



MONASH
University

**DETERRING RISKY DRIVING:
UNDERSTANDING FACTORS THAT MAY
PREVENT THE PERFORMANCE OF ABERRANT
DRIVING BEHAVIOUR**

Hayley Maree McDonald

BA (Hons), GradCertSci (Applied Statistics)

A thesis submitted in fulfilment of the degree of Doctor of Philosophy at Monash University

2020

Monash University Accident Research Centre

Copyright notice

© Hayley Maree McDonald (2020).

I certify that I have made all reasonable efforts to secure copyright permissions for third-party content included in this thesis and have not knowingly added copyright content to my work without the owner's permission.

Abstract

Aim

The aim of this thesis was to investigate whether there is evidence of a deterring influence following a driver receiving an infringement for a traffic offence in Victoria, Australia. Two outcomes were examined to assess deterrence – 1) further traffic infringement/s; 2) subsequent crash involvement. The thesis also examined factors beyond legal sanctions that may influence deterrence and driver behaviour.

Methods

Three studies were conducted using data from Victoria, Australia. Study one used licensing and infringements data to conduct a time-to-event analysis, examining recidivism in the twelve months that followed a driver receiving a traffic infringement. Study two used licensing, infringements and crash data to conduct a case-case-time-control study, examining subsequent crash involvement in the one-month period that followed a driver receiving an infringement for a driving offence. Study three used survey collected data to conduct a mediated regression analysis, examining the mediating influence that perceptions towards potential deterrents (enforcement; crash risk; social norms and disapproval; negative personal and emotional affect) have between the Big-Five personality factors and expectations to drive at up to 10km/h above the speed limit in the twelve months that followed.

Results

Study One: This study found a number of different factors influence whether infringements are able to achieve deterrence from further traffic offending. These include gender, age, years licensed, number of previous traffic offences and number of accumulated demerit points.

Study Two: This study found that the odds of receiving an infringement in the month prior to a crash were 35 per cent higher than receiving an infringement in the same month the year prior, for the case group, adjusted for change over time in the control group (OR = 1.35, 95% CI 1.17 – 1.57). Thus, the odds of receiving an infringement in the one-month period prior to a crash was greater than in a comparable one-month period the year prior.

Study Three: This study found that all Big-Five personality traits and perceptions towards potential deterrents were significantly associated with expectations to speed at up to 10km/h above the limit in the following 12 months. Personality was also found to be associated with drivers' perceptions towards the potential deterrents. Finally, perceptions towards the potential deterrents were found to have a mediating influence on the relationship between personality and expectations to speed in the following twelve months.

Discussion and Conclusions

The three research studies reported on in this thesis advance the existing body of knowledge on deterrence and driver behaviour, specifically for the Victorian jurisdiction, which in turn may provide valuable understandings for other jurisdictions within Australia, and internationally. The results provide evidence to suggest that different groups of drivers respond in different ways to potential deterrents. Furthermore, the research shows that, despite legal sanctions, in particular infringements, being the primary response to illegal driving behaviours, embracing non-legal sanctions may be beneficial. A system that seeks to strike a balance between the advantages of legal and non-legal sanctions may see us achieve great success in responding to illegal driving behaviours.

Publications during enrolment

Journal Papers

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2020). Traffic offending and deterrence: An examination of recidivism amongst drivers in Victoria, Australia born prior to 1975. *PLoS ONE*, 15(10), e0239942.

<https://doi.org/10.1371/journal.pone.0239942>

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2020). Preventing road crashes: Do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia. *Transportation Research Part F: Traffic Psychology and Behaviour*, 69, 91-100.

<https://doi.org/10.1016/trf.2020.01.001>

Conference Presentations

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2018). *Relative deterrence of infringements for risky driving behaviours: does time to next infringement differ based on offence type?* [Conference Presentation]. Australian and New Zealand Society of Criminology Conference, December 4-7, Melbourne, Australia.

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2018). *Infringements and crash risk: do sanctions for traffic offences have a deterrent effect?* [Conference Presentation]. Law Enforcement and Public Health Conference, October 21-24, Toronto, Canada.

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2018). *Road Traffic Infringements and Crash Risk: Is there Evidence of a Detering Influence?* [Conference Presentation]. Australasian Road Safety Conference, October 3-5, Sydney, Australia.

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes two original papers published in peer reviewed journals. The core theme of the thesis is deterrence of illegal driving behaviour. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Monash University Accident Research Centre under the supervision of Associate Professor Janneke Berecki-Gisolf, Dr Karen Stephan and Associate Professor Stuart Newstead.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of chapters five and seven my contribution to the work involved the following:

Thesis Chapter	Publication Title	Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution*	Co-author(s), Monash student Y/N*
Five	Traffic Offending and Deterrence: An Examination of Recidivism Amongst Drivers in Victoria, Australia Born Prior to 1975	Published	70%. Concept, analysis of data and writing of manuscript	J. Berecki-Gisolf: input into manuscript 15% K. Stephan: input into manuscript 10% S. Newstead: input into manuscript 5%	No
Seven	Preventing Road Crashes: Do Infringements for Traffic Offences Have a Deterrence Effect Amongst Drivers Aged 40+? An Examination of Administrative Data from Victoria, Australia	Published	70%. Concept, analysis of data and writing of manuscript	J. Berecki-Gisolf: input into manuscript 15% K. Stephan: input into manuscript 10% S. Newstead: input into manuscript 5%	No

I have renumbered pages of the published papers in order to generate a consistent presentation within the thesis.

Student name: Hayley McDonald

Student signature:

Date: 21/12/2020

I hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor name: Janneke Berecki-Gisolf

Main Supervisor signature:

Date: 21/12/2020

Acknowledgements

There are many people who I need to thank for helping me along this PhD journey. All have played an important role for which I am grateful.

First, I would like to thank my supervisors – Associate Professor Janneke Berecki-Gisolf, Dr Karen Stephan and Associate Professor Stuart Newstead.

Janneke, I cannot thank you enough for the many hours you dedicated to helping me develop my data analysis skills in SAS. Your encouragement to keep on trying when I encountered problems with my coding or when my analysis wasn't going to plan is greatly appreciated. I am also very grateful for your constructive feedback on drafts and guidance on improving my papers and chapters. When I was feeling stuck with getting my ideas down on the page, you always had some thoughtful advice to help me out. Your positivity around my work always gave me the motivation to keep going.

Karen, thank you for your advice, particularly on statistical and analytical questions. You always had helpful advice on different approaches I could take. Thank you also for your feedback on drafts. Your comments always made me stop and think about what I had written and how I could improve my work.

Stuart, thank you for your helpful advice, particularly when I was stuck on study design issues. You always had great ideas and that helped ensure each study was defined and achievable. Thanks also for your feedback on thesis drafts. You were always encouraging, and offered me guidance to improve my work.

Second, thank you to my supervisors whom I began my PhD journey with – Associate Professor Michael Fitzharris and Dr Amanda Stephens. You both offered helpful suggestions in the early stages of my candidature, guiding me in making decisions about the research direction I wanted to pursue.

Michael, thank you also for enabling me to join MUARC prior to my PhD journey even commencing. I had never considered working in road safety research before, but you gave me the opportunity to discover this area, and I am very grateful for that. Thank you also for your encouragement for me to pursue a PhD back in my early days at MUARC.

Third, thank you to Tim Powers. I was fortunate to be introduced to you at a critical point in my candidature when I was struggling with data analysis challenges. You came on board and

made yourself available to guide me when I needed it most. You always offered helpful advice, constructive criticism, and importantly, encouragement when I was stuck with making decisions about what I really wanted my data analysis to achieve. I am very appreciative for all you gave to my research.

Fourth, thank you to my PhD colleagues whom I have shared offices with throughout my candidature. Jianrong Qiu, Revathi N. Krishna, Shaminka Mangelsdorf, Nimmi Candappa, Renée St. Louis and Angela Batson. I am very happy to have been able to share our PhD journeys together.

Renée, thank you in particular for the fun we had in 315. Swimming across to the chocolate (and tea) table when we needed to get away from our screens and talk about whatever we were thinking at the time always helped me stay motivated. I will miss our impromptu meetings.

Fifth, thank you to Sujanie Peiris. Your friendship since I first joined MUARC and during my PhD is much appreciated. You are always willing to help me out with anything and also offer advice and encouragement when I need it. Thank you also for our phone chats, particularly during lockdown this year. I am also very happy that we have been able to spend this final year of my candidature as PhD buddies!

Sixth, thank you to Voula Stathakis. I always enjoyed our chats in the office. I am also very appreciative of the time you often took to check in with me about how my research was going. It always gave me motivation to keep going.

Seventh, thank you to Professor Jennie Oxley and Samantha Bailey. Your help with all PhD related matters ensured my candidature ran as smoothly as possible. Thank you for always providing me with answers to any questions I had and pointing me in the right direction to where I might find any information I was after. Thank you also for the coffees and lunches. It was always lovely to get together with the MUARC PhD student cohort and have time away from research and writing and to enjoy each-other's company.

Eighth, thank you to my milestone panel members throughout my candidature – Professor Max Cameron, Dr Jason Thompson and Dr Angela Watson. You all offered helpful advice and feedback on my research, and importantly reminded me to have confidence in my work.

Finally, I want to thank my family. To my Mum and Dad, thank you for the support you have provided me with to be able to undertake this educational opportunity. Without you, I would not have been able to do so. To my sister Nicole, thank you for providing me with a welcome distraction as we chatted each night. The many photos of Stella were just what I needed after a long day of data analysis and writing.

This research was supported by a Commonwealth Government Research Training Program (RTP) Scholarship and a Monash University Accident Research Centre Foundation Scholarship. The data that were used for statistical analysis were provided by VicRoads. Without the support offered by each, this PhD research would not have been possible.

Table of Contents

CHAPTER ONE: INTRODUCTION	1
1.1 BACKGROUND	1
1.2 FACTORS CONTRIBUTING TO ROAD TRAUMA	2
1.3 AIMS OF THE THESIS AND STUDIES CONDUCTED	3
1.4 THESIS STRUCTURE	8
CHAPTER TWO: RISKY DRIVING BEHAVIOUR, INFRINGEMENTS AND CRASHES – WHAT CAN THE EXISTING RESEARCH TELL US?.....	11
2.1 INTRODUCTION	11
2.2 ILLEGAL DRIVING BEHAVIOUR AND CRASH RISK	11
2.3 SANCTIONING SYSTEM IN VICTORIA, AUSTRALIA THAT OPERATES TO DETER ILLEGAL DRIVING BEHAVIOURS	18
2.4 THE EFFECTIVENESS OF INFRINGEMENTS IN DETERRING SUBSEQUENT DRIVER OFFENDING AND PREVENTING CRASH INVOLVEMENT	22
2.5 WHERE ARE THE GAPS IN THE INFRINGEMENT AND SUBSEQUENT DRIVER BEHAVIOUR LITERATURE?	30
2.6 FACTORS BEYOND LEGAL SANCTIONS THAT MAY INFLUENCE THE PERFORMANCE OF ILLEGAL DRIVING BEHAVIOUR	32
2.7 PERSONALITY AND DRIVER BEHAVIOUR	55
2.8 COMBINING PERSPECTIVES TO LEARN MORE ABOUT DRIVER BEHAVIOUR AND DETERRENCE	60
2.9 WHERE ARE THE GAPS IN EXPANDED MODELS OF DETERRENCE AND PERSONALITY LITERATURE IN RELATION TO DRIVER BEHAVIOUR?	62
2.10 CONCLUSION.....	64
CHAPTER THREE: THEORETICAL FRAMEWORKS FOR THE THESIS	66
3.1 INTRODUCTION	66
3.2 SAFE SYSTEM APPROACH.....	66
3.3 THE HADDON MATRIX	70
3.4 DETERRENCE THEORY	72
3.5 CONCEPTUAL MODEL FOR THE RESEARCH.....	75
3.6 EXPANDED MODEL OF DETERRENCE	77
3.7 CONCLUSION.....	83
CHAPTER FOUR: THE USE OF ADMINISTRATIVE DATA IN ROAD SAFETY RESEARCH.....	84
4.1 WHAT IS ADMINISTRATIVE DATA?	84
4.2 VICROADS DATA	85
4.3 STRENGTHS AND LIMITATIONS OF USING ADMINISTRATIVE DATA SETS IN RESEARCH	86
4.4 CONCLUSION.....	94
CHAPTER FIVE: TRAFFIC OFFENDING AND DETERRENCE: AN EXAMINATION OF RECIDIVISM AMONGST DRIVERS IN VICTORIA, AUSTRALIA BORN PRIOR TO 1975	96
5.1 INTRODUCTION	96
CHAPTER SIX: REVIEW AND COMPARISON OF STUDY DESIGNS FOR INVESTIGATING THE ASSOCIATION BETWEEN INFRINGEMENTS AND CRASHES	121
6.1 INTRODUCTION	121
6.2 CASE-CONTROL STUDY DESIGN.....	122
6.3 CASE-CROSSOVER STUDY DESIGN.....	125
6.4 CASE-TIME-CONTROL STUDY DESIGN	130
6.5 CASE-CASE-TIME- CONTROL STUDY DESIGN	133
6.6 CONCLUSION.....	136

CHAPTER SEVEN: PREVENTING ROAD CRASHES: DO INFRINGEMENTS FOR TRAFFIC OFFENCES HAVE A DETERRENT EFFECT AMONGST DRIVERS AGED 40+? AN EXAMINATION OF ADMINISTRATIVE DATA FROM VICTORIA, AUSTRALIA	137
7.1 INTRODUCTION	137
CHAPTER EIGHT: RESEARCH DESIGN AND DATA COLLECTION METHODS FOR STUDY THREE	148
8.1 INTRODUCTION	148
8.2 AIMS OF STUDY THREE	148
8.3 DETAILS OF QUESTIONS USED TO COLLECT DATA FOR EACH CONSTRUCT IN THE CONCEPTUAL MODEL	150
8.4 METHOD OF DATA COLLECTION USED IN STUDY THREE AND RATIONALE FOR USING THIS METHOD	157
8.5 COLLECTION OF SURVEY DATA AND PROCESS OF PARTICIPANT SELECTION	161
8.6 CONCLUSION	163
CHAPTER NINE: EXAMINATION OF DRIVER CHARACTERISTICS, PERCEPTIONS AND EXPECTATIONS RELATING TO DRIVING BEHAVIOUR	164
9.1 INTRODUCTION	164
9.2 DEMOGRAPHIC CHARACTERISTICS	164
9.3 PERSONALITY PROFILE	168
9.4 PERCEPTIONS TOWARDS POTENTIAL DETERRENTS OF ILLEGAL DRIVING BEHAVIOUR	169
9.5 HISTORY OF ILLEGAL DRIVING BEHAVIOUR AND SANCTIONS RECEIVED	179
9.6 EXPECTATIONS OF ILLEGAL DRIVING BEHAVIOUR IN THE NEXT TWELVE MONTHS	180
9.7 EXPERIENCE OF CRASH INVOLVEMENT	183
9.8 VEHICLE LICENCE TYPES AND EXPERIENCE OF BEING UNLICENSED	183
9.9 ALCOHOL AND ILLICIT DRUG USE	185
9.10 CONCLUSION	188
CHAPTER TEN: EXAMINING THE MEDIATING INFLUENCE THAT PERCEPTIONS TOWARDS POTENTIAL DETERRENTS HAVE BETWEEN PERSONALITY AND DRIVER BEHAVIOUR.....	189
10.1 INTRODUCTION	189
10.2 RESEARCH AIMS AND QUESTIONS	189
10.3 METHODS.....	190
10.4 RESULTS	194
10.5 DISCUSSION AND CONCLUSIONS	216
CHAPTER ELEVEN: DISCUSSION AND CONCLUSIONS	226
11.1 FRAMEWORKS THAT GUIDED THE RESEARCH.....	226
11.2 BROAD AIMS OF THE RESEARCH.....	227
11.3 SUMMARY OF STUDIES UNDERTAKEN, KEY FINDINGS AND CONTRIBUTIONS TO ROAD SAFETY.....	228
11.4 HOW HAVE THE THREE STUDIES ADDRESSED THE THESIS THEORETICAL FRAMEWORK AND AIMS?	236
11.5 WHAT ARE THE POTENTIAL IMPLICATIONS OF THE RESULTS FROM THE THREE STUDIES?.....	238
11.6 STRENGTHS OF THE RESEARCH.....	246
11.7 LIMITATIONS OF THE RESEARCH	249
11.8 AREAS FOR FUTURE RESEARCH.....	254
11.9 CONCLUSIONS	257
REFERENCES	259
APPENDIX A: MONASH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (MUHREC) ETHICS APPROVAL CERTIFICATE FOR STUDIES ONE AND TWO	306
APPENDIX B: MONASH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (MUHREC) ETHICS APPROVAL CERTIFICATE FOR STUDY THREE	307
APPENDIX C: EXAMPLE OF INVITATION EMAIL SENT TO QUALTRICS PANEL MEMBERS INVITING THEM TO COMPLETE A SURVEY	308

APPENDIX D: EXPLANATORY STATEMENT INCLUDED IN SURVEY USED TO COLLECT DATA FOR STUDY THREE	309
APPENDIX E: SURVEY USED TO COLLECT DATA IN QUALTRICS FOR STUDY THREE	312
APPENDIX F: PERSONALITY TRAIT EACH ITEM IN THE BIG FIVE INVENTORY SEEKS TO MEASURE.....	338

List of Tables

TABLE 1.1 AIMS THAT EACH STUDY CONDUCTED AS PART OF THIS PHD SOUGHT TO ADDRESS	3
TABLE 2.1 PENALTIES FOR DIFFERENT LEVELS OF SPEEDING IN VICTORIA, AUSTRALIA	20
TABLE 2.2 DETAILS OF STUDIES THAT HAVE APPLIED EXPANDED MODELS OF DETERRENCE TO ROAD SAFETY ..	35
TABLE 9.1 AGE AND GENDER OF SURVEY PARTICIPANTS IN COMPARISON TO THE VICTORIAN LICENSED DRIVER POPULATION	166
TABLE 9.2 EMPLOYMENT STATUS OF SURVEY PARTICIPANTS	167
TABLE 9.3 HIGHEST LEVEL OF EDUCATION ACHIEVED AMONGST SURVEY PARTICIPANTS.....	168
TABLE 9.4 MEAN SCORES ON BIG-FIVE PERSONALITY INDICATORS.....	168
TABLE 9.5 PERCEPTIONS TOWARDS CERTAINTY OF LEGAL SANCTIONS FOR ILLEGAL DRIVING BEHAVIOURS AMONGST SURVEY PARTICIPANTS.....	171
TABLE 9.6 PERCEPTIONS TOWARDS SEVERITY OF LEGAL SANCTIONS FOR ILLEGAL DRIVING BEHAVIOURS AMONGST SURVEY PARTICIPANTS.....	172
TABLE 9.7 PERCEPTIONS ON THE DEGREE TO WHICH SURVEY PARTICIPANTS BELIEVE THEY WOULD EXPERIENCE WORRY ABOUT BEING INVOLVED IN A CRASH IF THEY WERE TO PERFORM AN ILLEGAL DRIVING BEHAVIOUR	173
TABLE 9.8 PERCEPTIONS ON THE DEGREE TO WHICH SURVEY PARTICIPANTS BELIEVE THEY WOULD EXPERIENCE WORRY ABOUT INJURING THEMSELVES OR SOMEONE ELSE IF THEY WERE TO PERFORM AN ILLEGAL DRIVING BEHAVIOUR	174
TABLE 9.9 DEGREE TO WHICH SURVEY PARTICIPANTS PERCEIVE ILLEGAL DRIVING BEHAVIOURS AS WRONG.	177
TABLE 9.10 PERCEPTIONS OF HOW SURVEY PARTICIPANTS BELIEVE THOSE WHO MEAN THE MOST TO THEM WOULD RESPOND IF THEY WERE TO PERFORM AN ILLEGAL DRIVING BEHAVIOUR	177
TABLE 9.11 PERCEPTIONS ON THE DEGREE TO WHICH SURVEY PARTICIPANTS BELIEVE THEY WOULD EXPERIENCE SHAME IF THEY WERE TO PERFORM AN ILLEGAL DRIVING BEHAVIOUR	178
TABLE 9.12 PERCEPTIONS ON THE DEGREE TO WHICH SURVEY PARTICIPANTS BELIEVE THEY WOULD EXPERIENCE GUILT IF THEY WERE TO PERFORM AN ILLEGAL DRIVING BEHAVIOUR	178
TABLE 9.13 SURVEY PARTICIPANTS PERFORMANCE OF ILLEGAL DRIVING BEHAVIOURS IN THE LAST 12 MONTHS	181
TABLE 9.14 SURVEY PARTICIPANTS EXPERIENCE OF BEING APPREHENDED (BY POLICE OR A ROAD SAFETY CAMERA) FOR ILLEGAL DRIVING BEHAVIOURS IN THE LAST 12 MONTHS.....	181
TABLE 9.15 SURVEY PARTICIPANTS EXPECTATIONS OF PERFORMING ILLEGAL DRIVING BEHAVIOURS IN THE FOLLOWING 12 MONTHS	182
TABLE 9.16 SEVERITY OF CRASHES THAT SURVEY PARTICIPANTS HAD BEEN INVOLVED IN WHILST DRIVING IN THE LAST 3 YEARS.....	184
TABLE 9.17 FAULT AMONGST SURVEY PARTICIPANTS INVOLVED IN CRASHES IN THE LAST 3 YEARS.....	184
TABLE 9.18 VEHICLE TYPES SURVEY PARTICIPANTS REPORTED BEING LICENSED TO OPERATE	184
TABLE 9.19 SURVEY PARTICIPANTS EXPERIENCE OF LICENCE LOSS IN THE LAST 12 MONTHS	184
TABLE 9.20 SURVEY PARTICIPANTS REGULARITY OF ALCOHOL CONSUMPTION	185
TABLE 9.21 SURVEY PARTICIPANTS RISK LEVEL FOR ALCOHOL CONSUMPTION BASED ON AUDIT SCORE	186
TABLE 9.22 SURVEY PARTICIPANTS ILLICIT DRUG USAGE BY DRUG TYPE	187
TABLE 9.23 SURVEY PARTICIPANTS REGULARITY OF DRUG USAGE BY DRUG TYPE	187
TABLE 10.1 PERSONALITY, PERCEPTIONS AND BEHAVIOURAL EXPECTATIONS DESCRIPTIVE STATISTICS	195
TABLE 10.2 CORRELATIONS BETWEEN PERSONALITY TRAITS, PERCEPTIONS OF ENFORCEMENT, CRASH RISK, SOCIAL NORMS AND DISAPPROVAL, NEGATIVE PERSONAL/EMOTIONAL EFFECT AND BEHAVIOURAL EXPECTATIONS FOR DRIVING AT UP TO 10KM/H ABOVE THE SPEED LIMIT.....	198
TABLE 10.3 DIRECT, INDIRECT AND TOTAL EFFECTS FOR THE RELATIONSHIP BETWEEN THE PERSONALITY AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS, MEDIATED BY PERCEPTIONS OF ENFORCEMENT.....	201
TABLE 10.4 DIRECT, INDIRECT AND TOTAL EFFECTS FOR THE RELATIONSHIP BETWEEN THE PERSONALITY AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS, MEDIATED BY PERCEPTIONS OF CRASH RISK.....	205

TABLE 10.5 DIRECT, INDIRECT AND TOTAL EFFECTS FOR THE RELATIONSHIP BETWEEN THE PERSONALITY AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS, MEDIATED BY PERCEPTIONS OF SOCIAL NORMS AND DISAPPROVAL.....	209
TABLE 10.6 DIRECT, INDIRECT AND TOTAL EFFECTS FOR THE RELATIONSHIP BETWEEN THE PERSONALITY AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS, MEDIATED BY PERCEPTIONS OF NEGATIVE PERSONAL/EMOTIONAL AFFECT	213

List of Figures

FIGURE 3.1 IMAGE OF HADDON'S MATRIX	71
FIGURE 3.2 CONCEPTUAL MODEL SHOWING RELATIONSHIPS BETWEEN ILLEGAL DRIVING BEHAVIOUR, INFRINGEMENTS, DETERRENCE AND CRASHES	76
FIGURE 3.3 CONCEPTUAL MODEL FOR EXAMINATION IN STUDY THREE SHOWING PATHWAYS THAT MAY EXIST BETWEEN PERSONALITY, PERCEPTIONS OF POTENTIAL DETERRENTS AND BEHAVIOURAL EXPECTATIONS	79
FIGURE 8.1 CONCEPTUAL MODEL FOR EXAMINATION IN STUDY THREE SHOWING PATHWAYS THAT MAY EXIST BETWEEN PERSONALITY, PERCEPTIONS OF POTENTIAL DETERRENTS AND BEHAVIOURAL EXPECTATIONS	149
FIGURE 10.1 DIAGRAM SHOWING HOW MEDIATION WAS CONSIDERED AND EACH OF THE PATHWAYS THAT WERE EXAMINED.....	193
FIGURE 10.2 MEDIATING INFLUENCE OF PERCEPTIONS OF ENFORCEMENT BETWEEN EXTRAVERSION AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	201
FIGURE 10.3 MEDIATING INFLUENCE OF PERCEPTIONS OF ENFORCEMENT BETWEEN AGREEABLENESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	202
FIGURE 10.4 MEDIATING INFLUENCE OF PERCEPTIONS OF ENFORCEMENT BETWEEN CONSCIENTIOUSNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	202
FIGURE 10.5 MEDIATING INFLUENCE OF PERCEPTIONS OF ENFORCEMENT BETWEEN NEUROTICISM AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	203
FIGURE 10.6 MEDIATING INFLUENCE OF PERCEPTIONS OF ENFORCEMENT BETWEEN OPENNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	203
FIGURE 10.7 MEDIATING INFLUENCE OF PERCEPTIONS OF CRASH RISK BETWEEN EXTRAVERSION AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	205
FIGURE 10.8 MEDIATING INFLUENCE OF PERCEPTIONS OF CRASH RISK BETWEEN AGREEABLENESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	206
FIGURE 10.9 MEDIATING INFLUENCE OF PERCEPTIONS OF CRASH RISK BETWEEN CONSCIENTIOUSNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	206
FIGURE 10.10 MEDIATING INFLUENCE OF PERCEPTIONS OF CRASH RISK BETWEEN NEUROTICISM AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	207
FIGURE 10.11 MEDIATING INFLUENCE OF PERCEPTIONS OF CRASH RISK BETWEEN OPENNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	207
FIGURE 10.12 MEDIATING INFLUENCE OF PERCEPTIONS OF SOCIAL NORMS AND DISAPPROVAL BETWEEN EXTRAVERSION AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	209
FIGURE 10.13 MEDIATING INFLUENCE OF PERCEPTIONS OF SOCIAL NORMS AND DISAPPROVAL BETWEEN AGREEABLENESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	210
FIGURE 10.14 MEDIATING INFLUENCE OF PERCEPTIONS OF SOCIAL NORMS AND DISAPPROVAL BETWEEN CONSCIENTIOUSNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	210

FIGURE 10.15 MEDIATING INFLUENCE OF PERCEPTIONS OF SOCIAL NORMS AND DISAPPROVAL BETWEEN NEUROTICISM AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	211
FIGURE 10.16 MEDIATING INFLUENCE OF PERCEPTIONS OF SOCIAL NORMS AND DISAPPROVAL BETWEEN OPENNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	211
FIGURE 10.17 MEDIATING INFLUENCE OF PERCEPTIONS OF PERSONAL/EMOTIONAL AFFECT BETWEEN EXTRAVERSION AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	213
FIGURE 10.18 MEDIATING INFLUENCE OF PERCEPTIONS OF PERSONAL/EMOTIONAL AFFECT BETWEEN AGREEABLENESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	214
FIGURE 10.19 MEDIATING INFLUENCE OF PERCEPTIONS OF PERSONAL/EMOTIONAL AFFECT BETWEEN CONSCIENTIOUSNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	214
FIGURE 10.20 MEDIATING INFLUENCE OF PERCEPTIONS OF PERSONAL/EMOTIONAL AFFECT BETWEEN NEUROTICISM AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	215
FIGURE 10.21 MEDIATING INFLUENCE OF PERCEPTIONS OF PERSONAL/EMOTIONAL AFFECT BETWEEN OPENNESS AND EXPECTATIONS TO DRIVE AT UP TO 10KM/H ABOVE THE SPEED LIMIT IN THE FOLLOWING 12 MONTHS	215

Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
AUDIT	Alcohol Use Disorders Identification Test
BAC	Blood Alcohol Concentration
BFI	Big Five Inventory
BITRE	Bureau of Infrastructure, Transport and Regional Economics
DLS	Driver Licensing System
DBQ	Driver Behaviour Questionnaire
MBS	Medicare Benefits Schedule
MUHREC	Monash University Human Research Ethics Committee
NDSHS	National Drug Strategy Household Survey
PBS	Pharmaceutical Benefits Scheme
RCIS	Road Crash Information System
TAC	Transport Accident Commission
TIN	Traffic Infringement Notice
WHO	World Health Organization

Key Definitions

Demerit Point: points which accumulate on a driver's licence each time they are sanctioned for a driving offence. A high number of points can lead to licence loss.

Fine: a monetary sanction that a driver must pay if they were found to have driven illegally.

Illegal driving behaviour/risky driving behaviour/aberrant driving behaviour: used as alternative terms in this thesis to indicate a behaviour which violates traffic rules.

Performance of illegal driving behaviour: the act of driving in a manner that violates traffic rules.

Traffic Infringement Notice: specifies the details of a traffic offence. This includes the offence type, when it was committed and what the associated penalty is in terms of fine amount and demerit points.

Traffic Infringement: the term used throughout this thesis to indicate a driver has received a traffic infringement notice (as defined above). This term is used in the thesis to refer specifically to the associated punishment (i.e. fine and demerit points) rather than the actual notice itself.

Chapter One: Introduction

1.1 Background

Worldwide, the most common form of transportation is by road. Whilst the opportunities for connectedness and mobility that road transportation provides is undeniably of great benefit to society, its use comes at a significant cost, by contributing substantially to the occurrence of injuries and fatalities (Bureau of Infrastructure, Transport and Regional Economics, 2014). Road trauma is a significant public health issue that affects countries all over the globe (Peden et al., 2004; World Health Organization, 2015). Worldwide, around 1.35 million people die annually as a result of trauma sustained in road transport crashes (World Health Organization, 2020). Many more people sustain serious and life-changing injuries, the exact number of which is unknown, given many go unreported in official statistics (Peden et al., 2004; World Health Organization, 2013). Accordingly, it is difficult to place a definitive measure on the degree to which road trauma impacts society globally. This difficulty in measuring the impact of road trauma is compounded by the fact that we cannot fully measure the pain and suffering that is experienced in the period that follows a road crash (Hendrie & Miller, 2012; Risbey, Cregan & De Silva, 2010). Beyond the personal impacts that road trauma has on the lives of people involved, as well as on their families, friends and social networks, road trauma also comes at a great financial cost to the community. In Australia, estimates suggest that the annual cost of road trauma is 30 billion dollars (Economic Connections, 2017).

In 2019, 1195 deaths occurred on Australian roads (Bureau of Infrastructure, Transport and Regional Economics, 2020). Whilst the deaths that resulted from road trauma in 2019 represented an encouraging decrease of 16.3 per cent on the baseline number of deaths in Australia's current National Road Strategy 2011-2020, this is well below the strategy target of 30 per cent (Bureau of Infrastructure, Transport and Regional Economics, 2020). Road trauma thus remains a significant public health concern. Further efforts are essential to ensure that progress is made towards reducing the number of people who lose their lives on Australian roads.

1.2 Factors contributing to road trauma

Incidence of road trauma can have a multitude of contributing factors. These factors include road and road side design and condition (e.g. Holdridge, Shankar & Ulfarsson, 2005; Stanton & Salmon, 2009; Stigson, Krafft & Tingvall, 2008; Zein & Navin, 2003), vehicle design and condition (e.g. Bedard et al., 2002; Blows, Ivers, Connor., et al., 2003; Blows, Ivers, Woodward., et al., 2003; Bureau of Infrastructure, Transport and Regional Economics, 2011; Stanton & Salmon, 2009; Zein & Navin, 2003), environmental factors (e.g. Stanton & Salmon, 2009; Zein & Navin, 2003) and human error (e.g. Bureau of Infrastructure, Transport and Regional Economics, 2011; Salmon, Regan & Johnston, 2005; Stanton & Salmon, 2009; Wierwille et al., 2002; Zein & Navin, 2003). Stressful life events can also be grouped in with human error. Indeed, factors such as employment stress, relationship stress, and financial stress have all be identified as factors associated with unfavourable outcomes on the road (e.g. Carty, Stough & Gillespie, 1998; Cunningham & Regan, 2016; Kposowa & Breault, 2009; Lagarde et al. 2004; Legree et al., 2003; McMurray, 1970; Norris et al., 2000). Each of the factors contributing to road trauma require a set of countermeasures to be developed and evaluated, in efforts to reduce the road toll.

The performance of illegal driving behaviours has also been associated with an increased risk of road crashes (e.g. Blows, Ameratunga et al., 2005; Penmetsa & Pulugurtha, 2016). In efforts to address the risks that illegal driving behaviours pose, and to encourage compliance, drivers who are found to have performed illegal behaviours can expect to receive a legal sanction. In Victoria, Australia, like many other jurisdictions in Australia and internationally, the most common legal sanction drivers can expect to receive is an infringement (also termed a Traffic Infringement Notice – TIN). This most commonly requires payment of a monetary fine, and in some cases may also see demerit points placed on the driver's licence. Research that examines the effectiveness of sanctions for traffic offences in improving compliance and subsequently road trauma is essential. Such research has the potential to help identify areas and opportunities for change, and importantly, lead to progress in reducing the number of people that are seriously or fatally injured as a result of road crashes.

1.3 Aims of the thesis and studies conducted

Given the established contribution that human behaviour, including the performance of illegal driving behaviours, has on the incidence of road trauma, the overarching aim of this PhD research was to understand factors that may see drivers deterred, or alternatively, undeterred from the performance of illegal driving behaviours. A review of the literature, which is presented in chapter two, revealed a number of gaps in understandings of deterrence and the performance of illegal driving behaviours. Whilst chapter two provides details of these knowledge gaps, three broad thesis aims emerged to address these gaps:

- 1) To assess whether receiving an infringement for a driving offence has the desired effect of deterrence
- 2) To assess whether drivers' perceptions in relation to illegal driving behaviour have a deterring influence
- 3) To determine whether potential deterring factors differ depending on driver characteristics

In order to address the three overarching aims, three distinct, but closely interrelated studies were conducted:

- Study One – The deterring influence of traffic infringements upon future driver behaviour, as evidenced by subsequent traffic infringements
- Study Two – The deterring influence of traffic infringements upon future driver behaviour, as evidenced by subsequent crash involvement
- Study Three – The influence of personal characteristics and perceptions towards possible deterrents, upon self-reported expectations of future traffic offending

The three studies correspond with various aspects of the three aims. Each study addresses more than one aim, and aims one and three were addressed in more than one study. Table 1.1 provides an overview of which aim/s were addressed in each study.

Table 1.1 Aims that each study conducted as part of this PhD sought to address

	Study One	Study Two	Study Three
Aim One	✓	✓	
Aim Two			✓
Aim Three	✓	✓	✓

Studies one and two used administrative data, to understand patterns of deterrence and offending, whilst study three delved deeper, to examine a broader range of factors that may achieve deterrence, using self-report survey data collected from drivers. The mix of administrative and self-report data enabled gaps in the existing research to be filled, using the most appropriate data. All three studies used data collected in the Australian state of Victoria. Thus, the results that are reported throughout this thesis have particular relevance and significance to the jurisdiction of Victoria. Indeed, the results contained in this thesis seek to enhance the knowledge base on best practices in achieving deterrence from illegal driving behaviours, specifically for Victoria.

The Victorian road network spans some 150,000 kilometres of roads that are used by general traffic, with an additional 50,000 kilometres of roads and tracks that are located in parks and forests across the state (VicRoads, 2020a). The types of roads in Victoria vary widely. These include busy central business district roads, inner city laneways, roads shared with trams, suburban roads, residential streets, highways, freeways, tollways, roads that pass-through tunnels, roads in regional centres, as well as unsealed rural roads.

Victoria is the second most populous state in Australia, with over 6.5 million residents. This equates to over one quarter of Australia's total population of approximately 25.5 million (Australian Bureau of Statistics, 2020a). Consequently, it is important to note that whilst all data sources used came from Victoria, the very sizable population of the state, and the substantial proportion of Australia's total population it represents, means that the findings of the research are likely be generalisable to other jurisdictions.

It should be noted that whilst traffic laws are relatively uniform across Australia's eight states and territories, penalties and enforcement do vary. This should therefore be kept in mind when interpreting the results. Reference to this point is made throughout the thesis, in particular when discussing the significance of the results for policy and practice. Each of the three studies conducted as part of this PhD research are detailed in the sections that follow.

1.3.1 Study One – The deterring influence of traffic infringements upon future driver behaviour, as evidenced by subsequent traffic infringements

In study one, VicRoads (VicRoads, 2020b) licensing and infringements data were used to examine whether infringements for driving offences have the desired effect of deterrence, as evidenced by a reduction in subsequent driver offending behaviours in the twelve months that followed a driver receiving a traffic infringement. The study examined the entire licence history of drivers, using a time-to-event analysis, to determine the length of time between infringements, and whether this time changed based on offence type and number of previous offences. The study sought to answer two key research questions:

- 1) Do driver and offence characteristics, including gender, age at first licence, years licensed, licence type, demerit points and offence type have a relationship with the length of time to next offence within twelve months?
- 2) Is time to next offence within twelve months associated with the number of previous offences a driver has?

Study one has value in enhancing understandings of the effectiveness and limitations of the current enforcement system in Victoria; in particular, to what extent the system is successful in deterring the performance of further risky and illegal driving behaviours after a driver has been sanctioned.

The results of study one are presented in a research manuscript – *Traffic offending and deterrence: an examination of recidivism amongst drivers in Victoria, Australia born prior to 1975*. This paper has been published in the academic journal, PLOS One.

1.3.2 Study Two – The deterring influence of traffic infringements upon future driver behaviour, as evidenced by crash involvement

In study two, VicRoads (VicRoads, 2020b) licensing, infringements and crash data were used to examine whether infringements for driving offences have the desired effect of deterrence in changing driver behaviour, through looking at risk of crash involvement in the period that follows. This study applied an innovative research design, the case-case-time-control study design, which is an extension of the case-crossover design previously applied to examine the traffic infringement and crash relationship. Therefore, in addition to examining the deterring influence of infringements upon subsequent crash involvement in

Victoria, the study was also able to demonstrate the use of a study design not previously used in this area. The study sought to answer two key research questions:

- 1) Is there an association between receiving an infringement for a driving offence and subsequent crash involvement?
- 2) Are driver and offence characteristics associated with subsequent patterns of crash involvement in the period following an infringement for a driving offence being received?

Study two also has value in enhancing understandings of the effectiveness and limitations of the current enforcement system in Victoria; in particular, to what extent the system is successful in changing driver behaviour, such that the risk of being involved in a road crash is reduced.

The results of study two are presented in a research manuscript – *Preventing road crashes: do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia*. This paper has been published in the academic journal *Transportation Research Part F: Traffic Psychology and Behaviour*.

1.3.3 Study Three – The influence of personal characteristics and perceptions towards possible deterrents, upon self-reported traffic offending

In study three, an online survey was administered to a sample of 5,108 Victorian drivers, to investigate a range of factors, both legal and non-legal in nature, that may deter illegal driving behaviour. The survey was designed to examine pathways in a conceptual model that was developed as part of this PhD research program, based upon the existing body of literature.

Specifically, the developed model guided the study in examining whether perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval and perceptions of negative personal and emotional affect have a mediating influence on the relationship between the Big Five Model of personality (e.g. John, Donahue & Kentle, 1991; John, Naumann & Soto, 2008; John and Srivastava, 1999) and expectations of illegal driving behaviour.

The developed model also guided the study in examining a number of direct pathways. These pathways were between personality and expectations of illegal driving behaviour; personality and perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval and perceptions of negative personal and emotional affect; and perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval, perceptions of negative personal and emotional affect and expectations of illegal driving behaviour. In testing the developed conceptual model, the study addressed four key research questions:

- 1) Does personality have an influence on expectations to drive at up to 10km/h above the speed limit in the following twelve months?
- 2) Does personality have an influence on perceptions towards potential deterrents in relation to driving at up to 10km/h above the speed limit in the following twelve months?
- 3) Are there factors beyond legal sanctions that may influence expectations to drive at up to 10km/h above the speed limit in the following twelve months?
- 4) Do perceptions towards potential deterrents have a mediating influence on the relationship between personality and expectations to drive at up to 10km/h above the speed limit in the following twelve months?

Study three has value in enhancing understandings of factors beyond the traditionally used legal sanctions that are administered to drivers to respond to illegal behaviour on the roads. By including the Big Five Model of personality, alongside perceptions of non-legal sanctions (crash risk, social norms and disapproval and negative personal and emotional affect), the results may have value in highlighting the varying factors that potentially underlie illegal driving behaviour, and the limitations of the current enforcement system in achieving deterrence.

The results of study three are presented in two thesis chapters. The first of these chapters provides descriptive results of the key variables for which data were collected in the survey that was designed for this study. The second of these chapters provides the results of a mediated regression analysis, that was used to examine the pathways in the conceptual model developed for this study.

1.4 Thesis structure

This chapter has sought to provide broad background information and outline the research that follows in this thesis. The thesis contains eleven chapters in total, including this introductory chapter. Details of the remaining ten chapters, each of which fit within the three overarching aims of this thesis are outlined below.

Chapter Two: Risky driving behaviour, infringements and crashes – what can the existing research tell us? Is a literature review of studies that have considered the risks that illegal driving behaviours pose in relation to crash involvement; background information on the sanctioning system that operates in Victoria, Australia; an examination of existing research that has explored the effectiveness of sanctions for illegal driving behaviour; and finally literature that has explored other factors that may influence driving behaviour. The aim of this chapter was to first highlight the contribution that illegal driving behaviours have on the road trauma problem, and secondly, to evaluate existing research that has explored deterrence of illegal driving behaviour. In doing so, gaps in the existing knowledge were identified, creating a space for the current research to contribute to knowledge.

Chapter Three: Theoretical frameworks for the thesis presents the theoretical frameworks and conceptual models that guided research in this thesis – specifically, the Safe System Approach, Haddon's Matrix and deterrence theory. Each of these frameworks and theories complement each other, and provide a comprehensive framework to underpin the thesis. Links between these theoretical frameworks and the current research are discussed.

Chapter Four: The use of administrative data in road safety research is the first methodological chapter for the thesis. This chapter provides an introduction to the use of administrative data in research, including its strengths and limitations. The aim of the chapter is to provide a rationale for using the licensing, infringements and crash data sets to address the aims and answer the research questions for studies one and two.

Chapter Five: Traffic offending and deterrence: an examination of recidivism amongst drivers in Victoria, Australia born prior to 1975 is the first peer reviewed journal paper emerging from the PhD research program and presents the results of study one. In this paper, the factors associated with recidivism within twelve months of receiving an infringement for a traffic offence in Victoria are examined.

Chapter Six: Review and comparison of study designs for investigating the association between infringements and crashes is the second chapter describing the research methods used in the thesis. This chapter provides an overview of study designs that were potentially suitable in addressing the research questions in study two, including strengths and limitations of each. The chapter also explains how each study design could have been applied to answer the research questions, before finally providing a rationale for the choice of the study design ultimately used in study two.

Chapter Seven: Preventing road crashes: Do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia is the second peer reviewed journal paper emerging from the PhD research program, and presents the results of study two. In this paper, the results of a case-case-time-control study, which examined the relationship between receiving an infringement and being involved in a crash, are reported.

Chapter Eight: Research design and data collection methods for study three is the final chapter describing research methods used in the thesis. This chapter provides information relevant to study three of this PhD, which examines the influence of personal characteristics and perceptions towards possible deterrents, upon self-reported expectations of traffic offending. Three main areas are considered in this chapter:

- 1) a description of the measures used to collect data for each construct in the conceptual model
- 2) methods of data collection to examine the pathways in the conceptual model are considered, providing a rationale for the method used
- 3) information on the selection criteria that were used to assess eligibility to complete the survey

Chapter Nine: Examination of driver characteristics, perceptions and expectations relating to driving behaviour is the first of two chapters that report on the results of study three. This chapter describes the profile of the study sample and the responses that were provided on a range of key variables collected in the survey.

Chapter Ten: Examining the mediating influence that perceptions towards potential deterrents have on the relationship between personality and driver behaviour is the

second chapter to report on the results of study three. This chapter presents the results of a mediated regression analysis, that was used to examine the pathways defined in the conceptual model.

Chapter Eleven: Discussion and conclusions provides an overview of each of the three studies in the thesis, including the aims and research questions addressed, the key findings and how these findings relate to the existing research. The chapter then considers the research from a broader perspective, including its strengths and limitations, areas for future research and a discussion of the contribution that the research has the potential to make in enhancing road safety.

References are provided at the end of the thesis, along with six appendices. Details of the appendices are as follows:

Appendix A: ethics approval certificate received from the Monash University Human Research Ethics Committee (MUHREC) to conduct studies one and two.

Appendix B: ethics approval certificate that was received from the MUHREC to conduct study three.

Appendix C: example email invitation letter for study three.

Appendix D: explanatory statement for study three.

Appendix E: the survey that was used to collect the data in study three.

Appendix F: the scale that was used to collect the personality data, showing the personality trait that each item in the scale relates to.

Finally, it is important to note that given chapters five and seven are published journal papers, there is some overlap in the contents that is contained in other parts of the thesis. This was necessary, given the need for these papers to be able to stand alone from the thesis in the respective journal in which they are published.

Chapter Two: Risky driving behaviour, infringements and crashes – what can the existing research tell us?

2.1 Introduction

Chapter one identified a number of factors that contribute to crashes and subsequently trauma that occurs on the roads. One of these factors is the performance of risky and illegal driving behaviours. There is a substantial body of research that has examined the rate at which various illegal driving behaviours contribute to crashes occurring. To address the contribution risky and illegal driving behaviours have in road trauma, legal countermeasures are in place. These legal countermeasures seek to deter drivers from any initial performance of illegal driving behaviour (general deterrence), and when drivers do perform the behaviours, to deter them from further illegal driving behaviour (specific deterrence). Research has sought to examine the effectiveness of these sanctions.

This chapter has three broad aims: 1) establish the significance of illegal driving behaviour in relation to crashes, and therefore the importance of continued research on methods of deterring illegal driving behaviours; 2) provide a brief overview of the sanctioning system for traffic offences in Victoria, Australia; and 3) review the research into deterrence of illegal driving behaviour, identify gaps in this research, and provide a rationale for the research in this thesis, and in so doing, ensure it is able to contribute to the body of knowledge in the field.

2.2 Illegal driving behaviour and crash risk

There is an extensive body of literature that has explored the causes of road transport crashes. One area that has received a substantial level of attention is the relationship between illegal driving behaviour and crash risk. The following section seeks to highlight some of the road safety research that has specifically investigated this relationship. The overwhelming number of studies that have been conducted in this area means an exhaustive review of all the literature is not possible in this thesis. Furthermore, many of the papers are not relevant to this thesis, given the focus is on factors that may deter the performance of such behaviours, rather than the actual relationship between illegal driving behaviour and crashes. By examining the link between illegal driving behaviour and crash risk, the aim is to highlight the importance of further research into the effective deterrence

of illegal driving behaviour. Five illegal driving behaviours are covered: driving with a Blood Alcohol Concentration (BAC) level above the legal limit; driving after using an illicit drug/s; exceeding the speed limit; driving whilst using a mobile phone; and failing to stop at a red light. Of course, there are many other illegal driving behaviours that drivers may perform on the roads. These five were selected as they are amongst some of the most easily recognisable illegal driving behaviours. Additionally, the literature highlights, as evidenced below, that these offences make a significant contribution to the incidence of road trauma. Of course, there are many other offences that can be performed on the roads. These include driving without a seatbelt or driving an unregistered vehicle. These offences however do not in themselves increase the risk of crash, so are not of interest in considering the illegal driving behaviour and crash relationship. Similarly, there are offences such as unlicensed driving, that, whilst associated with high rates of crash involvement, when these relationships are examined, it emerges that there are other behaviours contributing to this relationship, such as driving with an illegal BAC and speeding (e.g. Sagberg, 2018). The decision was therefore made not to consider the offence of unlicensed driving independently.

2.2.1 Driving with a BAC above the legal limit

Of all the different offence types that have been examined in relation to crash risk, driving with an illegal BAC has received the greatest level of attention. A search of the literature reveals thousands of studies that have examined the relationship between alcohol consumption, driving and crash involvement. Indeed, the research in this area is further increased due to the complexity of the relationship between BAC level and driver behaviour. It is not simply the consumption of alcohol and subsequent risk of crash that these studies have examined, but also the level of alcohol consumption, the resulting BAC level and subsequent risk of crash. The World Health Organization (2014) has demonstrated that whilst the contribution that alcohol consumption has upon the incidence of fatal crashes varies between countries, one pattern is consistent – drinking alcohol and driving is a significant risk factor for the occurrence of crashes. Data from Victoria, Australia show that in 2015, 17 per cent of drivers and motorcyclists killed on the roads had a BAC greater than the legal limit of 0.05g/100ml (Transport Accident Commission, 2017). Whilst this is a substantial decline from the 38 per cent seen in Victoria in 1987 (Transport Accident

Commission, 2017), it nonetheless points to a (modifiable) factor that continues to be associated with the occurrence of serious road accidents.

To quantify the varying level of risk between different BAC levels, an in-depth case-control study conducted in two states in the USA by Blomberg et al. (2005) collected data from drivers involved in 2,871 crashes. Data were also collected from two control drivers for each crash. A statistically significant increase in crash risk was identified at BAC levels of 0.04 and above, while a substantial increase in crash risk was identified in BAC levels of 0.10 and above (Blomberg et al., 2005). As BAC levels increase, so does the level of associated impairment (Moskowitz & Fiorentino, 2000; Lacey et al., 2016).

Several other studies have also highlighted the road safety threat that drink driving poses (e.g. Borkenstein et al., 1974; Dingus et al., 2016; Keall, Frith & Patterson, 2005; Peck et al., 2008; Voas et al., 2012). Moskowitz and Fiorentino (2000) conducted an extensive review of the literature, identifying the many effects that alcohol consumption can have on driving ability. These include a reduction in the ability to give attention to more than one task, reduced vigilance, decreased ability to control and maintain position on the road, lowered perceptive ability, which includes the ability to process and interpret information in an individual's immediate environment, poorer visual and cognitive function, psychomotor skills and reaction times (Moskowitz and Fiorentino, 2000). These are all skills that are integral to operate a motor vehicle safely on the road. Taken together, the evidence is clear that drink driving poses a significant risk to road safety and is a behaviour which requires continued efforts to address its performance.

2.2.2 Driving after using an illicit drug

Drug driving is another illegal driving behaviour which is complex to address, given there are many different types of illicit drugs, with each potentially influencing driving behaviour in different ways. Data from Victoria, Australia show that across a five-year period, 41 per cent of drivers and motorcyclists who were killed in road accidents and who were tested for illicit drugs were found to have drugs present in their system (Transport Accident Commission, 2020a). The most common illicit drug detected was cannabis, which was found in 18 per cent of drivers and motorcyclists killed in 2015 on Victorian roads (Transport Accident Commission, 2020a). In an earlier study of injured Victorian drivers, 35 per cent tested

positive to illicit drugs, and, once again, cannabis was the most common drug type detected (Drummer et al., 2012). Other studies conducted in Australia have also found concerning high levels of illicit drug use in drivers who have been involved in road crashes, involving both injuries and fatalities (e.g. Ch'ng et al., 2007; Darke et al., 2004; Drummer et al., 2003; Sugrue et al., 1995; Tutt et al., 2001).

Other research has sought to examine the level of risk that use of illicit drugs poses for crash involvement. For example, Li, Brady & Chen (2013) used a case-control study design, including fatal crash and non-fatal crash involved drivers. The odds of fatal crash involvement were significantly higher for drivers using drugs (1.83 for marijuana, 3.03 for narcotics and 3.57 for stimulants), indicating that use of drugs presents an increased risk of being involved in a crash with the most serious of outcomes – a fatality (Li, Brady & Chen, 2013). Similarly, a study undertaken by Ashbridge, Brubacher and Chan (2005) examined young drivers and found that the risk of crash was almost double amongst cannabis using drivers compared to those not using cannabis.

The Driving Under the Influence of Drugs, Alcohol and Medicines (DRUID) study also provided evidence of the association between illicit drug use and crashes. In this comprehensive study of European drivers, using a case-control design, Schulze et al. (2012) found odds ratios ranging from 2 through to 7, indicating illicit drug use may pose a significant crash risk. Results consistent with those noted above, namely an increased risk of crash associated with illicit drug use have been identified in multiple studies (e.g. Ashbridge, Poulin & Donato, 2005; Ashbridge et al., 2014; Drummer et al., 2004; Dubois et al., 2015; Hels., 2013; Kuypers et al., 2012; Van Elslande., 2012). It is important to note that these studies are all based on observational research, and thus only establish a correlation between the use of illicit drugs and crash involvement. Despite this, the high levels of drug use associated with road crashes once again highlights this is an area where continued research to deter its performance would be of great value.

2.2.3 Driving above the speed limit

Speed is strongly related to crash risk (e.g. Aarts & van Schagen, 2006; De Pauw et al., 2014; Doecke & Kloeden, 2014; Kloeden et al., 2001; Kloeden et al., 2002; Lam, 2003; Mooren, Grzebieta & Job, 2014; Simons-Morton, 2017). Furthermore, like drink driving and illicit drug

driving, exceeding the speed limit is another driving behaviour for which the relationship to crash risk is quite complex. Levels of speeding vary significantly. A driver may exceed the speed limit by just a few kilometres per hour at one end of the spectrum, or may exceed the speed limit to an excessive level at the other end of the spectrum. As would be expected, differing levels of speeding pose different levels of crash risk. When crashes occur, speeding can also affect crash outcome. Crashes that occur as a result of excessive speed are likely to be more severe than crashes occurring at lower speeds (e.g. De Pauw et al., 2014).

Data published by the Bureau of Infrastructure, Transport and Regional Economics (2011) show that speeding was a major factor in an average of 28 per cent of fatal crashes in Australia the period between 1990 and 2006. In a case-control study conducted in the Australian city of Adelaide, Kloeden et al. (1997) compared the speeds of cars that were involved in a crash that resulted in a casualty (cases) with the speeds of cars that were not involved in a crash (controls). All crashes included in the study occurred on roads with a 60km/h speed limit. It was found that the speeds which crash involved drivers had been travelling at were in general greater than the speeds the non-crash involved drivers had been travelling at (Kloeden et al., 1997). Specifically, a driver travelling 5km/h over the 60km/h speed limit had double the risk of being involved in a crash resulting in a casualty. Travelling 10km/h above the speed limit, or in other words, travelling at 70km/h was found to be associated with four times the risk of crash involvement resulting in a casualty. Concerningly, for drivers traveling at 85km/h (25km/h above the speed limit), the risk of crash was found to be over 56 times greater than a car travelling at the speed limit (Kloeden et al., 1997).

Similarly, Moore, Dolinis and Woodward (1995) found that for drivers travelling in a 60km/h zone, vehicles that were exceeding the speed limit by 1-24km/h had an odds of crash 7.8 times higher when compared with drivers obeying the speed limit. The level of risk increased for drivers travelling 25km/h or more above the speed limit, where the odds ratio was 39.0 when compared to drivers travelling within the speed limit (Moore et al., 1995). A study undertaken by Elvik (2008) also provided evidence for speed reduction and avoidance of speeding as an effective measure for avoiding road trauma. Using a speed curve and formula that attributes the risk of fatality to speeding, Elvik (2008) proposed that the

elimination of speeding on roads in Norway that have an 80km/h speed limit would lead to a 22 per cent reduction in fatalities (Elvik, 2008).

Whilst higher speeds are associated with greater risk, the majority of drivers who speed do so at a low level (Alavi, Keleher & Nieuwesteeg, 2014). Despite this providing some degree of encouragement, it is important to note that low level speeding accounts for the majority of crashes that result from speeding on the roads in Victoria, Australia. Alavi et al. (2014) examined close to 350,000 speed records, using the same crash risk formula developed by Kloeden et al. (1997). It was found that 79 per cent of the casualty crashes that result from speeding were associated with low-level speeding. Conversely, only around 4 per cent of crashes were associated with high-level speeding (which was categorised as speeding 21km/h and above the posted limit). Together, these results demonstrate that speeding poses a significant risk to road users. The associations between speeding in road crashes means that examining deterrence should be of a high priority in road safety research.

2.2.4 Using a handheld mobile phone while driving

Driving a motor vehicle is a complicated task that requires a driver to use cognitive skills, physical skills, sensory skills and psychomotor skills (Young and Regan, 2007). Unfortunately, drivers often perform other tasks while they are responsible for operating a motor vehicle (e.g. Young & Regan, 2007). This leads to driver distraction, which can be defined as ‘a diversion of attention away from activities critical for safe driving toward a competing activity’ (Lee, Young & Regan, 2009, p. 38). Driver distraction has been identified as contributing to the occurrence of crashes (Guo et al., 2017). Research has found that 22 per cent of crashes or near crashes are a result of distraction that arises from people undertaking other tasks in a vehicle whilst they are driving (Klauer et al., 2006). Whilst many tasks and factors may present a distraction to drivers when they are operating a motor vehicle, one very common source is the use of a mobile phone (e.g. Oviedo-Trespalacios et al., 2016; Regan et al., 2009).

Using a mobile phone whilst driving, and the risk of crash that this action can pose is another area of road safety where the research is quite complex. Mobile phones can be used in many different ways. These include verbal conversations, sending and receiving text

messages, sending and receiving emails, using the phone to browse the internet, watch videos and as a GPS to view maps.

Whilst some studies have considered the mobile phone and crash risk relationship from a broad perspective, given the wide array of purposes for which mobile phones can be used, other research has considered only specific types of mobile phone use. One thing consistent amongst this research is that mobile phone use whilst driving is associated with an increased risk of crash involvement (e.g. Ige, Banstola & Pilkington, 2016; McEvoy, Stevenson & Woodward, 2006, 2007; Redelmeier & Tibshirani, 1997a), including in crashes where fault can be attributed to the driver using the mobile phone (e.g. Ashbridge, Brubacher & Chan, 2013).

In a study that explored the risk of crash associated with a variety of potentially distracting tasks amongst drivers aged 16-98 years, Guo et al. (2017) found that using a mobile phone increased the likelihood of being involved in a crash by between 2.1 and 5.7 times, depending on the age of the driver. Furthermore, research has found an association between crashes where mobile phone use was evident and serious injuries and fatalities (McEvoy et al., 2005; Overton et al, 2015). The contribution that mobile phones have to the occurrence of road crashes demonstrates that continued research on factors that may deter this behaviour has great potential to improve safety on the roads.

2.2.5 Failing to stop at a red light

Compared to the other types of illegal driving behaviour already discussed in this section, the body of research that has explored the association between failing to stop at a red light and crash involvement is far more limited and less complex. This may be due to the possibility that failing to stop at a red light is often a flow-on effect from engaging in other types of risky driving behaviour, such as drink driving, drug driving, speeding, mobile phone use whilst driving and aggressive driving. When a crash occurs when a driver fails to stop at a red light, the cause of this crash is possibly attributed to other types of behaviour, rather than the act of running the red light itself (e.g. Datta, Schattler & Datta, 2000; Wan et al., 2017). This is not to say that there has not been research that has specifically explored the contribution that failing to stop at a red light has upon crashes.

In a study undertaken in the USA, which explored crashes that occur as a result of drivers not obeying traffic signals, it was estimated that 260,000 crashes occur annually within the USA that can be attributed to drivers failing to stop at a red light, with 750 deaths resulting from these crashes (Retting, Ulmer & Williams, 1999). In another study, police reported crash data from four different locations in the USA were examined. This study found that the most common crash type was running a traffic control, accounting for 22 per cent of the crashes included in this study. 39 per cent of crashes that occurred as a result of a driver running a traffic signal resulted in injuries (Retting et al., 1995). This study thus highlights the association between red light running and crashes. Although the research that has explored red light running and crash involvement is limited, the available evidence once again highlights the need for continued research that identifies factors that may enhance deterrence of the behaviour.

2.3 Sanctioning system in Victoria, Australia that operates to deter illegal driving behaviours

Given the associations between illegal driving behaviours and crashes, sanctions are used to respond to their performance. The following section provides a brief overview of how illegal driving behaviours are responded to in the jurisdiction of Victoria, Australia. The information provided is of a very general nature. A complete and detailed evaluation of all the legal avenues that may be taken by authorities in response to illegal driving behaviour within Victoria would warrant an in-depth legal analysis. Such a review would require detailed legal knowledge of all the different pathways through which drivers may find themselves subject to harsher penalties, such as licence loss and even imprisonment. Given this thesis does not have a specific focus on legal system responses to illegal driving behaviour in Victoria, such a review is beyond the scope of this research. Therefore, a brief description is provided.

The VicRoads website (<https://www.vicroads.vic.gov.au>) provides easily accessible and easy to understand information to Victorian drivers on the penalties that are in place to respond to the performance of illegal driving behaviour. VicRoads (which recently became a part of the Victorian Department of Transport) is a Victorian state government agency that has a number of responsibilities in relation to road transportation within the state, and is guided

by the *Transport Integration Act 2010* (VicRoads, 2019a). In meeting its responsibilities, VicRoads undertakes tasks including (VicRoads, 2019b):

- Managing and regulating the network of arterial roads across Victoria
- Working to provide road safety initiatives for Victoria
- Provision of licensing and vehicle registration services to Victorian road users

Many of the common driving offences performed on Victorian roads will result in infringement notices being issued, in the event a driver is apprehended by police or captured by a road safety camera. In Victoria, the types of road safety cameras in use are fixed speed cameras, fixed red light cameras, point-to-point speed cameras, wet-film technology and mobile cameras (Cameras Save Lives, 2020). Recently, cameras for the enforcement of mobile phone use whilst driving have also been trialled.

In most cases, infringement notices require a driver to pay a fine, and often also result in demerit points being placed on a driver's licence. Demerit points accumulate on a driver's licence and exceeding a threshold may result in licence suspension. A full document, outlining all offence types, along with the associated fine amount and demerit points applicable is available on the VicRoads website (VicRoads, 2019c). Each offence type has an offence code number and the associated penalty units for the offence. For every penalty unit, a driver is fined \$165.22 (as per the amount in July 2020 – this is regularly revised and increases occur in each new financial year) (VicRoads, 2019c). This review will not list the details of all fine amounts and demerit points issued, given there are hundreds of different offences a driver may perform on the roads. Furthermore, there are sometimes different penalties depending on the type of vehicle being operated and a driver's licence type. Differences for licence type operate in Victoria due to there being a Graduated Driver Licensing System (GLS) in place, aimed at improving new driver safety. Details of the most common penalties for speeding offences, mobile phone offences, red-light offences, drink driving offences and drug driving offences are however outlined below.

Penalties for speeding are provided in Table 2.1, for different levels of speeding severity. The penalties provided in Table 2.1 are for speeding offences where the vehicle is not a heavy vehicle.

The penalties for handheld mobile phone offences, which also extend to other technologies such as in-car DVD players, smartwatches, and tablet devices, for example, attract a fine of \$496 and four demerit points for all drivers (VicRoads, 2019e). Whilst full licence holders are permitted to use a mobile when it is in a holder or does not require the phone to be touched, such as when an in-car system is used, learner and probationary (novice) drivers are not permitted to use a mobile phone at any time, irrespective of it being hands free, including phone mirroring on in-car infotainment systems (VicRoads, 2019e). Not stopping at a red light attracts a penalty of \$413 and three demerit points (VicRoads, 2019c).

