers with no impairment (RR=1.71 95%CI 1.00–2.95), however, this association did not remain significant after adjustment (RR=1.69 95% CI 0.97–2.93) | FAIR

At-fault crash-involved drivers were more likely to report diabetic neuropathy when compared to not-at-fault crash involved drivers (Crude rate: RR= 2.3, 95% CI 0.2-21.8; adjusted for age, sex, race, annual mileage: RR= 2.8, 95% CI 0.3-28.3)  
At-fault crash-involved drivers were more likely to report diabetic neuropathy when compared to non-crashed involved drivers (Crude rate: RR= 2.0, 95% CI 0.4-9.8; adjusted for age, sex, race, annual mileage: RR= 2.6, 95% CI 0.5-13.1)
### Vernon et al. (2002)

<table>
<thead>
<tr>
<th>Medical Conditions</th>
<th>Number of Drivers Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>One medical condition</td>
<td>n=54,938</td>
</tr>
<tr>
<td>Two medical conditions</td>
<td>n=10,595</td>
</tr>
<tr>
<td>Three medical conditions</td>
<td>n=2,403</td>
</tr>
<tr>
<td>Four medical conditions</td>
<td>n=653</td>
</tr>
<tr>
<td>Five medical conditions</td>
<td>n=146</td>
</tr>
<tr>
<td>Six medical conditions</td>
<td>n=28</td>
</tr>
<tr>
<td>Seven medical conditions</td>
<td>n=7</td>
</tr>
</tbody>
</table>

**MVC DATA:**
- Database records obtained through Utah Department of Transportation (1992-1996)

**SLEEP DATA:**
- Drivers self-reported medical conditions to Utah Driver Licence Division

- MVC risk for drivers reporting multiple medical conditions increased both those with restricted (RR=1.28, 95% CI 1.04-1.58, p <0.05) and unrestricted (RR=1.41, 95% CI 1.33-1.45, p <0.05) licenses compared to matched controls without the conditions.

### Brenner and Selzer (1969)

<table>
<thead>
<tr>
<th>Medical Conditions</th>
<th>Number of Drivers Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol dependence and psychopathology</td>
<td>n=36</td>
</tr>
<tr>
<td>Deceased and surviving fatal MVC drivers with alcohol dependence</td>
<td>n=36</td>
</tr>
<tr>
<td>Deceased and surviving fatal MVC drivers who consume alcohol in moderation or not at all</td>
<td>n=49</td>
</tr>
</tbody>
</table>

**MVC DATA:**
- At-fault fatal MVCs obtained from police records in Washtenaw County, Michigan, between October 29, 1961, and December 31, 1964

**CLINICAL DATA:**
- Information related to each driver's pattern of alcohol use, certain manifestations of psychopathology, stressful experiences within the preceding year, as well as other information was obtained through interviews

- Drivers with alcohol dependence (70%) involved in an MVC had psychopathology compared to moderate/non-users (29%; RR= 27, A/C ratio = 12.50)

---

**GOOD**

**POOR**
<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Condition</th>
<th>MVC and FVC Data</th>
<th>Clinical Data</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yates (1987)</td>
<td>Alcohol dependence and antisocial personality disorder</td>
<td>Male patients admitted to an alcohol treatment unit reporting injurious MVCs: n=57</td>
<td>Demographic and historical information and to determine whether patients met criteria for alcohol abuse or dependence and antisocial personality disorder as defined by DSM-III obtained via structured interview</td>
<td>Higher proportion of personal injury MVCs in those with alcohol abuse/dependence and comorbid antisocial personality disorder (45.5%) compared to those with alcohol abuse/dependence without antisocial personality disorder (25.7%; $X^2=5.4$, df=1, p&lt;0.05)</td>
</tr>
<tr>
<td>Philip et al. (2010)</td>
<td>Multiple sleep disorders</td>
<td>Drivers with multiple sleep disorders: n=1544</td>
<td>Drivers reported if they have ever been diagnosed and treated for sleep disorders, anxiety or depression</td>
<td>Higher proportion of those with multiple sleep disorders reporting MVCs compared to controls (OR=1.46, 95% CI 1.20-1.78, p&lt;0.001)</td>
</tr>
<tr>
<td>Dow et al. (2013)</td>
<td>Number of medical conditions</td>
<td>Drivers involved in MVC involving death or serious injury: n=96,692</td>
<td>Health data obtained from records of the health insurance agency (Régie d’assurance médicale du Québec or RAMQ) and the Ministry of Health and Social Services (MHSS)</td>
<td>MVC risk gradually increases with the number of multiple medical conditions such that: those with one medical condition (OR=1.18, 95% CI 1.16-1.20), two medical conditions (OR=1.35, 95% CI 1.32-1.38), three medical conditions (OR=1.48, 95% CI 1.44-1.53) and four or more medical conditions (OR=1.55, 95% CI 1.49-1.60)</td>
</tr>
<tr>
<td>Marottoli et al. (1994)</td>
<td>Number of medical conditions</td>
<td>Older drivers (aged 72 years and older): n=283</td>
<td>MVC DATA: Self-reported involvement in MVC in a one-year period</td>
<td>CLINICAL DATA: Health data was self-reported via structured interview</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Bhorade et al. (2016)</td>
<td>Glaucoma and number of other medical comorbidities</td>
<td>Patients with bilateral moderate or advanced glaucoma: n=21</td>
<td>ON-ROAD DATA: Overall performance of pass vs marginal/fail during an on-road driving evaluation by a masked driver rehabilitation specialist</td>
<td>CLINICAL DATA: Medical chart review and comprehensive clinical evaluation (including vision, psychometrics and mobility) by trained occupational therapist</td>
</tr>
<tr>
<td>Owsley et al. (1998b)</td>
<td>Diabetes and vision impairment (specifically diabetic retinopathy)</td>
<td>Injurious MVC-involved older drivers: n=78 Non-injurious MVC-involved older drivers: n=101 Non-MVC involved older drivers: n=115</td>
<td>MVC DATA: MVC records obtained for the Alabama Department of Public Safety CLINICAL DATA: Ophthalmological examination Tests of visual processing Chronic medical conditions (including a review of major eye diseases common in the elderly) obtained via interview</td>
<td>Drivers with diabetic retinopathy were not at greater risk of injurious MVCs (OR=0.7, 95% CI 0.1-8.2) or non-injurious MVCs (OR=1.0, 95% CI 0.1-7.5) compared to those without diabetic retinopathy (p=n.s.)</td>
</tr>
<tr>
<td>Authors</td>
<td>Medical Conditions</td>
<td>Articulated Truck Permit Holders</td>
<td>MVC Data</td>
<td>Single Unit Truck Permit Holders</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------</td>
<td>---------------------------------</td>
<td>----------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Laberge-Nadeau et al. (2000)</td>
<td>Diabetes and other medical comorbidities (cardiovascular, visual or hypertension)</td>
<td>Articulated truck-permit holders with diabetes (without complications): n=369</td>
<td>Data on permits and MVCs in the province of Québec for individuals were extracted from the administrative files of the Société de l'Assurance Automobile du Québec (SAAQ)</td>
<td>Single unit truck-permit holders with diabetes (without complications): n=127</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Articulated truck-permit holders with diabetes (with complications): n=299</td>
<td>- Self-reported driving exposure via survey</td>
<td>Single unit truck-permit holders with diabetes (treated with insulin): n=84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Articulated truck-permit holders with diabetes (treated with insulin): n=121</td>
<td></td>
<td>Single unit truck-permit holders with diabetes (treated with insulin): n=62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age-matched healthy controls with articulated permit: n=1,736</td>
<td>CLINICAL DATA: Health and medical reports from the SAAQ and the Régie de l'Assurance Maladie du Québec (RAMQ), the provincial public health insurer</td>
<td>Age-matched healthy controls with single unit permit: n=795</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single unit truck-permit holders with diabetes (without complications): n=127</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single unit truck-permit holders with diabetes (with complications): n=84</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single unit truck-permit holders with diabetes (treated with insulin): n=62</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age-matched healthy controls with single unit permit: n=795</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Influence of Chronic Illness on Motor Vehicle Crash Risk</td>
<td>Sleep apnoea plus myocardial infarction: n= 197</td>
<td>Sleep apnoea plus hypertension: n= 1257</td>
<td>Sleep apnoea plus stroke: n= 78</td>
<td>miles driven per year, &amp; number of MVC (as driver) in previous year</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Karimi et al. (2015)</td>
<td>Sleep apnoea, plus: diabetes, psychiatric disorder, cardiovascular disease</td>
<td>Drivers with sleep apnoea with MVC within 5 years before diagnosis: n = 56</td>
<td>Drivers with sleep apnoea with MVC after diagnosis: n = 26</td>
<td>MVC data: - MVC data incl. type, location, severity, cause, injuries &amp; property damages obtained from Swedish Traffic Accident Data Acquisition registry in time period between 2002-2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drivers with sleep apnoea with no MVCs: n=1,347</td>
<td>Comparison (i.e., general population): n=21,118</td>
<td>CLINICAL DATA: - Cardiorespiratory polygraphy recording during sleep</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- CPAP compliance obtained from device</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No significant difference in the proportion of individuals who experienced MVCs compared to those who did not experience MVCs (p&lt;0.08) in patients who reported comorbid diabetes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No significant difference in the proportion of individuals who experienced MVCs compared to those who did not experience MVCs (p&lt;0.70) in patients who reported comorbid psychiatric disorder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No significant difference in the proportion of individuals who experienced MVCs compared to those who did not experience MVCs (p&lt;0.65) in patients who reported comorbid cardiovascular disease</td>
</tr>
</tbody>
</table>

In drivers with sleep apnoea plus myocardial infarction, there was no significant difference in the proportion of individuals who experienced MVCs (5.0%) compared to those who did not experience MVCs (6.3%; p=0.34).

In drivers with sleep apnoea plus hypertension, there was no significant difference in the proportion of individuals who experienced MVCs (37.4%) compared to those who did not experience MVCs (39.4%; p=0.57).

In drivers with sleep apnoea plus stroke, there was no significant difference in the proportion of individuals who experienced MVCs (2.3%) compared to those who did not experience MVCs (2.5%; p=0.65).

In drivers with sleep apnoea plus myocardial infarction, there was no significant difference in the proportion of individuals who experienced MVCs (6.7%; p=0.66) compared to those who did not experience MVCs.
| Dischinger, Ho & Kufera (2000) | Number of medical conditions | Drivers of automobiles, light trucks, vans, and recreational vehicles: n=7,750 | MVC DATA: MVC data including culpability and driver condition obtained from linkage between police records and hospital discharge records  
CLINICAL DATA: Medical conditions obtained from hospital discharge records, using ICD-9 codes | Higher proportion of drivers with 3 or more conditions (73.5%) were responsible for an MVC in the last three years compared to drivers with no medical conditions (62%; p=NR) | NR because they were identified separately from the goldset studies |

- Self-reported habitual sleep time & ESS score  
- Self-reported comorbidity (p≥0.30) in patients who reported comorbid cardiovascular disease
Six studies were rated as ‘good’, five as ‘fair’ and three as ‘poor’ (2 studies not rated because they were identified separately from the goldset studies). Studies with a ‘poor’ quality of evidence rating were deemed to not contribute reliably to conclusions about the risk associated with multiple medical disorders.

10.3.3 Studies reporting evidence for MVC risk in drivers with diabetes, its complications and other medical comorbidities (n=4)

10.3.3.1 Studies reporting evidence of increased risk (n=2)

Case-control

Good quality:

- McGwin and colleagues (1999) found that at-fault crash-involved drivers were more likely to report diabetic retinopathy when compared to not-at-fault crash involved drivers (crude: RR=1.50, 95% CI 0.30-8.20; adjusted for age, sex, race, annual mileage: RR=1.90, 95% CI 0.30-10.90) and non-crashed involved drivers (crude: RR=1.10, 95% CI 0.30-3.80; adjusted for age, sex, race, annual mileage: RR=1.40, 95% CI 0.30-4.00). Additionally, at-fault crash-involved drivers were more likely to report diabetic neuropathy when compared to not-at-fault crash involved drivers (crude: RR=2.30, 95% CI 0.20-21.80; adjusted for age, sex, race, annual mileage: RR=2.80, 95% CI 0.30-28.30) and non-crashed involved drivers (crude: RR=2.00, 95% CI 0.40-9.80; adjusted for age, sex, race, annual mileage: RR=2.60, 95% CI 0.50-13.1 0).

Poor quality:

- According to Koepsell et al. (1994), those with both diabetes and coronary heart disease were more likely to be involved in MVC compared to those with neither condition (OR=8.00, 95% CI 1.70-37.70).

1.1.1.1 Studies reporting evidence of no difference in risk (n=2)

Case-control

Fair quality:

- Laberge-Nadeau et al. (2000) reported that Class AT (articulated truck) drivers with diabetes and other health complications (cardiovascular, visual or hypertension) were just as likely to be involved in an MVC compared to healthy controls (RR=1.17, 95% CI 0.96–1.43). All Class ST (single unit truck) drivers with diabetes and other health complications (visual, cardiovascular or hypertension) were also just as likely to be involved in an MVC compared to healthy controls (RR=1.03, 95% CI 0.73–1.46). Class AT (articulated truck) professional drivers with diabetes and other health complications (cardiovascular, visual or hypertension) were almost as likely to be involved in an MVC compared to healthy controls (RR= 0.87, 95% CI 0.61–1.25). Class ST (single unit truck) professional drivers with diabetes and other health complications (visual, cardiovascular or hypertension) were also almost as likely to be involved in an MVC compared to healthy controls (RR=0.96, 95% CI 0.48–1.91).

Cross-sectional/Cohort

Good quality:

- Owsley et al. (1998) found that those with diabetic retinopathy were not at greater risk of injurious MVCs (OR=0.70, 95% CI 0.10-8.20) or non-injurious MVCs (OR=1.00, 95% CI 0.10-7.50) compared to those without diabetic retinopathy, (p=n.s).
10.3.4 Studies reporting evidence for MVC risk in drivers with sleep disorders and other medical comorbidities (n=3)

10.3.4.1 Studies reporting evidence of increased risk (n=1)

Cross-sectional/Cohort

Fair quality:

- Philip et al. (2010) reported a higher proportion of those with multiple sleep disorders reporting MVCs compared to controls (OR=1.46, 95% CI 1.20-1.78, p<0.001).

10.3.4.2 Studies reporting evidence of no difference in risk (n=2)

Cross-sectional/Cohort

Good quality:

- Gottlieb et al. (2008) reported that, with a sample of patients with sleep apnoea who also had diabetes, there was no significant difference in the proportion of individuals who experienced MVCs (7.3%) compared to those who did not experience MVCs (6.7%) (p=0.66). Additionally, in patients with sleep apnoea and history of myocardial infarction, there was no significant difference in the proportion of individuals who experienced MVCs (5.0%) compared to those who did not experience MVCs (6.3%) (p=0.34). Within the sample of patients with sleep apnoea who also had hypertension, there was no significant difference in the proportion of individuals who experienced MVCs (37.4%) compared to those who did not experience MVCs (39.4%) (p=0.57). Within the sample of patients with sleep apnoea who also had a history of stroke, there was no significant difference in the proportion of individuals who experienced MVCs (2.3%) compared to those who did not experience MVCs (2.5%) (p=0.65).

- Karimi et al. (2015) found that, within the sample of patients with sleep apnoea who also had diabetes, there was no significant difference in the proportion of individuals who experienced MVCs compared to those who did not experience MVCs (p≥0.08). Within the sample of patients with sleep apnoea who also had psychiatric disorder, there was no significant difference in the proportion of individuals who experienced MVCs compared to those who did not experience MVCs (p≥0.70). Within the sample of patients with sleep apnoea who had cardiovascular disease, there was no significant difference in the proportion of individuals who experienced MVCs compared to those who did not experience MVCs (p≥0.30).

10.3.5 Studies reporting evidence for MVC risk in drivers with alcohol dependence and other medical comorbidities (n=3)

10.3.5.1 Studies reporting evidence of increased risk (n=3)

Case-control

Fair quality:

- Callaghan et al. (2013) reported that poly drug users (defined as more than one substance abuse from cocaine, methamphetamine, opioids, cannabis, or alcohol cohort groups) had an increased risk of MVC fatalities compared to the general population (SMR=2.60, 95% CI 2.40-2.90).

Poor quality:

- Brenner and Selzer (1969) reported that 70% of drivers with alcoholism involved in an MVC had psychopathology compared to 29% of moderate/non-users (RR=27.00, A/C ratio=12.50).

Cross-sectional/Cohort

Poor quality:
• Yates (1987) reported a significantly higher proportion of personal injury MVCs in those with alcohol abuse/dependence+ antisocial personality disorder (45.5%) compared to 25.7% of those with alcohol abuse/dependence without antisocial personality disorder ($X^2=5.40$, df=1, $p<0.05$).

10.3.6 Studies reporting evidence for MVC risk in drivers with dual sensory impairment (n=1)

10.3.6.1 Studies reporting evidence of increased risk (n=1)
Cross-sectional/Cohort

Fair quality:

• Green et al. (2013) reported that, following adjustment for age, race, gender, number of miles driven, number of medical conditions, general cognitive status, and visual processing speed, older drivers having both vision impairment defined by contrast sensitivity and hearing impairment (RR=2.41, 95% CI 1.62–3.57) indicated elevated MVC rates, compared to drivers with no visual or hearing impairments. Those with dual visual acuity impairment and hearing impairment had a significantly higher unadjusted rate for at-fault MVCs compared to drivers with no impairment (RR=1.71 95%CI 1.00–2.95). However, this association did not remain significant after adjustment (RR=1.69 95% CI 0.97–2.93). Drivers with visual acuity loss alone or hearing loss alone did not have significantly different MVC rates when compared to the no impairment group after adjustment for multiple variables.

10.3.7 Studies reporting evidence for driving performance in drivers with glaucoma and other medical comorbidities (n=1)

10.3.7.1 Studies reporting evidence of no difference in risk (n=1)
Case-control

Fair quality:

• Bhorade et al. (2016) found that the number of comorbidities reported by glaucoma participants was not significantly different between those who passed an on-road driving evaluation and those receiving a marginal/fail result ($p=0.76$).

10.3.8 Studies reporting evidence for MVC risk in drivers with two or more (unspecified) medical comorbidities (n=4)

10.3.8.1 Studies reporting evidence of increased risk (n=3)
Case-control

Good quality:

• Vernon et al. (2002) found MVC risk for drivers reporting multiple medical conditions increased both those with restricted (RR=1.28, 95% CI 1.04-1.58, $p<0.05$) and unrestricted (RR=1.41, 95% CI 1.33-1.45, $p<0.05$) licenses compared to controls; and at-fault MVC risk for drivers reporting multiple medical conditions increased both those with restricted (RR=1.67, 95% CI 1.31-2.13, $p <0.05$) and unrestricted (RR=1.60, 95% CI 1.49-1.71, $p<0.05$) licenses compared to controls.

• Dow et al. (2013) reported that the risk of crash increases gradually with the number of multiple medical conditions such that: those with one medical condition (OR=1.18, 95% CI 1.16-1.20), two medical conditions (OR=1.35, 95% CI 1.32-1.38), three medical conditions (OR=1.48, 95% CI 1.44-1.53) and four or more medical conditions (OR=1.55, 95% CI 1.49-1.60).

Cross-sectional/Cohort

Uncategorised quality:
• Marottoli et al. (1994) found a higher number of MVCs for drivers with 4 chronic medical conditions compared to those with less conditions (albeit with a very small sample < 5) (p<0.01).

10.3.8.2 Studies reporting inconclusive evidence of risk (N=1)

Cross-sectional/Cohort

Uncategorised quality:

• Dischinger et al. (2000) reported that a higher proportion of drivers with 3 or more conditions (73.5%) to have been responsible for an MVC in the last three years compared to drivers with no medical conditions (62%); however, no statistical comparisons were made.

10.4 CONCLUSIONS

10.4.1 Overall level of risk

This rapid review identified 16 studies that investigated the risk of MVC or on-road driving performance in with drivers with MMC. However, only six of these studies were rated as having a ‘good’ quality of evidence.

In terms of the studies with ‘good’ ratings, there were two studies that reported a small increase in MVC risk for those with multiple unspecified chronic medical conditions (Vernon et al., 2002; Dow et al., 2013).

In terms of diabetes and its complications, there were two ‘good’ studies that reported conflicting evidence in terms of diabetic retinopathy. McGwin and colleagues (1999) reported a mild increase in MVC risk for drivers with diabetic retinopathy, while Owsley et al. (1998) reported no difference in risk compared to those without diabetic retinopathy. McGwin et al. (1999) also found a moderate MVC risk associated with diabetic neuropathy.

In terms of sleep apnoea and comorbidities, there were two ‘good’ studies that found no difference in MVC risk associated with sleep apnoea with diabetes; or cardiovascular disease (Karimi et al., 2015; Gottlieb et al., 2018).

For the five studies with quality of evidence ratings of ‘fair’, there was a moderate MVC risk associated with poly drug abuse (i.e., cocaine, methamphetamine, opioids, cannabis, or alcohol dependence) reported in one study (Callaghan et al., 2013). In addition, one ‘fair’ study by Green et al. (2013) reported a mildly increased MVC risk associated with contrast sensitivity (visual) impairment and hearing impairment. However, this study found no difference in risk for those with visual acuity impairment plus hearing impairment compared to those with no impairment.

One ‘fair’ study reporting on diabetes and its complications also found no difference in MVC risk between those with diabetes plus health complications (including cardiovascular, visual or hypertension; Laberge Nadeau et al., 2000).

In addition, there was one ‘fair’ study that reported a mild increase in MVC risk for drivers with multiple sleep disorders (Philip et al., 2010).

There was only one study reporting on on-road test outcome by Bhorade and colleagues (2016) which found no difference in the number of comorbidities between those with glaucoma who passed or failed an on-road driving evaluation.

10.4.2 Study limitations

Despite reviewing 135 studies, very few studies had investigated the risk of MVC or on-road driving performance for drivers with MMC. Only one or two studies within each of the high-risk medical conditions identified provide evidence for MVC risk or on-road test outcomes. Moreover, five studies were of limited quality, including studies rated ‘poor’ or not assessed for quality.
Furthermore, for most studies, the MVC risk or the on-road driving performance associated with MMC was not the primary objective. It is likely that most studies did not a priori set out to investigate the impact of MMC and therefore provide limited findings. As a result, there are several studies with small sample sizes for populations with comorbidities, and results from these studies should be interpreted with caution.

10.4.3 Current fitness-to-drive guidelines

Most of the reviewed guidelines recommend an individualised approach utilising clinical judgement, considering factors such as the driving task, clinical and functional assessments around sensory, motor, cognitive, and risk of sudden incapacity, as well as practical on-road assessments.

It also may be necessary for the health professional to consider medical standards for each condition separately, while integrating all clinical information, bearing in mind the additive or compounding effect of each condition on the overall capacity of the patient to control the vehicle, and to act and react in an appropriate and timely way to emergent traffic and road conditions.

10.4.4 Recommendations

The current research evidence is limited in number, with inconsistent quality and a priori objectives. This makes it difficult to quantify the magnitude of MMC on MVC risk on either a general, or specific diagnosis basis and therefore does not support blanket restrictions. The individualised case-by-case approach recommended by international guidelines should continue. Based on these findings, a large-scale, prospective population-based controlled study of MVC risk and multiple medical conditions is warranted.

10.5 REFERENCES


11. INFLUENCE OF DEMENTIA ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the risk of motor vehicle crash for drivers with dementia, and quantify any impacts on on-road driving performance. For the full systematic literature review, refer to:


11.1 OVERVIEW AND KEY RECOMMENDATIONS

- In 2015, an estimated 47 million people worldwide were living with dementia, with this number projected to triple by 2050 driven largely by population ageing (World Health Organization, 2015; Prince, Guerchet, & Prina, 2015). Alzheimer’s disease is the most common form of dementia and may contribute to 60 to 70 percent of cases (World Health Organization, 2017).
- This study was registered with PROSPERO (CRD42016039018).
- A search of public health, psychology and transport databases was conducted in October 2015.
- The quality of evidence in each of the included studies containing primary data was assessed using a rating (Class I, II, or III). This approach, adapted from Dubinsky et al. (2000), classifies studies based on their research design and methodological characteristics. Class I is the strongest design (e.g., prospective cohort design), and Class III is the weakest design (e.g., case report; non-peer reviewed).
- An initial search identified 12,860 studies; two studies (Case-control: n=1; Cross-sectional: n=1) investigated MVC risk, and four studies investigated on-road test outcome (pass/fail; Case-Control: n=1; Cross-sectional: n=3). Details of inclusion/exclusion criteria can be found in the full systematic literature review (Chee, et al., 2017).
- In terms of the studies that investigated MVC risk, one study (cross-sectional, quality rating=I) reported more than a fourfold increase in risk of MVCs per 1,000 miles driven per week retrospectively in the three years prior to the study, whereas the other study (case-control, quality rating=I) showed no statistically significant increase in MVCs over the same time period.
- In terms of the studies that investigated on-road test outcomes, the results of four studies were pooled for a meta-analysis which showed that drivers with dementia were 10 times more likely to fail an on-road driving assessment than healthy comparison group participants (RR=10.77, 95% CI 3.00–38.62, z=3.65, p<0.001), with no significant heterogeneity (χ2=1.50, p=0.68, I2 = 0%).
- The main limitation for this systematic review is the paucity of data. In addition, there were several methodological and reporting limitations identified across many of the included studies that made the synthesis and interpretation of the data challenging.
- Key recommendations:
  - Although data regarding MVCs are limited and equivocal, even mild stages of dementia place individuals at a substantially higher risk of failing an on-road driving assessment.
  - This evidence aligns with the current Australian fitness-to-drive guidelines which specifies that an individual who has a diagnosis of dementia is not fit to hold an unconditional licence and that a conditional licence may be considered by the driver licensing authority subject to at least annual review, which takes into account: 1) the nature of the driving task; 2) information provided by the treating doctor regarding the level of functional impairment and the likely impact on driving ability; and 3) the results of a practical driver assessment if required.
Authors:
Justin N. Chee\textsuperscript{1,2}, Mark J. Rapoport\textsuperscript{2}, Frank Molnar\textsuperscript{3}, Nathan Herrmann\textsuperscript{2}, Desmond O’Neill\textsuperscript{4}, Richard Marottoli\textsuperscript{5}, Sara Mitchell\textsuperscript{1}, Mark Tant\textsuperscript{6}, Jamie Dow\textsuperscript{7}, Debbie Ayotte\textsuperscript{8}, Krista L. Lanctôt\textsuperscript{2}, Regina McFadden\textsuperscript{4}, John-Paul Taylor\textsuperscript{9}, Paul C. Donaghy\textsuperscript{9}, Kirsty Olsen\textsuperscript{9}, Sherrilene Classen\textsuperscript{10}, Yoassry Elzohairy\textsuperscript{11}, & David B. Carr\textsuperscript{12}.

Affiliations:
\textsuperscript{1}Department of Psychiatry, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, \textsuperscript{2}Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada, \textsuperscript{3}Ottawa Hospital Research Institute, Ottawa, Ontario, Canada, \textsuperscript{4}Royal College of Physicians of Ireland, Dublin, Ireland, \textsuperscript{5}School of Medicine, Yale University, New Haven, Connecticut, United States, \textsuperscript{6}Belgian Road Safety Institute, Brussels, Belgium, \textsuperscript{7}Société de l’assurance automobile du Québec, Québec City, Québec, Canada, \textsuperscript{8}Canadian Medical Association, Ottawa, Ontario, Canada, \textsuperscript{9}Institute of Neuroscience, Newcastle University, Newcastle, United Kingdom, \textsuperscript{10}School of Occupational Therapy, Western University, London, Ontario, Canada, \textsuperscript{11}Road User Safety Division, Ontario Ministry of Transportation, Toronto, Ontario, Canada, \textsuperscript{12}School of Medicine, Washington University St. Louis, St. Louis, Missouri, United States.

Sponsoring Organisation:
This knowledge synthesis was funded by the Canadian Institutes of Health Research (KRS grant 339665). The funders played no role in the study methodology, interpretation of results, preparation of the manuscript, or the process of disseminating this work. They accept no responsibility for the contents.

Keywords:
Dementia; Alzheimer disease; Motor vehicle crashes; Driving; Road Safety
### 11.2 SUMMARY OF RESULTS

Table 3: Summary Characteristics and Quality Assessments of Included Studies for Dementia (n=4)\(^{15}\)

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
<th>Groups</th>
<th>Measures</th>
<th>Key findings</th>
<th>Quality ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MVC RISK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Davis et al. (2012)</td>
<td>Cross-sectional observational study</td>
<td>Drivers with dementia (possible or probable AD) aged 60-90 years recruited from a hospital-based memory disorders clinic &amp; Clinical Dementia Rating scale (CDR) score of 0.5 or 1 (n=59)</td>
<td>MVC DATA: MVC history &amp; driving exposure obtained from an informant for drivers with dementia &amp; via self-report for healthy drivers</td>
<td>No difference between healthy driver group &amp; the dementia group: - Percentage of persons with MVCs (13.6 vs. 8.5) - Number of MVCs per year per/10,000 miles driven in past year (0.2 vs. 1.4).</td>
<td>Class I: Drivers with dementia had questionable/very mild/mild dementia based on CDR scores (0.5 and 1) Excluded drivers with dementia who experienced at-fault MVCs in the past year</td>
</tr>
<tr>
<td>Ott et al. (2008)</td>
<td>Case-control</td>
<td>Drivers with dementia (possible or probable AD) aged 40-90 years and with Clinical Dementia Rating scale (CDR) score of 0.5 or 1 (n=84)</td>
<td>MVC DATA: Self-reports of MVCs were supplemented by reports from family informants and state records.</td>
<td>No group differences in: -Percentage of persons with MVCs -MVC rate per driver per year -Total number of MVCs in three years before the baseline assessment</td>
<td>Class I</td>
</tr>
</tbody>
</table>

\(^{15}\) Adapted from Chee, et al. (2017). Update on the risk of motor vehicle collision or driving impairment with dementia: a collaborative international systematic review and meta-analysis. *The American Journal of Geriatric Psychiatry, 25*(12), 1376-1390.
<table>
<thead>
<tr>
<th>On-Road Test Outcome</th>
<th>Data</th>
<th>Clinical Data</th>
<th>On-Road Test Outcome Data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barco et al. (2015)</td>
<td>Cross-sectional</td>
<td>Active drivers with primary diagnosis of dementia from referring physician, recruited through Memory Diagnostic Center (n=60) Health controls aged 55 years and older with Assessing Dementia-8 Screening Interview score &lt;2 &amp; a Short Blessed Test score &lt;9 (n=32).</td>
<td>Neurological, cognitive visual, and physical examination</td>
</tr>
<tr>
<td>Davis et al. (2012)</td>
<td>Cross-sectional observational study</td>
<td>Drivers with dementia (possible or probable AD) aged 60-90 years recruited from a hospital-based memory disorders clinic &amp; Clinical</td>
<td>Neurological, cognitive visual, and physical examination</td>
</tr>
</tbody>
</table>

Excluded drivers with dementia who experienced at-fault MVCs in the past year

Drivers with dementia had questionable/very mild/mild dementia based on CDR scores (0.5 and 1)

Drivers with dementia who experienced at-fault MVCs in the past year

Drivers with dementia had questionable/very mild/mild dementia based on CDR scores (0.5 and 1)
<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Study Design</th>
<th>Participants</th>
<th>Outcome Measures</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ott et al. (2008)</td>
<td>Case-control</td>
<td>Drivers with dementia (possible or probable AD) aged 40-90 years and with Clinical Dementia Rating scale (CDR) score of 0.5 or 1 (n=84) Healthy age-matched drivers aged between 40-90 with a CDR score of 0 &amp; a MMSE score &gt;26 (n=44)</td>
<td>ON-ROAD TEST OUTCOME DATA: Performance on the Modified Washington University Road Test (mWURT) (Safe, Marginal, Unsafe) at baseline and 18-months CLINICAL DATA: Cognitive, neurological, visual, and physical function examination</td>
<td>Drivers with dementia were more likely to fail the on-road test at both baseline and 18-months (Baseline: Unsafe=15.0%; 18-months: Unsafe=15.0%) compared to healthy controls (Baseline: Unsafe=0.0%; 18-months: Unsafe=5.0%, Statistical comparison NR). Cox proportional hazard regression show that the hazard of on-road test failure in the CDR=1 group was 3.5 times higher than in the CDR=0.5 group (Hazard Ratio (HR) = 3.51, 95% CI = 1.09–11.32), after adjusting for differences in age and gender composition, educational level and years of driving experience</td>
</tr>
<tr>
<td>Lincoln et al. (2006)</td>
<td>Cross-sectional</td>
<td>Drivers with dementia following a referral from physician / specialist (n=37) Health controls with no known memory problems (n=31)</td>
<td>ON-ROAD TEST OUTCOME DATA: Performance on the Nottingham Neurological Driving Assessment (NNDA) (Definitely Unsafe, Probably Unsafe, Possibly Unsafe, Definitely Safe)</td>
<td>Drivers with dementia more likely to be rated as Probably Unsafe or Definitely Unsafe (27.0%) compared to healthy controls (0.0%) (Statistical comparison NR).</td>
</tr>
</tbody>
</table>

**CLINICAL DATA:**
Healthy drivers aged 60-90 years with no history of dementia & Mini-Mental State Examination score >26 (n=44)

Dementia Rating scale (CDR) score of 0.5 or 1 (n=59)

Excluded drivers with dementia who experienced at-fault MVCs in the past year

Pass, no recommendations: 56.8%, p<.001).
| META-ANALYSIS |  | Drivers with dementia were much more likely to fail a road test than healthy control drivers (RR=10.77, 95% CI 3.00–38.62, z=3.65, p<0.001), with no significant heterogeneity (χ2=1.50, p=0.68, I2 = 0%). |

| CLINICAL DATA: |
| Cognitive, neurological, visual, and physical function examination |
| definitely unsafe', 'probably ' |
11.3 REFERENCES


12. INFLUENCE OF STROKE / TIA ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the risk of motor vehicle crash after a stroke or TIA. For the full systematic literature review, refer to:


12.1 OVERVIEW AND KEY RECOMMENDATIONS

- Worldwide, the absolute numbers of people with first stroke (approximately 16-9 million), stroke survivors (approximately 33 million), stroke-related deaths (approximately 5.9 million), and disability-adjusted life years lost (approximately 102 million) are significant and increasing (Feigin et al., 2014). Two thirds of strokes occur in people over 65 years old, and occur more commonly in women compared to men (Feigin et al., 2014; Gargano et al., 2008). In 2018, an estimated 387,000 people—214,000 males and 173,000 females—had had a stroke at some time in their lives, based on self-reported data from the Australian Bureau of Statistics 2018 Survey of Disability, Ageing and Carers (ABS 2019). The estimated prevalence of stroke in 2018 was 1.3 percent (ABS 2019).
- This systematic review aimed to determine whether stroke and/or TIAs are associated with an increased MVC risk.
- This study was registered with PROSPERO (CRD42016054074).
- A search of public health, psychology and transport databases was conducted in December 2016.
- The quality of evidence in each of the included studies containing primary data was assessed using a rating (Class I, II, or III). This approach, adapted from Dubinsky et al. (2000), classifies studies based on their research design and methodological characteristics. Class I is the strongest design (e.g., prospective cohort design), and Class III is the weakest design (e.g., case report; non-peer reviewed).
- An initial search identified 5,605 studies and eight studies (case-control: n=3; cohort: n=5) specifically investigated MVC risk. Details of inclusion/exclusion criteria can be found in the full systematic literature review (Rapoport, et al., 2019).
- No studies investigated the impact of stroke/TIA on on-road driving test outcome (pass/fail).
- Of the case-control studies, only one study (quality rating=Class II) reported an association between stroke/TIA and increased MVC.
- Of five cohort studies, only one study (quality rating=Class II), limited to self-report, reported an increased risk of MVC associated with stroke/TIA.
- The main limitation of this systematic review is the lack of relevant studies. In addition, there was a lack of consistent adjustment for possible confounding factors, such as age, gender, driving exposure, medication use, or other comorbidities which may have a significant impact on MVC risk and driving performance, and can vary greatly between study populations.
- Key recommendations:
  - The evidence does not support a robust increase in risk of MVCs for drivers who have experienced stroke or TIAs.
  - The evidence aligns with the current Australian fitness-to-drive guidelines which specifies that a driver licensing authority may consider a return to driving on an unconditional licence, after at least four weeks, taking into account: 1) the nature of the driving task; 2) information provided by an appropriate specialist regarding any functional impairments that are likely to impact on driving ability; and 3) the results of a practical driver assessment if required.
While stroke clearly prevents some individuals from driving altogether, individualised assessment and clinical judgment must continue to be used in assessing and advising individuals about their safety to return to driving after a stroke/TIA including their MVC risk.

Authors:
Mark J. Rapoport¹,², Sarah C. Plonka¹,³, Hillel Finestone⁴, Mark Bayley²,⁵, Justin N. Chee¹,², Brenda Vrkljan⁶, Sjaan Koppel⁷, Elizabeth Linkewich¹,⁸, Judith L. Charlton⁷, Shawn Marshall¹⁰, Martin del Campo⁵, Mark I. Boulos¹,²,⁹, Richard H. Swartz¹,²,⁹, Jaspreet Bhangu¹, Gustavo Saposnik²,¹¹,¹², Jessica Comay¹³, Jamie Dow¹⁴, Debbie Ayotte¹⁵ & Desmond O’Neill¹⁶

Affiliations:
¹Department of Psychiatry, Sunnybrook Health Sciences Center, Toronto, Ontario, Canada, ²Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada, ³Road Safety Research Office, Ontario Ministry of Transportation, Toronto, Ontario Canada, ⁴Faculty of Medicine, Division of Physical Medicine and Rehabilitation, Bruyère Continuing Care, The Ottawa Hospital, University of Ottawa, Ottawa, Ontario, Canada, ⁵Toronto Rehabilitation Institute, University Health Network, Toronto, Ontario, Canada, ⁶School of Rehabilitation Science, McMaster University, Hamilton, Ontario, Canada, ⁷Monash University Accident Research Centre, Monash University, Victoria, Australia, ⁸Department of Occupational Science and Occupational Therapy, Rehabilitation Sciences, University of Toronto, Toronto, Ontario, Canada, ⁹Faculty of Medicine, Department of Medicine (Neurology), University of Toronto, Toronto, Ontario, Canada, ¹⁰Physical Medicine and Rehabilitation, Ottawa Hospital Research Institute, Ottawa, Ontario, Canada, ¹¹Stroke Outcomes and Decision Neuroscience Unit, St. Michael’s Hospital, Toronto, Ontario, Canada, ¹²Department of Economics, Neuroeconomics Lab, University of Zurich, Zurich, Switzerland, ¹³Department of Neurology, Assistive Technology Clinic, Toronto, Ontario, Canada, ¹⁴Société de l’assurance automobile du Québec, Québec City, Québec, Canada, ¹⁵Library, Canadian Medical Association, Ottawa, Ontario, Canada, ¹⁶Trinity College Dublin, The University of Dublin, Dublin, Ireland.

Sponsoring Organisation:
The Ministry of Transportation of Ontario provided financial support under the Road Safety Research Partnership Program [MTO RSRPP 16-17]; and partially funded by Joule Inc., A Canadian Medical Association Company [CMA-DS-001].

Keywords:
Stroke, Transient Ischemic Attack; TIA; Motor vehicle crash; Road safety
### 12.2 SUMMARY OF RESULTS

Table 4: Summary Characteristics and Quality Assessments of Included Studies for Stroke and Transient Ischaemic Attack (n=8)

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
<th>Groups</th>
<th>Measures</th>
<th>Key findings</th>
<th>Quality ratings</th>
</tr>
</thead>
</table>
| McGwin et al. (2000) | Case-control  | Drivers aged ≥ 65 years involved in at-fault MVC in 1996 in Alabama, US (n=249)  
Drivers with no MVC (n=454) | MVC DATA:  
Database & police records  
At-fault status based on review of police records  
CLINICAL DATA:  
Healthcare provider diagnosis via interview | 4.1% stroke in control group vs 7.8% involved in at-fault MVC group (OR=1.90, 95% CI 1.00–3.90)  
Limited to older drivers  
No correction for multiple comparisons or comorbidity | Class II:  
Interviewers blind to case or control status  
Analysis was adjusted for age, sex and driving exposure  
Limited to older drivers |
| Koepsell et al. (1994) | Case-control  | Drivers aged ≥ 65 years who received medical care within seven days for injuries sustained in an MVC in Washington US across 1987-1988 (n=234)  
Controls from same health cooperative without injuries from MVC (n=446) | MVC DATA:  
Health cooperative records  
CLINICAL DATA:  
Medical records & questionnaires within 3 years of the reference date | 2.2% stroke in control group vs 1.7% in MVC group (OR=0.80, 95% CI 0.20–2.50)  
1.8% TIA in control group vs 3.0% in MVC group (OR=1.60, 95% CI 0.50–4.80)  
Limited to older drivers | Class II  
No blinding  
Limited to older drivers |

---

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Characteristics</th>
<th>MVC Data</th>
<th>Clinical Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sims et al. (1998)</td>
<td>Case-control</td>
<td>Drivers aged ≥ 55 years with at least one at-fault MVC in the six years prior to an assessment in Alabama, US in 1991 (n=99) Drivers without an MVC in the same time period (n=75)</td>
<td>MVC reports, with three independent raters agreeing on at-fault status</td>
<td>12.5% TIA in control group vs 4.3% in MVC group (p&gt;0.10)</td>
<td>No ascertainment of driving exposure No at-fault determination Analysis was adjusted for age &amp; sex No correction for multiple comparisons or comorbidity</td>
</tr>
<tr>
<td>Sims et al. (2000)</td>
<td>Cohort</td>
<td>Drivers aged ≥ 55 years followed 5.5 years in Alabama, US from 1991-1996 (n=174)</td>
<td>MVC in 4.0% of sample with no medical diagnoses compared with 9.8% of sample with history of stroke/TIA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Method</td>
<td>Source</td>
<td>MVC Rate</td>
<td>CLINICAL DATA:</td>
<td>MVC Corresponding to Stroke Risk Ratio</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------</td>
<td>---------------------------------</td>
<td>-------------------------</td>
<td>---------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Haselkorn et al. (1998)</td>
<td>Cohort</td>
<td>Drivers hospitalised for stroke in Washington State, US in 1992 followed for 12 months following the reference date (n=1,910) Non-hospitalised cohort of drivers without stroke (n=3,732)</td>
<td>MVC in 3.1% of control group compared to 2.6% of stroke group (RR=0.80, 95% CI 0.60–1.20)</td>
<td>MVC in 3.1% of control group compared to 2.6% of stroke group (RR=0.80, 95% CI 0.60–1.20)</td>
<td>CLINICAL DATA: self-report</td>
</tr>
<tr>
<td>Schanke et al. (2008)</td>
<td>Cohort</td>
<td>Individuals with stroke who were 'fit to drive' based on an assessment of driving fitness in Norway between 1997-2000, and assessed six to nine years post-injury (n=65) Norwegian normative data</td>
<td>5.2 reported MVC per million km driven vs 6.49 in normative control group</td>
<td>CLINICAL DATA: assessed in hospital</td>
<td>MVC in 3.1% of control group compared to 2.6% of stroke group (RR=0.80, 95% CI 0.60–1.20)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Analysis adjusted for age, sex and MVC and citations in 12 months before hospitalisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Analysis adjusted for age, sex and MVC and citations in 12 months before hospitalisation</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Sample Description</td>
<td>MVC Data</td>
<td>Clinical Data</td>
<td>Risk of MVC</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Self-report</td>
<td></td>
<td>reported in 3.5% of sample &amp; not associated with MVC (HR=1.11, 95% CI 0.65–1.90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lundqvist et al. (2008)</td>
<td>Cohort</td>
<td>10-year follow up with individuals with stroke who were still driving (2005–2006) after initial 1995–1996 study in Sweden (n=9)</td>
<td>MVC DATA:</td>
<td>Self-report</td>
<td>MVC reported to insurance company in 3/9 individuals with stroke (33%) compared with 1/22 of controls (4%) (statistical analysis NR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
12.3 REFERENCES


13. INFLUENCE OF SYNCOPE ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated the available evidence regarding the influence of syncope on MVC risk. For the full systematic literature review, refer to:


13.1 OVERVIEW AND KEY RECOMMENDATIONS

- Syncope is a common medical problem. In the general population, the annual number episodes are 18.1–39.7 per 1000 individuals, with similar incidence between genders, and with high prevalence between 10 and 30 years of age, mainly of vasovagal syncope (Moya et al., 2009). However, there is a significant increase in the incidence of syncope after 70 years of age with annual rates of 11.1 per 1000 individuals/year (ages 70–79), and 19.5 per 1000 individuals after 80 years (da Silva, 2014; Moya et al., 2009).