Table 2.1 Penalties for different levels of speeding in Victoria, Australia

Offence	Fine Amount	Demerit Points or Licence Suspension
Exceed speed by less than 10km/h	\$207	1 point
Exceed speed limit by between 10km/h and 24km/h	\$330	3 points
Exceed speed limit by between 25km/h and 29km/h	\$454	3 months licence suspension
Exceed speed limit by between 30km/h and 34km/h	\$537	3 months licence suspension
Exceed speed limit by between 35km/h and 39km/h	\$624	6 months licence suspension
Exceed speed limit by between 40km/h and 44km/h	\$702	6 months licence suspension
Exceed speed limit by 45km/h or more	\$826	12 months licence suspension
Exceed the speed limit by between 20km/h and 24km/h in a 110km/h speed zone	\$330	3 months licence suspension

Source: VicRoads (2019d)

The penalties for drink driving offences and drug driving offences are generally more severe and complex than those for other offences. Individuals who are apprehended driving with a BAC above the legal limit (this limit varies based on licence type but is most commonly .05% for full licence holders not driving a heavy vehicle) receive a fine, which is a minimum of \$496, lose their licence generally for six months or more and are required to pay for installation of an alcohol interlock device in their vehicle before they are eligible to be reissued with their licence, at which stage a zero BAC condition is placed on their licence

(VicRoads, 2020c). These are the most common penalties an individual who engages in drink driving can expect to receive. However, the actual penalties vary between drivers, and are based on factors such as the nature of their drink driving offence, when the offence was committed, how old they were at the time of the offence, their licence type and the number of previous drink driving offences they have been apprehended for (VicRoads, 2020c). In some cases, individuals may be sentenced to a period of imprisonment following a drink driving offence (VicRoads, 2020c).

Like drink driving, penalties for drug driving vary based on a number of factors. Drivers may receive a penalty based on a failed roadside drug test, being apprehended by police for driving while impaired by an illicit drug or for refusing to undertake tests (either roadside or impairment tests) when directed to do so by a member of Victoria Police (VicRoads, 2020d). For a first-time drug-driving offence, identified through a roadside drug test, an individual will receive a \$496 fine and have their licence suspended for six-months (VicRoads, 2020d). Some drivers may also be required to go to court, which results in additional penalties (VicRoads, 2020d). For drivers who are found to be impaired by drugs, which occurs after an individual is observed by police to be displaying physical characteristics consistent with illicit drug use, such as patterns of behaviour, balance and coordination, and a blood or urine sample confirms use, the penalties are more severe than those seen for roadside drug tests (VicRoads, 2020d). For first time offenders, the driver must attend court, will receive a fine of \$1983, lose their licence for at least twelve months and have a zero BAC condition placed on their licence for three years (VicRoads, 2020d).

In the case of both drink driving and drug driving, driver education programs, specific to the offence type for which a driver is being sanctioned, must also be completed (VicRoads, 2020c; VicRoads, 2020d). There are more severe penalties for drivers found to have been drink driving and drug driving at the same time, which may also include a period of imprisonment in some instances (VicRoads, 2019f).

The Cameras Save Lives website (<https://www.camerassavelives.vic.gov.au>) provides information on consequences drivers may face if they fail to pay a fine issued to them for a driving offence. These consequences may include seizing and selling of property, suspending an individual's driver licence, suspending a vehicle's registration, preventing the renewal of

a vehicle's registration, wheel clamping an individual's vehicle, and if all other enforcement actions fail, arresting an individual (Cameras Save Lives, 2019).

In terms of demerit points, it is also important to note the cumulative nature of these sanctions. Once again, the number of points a driver can accumulate before their licence is suspended varies, based on factors including licence type and age. For full licence holders, twelve points may be accumulated in a three-year period. Drivers who exceed this limit will generally have their licence suspended, unless they choose to take an extended demerit point period. In such cases, a driver must not perform further offences or they will have a period of licence suspension double the length of time than was possible had they not taken the extended demerit point period (VicRoads, 2020e).

Whilst only a small number of offence types have been outlined in this section, they nonetheless demonstrate that the penalties for driving offences in Victoria vary widely. For more minor offences, the fines to be paid and the number of demerit points placed on an individual's licence are far less substantial. As severity increases, offences attract higher fines and greater numbers of demerit points. Beyond this, drivers can lose their licence for varying periods of time, dependent on the severity of the offence. In the most severe circumstances, driver offending can lead to imprisonment. Whilst the research contained in this thesis does not specifically focus on the legal system as it applies to the operation of sanctions for traffic offences in Victoria, but rather the deterring influence of these sanctions, a basic appreciation of the sanctioning system is nonetheless important background information to understand many aspects of the studies undertaken as part of this PhD and the research and results reported within this thesis.

2.4 The effectiveness of infringements in deterring subsequent driver offending and preventing crash involvement

Owing to the wide variety of different traffic offences that can be performed and the differing degrees of punishment severity for these offences, there is a substantial body of literature that has sought to examine the effectiveness of punishments for driving offences. Whilst licence loss and imprisonment are sanctions that drivers may receive, as indicated above, the most common punishment is a traffic infringement notice, requiring payment of a specified monetary value, and in many cases demerit points. It is also notable that whilst

traffic infringements have the primary goal of deterring drivers from performing illegal driving behaviours, other sanctions such as licence loss and imprisonment also seek to achieve functions such as retribution, incapacitation and restraint (e.g. Ross, 1992).

One area of research in road safety has been the examination of the effectiveness of infringements on subsequent driver behaviour. This research can largely be divided into two separate, but closely related and complementary groups. The first area of research has examined the effectiveness of infringements in deterring the performance of subsequent illegal driving behaviours. The second area of research has examined the effectiveness of infringements in reducing the risk of subsequent crash involvement. Notably, this second area of research has been the subject of disagreement. Some road safety research has cast doubt over the appropriateness and applicability of using previous traffic offences to predict crashes (e.g. Griep, 1970). Indeed, some research has suggested that previous crash involvement provides a better indicator of future crash involvement (e.g. Chandraratna, Stamatiadis & Stromberg, 2006; Daigneault, Joly & Frigon, 2002; Diamantopoulou et al., 1997). Despite this, many studies have successfully used data on previous infringements and their relationship to later crash involvement, highlighting the approach as a useful perspective from which drivers at risk of road crashes might be identified.

This section will provide a review of research on the effectiveness of traffic infringements (which may also be known as tickets), in influencing driver behaviour. The discussion in this section has been limited to traffic infringements (as opposed to more serious sanctions) for a number of reasons. First, these are the most commonly used punishments for driving offences. Second, the sheer volume of research in the road safety area, given all the different penalties available, such as licence suspension, licence loss, and imprisonment, as well as offence types meant that limits had to be drawn on the breadth of research that can be considered within this review and the confines on a single PhD research program. Third, when considering broader punishments, such as licence loss and terms of imprisonment, there are often lengthy histories of offending behaviour that see a driver get to this point of sanction severity. This presents another degree of complexity in understanding the effectiveness of these sanctions, and is also beyond the scope of this PhD research.

The main aim of this section is to identify gaps in knowledge that emerge in the existing body of research examining the deterring influence of traffic infringements upon

subsequent traffic offending and crash involvement. Furthermore, given the criticisms surrounding the use of subsequent crash involvement as an outcome variable to examine the effectiveness of infringements, this section will also seek to provide some commentary on the appropriateness and applicability of such research.

Before moving to exploring the existing research that has examined traffic infringements, it is also important to note that policing of traffic offences takes place at a jurisdictional level. Results of studies that are presented in this section come from varying jurisdictions where approaches to road safety may differ considerably, including in relation to the severity of traffic infringements and the level of enforcement. This may mean that the patterns identified between infringements and deterrence in one jurisdiction may not hold true in other jurisdictions. Despite this, consideration of research from a range of different settings is the first step in identifying strategies that may, with careful consideration of their application, prove useful in other jurisdictions. By examining research from other jurisdictions, areas where research is required in Victoria, Australia will most likely emerge.

[2.4.1 Recidivism following a traffic infringement](#)

The findings of studies that have sought to examine the effectiveness of traffic infringements in deterring subsequent illegal driving behaviour and reducing crash risk have been mixed. Whilst some studies have found evidence of a significant deterring influence following a driver receiving a traffic infringement, other studies do not support their effectiveness in changing driver behaviour and in encouraging safer road use. Where significant deterring effects were found, the effect sizes vary greatly.

It is also important to note a key methodological limitation across each of the studies that are examined below in this section. All use observational data, which means all would have been subject to the limitations of observational studies. Observational data are open to confounding, as there are likely many unmeasured variables that may have impact on the results. While associations may emerge, it is impossible to draw any conclusions about causality. Furthermore, the nature of illegal driving behaviour means that much of its performance goes undetected. When a person is apprehended, it is possible they have performed illegal driving behaviours before, without being detected. Once again, the nature of observational data means the true extent of offending behaviour goes unmeasured.

Li et al. (2011) undertook a study in the state of Maryland in the United States, to examine the influence that receiving a fine and demerit points for a speeding offence had upon recidivism. Comparisons were drawn with drivers who chose a court appearance to settle their sanction. The group who settled their sanction by appearing in court was further divided into five groups, depending on the outcome of their court appearance. Drivers were followed up for a three-year time period to see if they received a subsequent speeding ticket. It emerged that drivers who chose to appear in court rather than settle their offence through paying a fine and receiving demerit points out of court had lower risk of receiving a subsequent ticket in the follow up period. The authors suggested that it may be that for some speeding offences, the true deterring influence only comes when points accumulate to such a degree that suspension of a licence becomes possible. Interestingly, in this very same study, the opposite was found in terms of crashes. Higher risk of crash was found for drivers who chose to settle their sanction in a court setting.

Like Li et al., (2011) Studdert, Walter and Goldhaber-Fiebert (2017) also sought to examine the influence that infringements for traffic offences had on subsequent traffic offending and also crash involvement. Using data from Queensland, Australia, Studdert, Walter and Goldhaber-Fiebert (2017) examined a cohort of drivers who had performed a driving offence detected by camera for 21-days prior to notification of this offence and 90 days after notification of the offence. The aim was to draw comparisons in reoffending and crash involvement in the time prior to notification for the offence and the time after notification for the offence. The two outcomes examined were offences per 100,000 drivers per day and crashes per 100,000 drivers per day. Overall, it was found that in the period that followed a driver being notified of an offence and receiving an infringement notice, the rate of further offences dropped immediately by 25%, with the decrease evident right through the post-notification follow-up period. Comparatively, in the post-notification period, there was no significant change in the risk that drivers had of crashing when compared with the pre-notification period (Studdert et al., 2017). The authors sought to explain the apparent deterrence in further offending but not in crashes in two distinct ways. First, they suggested that it may have been the case that drivers avoided places they knew would place them at risk of subsequent identification of traffic offending, such as an intersection with a road safety camera. Second, they questioned whether the illegal driving behaviour and crash link

relationship is as strong as what most believe (Studdert et al., 2017). The study concluded that given the aim of sanctioning is ultimately to reduce the potential for harm on the roads, perhaps specific deterrence is not being achieved by handing infringements to drivers who violate traffic rules (Studdert et al., 2017).

Another research approach has been to consider the influence that increased sanctions may have upon recidivism. Yu (1994) conducted research in the United States, specifically New York State. Focussing on drink driving, Yu (1994) sought to examine the role that increases in fines had upon further offending. It is also notable that this study considered licence loss, however as noted the focus of this section is on examining infringements and tickets for driving offences. First and second time drink drivers were examined. Following each offence, drivers were followed up for three years, to see if they reoffended. The study found that when fines were increased, the risks of reoffending declined significantly. Licence loss was not, however, a deterrent. Yu (1994) contended that it may be the case that for some drivers, licence loss does not necessarily mean they stop driving, but fines of a substantial amount have the potential to cause significant burden. Unlike obeying licence loss, payment of the fine is unavoidable (Yu, 1994). Thus interestingly, whilst the payment of monetary fines are generally seen as the first option for traffic offenders, Yu (1994) suggested that much more weight should be put upon this type of sanction, at least in the case of drink driving behaviour, where the risks of continued driving, despite being unlicensed are high.

Watson et al. (2015) were also interested in the influence that increased sanctions can have on specific deterrence. Their study used data from drivers who had received a penalty for a speeding offence in 2003, in the Australian state of Queensland. One cohort of drivers received their infringement prior to the changes (sanction increase) coming into effect, while the other cohort received their infringement after the changes came into effect. Overall, a deterrent effect was identified. Among drivers who experienced the more severe speeding penalties, a greater deterrent effect was observed overall. A smaller proportion of the drivers who had received the higher penalties reoffended. The frequency of offending was also lower. However, amongst those who did reoffend and received the higher penalty, the time to reoffending was significantly less (Watson et al., 2015). Results of this study are similar to those of Yu (1994) in that an increase in sanction value did result in lower proportions of drivers reoffending.

Weatherburn and Moffat (2011) also examined the effects of fine size, however, their approach was somewhat different to that taken by Yu (1994) and Watson et al., (2015). Focussing on drink drivers in the Australian state of New South Wales, their aim was to examine the effect that differences in the size of fines determined by a magistrate had upon reoffending in the three years that followed. Examining data collected from 21,627 drivers, there was no significant deterrent effect found as a result of higher fines (Weatherburn and Moffat, 2011). A study undertaken by Briscoe (2004) found similar findings. Like the results uncovered by Watson et al. (2015), the results from Weatherburn and Moffat's (2011) and Briscoe's (2004) studies also place into question whether infringements have the desired effect of deterrence, given increases do not necessarily have the outcome they seek to achieve.

Two studies of particular significance regarding the effect of traffic infringements and subsequent traffic offending are those undertaken by Haque (1990) and Imberger, Watson and Kaye (2019). Both studies used data from Victoria, therefore providing insights into the Victorian infringements system, albeit at quite different points in time. Haque (1990) sought to examine the time between drivers' first and second driving offences and second and third driving offences. The aim was to examine the effect that demerit points may have on recidivism. Interestingly, he found that the length of time between driver's second and third infringements was longer than the length of time between their first and second infringements. This result was adjusted for the additional driving experience that drivers accumulated between these driving offences. Haque (1990) subsequently concluded that the demerit point system was indeed having a deterring influence.

Whilst Haque's (1990) study found evidence to suggest a deterring influence of demerit points in terms of subsequent offending, the same pattern was not revealed in the study undertaken by Imberger, Watson and Kaye (2019). Whilst the Imberger, Watson and Kaye (2019) study aimed to examine factors well beyond infringements, including licence bans and good behaviour bonds for serious speeding offenders, one aspect of their research did seek to examine the influence of increases in demerit points for high-level speeding offences. They found no significant reduction in future speeding behaviour by increasing demerit points for high-level speeding offences. It is important to note that the level of speeding that was examined in this study was such that periods of licence bans were also

handed down to drivers. This meant the penalties were more severe than just a traffic infringement. The study however does place into question once again whether increased penalties, in this case increased demerit points, actually achieve deterrence.

2.4.2 Crashes following traffic infringements

A study undertaken by Diamantopoulou et al., (1997) placed further doubt upon the effectiveness of demerit points, this time however the outcome of interest was in relation to crash involvement. In a study that examined a series of univariate and multivariate models, to identify factors that may influence crash involvement, Diamantopoulou et al., (1997) found that amongst drivers with a greater number of demerit points, there was a greater probability of being involved in a crash at a later time. Thus, it appears that for some drivers on the roads, despite the accumulation of demerit points, their behaviour seems particularly difficult to change, and patterns of risky driving continue.

Notably, a heightened risk of crash has been uncovered in a number of other studies that have examined the link between traffic infringements and crashes. A study by Factor (2014), undertaken in Israel found that drivers who received one ticket per year had a 65% higher probability of being involved in a crash when compared to drivers who received no tickets. Concerningly, for drivers who received six tickets in one year, the risk of being involved in a crash was more than eleven times greater than for the drivers who had only received one ticket (Factor, 2014). In a study of older drivers in New Zealand, where repeat driving tests were introduced for drivers every two years once they turned eighty, in cases where a driver received an infringement notice for a minor traffic offence, the odds of crash were two times greater when compared to drivers who had not received an infringement notice (Keall & Frith, 2004).

Similarly, in a study of older drivers, in this case, drivers aged 65 years and over living in Quebec, Canada, Daigneault, Joly & Frigon (2002) found that between 1995-1997, there was a significant positive correlation between sanctions for traffic offences and crashes in the period that followed. This relationship increased with driver age, meaning that whilst the association was significant for drivers aged 65-69 years, the strength of this relationship gradually increased and was found to be strongest for drivers aged 80 years and above (Daigneault, Joly & Frigon, 2002).

A study by Goldenbeld et al. (2013) took a slightly different approach, seeking to compare the risks of a crash based on the number and severity of traffic offences performed in an earlier time period. Whilst it was found that more serious offences (and subsequently more serious sanctions) had the strongest association with later crash involvement, an elevated risk of a crash was observed even where drivers had received earlier sanctions for low level speeding (speeding by less than ten kilometres an hour above the speed limit) (Goldenbeld et al., 2013). Whilst the studies outlined above took different approaches, one thing that they all have in common is that earlier traffic infringement have a statistically significant relationship with subsequent crash involvement.

A factor consistent in many of the studies outlined above was that they used case-control study designs. Case-control studies compare two groups of drivers, one group who has experienced an outcome of interest and one group who has not experienced the outcome. This leaves case-control studies open to significant levels of confounding, as there may be many factors that differ between the two groups over and above the outcome being examined. There are however three studies that are of particular interest that go some way to addressing this. Whilst they are still observational in nature, the case-crossover study design applied in these studies meant that drivers were used as their own controls, potentially addressing some of the confounding that can affect case-control studies (a more detailed description of the case-control and case-crossover study designs is provided in chapter six of this thesis). The three studies were undertaken by Redelmeier, Tibshirani and Evans (2003), Walter and Studdert (2015) and Davis et al. (2018). Each examined crash involvement following drivers receiving an infringement for a traffic offence. Despite using the same innovative case-crossover study design, not all revealed the same results.

Redelmeier, Tibshirani and Evans (2003) used data from Toronto, Ontario. 8975 drivers who had been involved in a fatal crash within an eleven-year period were included in their study. They found that the risk of a driver being involved in a fatal crash within one-month after receiving a sanction for a driving offence was approximately 35 per cent lower when comparisons were drawn to another one-month period where the same driver did not receive a sanction. A series of sub-analyses, focussed on factors including driver's personal characteristics revealed the same pattern of lower risk of being involved in a fatal crash in the month after receiving a traffic sanction. Interestingly, it was found that for speeding

offences, drivers who received penalty points with their sanction had lower risk of fatal crash involvement than those who did not. This offered further support to the use of demerit points as potentially achieving a deterring influence (Redelmeier, Tibshirani and Evans, 2003). The results of this study can be seen in stark contrast to those uncovered by Walter and Studdert (2015) and Davis et al. (2018).

In their study, Walter and Studdert (2015) used data from Queensland, Australia. 22,378 drivers who had been involved in a crash within a sixteen-year period were included in the study. They found that the odds of being involved in a crash in the month after receiving an infringement for a traffic offence was 32 per cent higher than a comparable one-month period. A series of further analyses, taking into account a range of driver characteristics also revealed a pattern of increased risk of crash in the period following a driver receiving a traffic infringement (Walter and Studdert, 2015).

Finally, Davis et al., (2018) used data from Iowa in the USA. Focussing specifically on drivers aged 50 years and above, 38,171 individuals were included in their study, all of whom were involved in a crash between 2011-2012. Like Walter and Studdert (2015), Davis et al. (2018) found that drivers had a greater risk of crash in the 30-day period that followed them receiving a traffic sanction when compared with a 30-day time period twelve months prior. Once again, a series of further analyses, focussed on factors such as age, weather and time of day found the same pattern of heightened crash risk in the 30-days following a traffic infringement when compared with the time period a year prior.

2.5 Where are the gaps in the infringement and subsequent driver behaviour literature?

The previous section has sought to examine existing literature that has explored the effect of traffic infringements on subsequent offending and crash involvement. What is clear from this analysis is that results are mixed. There are some promising signs that traffic infringements achieve deterrence, however it appears that there are just as many studies that place this into doubt. It therefore remains unclear whether infringements for traffic offences do indeed positively influence driving behaviour. Additionally, some gaps are evident in the literature that has examined the effectiveness of traffic infringements, meaning there is still much that remains to be explored. Some of the gaps in the existing knowledge are highlighted below.

2.5.1 Duration of deterrence

First, while it is important to understand whether or not a deterring effect operates, it is equally important to know, in cases where drivers do reoffend, the length of time for which they were able to avoid offending. This can help identify the time period where risk is perhaps greatest, and therefore the time at which the implementation of other strategies would be most beneficial.

Whilst, Watson et al. (2015) and Haque (1990) undertook research in Australia that sought to examine time to traffic reoffending, further work is required in this area. First, the study by Watson et al. (2015) focussed only on speeding. There are many other types of driving offences for which it would be valuable to examine time to subsequent traffic reoffending.

Second, despite the study undertaken by Watson et al. (2015), using Australian data, the data used were collected from Queensland. Given, as noted, traffic law enforcement takes place at a jurisdictional level, it is possible that the results of their study are applicable to the Queensland situation specifically, but of limited generalisability to other jurisdictions. Research that considers the Victorian situation has the potential to provide understandings unique to the Victorian context.

Third, the study by Haque (1990), whilst taking into account a broader range of offence types and using data relating to Victorian drivers, was conducted a considerable period of time ago (data used were from 1982-1985). Much has changed over the past 30+ years since this study was conducted. The range of offences that drivers can receive sanctions for has broadened (e.g. mobile phone offences were not in operation), the size of monetary fines and demerit points issued has increased, and greater levels of enforcement have been made possible through the increased use of automated road safety cameras. This highlights a gap in knowledge, and an opportunity for the current PhD research to contribute to the understanding of the deterring influence of infringements for traffic offences upon subsequent offending, in Victoria, Australia. Specifically, the PhD research contained in this thesis will provide current understandings about infringements and deterrence, in particular the length of time that deterrence may operate for following an infringement, for a range of driving offence types, with particular relevance to Victoria. This gap is addressed in the first study.

2.5.2 Methodological limitations

While there is a sizable body of research that has sought to examine the relationship between infringements and crashes, there are some methodological limitations of this research, signalling the need for continued focus in this area. In particular, the three studies by Redelmeier, Tibshirani and Evans (2003), Walter and Studdert (2015) and Davis et al. (2018) point to an area where further research would be beneficial. As indicated, despite all using the same methodology, differing results were uncovered by Redelmeier, Tibshirani and Evans (2003) when compared with the other two studies.

The research contained in this thesis will seek to build upon these existing studies, using data relevant to Victoria to examine the infringement and crash relationship. Additionally, the differing results in this existing research also highlights that using new and innovative methodologies, that have not have been applied to explore the traffic infringement and crash relationship, may be of benefit.

The case-crossover study design has some limitations, such as not being able to control for factors that may change over-time, such as enforcement. Whilst a more detailed evaluation of the strengths and weaknesses of the case-crossover study design (and other study designs) is provided in chapter six, it is worth noting here that in addition to seeking to explore the nature of the traffic infringement and crash relationship in Victoria, another gap that exists is therefore in relation to the use of methodologies to examine the infringement and crash relationship. In response, this PhD research will seek to apply an innovative methodology, similar to the case-crossover design, but addressing some of its limitations, to examine this relationship. These aims are addressed in study two of this PhD.

2.6 Factors beyond legal sanctions that may influence the performance of illegal driving behaviour

The review of the literature so far in this chapter has focussed specifically on research in relation to formal legal sanctions, specifically traffic infringements, administered to drivers following the performance of illegal driving behaviour. A limitation of this research is that it assumes legal punishments for traffic offences are the primary factor accounting for the patterns in driving behaviour that follow, both when deterrence is and is not achieved. This is problematic for a number of reasons, in particular given a large number of drivers who

perform illegal behaviours do not come to the attention of enforcement authorities. Thankfully, there is a body of deterrence research that goes far beyond examining the effectiveness of legal sanctions. This section will provide an overview of what can be termed *expanded models of deterrence research*.

In a review of literature focussed on deterrence theory, Nagin (1998) identified three main bodies of work that have applied the theory to the performance of illegal driving behaviour: 1) time series research studies; 2) ecological studies; and 3) perceptual studies. Perceptual studies are the most recent of the three bodies of research. They seek to determine the associations that may exist between the perceptions a person has towards the risks of being apprehended and punished for illegal behaviour and their self-reported performances of these behaviours (e.g. Nagin, 1998; Paternoster et al. 1982; Paternoster et al., 1983a; Saltzman et al., 1982). The expanded models of deterrence research is of a perceptual nature.

2.6.1 Non-legal sanctions and driver behaviour

There is an increasing body of research that has sought to examine factors beyond legal sanctions that may influence driver behaviour. As indicated by Freeman et al. (2006) and Freeman & Watson (2009) expanded models of deterrence began to emerge in research in the 1970s. These expanded models have highlighted that there are a multitude of factors that may influence the process through which offending and other aberrant behaviours occur, and these factors expand far beyond formal punishments that are handed down by enforcement authorities (e.g. Akers, 1990; Anderson, Chiricos, & Waldo, 1977; Bishop, 1984; Cochran et al., 1998; Gibbs, 1979; Jacob, 1980; Mann et al., 2016; Meier & Johnson, 1977; Nagin & Pogarsky, 2001; Piliavin et al., 1986; Piquero & Tibbetts, 1996; Sherman, 1993; Silberman, 1976; Vinglis, 1990; Williams & Hawkins, 1986). It is important to make the point that while there are many factors beyond legal sanctions that may influence driver behaviour, no single factor operates in a vacuum. Each factor rather builds on other factors to come together to influence behaviour. At the centre of this however is that these behaviours are illegal and have punishments attached to them.

Expanded models of deterrence have been explored in existing road safety research, primarily in relation to drink driving behaviour (Baum, 1999; Berger & Snortum, 1986;

Freeman, Liossis & David, 2006; Freeman et al., 2006; Freeman et al., 2016; Freeman & Watson, 2009; Grasmick & Bursik, 1990; Grasmick & Green, 1980; Green, 1989; Homel, 1988; Loxley & Smith, 1991; Meesmann, Martensen, & Dupont, 2015; Nagin & Pogarsky, 2001; Piquero and Paternoster, 1998). Other offence types have also been the subject of research that has applied expanded models of deterrence, albeit, less frequent attention. These include driving after using an illicit drug (Davey et al., 2008; Freeman et al., 2010; Jones et al., 2005); driving whilst unlicensed (Watson, 2004), speeding (Bradford et al., 2015) and running a red light (Bradford et al., 2015). Each of these studies are described in Table 2.2, which provides methodological details, variables studied and the key results. Following this table, the results of these studies are brought together, to highlight the range of factors, both legal and non-legal, that have been identified as having a potential deterring influence.

Table 2.2 Details of studies that have applied expanded models of deterrence to road safety

Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Baum (1999)	Central and Northern areas of Queensland, Australia (n=430)	Community survey using computer assisted telephone interviewing (CATI) Logistic regression	Self-reported on performance of drink driving in the 6 months prior	<ul style="list-style-type: none"> • Perceived certainty of apprehension • Disapproval and support from friends • Perceived level of performance of the behaviour in the community 	<ul style="list-style-type: none"> • Perceived certainty of apprehension non-significant • Perceived disapproval from friends associated with significantly lower level of drink driving. • Drink driving more prevalent in drivers who perceived the behaviour to be common
Berger & Snortum (1986)	United States (n=1000)	Telephone Interview Structural Equation Modelling	Most drinks consumed in the past year when still able to drive home. This was used to calculate BAC level	<ul style="list-style-type: none"> • Perceptions of friend's attitudes • Perceptions of accident risk • Perceptions of arrest risk • Knowledge of laws • Moral beliefs 	<ul style="list-style-type: none"> • Perceived risk of arrest and knowledge of the law was non-significant • Perceived support of friends and moral attitudes to the

					behaviour were found to have a strong significant relationship. Drivers who perceived support from friends and did not see the behaviours as wrong was associated with higher levels of drink driving behaviour
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Freeman, Liossis & David (2006)	Queensland, Australia (n=166)	<p>Primarily face-to-face interviews. When this was not possible, interviews were conducted over the phone</p> <p>Offending history data were obtained from the Queensland Police Service and Queensland Transport</p>	<p>1) Intentions to perform a further drink driving offence; 2) Frequency in drink driving in the six months prior to the study; 3) Frequency of drink driving in the driver's lifetime</p>	<ul style="list-style-type: none"> • Classic concept of deterrence theory (certainty, severity and swiftness of sanctions), • Defiance theory (shame, penalty fairness, legitimacy of government) • Deviance theory (respect towards 	<ul style="list-style-type: none"> • Perceived severity of sanctions had a negative association with expectations to drink drive again, suggesting deterrence. • Low level of respect for the law associated with higher

		Ordinal regression analyses.		the law, moral beliefs, general convictions, drink driving convictions)	intentions to drink drive <ul style="list-style-type: none"> • Low levels of shame associated with higher levels of drink driving behaviour in the six months prior • Perceptions of drink driving as wrong was not significantly associated with greater drink driving behaviour • Shame was not found to be associated with intentions to drink drive again
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Freeman, Liossis, Schonfeld, Sheehan, Siskind & Watson (2006)	Queensland, Australia (n=166)	Primarily face-to-face interviews. When this was not possible, interviews were conducted over the phone	1) Intentions to perform a further drink driving offence; 2) Frequency in drink driving in the six months prior to the study; 3) Frequency	<ul style="list-style-type: none"> • Perceptions of certainty • Perceptions of sanction severity • Perceptions of sanction swiftness 	<ul style="list-style-type: none"> • Perceptions of certainty and severity of sanctions were non-significant relationship with drink driving intentions

		<p>Offending history data were obtained from the Queensland Police Service and Queensland Transport</p> <p>Logistic regression analysis</p>	of drink driving in the driver's lifetime	<ul style="list-style-type: none"> • Perceptions of social loss • Perceptions of internal loss • Perceptions of physical loss 	<ul style="list-style-type: none"> • Social and internal loss were found to be negatively associated drink driving expectations, however were not significant when included in a model with other factors • Previous self-reported behaviour a strong predictor drink driving intentions
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Freeman, Szogi, Truelove, & Vingilis (2016)	Queensland, Australia (n=1253)	<p>Online or paper questionnaire</p> <p>Logistic regression</p>	Frequency of self-reported drink driving behaviour.	<ul style="list-style-type: none"> • Perceptions towards legal sanctions (certainty, severity and swiftness) • Perceptions towards non-legal sanctions (social sanctions, 	<ul style="list-style-type: none"> • Perceiving sanctions as severe had a significant negative association with drink driving • Worry about the non-legal sanctions (social

				internal loss and physical loss).	sanctions, internal loss and physical loss) all had a significant negative association with drink driving, indicating they may act as deterrents
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Freeman & Watson (2009)	Queensland, Australia (n=780)	Telephone survey using a random selection of phone numbers Logistic regression	Self-reported drink driving behaviour	<ul style="list-style-type: none"> Attitudes towards drink driving behaviour Perceptions towards legal and non-legal sanctions 	<ul style="list-style-type: none"> Certainty of apprehension, concern about being involved in a crash and worry about breaking the law all found to be a significant deterring factors Drivers who did not perceive drink driving as serious (held positive attitudes towards the behaviour) reported higher

					<p>levels of the behaviour</p> <ul style="list-style-type: none"> • In the overall model, certainty of apprehension, concerns about crash involvement, concern about hurting another person and attitudes towards drink driving were all significant deterring factors
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Grasmick & Bursik (1990)	A Southwestern city of the United States (n=360)	<p>Face-to-face interviews</p> <p>Logistic regression</p>	Self-reported intentions to drink drive in the future	<ul style="list-style-type: none"> • Perceived threats of legal sanctions (material loss as a result of sanctions imposed by the state) • Social sanctions (feelings of embarrassment and loss of 	<ul style="list-style-type: none"> • Threat of legal sanctions and personal costs (shame) were found to statistically significant in achieving deterrence, but personal costs had a greater effect

				respect from others) • Personal costs (shame)	• Threat of embarrassment was in the direction that suggested a deterring effect, but was non-significant
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Grasmick & Green (1980)	Polk City, United States (n=400)	Interviews either by phone or at residence Regression analyses	Self-reported performances and future estimations of drink driving	• Perceptions towards legal sanctions (certainty of arrest, severity of punishment) • Perceived threat of social disapproval • Moral commitment to the law	• All three factors examined (perceptions of legal sanctions, perceived social disapproval and moral commitment to the law) were found to have a statistically significant in achieving deterrence for both outcomes
Green (1989)	Minneapolis, USA (n=370)	Data were collected over the phone All drivers had to report to consuming	1) Estimates of drink driving in the future; 2) Actual performance of drink driving behaviour	• Perceptions towards certainty and severity of legal sanctions	• Non-legal (informal) sanctions had a greater influence on deterrence of

		alcohol and also drive a motor vehicle at least occasionally Bivariate relationships and logistic regression		<ul style="list-style-type: none"> • Moral commitment to the law • Perceived threat of social sanctions 	drink driving behaviour than the legal (formal) sanctions
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Homel (1988)	Sydney, New South Wales, Australia (n=400 in phase one; n=600 in phase two)	Face-to-face interviews Linear modelling to examine a chain model	There were multiple outcomes: 1) Exposure to random breath testing, 2) Probability of a random breath test 3) Probability of arrest for drink driving and 4) Drink driving behaviour	<ul style="list-style-type: none"> • Awareness of random breath testing • Perceptions of being apprehended drink driving • Perceptions of how unpleasant legal sanctions are • Perceptions of moral commitment to the law • Social sanctions (feelings of guilt, stigma, the risk of material deprivation, 	<ul style="list-style-type: none"> • Perceptions of legal sanctions found to have a deterring influence on drink driving behaviour • Amongst drivers who did not report drink driving, the factors most commonly cited were fear of having an accident and the behaviour going against the moral norm • Social factors in some respects

				including accident risk)	<p>encouraged drink driving. This included a sense of social pressure from peers to drink and drive.</p> <ul style="list-style-type: none"> • Despite both formal and informal sanctions being significant, informal (non-legal) sanctions had a greater influence
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Loxley & Smith (1991)	Western Australia, across five large population localities (n=500)	<p>Data collection took place using a face-to-face survey, by visiting the homes of study participants.</p> <p>Structural Equation Modelling.</p>	<p>1) Number of drinks drivers think they can have if driving</p> <p>2) Number of times driven while intoxicated in the year prior</p>	<ul style="list-style-type: none"> • Knowledge of anyone who has received a legal sanction for drink driving • Moral commitment to the law (how they believe their relatives would react if they were to drink drive; 	<ul style="list-style-type: none"> • Random breath testing (certainty of apprehension) did not have a deterrent effect • Moral commitment to the law had a significant deterring effect in achieving deterrence

				<p>how acceptable drink driving is).</p> <ul style="list-style-type: none"> • Perceptions in relation to peers (whether they feel at ease drinking less than their peers) • Perceptions of being apprehended if driving after consuming alcohol. • Whether drink less when driving • How often arrange for another person to drive when alcohol consumed 	<ul style="list-style-type: none"> • Moral beliefs also had an impact on how drivers perceived their peers would respond
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Meesmann, Martensen & Dupont (2015)	19 countries across Europe (n=12,507)	The majority of data were collected face-to-face. There was some variance, given 19 countries participated in the	Self-reported drink driving in the month prior to completing the survey	<ul style="list-style-type: none"> • Number of times tested for alcohol use while driving a car • Perceptions of apprehension 	<ul style="list-style-type: none"> • Drivers who perceived their friends would engage in drink driving had a higher-odds of

		<p>study. In depth details about the data collection process for the project are found in Cestac and Delhomme (2012)</p> <p>Analyses were completed using multiple logistic regression. Multilevel models were used, with examinations at both the individual and the country level</p>		<ul style="list-style-type: none"> Whether they believe their friends would drink and drive 	<p>also drink driving themselves</p> <ul style="list-style-type: none"> Drivers who had been checked for drink driving in the three-years prior had a higher-odds of drink driving behaviour Drivers who perceived a high chance of being apprehended for drink driving had a higher odds of reporting drink driving behaviour
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Nagin & Pogarsky (2001)	University of Arizona, USA (n=252)	Survey	Drivers were presented with a scenario and asked to indicate the chance they would drive themselves home. Responses were provided on a scale of 0 to 100	<ul style="list-style-type: none"> Perceptions of certainty, celerity and severity of punishments for drink driving. The price respondents would be willing to pay for legal representation, 	<ul style="list-style-type: none"> Certainty of punishment had a stronger deterring influence than severity of punishment Non-legal sanctions had at minimum an

				with different outcome scenarios	equal deterring effect as the traditional legal sanctions did
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Piquero and Paternoster (1998)	United States (n=1,686)	Telephone survey using random digit dialling to recruit participants	Expectations of drink driving behaviour in the following year	<ul style="list-style-type: none"> • Experience of being arrested for drink driving, • Experience of being pulled over at a roadside checkpoint, • Punishment avoidance • Perceived sanction certainty for self and others • Avoidance of punishment for self and others • Moral beliefs • Social sanctions (how respondents believe those close to them would react) 	<ul style="list-style-type: none"> • Both legal and non-legal sanctions were significant in achieving deterrence • Moral beliefs had a significant deterring influence • Certainty of legal sanctions also had a significant deterring influence • Drivers who experienced those around them being sanctioned for drink driving had greater expectations to drink and drive

				<ul style="list-style-type: none"> • Friends' performance of drink driving 	<ul style="list-style-type: none"> • Punishment avoidance had a significant influence on drink driving expectations
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Davey, Freeman, Palk & Lavelle (2008)	Queensland, Australia (n=516)	<p>Self-completed questionnaire</p> <p>Logistic regression</p>	Intentions to drive after using drugs in the next six months	<ul style="list-style-type: none"> • Perceptions of certainty, severity and swiftness of penalties • Perceptions of social sanctions (concern of disapproval from peers) • Perceptions of internal sanctions (ashamed or guilty) • Physical sanctions (perceptions of having an accident and damaging their vehicle) 	<ul style="list-style-type: none"> • Perceptions of there being a low risk of apprehension associated with higher behavioural expectations • The majority of drivers reported that they would be concerned about non-legal sanctions (social, internal and physical). However, when included in a model, the results were non-significant

Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Freeman, Watling, Davey & Palk (2010)	Queensland, Australia (n=898)	Self-completed questionnaire Logistic regression	1) Performance of drug driving behaviour in the six months prior 2) Intentions to drug drive in the following 6 months	Data were collected on legal sanctions and social sanctions	<ul style="list-style-type: none"> • Certainty of apprehension was found to be a significant predictor of intentions to drug drive in the following 6 months • Social sanctions were also found to be a statistically significant in predicting drug driving behaviour in the following 6 months • Having drug driven in the six months prior to the study and being a drug user had a greater influence than the perceptual factors

Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Jones, Donnelly, Swift & Weatherburn (2005)	New South Wales, Australia (n=320)	Face-to-face interviews Logistic regression	Driving under the influence of cannabis in the 12 months prior	<ul style="list-style-type: none"> • Perceptions towards accident risk • Perceptions of apprehension risk • Perceptions of sanction severity 	<ul style="list-style-type: none"> • Risk of apprehension and sanction severity were not found to be statistically significant • Drivers who perceived their risk of accident would stay the same or even decrease if they were to be driving after using cannabis were significantly more likely to report having driven after using cannabis in the 6 months prior. However, when this variable was put into the final model, alongside factors, it was no longer significant

Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Watson (2004)	Brisbane, Queensland (n=309)	Face-to-face interviews Hierarchical multiple regression	1) Frequency of previous performances of unlicensed driving 2) Intentions to drive unlicensed again in the future	<ul style="list-style-type: none"> • Traditional concept of deterrence (certainty, severity and swiftness) • Punishment avoidance, both for self and family or friends • Family and friends experience of punishment • Factors relating to social learning theory (knowing others who have driven unlicensed, attitudes to unlicensed driving, attitudes to other forms of transport, and social and non-social rewards and punishments) 	<ul style="list-style-type: none"> • Certainty, severity and swiftness did not have a statistically significant influence on previous unlicensed driving behaviour • A prior conviction for unlicensed driving associated with greater future intentions to drive unlicensed • Punishment avoidance found to be a significant predictor of previous unlicensed driving • Social learning variables found to be significant predictors of

				of unlicensed driving)	previous unlicensed driving and intentions to drive unlicensed in the future
Author(s)	Location and Sample Size	Data and Methods	Outcome Variable	Predictor Variable(s)	Results
Bradford, Hohl, Jackson & MacQueen (2015)	Scotland (n=816)	A self-completed questionnaire either in paper form or online Structural Equation Modelling	1) How likely drivers believe they are to exceed the speed limit in the future 2) How likely drivers believe they are to go through a red light if they are in a hurry in the future	<ul style="list-style-type: none"> • Police effectiveness • Perceived risk of sanctions • Police legitimacy • Personal morality • Group membership • Perceptions towards procedural justice • Social identity 	<ul style="list-style-type: none"> • Personal morality had the strongest association with the traffic offending behaviours. Drivers who reported they felt the behaviours are wrong were less likely to report they would perform them • Perceived risk of sanctioning was also found to be statistically significant, with drivers who thought the risk of apprehension

					was high less likely to report they would perform the behaviours
--	--	--	--	--	--

As can be seen in Table 2.2, existing research has examined a range of legal and non-legal sanctions in relation to illegal driving behaviours – both previous performances of the behaviours, as well as future intentions and expectations to perform the behaviours. The results of these studies suggest that, in addition to legal sanctions being certain, severe and swift, as well as perceptions of police legitimacy, there are a range of non-legal sanctions that may have an equal or even greater influence on the performance of illegal driving behaviours. Factors such as concern about crash involvement, concern about injuring oneself or others, concern about social consequences – including social disapproval, concern about negative internal feelings – such as shame or guilt and concern about going against moral norms have each been identified as potentially having a deterring influence upon the performance of illegal driving behaviour. Social sanctions were perhaps the factor that emerged as one of the most common deterring influences in the studies examined in Table 2.2. In many cases, drivers perceived that they would be met with social disapproval from family and friends if they were to perform the illegal driving behaviour.

Despite the deterring influence that social factors do appear to have in some studies, it is important to note another perspective. A number of studies above (Berger & Snortum, 1986; Homel, 1988; Meesmann, Martensen & Dupont, 2015) found evidence that suggested social factors can also encourage the performance of illegal driving behaviours. For some individuals, there may be a sense of encouragement from family and friends to perform the behaviours, or alternatively, a breakdown in social connectedness (Dana, 2001; Nagin & Paternoster, 1991). A study by Brown (1998), that examined drink driving found that individuals with social associations to others engaging in drink driving behaviour were also at greater risk of engaging in the behaviour themselves.

2.6.2 Considering legal sanctions from a broader perspective

In addition to the studies in Table 2.2, whilst not examining expanded models of deterrence per se, a number of studies have investigated legal sanctions from a broader perspective, applying Stafford and Warr's (1993) reconceptualization of deterrence theory. In their work, Stafford and Warr (1993) included the traditional concept of deterrence, this being personal apprehension for illegal behaviour. However, in addition, they included three other constructs – 1) Indirect experiences of punishment, such as seeing other individuals sanctioned; 2) Personal avoidance of punishment; and 3) indirect avoidance of punishment

(seeing other individuals avoid punishment). They proposed that avoidance of punishment can impact adherence to laws and the success of legal sanctions to achieve deterrence (Stafford and Warr, 1993).

Freeman and Watson (2006) applied Stafford and Warr's (1993) reconceptualization to recidivist drink drivers. Drivers who reported drink driving also reported avoiding punishment themselves, as well as witnessing friends avoiding punishment. These drivers also had lower levels of concern about being apprehended for drink driving (Freeman & Watson, 2006). A study by Piquero and Pogarsky (2002) also examined drink driving behaviour. They found that prior punishment did not deter offending, and experience of avoiding punishment appeared to act as encouragement to further offending. Similarly, in another study examining drink driving, Szogi et al. (2017) found that whilst there was evidence that being concerned about being apprehended and receiving a punishment can have an influence on drink driving behaviour, avoidance of receiving a punishment for the offence was more strongly associated with performance of the behaviour (Szogi et al., 2017). The study by Piquero and Paternoster (1998), included in Table 2.2, whilst considering a number of other factors, also applied Stafford and Warr's (1993) reconceptualised model of deterrence theory to drink driving. Like in the previous studies noted above, punishment avoidance (both for self and others) had a significant relationship with drink driving behaviour (Piquero and Paternoster, 1998). It is not just drink driving that Stafford and Warr's reconceptualised theory of deterrence has been applied. Watling et al. (2010) applied the theory to drug driving in Queensland, Australia. Once again, punishment avoidance of self and others were found to be predictors of future drug driving behaviour (Watling et al., 2010).

What emerges based on the studies outlined above that have applied Stafford and Warr's reconceptualization of deterrence theory, is that, while in some instances, experience of punishment does have a deterring influence, escaping punishment seems to be a more significant factor in predicting illegal driving behaviour. Of course, it is unrealistic to expect that every driver who engages in an illegal driving behaviour is going to be apprehended. Police simply do not have the resources. This of course opens up opportunity for drivers to offend, and at the same time, provides a level of encouragement for offending to occur, in cases where drivers believe the risk of apprehension is low. This provides a justification to

build on the research that examines other factors, including non-legal sanctions, that may have the potential to deter illegal driving behaviours. Furthermore, the examination of the perceptions that drivers have towards legal and non-legal sanctions provides a valuable opportunity to identify drivers who may be at greatest risk of performing illegal driving behaviours. Of course, there are many ways that drivers who may be at risk of performing illegal driving behaviour can be characterised. Personal factors, including personality traits are one such path. The following section explores the research in relation to *personality* and illegal driving behaviour. However, before covering this literature, a brief overview of the five-factor model of personality is provided.

2.7 Personality and driver behaviour

2.7.1 The Five-Factor model of personality

Historically, personality has been considered from many different perspectives (e.g. Barenbaum & Winter, 2008; Pervin, 1994). The most widely recognised approach to considering personality however is the Five-Factor model (e.g. Digman, 1990; Goldberg, 1993; John, Naumann & Soto, 2008; John and Srivastava, 1999; McCrae & John, 1992). As the name suggests, the Five-Factor model of personality, also known as the Big-Five personality factors, identifies five key factors that it is thought individuals differ on and can be understood by. Notably however, there has been disagreement amongst experts in personality research on how these five factors should be labelled (e.g. Digman, 1990; John, 1990). As research surrounding the five-factor model of personality has continued to evolve and develop, the five key factors that are most commonly accepted are: 1) conscientiousness; 2) extraversion; 3) agreeableness; 4) neuroticism; and 5) openness. A brief description of each of these five key factors is provided below.

Conscientiousness can be indicated by the display of behaviours such as being hard working, organised, placing priority upon being on time and meeting deadlines, being responsible and someone others can depend on. The opposite of someone who would be seen as conscientious would be someone who performs tasks in a careless manner, does not place priority upon planning or being on time, is irresponsible and cannot be relied upon by others (e.g. Jackson & Roberts, 2015).

Extraversion can be indicated by someone who enjoys the company of others and is talkative, social and dominant when with others. Comparatively, at the other end of the spectrum, a person who is not extraverted, but rather is introverted can be indicated by someone who enjoys spending time alone, is quiet and does not relish social situations and is highly independent (e.g. Wilt & Revelle, 2016).

Agreeable individuals can be described as those who seek to have positive interactions and relationships with the people around them, show sympathy, consideration, generosity, treat others with respect and as equals. At the other end of the spectrum, individuals scoring low on agreeableness may not interact well with others, and indeed may show aggressive or manipulative patterns of behaviour and little concern for other people (e.g. Graziano & Tobin, 2016).

Neurotic individuals can be described as those who display higher levels of negative emotions such as anxiety, worry, low mood, sadness and anger. At the other end of the spectrum, someone scoring low on neuroticism will be more stable with their emotions and may show more positive attitudes (e.g. Tackett & Lahey, 2016).

Finally, scoring highly on openness is associated with individuals who enjoy new experiences, display creative thinking patterns and a wide imagination. Comparatively, someone scoring low on openness likes routine, does not have a wide imagination, likes to see tasks through to completion in a set way and is reluctant to change (e.g. Sutin, 2015).

2.7.2 Existing research on the Five-Factor Model and road safety

The Five-Factor Model of personality has been drawn upon in a number of studies in road safety research, in efforts to understand driver behaviour from a personality perspective. This research has primarily aimed to understand how certain personality indicators may influence the performance of favourable or unfavourable patterns of driving. The research has been undertaken in many different countries globally and has considered a variety of different outcomes. The following sections provide an overview of literature that considers the Five-Factor model and illegal driving behaviours. Significant relationships are highlighted between risky driving and conscientiousness, extraversion, agreeableness, neuroticism and openness.

Whilst there are generally some personality traits that appear to emerge more consistently as either positively or negatively associated with risky and illegal behaviours, there are also some mixed results. In these cases, personality traits that show positive associations with risky driving behaviour in some studies, show negative associations with risky driving behaviour in other studies. It is notable that whilst the majority of studies have established one or multiple of the Five-Factor Model personality traits to have a significant association to an outcome indicative of risky and illegal driving behaviour, there are also a number of studies that have not found any of the five personality traits to have a significant relationship with such behaviour. Reference is also provided to this research following discussion of each of the personality traits.

2.7.2.1 Conscientiousness

Conscientiousness is one of the Big-Five personality traits for which quite consistent results in relation to risky and illegal driving behaviour have been identified. Specifically, studies have most commonly found that drivers scoring lower on conscientiousness are more likely to display higher levels of reckless and careless driving behaviours (and conversely, lower levels of patient and careful driving) (Ben-Ari and Yehiel, 2012), higher levels of risky driving outcomes (defined as involvement in a road accident, receiving a ticket for a traffic offence and suspension of a drivers licence) (Chraif et al., 2016), speed whilst driving a motor vehicle (Hong & Paunonen, 2009; Linkov et al., 2019), drive in an unsafe manner (Riendeau et al., 2018), self-report risky driving and violations (Šeibokaitė et al, 2014), self-report risky driving behaviour and acceptance of risky overtaking (Starkey & Isler, 2016) and display patterns of driving consistent with a risky and illegal style (Wang et al., 2018). Notably however, a study looking at distraction whilst driving (specifically the use of a mobile phone whilst operating a motor vehicle) found that amongst drivers aged 16-19 years, higher scores in conscientiousness were related to greater levels of mobile phone use whilst driving (Parr et al., 2016). This study is thus in contrast to the other studies highlighted above, where higher levels of conscientiousness are associated with safer and less risky patterns of driving behaviour.

2.7.2.2 Extraversion

Like conscientiousness, extraversion is another of the Big-Five personality traits for which consistent results have emerged in research that has sought to examine its association with

patterns of risky and illegal driving behaviour. Specifically, studies have tended to find that drivers scoring highly on extraversion are more likely to display higher levels of reckless and careless driving (Ben-Ari and Yehiel, 2012), higher levels of distraction whilst driving (amongst drivers aged 65+) (Parr et al., 2016), higher levels of unsafe driving (Riendeau et al., 2018) and higher levels of self-reported traffic violations (Šeibokaitė et al., 2014).

2.7.2.3 Agreeableness

In relation to the agreeableness factor, results have emerged to generally suggest that scoring highly on this personality trait is negatively associated with risky and illegal driving behaviour. This means that those scoring highly on agreeableness generally display safer patterns of driver behaviour, or alternatively those scoring low on agreeableness are more likely to display patterns of risky driving behaviour. Drivers scoring low on agreeableness have been reported to be more likely to display a reckless and careless style of driving behaviour (whilst those scoring highly on agreeableness were more likely to display a patient and careful driving style) (Ben-Ari and Yehiel, 2012), experience risky driving outcomes (road accidents, receive tickets for a traffic offences and suspension of a driver's licence) (Chraif et al., 2016), speed (Hong & Paunonen, 2009), receive traffic violation notices (Šeibokaitė et al., 2014), self-report risky driving behaviour and acceptance of speeding and risky overtaking (Starkey & Isler, 2016), display hooning patterns of driving behaviour (Thake, Armstrong & Leal, 2011), drive drunk (Vollrath, Knoch & Cassano, 1999), display patterns of driving that are consistent with a risky style (Wang et al., 2018) and use a mobile phone whilst driving (Parr et al., 2016).

2.7.2.4 Neuroticism

When compared to conscientiousness and agreeableness in particular, the results on neuroticism are more mixed. Some studies have found that individuals scoring highly on neuroticism display lower levels of risky driving behaviour, including speeding (Hong & Paunonen, 2009) and self-reported risky driving behaviour (Starkey & Isler, 2016).

Conversely, other studies have found that drivers scoring highly on neuroticism are at greater risk of displaying unsafe driving patterns in a simulator drive (Riendeau et al., 2018), driving in an illegal and risky manner (Zhang et al., 2018) and displaying negative patterns of driver behaviour (Shen et al., 2018).

2.7.2.5 Openness

Openness is a trait where there is more limited evidence of relationships to risky driving behaviour. Using a 35-item driving survey, that captured information on aggressive driving, risky driving, crashes and crash related events, Dahlen and White (2006) found that scoring low on openness was associated with the performance of risky driving behaviours, which can include for example not wearing a seatbelt whilst driving and passing another vehicle unsafely. Similarly, Wang et al. (2018) found that openness was associated with displaying a risky style of driving, including the performance of illegal driving behaviours. Parr et al. (2016) found that amongst young drivers (aged 16-19 years), those scoring highly on openness reported greater levels of mobile phone use whilst driving. Additionally, a study by Sârbescu and Maricutoiu (2019) found an association between lower levels of openness and traffic violations.

2.7.2.6 Non-significant relationships between personality and driver behaviour

Whilst the discussion above indicates that there are significant relationships, either positive or negative, between the Big-Five personality traits and risky and illegal driving behaviours, it is important to note that not all personality indicators were identified as statistically significant, in relation to risky and illegal driving behaviour in all studies. Furthermore, there is a body of research literature that suggests that none of the Big-Five personality indicators have a significant relationship with risky and illegal driving behaviours. When placing all the Big-Five traits into a model controlling for other factors, a study by Sârbescu and Maricutoiu (2019) found no traits had a significant relationship with violations. Indeed, studies in the broad area of personality and driving have also found the same pattern of non-significant relationships between personality and self-reported involvement in a traffic accident (af Wåhlberg, Barraclough & Freeman, 2017) and accident risk (Tao, Zhang & Qu, 2017) for example. These studies thus suggest that personality may not actually influence driving behaviour or alternatively that personality may influence driving behaviour through other factors or processes.

2.7.2.7 Other personality models and driver behaviour

Whilst the section above has focussed on road safety research using the Big-Five model of personality, it is important to note that existing research in the road safety area has used other models of personality (e.g. Classen et al., 2011; Jonah, 1997; Perry & Baldwin, 2000;

Scott-Parker et al., 2012; Scott-Parker et al., 2013). However, as noted earlier in this chapter, the Big-Five model of personality is the most widely recognised model. Drawing upon this model meant the research had a strong foundation, given its wide use in many areas of scientific research.

2.8 Combining perspectives to learn more about driver behaviour and deterrence

This chapter has so far highlighted two separate approaches, beyond traffic infringements, that have been applied to understanding illegal driving behaviour – one relating to expanded models of deterrence, and the second relating to the personality traits that drivers possess. These approaches have had success in identifying factors that may underlie the performance of illegal driving behaviours or how such behaviours might be successfully deterred.

A shortcoming of much of the research on deterrence that has seen it criticised by some scholars, is the general assumption that all offenders are the same, neglecting to take into account different offender typologies (Homel, 1988; Nagin & Paternoster, 1993). As Nagin and Paternoster (1993) indicated, there are two distinct theoretical perspectives that have been followed, in attempts to explain the performance of illegal behaviours. The first perspective is very much focussed upon the individual, and how their personal characteristics may be associated with offending (Nagin & Paternoster, 1993).

Characterising drivers in terms of personality can perhaps fall into this category.

Comparatively, the second perspective attempts to explain the performance of illegal behaviour in relation to factors that are in the immediate environment, in particular the situations that people experience at the time their choices are being made (Nagin & Paternoster, 1993). Perceptions towards potential deterrents, both legal and non-legal in nature can perhaps fall into this category (for example, feelings of support, or conversely, disapproval from peers to exceed the speed limit or drive after consuming alcohol).

Recognising that there is more than one perspective that can enhance understandings of the performance of illegal behaviour, Nagin and Paternoster (1993) proposed that theories of crime and offending could be enhanced by combining these perspectives.

Indeed, Montano and Kasprzyk (2008) argued that in order to develop effective interventions and policies to address problems and issues in society, it is essential that we

have a clear understanding and appreciation of the constructs that are the greatest predictors or contributors to an issue. Once we are aware of the constructs that are having the greatest influence, we can ensure that the interventions that are developed are targeted in areas that will have the greatest capacity to achieve change (Montano and Kasprzyk, 2008). In this process, we must also recognise that there is no single strategy that will be suitable for all circumstances (Montano and Kasprzyk, 2008). As Meier and Johnson (1977, p. 303) pointed out:

‘It is essential that we explore new research directions that conceptually anchor the deterrent effect among other mechanisms of social control and empirically focus on the relevant population parameters of noncompliance and compliance’

The literature in the area of road safety and deterrence has indeed taken a broader approach. In efforts to identify a range of constructs that may influence driver behaviour, theoretical perspectives have been combined. One approach has seen the combination of personality with attitudes and perceptions that drivers have towards illegal driving behaviour. Specifically, these studies have sought to examine whether personality has an influence on the attitudes and perceptions that drivers hold, which in turn has an influence on subsequent driving behaviour. It is this research which is considered within this final section of the current chapter – specifically how the relationship between *personality* and *driver behaviour* may operate.

2.8.1 Existing research that has combined perspectives that may explain illegal driving behaviour

In a study examining older road users in Italy, Lucidi et al., (2014) combined personality with an attitudes to road safety scale, to examine their influence on driving behaviour, through the use of the Driver Behaviour Questionnaire (DBQ), developed by Lawton et al. (1997). The study found that drivers who had higher anxiety scores and lower hostility and normlessness scores explained a relatively sizable proportion of the variance in attitudes. They also found that drivers who held positive attitudes in relation to safety on the roads, based on their responses to the attitudes scale, reported less traffic violations, lapses and errors on the DBQ. There were also direct relationships between some personality traits (hostility and excitement seeking) and lapses and errors (Lucidi et al., 2014).

Machin and Sankey (2008) also undertook a study that examined personality and perceptions in relation to driver behaviour, using data collected from young drivers aged 17-20 years studying at a university in Queensland, Australia. The study found that in some instances, perceptions to risk mediated the relationship between personality and speeding behaviour (Machin and Sankey, 2008). This study therefore highlighted the value in considering multiple factors together, and the additional insights they can provide to understanding driver behaviour.

Ulleberg and Rundmo (2003) examined how attitudes and risk perceptions may mediate the relationship between personality and speeding behaviour. This study also examined young drivers, and was conducted in Norway. Like Machin and Sankey (2008), Ulleberg and Rundmo (2003) also found that the effect of personality on driving behaviour was indirect, mediating through the attitudes that drivers expressed.

The mediating influence of perceptions and attitudes between personality and driver behaviour has been identified in other studies too, focussed on very specific subsets of drivers, or in specific driving situations. For example, Mallia et al. (2015) specifically focussed on bus drivers. This study also found that relationships between personality and driver behaviour mediated through attitudes relating to traffic safety, which then went on to influence the performance of risky and illegal driving behaviours (Mallia et al., 2015). Similarly, Steinbakk et al. (2019) also examined the relationship between personality and driver behaviour, and the role that attitudes and risk perception may play in this relationship, focussing on speeding specifically in areas where there were road works. Whilst the approach they took was quite different, asking drivers to indicate the speed they would see as appropriate to drive at when presented with video footage of a road, they also found the relationship between personality and driver behaviour was mediated by attitudes, in this case, to speed (Steinbakk et al., 2019).

2.9 Where are the gaps in expanded models of deterrence and personality literature in relation to driver behaviour?

The literature examined in Sections 2.6 and 2.7 of this chapter highlighted that there are a number of other approaches, beyond legal sanctions, that have been used to consider patterns of driver behaviour and deterrence. It is evident that in addition to, or maybe even rather than legal sanctions, non-legal sanctions may affect driving behaviour. In addition,

driver personality may also have a significant influence on the driving patterns that drivers display. However, as Section 2.8 showed, there are several studies that have taken a step further, examining whether personality may influence the attitudes and perceptions that drivers have towards illegal driving behaviour, which in turn may influence driver behaviour. There are however two main points that can be made in relation to the methodological approaches taken by these studies that highlight further research may be beneficial. First, these studies did not use the popular Big Five Model of personality, for which the research was examined in Section 2.7. As noted, the Big Five is a widely used model of personality and its application in research alongside other factors would likely be able to provide valuable understandings. Second, the attitudes and perceptions factors that were considered were not as neatly grouped when compared to the research that examined perceptions to legal and non-legal sanctions, examined in Section 2.6.

Despite these limitations, there was clear evidence of one key factor – when considering driver behaviour, and the factors that underlie the performance of risky, dangerous and illegal driving actions, it is important to examine potential relationships from a broad, multilayered approach. Indeed, this is consistent with McCrae and Costa's (1995) suggestion that personality traits influence habits and attitudes, which in turn can influence the actions a person takes. A multilayered approach enables recognition that, despite there being evidence to suggest a direct relationship between personality and illegal driving behaviour, it may be rather the case that personality is acting through some other construct that has an even closer relationship to risky driving. Furthermore, a multilayered approach means that more detailed understandings of the way in which different personality types may interact with attitudes and perceptions towards potential deterrents can be understood.

Despite expanded models of deterrence in road safety research growing in popularity over the last 50 years, much of this research has been undertaken in jurisdictions outside of Victoria, Australia. Furthermore, it is important to note that, irrespective of jurisdiction, perceptions towards different issues in society change overtime, including in relation to road safety (Kennedy, 2009a). As Kennedy (2009a) highlighted, these changes can impact the effectiveness of different sanctions. Changes in the economic climate, in community views and attitudes towards acceptable and unacceptable forms of behaviour and the level of respect that is directed towards those who have a responsibility to deliver sanctions can

all have an impact on how sanctions are perceived (Kennedy, 2009a). Therefore, continued research using expanded models of deterrence can provide understandings reflective of current circumstances.

Study three of this PhD will seek to further enhance the expanded models of deterrence literature in four broad ways. First, the research seeks to provide understandings of a broad range of factors that may underlie illegal driving behaviour and deterrence in Victoria, Australia, given the lack of such research that has been undertaken in this jurisdiction. Second, the research uses the five-factor personality model, given its popularity as a measure of personality. Third, the research applies a conceptual model developed as part of this PhD, that examines the mediating influence that some of the legal and non-legal sanctions that were considered in the research reported in Table 2.2 may have between the five-factor personality traits and driver behaviour. As noted, the attitude and perceptions variables applied in the existing research that has combined perspectives (explored in Section 2.8) were quite different to those considered in the expanded models of deterrence research in Table 2.2. Using the legal and non-legal sanctions variables as mediators may enable new understandings of the relationship between personality and driver behaviour. Fourth, much of the research considered in Section 2.8 used the DBQ as the outcome variable, whereas the expanded models of deterrence research in Table 2.2 most commonly used either past or expected patterns of future driving behaviour. Study three therefore also uses expected future driving behaviour in the multilayered model developed for this study, to seek to build upon the expanded models of deterrence literature.

2.10 Conclusion

In summary, the research examined in this chapter has identified three key areas in particular, where further research is required, to enhance understandings of deterrence and illegal driving behaviour. Specifically, further research is needed to 1) examine how long, if at all, there is evidence of a deterring influence upon traffic offending following an infringement for a driving offence in Victoria, Australia; 2) examine the deterring influence of traffic infringements upon subsequent crash involvement in Victoria, Australia; and 3) examine a broader range of factors that may influence the performance of illegal driving behaviour in Victoria, Australia.

Together, addressing each of these aims has the potential to enhance understandings of driver behaviour and deterrence specifically in Victoria, Australia, but also contribute to the body of literature on deterrence for traffic offences more broadly, beyond the Victorian jurisdiction. The following chapter will provide details of the theoretical frameworks that were used to guide the research contained in this thesis.

Chapter Three: Theoretical frameworks for the thesis

3.1 Introduction

The overall aim of this PhD research was to understand factors that may achieve deterrence (or alternatively act against successful deterrence) from the performance of illegal driving behaviours. Three separate, but closely related research studies were undertaken, each with a set of aims and research questions to be addressed. To achieve the thesis aims, three conceptual and theoretical frameworks were utilised to guide the research. These frameworks were the Safe System Approach, Haddon's Matrix and deterrence theory. These frameworks guided the research in different ways. First, the Safe System Approach and Haddon's Matrix highlight that amongst other factors, humans play a role in the incidence of road trauma, and thus, research that investigates how this contribution might be most effectively addressed is important. Second, deterrence theory provides a theoretical perspective from which the contribution that human behaviour in road trauma can potentially be successfully addressed. The following sections outline each of these frameworks and provide further details of their significance to the current PhD research.