- A search of public health, psychology and transport databases from 1806-2019 was conducted in January 2017 with a follow-up Medline search April 15, 2019.

- The quality of evidence in each of the included studies containing primary data was assessed using a rating (Class I, II, or III). This approach, adapted from Dubinsky et al. (2000), classifies studies based on their research design and methodological characteristics. Class I is the strongest design (e.g., prospective cohort design), and Class III is the weakest design (e.g., case report; non-peer reviewed).

- An initial search identified 887 studies; and 11 studies met inclusion criteria: 3 studies investigated Vasovagal Syncope (VVS), 2 investigated Arrhythmic Syncope (AS); and 6 studies investigated Syncope “not yet diagnosed” (NYD), that is, no causal diagnosis. Details of inclusion/exclusion criteria can be found in the full systematic literature review (Chee, et al., 2020).

- MVC risk was found to vary depending on type of syncope.
  - Of the three studies investigating VVS, (cohort: n=1; cross-sectional n=2) quality of evidence ratings were moderate (Class IIb/IIb+). All three reported a low MVC risk (< 1% per driver-year) and one of these studies reported a lower risk compared with the general population (UK, US, Canada).
  - For the two studies reporting on AS, quality of evidence was moderate (Class IIb). Both studies reported a higher annualised MVC risk (1.9% - 3.4% per driver-year).
  - For the six studies reporting on syncope NYD quality of evidence was rated moderate (n=5 studies Class IIb; n=1 Class I). Results were mixed, with the largest and strongest study reporting a 1.6% higher annualised MVC risk for first-time primary diagnosis of syncope; four studies showed variable effects ranging from 0% to 6.9% increased MVC risk per driver-year and one study provided insufficient information to calculate annualised risk. For the two studies that included comparison groups, older drivers with syncope in the US had a relative risk of MVC injury that was no worse than that of older drivers with other neurologic diseases. In contrast, patients who received a first-time primary diagnosis of syncope NYD exhibited a nearly two-fold increase in the risk of MVC relative to the general population in Denmark.

- The main limitation identified for this systematic reviews was the paucity of data. In addition, there was a lack of consistent adjustment for possible confounding factors,
such as age, gender, driving exposure, medication use and/or compliance which may have a significant impact on MVC risk and driving performance.

- Key recommendations:
  
  o While evidence from two moderate quality studies on VVS showed low risk, further prospective data using robust methodology are needed to determine the risk of MVC in patients with VVS while driving to better inform patients, health professionals, and policy makers.
  
  o For Arrhythmic Syncope: limited data regarding MVCs showed a relatively low risk of MVCs, but a risk that is slightly higher than for the general driving population.
  
  o The evidence aligns with the current Australian fitness-to-drive guidelines which specify that, if the episode of syncope is vasovagal in nature with a clear-cut precipitating factor (such as venesection) and the situation is unlikely to occur while driving, the driving can resume within 24 hours. For syncope due to other cardiovascular causes, the guidelines advise a non-driving period of at least four weeks for private vehicle drivers (and at least 3 months for commercial vehicle drivers), after which time their ongoing fitness to drive should be assessed.
  
  o Further research is recommended using a large prospective longitudinal study design which could provide confident estimates of outcomes of various syncope categories and permit analyses of demographic and diagnostic subgroups. Future research should also quantify the relative effectiveness of current interventions for drivers with syncope (e.g., restricted or modified licences) or that explores the efficacy of new interventions (e.g., monitoring physiologic signals for onset of prodrome).

Authors:

Justin N. Chee1,2,3, Chris Simpson4, Robert S. Sheldon5, Paul Dorian2,8, Jamie Dow7, Juan Guzman8, Satish R. Raj5, Roopinder K. Sandhu4, Venkatesh Thiruganasambandamoorthy10, Martin S. Green11, Andrew D. Krahn12, Sarah Plonka3, & Mark J. Rapoport1,2

Affiliations:

1Department of Psychiatry, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, 2Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada, 3Safety Program Development Branch, Ministry of Transportation of Ontario, Toronto, Ontario, Canada, 4Queen's University and Kingston Health Sciences Centre, Kingston, Ontario, Canada, 5Libin Cardiovascular Institute of Alberta, Department of Cardiac Sciences, University of Calgary, Health Research Innovation Centre, Calgary, Alberta, Canada, 6St Michael's Hospital, Toronto, Ontario, Canada, 7Société de l'assurance Automobile du Québec, Québec City, Québec, Canada, 8Department of Medicine, McMaster University, Hamilton General Hospital, Hamilton, Ontario, Canada, 9Division of Cardiology, Walter C. MacKenzie Health Sciences Centre, University of Alberta, Edmonton, Alberta, Canada, 10Ottawa Hospital Research Institute, Department of Emergency Medicine, University of Ottawa, Ottawa, Ontario, Canada, 11Division of Cardiology, University of Ottawa Heart Institute, University of Ottawa, Ottawa, Ontario, Canada, 12Heart Rhythm Vancouver, Division of Cardiology, Department of Medicine, Gordon & Leslie Diamond Health Care Centre, University of British Columbia, Vancouver, British Columbia, Canada.

Sponsoring Organisation:

This work was financially supported by the Ministry of Transportation of Ontario, under the Road Safety Research Partnership Program (MTO RSRPP 16-17) and partially funded by Joule, a Canadian Medical Association Company (CMA-DS-001).

Keywords:

None reported.
### 13.2 SUMMARY OF RESULTS

Table 5: Summary Characteristics and Quality Assessments of Included Studies for Syncope (n=11)

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
<th>Groups</th>
<th>Measures</th>
<th>Key findings</th>
<th>Quality ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VASOVAGAL SYNCOPE (VVS)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tan et al. (2016)</td>
<td>Prospective cohort</td>
<td>N=418 drivers with syncope from Canada, Columbia, Germany, USA, and Australia: ≥3 lifetime syncope episodes; +ve tilt test; or VVS diagnosis with Calgary Syncope Score (CSS)</td>
<td>MVC DATA: Cases: self-report Comparison group: publicly available population crash data accessed by internet search</td>
<td>2 out of 418 patients (0.48%) had syncope while driving (0.62% per patient-year), of which 1 had MVC: Sycope drivers had lower annualised MVC risk of 0.31%/driver-year vs. 0.49%/driver-year (UK) 0.56%/driver-year (Ca) 2.29%/driver-year (USA) 1.11%/driver-year (combined 3 countries)</td>
<td>Class IIb (+) Has comparison group; design not ideal; insufficient reporting of pertinent information</td>
</tr>
<tr>
<td>Bhatia et al. (1999)</td>
<td>Prospective cross-sectional</td>
<td>N=155 drivers with syncope: ≥1 syncope episode past 6 mo; +ve tilt test</td>
<td>MVC DATA: self-report CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td>0 out of 49 patients who continued to drive had an MVC despite an increase in number of</td>
<td>Class IIb Sample size concerns; lacks control group</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>N</td>
<td>MVC Data</td>
<td>Clinical Data</td>
<td>Hours driven per week: Lower annualized MVC risk of 0.00%/driver-year</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>---</td>
<td>----------</td>
<td>--------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Sheldon &amp; Koshman (1995)</td>
<td>Prospective cross-sectional</td>
<td>N=209 drivers with syncope: NMS diagnosis &amp;+ve tilt test</td>
<td>MVC DATA: self-report</td>
<td>4 MVCs over 5 years, 2 of which caused driver injury: Lower annualized MVC risk of 0.26%/driver-year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison group: N/A</td>
<td>CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akiyama et al. (2001)</td>
<td>Prospective cross-sectional</td>
<td>N=559 drivers with syncope</td>
<td>MVC DATA: self-report</td>
<td>Annual risk of 3.4% (95% CI 2.5-4.3) MVCs per patient-year: Higher annualised MVC risk of 3.4%/driver-year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison group: N/A</td>
<td>CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trappe et al. (1998)</td>
<td>Prospective cross-sectional</td>
<td>N=171 drivers with syncope</td>
<td>MVC DATA: self-report</td>
<td>11 accidents in 11 drivers, none related to syncopal symptoms (n=1 at-fault), corresponding to 6% over a mean follow-up of 38 _</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison group N/A</td>
<td>CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ARRHYTHMIC SYNCOPE**

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>N</th>
<th>MVC Data</th>
<th>Clinical Data</th>
<th>Class IIB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Comparison group: N/A</td>
<td>CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akiyama et al. (2001)</td>
<td>Prospective cross-sectional</td>
<td>N=559 drivers with syncope</td>
<td>MVC DATA: self-report</td>
<td>Some concerns with methodology; lacks control group</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison group: N/A</td>
<td>CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trappe et al. (1998)</td>
<td>Prospective cross-sectional</td>
<td>N=171 drivers with syncope</td>
<td>MVC DATA: self-report</td>
<td>Lacks control group</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparison group N/A</td>
<td>CLINICAL DATA: Well defined clinical details; no other detail provided on source</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## INFLUENCE OF CHRONIC ILLNESS ON MOTOR VEHICLE CRASH RISK

### SYNCOPE NOT YET DIAGNOSED

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>MVC DATA</th>
<th>Clinical DATA</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nume et al. (2016)</td>
<td>Prospective cohort</td>
<td>Administrative data</td>
<td>Hospital/ER diagnosis ICD-10 R 55.9</td>
<td>Patients who received a first-time primary diagnosis of syncope NYD exhibited a nearly two-fold increase in the risk of MVC relative to the general population in Denmark: Higher annualised MVC risk of 1.6%/year vs 1.0% for general driving population of Denmark. Crude MVC incidence rate of 20.6 (95% CI 19.7-21.6) per 1000 person-years for syncope and 12.1 (95% CI 12.0-12.1) per 1000 person-years for control, with a rate ratio of 1.83 (95% CI 1.74-1.91, p&lt; 0.001). 5-year crash risk (cumulative incidence) of 8.2% (95% CI 7.5-8.8%) for syncope and 5.1% (95% CI 4.7%-5.4%) for age- and sex-matched control.</td>
</tr>
<tr>
<td>Koepsell et al. (1994)</td>
<td>Retrospective, Case Control</td>
<td>Self-report and Administrative data</td>
<td>Medical records &amp; questionnaires within 3 years of the reference date</td>
<td>38 cases with syncope or dizziness had an MVC injury over 2 years. No significant differences between the percentage of drivers who did or did not experience an MVC injury with respect to: syncope (Odds Ratio: 1.8, 95%CI: 0.7-5.0); dizziness, etiology unknown (Odds Ratio: 1.2; 95%CI = 0.7-1.9); or any of the neurological conditions examined in combination (Odds Ratio: 1.1; 95%CI: 0.8-1.7).</td>
</tr>
</tbody>
</table>

### Notes:
- Class I (-) has a comparison group; good reporting pertinent information; uses administrative data; otherwise entirely Class I
- Class IIb Retrospective data; has a comparison group; design not ideal; some sample size concerns; insufficient reporting of pertinent information
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>n=</th>
<th>Source of MVC data</th>
<th>Source of clinical data</th>
<th>MVC cases</th>
<th>MVC risk during follow-up</th>
<th>Risk during follow-up</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silva et al. (2016)</td>
<td>Prospective cross-sectional</td>
<td>125</td>
<td>Self-report</td>
<td>Hospital records</td>
<td>25/125</td>
<td>1.6%</td>
<td>N=125 drivers in Portugal with syncope who were consecutive ED/admitted hospital patients with – transient LoC, classified as: reflex, cardiogenic, orthostatic hypertension, CNS origin, psychogenic or pseudopsychogenic, or unexplained syncope. Comparison group: n/a</td>
<td></td>
</tr>
<tr>
<td>Folino et al. (2018)</td>
<td>Prospective cross-sectional</td>
<td>40</td>
<td>Self-report</td>
<td>Patient clinical records</td>
<td>3/40 (7.5%)</td>
<td>N=3 out of 40 (7.5%) drivers who experienced syncope while driving crashed their vehicles as a consequence. Prospectively, n=8 of 40 (20%) had recurrences of syncope, but none while driving and none were hospitalized, for a 0.0% MVC risk during follow-up as well as per patient-year.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martikainen et al. (2011)</td>
<td>Prospective cross-sectional</td>
<td>56</td>
<td>Self-report</td>
<td>No other detail provided on source</td>
<td>2/29 (6.9%)</td>
<td>N=2 out of 29 (6.9 %) drove at the time of the 1-year follow-up had an MVC, corresponding to a 6.9% annualized MVC risk.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison group: n=56 active drivers age who were members of health cooperative aged > 65 years without syncope, with neurological condition:

Non-syncope cases: injured in at-fault MVC previous 2 years (1987-1988)

Non-syncope controls: not injured in MVC (matched within 1 year)
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Study Design</th>
<th>Sample Description</th>
<th>Data Collection</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maas et al. (2003)</td>
<td>Prospective cross-sectional</td>
<td>N=104 patients referred for investigation of syncope; licensed drivers</td>
<td>MVC DATA: self-report. CLINICAL DATA: Physician diagnosis of LOC in medical record; no other detail provided on source</td>
<td>N=1 out of 104 patients had an MVC resulting from syncope while driving in the past. Within the 1-year follow-up, none of the patients had an MVC, corresponding to an MVC risk of 0.0% during follow-up as well as per patient-year.</td>
</tr>
</tbody>
</table>

Class IIb some sample size concerns; lacks control group.
13.3 REFERENCES


14. INFLUENCE OF TBI ON MVC RISK

This chapter provides a high-level summary of the key findings and recommendations from the systematic literature review that evaluated available evidence on the MVC risk for drivers following TBI, and impacts on on-road driving test performance. The aim of the study from which this summary is extracted was to synthesize knowledge of the MVC risk following a TBI and the associated risk of driving impairment, as measured by on-road tests, computerized simulators, and self-reported or state-recorded driving records. The studies based on simulated driving performance are not presented here. For the full systematic literature review, refer to:


14.1 OVERVIEW AND KEY RECOMMENDATIONS

- The estimated global prevalence of TBI is 55.5 million (53.40–57.62 million) cases, with approximately 150,000 cases in Australia (James et al., 2019). A recent ABS survey estimated that 432,700 Australians (2.2% of the population) had an acquired brain injury with “activity limitations” or “participation restrictions” because of their disability (ABS, 2019).

- A search of seven public health, psychology and transport databases was conducted for literature pertaining to TBI and MVC or motor vehicle driving between 1990 and 2015. (Studies that examined the risk of having a TBI associated with being involved in an MVC were excluded).

- The quality of evidence in each of the included studies containing primary data was assessed using a rating (Class I, II, or III). This approach, adapted from Dubinsky et al. (2000), classifies studies based on their research design and methodological characteristics. Class I is the strongest design (e.g., prospective cohort design), and Class III is the weakest design (e.g., case report; non-peer reviewed).

- From 13,578 search results, six studies were included involving 1,646 participants with TBI and 4,780 controls. (Note the study reports eight in total; two were excluded from this summary due to use of a simulator (n=1) and no measure of on-road driving test outcome (n=1)). Details of inclusion/exclusion criteria can be found in the full systematic literature review (Chee, et al., 2018).

- Four studies (all Class IIb) reported on MVC risk: two using self-reported data, one using official crash data and one using both self-report and official. Analysis of the pooled data for these studies showed no significant difference in the risk of MVC for drivers with TBI compared with drivers without TBI (OR=1.24, 95% CI 0.80–1.91, p=0.34).

- Further analysis of three studies using self-reported crash data only showed the risk of MVC was higher for those without a TBI (OR=1.63, 95% CI 1.21–2.22, p=0.002). Notably, these studies involved TBI drivers soon after injury who, the authors speculated, may be more likely to self-regulate, drive fewer miles and take fewer risks than healthy controls.

- Two studies (both Class IIIb) evaluated on-road test performance of participants with TBI compared with age-matched drivers without TBI. Findings were mixed: one study (involving an Occupational Therapy driving assessor) reported that while overall road test scores were significantly lower in the TBI group, road test failure rate was not significantly different between the two groups. In contrast, the other
study (test protocol not specified) found that driving test failure rate was significantly higher in the TBI group (time post-injury unspecified) than in unmatched licensed drivers with excellent driving records.

- Limitations of reviewed studies included no adjustment for exposure, small sample sizes, failure to specify TBI severity or time post-injury, and absence of objective measures of risk and inadequate study protocol descriptions.

- Key recommendations:
  - Findings on the relationship between TBIs and MVC risk are, therefore, inconclusive.
  - The review concluded that there was no evidence to support major changes to existing clinical guidelines for driving with TBI. For example, the Australian fitness to drive guidelines specify that a person is not fit to hold an unconditional licence: if they have had a head injury producing significant impairment of any of the following: visuospatial perception, insight, judgement, attention, comprehension, reaction time, memory, sensation, muscle power, coordination, vision (including visual fields). On the other hand, a conditional licence may be considered, taking into account: the nature of the driving task; information regarding the likely impact of the neurological impairment on driving ability and the presence of other disabilities that may impair driving; the results of neuropsychological testing if indicated; and the results of a practical driver assessment if required.
  - Further research is recommended particularly to examine MVC risk with respect to TBI severity and time post-injury, with carefully defined injury severity and objective measures of MVC risk.

Authors:
Justin N. Chee¹, Carol Hawley², Judith L. Charlton³, Shawn Marshall⁴, Ian Gillepsie⁵, Sjaan Koppel³, Brenda Vrkljan⁶, Debbie Ayotte⁷, & Mark J. Rapoport¹

Affiliations:
¹Department of Psychiatry, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, ²Mental Health and Wellbeing, Warwick Medical School, University of Warwick, Coventry, United Kingdom, ³Monash University Accident Research Centre, Monash University, Victoria, Australia, ⁴Ottawa Hospital Research Institute, Ottawa, Ontario, Canada, ⁵Canadian Forces Health Services Centre (Pacific), Victoria, British Columbia, Canada, ⁶School of Rehabilitation Science, McMaster University, Hamilton, Ontario, Canada, ⁷Canadian Medical Association, Ottawa, Ontario, Canada.

Sponsoring Organisation:
This work was financially supported by the Canadian Institutes of Health Research (CIHR) (KRS grant #339665).

Keywords:
Driving; Motor vehicle collision; Traumatic brain injury
### 14.2 SUMMARY OF RESULTS

**Table 6: Summary Characteristics and Quality Assessments of Included Studies for Traumatic Brain Injury (n=6)**

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
<th>Groups</th>
<th>Measures</th>
<th>Key findings</th>
<th>Quality ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lew et al. (2011)</td>
<td>NR</td>
<td>TBI n=34; severity NR; 3.73y +/- 1.39 post-inj; Age: 33.5 (10)y; 93.2% male; Educ: ≤ HS 20%, PS: 80% No-TBI n=23; OIF/OEF veterans</td>
<td>MVC DATA: self-report CLINICAL DATA: Not reported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schultheis et al. (2002)</td>
<td>NR</td>
<td>TBI n=47; severity NR; (6mo-22y post inj); Age: 39.15 y (19.54); 72.3% male; 13.21y educ No-TBI n=22; Age 36.91y (12.78); 50% male; 13.86 (2.49) y educ</td>
<td>MVC DATA: Self-Report (Q’aire) And New Jersey DMV CLINICAL DATA: Not reported</td>
<td>OR 1.3 (0.37-4.52)</td>
<td>Class IIib</td>
</tr>
<tr>
<td>Haselkorn et al. (1998)</td>
<td>NR</td>
<td>TBI n=896; severity NR; (&lt;1 y post-inj) 69.1% male; Age: &lt;20y 12%, 20-69 75%, &gt;70 13% No-TBI n=1625</td>
<td>MVC DATA: Washington State licencing records CLINICAL DATA:</td>
<td>0.9 (0.27-2.89)</td>
<td>Class IIb</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Study</th>
<th>Group 1</th>
<th>Group 2</th>
<th>MVC Data</th>
<th>Clinical Data</th>
<th>Driving Test Data</th>
<th>Driving Score TBI</th>
<th>Failure Rate TBI</th>
<th>Failure Rate Controls</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL pooled analysis (4 studies above)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>On-road test outcome</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Class IIb</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Brooke et al. (1992)**
- **Group 1**: TBI n=13; severity NR; LoC ≥1hr; 3-6mo post inj; age 18-65y
- **Group 2**: No-TBI n=7; age matched +/- 5y; age 18-65y
- **Driving Test Data**: Stndzd On-Road test with evaluator
- **Clinical Data**: Not reported
- **Driving Score TBI** sig lower than controls 19.92 (4.87) vs 24.71 (2.91) (d’=1.19, large effect size); Statistical significance not tested in study, but confirmed in SR: t(18)=2.259, p=0.037
- **Failure Rate**: TBI 38.46% vs Controls 14.29%; Statistical significance not tested in study, but confirmed in SR: χ²(1)=1.27 (p=0.26); ie drivers with TBI not significantly different from drivers without TBI.

**Lambert et al. (1992)**
- **Group 1**: TBI n=71; severity NR; Age: ≤26y 44%, >26y 56%
- **Group 2**: No-TBI n=42 with excellent driving records; age: NR
- **Driving Test Data**: Details NR
- **Clinical Data**: Not reported
- **Failure Rate**: TBI 23.73% vs 0% (h=1.02, large effect size) Statistical significance not
tested in study, but confirmed in SR: \( \chi^2(1)=11.57 \ p<0.001; \) ie drivers with TBI had significantly higher failure rate than drivers without TBI.
14.3 REFERENCES


15. SUMMARY OF MOTOR VEHICLE CRASH RISK ASSOCIATED WITH MEDICAL CONDITIONS AND RECOMMENDATIONS

15.1 SUMMARY OF RISK ASSOCIATED WITH MEDICAL CONDITIONS

Using the evidence from each of the systematic reviews outlined in Chapters 3-14, a rating system was applied to describe the evidence for MVC risk associated with all medical conditions of interest in this research project. Four main categories of risk ratings were applied:

- Higher (H):
  - Slightly high (*): RR: 1.1-2.0
  - Moderately high (**): RR: 2.1-5.0
  - Considerably high (***): RR: 5.0+
- No difference (ND) (nominally RRs ~ 1)
- Lower (L)
- Inconclusive (I) (evidence highly equivocal or no evidence).

Quality ratings were considered and only studies with evidence rated ‘good’ and ‘fair’ were included. Thus, for each condition, studies providing good/fair quality evidence for H, ND, L, I were tallied. The ratings were assigned to evidence for MVC involvement, deemed to be of direct relevance in assessing MVC risk than driving performance. In addition, the evidence for on-road driving test outcomes was rated in the same way, however, at best this evidence was sparse for most conditions. The rating provided a means of identifying those conditions for which there was at least one H* ‘good’ quality study by consensus.

Information on post-treatment risk was also considered where available (e.g., treatment of sleep apnoea) and the same rating categories described above were applied. Evidence relating to treatment was relatively sparse and for the majority of conditions, no evidence could be found for post-treatment MVC risk. In some studies that did report crash data during or after treatment, serious methodological issues generally precluded the separate identification of treatment effects from the effects attributable to the disorder itself. Understandably, the comparison of treatment groups with non-treatment groups is difficult for obvious ethical reasons.

Risk ratings were based primarily on available Relative Risk or Odds Ratios, whichever was appropriate for the study design, and other statistical comparisons used for supportive evidence. It should be noted that comparisons across risk ratings are not strictly valid because of differences in study design and use of different control groups. For example, those studies examining the risk of crashes amongst drivers with cataracts generally recruited older participants (both cases and controls) because the condition is more prevalent in the older population. On the other hand, comparisons involving TBI (majority of studies: mean age 38-48 +/-18 years) were more likely to span age groups whose risk of crashes varies considerably from highest (i.e., novice drivers under 20 years) to lowest (25-50 years). Hence, differences in control groups prevent a direct comparison of risk ratios across different studies. Nevertheless, what can be established is that the conditions that were rated higher risk (at least moderately elevated) had significantly elevated MVC risks compared with relevant controls.

In total, there were 160 included studies across the 11 systematic reviews. Of the 160 studies, most were cross-sectional/cohort studies in design (n=35 case-control studies; n=113 cross-sectional/cohort studies; n=7 before-after studies; n=5 NR). In terms of quality, only around one third of studies were rated ‘good’. For multiple medical conditions, there were 16 studies included (n=7 case-control studies and n=9 cross-sectional/cohort studies). In terms of quality, only five were rated as ‘good’. Most studies were found to have some level of bias, such as recruitment of non-representative cases (including severity of
condition, time since onset), and a lack of control of confounding variables such as age, sex, comorbidities and driving exposure. Overall, the quality of evidence for elevated MVC risk was modest. Table 7
Table 1 summarises the categories of risk and quality of evidence for the eleven conditions and multiple medical conditions reviewed in this report.

Table 7: Summary of MVC risk associated with medical conditions and impairments

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prevalence %</th>
<th>MVC risk and Quality of Evidence*</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol Use Disorder (AUD)</td>
<td>*Europe: 14.8% males; 3.5% females The Americas: 11.5% males; 5.1% females Australia: 6.1% males; 2.7% females</td>
<td><strong>MVC:</strong> H* (2 'good', 'fair' studies) H** (1 'good', 2 'fair' studies) L (1 'good')</td>
<td>AUD should continue to be considered a risk for MVC; physicians urged to increase attention to ensuring accurate diagnosis, treatment and follow-up for drivers with heavy drinking patterns, binge drinking, known AUD, and those involved in traffic violations and MVC.</td>
</tr>
<tr>
<td>Diabetes</td>
<td>9.3% (age 20-79 y) 19.3% (aged &gt;65 y)</td>
<td><strong>MVC:</strong> H* (2 'good', 1 'fair' study) ND (2 'good', 1 'fair' study)</td>
<td>No basis for change to current fitness-to-drive standards, except to eliminate differentiation between insulin treated vs. treated with hypoglycaemic agents. Identifying drivers at risk of hypoglycaemia while driving remains a high priority.</td>
</tr>
<tr>
<td>Epilepsy and seizure disorders</td>
<td>*0.4-1.0%</td>
<td><strong>MVC:</strong> H* (2 'good', 2 'fair' studies) H*** (1 'good study) ND (2 'good', 1 'fair' studies) I (1 'good', 2 'fair' studies) Seizure-free interval (SFI) L (2 'fair' studies) for 6 &amp; 12 mo &amp; 3y ND (1 'good study) for 12 mo vs. 3 mo Anti-epileptic drugs (AED) H** (1 'good' study) H** (1 'fair' study for non-adherence L (1 'fair study) for AED modifications ND (1 'fair study)</td>
<td>Overall the weight of evidence suggests a slight elevation of risk. However, available evidence is mixed and not of high quality for MVC risk associated with epilepsy and/or seizure disorders. There may be an elevation of risk with AED non-compliance which justifies a guideline for restrictions of driving; some evidence of lower risk for longer seizure free periods.</td>
</tr>
<tr>
<td>Hearing loss</td>
<td>*5% have moderate-severe hearing loss (&gt; 40dB) *US: 38% age 80 y+ have mod. bilateral hearing loss</td>
<td><strong>MVC:</strong> ND (1 'good', 1 'fair' study) L (1 'good study)</td>
<td>No evidence warranting restrictions for a full licence (commercial or non-commercial) for drivers with hearing loss. For work-related driving, hearing requirements should be incorporated in regulations governing the activities (e.g., driving school bus; transporting dangerous materials).</td>
</tr>
<tr>
<td>Psychiatric conditions</td>
<td>*DSM-IV disorders 4.3-6.4%</td>
<td><strong>MVC:</strong> MOOD &amp; ANXIETY DISORDERS H* (2 'good', 1 'fair' study) H** (1 'fair study) ND (4 'fair' studies) OTHER PSYCHIATRIC H* (2 'good', 2 'fair' studies H** (2 'fair' studies) ND (1 'fair study) I (1 'fair study)</td>
<td>Available evidence is mixed and not of high quality, and also does not support a blanket restriction on licence holding. Individualised case-by-case approach is recommended as per international guidelines; recommend practice of looking for red-flags which would raise concern.</td>
</tr>
</tbody>
</table>
| Sleep disorders                     | Up to 6%     | **MVC:** SLEEP APNOEA H* (2 'good', 1 'fair' studies) H** (6 'good', 2 'fair' studies) H*** (2 'good', 1 'fair' studies) ND (2 'good', 4 'fair') I (1 'good', 1 'fair' studies) CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP) TREATMENT L (3 'good', 1 'fair' study ) UVULOPALATOPHARYNGOPLASTY (UPPP) TREATMENT L (1 'good study) HYPERSONMONOENCE/NARCOLEPSY H** (3 'good', 2 'fair' studies) | Most international guidelines do not give permission for drivers with sleep disorders to hold an unrestricted licence. Instead, the guidelines indicate a conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from the treating doctor (or a sleep specialist in the case of commercial drivers) subject to compliance with, and...
<table>
<thead>
<tr>
<th>Vision impairments and disorders</th>
<th>MVC:</th>
<th>Vision impairments and disorders</th>
<th>MVC:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLAUCOMA</td>
<td></td>
<td>GLAUCOMA</td>
<td></td>
</tr>
<tr>
<td>H* (1 ‘good’ study)</td>
<td></td>
<td>H* (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>H** (1 ‘good’, 1 ‘fair’ study)</td>
<td></td>
<td>H** (1 ‘good’, 1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>H*** (1 ‘good’, 1 ‘fair’ study)</td>
<td></td>
<td>L (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>ND (1 ‘good’, 1 ‘fair’ study)</td>
<td></td>
<td>ND (1 ‘good’, 1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>I (1 ‘fair’ study)</td>
<td></td>
<td>I (1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>On-road test:</td>
<td></td>
<td>On-road test:</td>
<td></td>
</tr>
<tr>
<td>H* (1 ‘good’ study)</td>
<td></td>
<td>H* (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>H (1 ‘fair’ study)</td>
<td></td>
<td>H (1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>ND (1 ‘good’ study)</td>
<td></td>
<td>ND (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>MVC:</td>
<td></td>
<td>MVC:</td>
<td></td>
</tr>
<tr>
<td>CATARACT</td>
<td></td>
<td>CATARACT</td>
<td></td>
</tr>
<tr>
<td>H* (1 ‘good’)</td>
<td></td>
<td>H* (1 ‘good’)</td>
<td></td>
</tr>
<tr>
<td>ND (2 ‘good’)</td>
<td></td>
<td>ND (2 ‘good’)</td>
<td></td>
</tr>
<tr>
<td>MVC:</td>
<td></td>
<td>MVC:</td>
<td></td>
</tr>
<tr>
<td>AGE-RELATED MACULAR DEGENERATION (AMD)</td>
<td></td>
<td>AGE-RELATED MACULAR DEGENERATION (AMD)</td>
<td></td>
</tr>
<tr>
<td>L (1 ‘good’ study)</td>
<td></td>
<td>L (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>ND (3 ‘good’, 1 ‘fair’)</td>
<td></td>
<td>ND (3 ‘good’, 1 ‘fair’)</td>
<td></td>
</tr>
<tr>
<td>On-road test:</td>
<td></td>
<td>On-road test:</td>
<td></td>
</tr>
<tr>
<td>H* (1 ‘good’ study)</td>
<td></td>
<td>H* (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>ND (1 ‘fair’ study)</td>
<td></td>
<td>ND (1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>MVC:</td>
<td></td>
<td>MVC:</td>
<td></td>
</tr>
<tr>
<td>VISUAL ACUITY (VA) IMPAIRMENT</td>
<td></td>
<td>VISUAL ACUITY (VA) IMPAIRMENT</td>
<td></td>
</tr>
<tr>
<td>H (1 ‘fair’)</td>
<td></td>
<td>H (1 ‘fair’)</td>
<td></td>
</tr>
<tr>
<td>ND (7 ‘good’, 3 ‘fair’ studies)</td>
<td></td>
<td>ND (7 ‘good’, 3 ‘fair’ studies)</td>
<td></td>
</tr>
</tbody>
</table>

Limited numbers of studies and conflicting findings preclude firm conclusions. Good quality evidence for increased MVC risk in binocular visual field impairment. No clear evidence for a specific cut-off criterion for visual fields. Evidence is mixed and no conclusions can be drawn on MVC risk for visual acuity impairment, cataract, glaucoma, age-related macular degeneration, and homonymous field loss.

---

**MULTIPLE MEDICAL CONDITIONS (MMC)**

<table>
<thead>
<tr>
<th>Multiple Medical Conditions (MMC)</th>
<th>MVC:</th>
<th>Multiple Medical Conditions (MMC)</th>
<th>MVC:</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIABETES:</td>
<td></td>
<td>DIABETES:</td>
<td></td>
</tr>
<tr>
<td>H* with Retinopathy (1 ‘good’ study)</td>
<td></td>
<td>H* with Retinopathy (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>ND with Retinopathy (1 ‘good’ study)</td>
<td></td>
<td>ND with Retinopathy (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>H** with Neuropathy (1 ‘good’ study)</td>
<td></td>
<td>H** with Neuropathy (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>ND with ‘Health complications’: cardiovascular, visual or hypertension (1 ‘fair’ study)</td>
<td></td>
<td>ND with ‘Health complications’: cardiovascular, visual or hypertension (1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>SLEEP DISORDER:</td>
<td></td>
<td>SLEEP DISORDER:</td>
<td></td>
</tr>
<tr>
<td>H* Multiple sleep disorders (1 ‘fair’ study)</td>
<td></td>
<td>H* Multiple sleep disorders (1 ‘fair’ study)</td>
<td></td>
</tr>
<tr>
<td>ND Apnoea with Diabetes; or Myocardial Infarction; or hypertension; or cardiovascular disease; or stroke (2 ‘good’ study); and psychiatric disorder (1 ‘good’ study)</td>
<td></td>
<td>ND Apnoea with Diabetes; or Myocardial Infarction; or hypertension; or cardiovascular disease; or stroke (2 ‘good’ study); and psychiatric disorder (1 ‘good’ study)</td>
<td></td>
</tr>
<tr>
<td>ALCOHOL USE DISORDER (AUD):</td>
<td></td>
<td>ALCOHOL USE DISORDER (AUD):</td>
<td></td>
</tr>
</tbody>
</table>

The available evidence on MVC risk associated with MMC is limited and does not support blanket restrictions. An individualised case-by-case approach recommended by most international guidelines should continue.
H** AUD with poly drug users (cocaïne, methamphetamine, opioids, cannabis, or alcohol cohort groups) (1 ‘fair’ study)
SENSORY LOSS:
H* Vision Contrast Sensitivity with hearing (1 ‘fair’ study)
ND VA with hearing (1 fair study)
MULTIPLE UNSPECIFIED:
H* (2 ‘good’ study)
On-road test:
ND Glaucome with multiple comorbidities (1 ‘fair’ study)

| Dementia | *North Africa/Middle East: 8.7% (aged ≥60 y)
Latin America: 8.4% (aged ≥60 y)
Australia: 7.0% (aged ≥60 y)
Central Europe: 4.7% (aged ≥60 y) |
|---|---|
| MVC: | H** (1 ‘good’ Class I study)
ND (1 ‘good’ Class I study)
On-road test: H*** fail (meta-analysis: 2 Class I, 2 Class IIb studies) |

Although finding on MVCs are limited and equivocal, even early stages of dementia place individuals at a substantially higher risk of failing an on-road driving assessment. This evidence aligns with the current Australian fitness-to-drive guidelines: i.e., a driver with a documented diagnosis of dementia is not fit to hold an unconditional licence; a conditional licence may be considered subject to at least annual review.

<table>
<thead>
<tr>
<th>Stroke; Transient Ischemic Attacks</th>
<th>*1.12 %</th>
</tr>
</thead>
</table>
| MVC: | H*(1 Class II studies)
H** (1 Class II studies)
ND (4 Class II study)
I (2 Class II study)
On-road test: 0 studies |

The evidence for an increase in risk of MVCs is not robust. The evidence aligns with the current Australian fitness-to-drive guidelines which specifies that a driver licensing authority may consider a return to driving on an unconditional licence, after at least four weeks.

<table>
<thead>
<tr>
<th>Syncope</th>
<th>*US: Lifetime=20%; Recurrent=13.5%</th>
</tr>
</thead>
</table>
| MVC: | VASOVAGAL SYNCOPE (VVS)
Low risk (<1% per driver year) (3 Class IIb studies)
ARRHYTHMIC SYNCOPE (AS)
H: higher annualised MVC risk (1.9% - 3.4% per driver-year) (2 Class IIb studies)
SYNCOPE “NOT YET DIAGNOSED” (NYD)
H: 1.6%-6.9% increased MVC risk per driver-year (1 Class I, 4 Class IIb studies)
ND (1 Class IIb study)
On-road test: 0 studies |

Evidence from two moderate quality studies on VVS showed low risk. Require more robust evidence.
Limited evidence on AS showed MVC risk slightly higher than for general driving population. Insufficient data to recommend a shorter duration of driving restriction than stipulated by current (Canadian) guidelines.

| Traumatic Brain Injury (TBI) | *12.1% (16.7% males, 8.5% females)
*US: 1-2% living with TBI disability |
|---|---|
| MVC: | ND (meta-analysis: 4 Class II studies)
On-road test: (0 Class I, II studies) |

Findings on MVC risk for TBI are inconclusive.
No evidence to support major changes to existing clinical guidelines for driving with TBI.

15.2 PREVALENCE AND RISK STATUS

It is instructive to examine the risk associated with medical conditions in the context of other road user high-risk groups as well as the prevalence of the condition amongst licensed drivers. World-wide figures suggest that younger drivers, 17-25 years is an over-represented group in road crashes, and over 50 percent higher annual fatality rate than for other age groups (BITRE, 2019). In Australia, the annual fatality rate for drivers in this group is around 18.26 percent of all driver lives lost, while they represent around 12 percent of the
population (BITRE, 2019). This is informative because it enables us to estimate the size of the problem.

However, for many conditions, specific prevalence data for the driving population are difficult to establish. For example, data from the large population-based study (State of Utah, USA.) by Vernon et al. (2002) are presented for a range of conditions including psychiatric conditions (0.4% of licensed drivers). However, these figures for licensed drivers (albeit almost twenty years out of date) reveal a substantial discrepancy when compared with population prevalence for the same condition (up to 18.2%, depending on sub-type). The lower prevalence figures reported for drivers in Utah may be due to under-reporting of medical conditions (because of fear of losing driving privileges) and a tendency for only those with more serious conditions to be reported to the authority.

Furthermore, confirming who is actually driving within the licenced population in order to use this as baseline is not straightforward. For example, for licensed older drivers, licensure does not correlate with actual driving exposure as, at least in Australia, a driver’s licence is the primary form of identification and can be retained for this purpose even if the driver has ceased driving. Similarly, holding a motorcycle or commercial driver’s licence does not necessarily correlate with frequent driving of that vehicle class.

Thus, on the basis of medical and disability prevalence data applicable to that age group, if young drivers are considered as a unit, the age-related risk overwhelms all of the risks associated with any of the individual medical conditions reviewed here, to such an extent that the impact of any single medical condition might seem minor. Nevertheless, the high risk associated with some medical conditions cannot be discounted. Hansotia and Broste (1991) make the point that a ban on all young male drivers would have a significant impact in enhancing road safety. However, they conclude that this would represent an unacceptable restriction of individual freedom. Clearly, decision-making about driving restrictions for high-risk groups is complex and politically and legally sensitive. The decision-making process should incorporate a range of relevant issues and should weigh up individual needs for mobility, while maintaining an acceptable level of safety for all road users. In the case of drivers with medical and disability conditions, while safety is the paramount consideration, important factors might also include the drivers’ capacity for rehabilitation, as well as their lifestyle and mobility needs (proximity to services; access to alternative transport, etc). These management factors are considered in more detail below.

15.3 MANAGEMENT OF DRIVERS WITH MEDICAL CONDITIONS

A framework adapted from the OECD report on Ageing and transport. Mobility needs and safety issues (2001, p. 25) is proposed for managing decisions for driver licensing and medical review:

**STEP I** Determine which medical conditions have functional impairments that affect driving;

**STEP II** If there are functional impairments, determine whether the evidence for increased MVC risk is sufficiently robust;

**STEP III** (a) If there is robust evidence for substantial injury risk, identify and implement countermeasures (treatment, rehabilitation or other compensatory strategies including modified/restricted licence) to reduce the risk; and

(b) If there is reasonable evidence for increased risk, identify and implement countermeasures (treatment, rehabilitation or other compensatory strategies including modified/restricted licence) to reduce the risk; and

**STEP IV** (a) If no effective countermeasures exist, and after considering relevant individual factors, decision needs to

(b) Manage potential risk case-by-case basis: countermeasures and
As summarised in Table 7, for a small number of conditions, there is evidence for at least a moderately elevated MVC risk associated with these selected medical conditions, albeit with qualifications or, in some cases, tempered by conflicting evidence. However, for the majority of conditions, evidence was mixed and lacked the level of robustness required to make definitive decisions about continuation of driving. Hence, we proposed a modification to the original ‘OECD model’ described in our earlier reports (Charlton et al 2004; 2010). As described in Steps III and IV above, the modified framework includes a more individualised approach that provides a pathway for decision-making both for when there is robust evidence of high MVC risk for a condition/impairment, as well as when the evidence is less robust but indicative of heightened risk.

In the following section the implications of this risk management approach are considered. Two medical conditions are discussed, highlighting different possible management outcomes (Figure 8). In sleep apnoea, a number of functional impairments have been identified including excessive daytime sleepiness. These impairments are likely to impact on aspects of driving by causing inattention, drowsiness while driving and poor judgements. The review of evidence showed a moderately to considerably elevated MVC risk (H* 2 ‘good’, 1 ‘fair’ studies; H** 6 ‘good’, 2 ‘fair’ studies; H*** 2 ‘good’, 1 ‘fair’ studies). In addition, the review identified sound and consistent evidence (3 ‘good’, 1 ‘fair’ study) for a significant reduction of risk with Continuous Positive Airways Pressure (CPAP) treatment to levels equal to drivers without sleep apnoea. Therefore, it would appear to be entirely appropriate to allow treatment compliant drivers with sleep apnoea undergoing CPAP treatment to continue to drive, with appropriate individualised monitoring.

![Figure 8: Risk management approach for two medical conditions](image-url)
In the case of dementia, there are also a number of functional impairments across a wide range of cognitive areas that are required for safe driving; for example, difficulties with decision-making, planning, attention and memory. The review revealed limited evidence for a moderately elevated MVC risk for drivers with a clinical diagnosis of dementia, drawn from MVC crash studies (H**: 1 ‘good’ Class I study; ND: 1 ‘good’ Class I study; and H*** fail on-road test; meta-analysis: 2 Class I, 2 Class II studies). However, in contrast to sleep apnoea, there is no evidence for an effective treatment in lowering MVC risk. Based on this evidence, a conservative decision would be to remove driving privileges. Such an approach also might appear prudent as the progressively declining nature of the condition and the likelihood of lack of insight associated with this disorder. This, however, does not take into account the severity of impairment. The approach adopted by many jurisdictions (Canada, UK, Ireland, Australia) is to recommend the provision of a conditional licence including ongoing periodic review, which is sensible given the progressive nature of the disorder, and wide individual differences in the nature and extent of cognitive decline.