3.2 Safe System Approach

2011-2020 has officially been declared the Decade of Action for Road Safety (United Nations Road Safety Collaboration, 2010). The goals of the Decade of Action for Road Safety are to first stabilise the road toll across the globe, but then, more importantly, to promote efforts to reduce the number of fatalities that occur as a result of road trauma (United Nations Road Safety Collaboration, 2010). Activities that have and are taking place over the Decade of Action, both within individual countries and at a global level, are structured around five action pillars: 1) Road safety management; 2) Safer roads and mobility; 3) Safer vehicles; 4) Safer road users; and 5) Post-crash response. The Decade of Action for Road Safety is built around the Safe System Approach, and provides guidance to countries all around the world in developing their respective road safety strategies.

A number of countries, including Australia (Australian Transport Council, 2011), and the states and territories within Australia, have adopted the Safe System Approach to underpin their road safety strategies. These include the Australian Capital Territory (ACT Government Justice and Community Safety Directorate, 2011), New South Wales (Transport for New

South Wales, 2012), the Northern Territory (Northern Territory Government Department of Infrastructure, Planning and Logistics, 2018), Queensland (Queensland Government Department of Transport and Main Roads, 2015), South Australia (Government of South Australia Department of Planning, Transport and Infrastructure, 2018), Tasmania (Tasmanian Government Department of State Growth, 2016), Western Australia (Government of Western Australia Road Safety Commission, 2009) and Victoria (Transport Accident Commission et al., 2016). Victoria is the state for which this research is of particular significance.

The Safe System Approach aims to create a safe road system for all users, and move towards zero fatalities and serious injuries as a result of crashes. The approach emphasises the importance of a road system that recognises humans make mistakes, but that these mistakes should not mean serious injuries and fatalities are to be accepted (United Nations Road Safety Collaboration, 2010). In seeking to achieve the goals of the Safe System Approach, road safety is promoted as a shared responsibility, with many different individuals and groups having a role to play in reducing road trauma (Organisation for Economic Co-operation and Development, 2008; United Nations Road Safety Collaboration, 2010). Whereas in the past, the responsibility was placed upon individual road users to behave in a manner that promoted road safety, the Safe System Approach has contributed to a shift in thinking (Organisation for Economic Co-operation and Development, 2008). Individuals in positions of professional responsibility, such as those designing roads and vehicles, enforcing road rules and making decisions in relation to effective interventions now have a greater role to play in enhancing road safety (United Nations Road Safety Collaboration, 2010).

Despite this shift, the responsibilities that road users have in creating a safe road transportation system are still an integral part of the Safe System Approach. Indeed, four key elements of a safe road system are highlighted in the approach: safe roads, safe speed, safe vehicles and safe people. Key aspects of each of these four elements of the safe system approach are summarised below.

Safe Roads: This element of the Safe System Approach recognises that infrastructure plays an integral role in helping to prevent crashes from occurring and in cases where a crash does occur, has the potential to reduce the severity of the injuries sustained. Design and

construction of safe roads is at the core of this element. This can include installing barriers, divided roads, sealed shoulders, rumble strips and traffic calming treatments (Australian Transport Council, 2011).

Safe Speeds: This element of the Safe System Approach recognises the importance of setting speed limits that are appropriate for the road on which they are designated. This element also recognises the need for drivers to travel within the speed limit, or at a speed that is appropriate for the conditions. Safe speeds have an important role to play in reducing the forces that people are subject to in the event of a crash, subsequently having the potential to reduce the risk of injuries (Australian Transport Council, 2011).

Safe Vehicles: This element of the Safe System Approach recognises the role that vehicles equipped with safety features can achieve in reducing serious injuries and fatalities. Features available in vehicles to promote safety have increased substantially overtime. Technologies such as anti-lock braking systems, electronic stability control, auto-emergency braking systems, lane departure warning or lane keep assist systems, and blind spot monitoring systems all have the potential to prevent crashes from occurring. In the event a crash does occur, vehicles equipped with airbags and structures that are able to absorb the forces of collisions provide protection for vehicle occupants. Recognising the benefit of these safety features, the Safe System Approach seeks to promote and in some cases, mandates their integration into the vehicle fleet (Australian Transport Council, 2011).

Safe People: This element of the Safe System Approach recognises the important role that all road users have in using the roads in a responsible and safe manner. Whilst this can include driving appropriately for the road conditions, weather conditions, traffic conditions and in accordance with one's personal capabilities and the capabilities of the vehicle they are operating, it also includes abiding by the road laws. By encouraging everyone to comply with the rules, through education, enforcement and the use of penalties, the aim is to reduce the number of people that make mistakes on the roads that would have been preventable, had they been driving in a manner consistent with the road rules that operate. This in turn has the potential to reduce the number of serious injuries and fatalities that occur on the roads (Australian Transport Council, 2011).

All elements of the Safe System Approach are essential in achieving safety across the road network. Unfortunately, the performance of illegal driving behaviours poses a significant barrier to achieving success in relation to the 'Safe People' element. As indicated above, this element of the Safe System Approach recognises the instrumental role that road users have in behaving in an appropriate manner when they are using the road network, to ensure safety for both themselves and other road users. This element also highlights the importance of having well developed education initiatives, appropriate enforcement practices and adequate penalties for illegal driving behaviours - all factors that may contribute towards achieving a safe road system. The element of 'Safe Speeds' also promotes the importance of using the roads in an appropriate, and indeed legal manner. One component of the 'Safe Speeds' element is also relevant to illegal driving behaviour, given as indicated above there is reliance on drivers obeying the speed limit as another step to achieving safety on the roads.

Recognising the effect that illegal driving behaviours have on the road toll, and working within the Safe System Approach, the current Road Safety Strategy that operates in Australia contains a number of directions that specifically seek to prevent the performance of illegal driving behaviours on the roads, and in turn create safer road networks (Australian Transport Council, 2011). The goals to achieve by the end of the current strategy, concluding in 2020, that relate directly to illegal driving behaviour on the roads are (Australian Transport Council, 2011):

'Elimination of driving while impaired by alcohol or drugs as significant contributors to road trauma' (pg. 91)

'Elimination of illegal mobile phone use while driving' (pg. 91)

'A substantial reduction in the rate of those driving without a licence' (pg. 91)

'All vehicle occupants are effectively restrained' (pg. 91)

Importantly, the current Australian Road Safety Strategy emphasises the value of ongoing research in informing the continued development of effective actions that promote safety on the roads (Australian Transport Council, 2011). Recognising this, the research in this thesis is aligned with the Australian Road Safety Strategy, and specifically addresses the

‘Safe People’ element of the Safe System Approach, as well as parts of the ‘Safe Speeds’ element. This highlights that the research in this thesis is timely and significant.

3.3 The Haddon Matrix

The Safe System Approach has its foundation in the work of William Haddon Junior, who developed a matrix that has come to be known as the ‘Haddon Matrix’ (Haddon, 1972). The Haddon Matrix provides an approach to conceptualising risk factors for crashes. The Haddon Matrix suggests that risk factors exist before a crash, during a crash and following a crash, within environmental, vehicle and person domains (Haddon, 1972, 1980). Haddon’s approach allows for the development of countermeasures based on each of these domains, that can prevent a crash occurring, prevent or reduce the severity of injuries if a crash does occur, and finally, ensure that the systems in place to respond after crashes are such that the most optimal outcomes possible can be achieved (Haddon, 1972, 1980). An image to provide a visual depiction of Haddon’s Matrix is provided in Figure 3.1.

The performance of risky and illegal driving behaviours as a risk factor for crashes can be placed at the pre-crash stage of Haddon’s matrix, and relates to person factors. In his approach, Haddon (1972) highlighted the importance of countermeasures at the crash and post-crash stage, given their strength in improving the outcomes of crashes, rather than relying on humans to regulate their own behaviour in the pre-crash phase. This certainly does not mean that research focussed on human behaviour, as means of preventing crashes, is not timely and worthwhile. Notably, it was not Haddon’s aim to suggest that human behaviour should be discounted from examinations of the best strategies to achieve safety on the roads. Rather, he recommended a holistic strategy should be implemented, ensuring countermeasures are used from each of the pre-crash, crash and post-crash phases (Haddon, 1975).

		FACTORS		
PHASE		HUMAN	VEHICLES AND EQUIPMENT	ENVIRONMENT
Pre-crash	Crash prevention	Information Attitudes Impairment Police enforcement	Roadworthiness Lighting Braking Handling Speed management	Road design and road layout Speed limits Pedestrian facilities
Crash	Injury prevention during the crash	Use of restraints Impairment	Occupant restraints Other safety devices Crash protective design	Crash-protective roadside objects
Post-crash	Life sustaining	First-aid skill Access to medics	Ease of access Fire risk	Rescue facilities Congestion

Figure 3.1 Image of Haddon's Matrix ¹

¹ Reprinted from the World Health Organization Road Traffic Injury Prevention Training Manual, Mohan, D., Tiwari, G., Khayesi, M., & Muyia Nafukho, F., page 24., Copyright (2006). https://apps.who.int/iris/bitstream/handle/10665/43271/9241546751_eng.pdf?sequence=1&isAllowed=y

This Haddon Matrix was developed by the above-mentioned authors, based upon content in: Haddon Jr, W. (1980). Advances in the epidemiology of injuries as a basis for public policy. *Public Health Report*, 95, 411-421.

Mohan et al., (2006) applied Haddon's Matrix (Figure 3.1), highlighting risk factors and countermeasures that can operate at the pre-crash, crash and post-crash phases, relating to the environment, vehicle and person. When thinking about the pre-crash stage, more specifically crash prevention, and how people might play a role here, they identified information, attitudes, impairment and police enforcement as central factors (Mohan et al., 2006). The inclusion of 'police enforcement' as a countermeasure in the application of Haddon's Matrix by Mohan et al (2006) also promotes the importance of individuals in positions of responsibility having an important role in working towards crash prevention.

In particular, attitudes and police enforcement as deterrents of the performance of illegal driving behaviour are addressed in the research in this thesis. In studies one and two, the influence of traffic infringements (an important component of police enforcement) in changing subsequent driving behaviour is explored. In study three, perceptions towards factors that may deter the performance of illegal driving behaviours (which may be closely related to a driver's attitudes) are explored.

3.4 Deterrence Theory

Deterrence theory complements both the Safe System Approach and Haddon's Matrix, and provided the overarching theoretical framework that guided the research presented in this thesis.

Deterrence theory is based upon the premise that individuals in our society undertake a rational and calculated decision-making process prior to performing a behaviour, weighing up the costs and benefits of obeying or not obeying the law (Hucklesby, 2004; Kennedy, 2009b; Muncie, 2004). In order to be deterred from performing an action, an individual must come to the conclusion that the potential costs they will experience should they be apprehended and receive a legal sanction, will outweigh the benefits they will experience from performing the action (Hucklesby, 2004; Kennedy, 2009b; McLaughlin, 2006).

Deterrence has a long history in the criminological literature, and the way in which we understand deterrence today can be traced back to a number of key early thinkers in the area – namely Thomas Hobbes, Cesare Beccaria and Jeremy Bentham (Brown, Finn-Aage & Geis, 2015). Their work is central to the three characteristics of effective deterrence – these being that penalties need to be certain, swift and severe (Paternoster & Bachman, 2012).

Each of these characteristics of effective deterrence is briefly described below, and placed in the context of illegal driving behaviour.

3.4.1 Characteristics of effective deterrence

The first characteristic of effective deterrence is that of certainty. When an illegal act is performed, punishment for the act should follow. Thus, for individuals to be deterred from performing an illegal behaviour, they must have a reasonably high belief that they risk being apprehended and punished if they do perform the behaviour (Akers & Sellers, 2004). For people to be deterred from performing an illegal driving behaviour, they must be of the belief that there is a high risk of being apprehended by police, or captured by a road safety camera.

The second characteristic of effective deterrence is that of severity. For a penalty to effectively deter the performance of an illegal behaviour, it must be severe enough such that a person reaches the conclusion they are likely to experience greater costs than benefits (Akers & Sellers, 2004). This means that a penalty that is not severe enough has little chance of deterring the performance of the behaviour that it is designed to address. The severity of penalties must also be appropriate for the offence (Akers & Sellers, 2004). Thus, for less serious offences, the penalty should also be less severe. Comparatively, for more serious offences, the penalties should be more severe. For people to be deterred from performing illegal driving behaviours, they must view the infringement they would receive as severe. This may include a monetary fine that is large enough to result in financial disadvantage to an individual, or alternatively, enough demerit points to make an individual feel concern about potential consequences for remaining licensed into the future. Furthermore, as some driving offences are more serious than others (for example, speeding at 25km/h above the speed limit compared to speeding at 10km/h above the speed limit), the severity of sanctions imposed must reflect the higher level of seriousness of the higher speeding category.

The third and final characteristic of effective deterrence is that of swiftness. For a penalty to effectively deter the performance of a behaviour, it must come quickly after the offence is performed, such that an individual develops an association between the punishment received and the action performed (Akers & Sellers, 2004). Thus, for an individual to be

deterred from performing a particular action, they must have a reasonable belief that they can expect to be punished within a short space of time and face the consequences of their actions quickly. For people to be successfully deterred from performing illegal driving behaviours, they must have a reasonable belief that they will receive a penalty soon after. This could include, for example, receiving a penalty notice soon after performing a behaviour that requires them to pay a monetary fine and also places demerit points on their licence. There can, however, be delays, that differ by offence type. For example, a speeding driver may receive an on-the-spot fine if apprehended by police, or a fine sent in the mail if they are captured by a fixed or mobile speed camera. The different modes of apprehension thus impact the swiftness with which a sanction is received, and subsequently may potentially impact its effectiveness in achieving deterrence.

3.4.2 Types of deterrence

The concept of deterrence can be separated into two broad types – general deterrence and specific deterrence (McLaughlin, 2006; Muncie, 2004). These two types of deterrence recognise that, depending on patterns of offending in the past, enforcement impacts individuals in different ways.

General deterrence refers to the way in which the operation of enforcement and legal sanctions can result in members of society in general refraining from the performance of illegal behaviours. General deterrence can occur through a person being aware that they may be apprehended and that sanctions exist. People must be aware that if they perform an illegal behaviour, they are at risk of being punished for their actions. This awareness would hopefully see them change their intentions to commit an offence. General deterrence can emerge through observing police out in public spaces enforcing laws and regulations, observing other individuals receiving sanctions for illegal behaviours, or through seeing campaigns that create awareness of the potential legal consequences (McLaughlin, 2006; Muncie, 2004).

Applying general deterrence in the road safety and driver behaviour context, a person who observes police out on the roads undertaking highway patrols, or performing duties such as random breath testing, roadside drug testing and monitoring speeds of vehicles, may be

deterred from performing illegal driving behaviours, out of concern or fear of being apprehended.

Furthermore, drivers who view other road users, family or friends being apprehended and sanctioned for illegal driving behaviours may be deterred from performing the behaviour themselves. Media campaigns, such as those run by the Transport Accident Commission (TAC), which promotes road safety in Victoria, may also have a general deterring effect. These advertisements highlight the consequences a person may experience if they engage in illegal driving behaviours (Transport Accident Commission, 2020b).

In comparison, specific deterrence refers to the way in which directly receiving a legal sanction for the performance of an illegal behaviour can result in an individual refraining from further performance of offending behaviour. This may occur as a result of a person fearing they will be apprehended and punished again if they perform the behaviour in the future, as well as recognising the punishment had a negative impact upon them, and therefore they wish to avoid receiving further punishments (McLaughlin, 2006; Muncie, 2004).

In the area of road safety and driver behaviour, specific deterrence may occur, for example, after a person receives a traffic infringement for performing a behaviour such as speeding, failing to stop at a red light or using a mobile phone whilst driving. If receiving punishments for these behaviours has the desired deterring effect, the individual will change their driving behaviour, to ensure they do not subject themselves to further punishments again in the future.

3.5 Conceptual model for the research

A conceptual model for the thesis was developed, taking into account the role that 'safe people' play, in the Safe System Approach, the importance of road user behaviour in the pre-crash stage of Haddon's Matrix, in addition to deterrence theory (Figure 3.2). It was hypothesised that relationships exist between illegal driving behaviour, deterrence, infringements and crashes. Two of these relationships were explored in the research in this thesis. These relationships are indicated by the blue arrows.

First, a relationship exists between illegal driving behaviour and infringements (Figure 3.2). This is already well established, given that for a driver to receive a traffic infringement, an

illegal driving behaviour must have been performed. Furthermore, the model also proposes that the relationship between illegal driving behaviour and infringements operates in the opposite direction, and that deterrence may impact this relationship. The deterring influence of infringements on illegal driving behaviour, is addressed in studies one and three.

Second, it is proposed that a relationship exists between illegal driving behaviour and crashes (Figure 3.2). Thus, the conceptual model draws relationships between infringements and deterring illegal driving behaviour, and illegal driving behaviour and crashes. It is this relationship, specifically that infringements may deter illegal driving behaviour, and subsequently reduce crash risk, that is assessed in study two.

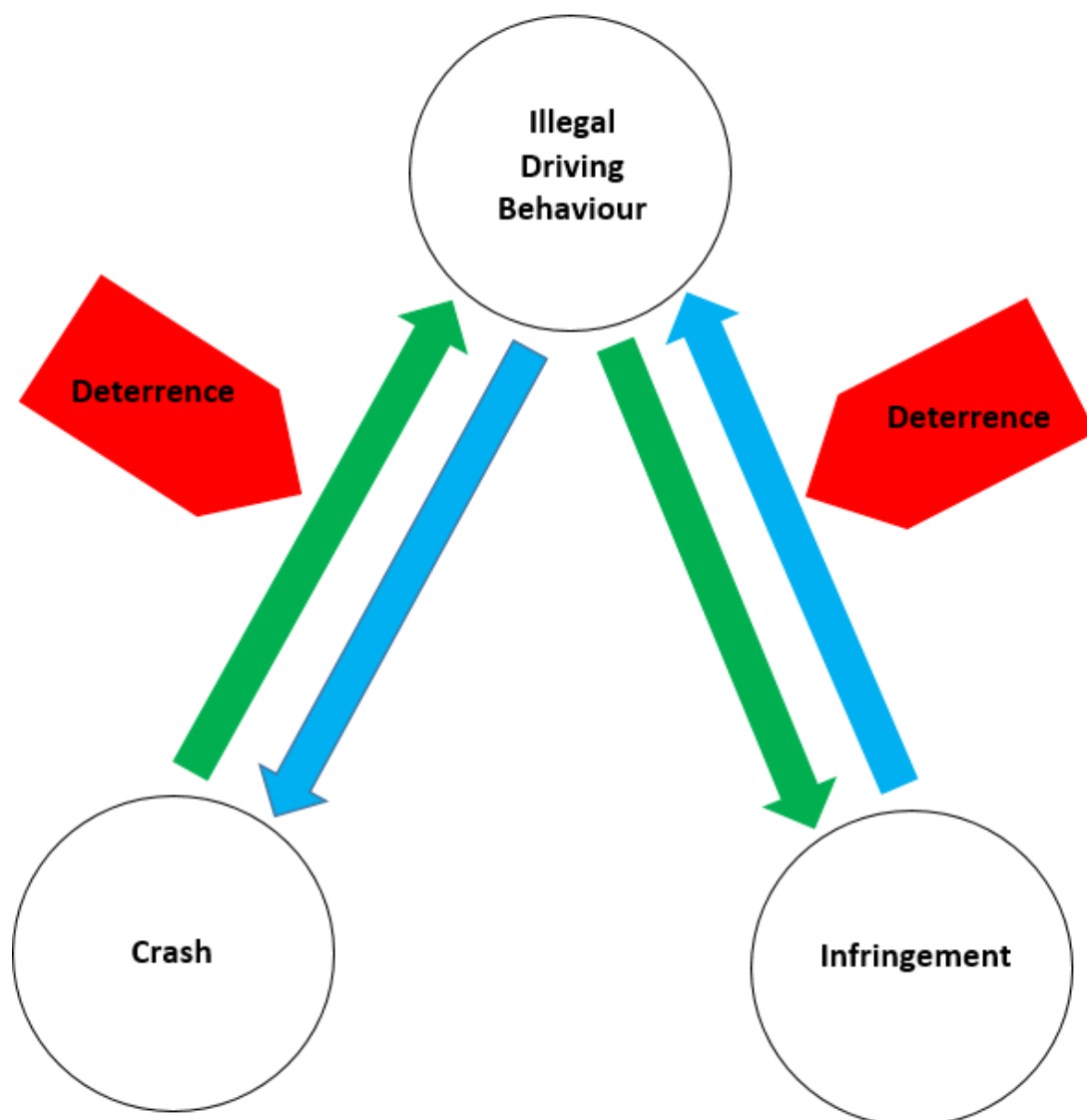


Figure 3.2 Conceptual model showing relationships between illegal driving behaviour, infringements, deterrence and crashes

Finally, there may be a relationship between crashes and illegal driving behaviour. Specifically, after involvement in a crash, it is possible that some drivers may change their driving behaviour in response to this experience. It is also possible some drivers may not be deterred by this experience, and will continue to drive in a manner that places them at further risk. This pathway is also indicated in Figure 3.2. Exploration of this relationship was beyond the scope and aims of this thesis. The relationship is included in Figure 3.2 to ensure a complete picture of the various interactions that may occur between illegal driving behaviour, deterrence, infringements and crashes.

3.6 Expanded model of deterrence

Whilst the theoretical model outlined above and provided in Figure 3.2 guided the research overall, study three of this PhD sought to examine more complex relationships that included personality, legal and non-legal sanctions. This study was therefore also guided by a more detailed conceptual model (Figure 3.3). Based upon the review of the literature in chapter two, the model proposed a number of relationships that exist between personality, perceptions towards potential deterring factors and expectations to perform an illegal driving behaviour (i.e. drivers believe they will perform an illegal driving behaviour in the following twelve months). The following pathways listed below are proposed in the model in Figure 3.3. It is important to note that while each construct in the model was considered independently, it should not be taken from this that each acts independently. For example, it is possible that perceptions of guilt and shame are closely related to perceptions of social norms and disapprovals. It is also possible that perceptions of these two factors emerge by reason of enforcement and knowing the behaviours are illegal.

- 1) Influence of personality on:
 - a. expectations to perform illegal driving behaviour/s
 - b. perceptions of enforcement
 - c. perceptions of crash risk
 - d. perceptions of social norms and disapproval
 - e. perceptions of negative personal and emotional affect
- 2) Influence of perceptions of:
 - a. enforcement on expectations to perform illegal driving behaviour/s
 - b. crash risk on expectations to perform illegal driving behaviour/s

- c. social norms and disapproval on expectations to perform illegal driving behaviour/s
 - d. negative personal and emotional affect on expectations to perform illegal driving behaviour/s
- 3) Mediating influence of perceptions of:
- a. enforcement, between personality and expectations to perform illegal driving behaviour/s
 - b. crash risk, between personality and expectations to perform illegal driving behaviour/s
 - c. social norms and disapproval, between personality and expectations to perform illegal driving behaviour/s
 - d. negative personal/emotional affect, between personality and expectations to perform illegal driving behaviour/s

Expectations of the performance of illegal driving behaviours used to examine the model were:

- 1) Driving with a Blood Alcohol Concentration (BAC) above the legal limit
- 2) Driving after using an illicit drug/s
- 3) Speeding – including differing levels of speeding severity:
 - a)** Driving at up to 10km/h above the speed limit; and
 - b)** Driving at more than 10km/h above the speed limit
- 4) Using a handheld mobile phone whilst driving
- 5) Failing to stop at a red light

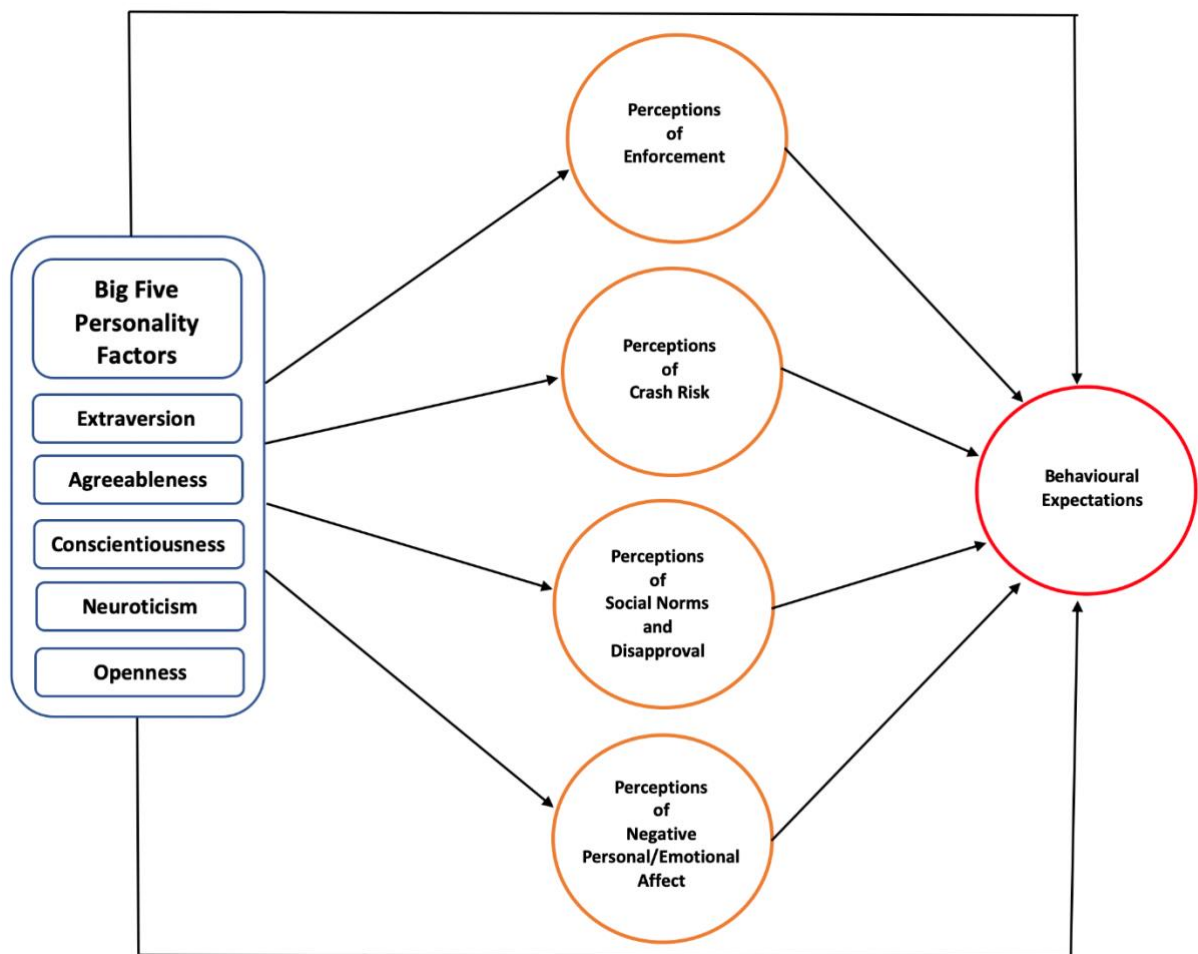


Figure 3.3 Conceptual model for examination in study three showing pathways that may exist between personality, perceptions of potential deterrents and behavioural expectations

3.6.1 Details of each construct in the theoretical model

3.6.1.1 Personality

As indicated in chapter two, research has found evidence to suggest that a person's personality influences their driving behaviour. Furthermore, there is evidence that the relationship between personality and driver behaviour may interact with other factors to influence driving behaviour.

The Five Factor model of personality was therefore included in the conceptual model to understand drivers on the five personality traits of: 1) conscientiousness; 2) extraversion; 3) agreeableness; 4) neuroticism; and 5) openness (e.g. Digman, 1990; Goldberg, 1993; John, Naumann & Soto, 2008; John and Srivastava, 1999; McCrae & John, 1992).

3.6.1.2 Perceptions of enforcement

This construct was included in the model to understand deterrence from a classical perspective, that is, based on legal sanctions. As Kennedy (2009a) noted, it is not necessarily the actual penalties that have a deterring effect, but rather the perceptions that people have, including what they believe could happen to them if they were to engage in a criminal act. This construct was therefore interested in understanding the perceptions drivers had towards the certainty and severity of legal sanctions.

3.6.1.3 Perceptions of crash risk

Many road safety campaigns, including those developed by the TAC, take an approach of highlighting the potential consequences that can occur when drivers engage in illegal driving behaviours. An approach taken in some campaigns is to show crashes that lead to road users being seriously injured or killed as a result of speeding, driving after drinking alcohol, or using illicit drugs (Transport Accident Commission, 2020b). Thus, given this is a strategy used by road safety agencies to encourage safe driving behaviour, this construct was therefore included in the model to understand the perceptions that drivers have in relation to crash risk if they engage in illegal driving behaviours.

3.6.1.4 Perceptions of social norms and disapproval

Humans place great value on social relationships and connections (e.g. Cacioppo & Patrick, 2008). The need for social connection exerts great influence upon patterns of behaviour (e.g. Walton et al., 2012). Thus, patterns of behaviour are often reflective of the perceptions a person has of how others think they should behave (e.g. Ajzen, 2011; Moan & Rise, 2011; Vereeck & Vrolix, 2007).

Moral beliefs are also associated with patterns of behaviour (e.g. Bradford et al., 2015; Silberman, 1976), with a person likely to avoid performing a behaviour that goes against their moral values (e.g. Jackson et al., 2012; Tyler, 2006; Van Damme & Pauwels, 2016) or that they see as wrong (e.g. Foglia, 1997; Paternoster & Simpson, 1996). The moral values a person holds are also guided by society, including feeling a sense of loyalty and obligation (e.g. Wheeler, McGrath & Haslam, 2019). Alternatively, a person may perform a behaviour because they get a sense of enjoyment and satisfaction out of that behaviour, and do not feel that its performance is morally wrong (Tyler, 2003).

It has been suggested that social sanctioning is the most significant form of sanctioning for illegal behaviour (Gottfredson & Hirschi, 1990). As indicated in the review of the literature, social factors have been found to exert significant influence over driver behaviour. This construct was therefore included in the model to understand the perceptions that drivers have in relation to the social consequences of illegal driving behaviour.

3.6.1.5 Perceptions of negative personal and emotional affect

Research has found that anticipation of feeling negative emotions can play a role in an individuals' decision to engage in illegal behaviour, across a range of different offences and offender groups (e.g. Sandberg & Conner, 2008; Svensson, Pauwels & Weerman, 2017; Wang & McClung, 2012). Existing road safety research has used negative emotions including shame (e.g. Freeman, Liossis & David, 2006; Sherman, Strang & Woods, 2000) and guilt (e.g. Grasmick & Bursik, 1990; Freeman et al., 2006). Furthermore, Braithwaite (1989) proposed the theory of reintegrative shaming as a way to achieve deterrence and lower crime rates. This construct was therefore included in the model to understand whether individuals believe illegal driving behaviours can have personal and emotional consequences.

3.6.1.6 Expectations to perform the illegal driving behaviours of interest

Expectations to perform each of the illegal driving behaviours listed earlier in this section was the outcome of interest in the conceptual model. Whilst previous criminal behaviour is considered to be a strong predictor of future criminal behaviour (Gottfredson & Hirschi, 1986; Nagin & Paternoster, 1991), a decision was made not to use this indicator as the outcome in the current study.

The perceptions a person has in relation to potential deterrents are not stable (Grasmick & Bursik, 1990; Minor & Harry, 1982; Paternoster et al., 1983a; Saltzman et al., 1982). Given the fluidity of perceptions, if drivers had been asked about their past patterns of behaviour, it would not have been possible to establish the nature of their perceptions towards the four deterring factors at the point of the previous offending behaviour. This would have made it difficult to draw any meaningful connections between the perceptions factors and the outcome variable.

As Greenberg (1981) and Paternoster et al. (1983b) indicated, the perceptions that a person has towards factors associated with illegal behaviour may be a consequence of their past

behaviour. Indeed, when considering drivers' perceptions in relation to driving behaviour, these perceptions may have altered following previous experiences of receiving an infringement, being involved in a crash, experiencing approval or disapproval from friends or family members and experiencing positive or negative emotions following performance of an illegal driving behaviour.

Intentions to perform a behaviour have been promoted as a good indicator of the actual patterns of behaviour a person will display and have been used successfully in existing research in the deterrence area, across a range of offence types (e.g. Ajzen, 2005; Bachman, Paternoster & Ward, 1992; Nagin & Paternoster, 1994). The suitability of using expectations of future patterns of behaviour was further supported by a longitudinal study undertaken by Green (1989), who collected data on two drink driving outcomes: 1) estimates of future drink driving behaviour and; 2) actual drink driving behaviour measured at follow-up. He found that the legal and non-legal sanctions predicting both outcomes were consistent, providing support for cross-sectional research that uses predicted future behaviour as a reliable substitute for actual future behaviour. Furthermore, two wave longitudinal study data became a popular approach to undertaking perceptual deterrence research, however Lundman (1986) argued that cross-sectional designs, where perceptions and future behavioural information are collected at one point in time can provide high-quality data, without the additional barriers that longitudinal research brings. This further supports the use of future behaviour as an appropriate outcome variable.

In the current study, the outcome variable was framed as an expectation rather than an intention, given illegal driving behaviour is not necessarily a planned and premeditated behaviour. For example, an individual may not plan to use a mobile phone whilst driving; however, if a text message or call is received during a journey, they may find it difficult to resist the urge to engage with the person sending the text or making the call. Thus, by using expectations, rather than intentions, the aim was to capture drivers' acceptability toward each illegal driving behaviour, and beliefs they have regarding each as a type of behaviour they may perform.

3.6.1.7 Conclusions on the expanded theoretical model

This section has provided a brief description of each construct included in the conceptual model shown in Figure 3.3. Whilst the developed model provides a variety of constructs, it

should not be taken to suggest this model represents a complete conceptualisation of deterrence. Indeed, other models in the existing body of research, such as Stafford and Warr's (1993) reconceptualization of deterrence theory and Homel's (1998) model to examine drink driving, have sought to consider a different range of factors. The model described in this chapter therefore presents another perspective from which deterrence can be considered. Furthermore, the use of the word 'expanded' should not be considered to be suggestive of an attempt to expand the widely accepted classical deterrence theory (described in section 3.4). The term 'expanded' rather should be taken to mean that the model is seeking to consider a broad range of factors that have the potential to deter illegal driving behaviour.

Finally, as noted, this model was examined in study three. Methodological details on how each construct was measured are provided in chapter eight, which is the methods chapter for study three.

3.7 Conclusion

This chapter has provided an overview of the theoretical frameworks that guided the research, including the Safe System Approach, Haddon's Matrix and deterrence theory. Furthermore, the chapter has introduced two conceptual models – one that guided all three studies broadly, and one that provided specific guidance to study three. The link between the current research and the Safe System Approach highlights the potential this PhD has in making a valid contribution towards achievement of the goals of the many jurisdictional road safety strategies, particularly in Victoria, Australia, and subsequently enhancing safety for road users. The thesis now moves to a discussion of one of the sources of data used to undertake the research, this being VicRoads administrative data.

Chapter Four: The use of administrative data in road safety research

As indicated in the introduction to this thesis, studies one and two used administrative data to examine the deterring influence of traffic infringements. The aim of this chapter is to provide a critical overview of the use of administrative data in research, and highlight how the administrative data sets used (the VicRoads licensing, infringements and crash data sets) were suitable for the conduct of these studies. The chapter begins with providing a detailed definition of what is meant by the term 'administrative data'. Second, the chapter describes the VicRoads data sets that were used in studies one and two, including the variables that are contained in these data sets. Third, the strengths and weaknesses of using administrative data in research are presented. Each of these strengths and weaknesses are then considered in the context of the VicRoads data sources.

4.1 What is administrative data?

Administrative data can be described, most simply as data that is collected as part of the day-to-day, routine operation of organisations, in order to carry out their administrative responsibilities (e.g. Dalla Valle & Kenett, 2015; Evans et al., 2010; Hashimoto et al., 2014; Jones & Elias, 2006; Pawlson, Scholle, & Powers, 2007). Whilst not exclusively, administrative data sets often hold data that is collected by government organisations (e.g. Cole, Friedlander, & Trinh, 2018).

Administrative data sets usually contain a wide array of information. The variables held in these data sets are guided by the purpose for which an organisation holds the data. Variables can include personal information on an individual, such as gender, date of birth and residential address, as well as information on any relevant processes and procedures carried out by an organisation relating to this individual. These variables may include, for example, a record of all services provided, payments received, and dates for which follow-up is required, if applicable (e.g. Connelly et al., 2016).

Administrative data sets are not generally collected for the purpose of undertaking research (e.g. Connelly et al., 2016; Evans et al., 2010; Jones & Elias, 2006; Langan et al., 2013; van Walraven & Austin, 2012). This does not mean they cannot provide a reliable source of data for undertaking research. The use of administrative data sources in research can be

described as secondary use of data. This involves using data collected for a purpose other than the current research project being conducted (e.g. Smith et al., 2011; Trinh, 2018). A vast number of research studies have successfully used administrative data – proving such data sources to be a viable option for undertaking research.

4.2 VicRoads data

As noted, both studies one and two of this thesis used administrative data from VicRoads. This section provides details on the data sets used to conduct the research.

4.2.1 Driver Licensing System (DLS)

The DLS contains detailed information on all drivers who hold, or who have ever held, a driver's licence in the state of Victoria. Variables include demographic information, such as a driver's date of birth, gender, residential address, and date of death, where applicable.

The DLS also contains variables that relate to all licensing events experienced by a driver. These include the date a driver first obtained a Victorian learner's permit, probationary licence, or full licence; each date they have renewed their driver's licence; and any dates, if applicable, where their licence has been suspended, cancelled, expired, surrendered or void. Information is also contained in the data set on whether a driver has ever held an interstate or overseas licence and transferred this licence to a Victorian licence, and if so, the date at which this licence transfer occurred.

Also contained in the DLS is a record of all traffic infringements licensed drivers have received in Victoria. Data held on traffic infringements includes the type of offence, the date of the offence, and the number of demerit points issued for the offence.

Each of the variables contained in the DLS are recorded for VicRoads to carry out their role of administering the driver licensing system in Victoria. They also, however, provide a rich and valuable set of data for undertaking research on the influence of infringements for traffic offences on subsequent driver behaviour. Thus, both studies one and two of this thesis made use of the DLS in answering the key research questions.

4.2.2 Road Crash Information System (RCIS)

Data contained in the RCIS are collected by Victoria Police and then provided to VicRoads. The data set contains information on police reportable crashes that occurred in Victoria,

Australia. Police reportable crashes are those which have resulted in an injury or fatality to at least one person.

Variables contained in the RCIS provide information on the circumstances surrounding the crash, including the date, time, location, weather conditions, road and lighting conditions, and the crash type.

The RCIS also contains information on all people involved in the crash, including drivers, passengers, cyclists and pedestrians. Variables relating to each individual involved include their age, gender and severity of any injuries they received.

Finally, the RCIS contains information on all vehicles involved in the crash. This includes the vehicle type, make and model, damage the vehicle sustained, and whether the vehicle had to be towed.

Licence details of drivers involved in crashes are also contained in the RCIS. This enabled linking RCIS data with DLS data. Just as the DLS provided a rich data source for undertaking research on the deterring influence of traffic infringements, through linking the RCIS with the DLS, a valuable data set emerged that was suitable to examine the influence that infringements have in relation to subsequent crash involvement. Thus, study two additionally made use of the RCIS in answering the key research questions.

4.3 Strengths and limitations of using administrative data sets in research

There is a substantial body of literature that has examined the strengths and limitations of using administrative data in research. It is notable that much of this literature is in the area of health care and provision of health services. All administrative data sets are different, given each is held to serve a specific administrative purpose. This means that a strength or limitation of one administrative data set may not apply to another data set. There are, however, characteristics that are common to most administrative data sets. This means that irrespective of the type of information they contain and the purpose for which an organisation has developed them, the same strengths and limitations will apply. Some of the strengths and limitations of using administrative data sets in research are outlined below. Reference is also made to the VicRoads administrative data sources, to highlight their suitability in undertaking research and more specifically, studies one and two of this thesis.

4.3.1 Strengths of using administrative data sources in research

The successful use of administrative data sets in existing research has highlighted these sources of data to be a highly valuable resource. Strengths of administrative data sets include:

- Avoiding the need for a researcher to collect new data
- Often contain a large number of individual records
- Their potential to be linked with other data sets to increase the range of information available for analysis
- Their often high levels of accuracy (and relative absence of reporting bias)
- They often provide longitudinal information

This is by no means an exhaustive list of all the benefits that a researcher can expect to experience when they make a decision to use administrative data in research. They are rather the common strengths that have emerged in the literature. Details of each strength is provided below.

4.3.1.1 Avoid the need for a researcher to undertake a process of data collection

The collection of primary data, through methods such as interviews and surveys can be costly, not only financially, but also in terms of time (e.g. Drake & Jonson-Reid, 1999; Fulton-Kehoe et al., 2007). Thus, perhaps one of the most advantageous aspects of using administrative data in research is that the lengthy and often costly process of data collection is avoided (e.g. Cole et al., 2018; Riley, 2009; Smith et al., 2011; Trinh, 2018; Windle, 2010). With access to administrative data sets for the purpose of research also improving, researchers have come to embrace them as a viable alternative to collecting new data, with their use becoming increasingly popular (e.g. Langan et al., 2013; Sun & Lipsitz, 2018; Windle, 2010).

Not having to undertake a process of data collection was indeed a strength of using the VicRoads licensing, infringements and crash data sets in studies one and two of this thesis. VicRoads allows researchers to request access to these data sets for the purpose of undertaking research. Thus, given these data sources were available, and contained a range of variables that were consistent with aims and research questions set out for studies one

and two, the need to collect new data was removed, making them a viable option for this research.

4.3.1.2 Large sample sizes available

Another strength of using administrative data sets in research is the large sample sizes they can provide (e.g. Connelly et al., 2016; Drake & Jonson-Reid, 1999; Kapteyn & Ypma, 2007; Windle, 2010). Administrative data sets often include the entire population of relevance to the purpose of the data set, meaning they capture a diverse group of people from wide geographical areas (e.g. Harbaugh & Cooper, 2018; Hashimoto et al., 2014). This can be considered in contrast to data that is collected by a researcher. If a process of data collection is undertaken as part of a research project, it would be highly unlikely a researcher would be able to access as many individuals as an administrative data set contains. Indeed, using primary data collection rather than an administrative database may introduce bias into a study. A group of individuals who choose to participate in research may be quite different a group who do not choose to participate in research (e.g. Fulton-Kehoe et al., 2007).

Use of the VicRoads licensing, infringements and crash data sets in studies one and two of this thesis undoubtedly provided a far larger sample size from a much wider geographical area (i.e. the whole state of Victoria) than would have been possible with any other method of data collection. Indeed, initial analyses using the VicRoads data were conducted on over 200,000 drivers. Use of alternate methods of data collection in studies one and two, such as interviews or surveys would without doubt have resulted in a far smaller data set.

4.3.1.3 Ability to link administrative data sets

Many administrative data sets contain a unique identifier for each individual, that can be used to link information held across multiple data sets that relates to the same individual. The linking of administrative data sets can provide a great opportunity for undertaking analyses that would not otherwise be possible if only one single data set was used (e.g. Drake & Jonson-Reid, 1999; Smith et al., 2011).

Linking data sets was crucial to the conduct of studies one and two of this thesis. Due to its size, the DLS comes as a series of smaller data sets, each containing a set of variables. For example, one data set holds drivers' personal information such as date of birth, gender and

postcode of residence. Another data set holds information on infringements received, whilst a third holds information on demerit points issued to drivers. Each component was essential in answering the research questions for studies one and two. In addition, for study three, the RCIS also needed to be linked with the DLS data. The inclusion of driver licence number in all components of the DLS and in the RCIS enabled the data sets to be linked and all analyses to be conducted.

4.3.1.4 Accuracy and completeness of administrative data sets

When data are collected through self-report methods, such as interviews and surveys, there is a potential for bias. Respondents may not remember the exact details of events as they occurred, or alternatively they may feel they could be judged if they provide the exact details, and as a result, make the decision not to provide truthful answers (e.g. Bowling, 2005; Fulton-Kehoe et al., 2007; Groves, 2006). Given administrative data sets are held for official record keeping purposes, containing, for example, all services provided to an individual, or all payments received from an individual, the potential for inaccuracy is far lower, as they do not require data to be collected from individual respondents.

Use of the VicRoads licensing, infringements and crash data sets in studies one and two of this thesis undoubtedly provided a more accurate data than would have been possible with any other method of data collection. It may be quite difficult for individuals to recall exactly the dates that they received and renewed their driver's licence. Furthermore, if they have experienced licence loss, they may also have difficulty recalling the dates this was in effect. Given there is stigma attached to licence loss and receiving traffic infringements, it may also be possible that a driver would be reluctant to admit to all details of their full licence history. Drivers with extensive infringement histories may likely decline to participate in a study altogether. If a driver has been involved in a crash, it would also be very difficult for them to recall all details of this crash to the degree that is contained in the RCIS. Thus, use of the DLS and the RCIS was identified as the best data source to conduct studies one and two.

4.3.1.5 Longitudinal nature of administrative data sets

Many administrative data sets contain data that has been collected on individuals over an extended period of time (e.g. Drake & Jonson-Reid, 1999; Riley, 2009; Smith et al., 2011).

This means that studies that would be near impossible to undertake using primary data can be undertaken using administrative data sets (e.g. Smith et al., 2011). For example, if a researcher wanted to examine a person's contact with a particular service over a 10-year period, they would either have to undertake 10 years of data collection or rely upon an individual to recall their experience with the service in the 10 years prior. Both methods have clear disadvantages that would make the conduct of such studies difficult.

Comparatively, a researcher who is able to identify an administrative data set that contains relevant data over a lengthy period of time will be able to conduct their research far more smoothly.

This was a particular strength of using the VicRoads licensing, infringements and crash data sets in studies one and two of this thesis. The DLS data set contained the full licence history of drivers, whilst the RCIS contained crash data for an extended period of time. This meant that analyses were able to be conducted on a wider span of time than would have been possible had a process of primary data collection been undertaken.

4.3.2 Limitations of using administrative data sources in research

Despite being successfully used in many research studies, administrative data sets, like all sources of data, do have limitations. It is important to consider these limitations when developing a research project, particularly when making a decision on the most appropriate data source to address a study's aims and to answer the research question/s that have been developed. Limitations of using administrative data in research that have emerged in the literature primarily result to challenges experienced by researchers, by reason of them not being directly involved in the data collection process. This means that:

- Researchers must spend a lengthy period of time familiarising themselves with the data
- Analyses are limited to the variables and data that are contained in the data set
- Difficulty can sometimes be experienced in gaining access to data
- Unique ethical issues can arise that do not present themselves in instances where a method of primary data collection is used

This is by no means an exhaustive list of all the limitations/challenges that a researcher may experience when they make a decision to use administrative data in research. They are

rather some of the more common limitations and are those that were relevant to the current research. Further details of each of these limitations are provided below. Discussion on how challenges were overcome when using the VicRoads administrative data is also provided.

4.3.2.1 Lengthy period of time for researchers to familiarise themselves with data sets

When administrative data is used in research, it often requires a lengthy period of initial familiarisation by the researcher before they can consider commencing analyses (e.g. Castle, 2003; Cole et al., 2018; Connelly et al., 2016; Drake & Jonson-Reid, 1999; Smith et al., 2011; Windle, 2010). Given administrative data sets have been developed by someone other than the researcher who chooses to use the data source in their study, it is likely the researcher will initially have a limited understanding of the structure of the data set. Researchers also require this time to look for issues and complexities in the data set that may need to be addressed before accurate analyses are possible (e.g. Connelly et al., 2016). Beyond the actual data set, it is useful for researchers to have a good understanding of the system through which that data was collected, the process that occurred and the purpose of the administrative data set. Researchers who do not take the time to adequately familiarise themselves with an administrative data set that they are using in a study run the risk of undertaking and presenting inaccurate analyses (e.g. Sarrazin & Rosenthal, 2012).

A long period of familiarisation with the VicRoads licensing, infringements and crash data used in studies one and two of this thesis was necessary. The DLS and RCIS are very complex data sets, containing hundreds of variables in total. At the outset of commencing studies one and two, a significant amount of time was dedicated to investigating the format of the variables required to undertake the analyses, to ensure a good understanding of the structure of the data sets. This meant that when planning timelines for the research process, an adequate amount of time had to be allocated to data exploration, prior to any analyses commencing. Whilst this was lengthy, the thorough approach undertaken provides confidence that the results that are presented for studies one (chapter five) and two (chapter seven) of this thesis are based on an accurate understanding of the data.

4.3.2.2 Analyses are limited to the variables and data that are contained in administrative data sets

Another limitation of using administrative data sets in research is that all analyses are limited by the range of variables and data that are contained in the data set (e.g. Drake & Jonson-Reid, 1999). As researchers themselves are not involved in the data collection process, the opportunity to collect data of their choosing is removed (e.g. Brownell & Jutte, 2013; Drake & Jonson-Reid, 1999; Smith et al., 2011; Windle, 2010). This may also extend to the way data is stored within a variable, as a result of coding processes (e.g. Harbaugh & Cooper, 2018; Smith et al., 2011). Researchers may as a result find themselves unable to conduct particular statistical tests, or run particular models (e.g. Drake & Jonson-Reid, 1999).

This was a limitation that in many respects could not be overcome in studies one and two. There are many factors that have been identified in the research literature that may influence driving behaviour. These include for example, relationship issues (e.g. Kposowa & Breault, 2009; Lagarde et al. 2004; Legree et al., 2003; McMurray, 1970), financial difficulties (e.g. Cunningham & Regan, 2016; Norris et al., 2000) and employment stress (e.g. Carty, Stough & Gillespie, 1998; Hartley & El Hassani, 1994; Norris et al., 2000; Rowden et al., 2011; Rowland et al., 2007; Smith, 2016). The VicRoads data sets do not contain any information on the individual life experiences and situations of drivers, meaning it was not possible to consider if the patterns that emerged were actually due to receiving a traffic infringement or other unmeasured factors. Furthermore, it is also likely that within the variables for which data were available, the information is not complete. For example, crashes involving single vehicles or unlicensed drivers may be under-reported. This means the analyses are limited only to those cases included in the data. Despite this, the fact that the DLS and the RCIS contain the core variables required for the analyses (e.g. demographic details such as gender and date of birth; licensing history; infringement history; and crash history data) and are the most comprehensive data sets available in Victoria, in terms of licensing, infringements and crashes, these data sets were the best option to undertake studies one and two.

4.3.2.3 Sometimes difficult to gain access to administrative data sets

Given administrative data sets are not owned by the researcher or their colleagues, it can be a difficult and time-consuming process to gain access (e.g. Connelly et al., 2016; Smith et al., 2011). As noted, administrative data sets are often held by government organisations, and there are usually strict protocols that need to be followed in order to gain approval to access data. In addition, given research using administrative data sets sometimes involves accessing multiple data sets and linking them together to create a data set that is fit for the study, the process of data linkage can be quite difficult and present a significant administrative burden for the researcher. To protect data privacy, owners of administrative data sets may be reluctant to share data sets that have any identifiers (Harron et al., 2017). Without gaining access to an identifier, data linkage is either not possible or is extremely difficult.

Challenges in accessing the VicRoads data sets were experienced. Access and approval to use the licensing, infringements and crash data was quite lengthy. Fortunately, data linkage was not a challenge encountered. Given all data sets came from VicRoads, there was a degree of confidence that linking records by licence number across data sets would not create privacy concerns.

4.3.2.4 Ethical issues associated with the use of administrative data sources

The use of administrative data in research has raised some ethical issues (e.g. Stiles & Boothroyd, 2005). This primarily relates to the fact that administrative data sets are not held for research purposes (Connelly et al., 2016). Some people may not feel comfortable with their personal details that are held in administrative data sets being used as part of a research study (Connelly et al., 2016). Furthermore, it is often not possible to obtain consent from individuals whose information is contained in administrative data sets due to the size of these data sets.

The Australian Government 'National Statement on Ethical Conduct in Human Research' (National Health and Medical Research Council, 2018) provides detailed information on undertaking ethical research where individuals do not provide consent and are otherwise unaware that their information is being considered in a research study. Certain conditions must be met for a 'waiver of consent' to be approved by an ethics committee. The

conditions that must be met are that the research does not pose any risks greater than low risk; that the benefits that can be expected to emerge from the research justifies any risks of harm that may potentially emerge; that obtaining consent is generally not possible for reasons such as the number of people consent would need to be sought from; that there are no clear reasons to suggest individuals would have opted not to participate if their consent was sought; their privacy and confidentiality can be assured; plans are in place to ensure the welfare of individuals whom the information belongs to; there is no risk of financial disadvantage to individuals; and finally that the waiver does not violate any laws (National Health and Medical Research Council, 2018, pp. 21-22).

Given the concerns surrounding the ethical use of administrative data sets, a high level of care was taken when using the VicRoads licensing, infringements and crash data for studies one and two of this thesis. Ethics approval was obtained from the Monash University Human Research Ethics Committee (MUHREC) (Appendix A contains the ethics approval certificate). This included a waiver, given the data sets were large and it would have been impossible to seek consent from all licensed individuals in Victoria whose information was contained in these data sets. No personal identifiers such as name and residential address were contained in the data sets. Linkage was performed using driver licence number. Given the size of the data sets, there was also no risk that individuals could be identified in the results from the analyses. Thus, despite not being to obtain consent from the individual drivers, every effort was made in the research process to ensure privacy was maintained.

4.4 Conclusion

Despite the use of administrative data sets in research presenting some limitations, their use comes with many advantages. This chapter has provided an overview of some of the strengths and limitations of using administrative data in research, and applied these strengths and limitations directly to the VicRoads licensing, infringements and crash data, that were used to conduct the research for studies one and two. The chapter has been able to demonstrate that, whilst using the VicRoads data sets did come with some challenges, overall, they provided a particularly effective data source. This chapter has also provided a reflection in many respects, on how, despite challenges being encountered in the research process, these challenges were overcome.

The chapter that follows provides the first set of results that emerged from this PhD research using the VicRoads data. This has been written as a manuscript and is published in the academic journal *PlosOne*. Chapter six will then provide an overview of some study designs that were explored for undertaking study two of this PhD research program, also using the VicRoads data, before chapter seven provides the results of study two. This study has also been written as a manuscript and is published in *Transportation Part F: Traffic Psychology and Behaviour*.

Chapter Five: Traffic offending and deterrence: an examination of recidivism amongst drivers in Victoria, Australia born prior to 1975

5.1 Introduction

This chapter presents the results of study one. VicRoads licensing and infringements data were used to examine whether infringements for driving offences have the desired effect of deterrence, as evidenced by a reduction in subsequent driver offending behaviours in the twelve months that followed a driver receiving a traffic infringement. The study examined the entire licence history of drivers born prior to 1975, using a time to event analysis, to determine the length of time between infringements, and whether this time changed based on offence type and number of previous offences. The study sought to answer two key research questions:

- 1) Do driver and offence characteristics, including gender, age at first licence, years licensed, licence type, demerit points and offence type have a relationship with the length of time to next offence within twelve months?
- 2) Is time to next offence within twelve months associated with the number of previous offences a driver has?

The study was published in 2020 in the academic journal, *PLOS One*.

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2020). Traffic offending and deterrence: An examination of recidivism amongst drivers in Victoria, Australia born prior to 1975. *PLoS ONE*, 15(10), e0239942.

<https://doi.org/10.1371/journal.pone.0239942>

RESEARCH ARTICLE

Traffic offending and deterrence: An examination of recidivism amongst drivers in Victoria, Australia born prior to 1975

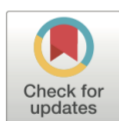
Hayley McDonald^{1*}, Janneke Berecki-Gisolf², Karen Stephan³, Stuart Newstead⁴

Monash University Accident Research Centre, Monash University, Clayton, Victoria, Australia

¹ These authors contributed equally to this work.

² These authors also contributed equally to this work.

* hayley.mcdonald@monash.edu



Abstract

To deter the performance of illegal driving behaviours, traffic infringement notices may be issued. Whilst there is a substantial body of research that has examined rates of reoffending following a traffic infringement, there have been few studies examining the length of time to next traffic offence. Where this research has been conducted, the findings do not provide current understandings, given the substantial changes in traffic sanctioning over time. The aim of this study was to address this gap, by examining risk factors for recidivism following a driver receiving a traffic infringement notice, as well as the time to next traffic offence. Licensing and infringements data held in the Driver Licensing System (DLS), maintained by the road authority in Victoria, Australia were used. All drivers included in the study were born prior to 1975, and received their first Victorian drivers licence between 1994 and 2016. Data from 203,620 drivers were used. Cox proportional hazards modelling was undertaken to examine factors associated with recidivism within 12 months of receiving a traffic infringement. 131,691 (64.7%) drivers had received at least one traffic infringement in Victoria, Australia since receiving their Victorian driver's licence. Factors found to be associated with longer time to further traffic offending in the year that followed the first infringement included being female; receiving a first Victorian driver's licence when aged 45+ years; and being licenced 10+ years. Traffic infringements deter some groups of Victorian drivers, but not others. If drivers are to be deterred from further illegal driving behaviour, it is important other countermeasures are developed and trialled.

OPEN ACCESS

Citation: McDonald H, Berecki-Gisolf J, Stephan K, Newstead S (2020) Traffic offending and deterrence: An examination of recidivism amongst drivers in Victoria, Australia born prior to 1975. PLoS ONE 15(10): e0239942. <https://doi.org/10.1371/journal.pone.0239942>

Editor: Quan Yuan, Tsinghua University, CHINA

Received: April 21, 2020

Accepted: September 15, 2020

Published: October 1, 2020

Copyright: © 2020 McDonald et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability Statement: The data set used for this research was provided to Monash University (acting through its Accident Research Centre – MUARC) by VicRoads, which is a Victorian (Australia) Government agency with authority to administer the driver licensing system within the state. This data set contains personal and sensitive information relating to all licenced drivers in Victoria. In accessing the data, an Information Protection Agreement was entered into between MUARC and VicRoads. As part of this agreement, the authors acknowledged that, as per Victorian Government legislation contained in the Road

Introduction

Road trauma is a significant global public health issue. In 2016, 1.35 million people died globally as a result of road trauma [1]. Factors associated with the incidence of trauma on the roads include road and roadside design and condition [2–5], vehicle design and condition [3, 5–8] and the environment [3, 5]. Human behaviour and error [3, 5, 9–12], which includes the performance of illegal driving behaviours, has also been found to be associated with increased risk of being involved in a road crash [13]. Speeding [14, 15], drink driving [16], drug driving [17]

Safety Act 1986, it is an offence for this data set to be distributed and disclosed to individuals who are not named on the Information Protection Agreement. These conditions have been imposed by the Privacy Branch at VicRoads. Any individual can seek to access this dataset by making a request directly to VicRoads (via confidentiality.agreement@roads.vic.gov.au). The authors had no special access privileges to the data that others would not have. VicRoads must however approve the manner in which individuals intend to use the data.

Funding: This research was supported by an Australian Government Research Training Program (RTP) Scholarship. The research was also supported by a Monash University Accident Research Centre Foundation Scholarship, awarded to the first author.

Competing interests: The authors have declared that no competing interests exist.

and mobile phone use whilst driving [18–20] are all associated with an increased occurrence of road crashes.

In many jurisdictions globally, drivers who are found to have performed an illegal driving behaviour receive a sanction that seeks to deter them from performing similar driving behaviours again [21]. Thus, punishments issued to drivers who perform illegal behaviours on the roads are consistent with the theory of specific deterrence. This theoretical perspective is based on the assumption that, after receiving a sanction for an illegal behaviour, a person will avoid the same pattern of behaviour in the future, to avoid further sanctions [22–27]. In the Australian state of Victoria, people who are detected by police or a road safety camera driving in an illegal manner will receive a traffic infringement notice. In most cases, this requires the driver to pay a fine, and demerit points are placed on their licence (which can ultimately result in licence suspension if a threshold is exceeded). The value of the fine and the number of demerit points issued is dependent upon the severity of the offence [28–30].

The significant body of research exploring specific deterrence, recidivism and traffic offending has primarily focused on drink driving [31–37] and speeding [38]. Much less is known about recidivism and traffic offending more broadly, as well as the many other types of offences that drivers may perform on the roads. Furthermore, the majority of studies have only quantified rates of recidivism, without considering the length of time following a traffic infringement that drivers are deterred from further offending. One exception is a study by Watson, Siskind, Fleiter, Watson and Soole, who, amongst other areas of analysis, examined time to reoffence following changes in speeding sanctions in the Australian state of Queensland [39]. They found that rather than time to reoffence increasing in length following the introduction of harsher sanctions, the time to a subsequent speeding offence actually decreased [39]. A second exception is a study by Haque, who applied a statistical model to examine the effectiveness of the demerit points system in Victoria, Australia [40]. Haque evaluated the time between drivers' first and second driving offences and second and third driving offences, to examine differences that could be attributed to the demerit point system [40]. It was found that the length of time between the second and third driving offences was longer than the length of time between the first and second, adjusting for the additional driving experience drivers had accumulated [40]. It was thus concluded that the demerit point system could be credited with achieving deterrence, by increasing the period of time between drivers offending behaviour [40].

Much has changed in the approximately 30 years since the Haque study was published (notably the data used by Haque was for driving offences between 1982 and 1985) [40], and these changes may have had an influence on deterrence, recidivism and the time between infringements. Melbourne, which is Victoria's capital city, has undergone a substantial rise in population numbers, and this rise continues to take place [41]. In addition to growth in the inner city and suburbs, growth has taken place in outer urban areas [41]. As would be expected in times of substantial population growth, traffic volumes also inevitably increase, meaning the number of people using the roads today is greater than the numbers seen 30 years ago. Automated enforcement, including the use of fixed red light and speed cameras, as well as mobile speed cameras is also widely used in Victoria today [42]. Indeed, in recent years, as technology has continued to be upgraded and improved, there has been a substantial increase in the number of infringements being issued as a result of automated cameras capturing dangerous driving behaviour [42]. The number of behaviours that drivers can receive an infringement for has also increased. For example, 30 years ago, mobile phones were not widely used, and therefore, the laws for using phones whilst driving that are in place today were not in operation at the time of the Haque study, with laws coming into effect in 1999 [43]. The severity of sanctions

has also increased over time. Drivers today can expect to receive fines that are of a greater monetary value and with a greater number of demerit points than would have been issued at the time of the Haque study.

The aim of the current study was therefore to examine factors associated with time until re-offending amongst drivers licenced to drive a car, in the current Victorian system of enforcement. This research identified whether infringements for traffic offences are an effective means of deterring illegal driving behaviours, through examining driver-related factors that may be associated with recidivism, as well as the effect of demerit points on subsequent traffic offending.

Materials and methods

Data source

Licensing and infringements data held by VicRoads (the Driver Licensing System (DLS)) were used. The Monash University Human Research Ethics Committee approved the research (approval number 2017-9868-13714). The data were analysed anonymously, so consent was not obtained from individuals. VicRoads is the government authority in Victoria, Australia, with responsibility for administering the licensing system [44]. The DLS contains information on all drivers who have ever held a Victorian drivers' licence. Variables in the data set include demographics, licence history and infringement history. The variables contained in the DLS used in this study were:

- sex;
- date of birth;
- date of death (where applicable);
- date Victorian driver's licence was first obtained;
- dates where a licence was cancelled, disqualified, expired, suspended, surrendered or void;
- licence type;
- dates of any traffic infringements received;
- type of offences for which traffic infringements were received;
- number of demerit points issued for each traffic offence;
- number of accumulated demerit points.

Due to changes in the way in which information was held in the Victorian DLS, complete records are only available for drivers first licensed since 8 July 1994. In the data extract available for this study, complete and accurate licensing records were available through to 21 May 2016; this was therefore the end date of the study.

The data extract used for this study only included records of drivers born on or prior to 31 December 1974. This meant the data available only included information on drivers who were at least 19.5 years old when they obtained their drivers licence. In Victoria, a driver's licence can be obtained at the age of 18. Thus, the drivers in this data extract for whom complete licensing information was available obtained their licence at a slightly older age than the minimum age drivers are able to obtain a driver's licence.

Study sample selection

The following inclusion criteria were applied:

1. Never held an interstate licence (a licence from an Australian state other than Victoria) or overseas licence: the study was focused on the deterring influence of infringements in Victoria, and required drivers' full licence history. Given full licence history was not accessible for drivers who had previously been licenced interstate and overseas, these drivers were not included.
2. Never received an infringement for a driving offence interstate: drivers who had ever received an interstate infringement were excluded from the study given the possible influence infringements received outside of Victoria could have upon driving within Victoria. It was not possible to determine if drivers had received any sanctions for driving offences committed overseas.