Cessation of driving has important implications for both the individual and society. For example, for an individual who is no longer able to drive, other transport options become increasingly important in order to maintain mobility and independence. Alternative transport options might include public transport, including taxis and various commercial ride-sharing options, car passenger, walking, cycling and motorised mobility scooters. However, these options may not necessarily be available, accessible, suitable for the home/community environment or safer than driving. The OECD (2001) report on ageing and transport showed that the crash injury risks for people aged 65 years and older associated with walking and cycling are not insignificant, and more recent hospital-admitted transport-related data from Australia/Victoria also shows these patterns (see Figure 9). However, a limitation of figures is the lack of exposure data. Moreover, these data do not include other health declines associated with driving cessation (e.g., Marottoli, 2001).

Figure 9: Transport-related injury hospital admissions in the Australian state of Victoria by road user type and age group (2004/05-2013/14). Source: Koppel et al. (2020)

15.4 LIMITATIONS
Several limitations were identified within each of the systematic reviews. It was interesting to note that these limitations were very similar across the systematic reviews and these are described below.

The main limitation identified in each of the systematic reviews is the paucity of data. A small number of studies were identified that had examined the influence of chronic illness on MVC risk, and an even smaller number that had examined on-road driving performance. For an issue that poses substantial challenges for clinicians and for driver licensing authorities, the paucity of evidence is noteworthy. Importantly, a small number of the included studies were rated as being of ‘good’ or ‘fair’ quality. For example, only 12 studies (of 160 included) used a population-based, prospective design. Generally, the best studies employed retrospective, case-control design, with adequate sample size. Furthermore, many of the included studies are at least 10 years old (with some over 20 years old). This is important for several reasons: 1) the way in which medical illnesses are treated and managed is likely to have changed over this period; 2) licensing requirements and guidelines may have changed in many jurisdictions over this period, and 3) the driving task demands have changed dramatically over the past decade due to vehicle technology, in-car technologies (driving and non-driving related), and driving environment complexity.

There were several methodological and reporting limitations identified across many of the included studies that made the synthesis and interpretation of the data challenging. For example, the included studies were conducted across different licensing jurisdictions, with different licensing requirements, and across a diverse range of participant populations, which may limit the generalisability of the findings. In addition, many studies included drivers with varying degrees of disease severity, and some studies restricted their recruitment to specific populations, including: male drivers, older drivers, drivers that sought medical attention, drivers referred for further assessment by a driver licensing authority, crash-involved drivers, or drivers who were hospitalised following an MVC. These limitations mean that the findings of these studies may not be entirely generalisable to the population of drivers with these medical conditions.

Further, very few studies incorporated populations of drivers with commercial/heavy vehicle licences. This is a significant research gap in our understanding of how medical conditions and disabilities may impact on this driver group, given the particular requirements placed on such drivers; high driving exposure, use of their vehicle “as a workplace”, complexity associated with the driving large, heavy vehicles, with hazardous loads and potentially on a large variety of transport infrastructure.

A significant proportion of the included studies (i.e., up to 50% in the alcohol use disorder, psychiatric disorder, vision disorders and visual impairment reviews) used a self-reported measure of either the medical condition or MVC. Self-reported data may be biased due to recall bias or a deliberate concealment of the true nature of one’s health status or MVC history due to a fear of loss of licence.

In terms of the data analysis, some of the included studies did not provide any information about the statistical tests that had been conducted, or whether the reported differences were statistically significant. In addition, there was a lack of consistent adjustment for possible confounding factors, such as age, gender, driving exposure, medication use and/or compliance, other comorbidities, as well as alcohol and/or illicit drug use, which may have a significant impact on MVC risk and driving performance, and can vary greatly between study populations.

Finally, this research focussed on published peer reviewed literature. There was no inclusion of technical reports, conference presentations or abstracts, case-studies, coroner reports or studies, cohort studies (without a control group) or review of consensus based medical standards for any of the medical conditions reviewed. Whilst the aforementioned research/endeavours are categorised on the lower stages of the evidence hierarchy (NHMRC, 2019) it is nonetheless valuable to review this material, as it can assist in gaining a broader understanding of what the issues are for a particular research domain or question.
and to highlight potential interventions or countermeasures. Notwithstanding this limitation, the advantage of the approach of the report is that it combines a series of systematic reviews for each of the selected medical conditions and therefore provides the highest level of evidence on MVC risk.

Figure 10: NHMRC Levels of Evidence and Grades for Recommendations for Developers of Clinical Practice Guidelines (National Health and Medical Research Council, 2009)

15.5 CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH

This review presents evidence in relation to medical conditions and driver risk. One of the most striking observations that can be made is that the quality and quantity of evidence does not do justice to the serious consequences associated with motor vehicle crashes. Methodological limitations were evident in most studies, including a lack of standardisation of inclusion criteria for medical conditions and unreliable measures of crash involvement (i.e., self-report).

The review of evidence for MVC risk was compared with guidelines regarding fitness to drive from selected jurisdictions. These comparisons revealed that the majority of guidelines reflected the current available evidence for MVC risk, and hence, no changes were recommended.

Information about management of medical conditions was reviewed where available evidence on risk was available and met criteria for inclusion in the systematic reviews. Intuitively, it would be reasonable to expect that well-established treatments might reduce risk. However, for most conditions there was extremely limited evidence for this. For example, the studies reviewed for MVC risk associated with vision conditions and impairment rarely identified whether drivers wore corrective lenses when driving. One notable exception was the treatment of sleep apnoea using CPAP which was shown to significantly reduce MVC risk to the same level as those without the condition. One large population-based study also provided evidence of risk benefits for drivers with medical conditions (e.g., epilepsy; psychiatric disorders) with and without licence restrictions demonstrating how licence modifications may be used to mitigate MVC risk (Vernon, et al., 2002). Other methods of management through special licensing conditions or restrictions include:

- A driver diagnosed with visual impairment may drive only when wearing corrective lenses, and driving during daylight hours;
• A driver with diabetes may be required to take insulin on a regular basis;
• A driver with cognitive impairment may be limited to driving only in their familiar local area (radius from home restriction)
• Technology such as interlocks
• Self-regulation is also a potentially useful management approach. For example, drivers with epilepsy are often advised not to drive if they are tired and to avoid precipitating factors such as emotional or physical stress. However, self-regulation is only likely to be effective if drivers have insight into the factors that place them at risk and can be reasonably expected to remember their driving limitations. In the case of dementia and some psychiatric conditions, the capacity for insight is likely to be impaired or unreliable. Moreover, there is little evidence that specifically addresses the benefit of self-regulation in reducing MVC risk.

In the light of the available information presented in this review, several recommendations can be made to improve safety outcomes associated with medical conditions, disabilities and associated functional impairments:

• Review licensing guidelines for fitness-to-drive in the light of all available evidence regarding MVC risk. For example, studies of coroner’s reports, research examining road trauma and culpability, peak medical group and consensus based medical practice guidelines or position statements;
• Promote public awareness, particularly amongst the driving population, about the known MVC risks and effective management for specific medical conditions or functional impairments. This is important particularly because many licensing jurisdictions are reliant on self-referral or voluntary reporting of medical conditions to the licensing authority, or disclosure of symptoms to a doctor. In addition, there is evidence of low levels of awareness among the general population of guidelines on medical fitness to drive. Hence the onus is on the driver to be aware whether they have symptoms consistent with a reportable medical condition or disability that could affect their driving;
• Improve knowledge within the health professions about the known MVC risks and effective management for medical conditions or functional impairments. This should emphasise that early intervention with driver rehabilitation or remediation/compensation approaches can enhance and extend driving safety;
• Ensure that the evaluation of a driver with a medical condition or disability (and especially in the case of multiple conditions) is conducted on a case by case basis which includes a review of the underlying condition(s), complications and concomitant conditions that may affect fitness-to-drive, and how this may impact on risks for certain types of driving (e.g., as relevant to private vs. commercial licensing requirements and application of licence conditions such as area restrictions or no night driving);
• Develop reliable methods of identifying and referring drivers who are potentially at risk because of a multiple medical condition(s) into the DLA medical review process;
• Investigate the capacity for the use of medical technologies for more effective monitoring of driver risk (e.g., in-vehicle blood glucose monitoring system; in-vehicle distraction and fatigue detection systems);
• Investigate the capacity for the use of adaptive technologies and intelligent transport systems (ITS) to enhance driver safety (e.g., safe following distance devices and rear collision warning and avoidance systems, lane departure warning systems);

Include appropriate licensing conditions/restrictions (e.g., alcohol interlocks for drivers with alcohol use disorders);

Investigate rehabilitation interventions and their value for overcoming functional impairments for drivers with specific medical conditions/disabilities, and

Advance scientific knowledge linking medical conditions, impacts on driver performance and MVC risk in order to improve the evidence base for formulating policy about licensing and fitness to drive.

Based on the findings of this review, it is recommended that a cooperative international approach to future research be adopted. This should take the form of a large scale, prospective study (or group of studies) using a population-based study design, including naturalistic methodology, as well as objective metrics (for both MVC outcomes and medical diagnoses) and appropriate controls, and in multiple licensing jurisdictions to investigate the following:

- Conditions or impairments associated with on-road test performance failure and/or high MVC risk;

- The effectiveness of treatments, rehabilitation and countermeasures, including advanced vehicle technologies, and conditional licences in reducing MVC risk;

- Risk and risk reduction strategies for targeted high-risk sub-groups, particularly with multiple medical conditions prevalent in the ageing population, and

- The social, health, safety, and economic consequences of licensing restrictions in at-risk populations.

15.6 REFERENCES


### CONCEPT 1A: DRIVER

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Automobile</td>
</tr>
</tbody>
</table>

**Keywords**

<table>
<thead>
<tr>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. car driving.tw.</td>
</tr>
<tr>
<td>3. motor-car driving.tw.</td>
</tr>
<tr>
<td>5. motor-car*.tw.</td>
</tr>
<tr>
<td>6. motorist*.tw.</td>
</tr>
<tr>
<td>7. motor-vehicle*.tw</td>
</tr>
</tbody>
</table>

8. **1 OR 2 OR 3 OR 4 OR...7**

### CONCEPT 1B: ALCOHOL DISORDERS (misuse/abuse, dependence)

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Alcohol-related disorder*</td>
</tr>
<tr>
<td>10. Alcohol related problem*</td>
</tr>
<tr>
<td>11. Alcohol-use disorder*</td>
</tr>
</tbody>
</table>

**Keywords**

<table>
<thead>
<tr>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Alcohol dependence.tw.</td>
</tr>
<tr>
<td>15. Alcohol abuse.tw.</td>
</tr>
<tr>
<td>17. Harmful alcohol consumption.tw.</td>
</tr>
<tr>
<td>19. Alcohol addiction.tw.</td>
</tr>
<tr>
<td>20. Driving offence.tw.</td>
</tr>
<tr>
<td>21. Driving under the influence.tw.</td>
</tr>
<tr>
<td>22. DUI.tw.</td>
</tr>
<tr>
<td>23. AUD.tw.</td>
</tr>
<tr>
<td>24. Drunk driving.tw.</td>
</tr>
<tr>
<td>25. Alcohol impaired driving.tw.</td>
</tr>
</tbody>
</table>

27. **9 OR 10 OR 11 OR ... 26**

### CONCEPT 1

28. **8 AND 27**

### CONCEPT 2A: CRASH RISK

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>29. Accidents</td>
</tr>
</tbody>
</table>

**Keywords**

<table>
<thead>
<tr>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>30. automobile crash risk.tw.</td>
</tr>
<tr>
<td>31. risk of crashes.tw.</td>
</tr>
<tr>
<td>32. car crash*.tw.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>33</td>
</tr>
<tr>
<td>34</td>
</tr>
<tr>
<td>35</td>
</tr>
<tr>
<td>36</td>
</tr>
<tr>
<td>37</td>
</tr>
<tr>
<td>38</td>
</tr>
<tr>
<td>39</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>41</td>
</tr>
<tr>
<td>42</td>
</tr>
<tr>
<td>43</td>
</tr>
<tr>
<td>44</td>
</tr>
<tr>
<td>45</td>
</tr>
</tbody>
</table>

**CONCEPT 2B: ON-ROAD DRIVING ASSESSMENT**

**MeSH Terms**
- Automobile Driver Examination /
- Licensure /

**Keywords**
- on-road.tw.
- (on adj1 road).tw.
- assess*.tw.
- reassess*.tw.
- licen*.tw.
- relicen*.tw.
- re-licen*.tw.
- test.tw.
- re-test*.tw.
- permit*.tw.
- (driv* exam*).tw.
- (driv* assess*).tw.
- (fitness adj2 driv*).tw.
- (safe adj2 driv*).tw.
- (unfit adj2 driv*).tw.
- (unsafe adj2 driv*).tw.
- (competen* adj2 driv*).tw.
- (driv* abilit*).tw.
- (driv* perform*).tw.
- 46 OR 47 ... OR 66

**CONCEPT 2**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>45 OR 67</td>
</tr>
</tbody>
</table>

**TOTAL**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>28 AND 68</td>
<td></td>
</tr>
</tbody>
</table>
### Current fitness-to-drive guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Licensing Category</th>
<th>Alcohol use disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>Austroads and National Transport Commission (2017)</td>
<td>All classified under Substance Abuse Disorders</td>
</tr>
<tr>
<td></td>
<td>New Zealand Transport Agency (NZTA) (2014)</td>
<td>A person is <strong>not</strong> fit to hold an unconditional licence if there is an alcohol or other substance use disorder, such as substance dependence or heavy frequent alcohol or other substance use that is likely to impair safe driving. A conditional licence may be considered by the driver licensing authority subject to periodic review, taking into account the nature of the driving task and information provided by the treating doctor as to whether the following criteria are met: the person is involved in a treatment program and has been in remission for at least one month; and</td>
</tr>
<tr>
<td>Licensing Category</td>
<td>Drivers of cars, light rigid vehicles or motorcycles unless carrying public passengers or requiring a dangerous goods driver license</td>
<td>Generally, no driving restrictions. However, if symptoms or effects may impair an individual’s ability to drive safely, the individual should not drive until effective treatment has been established.</td>
</tr>
<tr>
<td></td>
<td>Class 1 or class 5 license and/or a D, F, R, T or W endorsement</td>
<td>Not specifically covered</td>
</tr>
<tr>
<td></td>
<td>Not mentioned</td>
<td>Divided into Alcohol Misuse and Alcohol Dependence</td>
</tr>
<tr>
<td></td>
<td>Group 1: Car and motorcycle</td>
<td>A state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence</td>
</tr>
<tr>
<td></td>
<td>Group 1: Car and motorcycle</td>
<td>Must not drive and must notify the DVLA.</td>
</tr>
<tr>
<td></td>
<td>Non-commercial drivers</td>
<td>Licence will be refused or revoked until after:</td>
</tr>
<tr>
<td></td>
<td>Group 1: drivers of vehicles of categories A, A1, A2, AM, B, B1 and BE</td>
<td>- a minimum of six months of controlled drinking (14 units a week) or abstinence, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- normalisation of blood parameters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Dependence: A cluster of behavioural,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divided into Alcohol Misuse and Alcohol Dependence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Misuse: “A state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must not drive and must notify the DVLA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Licence will be refused or revoked until after:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- a minimum of six months of controlled drinking (14 units a week) or abstinence, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- normalisation of blood parameters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Dependence: A cluster of behavioural,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divided into Alcohol Misuse and Alcohol Dependence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Misuse: “A state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must not drive and must notify the DVLA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Licence will be refused or revoked until after:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- a minimum of six months of controlled drinking (14 units a week) or abstinence, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- normalisation of blood parameters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Dependence: A cluster of behavioural,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divided into Alcohol Misuse and Alcohol Dependence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Misuse: “A state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must not drive and must notify the DVLA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Licence will be refused or revoked until after:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- a minimum of six months of controlled drinking (14 units a week) or abstinence, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- normalisation of blood parameters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Dependence: A cluster of behavioural,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divided into Alcohol Misuse and Alcohol Dependence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Misuse: “A state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must not drive and must notify the DVLA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Licence will be refused or revoked until after:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- a minimum of six months of controlled drinking (14 units a week) or abstinence, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- normalisation of blood parameters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Dependence: A cluster of behavioural,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divided into Alcohol Misuse and Alcohol Dependence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Misuse: “A state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must not drive and must notify the DVLA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Licence will be refused or revoked until after:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- a minimum of six months of controlled drinking (14 units a week) or abstinence, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- normalisation of blood parameters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol Dependence: A cluster of behavioural,</td>
</tr>
</tbody>
</table>
there is an absence of cognitive impairments relevant to driving; and there is absence of end-organ effects that impact on driving (as described elsewhere in this publication).

* Remission is attained when there is abstinence from use of impairing substance/s or where substance use has reduced in frequency to the point where it is unlikely to cause impairment. Remission may be confirmed by biological monitoring for presence of drugs. An alcohol interlock may form part of the approach to managing driving for alcohol dependent people.

**Alcohol Dependence:**

"A cluster of behavioural, cognitive and physiological phenomena that develop after repeated alcohol use and which include a strong desire to take alcohol, difficulties in controlling its use, persistent use in spite of harmful consequences and with evidence of increased tolerance and sometimes a physical withdrawal state." Indicators may include any history of withdrawal symptoms, tolerance, detoxification or alcohol-related seizures. The World Health Organization’s classification (ICD-10) code F10.2 is relevant. Must not drive and must notify the DVLA.

Licence will be refused or revoked until after a minimum of 1 year free of alcohol problems.

Abstinence is required, with normalised blood parameters if relevant.

- licensing will require satisfactory medical reports from a doctor
- the DVLA may need to arrange independent medical examination and blood tests
- referral to and the support of a consultant specialist may be necessary.

relevant: driver must seek advice from medical or other sources during the period off the road

Alcohol Dependence: "A cluster of behavioural, cognitive and physiological phenomena that develop after repeated alcohol use and which include a strong desire to take alcohol, difficulties in controlling its use, persistence in its use despite harmful consequences, with evidence of increased tolerance and sometimes a physical withdrawal state." Indicators may include a history of withdrawal symptoms, of tolerance, of detoxification(s) and/or alcohol related fits The World Health Organization’s classification (ICD-10) code F10.2 is relevant.

Not permitted to drive until a six month period free from alcohol has been attained with normalisation of biomarkers, if relevant. Driver should notify driver licencing agency. Return to driving will
require satisfactory medical assessment from own doctor(s) and management of blood biomarkers if relevant. Consultant support/referral may be necessary.
### 17. APPENDIX B: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF DIABETES ON MVC RISK

#### Search Strategy

<table>
<thead>
<tr>
<th>CONCEPT 1A: DRIVER</th>
<th>MeSH Terms</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Automobile Driving/</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>driv*.tw.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>motorist*.tw.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 OR 2 OR 3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONCEPT 1B: DIABETES/HYPOGLYCEMIA</th>
<th>MeSH Terms</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>diabetes/</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hypoglycemia/</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>diabet*.tw.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>hypogly*.tw.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>gluc*.tw.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>5 OR 5 OR 7 OR 8 OR 9</td>
<td></td>
</tr>
</tbody>
</table>

| CONCEPT 1 | 4 AND 10 |

<table>
<thead>
<tr>
<th>CONCEPT 2A: CRASH RISK</th>
<th>MeSH Terms</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Accidents/</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>crash*.tw.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>collision*.tw.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>accident*.tw.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12 OR 13 OR 14 OR 15</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONCEPT 2B: ON-ROAD DRIVING ASSESSMENT</th>
<th>MeSH Terms</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Automobile Driver Examination/</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Licensure/</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>on-road.tw.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>(on adj1 road).tw.</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>assess*.tw.</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>reassess*.tw.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>licen*.tw.</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>relicen*.tw.</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>re-licen*.tw.</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>test.tw.</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>re-test*.tw.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>permit*.tw.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(driv* exam*).tw.</td>
<td>(driv* assess*).tw.</td>
</tr>
<tr>
<td>---</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Current Fitness-to-Drive Guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Reference</th>
<th>NZ</th>
<th>US</th>
<th>UK</th>
<th>Canada</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licensing Category</td>
<td>Drivers of non-commercial vehicles who are treated with regimens that do not include insulin are subject to five-yearly controls but will have an unconditional licence. Commercial drivers subject to annual medical reports.</td>
<td>Same as Australia</td>
<td>Non-commercial vehicles: varies by state Commercial vehicles for intrastate commerce – varies by state Commercial vehicles for interstate commerce – regulated by FMCSA</td>
<td>Group 1: Car and motorcycle (Private standards)</td>
<td>Group 1: drivers of vehicles of categories A, A1, A2, AM, B, B1 and BE (Private standards)</td>
<td>Group 2: drivers of vehicles of categories C, CE, C1, C1E, D, DE, D1 and D1E (Commercial standards)</td>
</tr>
<tr>
<td>Conditions for licensing</td>
<td>“Distinction between drivers with diabetes treated with insulin and those with other regimens for all classes of licence. No fixed period without driving following a severe hypoglycaemic episode. A specialist’s evaluation is required for a conditional (restricted) licence for all classes of licence. This is the case when there are end-organ complications of diabetes”</td>
<td>Same as Australia</td>
<td>FMCSA: Prior to 2018, regulations stated drivers using insulin were forbidden to drive interstate CMVs. In 2014 an exemption programme was introduced for these drivers and in 2018 a new regulation was approved allowing them to obtain a licence with a requirement for annual medical reports.</td>
<td>For non-commercial drivers, the individual may qualify for a driving licence not more than one severe hypoglycaemic episode in previous 12 months and none in previous three months as well as “adequate” awareness of hypoglycaemia. For commercial drivers, the individual must have an annual review with no severe hypoglycaemic episodes in previous 12 months and full awareness of hypoglycaemia. Insulin treated diabetes is subject to additional requirements and an annual review.</td>
<td>Distinction between T1D and T2D for all classes. Non-commercial drivers with diabetes treated with insulin are eligible for a licence with periodic reviews with the period at the discretion of the licensing agency. Commercial drivers treated with insulin are subject to annual review and more stringent requirements for renewal than non-commercial drivers. Severe hypoglycaemic episode – three months w/o driving for non-commercial drivers and six months for commercial drivers.</td>
<td>Same as UK</td>
</tr>
</tbody>
</table>
### CONCEPT 1A: DRIVER

**MeSH Terms**

Automobile Driving/

**Keywords**

1. driv*.tw.
2. motorist*.tw.
3. 1 OR 2 OR 3

### CONCEPT 1B: EPILEPSY / SEIZURE

**MeSH Terms**

Epilepsy/

**Keywords**

5. epilep*.tw.
6. seizure*.tw.
7. convulsion*.tw.
8. aura*.tw.
9. 5 OR 6 OR 7 ... 10

### CONCEPT 1

11. 4 AND 11

### CONCEPT 2A: CRASH RISK

**MeSH Terms**

Accidents/

**Keywords**

13. crash*.tw.
14. collision*.tw.
15. accident*.tw.
16. 13 OR 14 OR 15 OR 16

### CONCEPT 2B: ON-ROAD DRIVING ASSESSMENT

**MeSH Terms**

Automobile Driver Examination/

**Keywords**

18. on-road.tw.
19. (on adj1 road).tw.
20. assess*.tw.
22. licen*.tw.
23. relicen*.tw.
24. re-licen*.tw.
25. test.tw.
26. re-test*.tw.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>permit.tw.</td>
</tr>
<tr>
<td>30</td>
<td>(driv* exam*).tw.</td>
</tr>
<tr>
<td>31</td>
<td>(driv* assess*).tw.</td>
</tr>
<tr>
<td>32</td>
<td>(fitness adj2 driv*).tw.</td>
</tr>
<tr>
<td>33</td>
<td>(safe adj2 driv*).tw.</td>
</tr>
<tr>
<td>34</td>
<td>(unfit adj2 driv*).tw.</td>
</tr>
<tr>
<td>35</td>
<td>(unsafe adj2 driv*).tw.</td>
</tr>
<tr>
<td>36</td>
<td>(competen* adj2 driv*).tw.</td>
</tr>
<tr>
<td>37</td>
<td>(driv* abilit*).tw.</td>
</tr>
<tr>
<td>38</td>
<td>(driv* perform*).tw.</td>
</tr>
<tr>
<td>39</td>
<td>18 OR 19 OR 20 ... OR 38</td>
</tr>
</tbody>
</table>

**CONCEPT 2**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>17 OR 39</td>
</tr>
</tbody>
</table>

**TOTAL**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>11 AND 40</td>
</tr>
<tr>
<td>Country</td>
<td>Reference</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
</tbody>
</table>

**Focal aware seizures**

"Safe" seizures are defined as seizures that do not impair consciousness and ability to control the vehicle at all times.