The first licence received after 8 July 1994 had to be a car licence. Drivers could still be included if they subsequently received another licence type (heavy vehicle or motorcycle) following their car licence. Drivers were not included if they had already held another licence type prior to obtaining their car licence, even if this licence was obtained after 8 July 1994.

Statistical analyses

Drivers were stratified into two groups: 1) never received a traffic infringement; and 2) ever received a traffic infringement. Descriptive statistics (frequency and %) were used to compare these groups, in terms of sex, age at first licence and licence type.

The analyses then focused only on drivers who had been identified as having ever received a Victorian traffic infringement. Drivers' infringements were numbered in order of occurrence, up to a maximum of six. In cases where drivers received more than one infringement on the same day (for example a speeding infringement and a red light infringement), the more serious offence was used as the main offence type and another variable was developed to indicate where multiple infringements were received on a single day. Offence severity was based upon number of demerit points issued.

The outcome of interest was receiving a subsequent traffic infringement within 12 months of the index offence. The timeframe of 12 months was selected based on previous research that suggested the deterrent effect of a traffic infringement would likely not continue to influence driver behaviour for greater than one year [45]. The index offence was defined as the type of offence (or most serious offence) on a single day. Drivers could have up to six index offences. Five separate analyses were undertaken to examine time to reoffending following the first, second, third, fourth and fifth offences.

Descriptive statistics were used to examine the median time between infringements for drivers who reoffended within one year. Cox proportional hazards models [46, 47] were developed to estimate the association between driver and infringement characteristics and reoffending in the 12 months that followed. Kaplan-Meier survival curves were used to visually assess proportionality of hazards [48].

Due to multicollinearity, it was not possible to simultaneously include offence type and demerit points issued to a driver in the same Cox proportional hazards model. Two separate series of Cox proportional hazards modelling were therefore developed, one for each measure.

As per the time to event approach, censoring was used in specified circumstances [49, 50]. First, drivers who did not reoffend within 12 months of an index infringement date were censored. The date of censoring was the final date of follow up (12 months post-infringement), or in cases where this date exceeded the final date of the study, the censoring date was 21 May 2016. Drivers were censored at their date of death (if applicable), where this death occurred within 12 months of them receiving an infringement for a driving offence.

Drivers who experienced licence loss as a result of their driving behaviour were excluded from the study at the point this licence loss occurred, even if they were later reissued with a drivers' licence and received further infringements. Including drivers who had experienced licence loss would make it difficult to separate the effect of this sanction from the effects of receiving an infringement. Furthermore, keeping unlicensed drivers may result in an underestimation of the likelihood of reoffending as these drivers would most likely have a lower exposure to receiving a further infringement, as they would not have been driving if they were obeying the conditions of their licence loss.

Due to the offences of speeding at or more than 25km/h above the speed limit, drink driving and drug driving commonly leading to licence loss, drivers charged with these offences were excluded from the Cox proportional hazards modelling following this infringement. This decision was made due to concerns that the behaviour of the small number of drivers who did keep their licence following these offence types would not be representative of the subsequent driving behaviour generally of drivers following these offences. Drivers were included in all models prior to receiving an infringement for these offence types. For example, a driver whose first infringement was for mobile phone use whilst driving, their second infringement was for not stopping at a red light, their third infringement was for speeding at or more than 25km/h and their fourth infringement was for speeding at less than 10km/h above the speed limit, was still included in the modelling of their first and second infringements and second and third infringements. They were, however, excluded following their third infringement.

Drivers who experienced licence loss for reasons other than infringements were excluded from the study, but were introduced back into the study if they re-obtained their drivers licence and received further infringements. These drivers had been unlicensed for failing to renew their drivers licence on time or by reason of surrendering their licence, which can occur due to some health conditions. Unlike losing one's licence by reason of driving behaviour, there was not any identifiable risk in reintroducing these drivers back into the study once they reobtained their driver's licence.

Variables included in the Cox proportional hazards models to examine their association with recidivism

The first series of Cox proportional hazards models included the following variables: sex, age at first licence, years licenced at index offence, licence type, demerit points on day of index offence, accumulated demerit points, and total offences on day of index offence. There were two separate demerit point variables. The first was demerit points on the day of the index offence, which was used for the first model only, as drivers did not have previous infringements. The second was accumulated demerit points, which was used in the second, third, fourth and fifth models: for these models, all drivers had previous offences. In Victoria, demerit points accumulate, and remain on a driver's licence generally for three years following a driver receiving an infringement (there are some additional conditions for probationary drivers) [28]. If a driver exceeds 12 points in this three-year time period, they may lose their licence [28]. Thus, for these models, the accumulated demerit point variable was the sum of their index offence demerit points and any existing demerit points they had received in the three years prior.

In the second series of Cox proportional hazards models, sex, age at first licence, years licenced at index offence, licence type and total offences on day of index offence were again included. The second series differed from the first however, as the demerit point variables were excluded and the models were stratified by offence type. The decision to stratify by offence type was made given the offence type variable was found to be non-proportional: the

hazard ratio (the relative hazard of reoffending for those who had committed different offences) was not constant over time, which violates the assumption of proportional hazards. Thus, it was necessary to take a different approach, with stratification by offence type identified as being most appropriate. Models were developed for six offence types to examine time until reoffending following the first, second and third index offences (speeding below 25km/h; failure to obey a traffic signal; failure to stop or give way; seat, seatbelt and helmet offences; overtaking, lane use and U-turn offences; and mobile phone offences). Due to low numbers of drivers, models were only developed for a subset of offence types following the fourth (speeding below 25km/h; failure to obey a traffic signal; seat, seatbelt and helmet offences and mobile phone offences) and fifth (speeding below 25km/h and failure to obey a traffic signal) index offences.

Results

Characteristics of the study population

In total, 203,620 drivers met the inclusion criteria. Table 1 presents the descriptive characteristics of these drivers, stratified by whether or not they had ever received a traffic infringement. Chi Square tests were used to examine the relationships between history of receiving a traffic infringement since obtaining a Victorian drivers licence and sex, age at first licence and licence type. A higher proportion of males than females had received at least one Victorian traffic infringement since obtaining their licence (difference of 4.8%, 95% CI 4.4–5.2%). Among drivers who obtained their drivers licence at an older age (45+ years), the proportion that had ever received an infringement for a traffic offence was relatively low. For example, 20.6 percent more drivers who received their first drivers licence before age 25 years had received at least one traffic infringement since obtaining their licence, compared to drivers who had received their licence age 45+ (95% CI 19.8–21.3%). Drivers who held a car licence only were the least likely to have ever received a traffic infringement, compared to drivers who held a combined car and heavy vehicle licence, who were the most likely to have ever received an infringement for a traffic offence, with a difference of 10.4 percent (95% CI 9.4–11.4%).

Table 1. Descriptive characteristics of study cohort based on traffic offending status.

Variable	Never received a traffic infringement	Ever received a traffic infringement	Total	χ^2 (df)	p
	n (%)	n (%)	n (%)		
Overall	71,929 (35.3)	131,691 (64.7)	203,620 (100.0)		
Sex				500.3 (1)	< .0001
Female	43,435 (37.4)	72,763 (62.6)	116,198 (57.1)		
Male	28,494 (32.6)	58,928 (67.4)	87,422 (42.9)		
Age at first licence				4560 (3)	< .0001
19.5–24	7,842 (28.2)	19,935 (71.8)	27,777 (13.6)		
25–34	22,283 (29.9)	52,264 (70.1)	74,547 (36.6)		
35–44	23,998 (37.0)	40,817 (63.0)	64,815 (31.8)		
45+	17,806 (48.8)	18,675 (51.2)	36,481 (17.9)		
Licence type				572.0 (3)	< .0001
Car only	66,460 (36.1)	117,452 (63.9)	183,912 (90.3)		
Car and heavy vehicle	1,904 (25.7)	5,494 (74.3)	7,398 (3.6)		
Car and motorbike	2,636 (28.5)	6,602 (71.5)	9,238 (4.5)		
Car, heavy vehicle and motorbike	929 (30.2)	2,143 (69.8)	3,072 (1.5)		

<https://doi.org/10.1371/journal.pone.0239942.t001>

Median time between infringements: Driver and offence characteristics

Subsequent analyses only included drivers who had received at least one traffic infringement since obtaining their Victorian drivers' licence. Table 2 provides the number of drivers who received subsequent infringements within 12 months of a previous infringement, and the median time to this next infringement. Following the first offence, 34,850 drivers (27.4%) received a second infringement within 12 months; following the second offence, 31,665 drivers (33.2%) received a further infringement within 12 months; following the third offence, 27,468 drivers (37.1%) received a further infringement within 12 months; following the fourth offence, 23,517 (40.3%) drivers received a further infringement within 12 months; following the fifth infringement, 19,939 (43.2%) drivers received a further infringement within 12 months. The total number of drivers reoffending was actually higher than the totals in Table 2, given only reoffending in the 12 months that followed each index offence was examined. Where a driver reoffended within 12 months, the median time to next infringement was consistently around four months. The exception was drivers who had held their licence for less than one year and in that time had received multiple infringements. The median time between the fifth and sixth infringements for this group was less than 1 month. This is to be expected however, as to receive this number of infringements within just one year of obtaining a driver's licence would mean the offences would have been in close succession of one another. For those drivers with 7 or more accumulated demerit points, the time between their infringements in the following 12 months was less (between 3 and 4 months) when compared to drivers with a lower number of accumulated demerit points (over 4 months). Finally, where a driver received an infringement for more than one offence type on the day of the index offence, the median time to next infringement in the following 12 months was less than that observed for drivers who received an infringement for only a single offence on the day of the index offence (Table 2).

Factors associated with recidivism: Driver characteristics

Table 3 shows the results of the Cox proportional hazards modelling used to investigate associations between driver characteristics and recidivism within 12 months of each index offence. If hazard ratios are below one, this means the time to reoffending was longer and therefore the risk lower. If hazard ratios are above one, this means the time to reoffending was shorter and therefore the risk higher. Statistically significant differences between males and females were only identified following the first and second offences. Time to reoffence in the following 12 months was longer for females following the first (HR = 0.81, 95% CI 0.79–0.93) and second offence (HR = 0.93, 95% CI 0.90–0.95), compared to male drivers. There was no significant difference in time to re-offend in the following 12 months between males and females following the third, fourth and fifth offences. The number of years a driver had been licensed consistently showed a statistically significant association with the time to next infringement within 12 months. Hazards ratios were greater amongst drivers who had held their licence a shorter period of time. For example, for drivers licenced less than one year, hazard ratios ranged from 1.49 (95% CI 1.43–1.55) to 3.53 (95% CI 2.85–4.37) when compared to drivers who had held a drivers licence 10+ years, depending on the number of previous offences. Age at first licence was also significantly associated with time to next infringement within 12 months. Median time to next infringement within 12 months was generally greater for drivers who obtained their licence at an older age. For example, for drivers who obtained their licence when they were aged 45+ years, hazard ratios ranged from 0.91 (95% CI 0.86–0.96) to 0.88 (0.83–0.92) when compared to drivers who obtained their drivers licence when they were aged 19.5–24 years. The association between demerit points and deterrence was also statistically significant.

Table 2. Median time between traffic infringements received within 12 months of a previous infringement, by driver and offence characteristics.

Variable	One to two			Two to three			Three to four			Four to five			Five to six		
	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)
Overall	34,850 (27.4)	127,246	4.56	31,665 (33.2)	95,377	4.44	27,468 (37.1)	74,064	4.20	23,517 (40.3)	58,327	4.11	19,939 (43.2)	46,199	4.08
Sex															
Male	17,252 (30.6)	56,322	4.44	15,300 (35.4)	43,178	4.32	13,141 (38.3)	34,273	4.20	11,348 (41.3)	27,473	4.18	9,779 (44.0)	22,242	4.11
Female	17,598 (24.8)	70,924	4.68	16,365 (31.4)	52,199	4.44	14,327 (36.0)	39,791	4.32	12,169 (39.4)	30,854	4.04	10,160 (42.4)	23,957	4.04
Age at first licence (years)															
18–24	5,248 (27.5)	19,116	4.68	5,228 (33.6)	15,565	4.32	4,849 (37.5)	12,930	4.32	4,380 (40.9)	10,721	4.27	3,879 (43.1)	8,990	4.08
25–34	13,761 (27.3)	50,389	4.68	13,193 (33.4)	39,517	4.56	11,880 (37.5)	31,668	4.32	10,358 (40.6)	25,487	4.08	8,973 (43.6)	20,601	4.11
35–44	11,278 (28.5)	39,568	4.44	9,513 (33.5)	28,422	4.44	7,843 (37.0)	21,186	4.20	6,488 (40.2)	16,131	4.04	5,305 (43.3)	12,264	4.08
45+	4,563 (25.1)	18,173	4.32	3,731 (31.4)	11,873	4.20	2,896 (35.0)	8,280	4.20	2,291 (38.3)	5,988	4.27	1,782 (41.0)	4,344	3.91
Years licenced at index offence															
Less than 1 year	8,351 (33.0)	25,320	4.32	2,288 (45.6)	5,022	3.72	673 (56.5)	1,192	2.76	224 (65.5)	342	1.89	87 (72.5)	120	0.85
1–4 years	14,955 (27.4)	54,577	4.68	12,483 (36.8)	33,893	4.32	8,150 (43.6)	18,702	4.08	4,938 (48.8)	10,122	3.75	2,847 (53.4)	5,334	3.42
5–9 years	7,675 (25.8)	29,757	4.56	10,289 (32.5)	31,683	4.56	10,144 (37.6)	26,997	4.34	8,950 (42.7)	20,983	4.24	7,258 (46.4)	15,647	4.08
10+ years	3,869 (22.0)	17,592	4.56	6,605 (26.7)	24,779	4.56	8,501 (31.3)	27,173	4.47	9,405 (35.0)	26,880	4.27	9,747 (38.8)	25,098	4.34
Licence type															
Car only	30,694 (27.0)	113,647	4.56	27,714 (32.8)	84,438	4.44	23,859 (36.7)	65,006	4.21	20,429 (40.2)	50,824	4.11	17,188 (43.0)	39,976	4.08
Car and heavy vehicle	1,646 (31.3)	5,263	4.32	1,625 (37.4)	4,342	4.32	1,440 (39.8)	3,617	4.54	1,254 (41.3)	3,038	4.22	1,129 (44.8)	2,519	4.04
Car and motorbike	1,921 (30.5)	6,292	4.32	1,774 (36.7)	4,973	4.20	1,646 (40.2)	4,092	4.34	1,405 (41.9)	3,353	4.08	1,221 (43.8)	2,788	3.91
Car, heavy vehicle and motorbike	589 (28.8)	2,044	5.04	552 (34.0)	1,624	4.54	523 (38.8)	1,349	4.73	429 (38.6)	1,112	4.11	401 (43.8)	916	4.31
Demerit points on day of index offence ^a															
One	20,950 (29.3)	71,479	4.44												
Two	527 (22.6)	2,327	4.68												
Three	13,045 (25.0)	52,119	4.80												
Four or more	328 (24.9)	1,315	4.44												
Accumulated demerit points ^b															
1–2				14,412 (34.1)	42,239	4.44	7,262 (35.4)	20,540	4.31	5,142 (38.3)	13,443	4.27	3,629 (39.8)	9,120	4.14

(Continued)

Table 2. (Continued)

Variable	One to two			Two to three			Three to four			Four to five			Five to six		
	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)	Event (%)	Total	Median time (months)
3–4				12,652 (32.3)	39,129	4.44	9,567 (36.1)	26,512	4.44	7,521 (38.7)	19,426	4.31	5,553 (41.1)	13,515	4.31
5–6				3,828 (31.9)	11,997	4.56	6,392 (39.5)	16,196	4.21	5,892 (43.0)	13,691	4.01	4,863 (45.4)	10,722	4.27
7 or more				773 (38.4)	2,012	3.00	4,247 (39.3)	10,816	3.81	4,962 (42.2)	11,767	3.78	5,894 (45.9)	12,841	3.58
Total offences on day of index offence															
One	34,317 (27.4)	125,215	4.56	31,184 (33.3)	93,766	4.44	27,049 (37.2)	72,801	4.24	23,151 (40.2)	57,268	4.14	19,619 (43.3)	45,334	4.08
Two or more	533 (26.2)	2,031	4.44	481 (29.9)	1,611	3.72	419 (33.2)	1,263	3.78	366 (34.6)	1,059	3.21	320 (37.0)	865	3.29
Index offence type															
Exceeding the speed limit by less than 25km/h	28,025 (29.5)	94,982	4.44	26,026 (43.3)	60,163	4.32	22,664 (47.3)	47,889	4.18	19,460 (50.9)	38,207	4.01	16,498 (54.2)	30,446	3.98
Failure to stop or give-way	473 (14.6)	3,236	5.64	330 (40.4)	816	4.92	227 (42.9)	529	4.96	169 (42.9)	394	4.57	134 (45.9)	292	4.01
Overtaking, lane use and U-turn offences	385 (18.3)	2,101	4.80	275 (40.0)	688	5.04	214 (41.7)	513	4.55	167 (49.9)	335	4.93	151 (53.5)	282	5.06
Signalling and headlight offences	235 (22.7)	1,037	4.56	103 (39.5)	261	4.32	84 (47.2)	178	4.22	76 (56.3)	135	5.23	39 (45.9)	85	3.68
Mobile phone offences	366 (26.1)	1,403	4.92	440 (35.2)	1,249	5.28	423 (38.8)	1,090	5.23	440 (42.8)	1,027	4.90	477 (52.8)	904	4.90
Seat, seatbelt and helmet offences	646 (23.3)	2,774	5.52	528 (44.8)	1,179	5.28	432 (48.9)	883	4.49	357 (50.1)	712	4.57	273 (52.5)	520	4.31
Failure to obey traffic lights	4,416 (21.6)	20,472	4.80	3,367 (34.9)	9,634	4.56	2,905 (39.9)	7,289	4.54	2,441 (44.2)	5,519	4.77	2,010 (46.0)	4,365	4.64
Tailgating	91 (23.9)	381	5.04	62 (40.3)	154	4.92	41 (38.7)	106	3.52	45 (45.5)	99	5.69	43 (51.8)	83	4.41
Unsafe/Unroadworthy vehicle	c	25	1.92	6 (54.5)	11	6.60	6 (60.0)	10	1.89	c	c	3.60	c	c	5.88
Careless driving	c	122	5.16	30 (31.9)	94	4.80	26 (37.7)	69	5.98	c	66	6.02	c	53	3.86
Licence, number plate or P-Plate display offences	189 (26.5)	713	5.64	132 (69.8)	189	3.96	76 (68.5)	111	2.94	37 (60.7)	61	3.48	22 (48.9)	45	2.79

a Demerit points for the day only, as there were no accumulated demerit points.

b Accumulated demerit points were used. The accumulated demerit points variable was generated by summing together the demerit points a driver received on the day of the current index offence, with any demerit points placed on their licence in the three years prior.

c Some cell counts have been suppressed due to low cell counts. This has been done to maintain data confidentiality.

<https://doi.org/10.1371/journal.pone.0239942.t002>

Table 3. Association between driver characteristics, demerit points and driver reoffending within 12 months.

Variable	One to two	Two to three	Three to four	Four to five	Five to six
	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)
	34,850; 127,230 (72.6)	31,665; 95,369 (66.8)	27,468; 74,056 (62.9)	23,517; 58,322 (59.7)	19,939; 46,194 (56.8)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Sex					
Male	Ref	Ref	Ref	Ref	Ref
Female	0.81 (0.79–0.83)	0.93 (0.90–0.95)	1.00 (0.98–1.03)	1.00 (0.98–1.03)	1.01 (0.98–1.04)
Age at first licence					
19.5–24	Ref	Ref	Ref	Ref	Ref
25–34	0.99 (0.96–1.03)	0.98 (0.95–1.01)	0.99 (0.95–1.02)	0.98 (0.95–1.02)	1.00 (0.96–1.04)
35–44	1.04 (1.00–1.07)	0.96 (0.93–1.00)	0.95 (0.91–0.98)	0.94 (0.91–0.98)	0.97 (0.93–1.01)
45+	0.89 (0.85–0.92)	0.89 (0.86–0.93)	0.88 (0.84–0.92)	0.88 (0.83–0.92)	0.91 (0.86–0.96)
Years licenced at index offence					
Less than 1	1.49 (1.43–1.55)	1.96 (1.86–2.05)	2.37 (2.19–2.58)	2.82 (2.47–3.23)	3.53 (2.85–4.37)
1–4	1.20 (1.16–1.24)	1.46 (1.41–1.50)	1.53 (1.48–1.59)	1.57 (1.51–1.63)	1.54 (1.47–1.62)
5–9	1.14 (1.10–1.19)	1.23 (1.20–1.27)	1.24 (1.20–1.27)	1.26 (1.23–1.30)	1.24 (1.20–1.28)
10+	Ref	Ref	Ref	Ref	Ref
Licence type					
Car only	Ref	Ref	Ref	Ref	Ref
Car and heavy vehicle	1.04 (0.99–1.09)	1.08 (1.03–1.14)	1.04 (0.99–1.10)	0.98 (0.93–1.04)	1.02 (0.96–1.09)
Car and motorbike	1.03 (0.98–1.08)	1.03 (0.98–1.08)	1.07 (1.02–1.13)	1.00 (0.95–1.06)	1.00 (0.94–1.06)
Car, heavy vehicle and motorbike	0.92 (0.84–1.00)	0.96 (0.88–1.04)	1.02 (0.94–1.12)	0.92 (0.83–1.01)	0.99 (0.90–1.10)
Demerit points on day of index offence ^a					
One	Ref				
Two	0.62 (0.56–0.69)				
Three	0.82 (0.80–0.84)				
Four or more	0.62 (0.52–0.74)				
Accumulated demerit points ^b					
1–2		Ref	Ref	Ref	Ref
3–4		0.92 (0.90–0.94)	0.97 (0.94–1.00)	0.96 (0.93–1.00)	1.00 (0.96–1.04)
5–6		0.84 (0.81–0.87)	0.99 (0.95–1.02)	1.03 (0.99–1.07)	1.08 (1.04–1.12)
7 or more		1.06 (0.98–1.14)	0.94 (0.90–0.98)	0.95 (0.91–0.99)	1.03 (0.98–1.07)
Total offences on day of index offence					
One	Ref	Ref	Ref	Ref	Ref
Two or more	1.41 (1.21–1.64)	0.88 (0.81–0.97)	0.90 (0.81–0.99)	0.87 (0.78–0.96)	0.84 (0.75–0.94)

ABBREVIATIONS: HR = hazard ratio; CI = confidence interval

^a Demerit points for the day only, as there were no accumulated demerit points.

^b Accumulated demerit points were used. The accumulated demerit points variable was generated by summing together the demerit points a driver received on the day of the current index offence, with any demerit points placed on their licence in the three years prior.

Significant hazard ratios are shown in bold.

<https://doi.org/10.1371/journal.pone.0239942.t003>

Following a first offence, receiving more than one demerit point had a positive deterrent effect in the following 12 months. Notably, however, receiving four or more demerit points did not necessarily have a greater deterrent effect. This can be evidenced by the greatest effect being observed for offences with three demerit points. In terms of accumulated demerit points, the

results were very mixed, with no clear pattern evident of the effect on subsequent reoffending in the following 12 months (Table 3).

Factors associated with recidivism for specific offence types following each index offence

The next series of Cox proportional hazards models were stratified by offence type, this time not capturing demerit points.

Recidivism following the first offence. Table 4 provides the results of the Cox proportional hazards models used to examine factors associated with recidivism within 12 months following the first index offence for specific offence types. Gender was consistently found to be associated with time to re-offence within 12 months following the first offence. Females had a lower risk of reoffending in the 12 months that followed, for all offence types, when compared to males. The length of time a driver had held their drivers' licence was also found to be

Table 4. Association between driver characteristics, demerit points and driver reoffending within 12 months following the first offence, by offence type.

Variable	Speeding below 25km/h	Failure to obey traffic signal	Failure to stop or give way	Seat, seatbelt and helmet offences	Overtaking, lane use and U-turn offences	Mobile phone offences
	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)
	28,025; 94,974 (70.5)	4,416; 20,470 (78.4)	473; 3,236 (85.4)	646; 2,774 (76.7)	385; 2,101 (81.7)	366; 1,403 (73.9)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Sex						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.84 (0.82–0.87)	0.76 (0.71–0.81)	0.63 (0.52–0.76)	0.69 (0.59–0.82)	0.51 (0.41–0.63)	0.79 (0.63–0.98)
Age at first licence (years)						
19.5–24	Ref	Ref	Ref	Ref	Ref	Ref
25–34	1.02 (0.99–1.06)	1.03 (0.93–1.14)	0.75 (0.58–0.97)	0.82 (0.66–1.01)	0.88 (0.67–1.16)	0.71 (0.48–1.05)
35–44	1.09 (1.06–1.14)	0.99 (0.89–1.10)	0.79 (0.60–1.03)	0.87 (0.69–1.09)	0.72 (0.53–0.96)	0.70 (0.46–1.07)
45+	0.93 (0.89–0.97)	0.91 (0.81–1.02)	0.53 (0.38–0.75)	0.72 (0.54–0.97)	0.64 (0.44–0.93)	0.74 (0.45–1.22)
Years licenced at index offence						
Less than 1	1.43 (1.37–1.50)	1.72 (1.56–1.90)	2.09 (1.29–3.38)	1.47 (1.01–2.16)	1.70 (1.08–2.68)	2.82 (1.86–4.27)
1–4	1.15 (1.10–1.19)	1.35 (1.23–1.48)	1.81 (1.13–2.89)	1.37 (0.95–1.99)	1.25 (0.80–1.96)	2.10 (1.45–3.05)
5–9	1.08 (1.04–1.13)	1.29 (1.16–1.42)	1.89 (1.14–3.14)	1.18 (0.79–1.77)	1.25 (0.76–2.07)	1.90 (1.34–2.70)
10+	Ref	Ref	Ref	Ref	Ref	Ref
Licence type						
Car only	Ref	Ref	Ref	Ref	Ref	Ref
Car and heavy vehicle	0.99 (0.93–1.05)	1.39 (1.21–1.61)	1.18 (0.78–1.79)	0.80 (0.60–1.06)	1.02 (0.64–1.61)	1.32 (0.84–2.08)
Car and motorbike	0.99 (0.94–1.04)	1.26 (1.08–1.47)	0.86 (0.51–1.44)	1.17 (0.87–1.57)	0.51 (0.30–0.88)	1.51 (0.89–2.55)
Car, heavy vehicle and motorbike	0.88 (0.81–0.97)	0.82 (0.59–1.16)	1.02 (0.45–2.29)	0.97 (0.61–1.54)	1.21 (0.66–2.23)	1.12 (0.41–3.03)
Total offences on day of index offence						
One	Ref	Ref	Ref	Ref	Ref	Ref
Two or more	0.99 (0.90–1.08)	1.05 (0.72–1.54)	0.39 (0.10–1.58)	0.53 (0.34–0.84)	1.02 (0.45–2.28)	1.11 (0.59–2.09)

ABBREVIATIONS: HR = hazard ratio; CI = confidence interval.

Significant hazard ratios are shown in bold.

<https://doi.org/10.1371/journal.pone.0239942.t004>

associated with reoffending following the first offence. For all offence types, drivers who had been licenced less than one year had a greater risk of reoffending in the 12 months that followed when compared to drivers who had been licenced 10+ years. Indeed, for many offences, the risk of reoffending within 12 months was greater the shorter the length of time a driver had been licenced. This was particularly true following infringements for speeding below 25km/h, failure to obey a traffic signal, failure to stop or give way and mobile phone use. Age at first licence was also found to be associated with reoffending within 12 months following the first offence for some offence types. Drivers aged 45+ years when they first obtained their drivers licence and whose first infringement was for speeding below 25km/h offences, failing to stop or give way offences, seat, seat belt and helmet offences and overtaking, lane use or U-turn offences had a lower risk of reoffending in the 12 months that followed their first index offence when compared to drivers licenced prior to age 25 years. Licence type and total number of offences on the day of the index offence were not generally found to be associated with time to next infringement within 12 months across each of the offence types, with only a small number of statistically significant results observed and no clear pattern evident (Table 4).

Recidivism following the second offence. Table 5 provides the results of the Cox proportional hazards models used to examine factors associated with recidivism within 12 months following the second index offence, for specific offence types. Again, females generally had a lower risk of reoffending in the 12 months that followed the date of their second index offence, with the exception of seat, seatbelt and helmet index offences and overtaking, lane use and U-turn index offences, where, although the hazards ratios indicated a lower risk of reoffending, the results were not significant. The length of time a driver had held their licence also had an association with reoffending in the 12 months that followed the second offence, across all six offence types examined. Drivers licenced less than one year had a significantly greater risk of reoffending in the 12 months that followed the second offence, when compared to drivers licenced 10+ years. Indeed, for drivers whose second index offence was for speeding below 25km/h or failure to obey a traffic signal, all hazard ratios were statistically significant and showed a pattern that for each additional length of time licenced, the drivers in that group had a lower risk of reoffending in the following 12 months. The same pattern was also observed for drivers whose second offence was a seat, seat belt or helmet offence, an overtaking, lane use or U-turn offence or a mobile phone offence, although not all results were statistically significant. Receiving an infringement for more than one offence type on the day of the index offence was not significantly associated with recidivism in the 12 months that followed, with the exception of drivers whose most serious offence type was a speeding below 25km/h offence. For these drivers, receiving infringements for multiple offences on the same day appeared to have a deterrent effect. Age at first licence and licence type were not generally found to be associated with time to next infringement within 12 months across each of the offence types, with only a small number of statistically significant results (Table 5).

Recidivism following the third offence. Table 6 provides the results of the Cox proportional hazards models used to examine factors associated with recidivism within 12 months following the third index offence, for specific offence types. Unlike for the first and second index offences, there were no statistically significant associations for drivers' sex, across any of the six offence types examined. Age at first licence also did not generally have a statistically significant effect on recidivism or deterrence within 12 months, apart from drivers who had received an infringement for speeding below 25km/h offence. Amongst these drivers, those aged 45+ when they first obtained their drivers licence had a lower risk of reoffending within 12 months than those who obtained their drivers licence before age 25 years. This trend was also observed in some other offence types, but statistical significance was not reached. Again, years licenced was also found to generally have a significant effect on recidivism and

Table 5. Association between driver characteristics, demerit points and driver reoffending. Within 12 months following the second offence, by offence type.

Variable	Speeding below 25km/h	Failure to obey traffic signal	Failure to stop or give way	Seat, seatbelt and helmet offences	Overtaking, lane use and U-turn offences	Mobile phone offences
	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)
	26,449; 75,746 (65.1)	3,501; 13,162 (73.4)	304; 1,413 (78.5)	512; 1,642 (68.8)	245; 968 (74.7)	351; 1,298 (73.0)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Sex						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.94 (0.92–0.97)	0.88 (0.82–0.94)	0.78 (0.61–0.99)	0.83 (0.68–1.01)	0.79 (0.60–1.05)	0.76 (0.61–0.96)
Age at first licence (years)						
19.5–24	Ref	Ref	Ref	Ref	Ref	Ref
25–34	0.99 (0.95–1.02)	0.98 (0.88–1.10)	0.78 (0.61–0.99)	0.89 (0.71–1.11)	1.02 (0.71–1.47)	1.15 (0.84–1.58)
35–44	0.99 (0.96–1.03)	0.93 (0.83–1.05)	0.97 (0.67–1.41)	0.82 (0.63–1.05)	1.01 (0.69–1.49)	0.71 (0.49–1.05)
45+	0.91 (0.87–0.95)	0.92 (0.80–1.04)	1.06 (0.70–1.62)	0.69 (0.48–0.99)	1.12 (0.71–1.76)	0.86 (0.52–1.44)
Years licenced at index offence						
Less than 1	1.88 (1.78–1.99)	2.00 (1.73–2.32)	2.14 (1.37–3.36)	1.84 (1.26–2.70)	1.81 (1.03–3.19)	2.16 (1.38–3.39)
1–4	1.40 (1.36–1.45)	1.56 (1.44–1.70)	1.24 (0.88–1.75)	1.54 (1.15–2.07)	1.71 (1.16–2.52)	1.46 (1.08–1.97)
5–9	1.20 (1.16–1.25)	1.22 (1.11–1.33)	1.34 (0.94–1.93)	1.27 (0.93–1.74)	1.49 (0.98–2.25)	1.09 (0.84–1.43)
10+	Ref	Ref	Ref	Ref	Ref	Ref
Licence type						
Car only	Ref	Ref	Ref	Ref	Ref	Ref
Car and heavy vehicle	1.05 (1.00–1.12)	1.27 (1.08–1.49)	1.26 (0.83–1.92)	1.16 (0.89–1.53)	1.36 (0.78–2.35)	1.08 (0.71–1.64)
Car and motorbike	1.00 (0.95–1.06)	1.10 (0.93–1.31)	1.45 (0.86–2.42)	1.39 (1.02–1.89)	1.00 (0.62–1.61)	1.12 (0.71–1.77)
Car, heavy vehicle and motorbike	0.91 (0.83–1.00)	1.04 (0.72–1.49)	1.43 (0.70–2.93)	1.27 (0.82–1.97)	0.66 (0.21–2.08)	0.78 (0.32–1.92)
Total offences on day of index offence						
One	Ref	Ref	Ref	Ref	Ref	Ref
Two or more	0.90 (0.82–0.99)	0.78 (0.54–1.13)	0.91 (0.37–2.20)	0.68 (0.41–1.14)	0.22 (0.03–1.59)	1.23 (0.61–2.51)

ABBREVIATIONS: HR = hazard ratio; CI = confidence interval.

Significant hazard ratios are shown in bold.

<https://doi.org/10.1371/journal.pone.0239942.t005>

deterrence within 12 months. Across all offence types, with the exception of drivers whose third index offence was for an overtaking, lane use and U-turn offence, drivers who had held their licence less than 1 year were at greater risk of re-offending in the 12 months that followed, compared to drivers who had held their licence for 10+ years. Once again, a pattern was also observed where risk decreased gradually, the longer a driver had held a licence. This pattern was observed for all offence types, however not all results were statistically significant (Table 6).

Recidivism following the fourth offence. Table 7 provides the results of the Cox proportional hazards models used to examine factors associated with recidivism within 12 months following the fourth index offence for specific offence types. Consistent with recidivism following the third index offence, gender was not found to have a statistically significant effect on recidivism within 12 months for any offence type. Similarly, age at first licence was also not generally found to be associated with recidivism within 12 months, following the fourth offence, with only two statistically significant results identified. Amongst drivers who received

Table 6. Association between driver characteristics, demerit points and driver reoffending within 12 months following the third offence, by offence type.

Variable	Speeding below 25km/h	Failure to obey traffic signal	Failure to stop or give way	Seat, seatbelt and helmet offences	Overtaking, lane use and U-turn offences	Mobile phone offences
	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)	Event; Total (% censored)
	23,286; 59,875 (61.1)	2,828; 9,571 (70.5)	170; 813 (79.1)	400; 1,170 (65.8)	205; 682 (69.9)	382; 1,260 (69.7)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Sex						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.99 (0.97–1.02)	1.04 (0.96–1.12)	1.13 (0.81–1.58)	0.89 (0.71–1.11)	0.94 (0.70–1.28)	0.94 (0.76–1.17)
Age at first licence (years)						
19.5–24	Ref	Ref	Ref	Ref	Ref	Ref
25–34	0.99 (0.96–1.03)	1.02 (0.91–1.15)	0.96 (0.64–1.52)	0.91 (0.71–1.16)	1.09 (0.74–1.62)	1.28 (0.95–1.71)
35–44	0.97 (0.94–1.01)	0.91 (0.81–1.04)	0.88 (0.55–1.39)	0.78 (0.58–1.04)	0.96 (0.63–1.47)	1.05 (0.75–1.48)
45+	0.91 (0.87–0.96)	0.89 (0.77–1.03)	0.80 (0.46–1.42)	0.46 (0.29–0.75)	1.01 (0.59–1.72)	0.82 (0.47–1.42)
Years licenced at index offence						
Less than 1	2.24 (2.05–2.44)	2.63 (2.04–3.39)	3.29 (1.37–7.88)	2.80 (1.56–5.00)	2.00 (0.93–4.28)	2.43 (1.22–4.82)
1–4	1.45 (1.41–1.50)	1.78 (1.62–1.96)	1.87 (1.24–2.80)	1.75 (1.31–2.33)	1.75 (1.21–2.53)	1.23 (0.92–1.64)
5–9	1.20 (1.16–1.23)	1.25 (1.14–1.37)	1.37 (0.90–2.06)	1.42 (1.06–1.90)	1.33 (0.91–1.92)	1.07 (0.85–1.36)
10+	Ref	Ref	Ref	Ref	Ref	Ref
Licence type						
Car only	Ref	Ref	Ref	Ref	Ref	Ref
Car and heavy vehicle	1.02 (0.96–1.02)	1.23 (1.02–1.48)	1.70 (0.94–3.08)	0.84 (0.61–1.17)	1.72 (1.06–2.82)	0.89 (0.58–1.34)
Car and motorbike	1.04 (0.98–1.09)	1.26 (1.05–1.50)	1.34 (0.69–2.61)	0.98 (0.66–1.44)	1.54 (0.90–2.65)	1.10 (0.69–1.75)
Car, heavy vehicle and motorbike	0.97 (0.88–1.07)	1.48 (1.07–2.04)	1.91 (0.88–4.15)	1.09 (0.66–1.79)	1.36 (0.55–3.34)	0.50 (0.18–1.35)
Total offences on day of index offence						
One	Ref	Ref	Ref	Ref	Ref	Ref
Two or more	0.90 (0.81–1.00)	0.80 (0.54–1.19)	1.23 (0.32–5.23)	0.80 (0.50–1.26)	1.14 (0.42–3.07)	0.70 (0.26–1.88)

ABBREVIATION: HR = hazard ratio; CI = confidence interval.

Significant hazard ratios are shown in bold.

<https://doi.org/10.1371/journal.pone.0239942.t006>

an infringement for speeding below 25km/h or failing to obey a traffic signal, those who received their licence at age 45+ years had a lower risk of reoffending in the 12 months that followed compared to drivers who were licenced below the age of 25 years. As was observed with reoffending following the first, second and third offences, the length of time a driver had been licenced was found to be associated with recidivism within 12 months across all offence types examined. Indeed, the lesser the period of time that a driver had been licenced, the greater their risk of reoffending in the 12 months that followed. In terms of licence type, there were only two significant results found, indicating this factor was generally not associated with reoffending within 12 months following the fourth index offence. The number of offences on the day of the index offence was also generally not associated with recidivism within 12 months, with the exception of drivers whose fourth index infringement was for speeding below 25km/h. Amongst these drivers, those who received infringements for other offence types on the same day had a lower risk of recidivism in the 12 months that followed when compared to drivers who only received an infringement for the speeding offence (Table 7).

Table 7. Association between driver characteristics, demerit points and driver reoffending within 12 months following the fourth offence, by offence type.

Variable	Speeding below 25km/h Event; Total (% censored)	Failure to obey traffic signal Event; Total (% censored)	Seat, seatbelt and helmet offences Event; Total (% censored)	Mobile phone offences Event; Total (% censored)
	20,079; 47,660 (57.9)	2,346; 7,227 (67.5)	306; 890 (65.6)	343; 1,070 (67.9)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Sex				
Male	Ref	Ref	Ref	Ref
Female	1.01 (0.98–1.04)	0.98 (0.90–1.07)	0.90 (0.70–1.15)	0.82 (0.66–1.03)
Age at first licence (years)				
19.5–24	Ref	Ref	Ref	Ref
25–34	1.01 (0.97–1.04)	0.93 (0.82–1.05)	0.87 (0.65–1.15)	1.07 (0.81–1.41)
35–44	0.97 (0.93–1.01)	0.95 (0.83–1.08)	0.76 (0.54–1.07)	0.84 (0.60–1.18)
45+	0.92 (0.87–0.97)	0.82 (0.70–0.97)	0.78 (0.49–1.23)	0.23 (0.09–0.71)
Years licenced at index offence				
Less than 1	2.75 (2.38–3.19)	2.21 (1.43–3.41)	2.98 (1.08–8.23)	14.57 (4.56–46.57)
1–4	1.54 (1.48–1.60)	1.62 (1.44–1.81)	1.87 (1.37–2.56)	1.37 (0.96–1.94)
5–9	1.24 (1.20–1.28)	1.23 (1.12–1.35)	1.51 (1.13–2.03)	1.16 (0.92–1.47)
10+	Ref	Ref	Ref	Ref
Licence type				
Car only	Ref	Ref	Ref	Ref
Car and heavy vehicle	0.97 (0.91–1.03)	1.15 (0.95–1.39)	1.15 (0.81–1.63)	0.59 (0.36–0.98)
Car and motorbike	1.01 (0.95–1.07)	0.97 (0.70–1.21)	0.65 (0.37–1.15)	0.85 (0.51–1.42)
Car, heavy vehicle and motorbike	0.87 (0.78–0.97)	1.42 (1.03–1.95)	1.07 (0.61–1.87)	0.93 (0.44–1.99)
Total offences on day of index offence				
One	Ref	Ref	Ref	Ref
Two or more	0.88 (0.78–0.98)	0.70 (0.45–1.09)	0.96 (0.60–1.55)	0.48 (0.12–1.95)

ABBREVIATION: HR = hazard ratio; CI = confidence interval.

Significant hazard ratios are shown in bold.

<https://doi.org/10.1371/journal.pone.0239942.t007>

Recidivism following the fifth offence. Table 8 provides the results of the final series of Cox proportional hazards models, used to examine factors associated with recidivism within 12 months following the fifth index offence. Gender was not found to have any statistically significant effect on reoffending within 12 months. This was consistent with the pattern that emerged following the third and fourth index offences. Age at first licence was not generally found to be associated with recidivism within 12 months, with only one significant result emerging. Drivers who were aged 45+ years when they received their licence had a lower risk of reoffending in the 12 months that followed when compared to drivers licenced prior to the age of 25 years, where the fifth index offence was for speeding below 25km/h. Consistent with the patterns that emerged in the Cox proportional hazards models for the earlier index offences, length of time licenced was also found to be associated with recidivism within 12 months following the fifth index offence. The shorter the period of time a driver had been licenced, the greater was the risk of reoffending within 12 months, irrespective of offence type. No statistically significant associations were identified for licence type, irrespective of offence type. Finally, for drivers whose most serious offence was speeding below 25km/h on their fifth index offence, receiving an infringement for an additional offence had a deterrent effect when compared to drivers who only received a single infringement for the speeding offence (Table 8).

Table 8. Association between driver characteristics, demerit points and driver reoffending within 12 months following the fifth offence, by offence type.

Variable	Speeding below 25km/h Event; Total (% censored)	Failure to obey traffic signal Event; Total (% censored)
	17,015; 37,973 (55.2)	1,899; 5,451 (65.2)
	HR (95% CI)	HR (95% CI)
Sex		
Male	Ref	Ref
Female	1.01 (0.98–1.04)	1.00 (0.90–1.10)
Age at first licence (years)		
19.5–24	Ref	Ref
25–34	1.01 (0.97–1.05)	0.95 (0.83–1.09)
35–44	0.97 (0.93–1.02)	0.92 (0.80–1.06)
45+	0.93 (0.87–0.99)	0.88 (0.74–1.06)
Years licenced at index offence		
Less than 1	3.49 (2.79–4.36)	4.51 (2.13–9.56)
1–4	1.52 (1.45–1.59)	1.58 (1.36–1.83)
5–9	1.21 (1.17–1.25)	1.34 (1.21–1.49)
10+	Ref	Ref
Licence type		
Car only	Ref	Ref
Car and heavy vehicle	1.03 (0.96–1.10)	0.96 (0.77–1.20)
Car and motorbike	0.98 (0.92–1.05)	1.03 (0.83–1.27)
Car, heavy vehicle and motorbike	0.98 (0.88–1.09)	0.99 (0.66–1.48)
Total offences on day of index offence		
One	Ref	Ref
Two or more	0.88 (0.78–0.99)	0.62 (0.38–1.00)

ABBREVIATION: HR = hazard ratio; CI = confidence interval

Significant results are shown in bold

<https://doi.org/10.1371/journal.pone.0239942.t008>

Discussion

Summary and key findings

A number of driver characteristics were associated with recidivism and time to reoffending within 12 months following a traffic offence. Irrespective of offence type, male drivers were quicker to reoffend within 12 months than female drivers, amongst those with only one or two previous offences. These differences, however, were not observed in drivers with more than two previous infringements. These findings are in some respects consistent with existing international literature. Female drivers perceive levels of risk to be higher than male drivers, with male drivers subsequently showing higher rates of risky driving behaviour [51–53]. If drivers perceive levels of risk to be higher, we may reasonably expect they would be less likely to reoffend following a traffic infringement. The disappearance of the gender differences in latter offences may be explained by the idea of some offenders being incorrigible [54]. For drivers with extensive offending histories, it is likely that, regardless of gender, we are seeing a group of offenders for whom their behaviour is not amenable through the use of traffic infringements.

Irrespective of offence type, newly licenced drivers consistently had a higher risk of reoffending within 12 months, when compared with drivers who had held their licence for an

extended period of time. Previous studies have found that young, new drivers are one of the riskiest groups of drivers on the roads, and can be resistant to deterrence by legal sanctions [55–58]. However, the model used in this study adjusted for age, indicating that for any age group, those drivers who have had their licence for the least amount of time have a shorter time to next infringement. This may be the result of a combination of two factors. Firstly, inexperienced drivers may not recognise the risks associated with particular behaviours, such as mobile phone use whilst driving, and thus may be more inclined to perform such behaviours. Secondly, inexperienced drivers may be less skilled than more experienced drivers, meaning they may be more likely to make errors while driving, such as failing to stop or give way, resulting in them receiving traffic infringements.

Driver sex and years licenced are not factors that can be modified to decrease risk of further offending. They do, however, indicate groups of drivers for whom it may be beneficial to develop strategies that aim to prevent repeat offending.

Existing research has suggested that some groups of drivers, such as newly licenced drivers displaying P-plates, feel that police specifically target them for enforcement [59]. Whilst targeting of enforcement may potentially be a factor in the high levels of [captured] recidivism seen in some groups in the study, such as amongst drivers licenced less than one year, the results do not support this to be the primary factor. The two most prevalent offence types (speeding at less than 25km/h over the speed limit and failure to obey a traffic signal) are most widely enforced in Victoria via the use of an automated camera system. Police discretion is therefore unlikely to be a factor that explains the greater levels of recidivism within 12 months observed amongst drivers with less experience.

Licence type was not generally found to have a significant influence on recidivism and time to reoffending. Existing research has shown mixed results on whether drivers' behaviour differs depending on whether they are operating a car or a motorcycle. A study by Rowden et al found evidence to suggest that individuals ride motorcycles in a less aggressive and less risky manner compared to when they are driving a car, due to the increased vulnerability associated with motorcycle riding [60]. In contrast, a study by Horswill and Helman found that motorcycle riders generally travelled at higher speeds and took more risks when overtaking and changing lanes, when compared to car drivers [61]. The current study was not able to confirm either perspective. This was for two primary reasons. Firstly, the data used did not contain information on the type of vehicle a person was operating at the time of an offence. Thus, comparisons could not be drawn between differences associated with the operation of specific vehicle types. Secondly, given drivers in this study all held a car licence at a minimum, with potential other licence types held in addition to a car licence, they may be in some respects different to individuals who only have a motorcycle licence. Further research may seek to explore these differences.

The direction of associations between demerit points and deterrence were perhaps the most surprising and interesting results that emerged from this study. Following the first offence, drivers who received multiple demerit points were less likely to reoffend in the year that followed, when compared to drivers who received only a single demerit point. This suggests that demerit points issued to drivers following a first offence may achieve deterrence. Unfortunately, however, the subsequent influence of accumulated demerit points was not quite as promising. For drivers with multiple prior offences and a high number of accumulated demerit points, demerit points did not have a statistically significant deterrent effect. It may be possible we are seeing an emboldening effect here, where, as a result of receiving an infringement for a traffic offence, drivers were encouraged, as opposed to discouraged to perform further offences [62]. Similarly, Pogarsky & Piquero suggested that when drivers receive a punishment, they may have a higher risk of reoffending soon after, as a result of "gamblers fallacy", where they have a belief the risk of being apprehended again within quick succession is

small [63]. The findings relating to demerit points are not consistent with the results from Haque, who found that a higher number of accumulated demerit points had a positive influence on deterrence [40]. It is notable that there were some differences in the methodological approach taken by Haque [40]. Firstly, the previous study included a longer follow up time period of three years, compared to the one year undertaken in the current study [40]. Secondly, the time to event approach taken here, that required drivers to only have ever received one infringement, censoring them if they did not receive a second infringement within 12 months, was different to that taken in the Haque study [40]. Haque's study required that all drivers had to have received at least two infringements, with the second coming within three years of the first. Indeed, for this reason, Haque only included drivers who had held their licence a minimum of three years [40]. No minimum period for holding a licence was implemented in this study. This is of particular note, given the current study showed higher levels of deterrence in more experienced drivers. Thus, the differences in study findings observed may have been a result of methodological differences, in addition to or rather than changes that have occurred in use of the road network and sanctioning over the last 30+ years.

Study implications

Overall, despite the current traffic infringements system in Victoria appearing to have a positive influence on the behaviour of some drivers, there remain groups of drivers for whom the current infringements system may not be achieving deterrence, with the most notable being newly licenced drivers. Furthermore, the current demerit point system appeared effective for first-time offenders but not for repeat offenders. To achieve a reduction in the number of serious road crashes that result from drivers performing illegal driving behaviours, it is essential that the sanctioning system is flexible in responding to different groups of offenders. This could involve the use of mandatory driver education, or greater use of technology solutions such as speed limiting systems, in addition to traffic infringements, targeted at high-risk groups such as repeat offenders and novice drivers, to reduce reoffending in these groups.

Study strengths

The current study has many strengths that make it valuable in enhancing understandings of the Victorian infringements system. First, the study used a very large population of drivers. Second, with approximately 13 years of data available, the study was a comprehensive longitudinal analysis. Third, the range of variables and the depth of information available meant the study was able to take into account a range of potential risk factors for recidivism. Fourth, given some of the drivers whose data is included in the extract for this study were of quite advanced age by the end of the study period, the inclusion of older drivers in research is highly valuable. Existing research has tended to focus on younger drivers, with less focus on the mature driver population. This is despite the number of older drivers increasing [64, 65], a pattern that is expected to continue into the future [66].

Study limitations

There are some limitations that must be considered when interpreting the results. The most notable limitation is that the results are not necessarily generalizable beyond the jurisdiction of Victoria, Australia. Enforcement of traffic rules and regulations is the responsibility of individual jurisdictions. In Australia, there are eight states and territories. Each runs independently of one another on issues of licensing and infringements. Whilst there are many similarities between jurisdictions that may mean the results here are relevant, other jurisdictions should examine the degree to which these results may be applicable to their local situation.

A second limitation that should be acknowledged relates to the group of drivers for whom data was drawn upon for use in this study. Data were only available for drivers born prior to 31 December 1974 and licenced between 8 July 1994 and 21 May 2016. Many drivers who were born on or prior to 31 December 1974 would have already held their licence prior to July 1994, and were therefore not eligible for inclusion in the study, as their full infringement history was not available. As a result, the study sample is relatively aged and has a larger number of individuals who received their licence at an older age (resulting in an overrepresentation of females) than would generally be expected in the Victorian driving population. However, as noted above, an examination of older drivers may be considered advantageous.

Areas for future research

The current study has provided valuable information in relation to traffic infringements and reoffending. There are however a number of other areas where further research may be valuable in further developing knowledge in this area. First, research could focus on drivers with a high number of demerit points, such that they are close to losing their licence, or alternatively drivers who have reached 12-point demerit points (which is the demerit point limit in a three-year period for drivers on a full licence) and have elected to take an extended demerit point period. This extended demerit point period enables them to keep driving, but sees them have their licence suspended for double the suspension length they would have ordinarily received, if they reoffend within the following year. Such research may help us understand the factors that may be acting as barriers to deterrence amongst some of the most serious traffic offenders.

Second, the current study focussed on one type of sanction administered to drivers for traffic offences in Victoria, this being infringements. Drivers can also receive other sanctions for more serious offending, including licence suspension, and even a period of imprisonment. The results presented in this study are therefore not indicative of time to reoffending following these other forms of sanctioning. Future research could consider time to traffic reoffending in Victoria following licence loss or a period of imprisonment for a traffic offence. Furthermore, future research could draw comparisons between different types of sanctions, to gain an understanding of what might be the most effective strategy or strategies for responding to illegal driving behaviours. Such a study may be beneficial not only in Victoria, where the current study was undertaken, but also in other jurisdictions, considering local circumstances. Further research can also include comparisons between jurisdictions where approaches in responding to traffic offences vary. Such an approach may provide an opportunity to identify best practices and learn from the experiences of other jurisdictions.

Third, between 1994 and 2016, which, was the time period considered in the current study, vehicle technology underwent substantial change. Features such as Autonomous Emergency Braking (AEB) [67], Blind Spot Monitoring (BSM) [68], Lane Departure Warning (LDW) [69] and Traffic Sign Recognition (TSR) [70] became available in vehicles. Widespread use of smartphones also emerged across the study period [71]. In addition, technology that specifically seeks to respond to drivers who are repeat traffic offenders also came to be more widely used. This includes, for example, the use of alcohol interlock devices for drink drivers [72]. Future research that tracks the rollout of new and emerging technologies may prove valuable in examining the effects these technologies have on the performance of illegal driving behaviours and reoffending.

Finally, the analytical approach taken in the current research approach proved to be effective in addressing the aims of the study. However, to further enhance the longitudinal approach taken, future research could also multilevel modelling, to further explore traffic

offending and recidivism. Multilevel models are useful for examining events that can happen repeatedly. Data are arranged in a hierarchy, with level one, which is the occurrence of the event occurring, being nested in level two, which is the individual the event relates to [73]. Such a study may enable a detailed examination of the factors that underlie an individual moving in and out of traffic offending behaviour, through for example, experience of employment and unemployment or good health and poor health. The data set used in the current study did not provide this type of information, thus new data sources would need to be explored.

Conclusions

In conclusion, the current study shows that whilst infringements for some groups of drivers are associated with a lower risk of subsequent traffic offending within 12 months, infringements are not equally effective in deterring all groups of drivers. Rethinking how to respond to repeat offenders is a crucial step to achieving greater safety on the roads. Introducing new ways of responding to some groups of drivers will no doubt receive resistance from some members of the community. Despite this, it is important to recognise the most important goal is achieving safety for all road users. Finding the best approaches to responding to road user behaviour provides the greatest opportunities to make progress towards decreasing the number of road crashes, and ultimately deaths, that result from risky and illegal driving behaviours.

Acknowledgments

The authors would like to thank VicRoads for providing access to the data this study used.

Author Contributions

Conceptualization: Hayley McDonald, Janneke Berecki-Gisolf, Karen Stephan, Stuart Newstead.

Data curation: Hayley McDonald, Stuart Newstead.

Formal analysis: Hayley McDonald.

Methodology: Hayley McDonald, Janneke Berecki-Gisolf, Karen Stephan.

Project administration: Hayley McDonald.

Supervision: Janneke Berecki-Gisolf, Karen Stephan, Stuart Newstead.

Writing – original draft: Hayley McDonald.

Writing – review & editing: Hayley McDonald, Janneke Berecki-Gisolf, Karen Stephan, Stuart Newstead.

References

1. World Health Organization. Global status report on road safety 2018. Geneva: World Health Organization; 2018. Available from: https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/
2. Holdridge J, Shankar V & Ulfarsson G. The crash severity impacts of fixed roadside objects. *Journal of Safety Research*. 2005; 36; 139–147. <https://doi.org/10.1016/j.jsr.2004.12.005> PMID: 15885705
3. Stanton NA & Salmon PM. Human error taxonomies applied to driving: A generic driver error taxonomy and its implications for intelligent transport systems. *Safety Science*. 2009; 47: 227–237. <https://doi.org/10.1016/j.ssci.2008.03.006>
4. Stigson H, Krafft M & Tingvall C. Use of fatal real-life crashes to analyze a safe road transport system model, including the road user, the vehicle, and the road. *Traffic Injury Prevention*. 2008; 9: 463–471. <https://doi.org/10.1080/15389580802335240> PMID: 18836958

5. Zein S & Navin F. Improving Traffic Safety: A New Systems Approach. *Transportation Research Record: Journal of the Transportation Research Board*. 2003; 1830: 1–9. <https://doi.org/10.3141/1830-01>.
6. Bedard M, Guyatt G, Stones M & Hirdes J. The independent contribution of driver, crash, and vehicle characteristics to driver fatalities. *Accident Analysis & Prevention*. 2002; 34: 717–727. [https://doi.org/10.1016/S0001-4575\(01\)00072-0](https://doi.org/10.1016/S0001-4575(01)00072-0)
7. Blows S, Ivers R, Connor J, Ameratunga S & Norton R. Does periodic vehicle inspection reduce car crash injury? Evidence from the Auckland Car Crash Injury Study. *Australian and New Zealand Journal of Public Health*. 2003; 27: 323–327. <https://doi.org/10.1111/j.1467-842x.2003.tb00401.x> PMID: 14712793
8. Blows S, Ivers R, Woodward M, Connor J, Ameratunga S & Norton R. Vehicle year and the risk of car crash injury. *Injury Prevention*. 2003; 9: 353–356. <https://doi.org/10.1136/ip.9.4.353> PMID: 14693899
9. Ma C, Hao W, Xiang W & Yan W. The impact of aggressive driving behavior on driver-injury severity at highway-rail grade crossings accidents. *Journal of Advanced Transportation*. 2018; 2018: 1–10. <https://doi.org/10.1155/2018/9841498>
10. Ma C, Yang D, Zhou J, Feng Z & Yuan Q. Risk riding behaviors of urban e-bikes: A literature review. *International Journal of Environmental Research and Public Health*. 2019; 16: 2308. <https://doi.org/10.3390/ijerph16132308> PMID: 31261838
11. Salmon P, Regan M & Johnston, I. Human error and road transport: Phase one—Literature Review. Report No. 256. Clayton, Victoria, Australia: Monash University Accident Research Centre; 2005. Available from: https://www.monash.edu/_data/assets/pdf_file/0010/216946/Human-Error-and-Road-Transport-Phase-One-A-framework-for-an-error-tolerant-road-transport-system.pdf
12. Wierwille W., Hanowski R., Hankey J., Kieliszewski C., Lee S., Medina A, et al. Identification and Evaluation of Driver Errors: Overview and Recommendations. 2002. Report No. FHWA-RD-02-003. Virginia, USA: Federal Highway Administration. Available from: <https://rosap.nhtl.bts.gov/view/dot/922>
13. Penmetsa P & Pulugurtha S. Risk drivers pose to themselves and other drivers by violating traffic rules. *Traffic Injury Prevention*. 2016; 18: 1–7. <https://doi.org/10.1080/15389588.2016.1192284> PMID: 27258209
14. Aarts H & van Schagen I. Driving speed and the risk of road crashes: a review. *Accident Analysis and Prevention*. 2006; 38: 215–224. <https://doi.org/10.1016/j.aap.2005.07.004> PMID: 16256932
15. Kloeden C, McLean A, Moore V & Ponte G. Traveling speed and the risk of crash involvement: Volume 1-Findings. Canberra, Australia: Federal Office of Road Safety; 1997. Available from: https://www.infrastructure.gov.au/roads/safety/publications/1997/pdf/Speed_Risk_1.pdf
16. Blomberg R, Peck R, Moskowitz H, Burns M & Fiorentino D. Crash risk of alcohol involved driving: A case-control study. Connecticut: USA: Dunlap and Associates Inc; 2005. Available from: <http://www.dunlapandassociatesinc.com/crashriskofalcoholinvolveddriving.pdf>
17. Schulze H, Schumacher M, Urmeew R & Auerbach K. Final Report: Work performed, main results and recommendations. 2012. Available from: <https://www.oisevi.org/a/archivos/estudios-especificos/ong/Union-Europea-Druid-Final-Report.pdf>
18. McEvoy SP, Stevenson M & Woodward M. Phone use and crashes while driving: a representative survey of drivers in two Australian states. *Medical Journal of Australia*. 2006; 185: 630–634. <https://doi.org/10.5694/j.1326-5377.2006.tb00734.x> PMID: 17181509
19. McEvoy SP, Stevenson MR, McCartt AT, Woodward M, Haworth C, Palamara P, et al. Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. *BMJ*. 2005; 331: 428. <https://doi.org/10.1136/bmj.38537.397512.55> PMID: 16012176
20. Rakauskas ME, Gugerty LJ & Ward NJ. Effects of naturalistic cell phone conversations on driving performance. *Journal of Safety Research*. 2004; 35: 453–464. <https://doi.org/10.1016/j.jsr.2004.06.003> PMID: 15474548
21. Bates L, Soole D & Watson B. The effectiveness of traffic policing in reducing traffic crashes. In: Prentzler T, editor. *Policing and security in practice: Challenges and achievements*. Basingstoke, United Kingdom: Palgrave Macmillan Publishing; 2012. pp. 90–109.
22. Andrews D & Bonta J. *Prevention and Rehabilitation*. In: *Psychology of criminal conduct*. 5th Edition. New York, USA: LexisNexis; 2010.
23. Bagaric M & Alexander T. The capacity of criminal sanctions to shape the behaviour of offenders: Specific deterrence doesn't work, rehabilitation might and the implications for sentencing. *Criminal Law Journal*. 2012; 36: 159–172.
24. Brown S, Esbensen F & Geis G. *Deterrence and rational choice theories of crime*. In: *Criminology: Explaining crime and its context*. 9th Edition. New York, USA: Taylor and Francis; 2015.

25. Lab S. Specific deterrence and incapacitation. In: *Crime prevention: Approaches, practices and evaluations*. New York, USA: Taylor and Francis; 2016. 311–328.
26. Mitchell B. Crimes of misery and theories of punishment. *New Criminal Law Review: An International and Interdisciplinary Journal*. 2012; 15: 465–510. <https://doi.org/10.1525/nclr.2012.15.4.465>
27. Weisberg R. Meanings and measures of recidivism. *Southern California Law Review*. 2014; 87: 785–804.
28. VicRoads. About demerit points. 2017. Available from: <https://www.vicroads.vic.gov.au/licences/demerit-points-and-offences/about-demerit-points>
29. VicRoads. Fines. 2018. Available from: <https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties/fines>
30. VicRoads. Penalties. 2018. Available from: <https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties>
31. Ahlin EM, Zador PL, Rauch WJ, Howard JM & Duncan GD. First-time DWI offenders are at risk of recidivating regardless of sanctions imposed. *Journal of Criminal Justice*. 2011; 39: 137–142. <https://doi.org/10.1016/j.jcrimjus.2011.01.001> PMID: 21603059
32. Bouffard JA, Niebuhr N & Exum ML. Examining Specific Deterrence Effects on DWI Among Serious Offenders. *Crime & Delinquency*. 2016; 63: 1923–1945. <https://doi.org/10.1177/0011128716675359>
33. Freeman J, Liossis P & David N. Deterrence, defiance and deviance: an investigation into a group of recidivist drink drivers' self-reported offending behaviours. *The Australian and New Zealand Journal of Criminology*. 2006; 39: 1–19. <https://doi.org/10.1375/acri.39.1.1>
34. Hansen B. Punishment and deterrence: evidence from drunk driving. *American Economic Review*. 2015; 105: 1581–1617. <https://doi.org/10.1257/aer.20130189>
35. Rauch WJ, Zador PL, Ahlin EM, Howard JM, Frissell KC & Duncan G. D. Risk of alcohol-impaired driving recidivism among first offenders and multiple offenders. *The American Journal of Public Health*. 2010; 100: 919–924. <https://doi.org/10.2105/AJPH.2008.154575> PMID: 19846687
36. Terer K & Brown R. Effective drink driving prevention and enforcement strategies: approaches to improving practice. Trends and issues in crime and criminal justice. 2014. Number 472. Canberra, Australia: Australian Institute of Criminology. Available from: <https://aic.gov.au/publications/tandi/tandi472>
37. Trimboli L & Smith N. Drink-driving and recidivism in NSW. *Crime and Justice Bulletin*. 2009. Number 135. Sydney, Australia: NSW Bureau of Crime Statistics and Research. Available from: <https://www.bocsar.nsw.gov.au/Documents/CJB/cjb135.pdf>
38. Li J, Amr S, Braver ER, Langenberg P, Zhan M, Smith GS, et al. Are current law enforcement strategies associated with a lower risk of repeat speeding citations and crash involvement? A longitudinal study of speeding Maryland drivers. *Annals of Epidemiology*. 2011; 21: 641–647. <https://doi.org/10.1016/j.annepidem.2011.03.014> PMID: 21684176
39. Watson B, Siskind V, Fleiter J, Watson A & Soole D. Assessing specific deterrence effects of increased speeding penalties using four measures of recidivism. *Accident Analysis & Prevention*. 2015; 84: 27–37. <https://doi.org/10.1016/j.aap.2015.08.006> PMID: 26311201
40. Haque M. Evaluation of the demerit points system in deterring traffic offences. *Evaluation Review*. 1990; 14: 22–41. <https://doi.org/10.1177/0193841X9001400102>
41. Victorian Department Environment, Land, Water and Planning. Plan Melbourne 2017–2050. Metropolitan Planning Strategy. Melbourne, Victoria: State Government of Victoria; 2017. Available from: https://planmelbourne.vic.gov.au/_data/assets/pdf_file/0007/377206/Plan_Melbourne_2017-2050_Strategy_.pdf
42. Office of the Road Safety Camera Commissioner. Annual Report 2018–2019. Melbourne, Victoria: Office of the Road Safety Camera Commissioner; 2019. Available from: <https://cameracommissioner.vic.gov.au/publications/2018-19-annual-report>
43. Taylor D, MacBean C, Das A & Rosli R. Handheld mobile telephone use among Melbourne drivers. *Medical Journal of Australia*. 2017; 187: 432–434. <https://doi.org/10.5694/j.1326-5377.2007.tb01352.x>
44. VicRoads. About VicRoads. 2019. Available from: <https://www.vicroads.vic.gov.au/about-vicroads>
45. Walter SJ & Studdert DM. Relationship between penalties for road traffic infringements and crash risk in Queensland, Australia: a case-crossover study. *International Journal of Epidemiology*. 2015; 44: 1722–1730. <https://doi.org/10.1093/ije/dyv148> PMID: 26254199
46. Bradburn M, Clark T, Love S & Altman D. Survival analysis part II: multivariate data analysis—an introduction to concepts and methods. *British Journal of Cancer*. 2003; 89: 431–436. <https://doi.org/10.1038/sj.bjc.6601119>
47. Cox D. Regression models and life tables. *Journal of the Royal Statistical Society*. 1972; 34: 187–220. <https://doi.org/10.1111/j.2517-6161.1972.tb00899.x>

48. Bradburn M, Clark T, Love S & Altman D. Survival analysis part III: Multivariate data analysis—choosing a model and assessing its adequacy of fit. *British Journal of Cancer*. 2003; 89: 605–611. <https://doi.org/10.1038/sj.bjc.6601120> PMID: 12915864
49. Clark T, Bradburn M, Love S & Altman D. Survival analysis part 1: basic concepts and first analyses. *British Journal of Cancer*. 2003; 89: 232–238. <https://doi.org/10.1038/sj.bjc.6601118> PMID: 12865907
50. Flynn R. Survival analysis. *Journal of Clinical Nursing*. 2012; 21: 2789–2797. <https://doi.org/10.1111/j.1365-2702.2011.04023.x> PMID: 22860755
51. González-Iglesias B, Gómez-Fraguela JA & Luengo-Martín MÁ. Driving anger and traffic violations: Gender differences. *Transportation Research Part F: Traffic Psychology and Behaviour*. 2012; 15: 404–412. <https://doi.org/10.1016/j.trf.2012.03.002>
52. Lonczak HS, Neighbors C & Donovan DM. Predicting risky and angry driving as a function of gender. *Accident Analysis and Prevention*. 2007; 39: 536–545. <https://doi.org/10.1016/j.aap.2006.09.010> PMID: 17092475
53. Rhodes N & Pivik K. Age and gender differences in risky driving: The roles of positive affect and risk perception. *Accident Analysis & Prevention*. 2011; 43: 923–931. <https://doi.org/10.1016/j.aap.2010.11.015> PMID: 21376884
54. Pogarsky G. Identifying “deterable” offenders: implications for research on deterrence. *Justice Quarterly*. 2002; 19: 431–451. <https://doi.org/10.1080/07418820200095301>
55. Allen S, Murphy K & Bates L. What drives compliance? The effect of deterrence and shame emotions on young drivers’ compliance with road laws. *Policing and Society*. 2017; 27: 884–898. <https://doi.org/10.1080/10439463.2015.1115502>
56. Bates L, Darvell M & Watson B. Young and unaffected by road policing strategies: Using deterrence theory to explain provisional drivers’ (non)compliance. *Australian & New Zealand Journal of Criminology*. 2017; 50: 23–38. <https://doi.org/10.1177/0004865815589824>
57. Scott-Parker B & Oviedo-Trespalacios O. Young driver risky behaviour and predictors of crash risk in Australia, New Zealand and Colombia: Same but different? *Accident Analysis and Prevention*. 2017; 99: 30–38. <https://doi.org/10.1016/j.aap.2016.11.001> PMID: 27865138
58. Truelove V, Freeman J & Davey J. “you can’t be deterred by stuff you don’t know about”: Identifying factors that influence graduated driver licensing rule compliance. *Safety Science*. 2019; 111: 313–323. <https://doi.org/10.1016/j.ssci.2018.09.007>
59. Bates L, Scott-Parker B, Darvell M & Watson B. Provisional drivers’ perceptions of the impact of displaying P plates. *Traffic Injury Prevention*. 2017; 18: 820–825. <https://doi.org/10.1080/15389588.2017.1322697> PMID: 28453311
60. Rowden P, Watson B, Haworth N, Lennon A, Shaw L & Blackman R. Motorcycle riders’ self-reported aggression when riding compared with car driving. *Transportation Research Part F: Traffic Psychology and Behaviour*. 2016; 36: 92–103. <https://doi.org/10.1016/j.trf.2015.11.006>
61. Horswill MS & Helman S. A behavioral comparison between motorcyclists and a matched group of non-motorcycling car drivers: factors influencing accident risk. *Accident Analysis & Prevention*. 2003; 35: 589–597. [https://doi.org/10.1016/s0001-4575\(02\)00039-8](https://doi.org/10.1016/s0001-4575(02)00039-8)
62. Piquero AR & Pogarsky G. Beyond Stafford and Warr’s reconceptualization of deterrence: personal and vicarious experiences, impulsivity and offending behaviour. *Journal of Research in Crime and Delinquency*. 2002; 39: 153–186. <https://doi.org/10.1177/002242780203900202>
63. Pogarsky G & Piquero AR. Can punishment encourage offending? Investigating the “resetting effect”. *Journal of Research in Crime and Delinquency*. 2003; 40: 95–120. <https://doi.org/10.1177/0022427802239255>
64. Christensen K, Doblhammer G, Rau R & Vaupel JW. Ageing populations: the challenges ahead. *The Lancet*. 2009; 374: 1196–1208. [https://doi.org/10.1016/s0140-6736\(09\)61460-4](https://doi.org/10.1016/s0140-6736(09)61460-4) PMID: 19801098
65. Kwok C, Lloyd D & Yip P. Ageing population scenarios: an Australian experience. *Journal of Population Research*. 2013; 30: 335–345. <https://doi.org/10.1007/s12546-013-9114-0>
66. Anstey KJ, Eramudugolla R, Ross LA, Lautenschlager NT & Wood J. Road safety in an aging population: risk factors, assessment, interventions, and future directions. *International Psychogeriatrics*. 2016; 28: 349–356. <https://doi.org/10.1017/S1041610216000053> PMID: 26888735
67. Cicchino J. Effectiveness of forward collision warning and autonomous emergency braking systems in reducing front-to-rear crash rates. *Accident Analysis and Prevention*. 2017; 99: 142–152. <https://doi.org/10.1016/j.aap.2016.11.009> PMID: 27898367
68. Cicchino J. Effects of blind spot monitoring systems on police-reported lane-change crashes. *Traffic Injury Prevention*. 2018; 19: 615–622. <https://doi.org/10.1080/15389588.2018.1476973> PMID: 29927678

69. Isaksson-Hellman I & Lindman M. Traffic safety benefit of a lane departure warning system. *International Journal of Automotive Engineering*. 2018; 9: 289–295. https://doi.org/10.20485/jsaeijae.9.4_289
70. Roper Y, Rowland M, Chakich Z, McGill W, Nanayakkara V, Young D et al. Implications of Traffic Sign Recognition (TSR) Systems for Road Operators Operators. Research Report AP-R580-18. Sydney, New South Wales, Australia: Austroads; 2018. Available from: https://austroads.com.au/publications/connected-and-automated-vehicles/ap-r580-18/media/AP-R580-18_Implications_of_Traffic_Sign_Recognition.pdf
71. Oulasvirta A, Rattenbury T, Ma L & Raita E. Habits make smartphone use more pervasive. *Personal and Ubiquitous Computing*. 2012; 16: 105–114. <https://doi.org/10.1007/s00779-011-0412-2>
72. VicRoads. Victorian Alcohol Interlock Program: Key participant guidelines and rules of the program. 2020. Available from <https://www.vicroads.vic.gov.au/licences/demerit-points-and-offences/drink-and-drug-driving-offences/alcohol-interlock-program-participant-guidelines>
73. Steele F. Multilevel models for longitudinal data. *Journal of the Royal Statistical Society: series A (statistics in society)*. 2008; 171: 5–19. <https://doi.org/10.1111/j.1467-985X.2007.00509.x>

Chapter Six: Review and comparison of study designs for investigating the association between infringements and crashes

6.1 Introduction

This chapter provides a rationale for the selection of the study design used to explore the deterring influence of traffic infringements upon subsequent crash involvement (study two). Prior to commencing study two, a critical evaluation of four study designs was undertaken, to determine the most suitable design to answer the research questions. In this chapter, each study design is described and examples are cited to demonstrate the use of the study design in existing road safety research. The discussion then moves to presenting the strengths and limitations of the study design. A description of how the study design could be applied to address the aims of study two is provided, before finally evaluating the suitability of the design to address the research question.

In identifying an appropriate study design for study two of this thesis, the first criteria that was applied was that the design had to be observational in nature. This means that unlike experimental studies, the researcher does not randomly allocate subjects to an intervention group (Lu, 2009; Mann, 2003). Observational research design studies are suitable to be applied when undertaking research using administrative data sources, given the data has already been collected and the research aims to observe patterns within the data. Observational analyses may focus on examining exposure to risk/protective factors and later experience of an event of specific interest (Lu, 2009; Schneider et al., 2007). As indicated in chapter four, study two made use of VicRoads licensing, infringements and crash data. Research that involved allocating interventions to study participants was not possible, nor would it be appropriate for undertaking study two.

The four different study designs that were considered for use in study two were: 1) case-control study design; 2) case crossover study design; 3) case-time-control study design; 4) case-case-time-control study design. Each study design is examined in the following paragraphs.

6.2 Case-control study design

Case-control studies are undertaken in a retrospective manner. The researcher identifies an event of interest and categorises subjects into groups based on whether they have (cases) or have not (controls) experienced the event of interest. Prior exposures to possible risk factor/s are examined, to determine the potential influence that exposure to this risk factor may have had on the event occurring. Odds ratios are calculated to determine the strength of the relationship (Cole, 1979; Marshall, 2004).

6.2.1 Examples of road safety research that has used the case-control study design

Case-control studies have been successfully used in many road safety research studies (e.g. Blows et al., 2005a; Blows et al., 2005b; Chihuri, Li & Chen 2017; Meulenens et al., 2017). Indeed, the degree to which case-control studies have been used in the area of road safety research demonstrates the design's effectiveness in addressing road safety questions. However, prior to making a decision on whether this study design would be appropriate for use in study two of this thesis, an examination of its strengths and limitations was also essential. The following two sections provide an overview of these strengths and limitations.

6.2.2 Strengths of the case-control study design

An advantage of case-control studies is the relative ease with which they can be conducted. Case-control studies can be undertaken with speed and are an efficient option for examining risk factors for an outcome (e.g. Dupepe et al., 2019; Knol et al. 2008; Schulz & Grimes, 2002; van Stralen et al., 2010). The retrospective nature of the case-control study design means the researcher already knows the outcome at the outset of their study, and collects data on exposure at a time already passed. This means that there is no need for a researcher to wait, possibly multiple years, to follow individuals up and identify whether they ultimately experience the event of interest (Dupepe et al., 2019; Mann, 2003).

A second advantage of using the case-control study design is that researchers are able to examine an outcome of interest that is quite rare (Dupepe et al., 2019; Knol et al. 2008; Lu, 2009; Mann, 2003). Right at the beginning of the study, the researcher can identify a group of individuals who have experienced the outcome of interest, alongside a group who have not (Dupepe et al., 2019). In other types of study designs, such as cohort studies, a researcher follows groups of participants who have been exposed or not exposed to a risk

factor over an extended period-of-time, to determine if they experience one or more outcomes. In such designs, if the outcome is particularly rare, there is the risk that no study participants will have experienced the outcome during the study period. The researcher would then be left without any valuable data for analysis to understand risk or protective factors for the outcome of interest. In a case-control study design, the chance of not having any individuals who have experienced the outcome is removed (Mann, 2003).

A third advantage is that case-control studies require only relatively small sample sizes (Dupepe et al., 2019; Mann, 2003; Newman et al., 2013). This is closely linked to case-control studies being appropriate for examining outcomes that are rare. In other study designs, such as prospective cohort studies, if an outcome is rare, a researcher would require a large number of study subjects to have any chance of identifying a case. Given the researcher has already identified cases at the outset of a case-control study, they can proceed without having to recruit and follow up a large number of individuals, which can also enhance cost effectiveness (Dupepe et al., 2019; Mann, 2003; Newman et al., 2013).

6.2.3 Limitations of the case-control study design

Whilst, as indicated above, there are a number of strengths associated with using the case-control study design, there are also limitations. One limitation is that only one outcome can be studied (Lu, 2009; Mann, 2003; Newman et al., 2013). Given individuals are classified as cases or controls, based on the presence or absence of a particular outcome of interest, the researcher is unable to draw any conclusions on any other outcomes that the risk or protective factors examined may be associated with (Newman et al., 2013).

A second limitation of the case-control study design, and indeed perhaps the most significant one is the degree to which the design is open to bias (Mann, 2003; Newman et al., 2013; van Stralen et al., 2009). Bias in case-control studies can be introduced in two distinct ways (Newman et al., 2013). Firstly, bias may be introduced by the manner in which cases and controls are sampled (Newman et al., 2013; van Stralen et al., 2009). The group of individuals who are selected as case or controls may not be representative of the wider population that they are intended to represent (Newman et al., 2013).

The second way in which bias may be introduced into a case-control study is due to the retrospective nature of the study design (Newman et al., 2013). This primarily relates to

recall error from study participants, and their ability to remember accurately their exposure to varying factors (Grimes & Schulz, 2002; Lu, 2009; Mann, 2003; Newman et al., 2013; Schulz & Grimes, 2002; Sedgwick, 2012; van Stralen et al., 2009). This can be avoided by using existing data that has not been collected for the purpose of the study (Dupepe et al., 2019; Mann, 2003; Newman et al., 2013). As was discussed in chapter four, where the use of administrative data in research was discussed, the use of such data does come with limitations of its own. However, such data sources still provide an effective means of reducing recall bias in case-control studies.

A third limitation of case-control studies, like all observational studies, is that they are prone to confounding (Grimes & Schulz, 2002; Lu, 2009). A confounding variable is a variable that may influence both the exposure and outcome variables being examined, but is a factor that is not being considered in the study (Clapham & Nicholson, 2014; Jewell, 2003; Porta, 2014). For example, a confounding factor when considering any issue relating to road trauma and driving behaviour could be the regularity with which a person drives a car.

6.2.4 Application and suitability of the case-control study design to examine infringements and crashes

To conduct a case-control study design to examine the deterring influence of traffic infringements upon subsequent crash involvement, the first step would be to categorise drivers into two groups – those who had been involved in a road crash in a specified time period (cases) and those who had not been involved in a crash in the same specified time period (controls). The study would then involve looking back in time (for example in the six months prior) to examine whether drivers did or did not receive a traffic infringement during this time. Odds ratios would be generated, to examine whether drivers who did receive a traffic infringement during this time had a lower, higher or equal risk of crash involvement in the six months following. If it was found that the drivers who had received an infringement in the six months earlier had lower crash involvement, this would potentially indicate that traffic infringements have a deterring influence.

Although a case-control study could potentially be used to examine the association between traffic infringements and crashes, it was not ultimately selected for use. The primary reason the case-control study design was not selected was that, for licensed drivers in the DLS who did not receive any infringements and were not involved in a crash, there is no evidence to

suggest that they drove at any stage during the time-periods under study (due also in part to the limitations of the administrative data used, as it does not contain this information). If they had not driven at all, there was no chance of them experiencing the crash event or being exposed to an infringement. Therefore, other study designs that had additional strengths over and above those which the case-control study design can offer were sought.

6.3 Case-crossover study design

The second study design evaluated for potential use in study two of this thesis was the case-crossover study design. The case-crossover study design has its foundations in the case-control study design (Newman et al., 2013). There are, however, some very clear differences in the case-crossover study design when compared with the case-control study design.

The case-crossover study design was developed by Maclure (1991), to study risk factors for Myocardial Infarction. It was developed due to the many obstacles that are encountered when choosing an appropriate control group in the case-control design. When selecting a control group, researchers can encounter issues such as difficulty recruiting a group who have not experienced an outcome, selection bias in recruiting the control group and confounding caused by differing characteristics between the case and the control groups (Maclure, 1991).

The case-crossover approach, like the case-control approach, is undertaken in a retrospective manner. The researcher identifies an event of interest; however, unlike in a case-control study, only individuals who have experienced the event of interest, or in other words, are cases, are eligible to be included (Hernandez-Diaz, 2003; Maclure, 1991; Marshall & Jackson, 1993; Newman et al., 2013; Turner, 2020). No separate control group is included in the study design. The case group rather are used as their own controls (Hernandez-Diaz, 2003; Marshall & Jackson, 1993; Newman et al., 2013; Turner, 2020).

The case-crossover study design involves examining each individual's exposure to possible risk factor/s at or immediately prior to the time they experienced the event of interest, with this period termed the *case period*, and comparing exposure to possible risk factor/s in at least one other time period, with these comparison periods labelled the *control period* (Hernandez-Diaz, 2003; Lumley & Levy, 2000; Marshall & Jackson, 1993; Turner, 2020). Like

in a case-control study, the measure of association in a case-crossover study is also the odds ratio.

6.3.1 Examples of road safety research that has used the case-crossover study design

Compared to the case-control study design, case-crossover studies have been used less frequently in road safety research. Whilst hundreds of road safety studies have applied a case-control approach, a relatively small number of studies in this area have used the case-crossover study design. Despite this, the success of using case-crossover studies in road safety research has highlighted the design is robust and suitable for application in this area (e.g. Barbone et al., 1998; Davis et al., 2018; Di Bartolomeo et al., 2009; McEvoy et al., 2005; Redelmeier and Tibshirani, 1997a; Redelmeier, Tibshirani and Evans, 2003; Teschke et al., 2012; Walter and Studdert, 2015).

Like any study design, case-crossover studies have strengths and limitations, which must be considered when assessing the study design's suitability, and indeed were considered in making the decision about the most appropriate design for study two of this thesis.

6.3.2 Strengths of the case-crossover study design

Given the case-crossover study design has its foundations in the case-control study design, it also shares many of the same strengths. Case-crossover study designs are effective when studying an outcome of interest that is rare (Lumley & Levy, 2000; Mittleman, Maclure & Robins, 1995; Redelmeier & Tibshirani, 1997b), require small sample sizes (even smaller than case-control studies) (Maclure & Mittleman, 2000) and multiple risk factors for the outcome of interest can be examined (Maclure & Mittleman, 2000). The case-crossover study design, however, has a number of strengths that overcome some of the limitations of the case-control design.

One of the greatest benefits of the case-crossover study design is that the selection bias that can be introduced into the study when selecting a control group is eliminated (Hernandez-Diaz et al., 2003; Marshall & Jackson, 1993). The researcher does not need to go through the process of selecting a suitable control group. Rather, only cases are required, and if these cases provide a good representation of all the cases in the population which they are being drawn from, the risks of significant bias in study group selection are minimal (Marshall & Jackson, 1993).

Using individuals as their own controls can also reduce confounding (Hernandez-Diaz et al., 2003). For example, we can assume there are many factors unique to an individual that remain consistent across the case and control study periods that are considered in a case-crossover study. These include, for example, gender, personality type and level of self-control. There are also a range of other factors that may be controlled for, assuming they don't change across the case and control study periods. These include, for example, the number of kilometres a person generally drives, their usual driving patterns in terms of time of day they drive and the routes they take.

A case-crossover study can also enable the researcher to consider multiple control periods (Maclure & Mittleman, 2000). This can increase the reliability of the results obtained in a study. For example, in a study that examines infringements in relation to crashes, the researcher could examine infringements received in three other time periods, rather than just one time period.

6.3.3 Limitations of the case-crossover study design

Despite these advantages of the case-crossover study design, the design does have some limitations, like all study designs do. First, given individuals act as their own controls, the researcher needs to be able to understand what is considered the person's normal pattern of behaviour. This is essential in determining if the pattern of behaviour displayed at or just prior to the event of interest is out of character for the individual (Marshall & Jackson, 1993). This adds an additional level of complexity that is not required in a case-control study. The case-control study does not require the researcher to understand a study participant to such a degree.

A second limitation of the case-crossover study design is that, given the researcher examines exposure to a risk factor/s across at least two distinct time periods, there is potential that other time-varying factors are able to influence the study (Hernandez-Diaz et al., 2003; Lumley & Levy, 2000). Whilst many factors unique to the individual are likely to remain consistent between the two study periods, other external factors, such as those in the environment, may not. The researcher may mistakenly attribute the outcomes of the research to the risk factor being examined, when, unknown to them, there was in fact another factor that altered during the study and was responsible for the results (Lumley & Levy, 2000).

The COVID-19 pandemic presents a perfect example of a factor that may have substantial impact upon a case-crossover study¹. Governments across many countries responded to the pandemic by requiring individuals to stay at home, only leaving their homes for specified essential activities. This of course had a flow on effect, where most people drastically diverted from their regular day-to-day patterns of living. Many people worked from home, children undertook home schooling, people were unable to make visits to friends and relatives, cafes, restaurants and many retail stores were closed, and recreational travel was not permitted, amongst a multitude of other impacts this virus presented to society. Thus, if a time-period where lockdowns had been in place was considered within a case or control study period in a case-crossover study, it is possible that the results that emerged from such a study would not be due to the factor a researcher was examining, but rather the massive impact of COVID-19. The same could be said for many other events, including extreme weather events, natural disasters and economic recessions, as well as road safety enforcement. For example, police may have an operation in place at a particular point in time to target illegal driving behaviours. This operation may last for a one-month period. If the time period that such an operation was in place was included in a case-crossover study, once again, the results that emerged may be due to changes in enforcement, increasing the chances of being sanctioned, rather than actual changes in driver behaviour.

A third limitation of the case-crossover study design is that, despite the researcher ensuring there is a reasonable length of time between the case and control periods to be studied, it is possible that the effects of exposure in the control period can carry on into the case period, having an impact on the study results (Hernandez-Diaz et al., 2003).

A fourth limitation of the case-crossover study design is closely related to the third limitation. Case-crossover study designs are only effective when examining exposure to risk factors that are transient in nature (Lumley & Levy, 2000; Marshall & Jackson, 1993; Turner, 2013). This means that the exposure to the risk factor that is being examined may only be one that is experienced by an individual within a very short space of time, or in other words, cannot be a sustained exposure. Fortunately, exposure to a traffic infringement is a

¹ It must be noted that all data used in this PhD research program were collected prior to the COVID-19 pandemic. COVID-19 has simply been provided here as an example of a factor that could influence a case-crossover study in general

transient experience, and the exact point at which the individual was exposed can be identified, meaning this was not a limitation in the context of study two of this thesis. Despite this, assumptions must still be made on how long the effect a traffic infringement may last for.

A final limitation of the case-crossover study design is that, given data is collected in relation to the same individual at different time periods, they may be subject to recall bias (Hernandez-Diaz et al., 2003). This may primarily come as a result of a participant having a clearer memory of the exposure to risk factors in more recent time periods (Hernandez-Diaz et al., 2003). However, this limitation would not have presented itself in the current study, given, as noted, existing data were used. However, it is possible that there may be some differences with the way in which data has been recorded across the different time-frames that could have an influence on the study results, in the same way that differences in recall across the case and control periods could influence the study results.

6.3.4 Application and suitability of the case-crossover study design to examine infringements and crashes

The Redelmeier, Tibshirani and Evans (2003), Walter and Studdert (2015) and Davis et al. (2018) studies are examples of how the case-crossover design can be applied to the research question in study two of the thesis. A road crash was the event of interest, and infringements were examined in the one-month period just prior to a crash occurring and compared to the infringements in the same one-month period in the year prior. A higher odds of infringements in the month just prior to a crash occurring would indicate that these infringements were perhaps not having a deterrent effect, whilst a lower odds of infringement occurring in the month just prior to a crash occurring would potentially indicate that infringements were having a positive influence upon driver behaviour.

Redelmeier, Tibshirani and Evans (2003), Walter and Studdert (2015) and Davis et al. (2018) demonstrated that the case-crossover study design is useful in examining the relationships between infringements and crashes. Despite this, one particular limitation meant that the decision was made not to use a case-crossover study in the current research, this being the influence of time-varying factors.

As noted, time-varying factors can influence the results, where changes occur between the control period and the case period. Of particular note in relation to the current study, patterns of enforcement and areas of focus for police can change within relatively short periods of time. New offences can be legislated or penalties can change. By using a case-crossover study, none of these changes would have been controlled for when undertaking the analysis, potentially impacting the results.

6.4 Case-time-control study design

The third study design considered for use in study two was the case-time-control study design. This study design is an extension of the case-crossover study design. As noted, one limitation of the case-crossover study design is that changes in other factors over time that are not being examined in the study can influence the results (Hallas & Pottegard, 2014). Suissa (1995; 1998) proposed the case-time-control study design to account for time-varying factors.

In a case-time-control study, a case and a control group are used (similar to a standard case-control study). The cases are individuals who have experienced the outcome of interest being examined in the study. The controls are drawn from the same population, but comprise of a group of individuals who have not experienced the outcome of interest (Wang et al., 2011).

Case-time-control studies then examine exposure to a risk factor/s at the time of or just before an outcome occurred for the case group, which is labelled the *case time period*, as well as another time period where the outcome did not occur, which is labelled the *reference time period* (similar to the case-crossover study) (Wang et al., 2011). Exposure to the same risk factor/s in the same time periods is also examined for the control group. Odds ratios are calculated for both the case and the control groups (Hallas & Pottegard, 2014; Wang et al., 2011). Finally, an adjusted estimate is calculated. This involves dividing the odds ratio that was estimated for the case group by the odds ratio that was estimated for the control group (Hallas & Pottegard, 2014). Any differences that are then observed in the odds of the outcome, between the case and control groups, are then seen to be explainable by changes in experience of the risk factor being examined (Hallas & Pottegard, 2014).

6.4.1 Existing road safety research using the case-time-control study design

The case-time-control study design has only been used very rarely when compared with the case-control and case-crossover designs. Notably however, the study undertaken by Walter and Studdert (2015), which was highlighted in the case-crossover section, also made use the case-time-control study design to undertake a sensitivity analysis. The purpose of this additional analysis was to examine and provide correction for confounding that may have occurred in their case-crossover study, as a result of factors that may have varied between the case and control study periods amongst their study subjects. Ravera et al. (2012) also used the case-time-control study design to examine relationships between medications and crash involvement.

6.4.2 Strengths of the case-time-control study design

This design has a number of strengths that build upon what can be achieved in using a case-control study design or a case-crossover study design. Indeed, the case-time-control study design specifically addresses some of the limitations that are associated with the case-crossover study design.

Perhaps the most significant advantage of the case-time-control study design is its ability to minimise the influence that external factors which change over time can have on the study results, which is a major limitation of the case-crossover study design (Hernandez-Diaz et al., 2003). For example, if patterns of enforcement change, such as a substantial increase in the number of fixed road safety cameras being installed, a driver has a higher odds of receiving an infringement in a later time period, simply because exposure to cameras is higher. A case-crossover design would not be able to control for such changes, given it only includes a case group. By including a control group, the case-time-control study design controls for changes over time.

Another benefit of the case-time-control study design is that it is useful for controlling for factors unique to an individual that change over time, as they adjust for changes that occur between the reference and case study periods (Hallas & Pottegard, 2014). This could include one factor that changes for everyone over time, this being age. Indeed, age is a factor that influences driver behaviour (e.g. Bunce et al., 2012).

6.4.3 Limitations of the case-time-control study design

Despite the strengths of the case-time-control study design, there are some limitations that should be noted. The case-control study design is only appropriate for cases where the risk factor being examined in the case and control study periods is transient in nature. For example, in their examination of medication use and crash involvement, Ravera et al. (2012) noted that medication types included in their study were likely being used by individuals on a continued basis. Thus, identifying any increased crash risk at the time of taking the medication amongst crash drivers was difficult. However, in the context of study two of this thesis, it is not likely this limitation would have been of concern: given as noted, receiving an infringement is generally a transient experience. Whilst some individuals may of course receive infringements regularly, as a result of repeated patterns of poor driving behaviour, infringements are discrete events (unlike exposure to medication which can be continual and ongoing).

A second limitation of the case-time-control study is the potential for confounding to impact the study (Greenland, 1996). Given the case group experiences the outcome and the control group does not, there may be factors that are not captured/measured by the researcher, that lead to this outcome occurring (Greenland, 1996). In other words, the experience of the outcome may be just one aspect of many differences between the case and control groups.

6.4.4 Application and suitability of the case-time-control study design to examine infringements and crashes

To use a case-time-control study design to examine the deterring influence of traffic infringements upon subsequent crash involvement, the first step would be to categorise drivers into two groups – those who had been involved in a crash in a specified time period (cases) and those who had not been involved in a crash in the same specified time period (controls). The study would then have involved looking back in time to two time periods, the case period and the reference period, to examine infringements received by drivers in these time periods. Odds ratios would have been calculated for each of the case and the control groups, and the odds ratio for the case group would have been divided by the odds ratio for the control group. Lower odds of infringement in the case period for the case group drivers would potentially indicate that infringements have a deterring influence.

Although a case-time-control study could be valuable in examining the association between traffic infringements and crashes, the decision was made not to use this study design. The primary reason was because of the clear and distinct difference that exists between case group drivers and control group drivers. Case group drivers would be selected based on their involvement in a crash. Control group drivers would be selected based upon their non-involvement in a crash. There may be other factors that set these groups of drivers apart, other than experience of infringements (the risk factor being examined in the case and reference time periods). Indeed, research has shown lower socioeconomic status is a factor observed amongst many crash involved drivers (e.g. Braver, 2003; Males, 2009; Romano, Peck & Voas, 2012). This, as a result, may have potentially led to incorrect conclusions being made in relation to the association between infringements and crashes. It therefore made sense to look for another study design that overcomes this limitation, this being the case-case-time-control study design.

6.5 Case-case-time- control study design

The final study design considered for use in study two of this PhD, and the study design that was ultimately selected, was the case-case-time control study design. As the name suggests, the case-case-time-control study design is an extension of the case-time-control study design, and therefore, also an extension of the case-crossover study design. The design was proposed by Wang et al. (2011).

Similar to the case-crossover and case-time-control study design, a case group is selected based on experience of an outcome or event of interest. Comparisons are drawn on exposure to a potential risk factor across two time periods, one just prior to the event of interest and the other time period being where the event did not occur (Hallas & Pottegard, 2014). Also similar to the case-time-control study design, a control group is included; however, requirements for the control group in the case-case-time-control study design differ from those in the case-time-control study design. The control group in the case-case-time-control study design consists of individuals who have experienced the same event or outcome of interest; however, their experience of this outcome occurs at a time after that experienced by members of the case group (Wang et al., 2011).

Individuals in this control group also have comparisons drawn in relation to exposure to a risk factor in two different time periods (Wang et al., 2011). However, whilst their experience of the event occurred at a different time to drivers in the case group, the two time periods for which their exposure to a risk factor is consistent with the two time periods examined for drivers in the case group (Wang et al., 2011). Once again, odds ratios are calculated for both groups, and the measure of effect is a ratio of odds ratios: that is, the ratio of odds of exposure to the risk factor for individuals in the case group in the case period compared to the control period, divided by the ratio of odds of exposure to the risk factor for individuals in the control group in the case period compared to the control period (Wang et al. 2011).

6.5.1 Examples of road safety research that has used the case-case-time-control study design

An examination of the research literature in the area of road safety and driver behaviour reveals no previous application of the case-case-time-control study design. The design has been used primarily in the area of health research, originally applied to an examination of vitamin use and experience of stroke (Wang et al., 2011). Thus, using the case-case-time-control study design to understand the association between infringements and crashes provides a new and novel approach to exploring this area of research that overcomes limitations of the previous studies.

6.5.2 Strengths of the case-case-time-control study design

The case-case-time-control study design addresses one of the most significant limitations of the case-time-control study design, this being the degree to which the control group acts as an adequate control for the case group. As was noted in the discussion surrounding the case-time-control study, that design uses a control group who do not experience the event of interest. This in itself already presents a point of difference between the two groups, which has the potential to influence the study results. The case-case-time-control study on the other hand uses a group of individuals who have experienced the same event of interest, simply at a later time to the control group (Wang et al., 2011). Thus, by including a case and control group who have experienced the same outcome, the study is at the outset already reducing some of the selection bias that can occur when including a control group. For example, using a case-case-time-control study design in study two means both case and control groups must have experienced a crash. As a result, all drivers included in the study

may display the trait of being risk seekers when compared to a group of drivers who have not experienced a crash.

Furthermore, given the inclusion of the control group, the case-case-time control study design is equipped, like in the case-time-control study design, to control for changes in road safety law enforcement that may occur between the two study periods under examination (Wang et al., 2011). As noted above, this is of particular importance when considering research on road safety, given the changes that can occur in enforcement over time.

6.5.3 Limitations of the case-case-time-control study design

Like the other three study designs considered in this chapter, the case-case-time-control study design also has some limitations that must be considered. The main one that presents itself is the potential for the time period between the case and control groups experiencing the outcome to be too short, such that exposure to the factor under consideration is not actually removed far enough from the outcome (Wang et al., 2011). If the time at which the control group experiences the event is too close to the time at which the case group experiences the event, and thus, the time-period that exposure to a risk factor is examined, there is a potential that the same risk factor may also have been influencing the control group (Wang et al., 2011).

The case-case-time-control also shares another limitation with the case-crossover and case-time control study designs already noted. When using individuals as their own controls, the researcher needs to be able to understand what their normal patterns of behaviour are, to determine if their behaviour just prior to the event was out of character (Marshall & Jackson, 1993). Factors such as mental stresses, relationship issues and financial hardship may be responsible for differing patterns of behaviour at different points in time. The case-case-time-control study design does not enable the researcher to control for these time-varying individual factors. Despite this, such factors may only influence the results if the factors that vary over time do so differently between the case and the control groups.

6.5.4 Application and suitability of the case-case-time-control study design to examine infringements and crashes

The case-case-time-control study design was selected for use in study two of this thesis. Further details on how the study design was applied can be found in the following chapter,

which contains a manuscript published in the journal *Transportation Research Part F: Traffic Psychology and Behaviour*.

The main reasons for choosing the case-case-time control study design were first that it controls for changes that may have occurred in the level of enforcement, and potentially other changes in driving environment factors over time. As noted, this is not something that the case-crossover study is able to achieve. Second, given the case-case-time-control study design uses a group of controls who have also experienced the same outcome, in the case of study two, a crash, this meant an additional degree of similarity between case group drivers and control group drivers.

6.6 Conclusion

This chapter has provided an examination of four study designs: 1) the case-control study design; 2) the case-crossover study design; 3) the case-time-control study design; and 4) the case-case-time-control study design. Through considering the strengths and limitations of each of these four study designs, and reviewing the application of each to the specific area of research, it was identified that the case-case-time-control study design provided the most effective study design to examine the association between infringements and crashes. Furthermore, the application of the case-case-time-control study design provided a novel way of examining the relationship between infringements and crashes. This meant the study was able to make a unique and valid contribution to research in this area, and build upon the case-crossover studies conducted by Redelmeier, Tibshirani and Evans (2003), Walter and Studdert (2015) and Davis et al. (2018).

Chapter seven that follows provides the results and discussion that emerged from this study, in a paper titled 'Preventing road crashes: Do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia'.

Chapter Seven: Preventing road crashes: Do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia

7.1 Introduction

The chapter presents the results of study two. VicRoads licensing, infringements and crash data were used to examine whether infringements for driving offences have the desired effect of deterrence in changing driver behaviour, through looking at crash involvement in the period that follows. The study applied a case-case-time-control study design and sought to answer two key research questions:

- 1) Is there an association between receiving an infringement for a driving offence and subsequent crash involvement?
- 2) Are driver and offence characteristics associated with subsequent patterns of crash involvement in the period following an infringement for a driving offence being received?

The study was published in 2020 in the academic journal, *Transportation Research Part F: Traffic Psychology and Behaviour*.

McDonald, H., Berecki-Gisolf, J., Stephan, K., & Newstead, S. (2020). Preventing road crashes: Do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia. *Transportation Research Part F: Traffic Psychology and Behaviour*, 69, 91-100.
<https://doi.org/10.1016/j.trf.2020.01.004>



Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf



Preventing road crashes: Do infringements for traffic offences have a deterrent effect amongst drivers aged 40+? An examination of administrative data from Victoria, Australia



Hayley McDonald ^{*}, Janneke Berecki-Gisolf, Karen Stephan, Stuart Newstead

Monash University Accident Research Centre, Monash University, Victoria, Australia

ARTICLE INFO

Article history:

Received 16 September 2019

Accepted 8 January 2020

Available online 27 January 2020

Keywords:

Traffic infringements

Risky driving

Crashes

Deterrence

ABSTRACT

This study aimed to determine whether receiving a traffic infringement has a deterring influence on subsequent risky driving, measured through risk of crash involvement.

Licensing, infringements and crash data for drivers aged 40+ from the Australian state of Victoria were analysed. A case-case-time-control study design was used. Overall, the odds of receiving an infringement in the month prior to a crash were 35 per cent *higher* than receiving an infringement in the same month the year prior, for the case group, adjusted for the change over time in the control group (Odds Ratio = 1.35, 95% CI 1.17–1.57, $p < 0.001$). Rather than infringements preceding a period of reduced crash involvement, and thus potentially indicating a deterrent effect, the odds of receiving an infringement in the one-month period just prior to a crash occurring was greater. Infringements for traffic offences may not be deterring further risky driving behaviours.

© 2020 Elsevier Ltd. All rights reserved.

1. Introduction

Road trauma is a significant global public health issue (World Health Organization, 2015). Worldwide, around 1.25 million people die annually as a result of trauma sustained in traffic related accidents, with many more receiving serious and life changing injuries (World Health Organization, 2015). Encouragingly, World Health Organization data shows that the number of deaths globally, as a result of road trauma, has remained steady since 2007, despite increases in global population and the use of road transportation (World Health Organization, 2015). Furthermore, in some countries, including Australia, a decreasing trend in the incidence of injuries and fatalities resulting from road crashes has been observed (Bureau of Infrastructure Transport and Regional Economics, 2014). Despite these positive gains, road trauma remains a serious issue of concern. Data from the Australian Government Department of Infrastructure and Regional Development (2017) estimates that annually, the financial cost of road crashes in Australia is \$27 billion. The costs however go well beyond this monetary figure. For individuals directly involved, there are significant personal costs. These include the costs of pain and suffering that are very difficult to place a definitive measure on (Hendrie & Miller, 2012; Risbey, Cregan, & De Silva, 2010). Given the serious impacts that road trauma has on individuals and the community, effective strategies to minimize the incidence of crashes are essential.

A number of factors have been recognized as contributors to the road trauma problem. These include road and roadside design and condition (eg. Holdridge, Shankar, & Ulfarsson, 2005; Stanton & Salmon, 2009; Stigson, Krafft, & Tingvall, 2008;

^{*} Corresponding author at: Monash University Accident Research Centre, Building 70, 21 Alliance Lane, Monash University, Victoria 3800, Australia.

E-mail address: hayley.mcdonald@monash.edu (H. McDonald).

<https://doi.org/10.1016/j.trf.2020.01.004>

1369-8478/© 2020 Elsevier Ltd. All rights reserved.

Zein & Navin, 2003), vehicle design and condition (eg. Bedard, Guyatt, Stones, & Hirdes, 2002; Blows, Ivers, Conner, Ameratunga, & Norton, 2003; Blows, Ivers, Woodward, et al., 2003; Stanton & Salmon, 2009; Zein & Navin, 2003), environmental factors (eg. Stanton & Salmon, 2009; Zein & Navin, 2003) and the interactions between these factors. Each of these contributing factors requires a set of countermeasures, in efforts to reduce the road toll. Human error (eg. Salmon, Regan, & Johnston, 2005; Stanton & Salmon, 2009; Wierwille et al., 2002; Zein & Navin, 2003), including the performance of risky and illegal driving behaviours has also been associated with increased crash risk (eg. Penmetsa & Pulugurtha, 2016). Speeding (eg. Aarts & van Schagen, 2006; Kloeden, McLean, Moore, & Ponte, 1997), drink driving (eg. Blomberg, Peck, Moskowitz, Burns, & Fiorentino, 2005), drug driving (eg. Schulze, Schumacher, Urmeew, & Auerbach, 2012) and mobile phone use (eg. McEvoy, Stevenson, & Woodward, 2006; McEvoy et al., 2005; Rakauskas, Gugerty, & Ward, 2004) are associated with an increased risk of being involved in a crash. A sanctioning system operates to respond to drivers who perform risky and illegal driving behaviours. Drivers detected performing an illegal driving behaviour may receive a fine, have demerit points placed on their license, lose their license, and in extreme instances, be taken to court and receive a period of imprisonment (VicRoads, 2018). The sanctioning of drivers who engage in risky and illegal driving behaviours is consistent with the concept of specific deterrence. The theory of specific deterrence argues that a person who receives a sanction will change their patterns of behaviour, in attempts to avoid receiving further punishments (eg. Andrews & Bonta, 2010; Bagaric & Alexander, 2012; Brown, Esbensen, & Geis, 2015; Lab, 2016; Mitchell, 2012; Weisberg, 2014).

A meta-analysis (Barracough, af Wählberg, Freeman, Watson, & Watson, 2016) of 99 studies that explored the use of traffic offences as a predictor of traffic crashes concluded that the association between traffic offences and road crashes is generally not strong, and factors such as age, the size of the study sample used and the source of data all influenced the strength of the relationship. Notably, of the 99 studies that contributed to the meta-analysis, 74 were based on self-report data, with only 27 based on data from official administrative sources (Barracough & af Wählberg, Freeman, Watson, & Watson, 2016). Self-report data is subject to bias, and therefore there is a need for further research using official data sources (Barracough et al., 2016). What is evident however, is that whilst there is no shortage of research that has sought to determine the relationship between sanctions for traffic offences and crash involvement, much of this research focused on identifying factors that may be indicative of drivers at increased risk of crash involvement. The relationship between sanctions for traffic offences and crash involvement has not commonly been explored using a specific deterrence theoretical framework. In studies that have employed a deterrence framework, the results have been inconsistent.

Redelmeier, Tibshirani, and Evans (2003) investigated the relationship between infringements and fatal crashes of drivers in Ontario, Canada, who had been involved in a fatal crash in 1998–1999. Using a case-crossover study design, Redelmeier et al. (2003) found that the risk of being involved in a fatal crash was lower in the month that followed a driver receiving a sanction for a traffic offence, when compared to the same month in the year prior, where a driver did not receive a sanction for a traffic offence.

Walter and Studdert (2015) also applied the case-crossover study design, using data from Queensland, Australia. However, whilst the Canadian study by Redelmeier et al. (2003) only used data from drivers involved in a fatal crash, the study by Walter and Studdert (2015) used a far broader range of crash severities and types. Walter and Studdert (2015) found that the risk of being involved in a crash was greater in the month that followed a driver receiving a sanction for a traffic offence, when compared to the comparable one-month period in the year prior (Walter & Studdert, 2015). The authors concluded that traffic infringements and crashes are likely an indicator of a period of risky driving and that the issuing of infringements may provide an opportunity to intervene using other strategies to reduce risk (Walter & Studdert, 2015).

Despite using the same methodological approach, Redelmeier et al. (2003) and Walter and Studdert (2015) found conflicting results, however the reason for this is unclear. The studies focused on different jurisdictions, where sanctions and enforcement regimes potentially differ. Walter and Studdert (2015) however did not believe jurisdictional differences, along with a number of other explanations that they proposed, were probable or reasonable explanations for the differences. The studies were undertaken at somewhat different time-periods – 1998 through to 1999 for Redelmeier et al. (2003) compared to 1995–2010 for Walter and Studdert (2015). Underlying time trends, and in particular increases in enforcement may mean that drivers have become more likely to be penalized for traffic offences. Thus, given the data used by Walter and Studdert (2015) was in some instances over ten years more recent than that used by Redelmeier et al. (2003), it is possible changes in enforcement overtime (e.g. use of new technologies), may be a contributing factor to the differences in the results of these studies.

The nature of the case-crossover study design used by both Redelmeier et al. (2003) and Walter and Studdert (2015) means that factors that change over time, such as changes in enforcement patterns are not controlled for. The case-case-time-control study design is an extension of the case-crossover study design enabling changes in trends over time to be controlled for (Wang et al., 2011). Furthermore, in their study, Walter and Studdert (2015) proposed that given the differences between their results and those of Redelmeier et al. (2003), and the wide availability of administrative crash, infringement and licensing data, future research should consider replicating the study in other jurisdictions. Thus, the current study uses an extension of the case-crossover study design, applying the methodology to crash, licensing and infringements data from the Australian state of Victoria.

The current study also sought to contribute to understanding specific deterrence amongst older drivers, focusing only on those aged 40 years and over, for two main reasons. First, the driving population in many countries, including Australia is ageing (Christensen, Doblhammer, Rau, & Vaupel, 2009; Kwok, Lloyd, & Yip, 2013), so the number of aged drivers is expected to increase in the future (Anstey, Eramudugolla, Ross, Lautenschlager, & Wood, 2016). By including drivers aged 40 years and

above, this study provides the opportunity to better inform crash prevention in an ageing road user population, capturing both today's and the next generation of older drivers.

Secondly, we chose to only include drivers aged 40 and over given that, in many cases these drivers have held their license for an extended period of time. Over time, Victoria has observed significant changes in enforcement. For example, roadside testing for illicit drugs came into operation in 2004. Indeed, some older drivers may have held their license prior to the introduction of roadside breath testing for alcohol and compulsory seatbelt use, both introduced in the 1970s. Furthermore, alongside the introduction of penalties for new offences, increases in the severity of existing penalties have been implemented. It is possible that individuals who have been driving for an extended period have a specific set of attitudes and beliefs in relation to enforcement. These attitudes and beliefs may have impact on how drivers behave and how they are deterred. We therefore wanted to investigate the effect of specific deterrence on these drivers precisely.

Thus, the aim of current study was to determine whether infringements for traffic offences have a deterring influence on risky illegal driving behaviour, through looking at the association with crash involvement. If the specific deterrence theoretical framework is true, we would expect to see the risk of crash to be lower in the period that follows a driver receiving an infringement for a traffic offence.

2. Methods

2.1. Data source and variables studied

This study used data from Victoria, Australia. Like all states and territories in Australia and indeed like many jurisdictions globally, Victoria has an extensive system for detecting and responding to illegal driving behaviours. Drivers detected by police or by automated camera enforcement methods engaging in risky and illegal driving behaviour may receive an infringement notice that requires them to pay a monetary fine and places a specified number of demerit points on their license (VicRoads, 2018). Victorian legislation means that if a driver exceeds a specified number of demerit points over a given time period, they have the potential to lose their license (VicRoads, 2017). Whilst limits vary depending on the type of license a driver holds, for a full license holder, the threshold is 12 demerit points in a 3-year period (VicRoads, 2017).

Using de-identified licensing, infringements and crash data, supplied by the state licensing authority in Victoria, Australia (known as VicRoads), we examined the association between infringements for driving offences and subsequent crash involvement. Licensing and infringements data is held in the Driver Licensing System (DLS). This system contains all dates an individual held a license, and if relevant, any dates their license was cancelled or suspended. The data set also includes record of all offences and demerit points administered to a driver across their full Victorian license history. General demographic data is also held in the data set. These variables include drivers' date of birth, gender and residential postcode.

Victorian crash data is held in the Road Crash Information System (RCIS). This data is collected by Victoria Police, and held by VicRoads. It contains information on all crashes that resulted in the injury or death of at least one person involved. Details of a crash are collected when police attend an incident, or when a person makes a report to police following a crash. The RCIS includes details on the time and location of the crash, information on all people involved, including the severity of any resulting injuries, whether the crash resulted in any fatalities, details of the vehicles involved and the extent of damage to these vehicles. Data contained in the DLS and the RCIS were linked by driver license number. The final linked data set used for the current study thus contained license history, infringement history and crash history for each included driver, all of whom were aged 40 and over at the time of their crash.

2.2. Study design

The current study sought to build on the case-crossover studies by Redelmeier et al. (2003) and Walter and Studdert (2015), through using a case-case-time-control study design. Both study designs use individuals as their own controls. As in a case-crossover study, a case-case-time control design involves using a group of individuals who experience an outcome of interest and draws comparisons on exposure to a potential risk or protective factor across two different time periods, one prior to the outcome of interest and the other in a time-period where the outcome of interest did not follow (Hallas & Pottgard, 2014). In a case-case-time-control study, this group is labelled the case group. However, in contrast to a case-crossover study, a case-case-time control study also uses a control group, controlling for factors that may impact on the research. This control group consists of those who have experienced the same event of interest, however their experience of the event occurs at a point in the future in comparison to the case group (Wang et al., 2011). Comparisons are once again drawn on a potential risk or protective factor across two different time periods. These time periods are consistent with those used for the case group. Whilst in case-crossover studies the two time periods studied are identified as the case period and the control period, to avoid confusion with the case and control groups, in the current study we labelled the two time periods the event period and the reference period.

Fig. 1 provides a visual representation of the case-case-time control study design as it applies to the current study. In the current study, the event of interest was involvement in a crash. Drivers were included in the case group if their crash occurred in 2010–2012. Drivers were included in the control group if their crash occurred in 2013–2015. The risk factor explored was receiving an infringement for a traffic offence. For the case group, infringements were measured in the 30 days

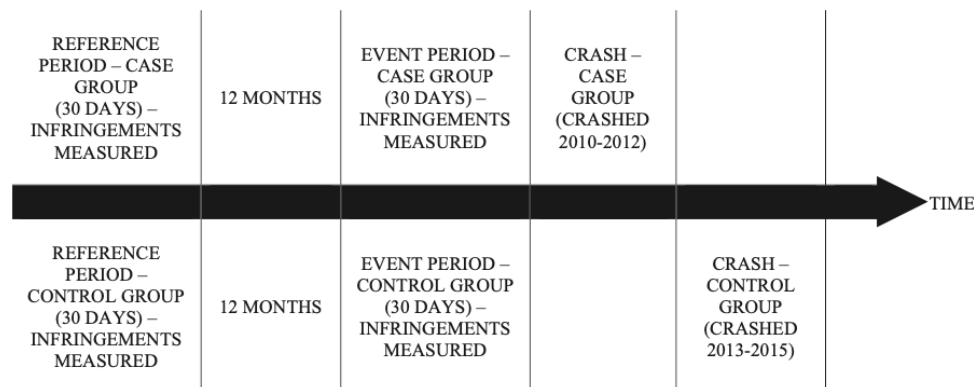


Fig. 1. Visual representation of the case-case-time control study design used in this research – case group (crashed in 2010–2012) and control group (crashed in 2013–2015) and periods infringements were measured.

prior to the crash (the event period) and for the same 30-day time period, 12-months prior (reference period). For the control group, the event period was the 30-day time-period prior to the crash, however backdated three years. The reference period was the 30-day time-period prior to the crash, backdated four years. By having the event period three years prior to the crash and the reference period four years prior to the crash, this ensured the time periods that were being considered were consistent between drivers in the case and the control periods.

Using 30-day event and reference periods was consistent with the studies by [Walter and Studdert \(2015\)](#) and [Redelmeier et al. \(2003\)](#). Furthermore, separating the event and reference periods by one-year controls for seasonal factors that may impact driving behaviour, as well as reduces the potential for infringements issued in the earlier (reference) period to continue to impact driver behaviour through to the later (event) period ([Walter & Studdert, 2015](#)).

The case-case-time control study design has a number of advantages over the case-crossover approach. Firstly, it has the capacity to control for factors, such as changes in a phenomenon over time that the case-crossover study would fail to account for ([Wang et al., 2011](#)). Whilst both approaches use individuals as their own controls, thus controlling for many individual person level factors, there are many factors beyond the individual, which can have impact on an outcome ([Wang et al., 2011](#)). These factors cannot be controlled for with the case-crossover design. This is of significance in relation to illegal driving, given approaches to enforcement change and evolve over time. The vehicle fleet may also change overtime, as more advanced technologies and safer vehicles become available. By using a control group who experience the same outcome of interest, but at a time in the future in comparison to the case group, and considering the presence of a risk or protective factor in the same event and reference periods as the case group, time trends can be accounted for in the analysis.

Another advantage of the case-case-time control study design is that not only is a control group included, the individuals who are included in this control group have experienced the same event of interest, just at a different time point to the case group ([Wang et al., 2011](#)). This sets the case-case-time control study design apart from other designs that use a control group, such as a case-control study and a case-time control study, which is also an extension of the case-crossover study design. These study designs include a control group who have not experienced the event of interest. Using individuals who have not experienced a particular event means there is potential for bias to be introduced, given the presence or absence of an event can be related to characteristics of an individual ([Wang et al., 2011](#)). Thus, considering drivers who have been involved in a crash, there may be inherent characteristics amongst this group that mean they are at greater risk of a crash.

To the best of our knowledge, the case-case-time-control study design does not appear to have been used before in road safety research. The current study therefore employs a novel approach to analysing the association between traffic infringements and crashes.

2.3. Study sample

Between January 1st 2010 and December 31st 2015, a total of 80,202 crashes were reported to Victoria Police. 131,443 drivers were involved in these crashes, 56,895 of whom were aged forty years and over at the time of their crash.

To be included in the case group, drivers met the following criteria:

1. Involved in a crash between January 1st 2010–December 31st 2012.
2. Received an infringement for a traffic offence in either the 30 days prior to their crash (the event period), or in the same 30-day period 12 months prior (reference period). Drivers who received an infringement in both periods or did not receive an infringement in either period were not included in the analysis, as these drivers do not contribute to the measurement of risk in a self-controlled study design, like the case-case-time control.

3. Held a current license throughout both the event period and the reference period. Recognizing that license loss may result from a traffic offence, drivers were still included if they had not held a current license for some part of the event period or the reference period (but not both). This criteria was applied to ensure that there was a reasonable chance drivers were actually driving during both time-periods, which was assumed based upon them holding a driver's license.
4. Aged 40 years or older on the day of their crash.

To be included in the control group, drivers met the following criteria.

1. Involved in a crash between January 1st 2013–December 31st 2015.
2. Received an infringement for a traffic offence in either the 30-day time period prior to the crash date, with the 30-day period backdated three years (event period) or in the same 30-day period 12 months prior to the event period (reference period).
3. Held a current license throughout both the event period and the reference period.
4. Aged 43 years or older on the day of their crash. By including drivers aged 43 + on the day of the crash, this ensured the age of drivers in the control group was consistent with the age of drivers in the case group during the event and reference periods.

In addition, a number of other criteria were applied to select the drivers in the case and the control groups. First, only drivers who held Victorian licenses were included. Second, only infringements issued in Victoria were considered. Third, only car license holders were included. Heavy vehicle and motorcycle licenses were excluded. For this reason, only crashes where the driver was operating a vehicle that can be driven on a car license were included. Finally, drivers who were eligible to be included in both the case and control groups (that is, who crashed during both periods) were excluded from the study.

2.4. Statistical analysis

The data were analysed using conditional logistic regression, using SAS version 9.4. Odds ratios, 95% Confidence Intervals (CI) and P-values were calculated to measure the odds that case drivers had received an infringement in the 30-day period prior to a crash in comparison to the same 30-day period in the year prior, adjusted for change over time in the controls. Odds ratios measure the association between two binary variables (Bland & Altman, 2000; Chen, Cohen, & Chen, 2010; Rosenthal, 1996). An odds ratio below 1.0 would indicate that infringements were less likely to have occurred in the event period than in the reference period, potentially indicating a deterring influence of traffic infringements on subsequent crash involvement.

3. Results

Table 1 provides the number of drivers from which the final sample was selected. The case group was selected from 22,782 drivers who were involved in a crash between 2010 and 2012, whilst the control group was selected from 21,019 drivers who were involved in a crash between 2013 and 2015. After excluding drivers who did not receive a driving infringement in either the event or reference periods, or received an infringement in both the event and reference periods, there were 1,656 drivers in the case group and 1,337 drivers in the control group (Table 1).

Table 2 provides the characteristics of the drivers from which the final case and control groups were selected. The majority were aged 40–49 years (38% case; 39% control), male (56% case; 55% control) and resided in the Victorian metropolitan area (74% case; 74% control) (Table 2).

Table 3 provides details on the final sample. Nine drivers were removed from both the case and the control groups because they met all the inclusion criteria for both. Thus, a total of 1,647 drivers were included in the case group for analysis. This consisted of 910 drivers recording at least one infringement in the event period and 737 drivers recording at least one

Table 1
Number of drivers from which the final sample was drawn.

Period infringed	Case Group – Crashes between 2010–2012 n	Control Group – Crashes between 2013–2015 n
Infringement in event period, no infringement in reference period	913	638
Infringement in reference period, no infringement in event period	743	699
Infringement in both event and reference periods	60	50
No infringement in event or reference periods	21,066	19,632
Total	22,782	21,019

Table 2

Characteristics of the driver population from which the final sample was drawn.

Characteristic	Case Group (n = 22782)		Control Group (n = 21019)	
	n	%	n	%
Age at final day of event period (years)				
40–49	8560	38	8194	39
50–59	6538	29	6064	29
60–69	4083	18	3682	18
70–79	2353	10	2191	10
80+	1248	5	888	4
Sex				
Male	12,773	56	11,596	55
Female	9892	43	9353	45
Unknown	117	1	70	<1
Postcode region				
Metro	16,842	74	15,590	74
Rural	5876	26	5395	26
Unknown	64	<1	34	<1

infringement in the reference period. A total of 1,328 drivers were included in the control group. This consisted of 634 drivers recording at least one infringement in the event period and 694 recording at least one infringement in the reference period.

In both the case and control groups, the majority of drivers were male (63% in case, 61% in control), and aged 40–49 years on the final day of the event period (43% in both the case and control groups) (Table 3). There was no significant difference between the groups in terms of sex (χ^2 (2) = 5.04, p = 0.08) or age-group (χ^2 (4) = 1.85, p = 0.76).

Table 3 also provides details on the infringement types amongst drivers in the case and the control groups. Amongst the 1,647 drivers in the case group, there was a total of 1,820 infringements in the event and reference periods. Amongst the 1,328 drivers in the control group, there was a total of 1,407 infringements in the event and reference periods. As per the case-case-time-control study design, drivers could be included when they had more than one infringement, as long as these infringements all occurred within only the event or the reference period, but not both. Infringements for exceeding the speed limit by less than 25 km/h were by far the most common type of infringement amongst drivers in the case (n = 1423, 78%) and the control groups (n = 1146, 81%). Infringements for traffic signal offences were the second most common infringement type in both the case (n = 169, 9%) and the control groups (n = 163, 12%) (Table 3).

Table 4 presents the results of the conditional logistic regression. The odds of receiving an infringement in the event period were significantly greater than in the reference period for the case group, adjusted for the change over time in the control group (Odds Ratio = 1.35, 95% CI 1.17–1.57). Analyses were also conducted for a number of subgroups. All showed the same pattern of higher odds of receiving an infringement for a traffic offence in the event period one month prior to a crash, compared to the reference period, however, not all were statistically significant. Amongst male drivers, the odds of receiving an infringement in the event period were higher than in the reference period for the case group, adjusted for change over time amongst males in the control group (Odds Ratio = 1.44, 95% CI 1.20–1.75). Amongst female drivers, the odds of receiving an infringement in the event period were slightly higher than in the reference period for the case group, however this effect was not statistically significant (Odds Ratio = 1.22, 95% CI 0.96–1.55, p = 0.115) (Table 4). In each of the age groups, the odds of receiving an infringement in the event period were greater than in the reference period, when adjusted for change over time in the control group.

Table 4 also shows the results stratified by different types of offences. Given the low number of infringements for some offence types, subgroup analyses were only undertaken for the most prevalent offences identified in the study sample; speeding less than 25 km/h above the speed limit, traffic light offences and mobile phone offences. While the odds of receiving an infringement for each of these offence types were greater in the event period than in the reference period for the case group, when adjusted for changes over time in the control group, the difference was only statistically significant for speeding less than 25 km/h. It is important to highlight however that the lack of statistical significance may also be due to the small sample sizes for some offence types.

Only metro residing drivers (Odds Ratio 1.33, 95% CI 1.13–1.57) had higher odds of receiving an infringement in the event period than in the reference period in the case group, adjusted for change over time in the control group. For rural residing drivers (Odds Ratio 1.39, 95% CI 0.99–1.94) the result was not significant (Table 4).

Finally, in terms of demerit points, the most common number of points a driver is issued for a driving offence is one point or three points, depending upon the severity of the offence. One demerit point is usually issued for less severe offences, for example, exceeding the speed limit by less than 10 km/h or for following behind another vehicle too closely. Three demerit points are usually issued for more severe offences, for example, exceeding the speed limit by more than 10 km/h (but less than 25 km/h), failing to stop or give way, or for disobeying a traffic signal. Both demerit point groups were associated with a higher incidence of crash in the following month. The difference between the event and the reference period was slightly greater for three demerit point offences for the case group, adjusted for change over time in the control group (Odds Ratio 1.56, 95% CI 1.22–1.97) when compared with the difference in the one demerit point offences (Odds Ratio 1.24, 95% CI 1.04–1.51) (Table 4).

Table 3
Characteristics of drivers in the case and control study groups.

Characteristic	Case Group (n = 22782)			Control Group (n = 21019)		
	Infringed in event period (n = 910)	Infringed in reference period (n = 737)	Total	Infringed in event period (n = 634)	Infringed in reference period (n = 694)	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Age at final day of event period (years)						
40–49	384 (42)	321 (44)	705 (43)	279 (44)	288 (42)	567 (43)
50–59	284 (31)	233 (32)	517 (31)	203 (32)	223 (32)	426 (32)
60–69	152 (17)	122 (17)	274 (17)	104 (16)	120 (17)	224 (17)
70–79	67 (7)	41 (6)	108 (7)	32 (5)	54 (8)	86 (6)
80+	23 (3)	20 (3)	43 (3)	16 (3)	9 (1)	25 (2)
Sex ^a						
Male	580 (64)	458 (62)	1038 (63)	377 (59)	430 (62)	807 (61)
Female	328 (36)	277 (38)	605 (37)	257 (41)	264 (38)	521 (39)
Postcode region ^b						
Metro	697 (77)	587 (80)	1284 (77)	504 (79)	565 (81)	1069 (80)
Rural	209 (23)	148 (20)	357 (22)	130 (21)	128 (18)	258 (19)
Infringements ^c						
Speeding (<25 km/h)	759 (74)	664 (83)	1423 (78)	560 (82)	586 (81)	1146 (81)
Traffic signal offences	90 (9)	79 (10)	169 (9)	78 (11)	85 (12)	163 (12)
Failure to stop/give-way	50 (5)	7 (1)	57 (3)	^e	^e	7 (1)
Mobile phone offence	22 (2)	20 (3)	42 (2)	18 (3)	22 (3)	40 (3)
Seat and seatbelt offences	14 (1)	11 (1)	25 (1)	8 (1)	9 (1)	17 (1)
Careless driving	^e	^e	19 (1)	^e	^e	7 (1)
Overtaking, lane use and U-turn offences	^e	^e	17 (1)	^e	^e	9 (1)
Speeding (25 km/h +)	^e	^e	13 (1)	^e	^e	8 (1)
Alcohol offences	^e	^e	5 (<1)	^e	^e	5 (<1)
Drug offences	^e	^e	^e	^e	^e	^e
Other	40 (4)	6 (1)	46 (3)	^e	^e	^e
Demerit points ^d						
1	608 (60)	498 (63)	1106 (61)	430 (63)	436 (60)	866 (62)
2	^e	^e	13 (1)	^e	^e	8 (1)
3	389 (38)	289 (36)	78 (37)	242 (36)	276 (38)	518 (37)
4+	12 (1)	5 (1)	17 (1)	5 (1)	8 (1)	13 (1)

^a The sex of 4 drivers in the case group was unknown.