For private drivers, a conditional licence may be considered if "safe" seizures have been present for at least two years, there have been no other types of seizure for at least two years, and the individual follows medical advice including adherence to AED. This is subject to at least an annual review, taking into account information provided by the treating doctor.

For commercial drivers, a person is not fit to hold an unconditional licence if the person has experienced a seizure. A conditional licence may be considered by the driver licensing authority subject to at least annual review, taking into account information provided by a specialist in epilepsy. The following criteria must be met:

- there have been no seizures for at least 10 years; and
- an EEG conducted in the last six months has shown no epileptiform activity and no

A private driver may resume driving after a 12-month seizure-free period. This period may be reduced to six months if a favourable specialist report indicates minimal risk of further seizures.

A commercial driver should not drive. However, the Transport Agency may consider granting a licence to individuals who have been seizure free for five years and are not on any medication to control seizures.

Not mentioned

Private drivers are eligible for a licence if it has been six months since the last seizure, or if the seizure pattern has been consistent for at least one year, and a favourable assessment from the treating physician or neurologist. Seizures must not cause impairment in level of consciousness or cognition, and no head or eye deviation with seizures.

Commercial drivers are eligible for a licence if it has been five years since the last seizure, OR the driver is experiencing seizures, but the seizure pattern has been consistent for three years – and therefore no seizure free waiting period required. The individual also requires favourable assessment from neurologist to drive, no impairment in level of consciousness or cognition, and no head or eye deviation with seizures. The conditions for maintaining a licence include routinely following treatment regime and physician’s advice regarding prevention of seizures, if the driver is treated, and reporting to the authority and physician if the symptoms of seizures change.

Private drivers who have not experienced seizures other than seizures which do not have an effect on consciousness or cause functional impairments can be declared fit to drive as long as this pattern has been established for a period no less than one year. If there is an occurrence of any other kind of seizure, then a one-year seizure-free period is required.
First, isolated epileptic seizure (prior to epilepsy diagnosis)

For private drivers, a conditional licence may be considered if driver has had no further seizures (with or without medication) for at least six months and the individual follows medical advice. This is subject to at least an annual review, taking into account information provided by the treating doctor.

For commercial drivers, a conditional licence may be considered by the driver licensing authority subject to at least annual review, taking into account information provided by a specialist in epilepsy. The following criteria must be met:
- there have been no seizures for at least five years (with or without medication); and
- an EEG conducted in the last six months has shown no epileptiform activity and no other EEG conducted in the last 12 months has shown epileptiform activity.

A private driver may resume driving after a 12-month seizure-free period. This period may be reduced to six months if a favourable specialist report indicates minimal risk of further seizures.

A commercial driver should not drive. However, the Transport Agency may consider granting a licence to individuals who have been seizure free for five years and are not on any medication to control seizures.

Following a “unique” seizure, individuals should be counselled not to drive until neurological and cardiac investigations reveal no cause, or a treatable cause with successful therapy.

A commercial licence may be considered for a sudden episode of a nonepileptic seizure or loss of consciousness of unknown cause which did not require antiseizure medication, the decision as to whether that person's condition will likely cause loss of consciousness or loss of ability to control a motor vehicle is made on an individual basis by the medical examiner in consultation with the treating physician. Before certification is considered, it is suggested that a six-month waiting period elapse from the time of the episode.

Following the waiting period, it is suggested that the individual have a complete neurological examination. If the results of the examination are negative and antiseizure medication is not required, then the driver may be qualified. In those individual cases where a driver has a seizure or an episode of loss of:

| Other EEG conducted in the last 12 months has shown epileptiform activity; and • the person follows medical advice, including adherence to medication if prescribed or recommended. If a driver undergoing treatment for epilepsy has experienced an extended seizure free period (more than 20 years) the driver licensing authority may consider reduced review requirements based on independent specialist advice. |
|---|---|---|---|
| A private driver may resume driving after a 12-month seizure-free period. This period may be reduced to six months if a favourable specialist report indicates minimal risk of further seizures. A commercial driver should not drive. However, the Transport Agency may consider granting a licence to individuals who have been seizure free for five years and are not on any medication to control seizures. | Following a "unique" seizure, individuals should be counselled not to drive until neurological and cardiac investigations reveal no cause, or a treatable cause with successful therapy. A commercial licence may be considered for a sudden episode of a nonepileptic seizure or loss of consciousness of unknown cause which did not require antiseizure medication, the decision as to whether that person's condition will likely cause loss of consciousness or loss of ability to control a motor vehicle is made on an individual basis by the medical examiner in consultation with the treating physician. Before certification is considered, it is suggested that a six-month waiting period elapse from the time of the episode. Following the waiting period, it is suggested that the individual have a complete neurological examination. If the results of the examination are negative and antiseizure medication is not required, then the driver may be qualified. In those individual cases where a driver has a seizure or an episode of loss of |
| Private drivers are eligible for a licence if a complete neurological assessment has been conducted and epilepsy is not diagnosed, and CNS imaging and EEG results do not suggest increased likelihood of seizure recurrence. Commercial drivers are eligible for a licence following a "single unprovoked seizure" if it has been at least 12 months since the seizure occurred, and a complete neurological assessment has been conducted to determine the cause of the seizure, and epilepsy is not diagnosed. and CNS imaging and EEG results are satisfactory. For private drivers, an individual can be declared able to drive after a six-month seizure-free period., subject to appropriate medical assessment. For commercial drivers, an individual who has had a first unprovoked epileptic seizure can be declared able to drive once five years' freedom from further seizures has been achieved without the aid of antiepileptic drugs, if there has been an appropriate neurological assessment. National authorities may allow drivers with recognized good prognostic indicators to drive sooner. |
| Epilepsy Diagnosis | For private drivers, a conditional licence may be considered if driver has had no seizures for at least 12 months and the individual follows medical advice, including adherence to AED. This is subject to at least an annual review, taking into account information provided by the treating doctor. For commercial drivers, a person is not fit to hold an unconditional licence if the person has experienced a seizure. A conditional licence may be considered by the driver licensing authority subject to at least annual review, taking into account information provided by a specialist in epilepsy. The following criteria must be met: | Private drivers may resume driving after a 12-month seizure-free period. This period may be reduced to six months if a favourable specialist report indicates minimal risk of further seizures. A commercial driver should not drive. However, the Transport Agency may consider granting a licence to individuals who have been seizure free for five years and are not on any medication to control seizures. A private driver who suffers a convulsive seizure is considered unfit to drive for a period of at least six months following the seizure. A diagnosis or history of seizures should preclude unconditional certification to drive. Conditional certification to drive should require a positive recommendation by the treating clinician to a) be unlikely to have a seizure while driving, b) unlikely to be impaired or have further complications that affect ability to safely operate a vehicle, c) free of a repeated pattern of AED side effects or noncompliance, d) show ability and willingness to properly monitor and manage their condition, e) be educated not to drive for long hours without rest, or when fatigued or ill, and to avoid excessive alcohol use, f) sign a document indicating adherence to AED therapy, awareness to AED toxicity, and | Private drivers are eligible for a licence if it has been six months since the seizure occurred (with or without the use medications). This period may be reduced to three months under a neurologist's recommendation if rationale is provided. Commercial drivers eligible for a licence if they have not had a seizure with or without medication for five years, routinely follow treatment regime and physician's advice regarding prevention of seizures, and cease driving and report to the authority and physician if a seizure occurs. For private drivers, individuals with epilepsy can be declared fit to drive after a one-year seizure-free period. For commercial drivers, individuals with epilepsy can be declared fit to drive with 10 years freedom from further seizures without the aid of antiepileptic drugs. |
• there have been no seizures for at least 10 years; and
• an EEG conducted in the last six months has shown no epileptiform activity and no other EEG conducted in the last 12 months has shown epileptiform activity; and
• the person follows medical advice, including adherence to medication if prescribed or recommended. If a driver undergoing treatment for epilepsy has experienced an extended seizure free period (more than 20 years) the driver licensing authority may consider reduced review requirements based on independent specialist advice.

Seizures while sleeping

For private drivers, a conditional licence may be considered if:
• there have been no previous seizures while awake, the first sleep-only seizure was at least 12 months ago, and the individual follows medical advice including adherence to AED.
• there have been previous seizures while awake but not in the past two years, sleep-only seizures have been occurring for at least two years, and the individual follows medical advice including adherence to AED.
• This is subject to at least an annual review, taking into account information provided by the treating doctor.

For commercial drivers, a person is not fit to hold an unconditional licence if the person has experienced a seizure. A conditional licence

A private driver may resume driving if they do not have seizures when awake for 12 months and have an established pattern of seizures during sleep or upon waking only for at least three years.

Any individuals who experience sleep epilepsy are normally considered permanently unfit to hold a commercial licence. The Transport Agency may consider granting a licence for these classes or endorsements where:
• an individual has only had seizures during sleep or upon waking for five years and no other seizures have occurred, and
• a neurologist’s opinion supports the application. A request should be made to the Chief Medical Adviser, accompanied by a

Not mentioned

Seizure reporting requirements. Drivers should undergo annual examination by the treating clinician.

Commercial drivers do not qualify for an unconditional licence if they have a medical history of epilepsy; a current clinical diagnosis of epilepsy; or are taking AED medication.

Commercial drivers with a history of epilepsy/seizures cannot be qualified to operate a commercial motor vehicle in interstate commerce until they are off antiseizure medication and seizure-free for 10 years.

Private drivers are eligible for a licence if it has been six months since the last seizure, or if the seizure pattern has been consistent for at least one year.

Commercial drivers eligible for a licence if the driver is experiencing seizures but the seizure pattern has been consistent for at least five years, there is no prolonged postictal impairment in wakefulness, they routinely follow their treatment regime and physician’s advice regarding prevention of seizures, if the driver is treated, they routinely follow physician’s advice regarding continued monitoring of seizures, and they report to the authority and physician if the pattern of seizures changes.

Private drivers who have not experienced any other type of seizure beyond seizures during sleep can be declared fit to drive as long as a pattern of sleep seizures is established for a period no less than one year. If there is a seizure occurrence while awake, a one-year seizure-free period is required.
may be considered by the driver licensing authority subject to at least annual review, taking into account information provided by a specialist in epilepsy. The following criteria must be met:
- there have been no seizures for at least 10 years;
- an EEG conducted in the last six months has shown no epileptiform activity and no other EEG conducted in the last 12 months has shown epileptiform activity; and
- the person follows medical advice, including adherence to medication if prescribed or recommended. If a driver undergoing treatment for epilepsy has experienced an extended seizure free period (more than 20 years) the driver licensing authority may consider reduced review requirements based on independent specialist advice.

Withdrawal of Medication

For private drivers, during period of planned AED withdrawal in an individual who satisfies the standard to hold a conditional licence, person must cease driving while the dose is being tapered, and for three months after the last dose. If seizures do not recur, the individual may become eligible for an unconditional licence. If seizures do recur, a conditional licence may be considered if the driver resumes a previously effective medication regime, a seizure-free period of four weeks after resuming the regime and the individual supporting report from a neurologist.

For private standards, during any period of withdrawal of treatment, a minimum six months seizure-free period is required before resuming driving. Any individuals who experience epilepsy are normally considered permanently unfit to hold a commercial licence. The Transport Agency may consider granting a licence for these classes or endorsements where:
- an individual has only had seizures during sleep or upon waking for five years
- Private drivers who suffer a seizure following a prescribed cessation of AEDs should be counselled not to drive until therapeutic levels of AEDs are achieved that are comparable to the levels prior to AED cessation. This adjustment period should be at least one to three months, and drivers should also undergo annual recertification for two years. If the seizure follows voluntary cessation of AEDs by the driver without medical supervision, then it is treated in the same manner as an unprovoked seizure. Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months since re-establishing treatment.
- Private drivers are eligible for a licence if it has been three months since change or withdrawal of medication, and they have not had a seizure during that time. In case there was a seizure following the change or withdrawal of medication, they will need to re-establish a previously effective treatment regime, the treating physician indicates that further seizures are unlikely, and a seizure-free period of three months since re-establishing treatment.
- Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months.

For private standards, during any period of planned AED withdrawal in an individual who satisfies the standard to hold a conditional licence, person must cease driving while the dose is being tapered, and for three months after the last dose. If seizures do not recur, the individual may become eligible for an unconditional licence. If seizures do recur, a conditional licence may be considered if the driver resumes a previously effective medication regime, a seizure-free period of four weeks after resuming the regime and the individual supporting report from a neurologist.

For private standards, during any period of withdrawal of treatment, a minimum six months seizure-free period is required before resuming driving. Any individuals who experience epilepsy are normally considered permanently unfit to hold a commercial licence. The Transport Agency may consider granting a licence for these classes or endorsements where:
- an individual has only had seizures during sleep or upon waking for five years
- Private drivers who suffer a seizure following a prescribed cessation of AEDs should be counselled not to drive until therapeutic levels of AEDs are achieved that are comparable to the levels prior to AED cessation. This adjustment period should be at least one to three months, and drivers should also undergo annual recertification for two years. If the seizure follows voluntary cessation of AEDs by the driver without medical supervision, then it is treated in the same manner as an unprovoked seizure. Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months since re-establishing treatment.
- Private drivers are eligible for a licence if it has been three months since change or withdrawal of medication, and they have not had a seizure during that time. In case there was a seizure following the change or withdrawal of medication, they will need to re-establish a previously effective treatment regime, the treating physician indicates that further seizures are unlikely, and a seizure-free period of three months since re-establishing treatment.
- Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months.

For private standards, during any period of planned AED withdrawal in an individual who satisfies the standard to hold a conditional licence, person must cease driving while the dose is being tapered, and for three months after the last dose. If seizures do not recur, the individual may become eligible for an unconditional licence. If seizures do recur, a conditional licence may be considered if the driver resumes a previously effective medication regime, a seizure-free period of four weeks after resuming the regime and the individual supporting report from a neurologist.

For private standards, during any period of withdrawal of treatment, a minimum six months seizure-free period is required before resuming driving. Any individuals who experience epilepsy are normally considered permanently unfit to hold a commercial licence. The Transport Agency may consider granting a licence for these classes or endorsements where:
- an individual has only had seizures during sleep or upon waking for five years
- Private drivers who suffer a seizure following a prescribed cessation of AEDs should be counselled not to drive until therapeutic levels of AEDs are achieved that are comparable to the levels prior to AED cessation. This adjustment period should be at least one to three months, and drivers should also undergo annual recertification for two years. If the seizure follows voluntary cessation of AEDs by the driver without medical supervision, then it is treated in the same manner as an unprovoked seizure. Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months since re-establishing treatment.
- Private drivers are eligible for a licence if it has been three months since change or withdrawal of medication, and they have not had a seizure during that time. In case there was a seizure following the change or withdrawal of medication, they will need to re-establish a previously effective treatment regime, the treating physician indicates that further seizures are unlikely, and a seizure-free period of three months since re-establishing treatment.
- Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months.

For private standards, during any period of planned AED withdrawal in an individual who satisfies the standard to hold a conditional licence, person must cease driving while the dose is being tapered, and for three months after the last dose. If seizures do not recur, the individual may become eligible for an unconditional licence. If seizures do recur, a conditional licence may be considered if the driver resumes a previously effective medication regime, a seizure-free period of four weeks after resuming the regime and the individual supporting report from a neurologist.

For private standards, during any period of withdrawal of treatment, a minimum six months seizure-free period is required before resuming driving. Any individuals who experience epilepsy are normally considered permanently unfit to hold a commercial licence. The Transport Agency may consider granting a licence for these classes or endorsements where:
- an individual has only had seizures during sleep or upon waking for five years
- Private drivers who suffer a seizure following a prescribed cessation of AEDs should be counselled not to drive until therapeutic levels of AEDs are achieved that are comparable to the levels prior to AED cessation. This adjustment period should be at least one to three months, and drivers should also undergo annual recertification for two years. If the seizure follows voluntary cessation of AEDs by the driver without medical supervision, then it is treated in the same manner as an unprovoked seizure. Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months since re-establishing treatment.
- Private drivers are eligible for a licence if it has been three months since change or withdrawal of medication, and they have not had a seizure during that time. In case there was a seizure following the change or withdrawal of medication, they will need to re-establish a previously effective treatment regime, the treating physician indicates that further seizures are unlikely, and a seizure-free period of three months since re-establishing treatment.
- Private drivers who no longer require AEDs and have been seizure-free for a period of at least two months.
| Epilepsy treated by surgery | For private drivers, a conditional licence may be considered if driver has had no seizures for at least 12 months following the surgery and the individual follows medical advice, including adherence to AED. This is subject to at least an annual review, taking into account information provided by the treating doctor. | Not mentioned | For private drivers, individuals who have had surgical treatment for epilepsy should be seizure-free for at least six months following the surgery, and should undergo a neurological examination to ensure there are no major surgical complications that could result in cognitive or visual field impairments that could affect safe driving. | Private drivers are eligible for a licence if they have not had a seizure for 12 months after surgery and are taking AED as directed by a physician. This period may be reduced to six months under a neurologist’s recommendation. Commercial drivers eligible for a licence if they have not had a seizure for five years after surgery with or without antiepileptic medication. Drivers must routinely follow their treatment regime and physician’s advice regarding prevention of seizures. If a seizure occurs, private drivers may be declared fit to drive following a one-year seizure-free period. |
For commercial drivers, a conditional licence may be considered by the driver licensing authority subject to at least annual review, taking into account information provided by a specialist in epilepsy as to whether the following criteria are met:
• there have been no seizures for at least 10 years; and
• an EEG conducted in the last six months has shown no epileptiform activity and no other EEG conducted in the last 12 months has shown epileptiform activity; and
• the person follows medical advice with respect to medication adherence.
The vision standard may also apply if there is a visual field defect.
If any antiepileptic medication is to be withdrawn, the person will no longer meet the criteria to hold a conditional licence.

occurs, they must cease driving and report to authority and physician. The waiting period may be reduced to three years upon neurologist/specialist recommendation.
### 19. APPENDIX D: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF HEARING LOSS ON MVC RISK

#### Search Strategy

**CONCEPT 1A: DRIVER**

<table>
<thead>
<tr>
<th>MeSH Terms</th>
<th>Keywords</th>
<th>1 OR 2 OR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Automobile Driving/</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>driv*.tw.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>motorist*.tw.</td>
<td></td>
</tr>
</tbody>
</table>

**CONCEPT 1B: HEARING LOSS**

<table>
<thead>
<tr>
<th>MeSH Terms</th>
<th>Keywords</th>
<th>5 OR 6 OR 7 OR 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Hearing loss</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Deafness</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>hear*.tw.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>deaf*.tw.</td>
<td></td>
</tr>
</tbody>
</table>

**CONCEPT 1**

4 AND 11

**CONCEPT 2A: CRASH RISK**

<table>
<thead>
<tr>
<th>MeSH Terms</th>
<th>Keywords</th>
<th>12 OR 13 OR 14 OR 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Accidents/</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>crash*.tw.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>collision*.tw.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>accident*.tw.</td>
<td></td>
</tr>
</tbody>
</table>