^b The postcode region of 6 drivers in the case group and 1 driver in the control group was unknown. Postcode region is based on the postcode of drivers' residential address held by VicRoads.

^c There were 1,820 infringements amongst case group drivers and 1,407 amongst control group drivers.

^d There were demerit point data for a total of 1,814 of the infringements amongst case group drivers and 1,405 of the infringements amongst control group drivers.

^e Cell counts of less than 5 have been suppressed to ensure data confidentiality.

4. Discussion and conclusions

The current study explored whether infringements for traffic offences have a deterring influence on illegal driving behaviours amongst drivers aged 40 years and over in the Australian state of Victoria, through looking at the occurrence of subsequent crash involvement. Applying a case-case-time-control study design, it was found that crash risk increased rather than decreased in the period that followed an infringement for a traffic offence. This pattern of increased crash risk following an infringement was apparent for all sub-analyses undertaken on specific groups in the study. These results fail to support the hypothesis that infringements for traffic offences deter illegal driving behaviour and subsequently reduce crash risk in the period that follows a driver receiving a sanction.

Table 4

Odds of having received an infringement in the month prior to a crash compared to 12 months earlier for the case group, relative to the control group.

Characteristic	Odds Ratio	95% Confidence Interval	P-Value
Overall	1.35	[1.17, 1.57]	p < 0.001
Males	1.44	[1.20, 1.75]	p < 0.001
Females	1.22	[0.96, 1.55]	p = 0.115
40–54 years	1.34	[1.10, 1.62]	p = 0.003
55–74 years	1.30	[1.01, 1.67]	p = 0.044
75 + years	2.05	[1.01, 4.23]	p = 0.048
Metro residing drivers ^a	1.33	[1.13, 1.57]	p < 0.001
Rural residing drivers ^a	1.39	[0.99, 1.94]	p = 0.054
Speeding (<25 km/h)	1.21	[1.03, 1.42]	p = 0.022
Traffic signal offences	1.24	[0.79, 1.96]	p = 0.381
Mobile phone offences	1.34	[0.52, 3.53]	p = 0.655
One demerit point offence	1.24	[1.04, 1.51]	p = 0.018
Three demerit point offence	1.56	[1.22, 1.97]	p < 0.001

^a Based on the postcode of drivers' residential address held by VicRoads.

The results of the current study are consistent with those of [Walter and Studdert \(2015\)](#), in which the likelihood of having received an infringement in the month prior to a crash was greater than in a comparable period, both across the entire sample as well as amongst subgroups. These results thus sit in contrast to that of the study by [Redelmeier et al. \(2003\)](#), who found that risk of crash was lower in the period that followed a driver receiving an infringement.

[Walter and Studdert \(2015\)](#) proposed a number of factors that may have contributed to the differences in their results to those seen in the study conducted by [Redelmeier et al. \(2003\)](#). These included that the sample size used by [Redelmeier et al. \(2003\)](#) was smaller and only took into account fatal crashes, as well as possible cultural and historical influences and differences in enforcement. [Walter and Studdert \(2015\)](#) however did not believe any of these factors would have been responsible for the contrasting results observed. It therefore remains unclear why the results of the study by [Redelmeier et al. \(2003\)](#) differ from the results of both our study and the study conducted by [Walter and Studdert \(2015\)](#). Potentially the results may point to differences in driving culture between Australia and Canada. Notably, each of the three studies had significant consistencies between them. Each considered the whole array of driving offence types, used the same 30-day period prior to the crash to consider traffic infringements, along with a 12-month lookback period, and applied study designs that use individuals as their own controls.

Like all studies, the current study had both strengths and weaknesses that should be taken into account when considering the results presented. First, the generalizability of the results cannot be determined. Despite the results being consistent with those found in the [Walter and Studdert \(2015\)](#) study conducted in Queensland, Australia, given traffic law enforcement is conducted on an individual jurisdictional basis, we cannot be certain that the patterns observed here would be replicated in other jurisdictions either within Australia or internationally. Furthermore, given we only included drivers aged 40 years and over, the patterns observed may not be true for younger drivers.

The remaining limitations primarily relate to the case-case-time control study design.

Whilst, as noted there are many advantages in using individuals as their own controls, this does not mean the approach does not suffer from disadvantages, as all study designs do. First, whilst the case-case-time-control study design controls for static individual factors, it does not control for individual time-variant factors that may change between the reference and event periods. Individual time-variant factors could influence the travel and driving patterns of a person. Changes in driving patterns can impact both risks of receiving an infringement and crash involvement, through increased or decreased exposure. Between the start of the reference period and the end of the event period, drivers may have moved house, started a new job, changed their working hours, begun taking different commuting patterns or had altered family responsibilities. Each of these factors may have changed time, distance and routes travelled, as well as propensity for risk taking. Another individual time-variant factor is stress. Stress from work and personal issues has been found to adversely influence driving behaviour and outcomes ([Rowden, Matthews, Watson, & Biggs, 2011](#)). Such events may have occurred for drivers included in the current study, and thus patterns of driving behaviour and how individuals responded to different situations may have varied between the event and the reference periods. As this study was based on data available in the Driver Licensing System, there was no information available that could serve as a proxy for time-variant stress levels. Infringements may have a positive impact on driving behaviour, but there may have been many other factors that we failed to capture that had greater effect on patterns of driving behaviour. This has limitations for the validity of our study findings, meaning we cannot rule out a deterrent effect of infringements. Future research could utilize a cohort study design using a combination of administrative and self-report data, to capture information on the personal experiences of individuals at different points in time.

Despite the limitations of the current study, there are a number of strengths, primarily in relation to how the study design builds upon the case-crossover approach taken by [Redelmeier et al. \(2003\)](#) and [Walter and Studdert \(2015\)](#). The case-case-time control uses a control group who experience the same outcome of interest at a time in the future in relation to the case group. By applying this design, the current study controlled for a number of external factors that changed over time, such as

enforcement, which the case-crossover study design does not control for. Furthermore, by using a control group who had also experienced a crash, the two study groups demonstrated a degree of similarity.

The current study did not support the hypothesis of a specific deterrent effect emerging from infringements for traffic offences, as reflected in a reduced subsequent crash risk. There are many other factors that may have contributed to this finding, most notably, individual time-variant factors that were not controlled for, given the administrative data set used. The results must therefore be interpreted with caution. Continued research that seeks to determine the effectiveness of traffic infringements is essential if gains are to be made in relation to road safety. Further research should use study designs that incorporate data on time-variant individual factors such as driver exposure and stressors, to look at both the effectiveness of infringements in reducing subsequent crash involvement but also in reducing subsequent performance of illegal driving behaviours. Using methodological approaches that combine both official and self-report data will enhance the rigor of research in this area.

Declaration of Competing Interest

None.

Acknowledgements

Thank you to VicRoads who provided the data set which enabled this research to be conducted.

Funding

This research was undertaken as part of a PhD program at the Monash University Accident Research Centre (MUARC). The student researcher was supported by a MUARC Foundation Scholarship.

References

- Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention*, 38(2), 215–224. <https://doi.org/10.1016/j.aap.2005.07.004>.
- Andrews, D., & Bonta, J. (2010). *Prevention and rehabilitation*. In *Psychology of criminal conduct*, pp. 345–392. New York, USA: Elsevier Science & Technology.
- Anstey, K. J., Eramudugolla, R., Ross, L. A., Lautenschlager, N. T., & Wood, J. (2016). Road safety in an aging population: Risk factors, assessment, interventions, and future directions. *International Psychogeriatrics*, 28(3), 349–356. <https://doi.org/10.1017/S1041610216000053>.
- Australian Government Department of Infrastructure and Regional Development. (2017). Road Safety. Retrieved from <https://infrastructure.gov.au/roads/safety/>.
- Bagaric, M., & Alexander, T. (2012). The capacity of criminal sanctions to shape the behaviour of offenders: Specific deterrence doesn't work, rehabilitation might and the implications for sentencing. *Criminal Law Journal*, 36(3), 159–172.
- Barracough, P., af Wahlberg, A., Freeman, J., Watson, B., & Watson, A. (2016). Predicting crashes using traffic offences: A meta-analysis that examines potential bias between self-report and archival data. *PLoS One*, 11(4). <https://doi.org/10.1371/journal.pone.0153390>.
- Bedard, M., Guyatt, G., Stones, M., & Hirdes, J. (2002). The independent contribution of driver, crash, and vehicle characteristics to driver fatalities. *Accident Analysis & Prevention*, 34(6), 717–727. [https://doi.org/10.1016/S0001-4575\(01\)00072-0](https://doi.org/10.1016/S0001-4575(01)00072-0).
- Bland, J., & Altman, D. (2000). The odds ratio. *British Medical Journal*, 320(7247), 1468. <https://doi.org/10.1136/bmj.320.7247.1468>.
- Blomberg, R., Peck, R., Moskowitz, H., Burns, M., & Fiorentino, D. (2005). Crash risk of alcohol involved driving: A case-control study. Retrieved from Dunlap and Associates Inc website: <http://www.dunlapandassociatesinc.com/crashriskofalcoholinvolveddriving.pdf>.
- Blows, S., Ivers, R., Conner, J., Ameratunga, S., & Norton, R. (2003). Does periodic vehicle inspection reduce car crash injury? Evidence from the Auckland Car Crash Injury Study. *Australian and New Zealand Journal of Public Health*, 27(3), 323–327. <https://doi.org/10.1111/j.1467-824X.2003.tb00401.x>.
- Blows, S., Ivers, R., Woodward, M., Connor, J., Ameratunga, S., & Norton, R. (2003). Vehicle year and the risk of car crash injury. *Injury Prevention*, 9(4), 353–356. <https://doi.org/10.1136/ip.9.4.453>.
- Brown, S., Esbensen, F., & Geis, G. (2015). Deterrence and rational choice theories of crime. In *Criminology: Explaining crime and its context*, pp. 153–209. New York, USA: Routledge, Taylor and Francis Group.
- Bureau of Infrastructure, Transport and Regional Economics. (2014). Road Safety – Modelling a Global Phenomenon. (Report 141). Retrieved from https://bitre.gov.au/publications/2014/files/report_141.pdf.
- Chen, H., Cohen, P., & Chen, S. (2010). How big is a big odds ratio? interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics - Simulation and Computation*, 39(4), 860–864. <https://doi.org/10.1080/03610911003650383>.
- Christensen, K., Doblhammer, G., Rau, R., & Vaupel, J. W. (2009). Ageing populations: The challenges ahead. *The Lancet*, 374(9696), 1196–1208. [https://doi.org/10.1016/S0140-6736\(09\)61460-4](https://doi.org/10.1016/S0140-6736(09)61460-4).
- Hallas, J., & Pottegard, A. (2014). Use of self-controlled designs in pharmacoepidemiology. *Journal of Internal Medicine*, 275(6), 581–589. <https://doi.org/10.1111/joim.12186>.
- Hendrie, D., & Miller, T. (2012). Measuring the costs of road trauma and its longer term consequences (RR-09-002). Retrieved from Curtin-Monash Accident Research Centre website: https://c-marc.curtin.edu.au/local/docs/MCRTLTC_FINAL.pdf.
- Holdridge, J., Shankar, V., & Ulfarsson, G. (2005). The crash severity impacts of fixed roadside objects. *J Safety Res*, 36(2), 139–147. <https://doi.org/10.1016/j.jsr.2004.12.005>.
- Kloeden, C., McLean, A., Moore, V., & Ponte, G. (1997). Traveling speed and the risk of crash involvement: Volume 1-Findings. Retrieved from NHMRC Road Accident Research Unit: The University of Adelaide.
- Kwok, C., Lloyd, D., & Yip, P. (2013). Ageing population scenarios: An Australian experience. *Journal of Populations Research*, 30(4), 335–345. <https://doi.org/10.1007/s12546-013-9114-0>.
- Lab, S. (2016). Specific deterrence and incapacitation. In *Crime prevention: Approaches, practices and evaluations*, pp. 311–328. New York, USA: Routledge.
- McEvoy, S. P., Stevenson, M., & Woodward, M. (2006). Phone use and crashes while driving: A representative survey of drivers in two Australian states. *Medical Journal of Australia*, 185(11/12), 630–634. <https://doi.org/10.5694/j.1326-5377.2006.tb00734.x>.
- McEvoy, S. P., Stevenson, M. R., McCart, A. T., Woodward, M., Haworth, C., Palamara, P., & Cercarelli, R. (2005). Role of mobile phones in motor vehicle crashes resulting in hospital attendance: A case-crossover study. *BMJ*, 331(7514), 428. <https://doi.org/10.1136/bmj.38537.397512.55>.
- Mitchell, B. (2012). Crimes of misery and theories of punishment. *New Criminal Law Review*, 15(4), 465–510. <https://doi.org/10.1525/nclr.2012.15.4.465>.

- Penmetsa, P., & Pulugurtha, S. (2016). Risk drivers pose to themselves and other drivers by violating traffic rules. *Traffic Injury Prevention*, 18(1), 1–7. <https://doi.org/10.1080/15389588.2016.1177637>.
- Rakauskas, M. E., Gugerty, L. J., & Ward, N. J. (2004). Effects of naturalistic cell phone conversations on driving performance. *Journal of Safety Research*, 35(4), 453–464. <https://doi.org/10.1016/j.jsr.2004.06.003>.
- Redelmeier, D., Tibshirani, R., & Evans, L. (2003). Traffic-law enforcement and risk of death from motor-vehicle crashes: Case-crossover study. *The Lancet*, 361(9376), 2177–2182. [https://doi.org/10.1016/S0140-6736\(03\)13770-1](https://doi.org/10.1016/S0140-6736(03)13770-1).
- Risbey, T., Cregan, M., & De Silva, H. (2010). Social Cost of Road Crashes. Paper presented at the Australasian Transport Research Forum 2010, Canberra, Australian Capital Territory. Retrieved from https://www.bitre.gov.au/publications/2010/files/sp_003_Risbey_Cregan_deSilva.pdf.
- Rosenthal, J. A. (1996). Qualitative descriptors of strength of association and effect size. *Journal of Social Service Research*, 21(4), 37–59. https://doi.org/10.1300/J079v21n04_02.
- Rowden, P., Matthews, G., Watson, B., & Biggs, H. (2011). The relative impact of work-related stress, life stress and driving environment stress on driving outcomes. *Accident Analysis and Prevention*, 43(4), 1332–1340. <https://doi.org/10.1016/j.aap.2011.02.004>.
- Salmon, P., Regan, M., & Johnston, I. (2005). Human error and road transport: Phase one - Literature Review (256). Retrieved from Monash University Accident Research Centre website: https://www.monash.edu/data/assets/pdf_file/0010/216946/Human-Error-and-Road-Transport-Phase-One-A-framework-for-an-error-tolerant-road-transport-system.pdf.
- Schulze, H., Schumacher, M., Urmeeuw, R., & Auerbach, K. (2012). Final Report: Work performed, main results and recommendations (TREN-05-FP6TR-S07.61320- 518404-DRUID). Retrieved from <https://www.oisevi.org/a/archivos/estudios-especificos/ong/Union-Europea-Druid-Final-Report.pdf>.
- Stanton, N. A., & Salmon, P. M. (2009). Human error taxonomies applied to driving: A generic driver error taxonomy and its implications for intelligent transport systems. *Safety Science*, 47(2), 227–237. <https://doi.org/10.1016/j.ssci.2008.03.006>.
- Stigson, H., Kraft, M., & Tingvall, C. (2008). Use of fatal real-life crashes to analyze a safe road transport system model, including the road user, the vehicle, and the road. *Traffic Injury Prevention*, 9(5), 463–471. <https://doi.org/10.1080/15389580802335240>.
- VicRoads. (2017). About demerit points. Retrieved from <https://www.vicroads.vic.gov.au/licenses/demerit-points-and-offences/about-demerit-points>.
- VicRoads. (2018). Penalties. Retrieved from <https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties>.
- Walter, S. J., & Studdert, D. M. (2015). Relationship between penalties for road traffic infringements and crash risk in Queensland, Australia: A case-crossover study. *International Journal of Epidemiology*, 44(5), 1722–1730. <https://doi.org/10.1093/ije/dyv148>.
- Wang, S., Linkletter, C., Maclure, M., Dore, D., Mor, V., Buka, S., & Wellenius, G. A. (2011). Future cases as present controls to adjust for exposure trend bias in case-only studies. *Epidemiology*, 22(4), 568–574. <https://doi.org/10.1097/EDE.0b013e31821d09cd>.
- Weisberg, R. (2014). Meanings and measures of recidivism. *Southern California Law Review*, 87(3), 785–804.
- Wierwille, W., Hanowski, R., Hankey, J., Kieliszewski, C., Lee, S., Medina, A., ... Dingus, T. (2002). Identification and Evaluation of Driver Errors: Overview and Recommendations. (FHWA-RD-02-003). Virginia, USA: Federal Highway Administration Retrieved from <https://rosap.nhtl.bts.gov/view/dot/922>.
- World Health Organization. (2015). Global status report on road safety 2015. Retrieved from World Health Organization website: http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/.
- Zein, S., & Navin, F. (2003). Improving traffic safety: A new systems approach. *Journal of the Transportation Research Board*, 1830(1). <https://doi.org/10.3141/1830-01>.

Chapter Eight: Research design and data collection methods for study three

8.1 Introduction

Studies one and two of this PhD focussed solely on legal sanctions, specifically traffic infringements, and their effectiveness in deterring subsequent illegal driving behaviour and in achieving crash avoidance. However, as the review of the existing literature in chapter two indicated, there is evidence that other factors, including non-legal sanctions and personality may also influence driver behaviour. Furthermore, research has suggested that personality may interact with other factors to influence driver behaviour. This broader idea of deterrence was the focus of study three.

The aim of the current chapter is to provide methodological information relating to the conduct of study three. First, **the questions used to collect the data** for each construct in the conceptual model for study three are described. Second, the chapter provides a rationale for **using an online survey** to collect the data. This includes a discussion of the strengths and weaknesses of online data collection methods, considering these in the context of study three. Finally, **details on participant recruitment** are provided. The current chapter provides an important introduction for understanding the two chapters that follow, which report on the results of the data analysis phase of this study three.

8.2 Aims of study three

As indicated in the introduction, study three had three broad aims:

- 1) To assess whether receiving an infringement for a driving offence has the desired effect of deterrence
- 2) To assess whether drivers' perceptions in relation to illegal driving behaviour have a deterring influence
- 3) To determine whether potential deterring factors differ depending on driver characteristics

The conceptual model that was developed for examination in study three and to address these aims (introduced in chapter three) is again provided in Figure 8.1. As was described, the model sought to guide an examination of whether perceptions towards potential

detering factors have a mediating influence between personality and expectations to perform an illegal driving behaviour/s. Furthermore, the model also sought to guide an examination of a number of direct links, these being links between personality and perceptions towards the four potentially deterring factors; personality and behavioural expectations; and perceptions towards the four potentially deterring factors and behavioural expectations.

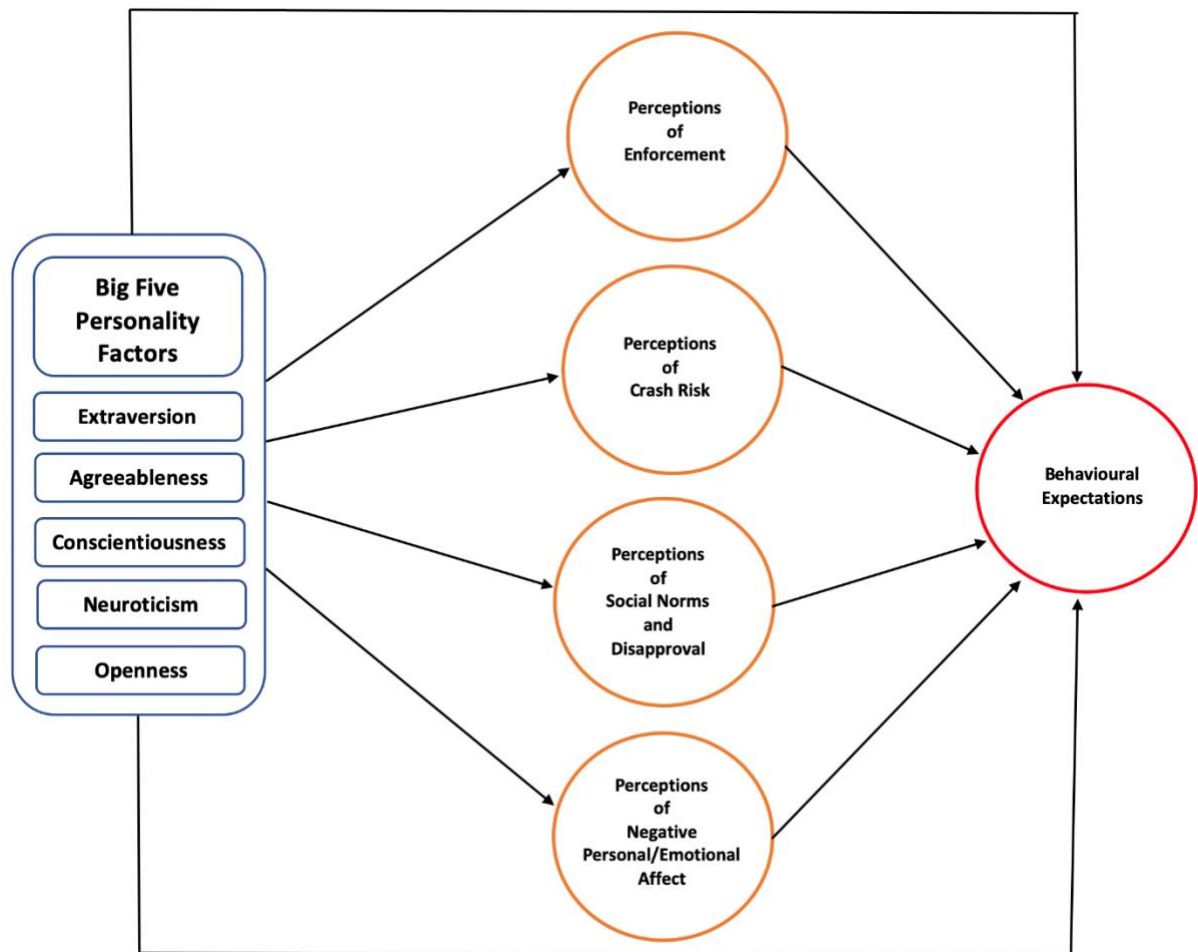


Figure 8.1 Conceptual model for examination in study three showing pathways that may exist between personality, perceptions of potential deterrents and behavioural expectations

A survey was designed to collect data on each of the constructs in the theoretical model. Separate questions were asked for each offence type in relation to perceptions of enforcement, crash risk, social norms and disapproval, negative personal and emotional affect and behavioural expectations.

Illegal driving behaviours that data were collected for are:

- 1) Driving with a Blood Alcohol Concentration (BAC) above the legal limit

- 2) Driving after using an illicit drug/s
- 3) Speeding – including differing levels of speeding severity:
 - a) Driving at up to 10km/h above the speed limit; and
 - b) Driving at more than 10km/h above the speed limit
- 4) Using a handheld mobile phone whilst driving
- 5) Failing to stop at a red light

Details about the questions used to collect the data are provided in the following section.

8.3 Details of questions used to collect data for each construct in the conceptual model

The following section provides information on how data were collected for each of the constructs included in the theoretical model in Figure 8.1. Information is also provided on other measures data were collected for in study three. These include demographics, previous driving behaviour, previous crash involvement, licence details and use of alcohol and illicit drug/s. In some instances, validated scales were used. In other instances, questions from existing research were used as a guide, and adapted to make them applicable to the current study. A copy of the survey is included in Appendix E.

8.3.1 Personality

The Big Five Inventory (BFI) was used to measure the five personality traits of extraversion, agreeableness, conscientiousness, neuroticism and openness (John, Donahue & Kentle, 1991; John, Naumann & Soto, 2008; John and Srivastava, 1999). The BFI includes 44 items with a five-point scale of 'Disagree Strongly' (1); 'Disagree a little' (2); 'Neither Agree nor Disagree' (3); 'Agree a little' (4); 'Agree Strongly' (5) (John, Naumann & Soto, 2008; John and Srivastava, 1999). Scale scores are calculated by averaging the item scores for each of the five personality traits. A higher score indicates that an individual generally displays behaviour consistent with the trait. Due to the nature of some items in the BFI, they are reverse coded. This is because these items are framed in a way that responses higher on the scale means the person displays behaviour not consistent with the trait (John, Naumann & Soto, 2008; John and Srivastava, 1999).

Extraversion is measured using eight items in the BFI (e.g. 'Is talkative', 'Is full of energy', 'Generates a lot of enthusiasm'). Agreeableness is measured using nine items in the BFI (e.g. 'Is helpful and unselfish with others', 'Has a forgiving nature', 'Is generally trusting').

Conscientiousness is measured using nine items in the BFI (e.g. 'Does a thorough job', 'Is a reliable worker', 'Makes plans and follows through with them'). Neuroticism is measured using eight items in the BFI (e.g. 'Is depressed, blue', 'Worries a lot', 'Can be moody'). Openness is measured using ten items in the BFI (e.g. 'Is curious about many different things', 'Has an active imagination', 'Is inventive') (John, Donahue & Kentle, 1991; John, Naumann & Soto, 2008; John and Srivastava, 1999). A full list of the 44 items included in the BFI and the personality trait they measure can be found in Appendix F.

The BFI has been widely used in research in a diverse range of study areas and with many different study samples. Recent examples include a study examining the personality of Australian pharmacists (Waddell et al., 2020), victimization experienced by adolescents in schools (Kulig et al., 2019), emotional intelligence and autism (Robinson, Hull & Petrides, 2020) and creativity (Kaspi-Baruch, 2017). The BFI has been found to have good internal consistency, test-retest stability, discriminant validity, convergent validity, construct validity and external validity (Rammstedt & John 2007).

8.3.2 Perceptions of enforcement

Two items for each offence type were used to capture data on perceptions of enforcement. One focussed on certainty of sanctions and one focussed on severity of sanctions. Given legal sanctions vary between the offences, the questions were tailored for each offence type.

While additional context was added, the questions used to examine perceptions of enforcement were based on those used by Davey et al. (2008), Freeman, Liossis & David (2006), Freeman et al., (2016), Freeman et al., (2010), Freeman and Watson (2006) and Szogi et al. (2017). For example, Freeman, Liossis & David (2006) asked recidivist drink drivers to indicate the impact penalties for drink driving had on their lives. Similarly, Freeman and Watson (2006) and Freeman et al. (2016) asked drivers to indicate the impact a drink driving penalty would have on their life. Freeman et al. (2016) also asked drivers to indicate if they would be worried about getting caught for a drink driving offence. Szogi et al. (2017) also asked drivers about worry of being caught and the impact a sanction would have on their life. Given the success of these studies in examining deterrence, similar questions were used, adding in additional context to the offence type, as indicated above.

The items that were included to capture perceptions of enforcement in relation to driving with a BAC above the legal limit and driving after using an illicit drug were:

- 1) If I was to [offence type] I'd worry that I would get caught by police
- 2) Loss of my licence for [offence type] would have a significant negative impact on my life

The items that were included to capture perceptions of enforcement in relation to driving up to 10km/h above the speed limit were and driving at more than 10km/h above the speed limit were:

- 1) If I was to drive [offence type], I'd worry that I would get caught by police or a speed camera
- 2) Receiving a fine and/or demerit points on my licence for [offence type] would have a significant negative impact on my life

The items that were included to capture perceptions towards enforcement in relation to using a handheld mobile phone whilst driving were:

- 1) If I was to use a handheld mobile phone whilst driving, I'd worry that I would get caught by police
- 2) Receiving a fine and/or demerit points on my licence for using a handheld mobile phone whilst driving would have a significant negative impact on my life

The items that were included to capture perceptions towards enforcement in relation to failing to stop at a red light were:

- 1) If I was to drive through a red light, I'd worry that I would get caught by police or a red light camera
- 2) Receiving a fine and/or demerit points on my licence for driving through a red light would have a significant negative impact on my life

Responses were measured on a 7-point scale of: 1) Strongly Disagree; 2) Disagree; 3) Somewhat Disagree; 4) Neither Agree nor Disagree; 5) Somewhat Agree; 6) Agree; 7) Strongly Agree. Higher scores were therefore indicative of greater levels of deterrence.

8.3.3 Perceptions of crash risk

Two items for each offence type were included in the survey to capture data on perceptions of crash risk. The first item examined drivers' perceptions in relation to the level of risk of being involved in a crash if they performed each of the driving behaviours of interest. The

second item examined drivers' perceptions in relation to the risk of injuring oneself or others in the event of a crash occurring as a result of each of the illegal driving behaviours of interest.

The questions used to examine perceptions of crash risk were based on questions used in existing research that has explored the deterring influence of worry about being involved in a crash and the potential physical loss that may result (Freeman et al., 2006; Freeman et al., 2016; Freeman & Watson, 2009). Whilst the exact questions asked in these studies varied, between them, they each sought to examine concern about being involved in a crash and/or concern about injury. Whilst in some cases, questions were only asked about injury to oneself, other studies examined injury to others also. Thus, to ensure a full picture of injury risk, in the current study, drivers were asked to indicate perceived risk of crash and perceived risk of injury to themselves and others.

The items that were included to capture perceptions of crash risk for all offence types were:

- 1) I would be worried that I could have a crash if I [offence type]
- 2) I would be worried that I could injure myself or someone else if I [offence type]

Responses were measured on a 7-point scale of: 1) Strongly Disagree; 2) Disagree; 3) Somewhat Disagree; 4) Neither Agree nor Disagree; 5) Somewhat Agree; 6) Agree; 7) Strongly Agree. Higher scores were therefore considered indicative of greater levels of deterrence.

8.3.4 Perceptions of social norms and disapproval

Two items for each offence type were used to capture data for the perceptions of social norms and disapproval construct. The first item examined drivers' perceptions of how much of the time they feel performing illegal driving behaviours is wrong. The second item examined drivers' perceptions on how they believe those closest to them would respond if they were to engage in any of the driving behaviours of interest.

The measures examining how much of the time drivers perceive the performance of the illegal driving behaviours to be wrong were similar to items used to examine moral attachment to the norm in studies conducted by Freeman, Liossis and David (2006) and Grasmick and Green (1980). Freeman, Liossis and David (2006) asked repeat drink drivers if they believe it is wrong to drink and drive. Grasmick and Green (1980), asked individuals

how much of the time it is wrong to drink drive. As in previous constructs, the questions were amended slightly to be applicable to the current study.

The items that were included to capture perceptions of social norms and disapproval for all offence types were:

- 1) How much of the time do you think it is wrong to [offence type]?
- 2) Thinking about the people who mean the most to you, how do you think they would respond if you [offence type]?

Two different scales were used for the items that examined perceptions of social norms and disapproval. The items that asked drivers about how much of the time they think each of the behaviours are wrong were measured on a 5-point scale of: 1) Never wrong to do it; 2) Rarely wrong to do it; 3) Sometimes wrong to do it; 4) Usually wrong to do it; 5) Always wrong to do it. The items that asked drivers about how those who mean those most to them would respond if they were to perform each of the driving behaviours were measured on a 7-point scale of: 1) Strongly Approve; 2) Approve; 3) Somewhat Approve; 4) Neither Approve nor Disapprove; 5) Somewhat Disapprove; 6) Disapprove; 7) Strongly Disapprove. Higher scores were therefore considered to be indicative of greater levels of deterrence.

8.3.5 Perceptions of negative personal and emotional affect

Two items for each offence type were used to capture data for the perceptions of negative personal and emotional affect construct. The first item examined drivers' perceptions of whether they expect they would experience shame if they were to engage in each of the illegal driving behaviours of interest. The second item examined drivers' perceptions of whether they expect they would experience guilt if they were to engage in each of the illegal driving behaviours of interest.

Freeman et al. (2006) asked repeat drink drivers if they feel guilty after drinking and driving. Similarly, Grasmick and Bursik (1990) asked individuals if they would feel shame or guilt if they were to drink and drive (the words shame and guilt were used interchangeably in their research). Thus, given shame and guilt have already been used in established road safety research, proving their suitability in examining non-legal sanctions, they were identified as suitable emotions to measure this construct. Furthermore, these existing questions guided the development of the questions used in the survey in current research.

To ensure participants understood what was meant by shame and guilt, definitions were provided in the survey for each word. These definitions were taken from the Oxford Dictionary. Shame was defined as 'a painful feeling of humiliation or distress caused by the consciousness of wrong or foolish behaviour'. Guilt was defined as 'the fact of having committed a specified or implied offence or crime'. Individuals were instructed to think about these definitions prior to responding to the survey items that examined perceptions of negative personal/emotional affect.

The items that were included to capture perceptions of negative personal/emotional affect for all offence types were:

- 1) Would you feel shame if you [offence type]?
- 2) Would you feel guilt if you [offence type]?

All items were measured on a 7-point scale of: 1) Strongly Disagree; 2) Disagree; 3) Somewhat Disagree; 4) Neither Agree nor Disagree; 5) Somewhat Agree; 6) Agree; 7) Strongly Agree. Higher scores were therefore considered to be indicative of greater levels of deterrence.

8.3.6 Expectations to perform the driving behaviour of interest

Expectations to perform each of the illegal driving behaviours was examined using one item per behaviour. A reference period of expecting to perform the behaviour in the following twelve months was provided, to give to a definitive length of time to consider when responding. The item used to examine behavioural expectations for all behaviours was:

- 1) How likely do you think it is that you will [offence type] in the next twelve months?

All items were measured on a 7-point scale of: 1) Extremely Unlikely; 2) Moderately Unlikely; 3) Slightly Unlikely; 4) Neither Likely or Unlikely; 5) Slightly Likely; 6) Moderately Likely; 7) Extremely Likely. Higher scores were therefore indicative of greater expectations to perform the driving behaviours and considered to be evidence of not being deterred.

8.3.7 Other variables measured in the survey

In addition to each of the constructs outlined above, that were included in the conceptual model for examination in study three, a number of other measures were included in the survey for data collection. These additional items were collected to gather information about the profile of individuals who completed the survey. First, data on a number of demographic factors were collected in the survey. These included gender, current age, age

at first licence, licence type, Victorian area of residence, highest level of education achieved and current employment status.

Second, data on previous performances of the illegal driving behaviours were collected. Respondents were asked both how often they performed each of the behaviours when they drove in the twelve months prior, and also experience of apprehension for the behaviours. This factor sought to quantify the level of previous offending in the study sample. The question based on regularity of offending was similar to that successfully used in existing research by Freeman et al. (2016). However, once again, the wording and response options were changed slightly to be applicable to the current study.

Third, respondents were asked to indicate if they had been involved in a crash in the three years prior, and if so, details on crash severity and fault were also collected.

Fourth, drivers were asked questions about their licence details. These included the type/s of licence/s held, both in terms of probationary or full licence and whether the licence enables them to drive a motorcycle and/or heavy vehicle, in addition to a car. Drivers were also asked to indicate whether they had any experience of being unlicensed in the twelve months prior to survey completion.

Fifth, drivers were asked about their use of alcohol and illicit drugs. Alcohol use data were collected using the Alcohol Use Disorders Identification Test (AUDIT), developed by the World Health Organization (WHO). The scale consists of ten items in total: three that seek to understand patterns of alcohol consumption; three that collect information on alcohol dependency; and four that collect information on problems that may have arisen as a result of alcohol consumption (Babor, et al., 2001).

In terms of illicit drug use, questions were asked in relation to heroin, cocaine, amphetamines, cannabis and ecstasy. An open-ended question was also included, to enable drivers to specify other illicit drug types they had used. Drivers were asked to indicate which, if any, illicit drug type/s they had used. Where a driver indicated they had used an illicit drug/s, they were asked how regularly they had used the drug/s in the last twelve months. This question was modelled off the frequency of use question contained within the AUDIT, to ensure consistency throughout the survey. The alcohol and illicit drug use questions were included to gain an understanding on the extent and regularity of use of

substances amongst study participants. Descriptive statistics on all these survey items are provided in chapter nine.

Finally, it is important to note that the survey also included questions on self-control. However, self-control was not ultimately considered in the analyses presented in this thesis. Initial analyses revealed significant levels of multicollinearity between self-control and the Big-Five personality factors. The model was therefore revised to only include the Big-Five personality factors.

8.4 Method of data collection used in study three and rationale for using this method

As indicated, a survey was designed and used for collection of data for study three. When a researcher embarks upon a study where the collection of new data is required to answer the research questions developed, there are many different methods of data collection available that they can choose from. When selecting the most appropriate method, there are a number of factors that must be considered, which will in turn indicate the method or methods that are most appropriate. Factors that were considered in the current research when choosing the most appropriate method of data collection were:

- 1) Sample Size: Data were sought from a large sample of drivers from across Victoria, Australia.
- 2) Accessibility: The survey had to be accessible to a wide a range of Victorian drivers, covering both metropolitan and regional areas.
- 3) Time and budget constraints: Given the research was being undertaken as part of a PhD research program, the data collection phase had to occur within a relatively short period of time and had limited financial resources available to complete it.
- 4) Not all questions were relevant to all individuals: The survey collected a variety of information, however not all questions were relevant all individuals (e.g. illicit drug type questions were only applicable to individuals who reported they had used an illicit drug). There was therefore a need to present some questions to some people, based upon their response to a filter question.
- 5) Sensitive data were being collected: The survey collected potentially sensitive information. This included the performance of illegal driving behaviours, use of illicit drugs, consumption of alcohol and previous involvement in crashes.

After a period of consideration and evaluation, the decision was made to collect data for the current study through the use of an online, self-completed survey. The following section provides an overview of the use of online surveys for the collection of research data. In particular, the aim is to describe some of the advantages and disadvantages that have been identified in the research literature surrounding the use of online surveys. Comparisons are drawn with other possible methods that could have been used, including face-to-face, mail and telephone data collection.

8.4.1 Accessibility to online surveys

The number of Australians with access to the internet has increased markedly overtime. Australian Bureau of Statistics (ABS) data show that the number of households with internet access went from 56 percent in 2004-05 to 86 percent in 2016-17 (Australian Bureau of Statistics, 2018). The expansion of the internet has opened up new opportunities for research, including the online collection of data (e.g. Granello & Wheaton, 2004; Lazar & Preece, 1999). Whereas in the past, face-to-face interviews, mail out surveys and telephone surveys were commonly used for data collection, the use of the internet to administer surveys has now become a prevalent option (e.g. Couper, 2000; Hardré et al., 2007). Given the widespread availability of internet access in Australia today, the use of online methods of data collection therefore provides the opportunity to collect information from a large number of people with relatively minimal effort.

Despite the ease of accessibility that the internet has provided, it is important to recognise that internet accessibility is not equal across Australia. There are certain groups in the community that do not have equal access to the internet (Shih & Xitao, 2008; Sue & Ritter, 2012a). This may include the elderly and people who experience socio-economic disadvantage. Some people may also have limited skills in using a computer (Schleyer & Forrest, 2000). This has the potential to exclude individuals in these groups from being able to participate in the research, therefore limiting the generalisability of the results (e.g. Zhang, 1999).

8.4.2 Speed with which data can be collected online

Online data collection is an effective method for the quick collection of data, particularly because it enables multiple responses to be collected simultaneously (Couper, 2000; Sue &

Ritter, 2012a). Response turnaround time is also much faster in comparison to other techniques, such as mail surveys (Kwak & Radler, 2002, Schleyer & Forrest, 2000).

8.4.3 Cost effectiveness of online data collection

The collection of research data online is very economical (Cobanoglu, Warde & Moreo, 2001; Couper, 2000; Schleyer & Forrest, 2000; Schmidt, 1997; Wright, 2005). Other methods of data collection can be costly, particularly where the researcher has to travel to meet with study participants (Sue & Ritter, 2012a), pay for printing and postage costs associated with mail out surveys (Cobanoglu et al., 2001; Couper, 2000; Schleyer & Forrest; Wright, 2005) or pay for the cost of making calls if a telephone method is used (Wright, 2005). Following data collection, there are also costs of coding and data entry if non-electronic methods of data collection are used (Cobanoglu et al., 2001; Granello & Wheaton, 2004; Kaplowitz, Hadlock, & Levine, 2004; Schleyer & Forrest, 2000).

8.4.4 Ease of completing online surveys

Online surveys can assist in ensuring that participants can easily respond to questions. Online data collection enables skip patterns to be embedded into the survey, meaning that respondents are only presented with relevant questions (Sue & Ritter, 2012a). Individuals are not burdened with the responsibility of having to read and follow skip patterns through the survey completion process, which can open up the possibility for errors to be made (Sue & Ritter, 2012a).

Respondents are also able to complete the surveys at a pace that suits them. This means that participants can choose a time that suits them to complete the survey, can stop at any time to attend to other tasks and responsibilities, as well as to consider their responses for as long as they feel is appropriate (Sue & Ritter, 2012a).

Despite the ease that online surveys present for participants completing them, at the same time, online surveys can present some challenges. As with all data collection methods that are self-administered, the researcher is not able to quickly and directly respond to questions that a respondent has. The researcher is also not able to elicit further information or clarify responses when an individual provides an answer that is not applicable or does not provide an adequate level of information (Couper, 2000). Whilst these barriers can be overcome with face-to-face or telephone interviews, such a method of data collection was not possible

in this research, given it would be very time intensive and difficult to access a diverse driver group across Victoria.

8.4.5 Suitable for asking sensitive and personal questions

Online surveys are a good method for collecting data that may be considered by some individuals to be sensitive and/or personal (e.g. Granello & Wheton, 2004). The non-face-to-face nature means respondents are able to remain anonymous, which is not possible with data collection methods in which a person responds directly to a researcher (e.g. Hewson, Laurent & Vogel, 1996). As a result, the responses that are obtained may be more accurate and truthful, as individuals do not fear judgement or consequences when providing responses that may not be as favourable or acceptable (e.g. Hewson et al., 1996).

8.4.6 Ability to collect responses from a large sample of individuals

Researchers may be able to collect data from larger groups of individuals than would be possible with other methods. Despite this, there are also disadvantages to achieving the desired sample size in relation to online surveys. One such disadvantage is the relatively high risk that respondents will start the survey, but not complete it, a problem attributed to the independent and non-contact nature of the data collection method (Sue & Ritter, 2012b). Participants may not feel as obligated to complete the survey as they would feel if they were directly responding to a researcher. Indeed, a number of studies have found that online surveys have lower response rates than those achieved in other methods of data collection (e.g. Bech & Kristensen, 2009; Couper, 2000; Kwak & Radler, 2002; Miller et al., 2002; Shih & Zitao, 2008).

8.4.7 Conclusions for why an online survey was used

As can be seen, the use of an online survey met all the requirements that were set out for data collection (sample size, accessibility, time and budget constraints, not all questions were relevant to all individuals and sensitive data was being collected). Whilst there were other data collection methods that could have been used, such as paper-based surveys or telephone interviews, ultimately, an online survey was able to meet all the requirements and was therefore considered the most sensible option.

8.5 Collection of survey data and process of participant selection

8.5.1 Collection of the data

Ethics approval for the research was received from the Monash University Human Research Ethics Committee (MUHREC). The online survey was administered via the survey platform *Qualtrics*. *Qualtrics* is a large research services company that provides access to survey software to enable individuals to create and build online surveys to collect data for their requirements (Qualtrics, 2020a).

Thus, as part of this PhD research program, the survey questions that had been developed were built in the *Qualtrics* platform. *Qualtrics* enabled the survey to be developed in a way that ensured it would be as easy as possible to complete for study participants, through a clear and easy to follow format.

Data collection took place between July-August, 2019. The survey took approximately 15 minutes for individuals to complete. An initial pilot period of data collection was undertaken. A small number of changes were then made to the survey, to ensure the data that was eventually collected would be of the highest quality possible.

8.5.2 Selection Criteria

A number of selection criteria were applied, in order to identify drivers who were eligible for inclusion. The selection criteria that drivers had to meet to be included in the study were:

- 1) A drivers licence for Victoria, Australia that enabled them to operate a car (Drivers who held a car learners permit were not eligible to participate)
- 2) Living in Victoria, Australia at the time of completing the survey
- 3) Had to have driven at least once on Victorian roads in the twelve-month period prior to completing the survey

8.5.3 Access to study participants

To facilitate access to individuals who met all the selection criteria that was outlined above, the *Qualtrics* online sample research panel service was used.

As part of their panel service, *Qualtrics* has access to individuals who have agreed to participate in research studies. Individuals receive links, via email, to surveys that are potentially relevant to them and for which they may meet the eligibility criteria. For participating, individuals earn credit points, which can then be used to obtain gift card

rewards of their choice (Qualtrics, 2020b). *Qualtrics* were approached and the full selection criteria and sample size requirements for the study were specified. *Qualtrics* then handled all the data collection phase of the research, which included recruitment of eligible individuals, monitoring data quality and providing the data set containing all responses.

8.5.4 Quality control processes in place

The use of *Qualtrics* for the collection of data meant a number of quality control functions were put in place. This ensured the final data set was of a high standard and was able to produce accurate analyses.

First, *Qualtrics* monitored the length of time it took each respondent to complete the survey. Responses that were completed in less than five minutes, potentially suggesting an individual was not providing high-quality and accurate responses were removed.

Second, *Qualtrics* ensured that all individuals met the selection criteria by requiring them to confirm the three conditions specified in Section 8.5.2 were true for them. Any individual who did not meet these criteria were not able to complete the survey.

Third, responses that were collected outside of Australia (potentially indicating an individual did not actually meet the selection criteria of being a Victorian licensed driver) were also removed by *Qualtrics*. Whilst it is possible that some individuals could have completed the survey while on a work or holiday trip, there was also a risk that an individual had given false information in the screening questions, and thus it was decided to exclude them and replace them with another respondent.

Fourth, to ensure a representative sample of licensed drivers were captured in the survey, *Qualtrics* set up quotas for age and gender. Quotas meant that a set number of responses from individuals with a particular characteristic were sought, and once the desired number of responses were received from individuals who fell within the group, the survey ceased to be available to others with the same characteristics. This ensured the sample of drivers was not heavily weighted to specific age and genders, but was rather diverse and included males and females from all age categories.

8.5.5 The final data set

Following completion of data collection, the data file was downloaded into SPSS Version 25 (IBM Corp, 2017). Whilst as outlined above, *Qualtrics* had in place rigorous quality control, further data checking and cleaning was undertaken, to ensure completeness of the data set and that all items were coded correctly. A total of 5,108 responses were included in the final data set.

To obtain descriptive statistics, which are reported in the following chapter, the data set was exported to the data analysis program, SAS[®] Version 9.4 (SAS Software, 2014). Finally, the data set was then exported to MPlus Version 8.4 (Muthén & Muthén, 1998-2017) to conduct the analyses where the pathways in the conceptual model were examined. Further details about these statistical analyses are included in chapter ten.

8.6 Conclusion

This chapter has provided a range of information relevant to study three of this PhD. First, the survey items were described. Second, justification for the use of an online survey was provided, before finally providing the details of the data collection process, including participant recruitment and eligibility criteria. The results for study three are contained in the following two chapters. Further conclusions about this study are therefore provided following presentation of the results.

Chapter Nine: Examination of driver characteristics, perceptions and expectations relating to driving behaviour

9.1 Introduction

The following chapter provides the results of a descriptive analysis for a range of variables on which data were collected in the survey designed for study three of this PhD. The aim of this chapter is to provide an overview of the characteristics of the group of drivers who responded to the survey, prior to reporting on the results of the mediated regression modelling in chapter ten.

This chapter is divided into a number of sections. These include an examination of the demographic characteristics of the drivers who responded to the survey (Section 9.2); personality profile in relation to the Big Five Personality factors (Section 9.3); perceptions towards the potentially deterring factors (section 9.4); previous performance of illegal driving behaviours and sanctions received (Section 9.5); expectations to perform illegal driving behaviours in the following twelve months (Section 9.6); previous crash involvement (Section 9.7); licence type and experience of being unlicensed (Section 9.8); alcohol use and illicit drug use (Section 9.9). Where relevant, comparisons are drawn with statistics on demographic indicators from the broader population. Ideally, all comparisons would be drawn with the Victorian driver population, to examine the extent to which the sample of drivers in this study were representative of Victorian licence holders. Unfortunately, data that would enable these comparisons were generally not available. Despite this, the relatively large sample size from a broad spectrum of the Victorian driver population, including both males and females, aged from 18-90 years and from both metropolitan Melbourne and regional Victoria means we can have some confidence that drivers come from a wide spectrum of the Victorian driver population.

9.2 Demographic characteristics

A total of 5,108 drivers completed the online survey. All of these drivers met the study criteria of being residents of Victoria, Australia and holders of a Victorian driver's licence that enabled them to drive a car. Just over two-thirds (69.2%, n=3536) of the drivers reported that they live in the Melbourne metropolitan region, whilst 29.1% (n= 1484)

reported living in a Victorian regional area. The mean age of drivers in the study sample was 46.1 years (SD=17.5). Males had a slightly older mean age of 49.6 (SD=17.6) compared to females (M=43.1, SD=16.9).

Table 9.1 provides an age and gender breakdown of study participants. There was a slightly higher number of females who responded to the study (n=2682, 52.5%) compared to males (n=2410, 47.2%). Table 9.1 also provides the age and gender breakdown for the Victorian driver population in 2018, for comparison. In the Victorian driver population, 49.3% of drivers were female and 50.7% of drivers were male (Bureau of Infrastructure, Transport and Regional Economics, 2019). Thus, in the study sample, females were slightly overrepresented, and males slightly underrepresented.

In terms of age, the highest proportions of drivers in the study sample were in the 30-39 year-old age group (n=1021, 20.0%) and the 60-69 year-old age group (n=876, 17.2). As would be expected, given driving involvement amongst older people declines (e.g. Gallo, Rebok & Lesikar, 1999; Hakamies-Blomqvist & Wahlstrom, 1998; Musselwhite & Shergold, 2013), the smallest proportion of drivers were in the 80+ age category (n=61, 1.2%). When comparing the age breakdown in the study sample with the wider Victorian driver population, both similarities and differences emerged. Like in the current study, the largest proportion of drivers in the Victorian driver population were aged 30-39 (19.9%). The smallest proportion were also aged 80+, however, the proportion in the driver population (3.2%) was actually larger than that observed in the study sample. It is possible that the online method of data collection used in the research potentially led to a lower proportion of older drivers accessing the survey (Table 9.1).

Table 9.1 also enables an examination of the age breakdown by gender. In the 18-19, 20-24, 25-29, 30-39, 40-49 and 50-59 year age groups, the proportion of females who responded to the survey was greater than the proportion of males, with females accounting for over two-thirds of respondents in these age groups. This pattern was reversed in the older age groups, where the proportion of males was greater than the proportion of females completing the survey. Indeed, for the group of drivers aged 80+, over 70% who drivers who responded were male. These proportions were however not consistent with the wider Victorian driver population, where across all age groups the proportion of males licensed is greater than females. Furthermore, the proportion of females who completed the survey in

the younger age groups (18-19 and 20-24 in particular) was considerably greater than the proportion they represent in the Victorian driver population. Similarly, the proportion of females who completed the survey in the oldest age group (80+) was considerably lower than the proportion of female drivers in this age group in the Victorian driver population (Table 9.1).

The age and gender breakdown in the current study nonetheless still reflected the driving population in general, where females were historically less likely to obtain a drivers licence than males (e.g. Dowling, 2000; Parkin, 2017), in addition to older females being more likely to cease driving than their male counterparts (e.g. Anstey et al. 2006; Ross et al. 2009), even when they have a level of health that means they may still be fit to drive (e.g. Forrest et al. 1997; Siren, Hakamies-Blomqvist & Lindeman, 2004).

Table 9.1 Age and gender of survey participants in comparison to the Victorian licensed driver population

	Male			Female			Total		
Age Group	n	% of age group	Vic % of age group ^a	n	% of age group	Vic % of age group ^a	n	% of sample	Vic % of population ^a
18-19 ^b	47	30.9	50.3	105	69.1	49.7	152	3.0	4.8
20-24	158	30.9	51.4	354	69.1	48.6	512	10.1	7.8
25-29	188	41.3	50.7	267	58.7	49.3	455	8.9	9.3
30-39	452	44.3	50.6	569	55.7	49.4	1021	20.0	19.9
40-49	323	43.9	50.1	413	56.1	49.2	736	14.5	17.9
50-59	382	48.7	50.3	402	51.3	49.7	784	15.4	16.2
60-69	499	57.0	50.3	377	43.0	49.7	876	17.2	13.0
70-79	319	64.2	52.0	178	35.8	48.0	497	9.8	8.0
80+	43	70.5	54.3	18	29.5	45.7	61	1.2	3.2
Total	2411	47.2	50.7	2683	52.5	49.3	5094	100.00	100.00

a Victorian licensing data obtained from Bureau of Infrastructure, Transport and Regional Economics (BITRE) (2019) – Data are for 2018

b The comparison data also included drivers aged below 18 (16 and 17 year-olds)

In terms of current educational involvement, 908 (17.8%) respondents reported that they were engaged in study, either full-time (n=548, 10.7% of total sample) or part time (n=360, 7.1% of total sample). Survey participants were also asked about their employment status. The majority of the sample were engaged in some form of employment, either full-time (n=2032, 39.8%), or part-time/causal (n=1223, 23.9%). There was also a relatively high

number of retired people who participated in the survey, representing almost one fifth of the study sample (n=979, 19.2%) (Table 9.2). It is notable that of the 343 people that identified being unemployed, 137 (39.9%) identified they were engaged in study, either full-time (n=104) or part-time (n=33).

Considering these results provided above in comparison to the broader Australian population requires looking at the data by age. ABS data show that 80 per cent of people aged 15-64 years were engaged in some form of work or study in 2020 (Australian Bureau of Statistics, 2020b). When considering the 4070 people in the sample who fall into this age group (18-64 years, given the legal licensing age in Victoria), 78 per cent were engaged in some work or study. In terms of retirement, ABS data in 2020 show that amongst people aged 65-69 years, 64 per cent are retired, while amongst those aged 70 years and over, 86 per cent are retired (Australian Bureau of Statistics, 2020c). When these specific age groups were considered in the current study sample, results were relatively consistent. In the current study, of the 480 people aged 65-69 years, 308 (64.2%) were retired, while of the 558 people aged 70 years and older, 472 (84.6%) were retired. These results thus indicate the sample was, for the most part, indicative of the population more broadly in terms of current employment status.

Respondents were also asked to indicate the highest level of education they had achieved. Over two fifths (n=2162, 42.3%) of drivers indicated that they had completed a university qualification (Table 9.3). The sample completing the survey in the current study had a relatively higher level of education, when compared to the broader Australian community. In the most recent Australian census data, collected in 2016, 24.3 per cent of Australians reported they held a Bachelor degree and above (Australian Bureau of Statistics, 2017).

Table 9.2 Employment status of survey participants

Current employment status	n	%
Unemployed	343	6.7
Employed full-time	2032	39.8
Employed part-time or casual	1223	23.9
Home duties	346	6.8
Retired	979	19.2
Disability pension	117	2.3
Other	42	0.8
Do not wish to respond	26	0.5

Table 9.3 Highest level of education achieved amongst survey participants

Level of education achieved	n	%
Did not complete school (Left before Year 12/Form 6)	593	11.6
Completed High School (Completed Year 12/Form 6)	982	19.2
Completed an Apprenticeship/TAFE/Technical College	1241	24.3
Completed a University degree (Bachelor/Graduate/Post-Graduate)	2162	42.3
Other	102	2.0
Do not wish to respond	28	0.6

9.3 Personality profile

Table 9.4 provides the mean and standard deviation for each of the five personality indicators measured using the Big Five Inventory (BFI) (John & Naumann, 2008; John & Srivastava, 1999). As was discussed in chapter eight, the BFI collects data on extraversion, agreeableness, conscientiousness, neuroticism and openness personality traits (John & Naumann, 2008; John & Srivastava, 1999). Responses are collected on a five-point scale, with higher scores indicating a stronger display of the personality trait in question (John & Naumann, 2008; John & Srivastava, 1999). Mean scores on the personality scale were highest for agreeableness ($M=3.80$, $SD=0.63$) and conscientiousness ($M=3.76$, $SD=0.65$). The lowest mean score was for neuroticism ($M=2.81$, $SD=0.79$) (Table 9.4). Unfortunately, there are no widely accepted norms for the Big Five Inventory to which these results can be compared. It is also not possible to compare how these results compare to the wider Australian population or indeed the Victorian driver population.

Table 9.4 Mean scores on Big-Five personality indicators

Personality indicator	Mean	Standard Deviation
Extraversion	3.05	0.72
Agreeableness	3.80	0.63
Conscientiousness	3.76	0.65
Neuroticism	2.81	0.79
Openness	3.38	0.56

9.4 Perceptions towards potential deterrents of illegal driving behaviour

9.4.1 Perceptions towards enforcement

Table 9.5 provides the results from the first measure of perceptions towards enforcement, this being whether drivers feel they would be worried they would get caught if they were to perform a specified illegal driving behaviour. Across all offence types, only a small number of drivers responded that they 'strongly disagreed', 'disagreed' or 'somewhat disagreed' they would be worried they would be caught if they performed a specified driving behaviour, ranging from 2.7 per cent (n=133) for driving with an illegal BAC to 5.7 per cent (n=290) for driving at up to 10km/h above the speed limit. Comparatively, across all offence types, the highest proportions of drivers responded they 'strongly agreed' they would worry they would be caught if they performed a specified driving behaviour. Drivers reported being most worried about being caught for driving after using an illicit drug (n=3550, 69.5%) and driving with an illegal BAC (n=3538, 69.3%), with driving at up to 10km/h above the speed limit the behaviour that drivers were least likely to report they 'strongly agreed' they would be worried they would get caught (n=2122, 41.5%) (Table 9.5).

Table 9.6 provides the results for the second measure that was used to examine perceptions towards enforcement, this being whether drivers feel a sanction for a specified driving offence would have a significant negative impact on their life. In relation to driving with a BAC over the legal limit and driving after using an illicit drug/s, drivers were asked the impact that loss of their licence for these offences would have on their life. 71 per cent (n=3625) 'strongly agreed' loss of licence for driving after using an illegal drug/s would have a significant negative impact on their life. This was slightly higher than the 68 per cent of respondents (n=3474) who 'strongly agreed' that loss of their licence for driving with an illegal BAC would have a significant negative impact on their life. For the remaining four behaviours (speeding up to 10km/h above the speed limit, speeding at more than 10km/h above the speed limit, using a handheld mobile phone whilst driving and driving through a red light), drivers were asked how much they agree a fine or demerit points would have a negative impact on their lives. Around one third of drivers reported that they 'strongly agreed' a fine or demerit points would have a negative impact on their life for each of the four offence types (speeding up to 10km/h, n= 1484, 29.1%; speeding more than 10km/h

above the speed limit, n=1653, 32.4%; using a handheld mobile phone whilst driving, n=1734, 34%; and driving through a red light, n=1704, 33.4%) (Table 9.6).

9.4.2 Perceptions towards crash risk

Table 9.7 provides the results of the first measure of perceived crash risk, this being whether drivers feel they would be worried about having a crash if they were to perform a specified driving behaviour. Drivers were most likely to 'strongly agree' they would be worried they could have a crash if they were to drive after using an illicit drug/s (n=3707, 72.6%) and drive with a BAC above the legal limit (n=3652, 71.5%). Comparatively, speeding offences were perceived as having the lowest level of crash risk. Only one third of drivers reported that they 'strongly agreed' they would worry they could have a crash if they were to drive at up to 10km/h above the speed limit (Table 9.7).

Table 9.8 provides the results of the second measure of perceived crash risk, this being whether drivers feel they would be worried about injuring themselves or others if they were to perform a specified driving behaviour. Responses on this measure were consistent with responses on the previous measure of crash risk. Drivers were most likely to 'strongly agree' they would be worried they could injure themselves or someone else if they were to drive after using an illicit drug/s (n=3807, 74.5%) or drive with an illegal BAC (n=3802, 74.4%). Once again, drivers were least likely to 'strongly agree' that they would be worried about injuring themselves or someone else if they were to drive up to 10km/h above the speed limit (n=2066, 40.5%). This was followed by speeding at more than 10km/h above the speed limit, with just over half of drivers (n=2694, 52.7%) reporting they 'strongly agree' they would be worried about injuring themselves or someone else if they were to perform the behaviour (Table 9.8).

Table 9.5 Perceptions towards certainty of legal sanctions for illegal driving behaviours amongst survey participants

Worry about getting caught	Strongly Agree		Agree		Somewhat Agree		Neither Agree nor Disagree		Somewhat Disagree		Disagree		Strongly Disagree		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drive with an illegal BAC	3538	69.3	944	18.5	291	5.7	170	3.3	30	0.6	34	0.7	69	1.4	32	0.6
Drive after using illicit drug/s	3550	69.5	870	17.0	296	5.8	183	3.6	40	0.8	43	0.8	83	1.6	43	0.8
Drive at up to 10km/h above the speed limit	2122	41.5	1467	28.7	907	17.8	306	6.0	146	2.9	87	1.7	57	1.1	16	0.3
Drive at more than 10km/h above the speed limit	2852	55.8	1320	25.9	555	10.9	180	3.5	83	1.6	58	1.1	44	0.9	16	0.3
Using a handheld phone whilst driving	2645	51.8	1311	25.7	626	12.3	250	4.9	117	2.3	73	1.4	66	1.3	20	0.4
Driving through a red light	3062	60.0	1232	24.1	458	9.0	195	3.8	64	1.3	40	0.8	42	0.8	15	0.3

Table 9.6 Perceptions towards severity of legal sanctions for illegal driving behaviours amongst survey participants

Worry about sanction having a significant negative impact on life	Strongly Agree		Agree		Somewhat Agree		Neither Agree nor Disagree		Somewhat Disagree		Disagree		Strongly Disagree		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drive with an illegal BAC	3474	68.0	929	18.2	350	6.9	200	3.9	50	1.0	45	0.9	45	0.9	15	0.3
Drive after using illicit drug/s	3625	71.0	835	16.4	306	6.0	191	3.7	40	0.8	33	0.7	54	1.1	24	0.5
Drive at up to 10km/h above the speed limit	1484	29.1	1282	25.1	1139	22.3	523	10.2	317	6.2	263	4.9	98	1.9	12	0.2
Drive at more than 10km/h above the speed limit	1653	32.4	1454	28.5	963	18.9	485	9.5	260	5.1	196	3.8	86	1.7	11	0.2
Using a handheld phone whilst driving	1738	34.0	1431	28.0	936	18.3	446	8.7	248	4.9	202	4.0	89	1.7	18	0.4
Driving through a red light	1704	33.4	1433	28.1	961	18.8	459	9.0	275	5.4	182	3.6	80	1.6	14	0.3

Table 9.7 Perceptions on the degree to which survey participants believe they would experience worry about being involved in a crash if they were to perform an illegal driving behaviour

	Strongly Agree		Agree		Somewhat Agree		Neither Agree nor Disagree		Somewhat Disagree		Disagree		Strongly Disagree		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drove with an illegal BAC	3652	71.5	831	16.3	254	5.0	178	3.5	55	1.1	47	0.9	66	1.3	25	0.5
Drove after using an illicit drug/s	3707	72.6	763	14.9	239	4.7	173	3.4	74	1.5	60	1.2	60	1.2	32	0.6
Drove at up to 10km/h above the speed limit	1684	33.0	1078	21.1	903	17.7	566	11.1	389	7.6	304	6.0	162	3.2	22	0.4
Drove at more than 10km/h above the speed limit	2358	46.2	1168	22.9	725	14.2	404	7.9	187	3.7	147	2.9	93	1.8	26	0.5
Used a handheld mobile phone whilst driving	2917	57.1	1113	21.8	546	10.7	247	4.8	115	2.3	78	1.5	68	1.3	24	0.5
Drove through a red light	3181	62.3	1030	20.2	427	8.4	220	4.3	89	1.7	77	1.5	61	1.2	23	0.5

Table 9.8 Perceptions on the degree to which survey participants believe they would experience worry about injuring themselves or someone else if they were to perform an illegal driving behaviour

	Strongly Agree		Agree		Somewhat Agree		Neither Agree nor Disagree		Somewhat Disagree		Disagree		Strongly Disagree		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drove with an illegal BAC	3802	74.4	744	14.6	222	4.4	172	3.4	53	1.0	42	0.8	52	1.0	21	0.4
Drove after using an illicit drug/s	3807	74.5	702	13.7	243	4.8	161	3.2	67	1.3	40	0.8	60	1.2	28	0.6
Drove at up to 10km/h above the speed limit	2066	40.5	1125	22.0	810	15.9	467	9.1	291	5.7	196	3.8	130	2.6	23	0.5
Drove at more than 10km/h above the speed limit	2694	52.7	1119	21.9	588	11.5	332	6.5	155	3.0	120	2.4	79	1.6	21	0.4
Used a handheld mobile phone whilst driving	3137	61.4	1017	19.9	467	9.1	239	4.7	98	1.9	64	1.3	65	1.3	21	0.4
Drove through a red light	3373	66.0	963	18.9	361	7.1	183	3.6	79	1.6	75	1.5	57	1.1	17	0.3

9.4.3 Perceptions of social norms and disapproval

Table 9.9 provides results of the first measure of social norms and disapproval, this being the degree to which drivers feel performance of the specified driving behaviours is wrong. In each of the offence types examined, with the exception of speeding at up to 10km/h above the speed limit, the majority of drivers reported that they perceived the behaviour as 'always wrong to do it'. The highest proportions of drivers reporting that the behaviours were 'always wrong' were for driving after using an illicit drug/s (n=4367, 85.5%) and driving with an illegal BAC (n=4337, 84.9%). Conversely, less than half (n=2172, 42.5%) of respondents felt it was 'always wrong' to drive at up to 10km/h above the speed limit. Interestingly, when looking at drivers who perceived the behaviours as 'never wrong' the highest proportions were once again observed for driving with an illegal BAC (n=221, 4.3%) and driving after using an illicit drug (n=201, 3.9%). This potentially suggests that with these two offences, there is less variance in how people perceive them, with higher proportions either seeing them as either acceptable or unacceptable types of behaviour when compared to other offence types where responses were more mixed (Table 9.9).

Table 9.10 provides the results of the second measure of social norms and disapproval, this being drivers' perceptions of how they believe those who are closest to them would respond if they were to perform the specified driving behaviours. Across all offence types, only a very small number of drivers noted that they believe those closest to them would 'somewhat approve', 'approve' or 'strongly approve', with the lowest being for driving with a BAC above the legal limit (n=199, 3.9%). Comparatively, whilst only 30.4% (n=1551) perceived that those closest to them would 'strongly disapprove' if they were to drive at up to 10km/h above the speed limit, 77.1% (n=3940) of drivers perceived those closed to them would 'strongly disapprove' if they were to drive after using an illicit drug/s (Table 9.10).

9.4.4 Perceptions of negative personal/emotional effect

Table 9.11 provides the results of the first measure of negative personal/emotional effect, this being drivers' perceptions of whether they would experience shame if they were to perform each of the illegal driving behaviours. Drivers were most likely to report that they 'strongly agree' they would experience shame in relation to driving after using an illicit drug/s (n=3380, 66.2%) and driving with an illegal BAC (n=3075, 60.2%). Comparatively, drivers were least likely to report that they 'strongly agree' they would experience shame if

they were to drive at up to 10km/h above the speed limit (n=1167, 22.9%) followed by just over a third (n=1727, 33.8) in relation to driving at more than 10km/h above the speed limit (Table 9.11).

Table 9.12 provides the results of the second measure of negative personal/emotional effect, this being drivers' perceptions of whether they would experience guilt if they were to perform each of the illegal driving behaviours. As in the case of shame, drivers were most likely to report that they 'strongly agree' they would experience guilt if they were to drive after using an illicit drug/s (n=3484, 68.2%). Similarly, following the same pattern as that observed in relation to shame, drivers were least likely to report that they 'strongly agree' they would experience guilt if they were to perform a speeding offence. In terms of driving at up to 10km/h above the speed limit, less than one third of drivers (n=1485, 29.1%) reported they 'strongly agree' they believe they would experience guilt if they were to perform the behaviour, whilst in relation to driving at more than 10km/h above the speed limit, 41 per cent reported they 'strongly agreed' they would experience guilt if they were to perform the behaviour (Table 9.12).

Table 9.9 Degree to which survey participants perceive illegal driving behaviours as wrong

	Never wrong to do it		Rarely wrong to do it		Sometimes wrong to do it		Usually wrong to do it		Always wrong to do it		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%
Driving with an illegal BAC	221	4.3	116	2.3	141	2.8	260	5.1	4337	84.9	33	0.7
Driving after using an illicit drug/s	201	3.9	98	1.9	174	3.4	239	4.7	4367	85.5	29	0.6
Driving at up to 10km/h above the speed limit	119	2.3	268	5.3	819	16.0	1706	33.4	2172	42.5	24	0.5
Driving at more than 10km/h above the speed limit	146	2.9	162	3.2	374	7.3	1119	21.9	3281	64.2	26	0.5
Using a handheld mobile phone whilst driving	155	3.0	127	2.5	281	5.5	711	13.9	3800	74.4	34	0.7
Driving through a red light	156	3.1	118	2.3	208	4.1	664	13.0	3924	76.8	38	0.7

Table 9.10 Perceptions of how survey participants believe those who mean the most to them would respond if they were to perform an illegal driving behaviour

	Strongly Disapprove		Disapprove		Somewhat Disapprove		Neither approve nor disapprove		Somewhat Approve		Approve		Strongly Approve		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drove with an illegal BAC	3652	71.5	810	15.9	231	4.5	193	3.8	65	1.3	57	1.1	77	1.5	23	0.5
Drove after using an illicit drug/s	3940	77.1	558	10.9	170	3.3	190	3.7	75	1.5	88	1.7	63	1.2	24	0.5
Drove at up to 10km/h above the speed limit	1551	30.4	1195	23.4	1052	20.6	1005	19.7	127	2.5	94	1.8	64	1.3	20	0.4
Drove at more than 10km/h above the speed limit	2265	44.3	1370	26.8	728	14.3	490	9.6	90	1.8	87	1.7	55	1.1	23	0.5
Used a handheld mobile phone whilst driving	2709	53.0	1161	22.7	577	11.3	373	7.3	113	2.2	92	1.8	60	1.2	23	0.5
Drove through a red light	2990	58.5	1126	22.0	425	8.3	280	5.5	91	1.8	105	2.1	72	1.4	19	0.4

Table 9.11 Perceptions on the degree to which survey participants believe they would experience shame if they were to perform an illegal driving behaviour

	Strongly Agree		Agree		Somewhat Agree		Neither Agree nor Disagree		Somewhat Disagree		Disagree		Strongly Disagree		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drove with an illegal BAC	3075	60.2	1077	21.1	411	8.1	249	4.9	85	1.7	66	1.3	126	2.5	19	0.4
Drove after using an illicit drug/s	3380	66.2	893	17.5	314	6.2	220	4.3	67	1.3	78	1.5	133	2.6	23	0.5
Drove at up to 10km/h above the speed limit	1167	22.9	1100	21.5	1176	23.0	695	13.6	413	8.1	333	6.5	208	4.1	16	0.3
Drove at more than 10km/h above the speed limit	1727	33.8	1367	26.8	907	17.8	480	9.4	246	4.8	209	4.1	154	3.0	18	0.4
Used a handheld mobile phone whilst driving	2125	41.6	1297	25.4	765	15.0	420	8.2	210	4.1	133	2.6	139	2.7	19	0.4
Drove through a red light	2308	45.2	1353	26.5	665	13.0	377	7.4	148	2.9	117	2.3	121	2.4	19	0.4

Table 9.12 Perceptions on the degree to which survey participants believe they would experience guilt if they were to perform an illegal driving behaviour

	Strongly Agree		Agree		Somewhat Agree		Neither Agree nor Disagree		Somewhat Disagree		Disagree		Strongly Disagree		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drove with an illegal BAC	3320	65.0	974	19.1	366	7.2	204	4.0	58	1.1	67	1.3	96	1.9	23	0.5
Drove after using an illicit drug/s	3484	68.2	847	16.1	313	6.1	201	3.9	56	1.1	75	1.5	99	1.9	33	0.7
Drove at up to 10km/h above the speed limit	1485	29.1	1229	24.1	1057	20.7	542	10.6	331	6.5	254	5.0	188	3.7	22	0.4
Drove at more than 10km/h above the speed limit	2096	41.0	1323	25.9	779	15.3	407	8.0	185	3.6	168	3.3	127	2.5	23	0.5
Used a handheld mobile phone whilst driving	2448	47.9	1251	24.5	647	12.7	346	6.8	162	3.2	110	2.2	119	2.3	25	0.5
Drove through a red light	2622	51.3	1256	24.6	591	11.6	302	5.9	115	2.3	96	1.9	105	2.1	21	0.4

9.5 History of illegal driving behaviour and sanctions received

Drivers were asked to indicate both how regularly they had performed the six driving behaviours of interest in the last twelve months, as well as the number of times they had been apprehended by police or captured by a road safety camera in the last twelve months for these driving behaviours. Less than one quarter (n=1151, 22.5%) of drivers responded that in the last twelve months, they had 'never' performed any of these behaviours. Comparatively, over three quarters (n=4155, 81.3%) of drivers responded that they had 'never' been caught by police or a road safety camera in the last twelve months. This means that while a relatively high number of drivers reported having performed a driving offence on at least one occasion, the number of drivers who were actually caught was much lower. Notably, of the drivers who reported they had performed a driving offence at least once in the last twelve months (n=3957), only 912 (23.1%) reported they had been caught. Also of significance, was a small number of drivers (n=41) who reported they had 'never' performed a traffic offence in the last twelve months, but who also reported having being apprehended by police or a road safety camera in the same time period. There are two possible explanations for this result. Respondents may have misread a question, therefore providing an incorrect response, or alternatively, and perhaps more likely, may, despite performing illegal driving behaviours, fail to recognise their actions or alternatively are not willing to accept that they did violate a traffic rule.

Table 9.13 provides information on the performance of each of the six driving behaviours, including how regularly drivers indicated they had performed each individual behaviour. As could be expected, the more 'serious' offences such as drink driving and drug driving had the highest proportions of drivers reporting they had 'never' performed the behaviour in the twelve months prior, with 4178 (81.8%) and 4592 (90.0%) respectively. For all offence types, only a very small number reported that they performed the behaviour 'every trip' in the last twelve months, with the highest proportion observed being for speeding up to 10km/h above the speed limit (n=97, 1.9%). 29.2% of drivers (n=1490) reported that they 'occasionally' or on 'some trips' speed at up to 10km/h above the speed limit. The use of mobile phones whilst driving was reported by almost 40 per cent of drivers (n=1898). Whilst the majority of drivers who did report having used a mobile phone whilst driving in the last twelve months had only done so 'rarely' (n=1048, 55% of mobile phone users), it was

concerning that 278 drivers reported to have used a mobile phone on 'most trips' or 'every trip'. Also, of concern, was that almost 20 per cent of drivers reported to have driven at some time in the last twelve months when they suspected they had a BAC above the legal limit (Table 9.13).

Table 9.14 provides information on the experience of being caught by police or a road safety camera in the last twelve months, for each of the six offence types examined in the survey. Lower level speeding (speeding up to 10km/h above the speed limit) was the most common offence type that drivers had been caught performing, with 13.2 per cent (n=668) drivers having being caught at least once in the last twelve months. This was followed by speeding 10km/h or more above the speed limit, as the second most common offence type drivers reported being apprehended for in the last twelve months (n=436, 8.5%). It is notable that despite 1898 (37.2%) of drivers reporting to have used a mobile phone whilst driving in the twelve months prior, the rates of apprehension for this offence was consistent with those for drink driving and driving after using illicit drugs, which were reported by drivers as being far less common offences to perform (Table 9.14).

9.6 Expectations of illegal driving behaviour in the next twelve months

In addition to capturing information on previous performances of illegal driving behaviours and apprehension for illegal driving behaviours, drivers were also asked to indicate the likelihood of them performing an illegal driving behaviour in the twelve months that followed. Table 9.15 shows that the majority of drivers indicated that it was 'extremely unlikely' that they would drink drive (n=4241, 83.0%) or drive after using illicit drugs (n=4467, 87.5%). In comparison, much smaller numbers of drivers indicated that they were 'extremely unlikely' to speed at up to 10km/h above the speed limit (n=1150, 30.3%) and speed at more than 10km/h above the speed limit (n=2615, 51.2%). Whilst in general the number of drivers who indicated that they were 'extremely likely' or 'moderately likely' to perform the illegal driving behaviours in the next twelve months was low, it is still notable that almost 1 in 5 drivers provided these responses in relation to speeding up to 10km/h (n=961, 18.8%) (Table 9.15).

Table 9.13 Survey participants performance of illegal driving behaviours in the last 12 months

	Every Trip		Most Trips		Occasionally/ Some Trips		Rarely		Never		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%
Driven with an illegal BAC	68	1.3	105	2.1	188	3.7	547	10.7	4178	81.8	22	0.4
Driven after using an illicit drug/s	68	1.3	130	2.6	151	3.0	138	2.7	4592	90.0	29	0.6
Driven at up to 10km/h above the speed limit	97	1.9	391	7.7	1490	29.2	1659	32.5	1455	28.5	17	0.3
Driven at more than 10km/h above the speed limit	80	1.6	142	2.8	633	12.4	1484	29.1	2752	53.9	17	0.3
Used a handheld mobile phone whilst driving	81	1.6	197	3.9	572	11.2	1048	20.5	3192	62.5	18	0.4
Driven through a red light	64	1.3	96	1.9	207	4.1	831	16.3	3894	76.2	16	0.3

Table 9.14 Survey participants experience of being apprehended (by police or a road safety camera) for illegal driving behaviours in the last 12 months

	Never		Once		Twice		Three times		Four or more times		Do not wish to respond	
Offence	n	%	n	%	n	%	n	%	n	%	n	%
Driving with an illegal BAC	4810	94.2	109	2.1	92	1.8	52	1.0	22	0.4	23	0.5
Driving after using an illicit drug/s	4835	94.7	91	1.8	87	1.7	44	0.9	28	0.6	23	0.5
Driving at up to 10km/h above the speed limit	4417	86.5	431	8.5	125	2.5	75	1.5	37	0.7	23	0.5
Driving at more than 10km/h above the speed limit	4651	91.1	255	5.0	100	2.0	43	0.8	38	0.7	21	0.4
Using a handheld mobile phone whilst driving	4799	94.0	113	2.2	79	1.6	66	1.3	31	0.6	20	0.4
Driving through a red light	4729	92.6	204	4.0	74	1.5	50	1.0	28	0.6	23	0.5

Table 9.15 Survey participants expectations of performing illegal driving behaviours in the following 12 months

Offence	Extremely Likely		Moderately Likely		Slightly Likely		Neither likely nor unlikely		Slightly Unlikely		Moderately Unlikely		Extremely Unlikely		Do not wish to respond	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drive with an illegal BAC	93	1.8	97	1.9	163	3.2	181	3.5	86	1.7	231	4.5	4241	83.0	16	0.3
Drive after using an illicit drug/s	116	2.3	116	2.3	105	2.1	140	2.7	55	1.1	89	1.7	4467	87.5	20	0.4
Drive at up to 10km/h above the speed limit	464	9.1	497	9.7	814	15.9	552	10.8	428	8.4	779	15.3	1150	30.3	24	0.5
Drive at more than 10km/h above the speed limit	189	3.7	240	4.7	470	9.2	403	7.9	431	6.7	830	16.3	2615	51.2	20	0.4
Use a handheld mobile phone whilst driving	208	4.1	203	4.0	374	7.3	323	6.3	300	5.9	558	10.9	3121	61.1	21	0.4
Drive through a red light	95	1.9	109	2.1	222	4.4	315	6.2	250	4.9	768	15.0	3332	65.2	17	0.3

9.7 Experience of crash involvement

Survey respondents were also asked to indicate any crashes they had been involved in whilst driving a motor vehicle (including motorcycle accidents) in the previous three years. 955 (18.7%) drivers indicated that they had been involved in a crash in this time period, with 297 (31.1%) of the crash-involved drivers having been involved in two or more crashes. The drivers who had been involved in a crash were asked to indicate the severity of this crash and also who had been at fault. For those drivers who had been involved in more than one crash in the three years prior, they were asked to answer based on the most serious crash in which they had been involved. The majority of crashes (n=683, 71.5%) only resulted in damage to property or the vehicles involved. Eleven (1.2%) crash-involved drivers did however report that a crash in which they had been involved as a driver resulted in the death of an individual. A further 126 (13.2%) of crash involved drivers noted that medical treatment was required for at least one person involved (Table 9.16).

In terms of fault in the accident which the drivers reported on, only around one quarter (n=247, 25.9%) of the crash-involved drivers reported that they were at fault in the accident. Comparatively, almost half (n=459, 48.1%) reported that another driver was at fault. A further 146 (15.3%) drivers indicated that the accident occurred as a result of both themselves and another driver (Table 9.17).

9.8 Vehicle licence types and experience of being unlicensed

Drivers were asked to indicate the types of vehicles that they are licensed to drive. As would be expected, the majority of drivers are licensed to drive a car only (n=4471, 88.1%) (Table 9.18). Drivers were also asked to indicate whether they had experienced any licence loss in the twelve-month period prior to participating in the study. As can be seen in table 9.19, the overwhelming majority (n=4800, 94.0%) reported that they had not been unlicensed for any reason in the last twelve months. When considering reasons for being unlicensed, licence suspension was the most common reason, with 2.1 per cent (n=105) of the sample indicating they had experienced licence suspension in the last twelve months (Table 9.19).

Table 9.16 Severity of crashes that survey participants had been involved in whilst driving in the last 3 years

Crash Severity	n	%
Accident only resulted in damage to vehicles and/or property	683	71.5
At least one person was injured, but no medical treatment was required	117	12.3
At least one person was injured, requiring a visit to the doctor and/or first aid	64	6.7
At least one person was injured, requiring them to be taken to a hospital emergency department	62	6.5
Someone died	11	1.2
Not sure/Cannot remember	11	1.2
Do not wish to respond	7	0.7

Table 9.17 Fault amongst survey participants involved in crashes in the last 3 years

Fault in accident	n	%
I was at fault	247	25.9
Another driver was at fault	459	48.1
Both myself and another driver were at fault	146	15.3
Nobody was at fault	82	8.6
Not sure/Cannot remember	14	1.5
Do not wish to respond	7	0.7

Table 9.18 Vehicle types survey participants reported being licensed to operate

Vehicle type licensed to operate	n	%
Car	4471	88.1
Car and heavy vehicle	214	4.2
Car and motorcycle	300	5.9
Car, heavy vehicle and motorcycle	93	1.8

Table 9.19 Survey participants experience of licence loss in the last 12 months

Licence status	n	%
Cancelled	44	0.9
Suspended	105	2.1
Disqualified	41	0.8
Void	28	0.6
Expired	52	1.0
Surrendered	16	0.3
Licence not subject to any of the conditions above	4800	94.0
Not sure/Can't remember	69	1.4
Do not wish to respond	48	0.94

9.9 Alcohol and illicit drug use

In relation to alcohol consumption, 79.1 per cent (n=4038) of respondents reported that they consume alcohol. Table 9.20 shows the regularity of alcohol consumption amongst the study sample. Just under half of the sample (n=2470, 48.3) reported they consume alcohol 2-4 times a month or less. Only 12.8 per cent (n=654) of respondents reported to consume alcohol 4 or more times a week (Table 9.20).

Table 9.20 Survey participants regularity of alcohol consumption

Drink alcohol	n	%
Never	1056	20.7
Monthly or less	1412	27.6
2-4 times a month	1058	20.7
2-3 times a week	914	17.9
4 or more times a week	654	12.8
Do not wish to respond	14	0.3

The mean score on the alcohol screen (AUDIT) in the study sample was 5.04 (SD=6.23). The majority of respondents (n= 4028, 78.9%) had a 'low risk' score as indicated by the World Health Organization (WHO) Alcohol Use Disorders Identification Test (AUDIT) (Babor et al., 2001). This included individuals who reported that they do not consume alcohol, or only generally consume alcohol at low levels and did not report any negative consequences of their occasional alcohol consumption. The remaining respondents (21.2%) alcohol consumption patterns indicated some form of intervention may be required. Indeed, 248 (4.9%) drivers had a score on the AUDIT that indicated they are at high risk of alcohol related harm and likely had alcohol dependence (Table 9.21).

These results can be compared to data collected as part of the National Drug Strategy Household Survey (NDSHS). The NDSHS is administered by the Australian Institute of Health and Welfare (AIHW), and collects data from members of the Australian population on patterns of alcohol and drug use. Data are collected in waves, every three years (AIHW, 2020). O'Brien et al. (2020) examined AUDIT data collected in the NDSHS, and found the mean score in 2016 was 4.58, with 22.2 per cent of people reporting alcohol consumption at a level which suggested some intervention may be required. Comparing these results with those collected from the current study sample, it emerged that whilst there was a lower proportion of drivers reporting they were consuming alcohol at a level that may raise

concern, the mean score was higher. This may suggest that amongst those drivers in the current sample consuming alcohol to levels of concern, they were doing so at particularly high-risk levels.

Table 9.21 Survey participants risk level for alcohol consumption based on AUDIT score

Alcohol Screen (AUDIT) score	n	%
Low risk	4028	78.9
Risky or hazardous level	688	13.5
High risk or harmful level	144	2.8
High risk and dependence likely	248	4.9

In terms of illicit drug use, 12 per cent (n=614) of survey respondents reported they had used an illicit drug/s in the last twelve months. Table 9.22 provides data on use of individual drug types, both as a proportion amongst drug users and also as a proportion of the whole study group. Cannabis was the most common drug type respondents reported to have used (n=449, 73.1% of drug users, 8.8% of total study sample). Cocaine was the second most common drug type respondents reported to have used (n=174, 28.3% of drug users, 3.4% of total study sample). Heroin was the least common drug that respondents reported to have used (n=76, 12.4% of drug users, 1.5% of total sample) (Table 9.22).

Table 9.23 shows the regularity of drug use by drug type, amongst those respondents who reported using each specific drug type. Amphetamine/Speed/Methamphetamine/Ice users were most likely to report using the drug four or more times a week (25.7% of users) closely followed by Heroin, with 25 per cent of users reporting to have used the drug four or more times a week. In comparison, Ecstasy users were most likely to report only using the drug monthly or less (62.2%). This was followed by Cocaine (51.2%) and Cannabis (50.3%) users who reported only using the drug monthly or less (Table 9.23).

Table 9.22 Survey participants Illicit drug usage by drug type

Drug type	n	% amongst drug users (n = 614)	% amongst overall study sample (n = 5108)
Cannabis	449	73.1	8.8
Cocaine	174	28.3	3.4
Heroin	76	12.4	1.5
Amphetamines/Speed/Methamphetamine/Ice	140	22.8	2.7
Ecstasy	111	18.1	2.2
Other	32	5.2	0.6

Table 9.23 Survey participants regularity of drug usage by drug type

	Cannabis (n = 449)		Cocaine (n = 174)		Heroin (n = 76)		Amphetamines / Speed / Methamphetamines/ Ice (n = 140)		Ecstasy (n = 111)		Other (n = 32)	
Regularity of use	n	%	n	%	n	%	n	%	n	%	n	%
Monthly or less	226	50.3	89	51.2	17	22.4	48	34.3	69	62.2	20	62.5
2-4 times a month	66	14.7	26	14.9	11	14.5	28	20.0	19	17.1	a	a
2-3 times a week	51	11.4	23	13.2	21	27.6	20	14.3	8	7.2	a	a
4 or more times a week	90	20.0	20	11.5	19	25.0	36	25.7	7	6.3	a	a
Don't know/Can't remember	6	1.3	a	a	a	a	a	a	a	a	a	a
Do not wish to respond	10	2.2	a	a	a	a	a	a	a	a	a	a

a Some cell counts have been suppressed to protect data privacy

9.10 Conclusion

This chapter has provided descriptive results on a range of variables for which data were collected using the online survey developed for study three. Unfortunately, for a number of variables, comparative data were not available. However, where comparative data were available, as can be seen in the demographic section in particular, there are a number of aspects for which the data accurately reflects the patterns that seen in the Australian population more broadly, as well as to some extent the Victorian driver population.

In particular, the results indicated that in the study sample, there were low numbers of drivers in the oldest age group, consistent with the Victorian driver population and the literature that highlights declines in driving participation amongst older people.

Similarly, the proportion of drivers reporting involvement in a program of study were consistent with the proportions across Australia. In terms of employment status, the proportion of drivers who reported engagement with some form of employment, which includes full-time work, part-time work or study were also consistent with proportions in Australia. However, a notable difference did emerge in the sample when compared with the Australian population more broadly, and that relates to the highest level of education that was achieved. The sample of individuals which data were captured from in this study were more highly educated, with a greater proportion having completed an undergraduate, graduate or postgraduate degree.

Despite this difference in education status, the similarities observed in relation to other demographic indicators provide a degree of confidence in the data collected. This is important to consider when thinking about the results in the following chapter, which reports on the results of a mediated regression analysis using these data.

Chapter Ten: Examining the mediating influence that perceptions towards potential deterrents have between personality and driver behaviour

10.1 Introduction

The current chapter is the final chapter that reports on study three of this PhD. Using the data set described in chapters eight and nine, this chapter focuses on the most common type of offence that drivers expect to perform in the following twelve months (as identified in the survey), this being driving at up to 10km/h above the speed limit. Low-level speeding was also selected given it accounts for the majority (around 79%) of crashes that result from speeding on Victorian roads (Alavi et al., 2014). Given the prevalence of this behaviour and its contribution to crashes, a detailed examination of the factors underlying its performance has the potential to provide valuable information towards achieving deterrence, and subsequently, improved safety on the roads. The higher number of drivers reporting this behaviour also ensured the analysis had adequate power.

10.2 Research Aims and Questions

The conceptual model (refer to Chapter 3) developed for study three proposed relationships that the Big Five personality traits (extraversion, agreeableness, conscientiousness, neuroticism and openness) have with perceptions towards potential deterrents (enforcement, crash risk, social norms and disapproval and negative personal/emotional affect), and subsequently expectations to perform illegal driving behaviours in the following twelve months. The results in this chapter examine four key research questions:

- 1) Does personality have an influence on expectations to drive at up to 10km/h above the speed limit in the following twelve months?
- 2) Does personality have an influence on perceptions towards potential deterrents in relation to driving at up to 10km/h above the speed limit?
- 3) Are there factors beyond legal sanctions that may influence expectations drive at up to 10km/h above the speed limit in the following twelve months?

- 4) Do perceptions towards potential deterrents have a mediating influence on the relationship between personality and expectations to speed in the following twelve months?

10.3 Methods

Prior to examining mediated pathways in the model, a series of preliminary analyses were undertaken. First, descriptive statistics were obtained for all variables. Second, the relationships between each of the variables included in the model were examined. To examine these relationships, correlations and bivariate regression were used. In order to examine the relationship between personality and expectations to drive at up to 10km/h in the following twelve months, and whether perceptions towards potential deterrents played a mediating role in this relationship, a mediated regression analysis was undertaken.

A mediator variable is a variable that sits in a chain of relationships (Baron & Kenny, 1986; Gonzalez & MacKinnon, 2020; MacKinnon, Kisbu-Sakarya & Gottschall, 2013; MacKinnon et al., 2002; MacKinnon, Fairchild & Fritz, 2007; Tate, 2015). The predictor variable (independent variable) may have an effect on a mediator variable, which may then go on to have an effect on an outcome variable (dependent variable) (Baron & Kenny, 1986; Gonzalez & MacKinnon, 2020; MacKinnon, Kisbu-Sakarya & Gottschall, 2013; MacKinnon et al., 2002; MacKinnon, Fairchild & Fritz, 2007; Tate, 2015). Mediation can be complete or partial, or alternatively, there may be no mediating effect at all.

Figure 10.1 shows how mediation was considered in the current study. The predictor variable was personality (X). Personality was regressed on the mediator variable, which was perceptions towards potential deterrents (M). Perceptions towards potential deterrents was then regressed on the outcome variable, which was expectations to speed (Y). The current study took the four-step approach for assessing mediation proposed by Baron and Kenny (1986), which involved the following steps:

- 1) The bivariate relationship between X (personality) and Y (expectations to speed) was first examined. This is indicated by path c in figure 10.1. This addressed research question one in the current study.

- 2) The relationship between X (personality) and M (perceptions towards potential deterrents) was examined. This is indicated by path a in figure 10.1. This addressed research question two.
- 3) The relationship between M (perceptions towards potential deterrents) and Y (expectations to speed) was examined. This is indicated by path b in figure 10.1. This addressed research question three.
- 4) The relationship that both X (personality) and M (perceptions of potential deterrents) have towards Y (expectations to speed) was examined. This is the mediated analysis and addressed research question four.

Mediated regression models were run separately for each personality trait across each of the four perceptions towards the potentially deterring factors. Thus, with five different personality traits and four different perceptions, there were 20 separate mediated models in total.

In each of the mediated regression models, three different effects were estimated – the direct, indirect and total effects. The direct effect, as the name suggests, is the direct relationship between the predictor variable and the outcome variable, where the value of the mediating variable is held constant between cases (Hayes, 2013). For example, in the model that examines the mediating influence of perceptions of crash risk between agreeableness and expectations to speed at up to 10km/h above the speed limit, the direct effect assumes that all cases have the same value on perceptions of crash risk. A positive direct effect means that individuals who score higher on the personality trait under examination report greater expectations of speeding at up to 10km/h in the twelve months that followed. Conversely, a negative direct effect means that individuals more strongly displaying the personality trait under examination reported lower expectations of speeding at up to 10km/h in the twelve months that followed. In Figure 10.1, the direct effect is indicated by path c'.

The indirect effect is the relationship between the predictor variable and the outcome variable, when values differ on the mediating variable (Hayes, 2013). For example, in the model that examines the mediating influence of perceptions of enforcement, between agreeableness and expectations of enforcement and expectations to speed at up to 10km/h above the speed limit, the indirect effect tells us how much of the relationship is due to

differences in perceptions of enforcement. The indirect effect is the product of a and b , as indicated in figure 10.1. This means that if there are two cases that differ by one single unit on the predictor variable, it is estimated they will differ by the product of a and b on the outcome variable. This is as a result of the effect that the predictor variable has on the mediating variable, which in turn affects the outcome variable.

The total effect is the sum of both the direct and the indirect effects and provides an overall quantification of the relationship between the predictor variable and the outcome variable (Hayes, 2013). The total effect is useful in understanding the proportion of the total effect that is a result of the mediating variable, and the proportion that is a result of the direct relationship between the predictor variable and the outcome variable. In figure 10.1, this relationship is indicated by the c .

Each of the direct, indirect and total effects reported on in this chapter are standardized. The nature of the variables considered in this analysis meant that if unstandardized results had been examined, it would have been difficult to interpret their meaning. Unstandardized results are used to examine how a one-point change in a predictor variable changes the outcome variable. Of course, a one-point change in neuroticism does not tell us a lot about the patterns occurring in the outcome variable of expectations to speed, as it is difficult to imagine what a one-point change in neuroticism actually represents. Using standardized total effects enabled comparisons to be drawn between the relative importance of the mediating variables, given some were measured on a five-point scale and others were measured on a seven-point scale. By using standardized results, it was possible to examine in which instances larger effect sizes were emerging, and which variables had a more substantial influence. Analyses were conducted using Mplus Version 8.4 (Muthén & Muthén, 1998-2017).

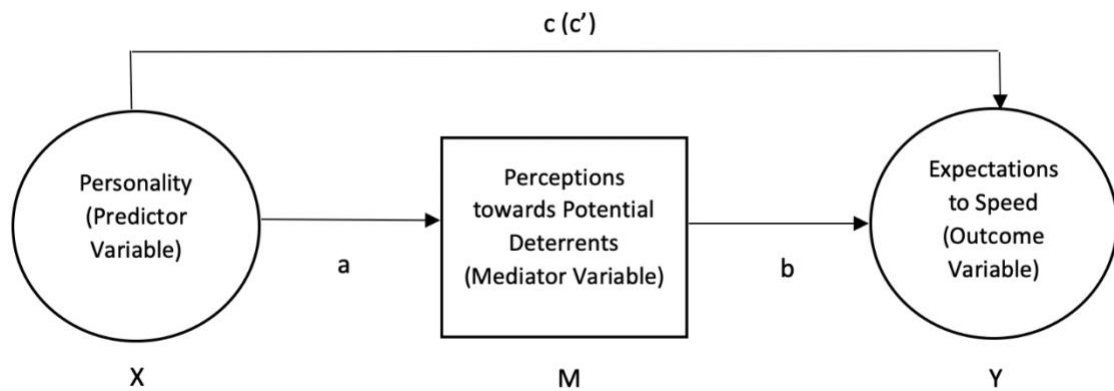


Figure 10.1 Diagram showing how mediation was considered and each of the pathways that were examined

The decision to use a mediated regression analysis rather than Structural Equation Modelling was made for a number of reasons. First, examining the five personality traits independently enabled a close examination of each. If all personality traits had been considered in a single Structural Equation Model, important relationships between factors may have been missed, due to the influence of the other personality traits. Second, there was multicollinearity between some of the perceptions towards the potential deterrents, so it was inappropriate to simultaneously include them in the same model. Finally, the aim of this study was to examine each of the different pathways proposed in the model described in chapter three, rather than to prove the model necessarily fits as an all-encompassing model of deterrence. Examining each mediated pathway separately provides a more detailed understanding of potential points of intervention, that may assist in achieving deterrence and subsequently improved road safety.

Perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval and perceptions of negative personal and emotional affect were latent variables, each with two measured items that were indicators of the factor. Perceptions of enforcement was measured by asking drivers about their perceptions of sanction certainty and sanction severity for driving at up to 10km/h above the speed limit. Perceptions of crash risk was measured by asking drivers about their perceptions towards risk of being involved in a crash and risk of injuries to themselves or others if a crash was to occur as a result of driving at up to 10km/h above the speed limit. Perceptions of social norms and disapproval was measured by asking drivers if they believed driving at up to 10km/h above the speed limit is wrong and also how they perceive those closest to them would respond if they were to drive at up to 10km/h above the speed limit. Finally, perceptions of negative

personal and emotional affect was measured by asking drivers if they perceived they would experience guilt and shame if they were to drive at up to 10km/h above the speed limit. Prior to using the four latent factors in the mediated regression analysis, it was important to ensure that the measured items had acceptable loadings in relation to their associated latent factor. Factor loadings were all found to be good, ranging from 0.55 to 0.95. This confirmed that all items were adequate measures of the relevant latent variable they were an indicator of.

10.4 Results

10.4.1 Initial analyses

Table 10.1 provides the mean, standard deviation and 95% Confidence Interval for each variable included in the modelling. Higher mean scores on the Big Five Inventory personality traits indicate a stronger tendency towards the specified personality trait, with each measured on a five-point scale where 1 equalled 'Disagree Strongly' through to 5 which equalled 'Agree Strongly'. The highest scores were observed for agreeableness and conscientiousness, indicating these were the personality traits most strongly displayed by the study sample.

Table 10.1 describes each of the measured variables for the latent factors. The two measured variables for each of perceptions of enforcement, perceptions of crash risk and perceptions of negative personal and emotional affect were measured on a seven-point scale, where 1 equalled 'Strongly Disagree' and 7 equalled 'Strongly Agree'. Higher scores on each of these variables are therefore indicative of higher levels of agreement from drivers that the factor under examination acts as a deterrent to them driving at up to 10km/h above the speed limit. The two variables that were used to measure perceptions of social norms and disapproval were measured on a different scale. In terms of the behaviour being wrong, 1 equalled 'None of the Time' whilst 5 'equalled 'All of the time'. In terms of perceptions of how those closest would respond, 1 equalled 'Strongly Approve' while 7 equalled 'Strongly Disapprove'. Once again, higher scores on each of these variables was indicative of higher levels of agreement from drivers that they act as a deterrent to driving at up to 10km/h above the speed limit. Means were relatively consistent across variables, indicating drivers generally perceived all factors to influence their behaviour. For each of the

variables measured on a seven-point scale, the means varied between 5.02 (for perceptions of experiencing shame), to 5.91 (for worry about getting caught).

The final results provided in Table 10.1 relate to behavioural expectations – specifically the expectations drivers have that they will drive at up to 10km/h above the speed limit in the following twelve months. Higher scores here indicate a greater expectation (or alternatively a lower level of deterrence) to perform the behaviour. The question was asked on a seven-point scale of 1 ‘Highly Unlikely’ through to 7 ‘Highly Likely’. The mean score of 3.3 indicated that most people thought it was generally unlikely that they would drive at up to 10km/h above the speed limit in the following twelve months (Table 10.1).

Table 10.1 Personality, perceptions and behavioural expectations descriptive statistics

Measure	Scale Range	Mean (Standard Deviation)	95% Confidence Interval
Big Five Inventory			
Extraversion	1-5	3.05 (0.72)	3.03-3.07
Agreeableness	1-5	3.80 (0.64)	3.78-3.82
Conscientiousness	1-5	3.76 (0.65)	3.74-3.78
Neuroticism	1-5	2.81 (0.79)	2.79-2.83
Openness	1-5	3.38 (0.56)	3.37-3.40
Perceptions of enforcement for driving up to 10km/h above speed limit			
Worry about getting caught	1-7	5.92 (1.27)	5.89-5.96
Worry sanction would have a significant negative impact on life	1-7	5.38 (1.54)	5.34-5.42
Perceptions of crash risk for driving up to 10km/h above speed limit			
Worry about being involved in a crash	1-7	5.31 (1.71)	5.26-5.36
Worry could injure self or someone else	1-7	5.62 (1.59)	5.58-5.67
Perceptions of social norms and disapproval for driving up to 10km/h above speed limit			
Perceptions of behaviour as being wrong	1-5	4.10 (1.00)	4.07-4.12
Perceptions of how those closest would respond	1-7	5.50 (1.36)	5.46-5.54
Perceptions of negative personal/emotional affect for driving up to 10km/h above speed limit			
Perceptions of experiencing shame	1-7	5.02 (1.68)	4.98-5.07
Perceptions of experiencing guilt	1-7	5.30 (1.65)	5.25-5.34
Behavioural Expectations for driving at up to 10km/h above the speed limit			
Expect to perform behaviour	1-7	3.33 (2.09)	3.27-3.38

An examination of correlations between personality traits was also undertaken (Table 10.2). There were strong positive associations between four of the personality traits: extraversion, agreeableness, conscientiousness, and openness. Comparatively, there were strong negative associations between neuroticism and the four other personality traits: extraversion, agreeableness, conscientiousness and openness. These associations demonstrate that high scores on extraversion, agreeableness, conscientiousness, and openness tend to be seen in the same people, who also score low on neuroticism. Alternatively, those scoring highly on neuroticism tended to score low on extraversion, agreeableness, conscientiousness, and openness.

10.4.2 Influence of personality on expectations to speed

The first research question was focussed on examining how personality is associated with expectations to drive at up to 10km/h above the speed limit in the twelve months that follow. Table 10.2 shows the correlations between each of the five personality factors and speeding expectations. Significant correlations were observed between all personality traits and expectations to speed in the twelve months that followed, with all showing a negative association, with the exception of neuroticism, where the association was positive. Thus, higher scores on neuroticism ($r=0.10$, $p<0.001$) were associated with expressing higher expectations to drive at up to 10km/h above the speed limit in the twelve months that follow. Conversely, scoring highly on agreeableness ($r=-0.14$, $p<.001$) and conscientiousness (-0.11 , $p<.001$), were associated with lower expectations to drive at up to 10km/h above the speed limit in the twelve months that followed. It must be noted however that these correlations were weak. These results indicate that personality is related to expectations to speed, with the size and direction of associations differing depending on personality trait.

10.4.3 Influence of personality on perceptions of enforcement, crash risk, social norms and disapproval and negative personal/emotional affect

The second research question was focussed on examining how personality may influence the perceptions drivers have towards the four possible deterring factors – perceptions of enforcement, crash risk, social norms and disapproval and negative personal/emotional affect. Table 10.2 shows the correlations between personality and perceptions variables. Across all four perceptions factors, drivers scoring highly on agreeableness expressed perceptions that were consistent with greater levels of deterrence, ranging from $r=0.16$,

$p < .001$ for perceptions of crash risk, through to $r = 0.33$, $p < .001$ for perceptions of social norms and disapproval. Drivers scoring highly on conscientiousness also expressed perceptions that were consistent with greater levels of deterrence, ranging from $r = 0.09$, $p < .001$ for perceptions of crash risk, through to $r = 0.26$, $p < .001$ for perceptions of social norms and disapproval. Neuroticism, however, emerged as a standout personality trait when considered in relation to perceptions towards the potential deterrents. Higher scores on neuroticism were associated with expressing perceptions that were indicative of lower levels of deterrence for each of perceptions of crash risk ($r = -0.03$, $p = 0.02$), perceptions of social norms and disapproval ($r = -0.13$, $p < .001$) and perceptions of negative personal/emotional affect -0.04 , $p = 0.01$). The relationship between neuroticism and perceptions of enforcement was non-significant. These results indicate that personality has an influence on how an individual perceives factors that may act as deterrents.

10.4.4 Factors beyond legal sanctions that may influence expectations to speed

The third research question was focussed on examining factors beyond legal sanctions that may influence the expectations drivers have to speed at up to 10km/h above the limit in the following twelve months. As noted, perceptions of four different potential deterrents were examined – perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval and perceptions of personal/emotional affect. Table 10.2 shows the correlations between variables. The correlation between social norms and disapproval, in relation to expectations to drive at up to 10km/h above the speed limit had the strongest correlation when considering these four perceptions factors ($r = -0.72$, $p < .001$). This result can be compared with the results that emerged for the remaining three perceptions variables – perceptions of enforcement ($r = -0.49$, $p < .001$) perceptions of crash risk ($r = -0.50$, $p < .001$) and perceptions of negative personal/emotional affect ($r = -0.51$, $p < .001$).

Table 10.2 Correlations between personality traits, perceptions of enforcement, crash risk, social norms and disapproval, negative personal/emotional effect and behavioural expectations for driving at up to 10km/h above the speed limit

	1	2	3	4	5	6	7	8	9
1.Extraversion									
2.Agreeableness	0.19**								
3.Conscientiousness	0.22**	0.55**							
4.Neuroticism	-0.31**	-0.40**	-0.45**						
5.Openness	0.34**	0.24**	0.23**	-0.10**					
6.Perceptions of enforcement	0.10**	0.22**	0.14**	0.01	0.12**				
7.Perceptions of crash risk	0.10**	0.16**	0.09**	-0.03*	0.05**	0.63**			
8.Perceptions of social norms and disapproval	0.10**	0.33**	0.26**	-0.13**	0.06*	0.70**	0.80**		
9.Perceptions of negative personal/emotional affect	0.08**	0.19**	0.13**	-0.04*	0.07**	0.74**	0.74**	0.78**	
10.Expectations to perform the behaviour	-0.07**	-0.14**	-0.11**	0.10**	-0.03*	-0.49**	-0.50**	-0.72**	-0.51**

*<0.05; **<.001

10.4.5 Mediating influence of perceptions of enforcement, crash risk, social norms and disapproval and negative personal/emotional affect between personality and expectations to speed

The final research question was focussed on examining how perceptions towards the four potential deterring factors mediate the relationship between each of the five personality traits and expectations to drive at up to 10km/h above the speed limit in the following twelve months. As noted above, a series of 20 mediated regression models were run, with each of these individual models shown in figures 10.2 to 10.21. Statistically significant pathways are shown in bold, whilst non-statistically significant pathways are shown using broken lines. The following sections consider the mediating influence of each of the four perceptions factors in turn. Results are also provided in tables 10.3-10.6. These tables provide a summary of mediation effect (partial, complete, non-significant).

10.4.5.1 Mediating influence of perceptions of enforcement between personality and behavioural expectations

The models showing the mediating influence of perceptions of enforcement between personality and expectations to drive at up to 10km/h above the speed limit in the following twelve months are shown in figures 10.2 to 10.6. Table 10.3 shows the direct, indirect and total effects for the relationship between each personality trait and expectations to drive at up to 10km/h above the speed limit in the following twelve months, mediated by perceptions of enforcement.

The model that examined the relationship between extraversion and expectations to drive at up to 10km/h above the speed limit was completely mediated by perceptions of enforcement, with the direct effect of extraversion on expectations to drive at up to 10 km/h over the speed limit non-significant ($\beta=-0.02$, $p=0.18$) and the indirect effect (mediated by perceptions of enforcement) statistically significant ($\beta=-0.05$, $p<.001$). This meant that a higher score on extraversion was related to a lower expectation to speed at up to 10km/h above the speed limit in the following twelve months. This relationship emerged as a result of drivers who scored highly on extraversion agreeing that the risks of enforcement for the offence are high.

For the remaining personality types, whilst there were statistically significant direct effects of personality type on expectations to speed, the effect sizes were very small in most cases ($\beta=-0.03$, $p=0.03$ for agreeableness; $\beta=0.03$; $p<0.05$ for openness; $\beta=-0.04$, $p=0.01$ for conscientiousness). Thus, despite the relationships between agreeableness, conscientiousness, openness and expectations to drive at up to 10km/h above the speed limit being only partially mediated by perceptions of enforcement, the larger indirect effects indicated that the associations between personality and speeding expectations occurred primarily through perceptions of enforcement ($\beta=-0.11$ for agreeableness; $\beta=-0.06$ for openness; $\beta=-0.07$ conscientiousness) which were all statistically significant at the $p<0.01$ level. Thus, once again, it can generally be concluded that drivers scoring highly on these three personality traits had a lower expectation to drive at up to 10km/h above the speed limit in the following twelve months, partially mediated by their agreement that the risks of enforcement for the offence are high.

Scoring highly on neuroticism was the only personality trait where a different pattern was observed. The direct effect of neuroticism on expectations to drive at up to 10km/h above the speed limit was large and statistically significant ($\beta=0.11$, $p<.001$), whilst the indirect effect (mediated by perception of enforcement) was small and non-significant ($\beta=-0.01$, $p=0.36$). This indicated that perceptions of enforcement have no significant mediating effect on the relationship between neuroticism and expectations to drive at up to 10km/h above the speed limit in the following twelve months, with drivers scoring highly on neuroticism reporting greater expectations to speed at up to 10km/h above the limit in the following twelve months.

The model relating to openness was of particular interest. Whilst the direct effect between openness and expectations to drive at up to 10km/h was positive (that is, higher scores on openness were associated with higher expectations of speeding when perception of enforcement were held constant), when perceptions of enforcement were included, the total effect became negative, indicating a deterring effect. Thus, when drivers who scored highly on openness agreed the risk of enforcement for speeding up to 10km/h above the limit was high, this had a very positive effect in relation to deterrence being achieved.

Table 10.3 Direct, indirect and total effects for the relationship between the personality and expectations to drive at up to 10km/h above the speed limit in the following 12 months, mediated by perceptions of enforcement

Personality Trait	Expectations to drive at up to 10km/h above the speed limit			
	Direct Effect	Indirect Effect	Total Effect	Mediation Effect
Extraversion	-0.02	-0.05**	-0.07**	Complete
Agreeableness	-0.03*	-0.11**	-0.14**	Partial
Conscientiousness	-0.04*	-0.07**	-0.11**	Partial
Neuroticism	0.11**	-0.01	0.10**	Non-significant
Openness	0.03*	-0.06**	-0.03*	Partial

*<0.05; **<.001

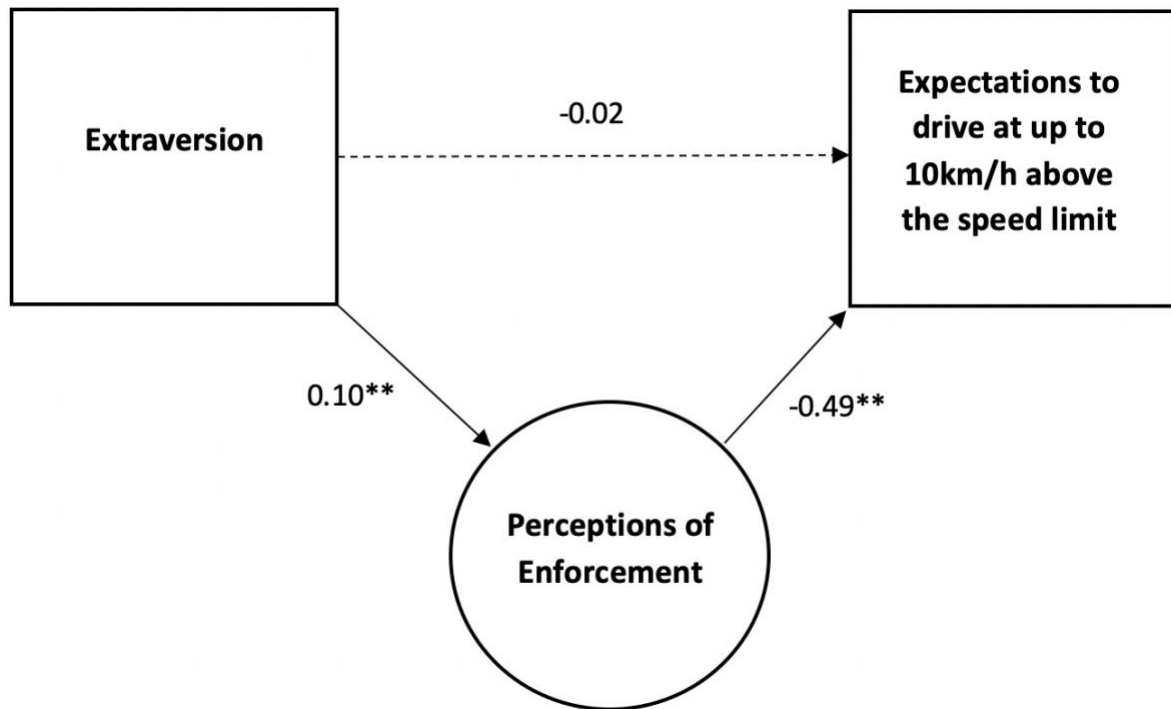


Figure 10.2 Mediating influence of perceptions of enforcement between extraversion and expectations to drive at up to 10km/h above the speed limit in the following 12 months

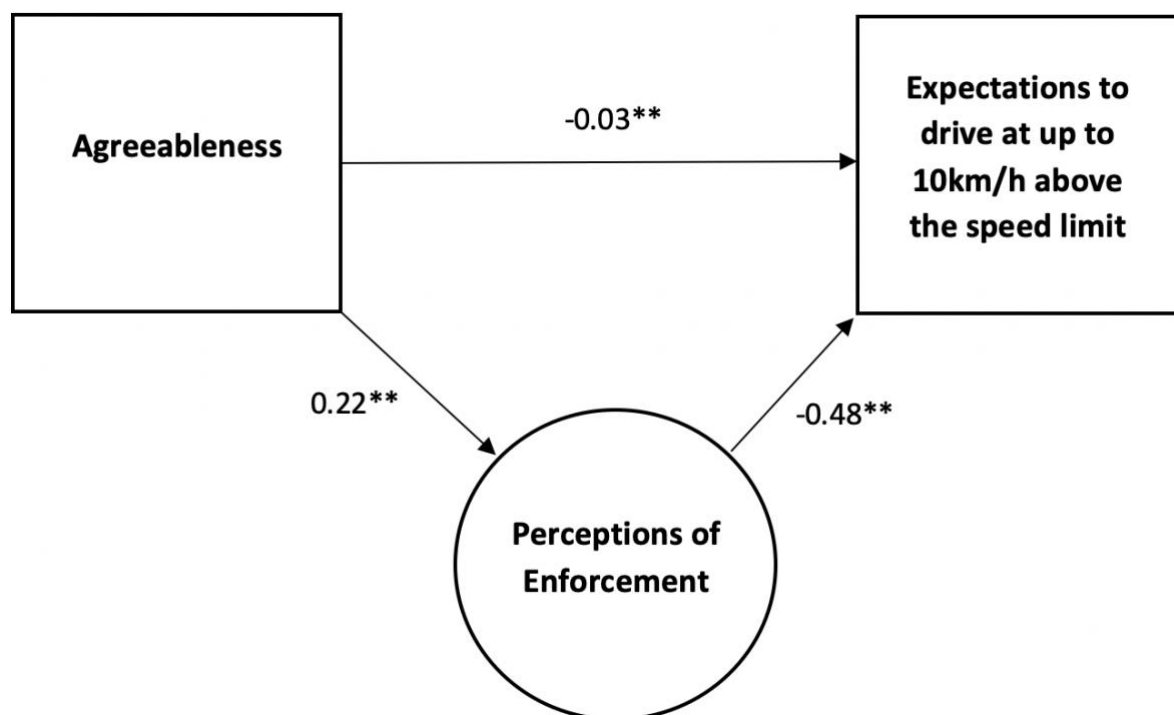


Figure 10.3 Mediating influence of perceptions of enforcement between agreeableness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

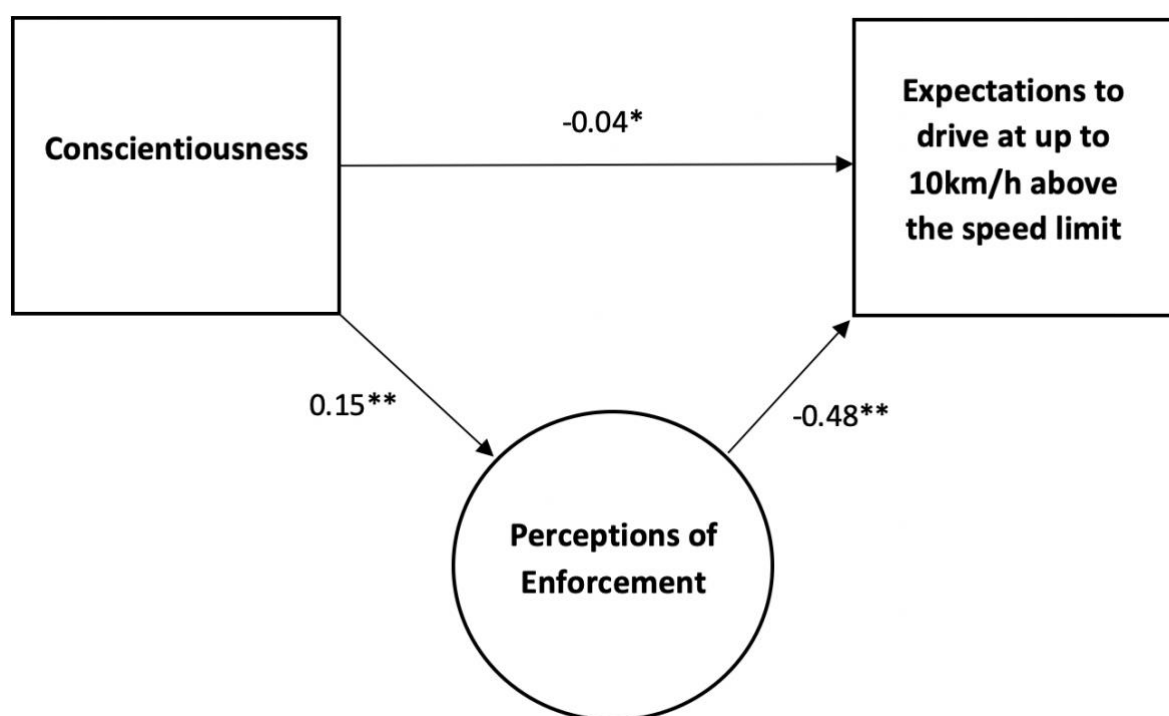


Figure 10.4 Mediating influence of perceptions of enforcement between conscientiousness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

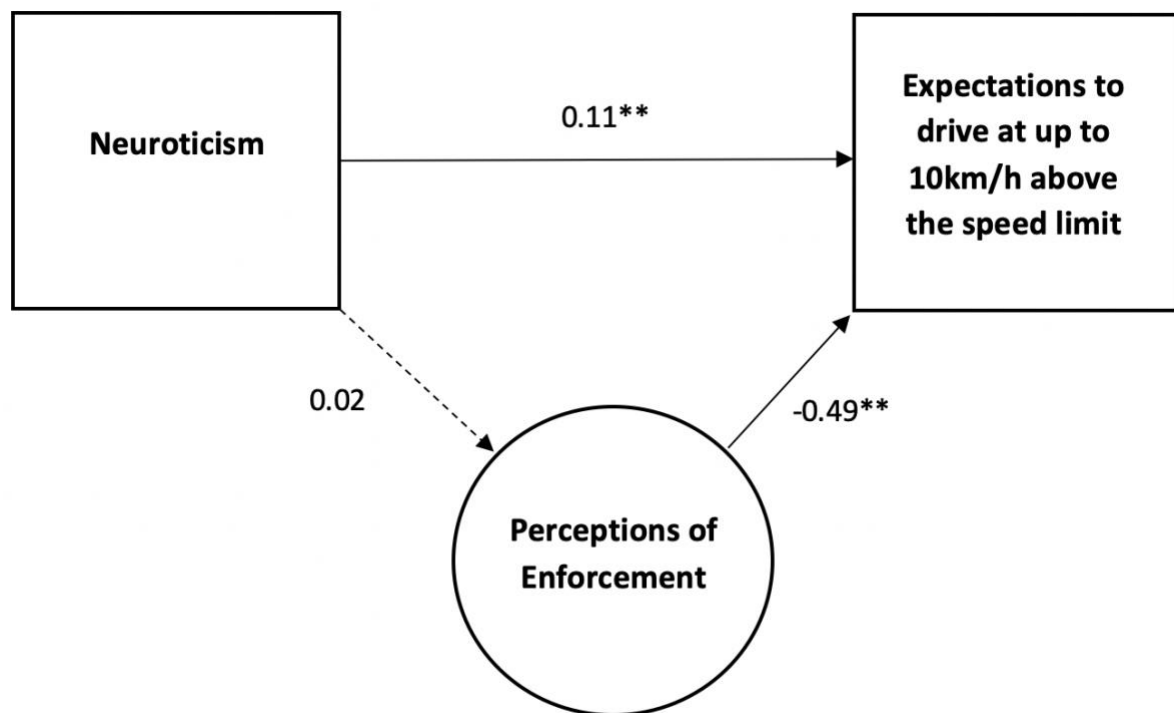


Figure 10.5 Mediating influence of perceptions of enforcement between neuroticism and expectations to drive at up to 10km/h above the speed limit in the following 12 months

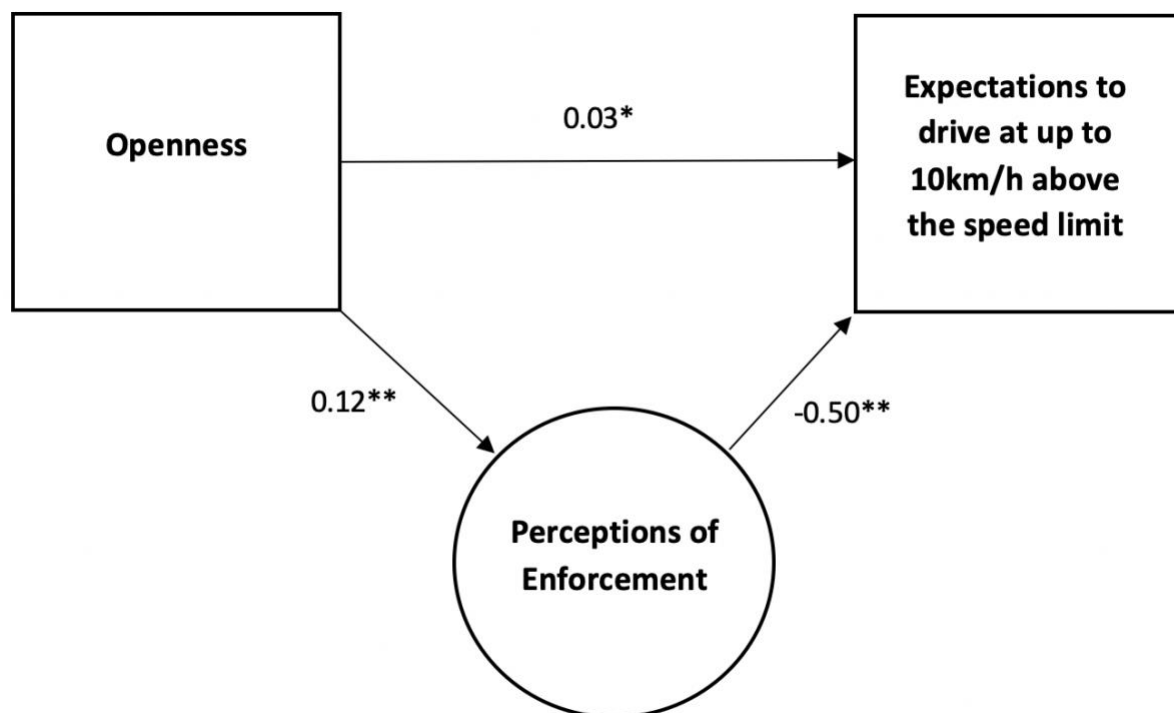


Figure 10.6 Mediating influence of perceptions of enforcement between openness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

10.4.5.2 Mediating influence of perceptions of crash risk between personality and behavioural expectations

The models showing the mediating influence of perceptions of crash risk are shown in figures 10.7 to 10.11. Table 10.4 shows the direct, indirect and total effects for the relationship between each personality trait and expectations to drive at up to 10km/h above the speed limit in the following months, mediated by perceptions of crash risk.

Once again, the model that examined extraversion was completely mediated by the perceptions factor (perceptions of crash risk), with the direct effect between extraversion and speeding expectations non-significant ($\beta=-0.02$, $p=0.14$), whilst the indirect effect (mediated by crash risk) was statistically significant ($\beta=-0.05$, $p<.001$). This meant that a higher score on extraversion was related to a lower expectation to speed at up to 10km/h above the speed limit in the following twelve months, with this relationship emerging as a result of drivers who scored highly on extraversion agreeing that the risks of a crash emerging from speeding are high.

A similar pattern was observed with openness. The direct effect between openness and expectations to drive at up to 10km/h was non-significant ($\beta=-0.01$, $p=0.63$). Notably, whilst the indirect effect (mediated by crash risk) was significant, it was still very small ($\beta=-0.03$, $p=0.01$). However, once again these results suggest that drivers scoring highly on openness have a lower expectation to speed at up to 10km/h above the limit in the following twelve months, with this relationship mediated by their agreement that there are high crash risks associated with the behaviour.

Significant direct effects were observed between agreeableness ($\beta=-0.07$, $p<.001$), conscientiousness ($\beta=-0.07$, $p<.001$), neuroticism ($\beta=0.09$, $p<.001$) and expectations to drive at up to 10km/h above the speed limit. The indirect effects of the relationship between agreeableness ($\beta=-0.07$, $p<.001$), conscientiousness ($\beta=-0.04$, $p<.001$) and neuroticism ($\beta=0.02$, $p=0.03$) were all statistically significant; however, the effect sizes were equal to or less than the direct effects. This indicates that the mediating influence of perceptions of crash risk explained only a minimal amount of the total effect of these personality traits on expectations to drive at up to 10km/h above the speed limit. In these cases, it is evident that perceptions of crash risk are not accountable for the majority of the relationship

between agreeableness, conscientiousness and neuroticism and expectations to drive at up to 10km/h over the speed limit.