**CONCEPT 2B: ON-ROAD DRIVING ASSESSMENT**

<table>
<thead>
<tr>
<th>MeSH Terms</th>
<th>Keywords</th>
<th>(driv* exam*).tw.</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Automobile Driver Examination/</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Licensure/</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>on-road.tw.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>(on adj1 road).tw.</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>assess*.tw.</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>reassess*.tw.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>licen*.tw.</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>relicen*.tw.</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>re-licen*.tw.</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>test.tw.</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>re-test*.tw.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>permit*.tw.</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>(driv* assess*).tw.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(fitness adj2 driv*).tw.</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>(safe adj2 driv*).tw.</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>(unfit adj2 driv*).tw.</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>(unsafe adj2 driv*).tw.</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>(competen* adj2 driv*).tw.</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>(driv* abilit*).tw.</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>(driv* perform*).tw.</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>17 OR 18... OR 37</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CONCEPT 2</strong></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>16 OR 37</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>11 AND 38</td>
<td></td>
</tr>
</tbody>
</table>
## Current Fitness-to-Drive Guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Reference</th>
<th>NZ</th>
<th>US</th>
<th>UK</th>
<th>Canada</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Licensing Category</td>
<td>Drivers of cars, light rigid vehicles or motorcycles unless carrying public passengers or requiring a dangerous goods driver licence (Private standards)</td>
<td>Class 1 or class 6 licence and/or a D, F, R, T or W endorsement (Private standards)</td>
<td>Non-Commercial Vehicles (regulated by state, no national standards)</td>
<td>Group 1: Car and motorcycle (Private standards)</td>
<td>Non-commercial (Classes 5 (Cars) and 6 (Motorbikes))</td>
<td>All classes</td>
</tr>
<tr>
<td></td>
<td>Drivers of heavy vehicles, public passenger vehicles or requiring a dangerous goods driver licence (Commercial standards)</td>
<td>Class 2, 3, 4 or 5 licence and/or a P, V, I or O endorsement (Commercial standards)</td>
<td>Commercial vehicles (Interstate commerce)</td>
<td>Group 2: bus and lorry (Commercial standards)</td>
<td>Commercial drivers: Class 2 (bus of any seating capacity) Class 4 (Bus with a seating capacity of not more than 42 passengers, Taxi, emergency response vehicles (ambulances, fire trucks and police cars))</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>No hearing standard for private drivers</td>
<td>Class 1 or Class 6: no hearing standard</td>
<td>Non-commercial vehicles: no hearing standard</td>
<td>Group 1: no hearing standard.</td>
<td>Non-commercial: no hearing standard.</td>
<td>There are no hearing standards for drivers</td>
</tr>
<tr>
<td></td>
<td>Commercial standards: Drivers of heavy vehicles, public passenger vehicles or requiring a dangerous goods driver licence: A person is not fit to hold an unconditional licence if the person has unaided hearing loss greater than or equal to 40 dB in the better ear (averaged over the frequencies 0.5, 1, 2 and 3KHz.) A conditional licence may be considered by the driver licensing authority subject to periodic review, taking into account the nature of the driving task and information provided by an ear, nose and throat specialist or audiologist as to whether: the standard is able to be met with a hearing aid.</td>
<td>FMCSA standard for interstate commerce: First perceives a forced whispered voice in the better ear at not less than five feet with or without the use of a hearing aid or, if tested by use of an audiometric device, does not have an average hearing loss in the better ear greater than 40 decibels at 500 Hz, 1,000 Hz, and 2,000 Hz with or without a hearing aid when the audiometric device is calibrated to American National Standard (formerly ASA Standard) Z24.5—1951</td>
<td>Group 2: Must be assessed but may not need to notify DVLA. For licensing, the paramount importance is placed on a proven ability to communicate in an emergency by: speech or suitable alternative, for example, SMS text.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Influence of Chronic Illness on Motor Vehicle Crash Risk

185
| or requiring a dangerous goods driver licence |   |   |   |   |
**SEARCH STRATEGY**

<table>
<thead>
<tr>
<th>CONCEPT 1: PSYCHIATRIC DISORDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Mental Disorders/</td>
</tr>
<tr>
<td>2 (mental adj disorder*).tw.</td>
</tr>
<tr>
<td>3 Psychotic Disorders/</td>
</tr>
<tr>
<td>4 affective disorders, psychotic/</td>
</tr>
<tr>
<td>5 paranoid disorders/</td>
</tr>
<tr>
<td>6 psychotic disorders/</td>
</tr>
<tr>
<td>7 schizophrenia/</td>
</tr>
<tr>
<td>8 schizophrenia, catatonic/</td>
</tr>
<tr>
<td>9 schizophrenia, disorganized/</td>
</tr>
<tr>
<td>10 schizophrenia, paranoid/</td>
</tr>
<tr>
<td>11 (schizophreni* or schizoaffect* or schizoaffect* or hebephreni* or schizophreniform or dementia praecox or dementia precox or shared paranoid disorder* or (delusional adj2 disorder*) or (brief psychotic adj2 disorder*) or first psychotic episode* or first episode psychos*).ti,ab.</td>
</tr>
<tr>
<td>12 mood disorders/</td>
</tr>
<tr>
<td>13 depressive disorder/</td>
</tr>
<tr>
<td>14 depression, postpartum/</td>
</tr>
<tr>
<td>15 depressive disorder, major/</td>
</tr>
<tr>
<td>16 depressive disorder, treatment-resistant/</td>
</tr>
<tr>
<td>17 dysthymic disorder/</td>
</tr>
<tr>
<td>18 premenstrual dysphoric disorder/</td>
</tr>
<tr>
<td>19 seasonal affective disorder/</td>
</tr>
<tr>
<td>20 cyclothymic disorder/</td>
</tr>
<tr>
<td>21 “Bipolar and Related Disorders”/</td>
</tr>
<tr>
<td>22 Bipolar Disorder/</td>
</tr>
<tr>
<td>23 (depressed or depression or depressive or SAD or melanchol* or MDD or dysthym* or PPD).ti,ab.</td>
</tr>
<tr>
<td>24 (Depressive neuros* or depressive syndrome* or endogenous depressi*).ti,ab.</td>
</tr>
<tr>
<td>25 (Bipolar* or bi polar or mania* or manic* or hypomania* or manicdepress* or maniodepress* or manic-depress* or cyclothymia* or cyclothymic* or BPD).ti,ab.</td>
</tr>
<tr>
<td>26 Anxiety Disorders/</td>
</tr>
<tr>
<td>27 agoraphobia/</td>
</tr>
<tr>
<td>28 neurotic disorders/</td>
</tr>
<tr>
<td>29 obsessive-compulsive disorder/</td>
</tr>
<tr>
<td>30 panic disorder/</td>
</tr>
<tr>
<td>31 phobia, social/</td>
</tr>
<tr>
<td>32 stress disorders, post-traumatic/</td>
</tr>
<tr>
<td>33 stress disorders, traumatic, acute/</td>
</tr>
<tr>
<td>34 stress disorders, traumatic/</td>
</tr>
<tr>
<td>35 (anxiety or anxious or anxieties or hypervigilan* or nervousness).tw.</td>
</tr>
<tr>
<td>36 ((generalised or generalized) adj anxiety).tw.</td>
</tr>
<tr>
<td>37 ((post traumatic* or Posttraumatic* or combat or war or wars or battle) adj3 (neuroses* or neurosis* or stress or fatigue* or disorder*)).ti,ab.</td>
</tr>
<tr>
<td>38 PTSD.tw.</td>
</tr>
<tr>
<td>39</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>41</td>
</tr>
<tr>
<td>42</td>
</tr>
<tr>
<td>43</td>
</tr>
<tr>
<td>44</td>
</tr>
<tr>
<td>45</td>
</tr>
<tr>
<td>46</td>
</tr>
<tr>
<td>47</td>
</tr>
<tr>
<td>48</td>
</tr>
<tr>
<td>49</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>51</td>
</tr>
<tr>
<td>52</td>
</tr>
<tr>
<td>53</td>
</tr>
<tr>
<td>54</td>
</tr>
<tr>
<td>55</td>
</tr>
<tr>
<td>56</td>
</tr>
<tr>
<td>57</td>
</tr>
<tr>
<td>58</td>
</tr>
</tbody>
</table>

**CONCEPT 1**

| 59 | or/1-58 |

**CONCEPT 2A: FITNESS TO DRIVE/ON-ROAD DRIVING TEST**

| 60 | Safety/ |
| 61 | Automobile Driver Examination/ |
| 62 | Licensure/ |
| 63 | ((driv* or motor* or safe*) adj3 (assess* or reassess* or screen* or licen* or relicen* or re-licen* or test or re-test* or permit*)).tw. |
| 64 | driv* exam*.tw. |
| 65 | fitness to driv*.tw. |
| 66 | (safe* adj1 driv*).tw. |
| 67 | unfit to driv*.tw. |
| 68 | (unsafe adj2 driv*).tw. |
| 69 | (competen* adj1 driv*).tw. |
| 70 | driv* abilit*.tw. |
| 71 | ability to drive.tw. |
| 72 | driv* perform*.tw. |
| 73 | or/60-72 |

**CONCEPT 2B: CRASH RISK**

<p>| 74 | Accidents, Traffic/ |
| 75 | crash*.tw. |
| 76 | collision*.tw. |
| 77 | accident*.tw. |
| 78 | or/74-77 |</p>
<table>
<thead>
<tr>
<th>CONCEPT 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>73 OR 78</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>59 AND 79</td>
</tr>
</tbody>
</table>
### Current fitness-to-drive guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Australia</th>
<th>NZ</th>
<th>US</th>
<th>UK</th>
<th>Canada</th>
<th>EU</th>
</tr>
</thead>
</table>

#### Psychiatric disorder/conditions / mental disorders

Psychiatric conditions encompass a range of cognitive, emotional and behavioural conditions such as schizophrenia, depression, anxiety disorders and personality disorders.

For private drivers, a conditional licence may be considered by the driver licensing authority if the condition is well controlled and the person is compliant with treatment over a substantial period; and the person has insight into the potential effects of their condition on safe driving; and there are no adverse medication effects that may impair their capacity for safe driving; and the impact of comorbidities has been considered (e.g., substance abuse. This is subject to periodic review, taking into account the nature of the driving task and information provided by the treating doctor.

For commercial drivers, a person is not fit to hold an unconditional licence if the person has a chronic psychiatric condition of such severity that is likely to make them unfit to drive until they have been satisfactorily treated, or the factors that were considered to make them unfit to drive are no longer present, or are no longer at a level that would affect the individual’s ability to drive safely.

For commercial drivers whether an individual should or should not drive will be based on the assessment of the following factors, and how they affect the individual’s ability to drive safely:

- Language and expression
- Motor control
- Perception
- Judgment
- Attention
- Memory
- Reasoning
- Gait
- Mood
- Insight
- Suicide risk

For private drivers whether an individual should or should not drive will be based on the assessment of the following factors, and how they affect an individual’s ability to drive safely:

- Language and expression
- Motor control
- Perception
- Judgment
- Attention
- Memory
- Reasoning
- Gait
- Mood
- Insight
- Suicide risk

Private standards: Not mentioned

Commercial standards: All individuals with a history within the past three years of the following psychiatric disorders should undergo additional medical and psychiatric evaluation to further assess functional ability before being considered qualified to drive a CMV: Psychotic Disorders; Bipolar Disorders; Major Depressive Disorder with a history of psychosis, suicidal ideation, homicidal ideation or a suicide attempt; Obsessive Compulsive Disorder; Antisocial Personality Disorder. Such individuals must demonstrate that they are likely to be able to perform their normal duties by undergoing a thorough evaluation of physical and mental function by a qualified psychiatrist.

Categorized according to:

- Anxiety or depression – mild to moderate
- Severe anxiety or depression
- Acute psychotic disorder
- Hypomania or mania
- Schizophrenia – and other chronic relapsing/remitting disorders
- Neurological developmental conditions
- Mild cognitive impairment (not mild dementia)
- Dementia – and/or any organic syndrome affecting cognitive functioning
- Learning disability
- Behavioural disorders – including post-head injury, non-epileptic seizures
- Personality disorders

Specific details of each are set out below.

<table>
<thead>
<tr>
<th>Psychiatric Disorders</th>
<th>Categorized according to:</th>
<th>Given the nature of psychiatric disorders, assessment must rely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mood disorders, depression disorders</td>
<td>Anxiety or depression – mild to moderate</td>
<td>Private drivers, licences shall not be issued to, or renewed for, applicants or drivers who suffer from: 1) severe mental disturbance, whether congenital or due to disease, trauma or neurosurgical operations, 2) severe mental retardation, 3) severe behavioural problems due to ageing; or personality defects leading to seriously impaired judgment, behaviour or adaptability unless their application is supported by authorised medical opinion and, if necessary, subject to regular medical check-ups.</td>
</tr>
<tr>
<td>Mood disorders, personality disorders</td>
<td>Severe anxiety or depression</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, psychosis, suicide risk</td>
<td>Acute psychotic disorder</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, mania</td>
<td>Hypomania or mania</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, schizophrenia</td>
<td>Schizophrenia – and other chronic relapsing/remitting disorders</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, dementia</td>
<td>Neurological developmental conditions</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, cognitive functioning</td>
<td>Mild cognitive impairment (not mild dementia)</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, dementia, organic syndrome affecting cognitive functioning</td>
<td>Dementia – and/or any organic syndrome affecting cognitive functioning</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, learning disability</td>
<td>Learning disability</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, behavioural disorders</td>
<td>Behavioural disorders – including post-head injury, non-epileptic seizures</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, personality disorders</td>
<td>Personality disorders</td>
<td></td>
</tr>
<tr>
<td>Mood disorders, personality disorders, severe mental disorder</td>
<td>Severe mental disorder</td>
<td></td>
</tr>
</tbody>
</table>

Commercial drivers involved in the driving of vehicles will be given due consideration to the additional risks and dangers by the competent medical authority.
impair behaviour, cognitive ability or perception required for safe driving.

A conditional licence may be considered by the driver licensing authority subject to periodic review, taking into account the nature of the driving task and information provided by a psychiatrist as to whether the following criteria are met:

- The condition is well controlled and the person is compliant with treatment over a substantial period;
- and the person has insight into the potential effects of their condition on safe driving; and there are no adverse medication effects that may impair their capacity for safe driving; and the impact of comorbidities has been considered (e.g., substance abuse).

Health practitioners should consider any possible public safety risks that may occur because of the nature of work these endorsements entail and report any individual who poses a public safety risk by driving when advised not to.

Severe chronic mental disorder

A person with a severe chronic or relapsing psychiatric condition needs to be assessed regarding the effect of the illness on impairment and the skills needed to drive and the impairments that may arise. This may include a clinical assessment (e.g., neuropsychological) and may also include an on-road driving assessment.

Private driver: Not mentioned
Commercial driver: Chronic psychiatric disorders are defined as those which have lasted more than six months. Drivers who had a history of a psychiatric disorder of concern within the past three years or a history of a recurrent disorder of concern should be re-evaluated intermittently by a qualified psychologist or psychiatrist upon referral from the medical examiner.
should not drive will be based on the assessment of the following factors, and how they affect an individual’s ability to drive safely:

1) psychomotor and cognitive functioning
2) behaviour
3) mood (including suicidal ideation)
4) medication
5) insight and judgment

Driving should cease where an individual's ability to drive safely may be impaired. The individual is generally unfit to drive until effective treatment is in place, and a period of observation, usually six months, has been undertaken. However, the time away from driving will depend on how the individual responds to treatment, and the likelihood of further relapses. A psychiatric assessment is required before allowing the individual to drive again.

For commercial drivers driving any severe and chronic mental condition that impairs an individual’s ability to drive safely for an extended period will render the individual unfit to drive for a period of observation, usually 12 months. In exceptional circumstances, the return to commercial driving can be significantly less than 12 months but this will depend on:

• a satisfactory period of being stable and symptom free
### Anxiety or depression – mild to moderate

| Drivers with anxiety conditions (including post-traumatic stress disorder) may: be preoccupied or distractible, and/or experience panic attacks or obsessional behaviours that may impair driving. Drivers with depression may demonstrate disturbances in attention, information processing and judgement, including reduced ability to anticipate; psychomotor retardation and reduced reaction times; sleep disturbances and fatigue, and/or suicidal ideation that may manifest in reckless driving. | Anxiety or panic attacks need not prevent driving, but the individual should be advised not to drive at times when acute symptoms occur. | Not mentioned | Defined as without significant memory or concentration problems, agitation, behavioural disturbance or suicidal thoughts. 
Private drivers, the individual may drive and are not required to notify the DVLA. However, doctors prescribing medications have a duty of care to advise their patients of the potential dangers of adverse effects from medications and their interactions with other substances, especially alcohol. 
Commercial drivers, may drive and are not required to notify the DVLA, provided the illness is short-lived. When planning medication treatment account should be made for the older tricyclic antidepressants that can have pronounced anticholinergic and antihistaminic effects, which may impair driving, whereas... | Not mentioned | Not mentioned |
| Severe anxiety or depression | Not mentioned | For private drivers where an individual’s mental condition is severe and chronic and affects their ability to drive safely for extended periods, the individual is considered unfit to drive until effective treatment is in place and a period of observation, usually six months, has been undertaken. However, the time away from driving will depend on how the individual responds to treatment, and the likelihood of further relapses. A psychiatric assessment is required before allowing the individual to drive again. For commercial drivers any severe and chronic mental condition that impairs an individual’s ability to drive safely for an extended period will render the individual unfit to drive for a period, usually 12 months. In exceptional circumstances, the return to commercial driving can be significantly less than 12 months but this will depend on:   • a satisfactory period of being stable and symptom free   • a full, supportive, relevant psychiatric opinion   • a low risk of recurrence or relapse | Private drivers: Not mentioned   Commercial drivers: Major depressive disorder (or unipolar depression) a medical examination questionnaire should be used to screen for possible depression, if indicated the medical examiner should then refer the individual to a psychiatrist to conduct an interview for major depression, including suicidal ideation and/or attempt. Obsessive-Compulsive Disorder (OCD) is a type of anxiety disorder characterized by obsessions and/or compulsions and may increase the risk of a motor vehicle crash if the symptoms are severe enough to interfere with concentration or motor/functional skills needed for safe driving. Defined as Significant memory or concentration problems, agitation, behavioural disturbance or suicidal thoughts. Private drivers, the individual must not drive and must notify the DVLA. Commercial drivers, must not drive and must notify the DVLA. Licensing may be granted after six months if: the person has been well and stable and is not taking medication with side effects that would affect alertness or concentration. Reports from a specialist in psychiatry may be required. Driving is usually permitted after six months if the anxiety or depression has been long-standing but symptoms are under control and if maintenance on a dosage of psychotropic medication does not cause impairment. Not mentioned | Not mentioned | Not mentioned |
**Acute psychotic disorder/** Hypomania or mania/** Schizophrenia – and other chronic relapsing/remitting disorders**

<table>
<thead>
<tr>
<th>Acute psychotic disorder</th>
<th>Psychiatric conditions may be associated with disturbances of behaviour, cognitive abilities and perception and therefore have the potential to affect driving ability. They do, however, differ considerably in their aetiology, symptoms and severity, and may be occasional or persistent. The impact of mental illness also varies depending on a person’s social circumstances, occupation and coping strategies. Assessment of fitness-to-drive must therefore be individualised and should rely on evaluation of the specific pattern of illness and potential impairments as well as severity, rather than the diagnosis per se.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private driver: where an individual’s mental condition is severe and chronic and affects their ability to drive safely for extended periods, the individual is considered unfit to drive until effective treatment is in place and a period of observation, usually six months, has been undertaken. However, the time away from driving will depend on how the individual responds to treatment, and the likelihood of further relapses. A psychiatric assessment is required before allowing the individual to drive again.</td>
<td></td>
</tr>
<tr>
<td>For commercial drivers any severe and chronic mental condition that impairs an individual’s ability to drive safely for an extended period will render the individual unfit to drive for a period, usually 12 months. In exceptional circumstances, the return to commercial driving can be significantly less than 12 months but this will depend on:</td>
<td></td>
</tr>
<tr>
<td>Private driver: Not mentioned</td>
<td></td>
</tr>
<tr>
<td>Commercial driver: Acute psychiatric disorders are defined as those that have occurred for less than six months. Drivers who had a history of a psychiatric disorder of concern within the past three years or a history of a recurrent disorder of concern should be re-evaluated intermittently by a qualified psychologist or psychiatrist upon referral from the medical examiner.</td>
<td></td>
</tr>
<tr>
<td>Defined as persistent alcohol and/or drug misuse or dependence.</td>
<td></td>
</tr>
<tr>
<td>Private drivers, the individual must not drive during acute illness and must notify the DVLA.</td>
<td></td>
</tr>
<tr>
<td>Defined as persistent alcohol and/or drug misuse or dependence.</td>
<td></td>
</tr>
<tr>
<td>Licensing may be considered if all of these conditions are met: remained well and stable for at least 3 months. Adheres to any agreed treatment plan. Free from any medication effects that would impair driving. Subject to a suitable specialist report being favourable.</td>
<td></td>
</tr>
<tr>
<td>A lack of insight which impacts upon the ability to drive safely would be a bar to licensing.</td>
<td></td>
</tr>
<tr>
<td>Drivers with a history of instability and/or poor engagement with treatment will be required not to drive for a longer period before any relicensing.</td>
<td></td>
</tr>
<tr>
<td>Commercial drivers must not drive during acute illness and must notify the DVLA.</td>
<td></td>
</tr>
<tr>
<td>Personality disorders</td>
<td>People with some personality conditions may display aggressive or impulsive, irresponsible or erratic behaviour. These impairments are difficult to determine because impairment differs at various phases of the illness and Not mentioned</td>
</tr>
</tbody>
</table>
may vary markedly between individuals. The impairments described above are particularly important for commercial vehicle drivers. Such people may benefit from psychiatric interventions. Their licence status may also need to be managed through administrative, police or legal channels.

It is associated with behaviours such as aggression, egocentricity, impulsiveness, resentment of authority, disregard of rules, intolerance of frustration, substance misuse, and irresponsibility. All of these behaviours may increase the risk for a motor vehicle crash or not likely to adversely affect driving and road safety.

Commercial drivers must not drive and must notify the DVLA. Licensing will be refused or revoked if there is likely to be danger at the wheel. Licensing may be given consideration if a specialist confirms stability.
### 21. APPENDIX F: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF SLEEP DISORDERS ON MVC RISK

**SEARCH STRATEGY**

#### CONCEPT 1A: DRIVER

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

#### CONCEPT 1B: SLEEP DISORDERS

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>17</td>
</tr>
</tbody>
</table>

#### CONCEPT 1

| 18 | 4 AND 17                      |

#### CONCEPT 2A: CRASH RISK

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
</tr>
<tr>
<td>21</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>23</td>
</tr>
</tbody>
</table>

#### CONCEPT 2B: ON-ROAD DRIVING ASSESSMENT

<table>
<thead>
<tr>
<th>MeSH Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
</tr>
</tbody>
</table>

<p>| 26 | on-road.tw.                   |
| 27 | (on adj1 road).tw.            |
| 28 | assess*.tw.                   |
| 29 | reassess*.tw.                 |</p>
<table>
<thead>
<tr>
<th>Line</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>licen*.tw.</td>
</tr>
<tr>
<td>31</td>
<td>relicen*.tw.</td>
</tr>
<tr>
<td>32</td>
<td>re-licen*.tw.</td>
</tr>
<tr>
<td>33</td>
<td>test.tw.</td>
</tr>
<tr>
<td>34</td>
<td>re-test*.tw.</td>
</tr>
<tr>
<td>35</td>
<td>permit*.tw.</td>
</tr>
<tr>
<td>36</td>
<td>(driv* exam*).tw.</td>
</tr>
<tr>
<td>37</td>
<td>(driv* assess*).tw.</td>
</tr>
<tr>
<td>38</td>
<td>(fitness adj2 driv*).tw.</td>
</tr>
<tr>
<td>39</td>
<td>(safe adj2 driv*).tw.</td>
</tr>
<tr>
<td>40</td>
<td>(unfit adj2 driv*).tw.</td>
</tr>
<tr>
<td>41</td>
<td>(unsafe adj2 driv*).tw.</td>
</tr>
<tr>
<td>42</td>
<td>(competen* adj2 driv*).tw.</td>
</tr>
<tr>
<td>43</td>
<td>(driv* abilit*).tw.</td>
</tr>
<tr>
<td>44</td>
<td>(driv* perform*).tw.</td>
</tr>
<tr>
<td>45</td>
<td>24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44</td>
</tr>
<tr>
<td>46</td>
<td>23 OR 45</td>
</tr>
<tr>
<td>47</td>
<td>18 AND 46</td>
</tr>
</tbody>
</table>
## CURRENT fitness-to-drive GUIDELINES

<table>
<thead>
<tr>
<th>Country</th>
<th>Australia</th>
<th>NZ</th>
<th>US</th>
<th>Canada</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep Apnoea</td>
<td>Drivers may not hold an unconditional licence if: • diagnosed with a sleep apnoea syndrome (either through a diagnostic sleep study, or moderate to severe excessive daytime sleepiness [ESS: 16-24]); or • frequent self-reported episodes of sleepiness or drowsiness while driving are experienced; or • they have been involved in MVC(s) caused by inattention or sleepiness; or • a treating doctor deems the driver at significant driving risk as a result of their sleep disorder. Conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from the treating doctor (or a sleep specialist in the case of commercial drivers) on the following criteria: • compliance with treatment; and • satisfactory response to treatment.</td>
<td>Drivers shall cease, or restrict, driving if: • they are suspected of having OSA with a high risk of excessive sleepiness while until a diagnosis is confirmed through a sleep study; or • they complain of severe daytime sleepiness and have a history of sleep-related MVCs (or there is an equivalent level of concern); or • they have been diagnosed with severe OSA (through a sleep study) that is untreatable or where appropriate treatment has not been carried out. Drivers may resume driving if their OSA has been treated under specialist supervision, with satisfactory control of symptoms. Annual medical assessment may be required. Drivers may be granted a conditional license if: • they have untreated OSA (AHI: &gt;20) with no daytime sleepiness, or otherwise have undergone effective treatment; or • they have OSA (AHI: &gt;20) and have undergone effective treatment. Cessation of treatment shall lead to cessation of license if OSA is untreated. and • are re-certified annually by a qualified clinician for satisfactory compliance with treatment; and • do not report excessive sleepiness while driving, or have been involved in an MVC(s) due to sleepiness; and Drivers treated with surgery shall be re-evaluated for driving safety. Drivers are eligible for a license if: • untreated OSA with lower severity (AHI: &lt; 20) and no daytime sleepiness; or • OSA is treated successfully. Drivers who have experienced a crash associated with falling asleep or reports excessive sleepiness while driving may not operate any class of vehicle until the sleep disorder has been treated successfully. Drivers are assessed for fitness to drive on a case by case basis, taking into account the treating physician’s specific recommendations. Re-assessment is carried out at the discretion of the authority. Periodic mandatory medical reports are required to assess their fitness to hold a commercial licence. Annual medical review is required.</td>
<td>Drivers are eligible for a license if: • untreated OSA with lower severity (AHI: &lt; 20) and no daytime sleepiness; or • OSA is treated successfully. Drivers who have experienced a crash associated with falling asleep or reports excessive sleepiness while driving may not operate any class of vehicle until the sleep disorder has been treated successfully.</td>
<td>Drivers with a moderate (AHI: 15-29) or severe (AHI: ≥30) OSA: • need further medical advice before a driving licence is issued or renewed. • may be issued a driving license if they show adequate control of their condition and compliance with appropriate treatment and improvement of sleepiness, that is confirmed by authorised medical opinion. • shall be subject to a periodic medical review every 3 years (for group 1) or annually (for group 2).</td>
<td></td>
</tr>
<tr>
<td>Narcolepsy</td>
<td>Drivers may not hold an unconditional licence</td>
<td>Drivers may not hold an unconditional licence</td>
<td>Drivers shall cease driving if they are</td>
<td>Drivers shall cease driving if they suffer from</td>
<td>No specific recommendations are made for</td>
</tr>
<tr>
<td>Licence if diagnosed with narcolepsy.</td>
<td>Licence if diagnosed with narcolepsy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from a sleep specialist on the response to treatment.</td>
<td>Conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from a sleep specialist on the following criteria:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• cataplexy has not occurred; and</td>
<td>• daytime sleep attacks within the past 12 months (with or without treatment); and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• adherence to medication; and</td>
<td>• episodes of cataplexy within the past 12 months (with or without treatment).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• absence of symptoms for at least six months; and</td>
<td>Reassessment may be required at discretion of the Authority.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• normal sleep latency present on maintenance of wakefulness test.</td>
<td>A licence can only be maintained if:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• regular medical supervision is maintained; and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• commercial vehicles are not driven for long hours, overnight or during irregular shifts (the driver’s work schedule may be subject to a sleep specialist’s approval).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reassessment may be required at discretion of the Authority.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Narcolepsy, however, the guidelines state that narcolepsy is incompatible with safe driving unless it is successfully treated by a clinician or health care provider.

Severe narcolepsy or narcolepsy with excessive sleepiness or cataplexy.

Drivers may resume driving if: |

• there is a satisfactory treatment, and |
• are cleared to resume driving by an appropriate specialist; or |
• diagnosis has established that the person does not suffer from the full range of symptoms, particularly in regard to unpredictable episodes of cataplexy. |

Reassessment may be required at discretion of the Authority.

Regular medical assessment may be required.

Licence if diagnosed with narcolepsy.

Conditional licence may be granted subject to periodic review, in consideration of the driving task and recommendation from a sleep specialist on the following criteria: |

• cataplexy has not occurred; and |
• adherence to medication; and |
• absence of symptoms for at least six months; and |
• normal sleep latency present on maintenance of wakefulness test. |

A licence can only be maintained if: |

• regular medical supervision is maintained; and |
• commercial vehicles are not driven for long hours, overnight or during irregular shifts (the driver’s work schedule may be subject to a sleep specialist’s approval). |

Reassessment may be required at discretion of the Authority.
### 22. APPENDIX G: SUPPLEMENTARY INFORMATION FOR INFLUENCE OF VISION DISORDERS & VISION IMPAIRMENT ON MVC RISK

**SEARCH STRATEGY**

<table>
<thead>
<tr>
<th>CONCEPT 1A: DRIVER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MeSH Terms</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Automobile Driving/</td>
</tr>
<tr>
<td><strong>Keywords</strong></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>driv*.tw.</td>
</tr>
<tr>
<td>3</td>
<td>motorist*.tw.</td>
</tr>
<tr>
<td>4</td>
<td>1 OR 2 OR 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONCEPT 1B: VISION DISORDERS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MeSH Terms</strong></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Glaucoma/</td>
</tr>
<tr>
<td>6</td>
<td>Cataract/</td>
</tr>
<tr>
<td>7</td>
<td>Macular Degeneration/</td>
</tr>
<tr>
<td>8</td>
<td>Hemianopsia/</td>
</tr>
<tr>
<td>9</td>
<td>Diabetic Retinopathy/</td>
</tr>
<tr>
<td>10</td>
<td>Visual Acuity/</td>
</tr>
<tr>
<td>11</td>
<td>Visual Fields/</td>
</tr>
<tr>
<td>12</td>
<td>Vision Disorders/</td>
</tr>
<tr>
<td>13</td>
<td>Blindness/</td>
</tr>
<tr>
<td>14</td>
<td>Vision, Ocular/</td>
</tr>
<tr>
<td>15</td>
<td>Eye Diseases/</td>
</tr>
<tr>
<td><strong>Keywords</strong></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Glaucoma.tw.</td>
</tr>
<tr>
<td>17</td>
<td>Cataract*.tw.</td>
</tr>
<tr>
<td>18</td>
<td>Macular Degeneration.tw.</td>
</tr>
<tr>
<td>19</td>
<td>Hemianopsia.tw.</td>
</tr>
<tr>
<td>20</td>
<td>Retinopathy.tw.</td>
</tr>
<tr>
<td>21</td>
<td>Diabetic Retinopathy.tw.</td>
</tr>
<tr>
<td>22</td>
<td>Visual Acuity.tw.</td>
</tr>
<tr>
<td>23</td>
<td>Contrast sensitivity.tw.</td>
</tr>
<tr>
<td>24</td>
<td>visual field*.tw.</td>
</tr>
<tr>
<td>25</td>
<td>visual impairment*.tw.</td>
</tr>
<tr>
<td>26</td>
<td>impaired vision.tw.</td>
</tr>
<tr>
<td>27</td>
<td>vis* loss.tw.</td>
</tr>
<tr>
<td>28</td>
<td>vision.tw.</td>
</tr>
<tr>
<td>29</td>
<td>ocular disease*.tw.</td>
</tr>
<tr>
<td>30</td>
<td>eye disease*.tw.</td>
</tr>
<tr>
<td>31</td>
<td>ocular condition.tw.</td>
</tr>
<tr>
<td>32</td>
<td>eye condition.tw.</td>
</tr>
<tr>
<td>33</td>
<td>5 or 6 or 7 or 8 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32</td>
</tr>
<tr>
<td><strong>CONCEPT 1</strong></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>4 AND 33</td>
</tr>
</tbody>
</table>
### CONCEPT 2A: CRASH RISK

**MeSH Terms**

35 Accidents/

**Keywords**

36 crash*.tw.
37 collision*.tw.
38 accident*.tw.
39 35 or 36 or 37 or 38

### CONCEPT 2B: ON-ROAD DRIVING ASSESSMENT

**MeSH Terms**

40 Automobile Driver Examination/
41 Licensure/

**Keywords**

42 on-road.tw.
43 (on adj1 road).tw.
44 assess*.tw.
45 reassess*.tw.
46 licen*.tw.
47 relicen*.tw.
48 re-licen*.tw.
49 test.tw.
50 re-test*.tw.
51 permit*.tw.
52 (driv* exam*).tw.
53 (driv* assess*).tw.
54 (fitness adj2 driv*).tw.
55 (safe adj2 driv*).tw.
56 (unfit adj2 driv*).tw.
57 (unsafe adj2 driv*).tw.
58 (competen* adj2 driv*).tw.
59 (driv* abilit*).tw.
60 (driv* perform*).tw.
61 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60

### CONCEPT 2

62 39 OR 61

### TOTAL

63 34 OR 62
64 63 not (exp animals/ not humans.sh.)
65 limit 64 to English language
## Current Fitness-to-Drive Guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Australia</th>
<th>NZ</th>
<th>UK</th>
<th>US</th>
<th>Canada</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acuity (assessed using Snellen chart or similar)</td>
<td>Unconditional licence (without corrective lenses): Minimum uncorrected visual acuity of 6/12 (metric) using both eyes together, or in the better eye (more than two errors on any line of the chart is a fail). A conditional licence may be considered subject to periodic review if the standard is met with corrective lenses. Some discretion is allowed in application of the standard by an optometrist or ophthalmologist if the better eye is equal to or better than 6/24.</td>
<td>With or without corrective lenses: Minimum visual acuity using both eyes together of 6/12.</td>
<td>With or without prescribed glasses or contact lenses: In good daylight, the ability to read the registration mark (number-plate) fixed to a vehicle registered under current standards: At 20m with letters and numbers 79mm high by 50mm wide on a car registered since 1/9/2001 or At 20.5m with letters and numbers 79mm high by 57mm wide on a car registered before 1/9/2001 Visual acuity must be at least Snellen 6/12 with both eyes open or in the only eye if monocular Biopic telescope devices not accepted for driving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>With or without prescribed glasses or contact lenses: Minimum visual acuity of 6/15 using both eyes together.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In 2010, MUARC published a comprehensive literature review, *Influence of chronic illness on crash involvement of motor vehicle drivers* (2nd edition, 621 pages), which underpins much of VicRoads’ medical review policy and the Australian national 2016 *Assessing FitFitness-to-drive* (AFTD) guidelines related to medically impaired drivers of private or commercial vehicles. Within the 2010 review, MUARC identified eight chronic illnesses/conditions that were associated with increased motor vehicle crash (MVC) risk. These included:

- Dementia;
- Epilepsy/Seizure disorders;
- Alcohol abuse/dependence;
- Sleep apnoea;
- Psychiatric conditions in general;
- Schizophrenia;
- Cataracts, and
- Multiple sclerosis.

In 2019, Road Safety Victoria (Department of Transport) commissioned MUARC to update their review and capture the extensive research which has been conducted over the last eight years related to medical impairment, disability, driving competence and MVC risk. Systematic literature reviews regarding the MVC risk for drivers with dementia, stroke / transient ischemic attacks (TIA), and traumatic brain injury (TBI) have recently been published:


In addition, MUARC and their international colleagues are currently conducting several systematic literature reviews aimed at exploring the MVC risk for drivers with other high-risk medical conditions:

- Alcohol abuse/dependence;
- Diabetes;
- Epilepsy and/or Seizure disorders;
- Hearing loss;
- Sleep disorders (including sleep apnoea);
Psychiatric conditions (including schizophrenia and an umbrella review for Attention Deficit Hyperactivity Disorder), and

Vision disorders (including cataracts).

VicRoads recently obtained feedback from key Victorian based external and internal (medical review) stakeholders regarding medical condition or medical treatment gaps that aren’t discussed at all, or only briefly discussed in the 2010 ‘Influence of chronic Illness on crash involvement of motor vehicle drivers’ report and/or the 2016 AFTD guidelines.

The significant and emerging medical and disability-related conditions that were identified by stakeholders (including some medical treatments/interventions) were: Autism Spectrum Disorders, interstitial glucose monitoring devices, dialysis treatment for permanent/irreversible renal failure, chronic/irreversible hepatic encephalopathy or chronic liver disease, drug dependency, medicinal cannabis use, congenital limb deficiencies or limb amputation and use of prostheses to drive, the combination of multiple medical and eyesight conditions, and cancer treatment interventions (e.g., chemotherapy, radiation).

There may also be other high-risk medical conditions or driver requirements with regard to reporting that have not been identified in the 2010 compendium.

Aim: Given the long list of issues identified, one of the first tasks of the expert international panel is to determine, by consensus, a ranking of which of the emerging and significant medical conditions, functional issues or treatments, listed below, should be addressed in a supplementary literature review conducted by MUARC.

PLEASE PROCEED TO NEXT PAGE TO BEGIN SURVEY.

Q1a What would be the highest priority review conditions in terms of greatest value for FTD decisions? Click and drag to re-order (highest priority on the top of the list).

______ Autism Spectrum Disorders
______ Cancer treatment
______ Congenital limb deficiencies / Limb amputation and use of prostheses to drive
______ Deep brain stimulation (treatment of Parkinson’s Disease)
______ Dialysis (renal failure)
______ Drug dependency
______ Hepatic encephalopathy or chronic liver disease
______ Intellectual disability (associated with several medical/congenital conditions)
______ Use of Interstitial glucose monitoring devices
______ Medical cannabis use
______ Multiple medical conditions (i.e., comorbidity)
______ Spinal cord stimulation (for chronic pain)

Please elaborate on which combinations of medical conditions you consider important to review - if any - for example, diabetes AND eye conditions, or alcohol dependency AND psychiatric illness]:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Q1b Please list any other significant and/or emerging medical and/or disability-related conditions, or treatments that you consider important to address (excluding the conditions listed in Item Q1a, or those conditions for which SLRs are either in progress or have recently been completed as described above)

________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Q2a Please tick any of the boxes below to indicate which reasons guided your ratings (i.e., what dictated how you prioritised the conditions above)?

☐ size of problem (e.g., population prevalence; likelihood people with the condition will be driving etc)

☐ likely impact of the condition on driving

☐ current level of guidance on the topic/condition and FTD

☐ current level of knowledge/uncertainty on the topic/condition and FTD amongst health professionals

☐ current low level of research addressing the topic and its’ association with FTD and mismatch with perceived crash risk

☐ Newly emerging population attempting to gain licensure (e.g., as a result of relatively recent patient independence funding availability, such as in Australia, the recent National Disability Insurance Scheme)

☐ Other (specify)

Q2b Specify any other comments/considerations relevant to topic prioritisation:

________________________________________________________________
________________________________________________________________

WE THANK YOU FOR YOUR TIME SPENT COMPLETING THIS SURVEY. YOUR RESPONSES HAVE BEEN RECORDED.
SUMMARY OF EXPERT PANEL ONLINE SURVEY RESULTS

Top five expert-ranked conditions for focus of literature review based on survey:

<table>
<thead>
<tr>
<th>Expert #1</th>
<th>Expert #2</th>
<th>Expert #3</th>
<th>Expert #4</th>
<th>Expert #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Multiple medical</td>
<td>1</td>
<td>Multiple medical</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Intellectual disability</td>
<td>2</td>
<td>Medicinal cannabis</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Congenital limb/amputations</td>
<td>3</td>
<td>Dialysis</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Drug dependency</td>
<td>4</td>
<td>Hepatic encephalopathy/Liver disease</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>ASD</td>
<td>5</td>
<td>Cancer treatments</td>
<td>5</td>
</tr>
</tbody>
</table>

Other significant and/or emerging medical and/or disability-related conditions identified by the expert panel included:

- Chronic renal failure and dialysis.
- Respiratory conditions.
- Frailty.

Reasons guiding expert panel members’ ratings (in order of most common to least common) are identified in the figure below.

In terms of which combinations of medical conditions expert panel members considered important to review, the following results were found:

- Cardiovascular conditions and risk factors such as diabetes, angina, family and past history, hypertension, congestive heart failure and sleep apnoea, AND any other medical condition.
- Respiratory conditions such as chronic lung disease and chronic obstructive pulmonary disease AND any other medical condition.
- Cerebrovascular conditions, mild cognitive impairment, dementia and Parkinsonism/Parkinson’s disease, AND any other medical condition.
- Alcohol/substance abuse/dependency AND psychiatric conditions such as psychosis or bipolar disorders.
- Visual/eye conditions AND diabetes.
<table>
<thead>
<tr>
<th>Concept/Condition</th>
<th>Key words/phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comorbidity</td>
<td>Comorbid, co-morbid</td>
</tr>
<tr>
<td>Multiple medical conditions</td>
<td>Multiple medical, multiple health, existing, MMC, chronic</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>Epilepsy, seizures</td>
</tr>
<tr>
<td>Vision disorders</td>
<td>Vision, sight (then check if relating to impairment), visual, eye</td>
</tr>
<tr>
<td>Psychiatric conditions</td>
<td>Psychiatric, mental illness, depression, anxiety, schizophrenia, bipolar psychosis (other specific conditions but these are often the main ones)</td>
</tr>
<tr>
<td>Hearing Loss</td>
<td>Hearing, deafness (then check if relating to impairment), ear</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Diabetes, T2DM</td>
</tr>
<tr>
<td>Alcohol dependency</td>
<td>Alcohol, drinking, DUI, addiction</td>
</tr>
<tr>
<td>Drug dependency</td>
<td>Drug, addiction, dependence</td>
</tr>
<tr>
<td>Sleep disorders</td>
<td>Sleep disorders, apnea, apnoea, hypersomnia, insomnia, narcolepsy</td>
</tr>
<tr>
<td>ADHD</td>
<td>Attention (then check if it relates to ADHD), ADHD</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>Cardio, heart, myocardial infarction, coronary artery disease, arrythmia, cholesterol</td>
</tr>
<tr>
<td>Angina</td>
<td>Angina</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>Congestive heart, heart failure</td>
</tr>
<tr>
<td>Family/past history of cardiovascular disease</td>
<td>Cardio (then check if relating to family)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Hypertension, high blood pressure</td>
</tr>
<tr>
<td>Chronic respiratory disease</td>
<td>Chronic respiratory, lung, breathing (and then check if impairment)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>Pulmonary disease, COPD</td>
</tr>
<tr>
<td>Substance use</td>
<td>Substance abuse, drug, illicit (as above)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>Cere*, Stroke, CVA, CVD</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>Cognitive impairment, retardation, intellectual disability</td>
</tr>
<tr>
<td>Dementia</td>
<td>Dementia, Alzheimers Disease</td>
</tr>
<tr>
<td>Neurological</td>
<td>Neuro*</td>
</tr>
</tbody>
</table>