Table 10.4 Direct, indirect and total effects for the relationship between the personality and expectations to drive at up to 10km/h above the speed limit in the following 12 months, mediated by perceptions of crash risk

	Expectations to drive at up to 10km/h above the speed limit			
Personality Trait	Direct Effect	Indirect Effect	Total Effect	Mediation Effect
Extraversion	-0.02	-0.05**	-0.07**	Complete
Agreeableness	-0.07**	-0.07**	-0.14**	Partial
Conscientiousness	-0.07**	-0.04**	-0.11**	Partial
Neuroticism	0.09**	0.02*	0.10**	Partial
Openness	-0.01	-0.03*	-0.03*	Complete

* <0.05 ; ** $<.001$

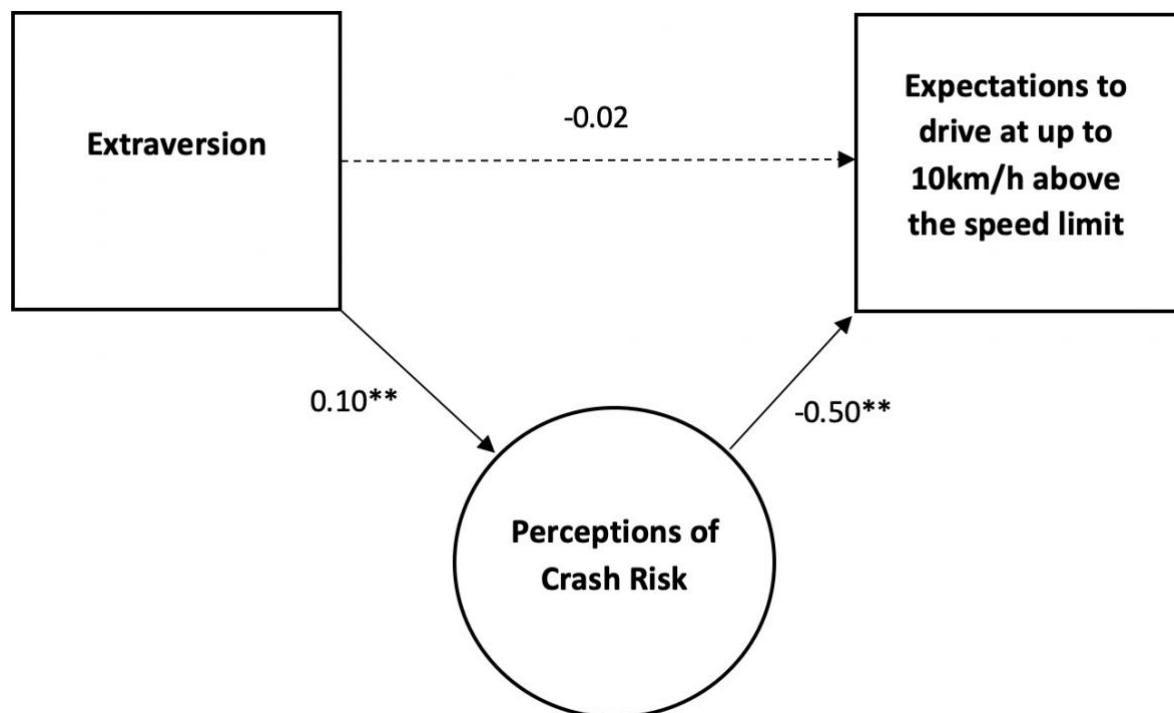


Figure 10.7 Mediating influence of perceptions of crash risk between extraversion and expectations to drive at up to 10km/h above the speed limit in the following 12 months

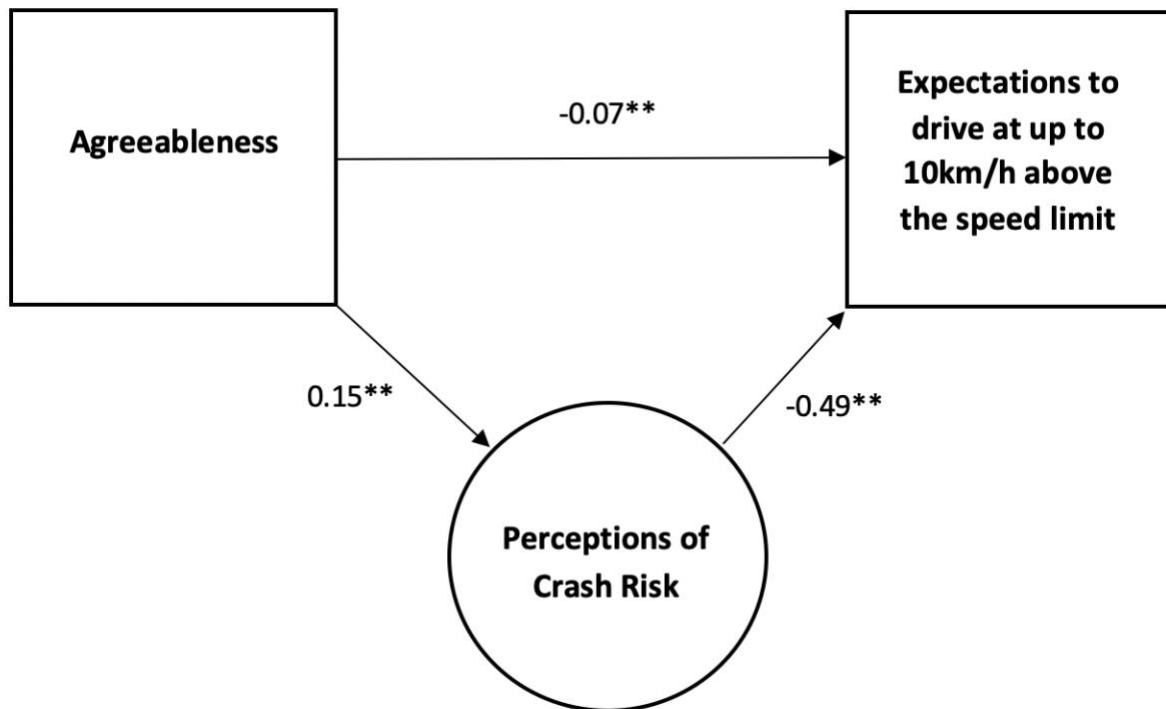


Figure 10.8 Mediating influence of perceptions of crash risk between agreeableness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

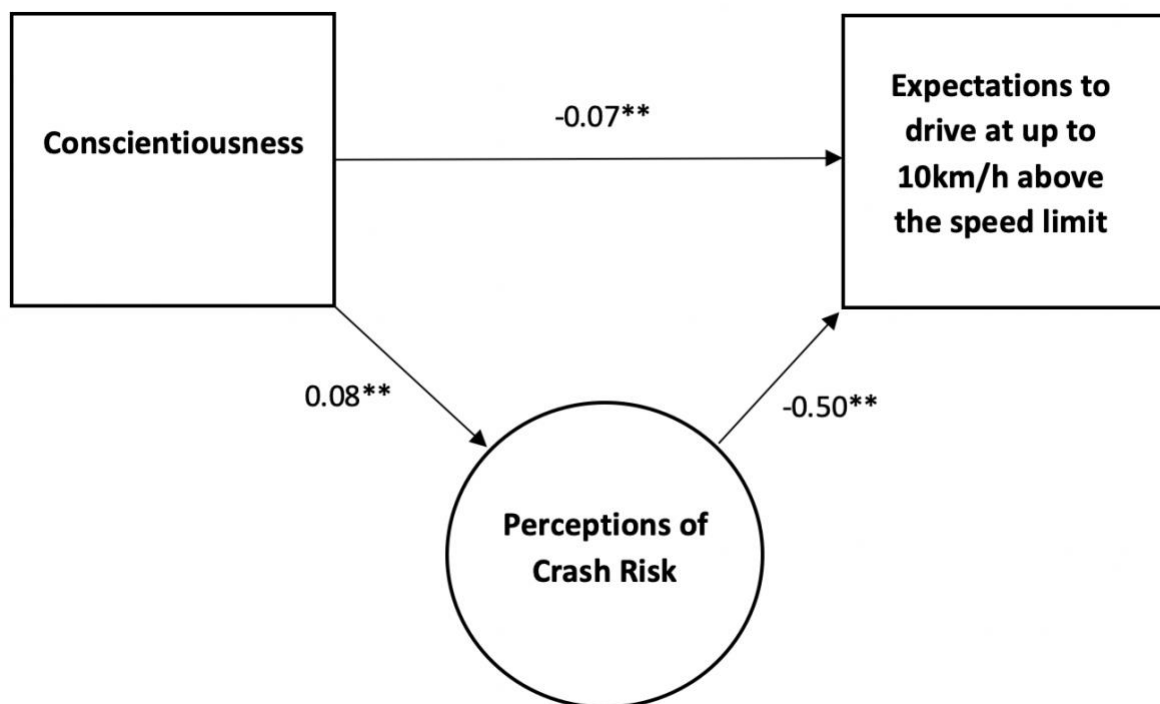


Figure 10.9 Mediating influence of perceptions of crash risk between conscientiousness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

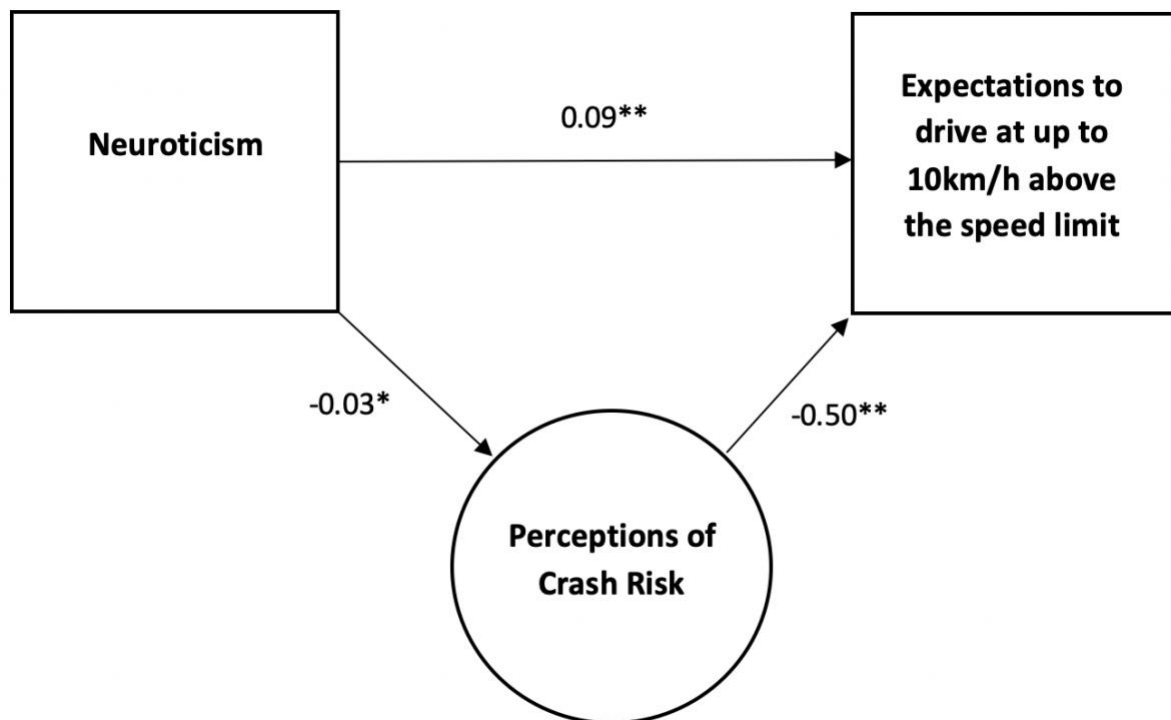


Figure 10.10 Mediating influence of perceptions of crash risk between neuroticism and expectations to drive at up to 10km/h above the speed limit in the following 12 months

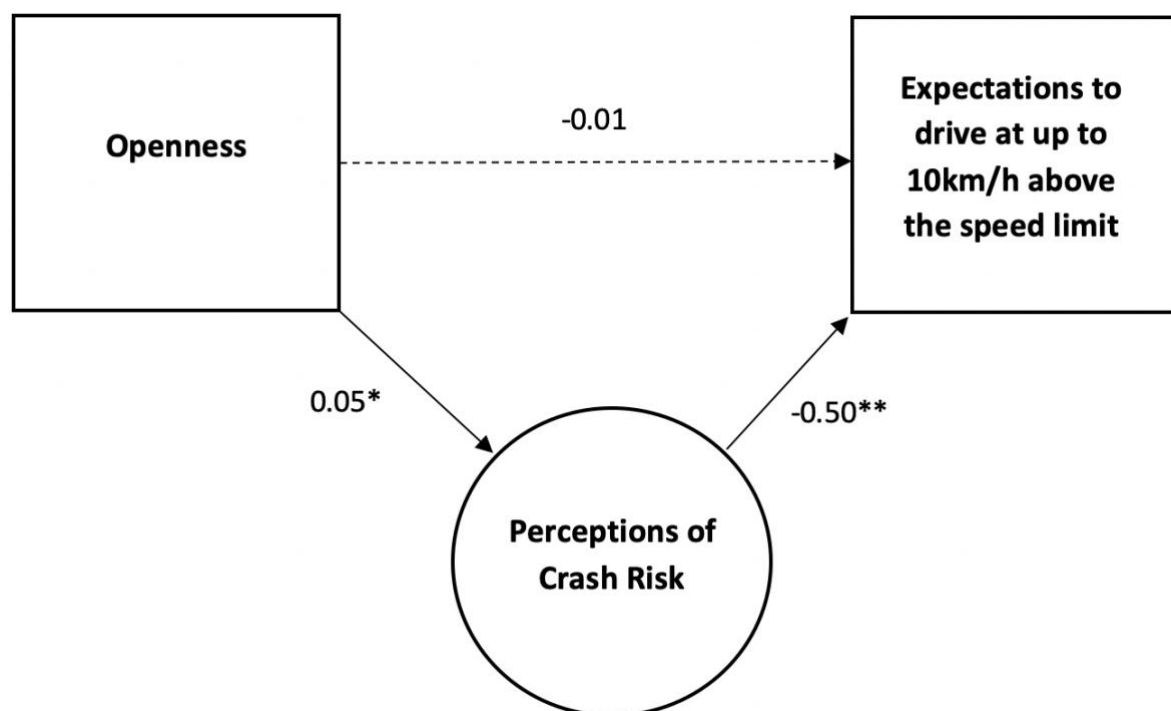


Figure 10.11 Mediating influence of perceptions of crash risk between openness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

10.4.5.3 Mediating influence of perceptions of social norms and disapproval between personality and behavioural expectations

The models showing the mediating influence of social norms and disapproval are shown in figures 10.12 to 10.16. Table 10.5 shows the direct, indirect and total effects for the relationship between each personality trait and expectations to drive at up to 10km/h above the speed limit in the following twelve months, mediated by perceptions of social norms and disapproval.

The models that examined extraversion ($\beta=0.00$, $p=0.85$), neuroticism ($\beta=0.01$, $p=0.45$) and openness ($\beta=0.01$, $p=0.48$) all had non-significant direct effects, indicating that the relationships between these personality traits and expectations to drive at up to 10km/h above the speed limit were completely mediated by perceptions of social norms and disapproval.

The indirect effects were statistically significant, at $\beta=-0.07$, $p<.001$ for extraversion, $\beta=0.09$, $p<.001$ for neuroticism and $\beta=-0.04$, $p=0.01$ for openness. This once again meant that a higher score on extraversion or openness was related to a lower expectation to speed at up to 10km/h above the limit in the following twelve months, with this relationship mediated by perceptions of social norms and disapproval. Comparatively, the relationship between neuroticism and expectations to drive at up to 10km/h above the speed limit was in complete contrast. Drivers who scored highly on neuroticism had a greater expectation to speed at up to 10km/h above the speed limit in the following twelve months, with this relationship emerging as a result of drivers who scored highly on this trait not expressing perceptions of speeding going against social norms or being a behaviour that would be disapproved of.

In the case of the models that examined agreeableness and conscientiousness, the relationship with expectations to drive at up to 10km/h above the speed limit was partially mediated by perceptions of social norms and disapproval, with both the direct ($\beta=0.11$, $p<.001$ for agreeableness; $\beta=0.08$, $p<.001$ for conscientiousness) and indirect ($\beta=-0.25$, $p<.001$ for agreeableness; $\beta=-0.19$, $p<.001$ for conscientiousness) effects statistically significant. In these cases, whilst agreeableness and conscientiousness had a direct relationship to driving at up to 10km/h, with this relationship in fact positive, these drivers

were in high agreeance that speeding at up to 10km/h above the limit is against social norms and would be met with disapproval. Indeed, this mediating influence was so strong that deterrence from expecting to perform the behaviour was ultimately observed. It is notable that the indirect effect sizes seen in relation to perceptions of social norms and disapproval were the largest seen for each personality trait, with the exception of openness, when compared with the models that examined the other perceptions factors. This highlights the substantial effect that perceptions of social norms and disapproval potentially have upon driver behaviour and deterrence.

Table 10.5 Direct, indirect and total effects for the relationship between the personality and expectations to drive at up to 10km/h above the speed limit in the following 12 months, mediated by perceptions of social norms and disapproval

Personality Trait	Expectations to drive at up to 10km/h above the speed limit			
	Direct Effect	Indirect Effect	Total Effect	Mediation Effect
Extraversion	0.00	-0.07**	-0.07**	Complete
Agreeableness	0.11**	-0.25**	-0.14**	Partial
Conscientiousness	0.08**	-0.19**	-0.11**	Partial
Neuroticism	0.01	0.09**	0.10**	Complete
Openness	0.01	-0.04*	-0.03*	Complete

* <0.05 ; ** $<.001$

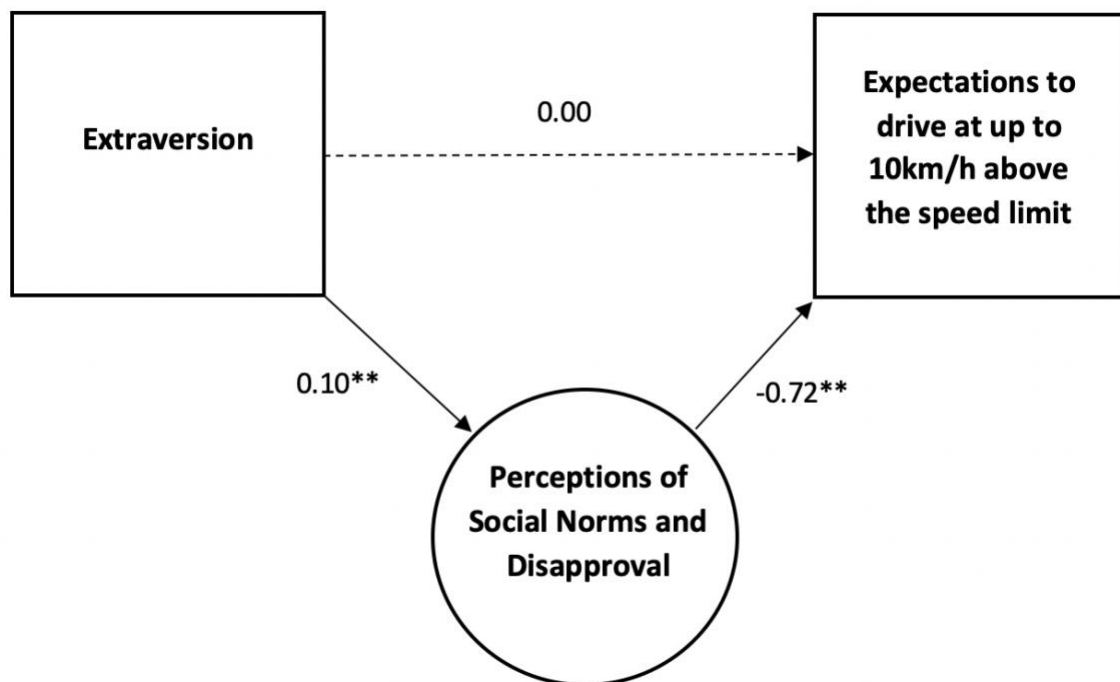


Figure 10.12 Mediating influence of perceptions of social norms and disapproval between extraversion and expectations to drive at up to 10km/h above the speed limit in the following 12 months

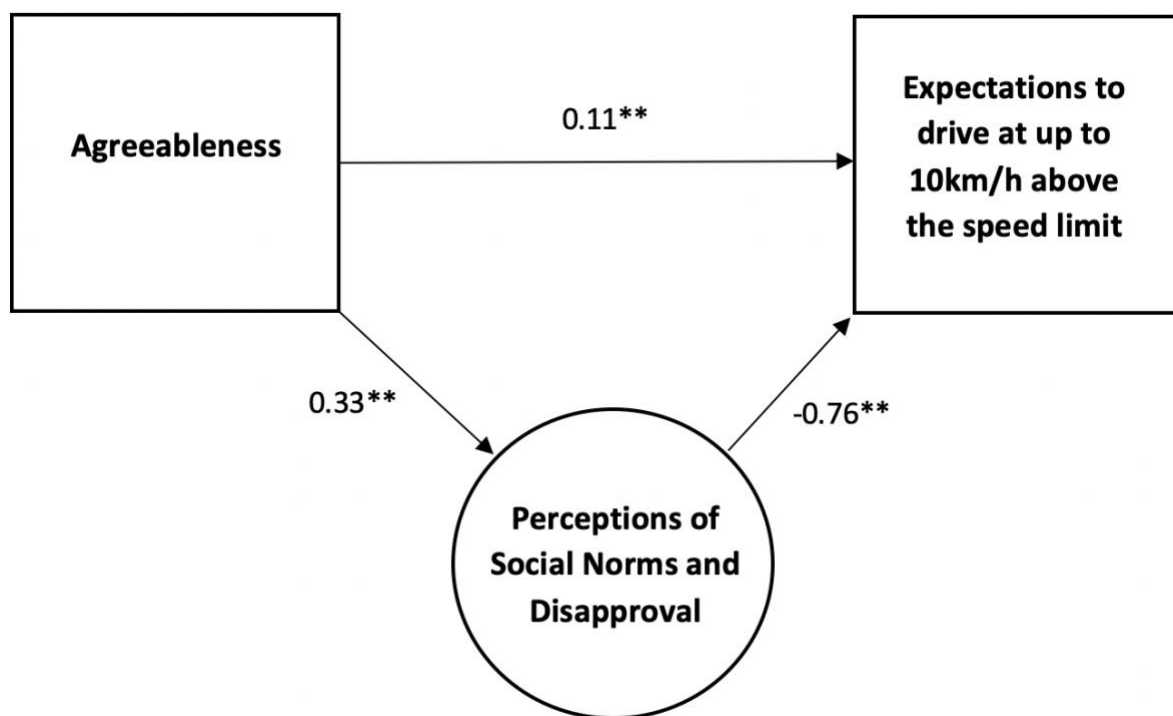


Figure 10.13 Mediating influence of perceptions of social norms and disapproval between agreeableness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

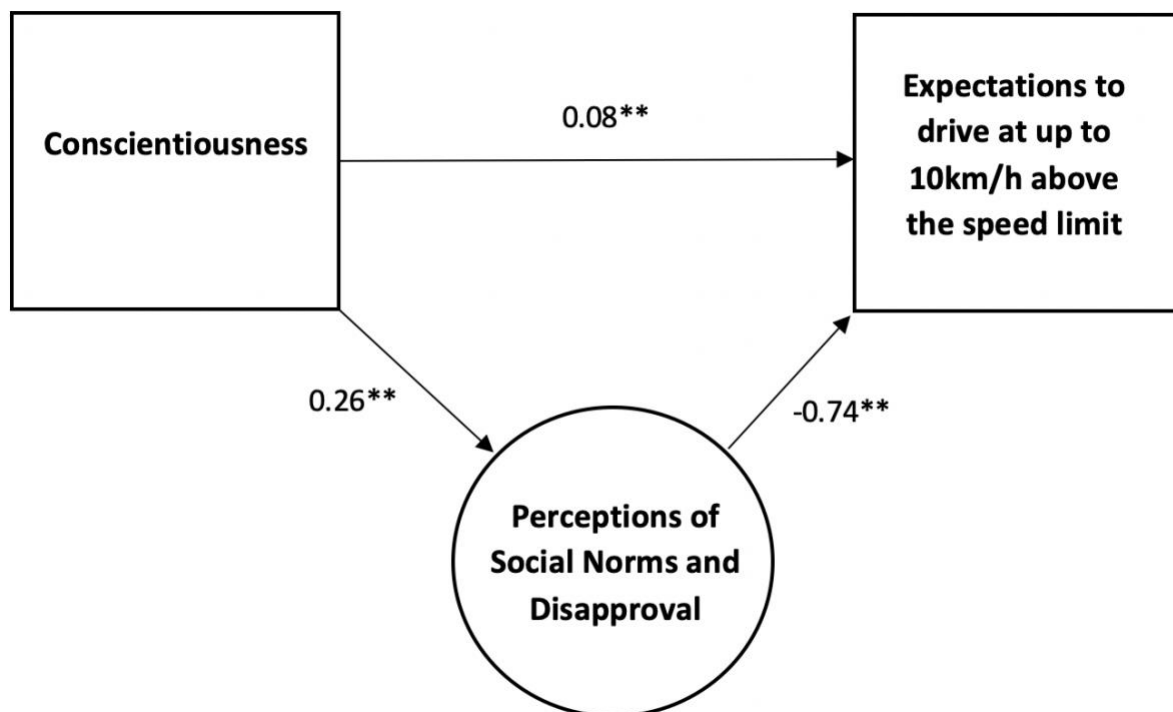


Figure 10.14 Mediating influence of perceptions of social norms and disapproval between conscientiousness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

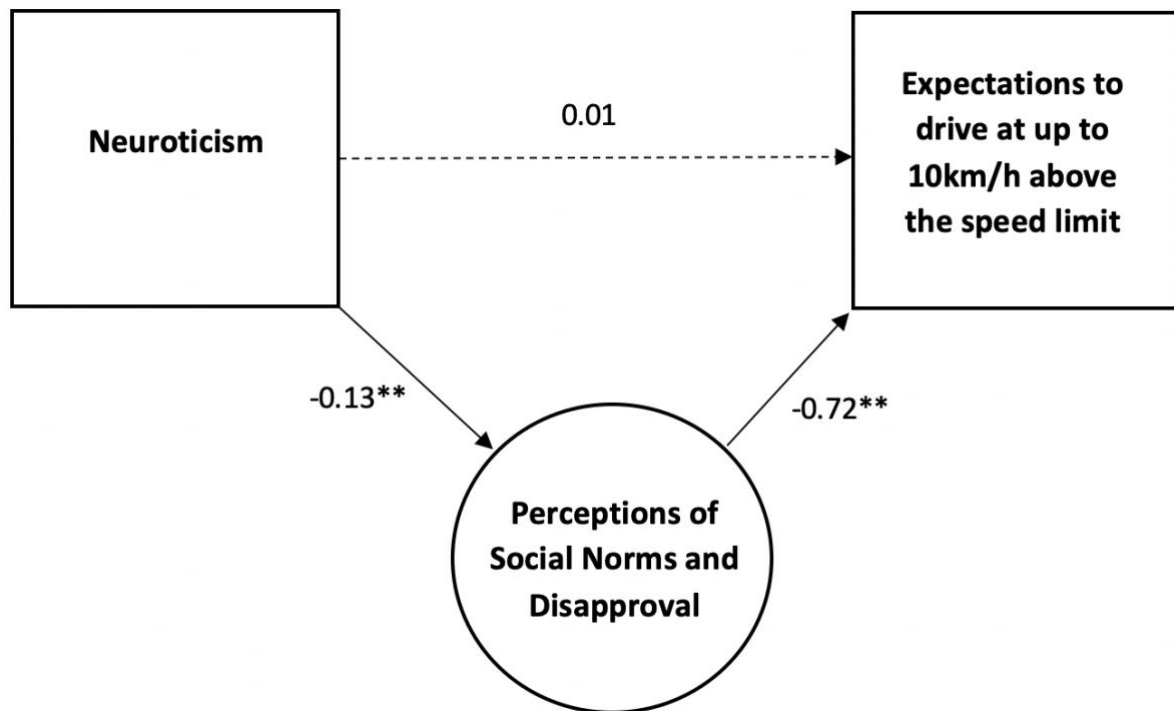


Figure 10.15 Mediating influence of perceptions of social norms and disapproval between neuroticism and expectations to drive at up to 10km/h above the speed limit in the following 12 months

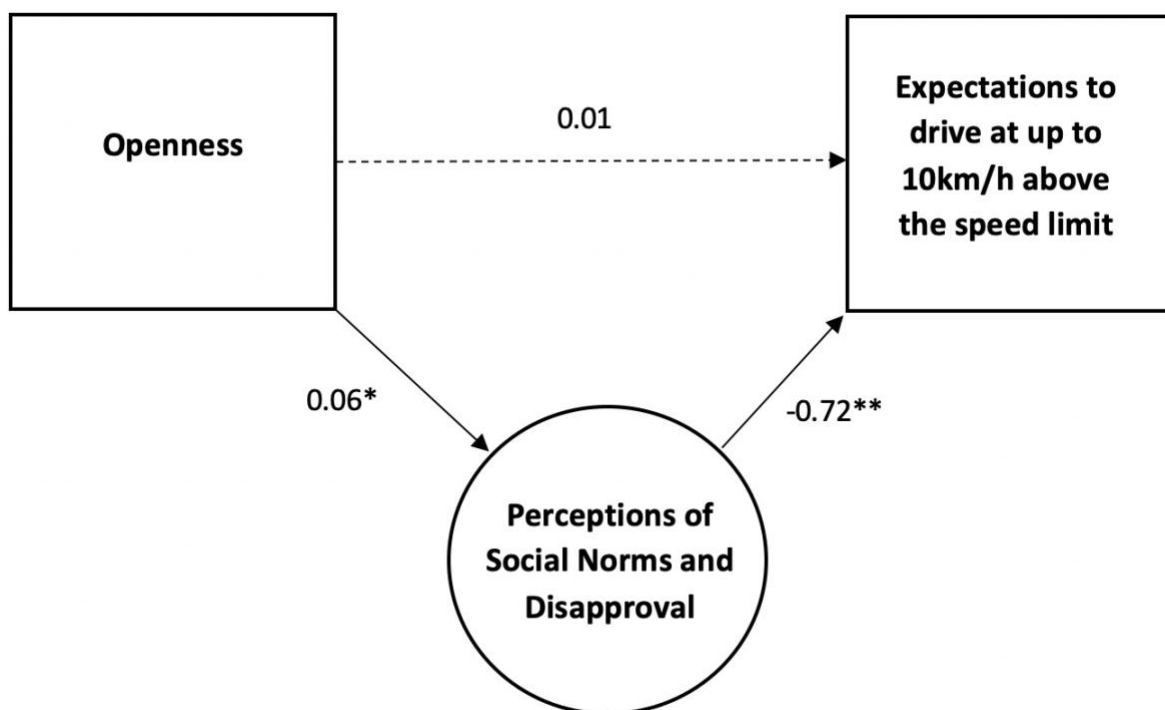


Figure 10.16 Mediating influence of perceptions of social norms and disapproval between openness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

10.4.5.4 Mediating influence of perceptions of negative personal and emotional affect between personality and behavioural expectations

The models showing the mediating influence of perceptions of negative personal and emotional affect are shown in figures 10.17 to 10.21. Table 10.6 shows the direct, indirect and total effects for the relationship between each personality trait and expectations to drive at up to 10km/h above the speed limit in the following twelve months, mediated by perceptions of negative personal and emotional affect.

Complete mediation was observed in relation to extraversion and openness, with the direct effects between these personality traits and expectations to drive at up to 10km/h above the speed limit non-significant ($\beta=-0.02$, $p=0.06$ for extraversion; $\beta=0.00$, $p=$ for openness). The indirect effects were statistically significant ($\beta=-0.04$, $p<.001$ for extraversion; $\beta=-0.03$, $p<.001$ for openness). This meant that a higher score on extraversion or openness was related to a lower expectation to speed at up to 10km/h above the limit in the following twelve months, with this relationship emerging as a result of drivers who scored highly on extraversion agreeing that they perceive they would experience negative emotions and personal affect if they were to perform the behaviour.

For the remaining personality traits, the relationship with expectations to drive at up to 10km/h above the speed limit was partially mediated by perceptions of negative personal and emotional affect. In the case of agreeableness (direct effect $\beta=-0.05$, $p<.001$; indirect effect $\beta=-0.09$, $p<.001$) and conscientiousness (direct effect $\beta=-0.05$, $p<.001$; indirect effect $\beta=-0.07$, $p<.001$) the larger indirect effect sizes indicate that whilst there were significant direct effects, a greater part of the total effect was operating through perceptions of negative personal and emotional affect. Thus, once again, drivers scoring highly on these personality traits had a lower expectation to speed at up to 10km/h above the limit in the following twelve months, with high levels of agreeance that they would experience negative emotions and personal affect if they were to perform the behaviour contributing to this relationship.

In comparison, whilst the model for neuroticism also revealed partial mediation by perceptions of negative personal/emotional affect, the larger direct effect size ($\beta=0.08$, $p<.001$) and the smaller indirect effect size ($\beta=0.02$, $p=0.01$) indicated that only a minimal

amount of the total effect on expectations to drive at up to 10km/h above the speed limit was explained by perceptions of negative personal/emotional affect. Furthermore, as had been observed in the models examining neuroticism in relation to perceptions of crash risk and perceptions of social norms and disapproval, a deterrence effect was not observed, indicating that drivers scoring highly on neuroticism expressed greater expectations to drive at up to 10km/h above the speed limit in the twelve months that followed; this still holds true when perceptions towards deterrents are taken-into-account.

Table 10.6 Direct, indirect and total effects for the relationship between the personality and expectations to drive at up to 10km/h above the speed limit in the following 12 months, mediated by perceptions of negative personal/emotional affect

Personality Trait	Expectations to drive at up to 10km/h above the speed limit			
	Direct Effect	Indirect Effect	Total Effect	Mediation Effect
Extraversion	-0.02	-0.04**	-0.07**	Complete
Agreeableness	-0.05**	-0.09**	-0.14**	Partial
Conscientiousness	-0.05**	-0.07**	-0.11**	Partial
Neuroticism	0.08**	0.02*	0.10**	Partial
Openness	0.00	-0.03**	-0.03*	Complete

*<0.05; **<.001

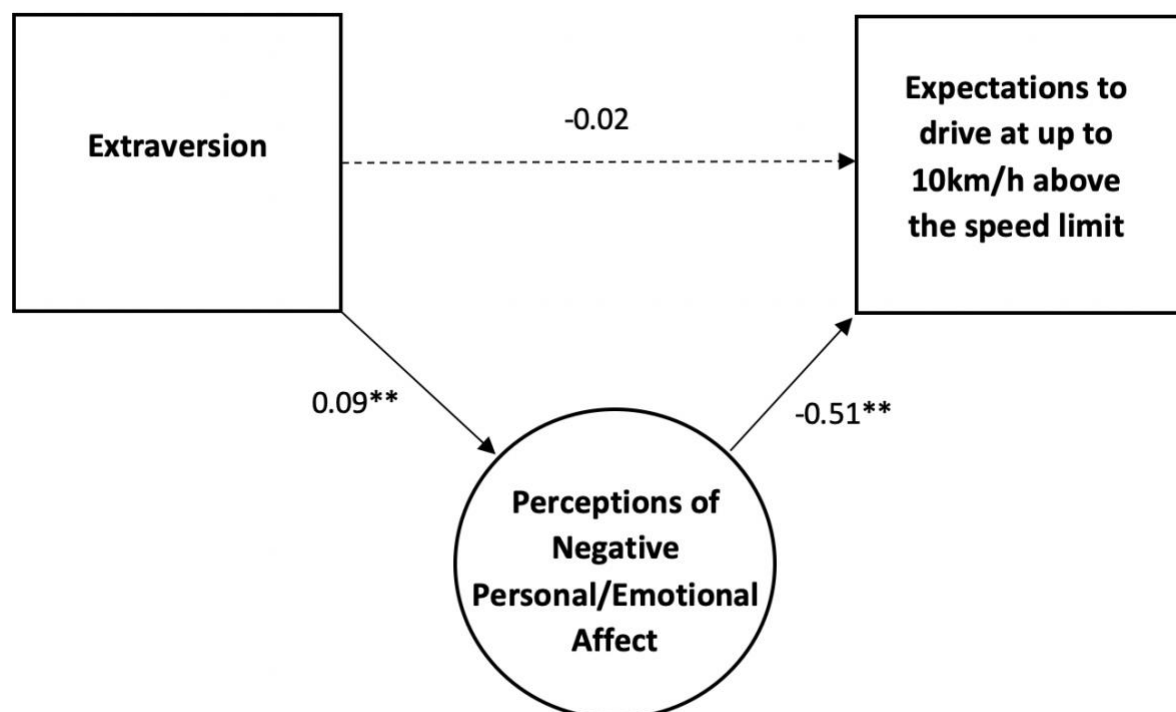


Figure 10.17 Mediating influence of perceptions of personal/emotional affect between extraversion and expectations to drive at up to 10km/h above the speed limit in the following 12 months

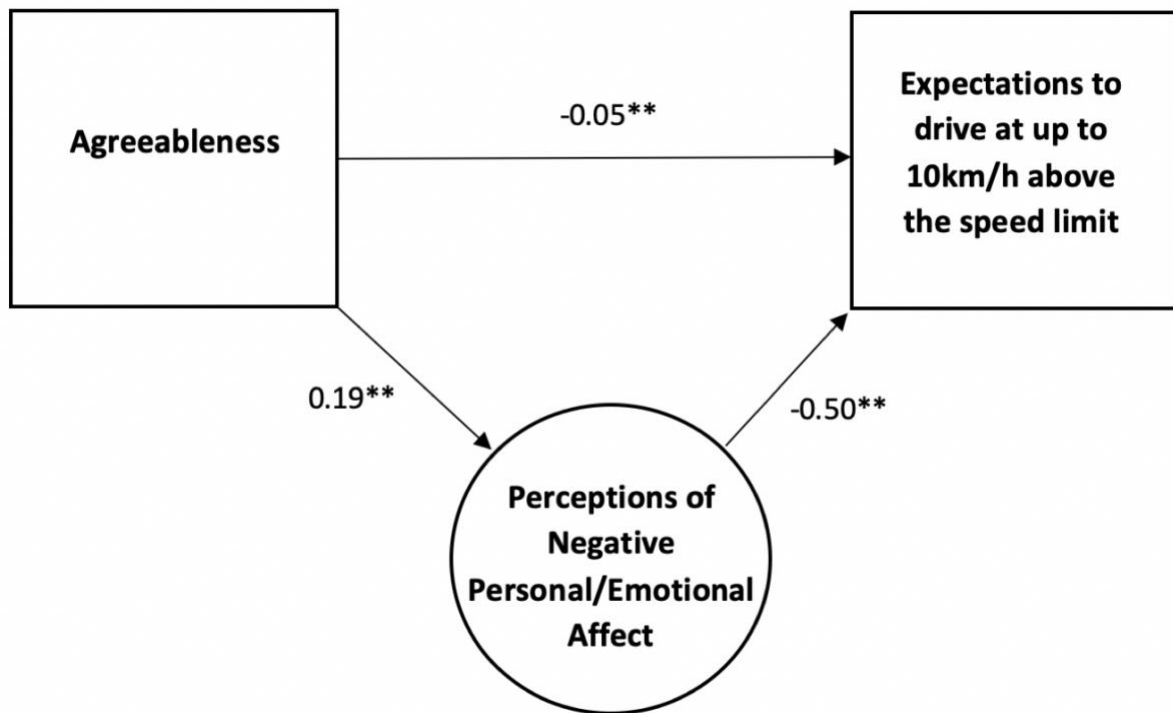


Figure 10.18 Mediating influence of perceptions of personal/emotional affect between agreeableness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

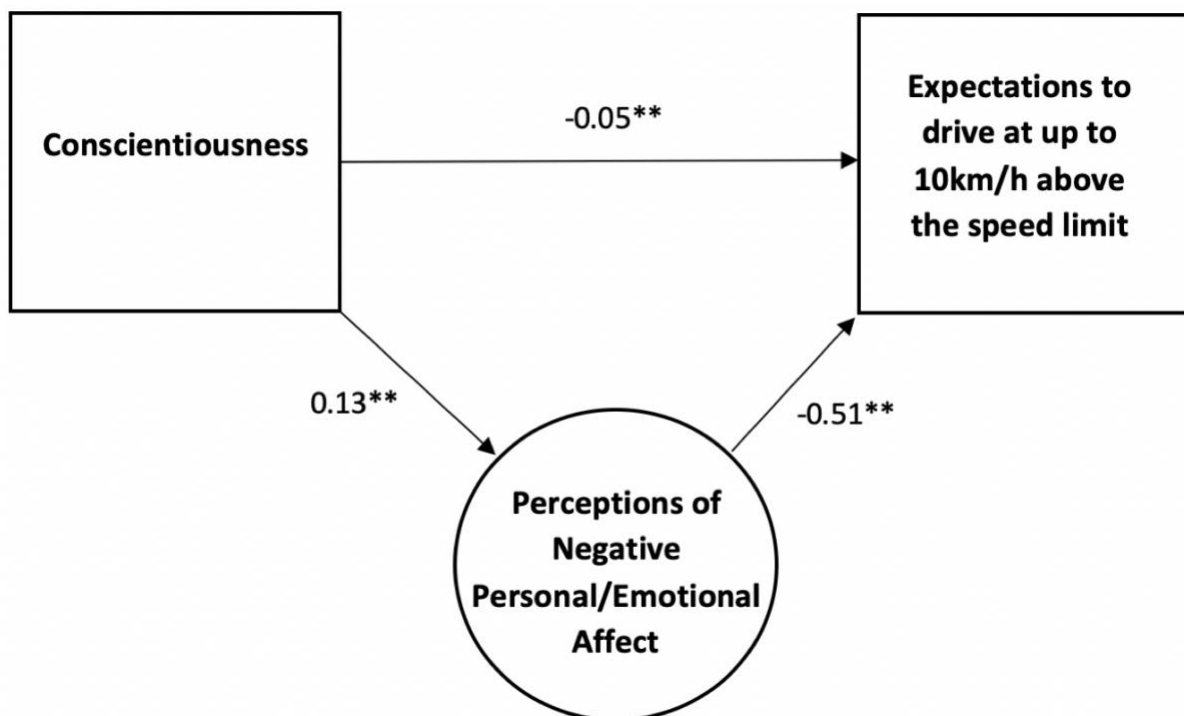


Figure 10.19 Mediating influence of perceptions of personal/emotional affect between conscientiousness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

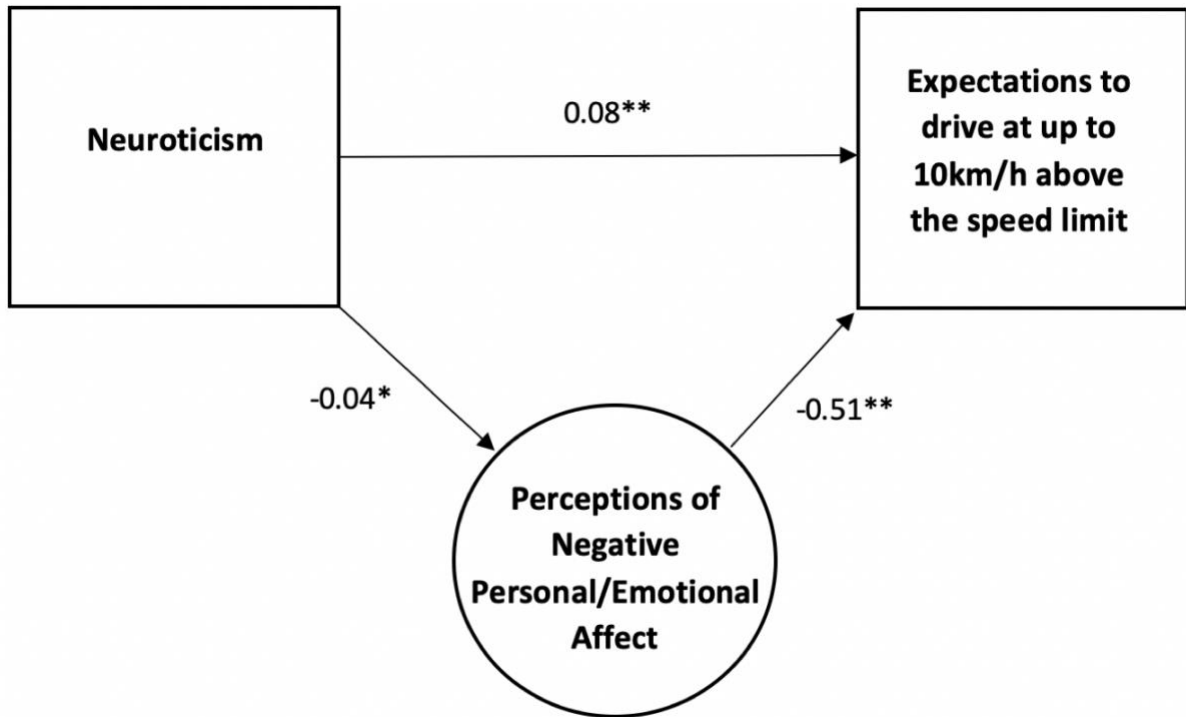


Figure 10.20 Mediating influence of perceptions of personal/emotional affect between neuroticism and expectations to drive at up to 10km/h above the speed limit in the following 12 months

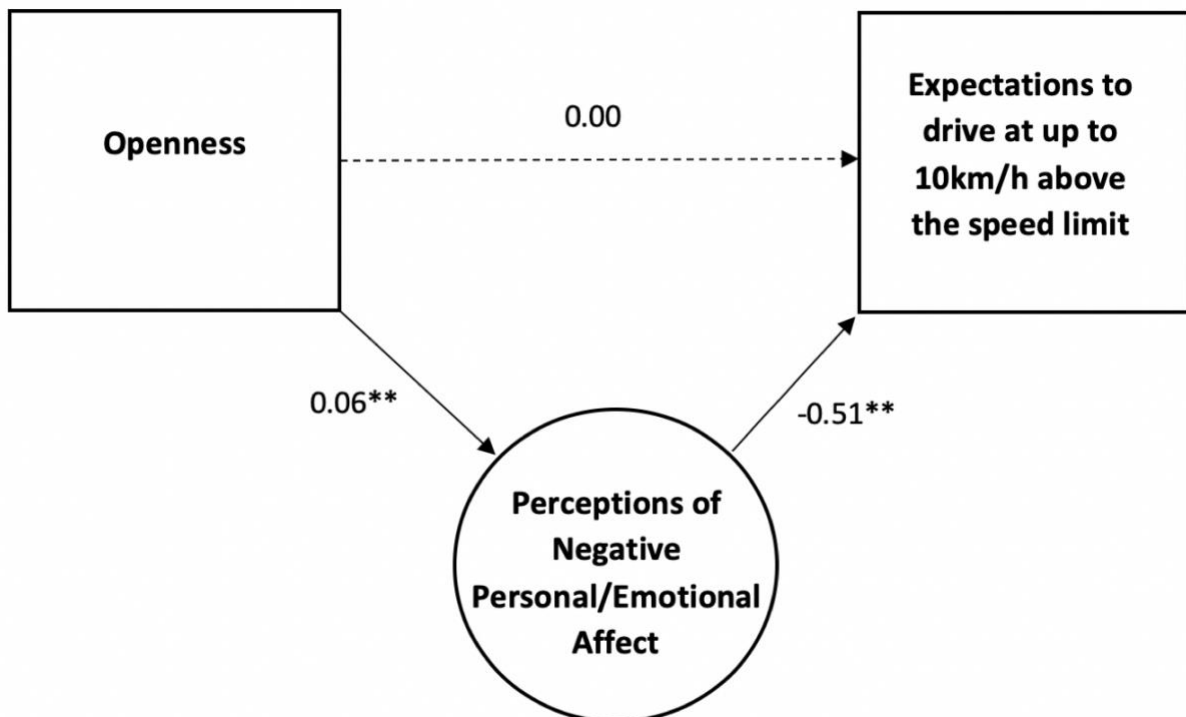


Figure 10.21 Mediating influence of perceptions of personal/emotional affect between openness and expectations to drive at up to 10km/h above the speed limit in the following 12 months

10.5 Discussion and conclusions

This study sought to examine a series of pathways in a model which proposed that perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval and perceptions of negative personal and emotional affect mediate the relationship between personality and expectations to drive at up to 10km/h above the speed limit in the following twelve months. Direct pathways between personality and expectations to drive at up to 10km/h above the speed limit in the following twelve months; personality and perceptions of enforcement, crash risk, social norms and disapproval and negative personal and emotional affect; as well as perceptions of enforcement, crash risk, social norms and disapproval and negative personal and emotional affect and expectations to drive at up to 10km/h above the speed limit were also examined.

10.5.1 Personality and deterrence

The first research question this chapter sought to address was to examine if personality has an influence on expectations to drive at up to 10km/h above the speed limit in the following twelve months. All personality traits were found to have a statistically significant (it must be noted in some cases however, weak) relationship with expectations to drive at up to 10km/h above to speed limit, with high scores on agreeableness and conscientiousness, in particular, found to be associated with lower expectations to drive at up to 10km/h above the speed limit. In other words, individuals scoring highly on these personality traits showed more positive patterns of deterrence, given their relatively low expectations to drive at up to 10km/h in the following twelve months. Comparatively, high scores on neuroticism were found to be associated with greater expectations to drive at up to 10km/h above the speed limit. In other words, individuals scoring highly on the trait of neuroticism showed less positive patterns of deterrence.

The second research question this chapter sought to address was to examine if personality has an influence on perceptions towards the potential deterrents in relation to driving at up to 10km/h above the speed limit. Scoring highly on agreeableness and conscientiousness in particular, were associated with agreement that the risks of enforcement, crash risk, social norms and disapproval and experiencing negative personal and emotional affect for driving at up to 10km/h above the speed limit were high. In other words, these drivers responded

more favourably to factors that may deter illegal driving behaviour. Similarly, drivers scoring highly on neuroticism once again showed lower levels of agreeance.

These results are consistent with studies that report that scoring highly on the traits of agreeableness (e.g. Chraif et al., 2016; Hong & Paunonen, 2009; Parr et al., 2016; Šeibokaitė et al., 2014; Starkey & Isler, 2016; Taubman-Ben-Ari and Yehiel, 2012; Thake, Armstrong & Leal, 2011; Vollrath, Knoch & Cassano, 1999; Wang et al., 2018) and conscientiousness (e.g. Chraif, Aniței, Burtăverde & Mihăilă, 2016; Hong & Paunonen, 2009; Linkov, Zaoral, Rezač, 2019; Riendeau, Stinchombe, Weaver & Bédard, 2018; Šeibokaitė, Endriulaitienė, Markšaitytė, Žardeckaitė-Matulaitienė, 2014; Starkey & Isler, 2016; Taubman-Ben-Ari and Yehiel, 2012) provides some protection from the performance of risky driving behaviours.

The results in relation to neuroticism are also consistent with existing research that has found drivers scoring highly on this trait display higher patterns of risky driving behaviour (e.g. Riendeau et al., 2018; Shen et al., 2018; Zhang et al., 2018). It is however important to note that other research has found evidence to suggest that individuals scoring highly on neuroticism display lower levels of risky driving behaviour (e.g. Hong & Paunonen, 2009; Starkey & Isler, 2016). Whilst it is difficult to determine what may be behind the differences in the relationship between personality and driving behaviour between different studies, one possible explanation that has been put forward is the influence of cultural differences (e.g. Hofstede & McCrae, 2004). Therefore, the patterns that emerged in the current research may be in part a reflection of cultures and norms that operate in Victoria, Australia.

10.5.2 Perceptions and deterrence

The third research question this chapter sought to address was to examine whether there are factors beyond legal sanctions that may influence expectations to drive at up to 10km/h above the speed limit in the following twelve months. The results that emerged showed that perceptions towards all four of the potentially deterring factors that were examined (enforcement, crash risk, social norms and disapproval and negative personal and emotional affect) have a statistically significant relationship with expectations to drive at up to 10km/h above to speed limit. Drivers who expressed perceptions that the risks of enforcement and crash risk for driving at up to 10km/h above the speed limit were high, that driving at up to

10km/h above the speed limit goes against social norms and would be disapproved of by those closest to them, and finally that they expect they would experience negative personal and emotional affect if they were to drive at up to 10km/h above the speed limit, expressed lower expectations to drive at up to 10km/h above the speed limit in the following twelve months. Perceptions of social norms and disapproval had the strongest correlation with speeding behaviour expectations. This result was consistent with many existing studies that have applied expanded models of deterrence in the road safety area, and have found that non-legal sanctions, in particular social sanctions, have an equal to or ever greater influence on the performance of illegal driving behaviours (e.g. Baum, 1999; Berger & Snortum; Freeman et al., 2016; Freeman & Watson, 2009; Grasmick & Green, 1980; Green, 1989; Loxley & Smith, 1991; Piquero & Paternoster, 1998).

10.5.3 The mediating influence of perceptions between personality and behavioural expectations

The final research question this chapter sought to address was to examine whether perceptions towards potential deterrents have a mediating influence on the relationship between personality and expectations to speed in the following twelve months.

The results showed that perceptions of enforcement, perceptions of crash risk, perceptions of social norms and disapproval and perceptions of negative personal and emotional affect in many cases mediated the relationship between personality and expectations to drive at up to 10km/h above the speed limit in the following twelve months, with some common patterns emerging. First, the relationship between extraversion and expectations to drive at up to 10km/h above the speed limit was always completely mediated, irrespective of the perceptions factor that was being examined. Second, the relationships between agreeableness and expectations to drive at up to 10km/h above the speed limit and conscientiousness and expectations to drive at up to 10km/h above the speed limit were always partially mediated, irrespective of the perceptions factor that was being examined. Third, the relationship between openness and expectations to drive at up to 10km/h above the speed limit was completely mediated by each of the perceptions factors examined, except for perceptions of enforcement, where there was partial mediation. Finally, in relation to neuroticism, the results that emerged in relation to mediation were mixed. Perceptions of crash risk and perceptions of negative personal and emotional affect partially

mediated the relationship between neuroticism and expectations to drive at up to 10km/h above the speed limit. Perceptions of social norms and disapproval completely mediated the relationship between neuroticism and expectations to drive at up to 10km/h above the speed limit. Finally, the mediating influence of enforcement between neuroticism and expectations to drive at up to 10km/h above the speed limit was non-significant.

Taken together, these results suggest that personality influences the perceptions drivers have towards enforcement, crash risk, social norms and disapproval and negative personal and emotional affect, which in turn then goes on to influence expectations to drive at up to 10km/h above the speed limit. This result is consistent with previous studies into personality and attitudes towards road safety that are expressed by drivers (e.g. Lucidi, 2014; Machin and Sankey, 2008; Mallia et al., 2015; Steinbakk et al., 2019; Ulleberg and Rundmo, 2003; Zhang et al., 2018). Despite the models examined in previous research using different personality scales and focussing on different attitudes to those used in the current study, what is evident is that the inclusion of multiple theoretical perspectives within a conceptual model can enhance understandings of factors that may interact to influence the performance of illegal driving behaviour.

The current study enhances understandings for Victoria, as not only do the results demonstrate that the personality traits that drivers possess have a significant relationship with their expectations to drive at up to 10km/h above the speed limit, the inclusion of the four perceptions factors in the conceptual model provides understandings of the process through which this relationship may emerge. By understanding how different groups of drivers respond to different deterring factors, we equip ourselves with valuable information on how drivers may be most effectively deterred.

10.5.4 How might the results of this research be used in efforts to enhance road safety?

The results suggest that whilst traditionally used legal sanctions do have an influence upon driving behaviour, and show a relationship with deterrence in many cases, embracing other avenues may also have the same or even greater benefits than what can be experienced using legal sanctions alone.

First, it may be the case that punishment is not the best method to respond to illegal driving behaviour. It may be appropriate to look at other options to encourage safe driving. For

example, in Victoria, VicRoads have a 'Free Licence Scheme' which rewards drivers for road rule compliance, by providing a free three-year full licence to drivers who have a clean driving record during their probationary period (VicRoads, 2020f). The expansion of such a program, that enables all drivers (not just those moving from a probationary to full licence) to renew their licence free of charge if they display patterns of safe driving behaviour may have benefit in encouraging drivers to use the roads safely. By providing good drivers with free licence renewals, a system where drivers are rewarded for good driving behaviour, rather than just punished for poor driving behaviour may see the community truly embrace a very material benefit (i.e. the avoidance of significant costs that would otherwise be incurred to renew a driver's licence) of obeying road rules. The effectiveness of such a system would need to be evaluated, however.

Second, another option that may help to encourage safer road use would be to highlight the consequences of illegal driving behaviour from a social perspective. In Victoria, the Transport Accident Commission has a long history of using social marketing (advertisements) to emphasise the consequences of illegal driving behaviour (e.g. Cameron et al., 1993; Transport Accident Commission, 2020b). These include the risks of crashing, and the physical and emotional harm that crashes result in, not only for those directly involved, but also their families, when an individual experiences life changing injuries, or loses their life.

One campaign in particular attempts to highlight that illegal driving behaviour can result in disappointment and disapproval from family or friends. The advertisement, which appeared on free to air television in Victoria, Australia in recent years shows a young man driving his grandmother home from a family gathering (see Transport Accident Commission, 2020a to view the advertisement). The man undergoes a roadside drug test and is found to be positive to an illicit substance. The advertisement then returns to an image of his grandmother waiting in the vehicle, who appears to be shocked and surprised. Thus, whilst this campaign highlighted the legal consequences of illegal driving behaviour, given the focus on roadside drug testing, images of the family gathering and also the man's grandmother show that illegal driving behaviour also comes with social consequences, specifically disapproval from family members. These consequences come in addition to the

traditional legal consequences a driver can expect to experience and indeed did experience in the images portrayed in this advertisement.

Further use of campaigns of this nature, that highlight the consequences of illegal driving behaviour beyond legal sanctions may have a positive influence in deterring a wider group of drivers than legal sanctions can achieve alone. Furthermore, disapproval from family, friends and peers for illegal driving behaviours may come more swiftly than legal sanctions can, and may therefore have a more immediate effect on deterring further illegal driving behaviour.

Third, whilst personality is unfortunately not a factor that can be influenced to achieve change, the results of this study provide us with an understanding of the personality traits of drivers who do not respond positively to deterring factors and who are at higher risk of offending. This presents a possible point of intervention.

There is a body of research which indicates that different personality types vary in how they learn and take in information (e.g. Bidjerano & Dai, 2007; Vincent & Ross, 2001; Zhang, 2003). Research has found that individuals scoring highly on neuroticism tended to prefer web-based learning than in person learning (Caspi et al., 2006). Furthermore, neurotic individuals have also been found to show preference to a 'surface learning approach' where they are only interested in learning the minimum amount of information required. This can be compared with the 'deep learning approach' where individuals have a desire to delve deep into a topic (Chamorro-Premuzic, Furnham & Lewis, 2007). Neurotic individuals have also been identified as more susceptible to mind-wandering, poor memory capacity and shorter attention span (Robinson, Gath & Unsworth, 2017). As indicated, individuals scoring highly in neuroticism expressed perceptions and behavioural expectations that were not indicative of being deterred. Such information may prove useful when responding to individuals with lengthy histories of illegal driving behaviour in particular. For example, driver education programs may find value in designing their content around specific personality traits and the ways in which individuals scoring highly on these traits learn best. For drivers scoring highly on neuroticism, interventions may be designed around delivering education online, providing a broad overview of topics, and ensuring programs are interactive, to avoid mind-wandering and loss of attention, as much as possible. The careful

development and testing of such interventions may provide another opportunity to enhance safety on the roads.

Despite personality not being amendable to change, this does not mean that drivers, irrespective of the personality traits they display, cannot change their behaviour. Behaviour change theories have long proposed that changes in behaviour may be possible in a range of areas, including in the area of driver behaviour (e.g. Dykstra, Davis & Conlon, 2020; Freeman et al., 2005a; Freeman et al., 2005b; Kowalski, Jeznach & Tuokko, 2014; Ouimet et al., 2010; Sinelnikov & Wells, 2017). Continued application of behaviour change theoretical models and perspectives to road safety, including to speeding behaviour, may ensure that strategies and interventions which are put in place have the greatest potential to create change and ultimately achieve success in improving safety on the roads.

10.5.5 Strengths and limitations of the research

The current study has many strengths that make it valuable in enhancing the understandings of driver characteristics and perceptions that may underlie speeding behaviour in Victoria, Australia. First, the study had a relatively large sample size of just over 5100 drivers. Second, data were collected from drivers across the state of Victoria, both males and females, young drivers all the way through to older drivers, drivers newly licensed and those with many years of experience. Thus, the study sample was comprehensive and data were collected from a very diverse group of drivers. Third, the range of variables used, which took into account driver characteristics (personality) and driver's perceptions (enforcement, crash risk, social norms and disapproval and negative personal and emotional affect) meant that the study was able to take a broad view of driver behaviour and combine theoretical perspectives. Given a criticism of existing research has been its tendency to focus on driver behaviour from a somewhat narrow perspective, it is hoped this study is able to provide new insights into the Victorian driver population.

Despite these strengths, there are also some limitations that should be considered when interpreting the results. The first limitation is one which has been emphasised previously in this thesis. This relates to the use of data collected from licensed drivers in Victoria, Australia. Given traffic rules are enforced at a jurisdictional level, it is possible that this may influence perceptions towards enforcement in particular (for example higher levels of

enforcement may mean drivers perceive their risks of apprehension to be greater). Furthermore, given data were collected in relation to perceptions towards factors such as social norms and disapproval and negative personal and emotional affect, it may be the case that different cultures and groups of people have different expectations about what is and is not socially acceptable behaviour, as well as the subsequent emotions they expect to experience. These factors may influence the generalisability of the results of this study beyond Victoria.

Second, the analyses presented in this chapter examined the pathways in the developed theoretical model in relation to driving at up to 10km/h above the speed limit. Whilst low level speeding is one of the most common illegal behaviours drivers perform on the roads, it is unclear whether the same pathways would hold true for other offence types. Future research that focuses on examining these pathways for a broader range of offence types, in particular offences with more severe legal and social consequences, may be valuable (it is notable the survey used to collect data for this PhD did collect data on other offence types, but the nature of PhD research meant it was not possible to consider all offences). Such research may help to ensure that any strategies put in place to respond to specific offence types are based on the factors that have the greatest potential to have an influence on their performance.

Third, in the survey (and subsequently the analyses) the construct of perceptions of enforcement was considered in terms of certainty of sanctioning and severity of sanctioning. As was noted in chapter three, swiftness of sanctioning is another aspect of traditional deterrence theory. The decision not to include swiftness of sanctioning was based upon deterrence research that suggests its impact on effective deterrence is questionable (e.g. Nagin, 2013).

Fourth, the current study used data collected from a self-report survey. Whilst self-report methods of data collection have many advantages, there are also many disadvantages. Respondents may have rushed through the survey and given little thought to their responses, misread questions, may not have been eligible to participate (but nonetheless did), may not have an awareness of their own behaviour or simply may not have been truthful. Indeed, this final limitation may be of particular significance given many drivers may not have been willing to acknowledge they may drive in an illegal manner in the future,

given the sensitivity of the topic. Each of these limitations of self-report data may have had an influence on the quality of the data used in the analyses, and subsequently the accuracy of the results presented.

10.5.6 Areas for future research

Whilst some of the limitations of self-report data are very difficult to address, some can be addressed in future research. For example, self-report data could still be used to collect personality and perceptions data. However, in terms of future performance of an illegal driving behaviour, such as speeding at up to 10km/h above the speed limit, a data linkage study, where the self-report data collected in the survey is linked with official driver records, to see if there are any traffic infringements in a relevant period may prove useful.

A naturalistic driving study may also prove useful in examining the relationships between personality, perceptions and driver behaviour. Naturalistic driving studies involve observing drivers as they travel in their 'natural' driving environment, where factors such as the roadway, vehicle, vehicle occupants and traffic are as they would be when a driver is not under observation (e.g. Eby, 2011; Foss & Goodwin, 2014; Guo, 2019; Guo et al., 2010; Stutts et al., 2005). Observation can take place either in real time, with the researchers observing drivers at the exact time specific driving behaviours are occurring, or alternatively, recording equipment may be used to capture footage, which is then observed by a researcher at a time that follows the actual behaviour occurring (e.g. Eby, 2011; Hanowski, Perez & Dingus, 2005; Klauer, Perez & McClafferty, 2011; Kuo et al, 2016). Naturalistic driving studies have the advantage that they directly observe behaviour, rather than rely on self-reporting (e.g. Eby, 2011). It is important to note that in this case it may not be possible to examine some offence types. For example, use of alcohol and illicit drugs outside of the vehicle would go undetected. It would, however, prove useful to examine behaviours such as speeding, failing to stop at a red light or stop sign, handheld mobile phone use while driving or tailgating.

Finally, future research could be undertaken in other jurisdictions, applying the model and using the survey developed in the current study. Not only would such research enhance understandings in individual jurisdictions, it may also provide a valuable opportunity for comparisons across jurisdictions. Indeed, if differences were to emerge, an analysis of the

factors that may be underlying these differences would also be beneficial to furthering understandings.

10.5.7 Conclusions

In conclusion, the results of the current study showed that personality type and the perceptions drivers hold towards enforcement, crash risk, social norms and disapproval and negative personal and emotional affect have an influence on expectations to drive at up to 10km/h above the speed limit in the following twelve months. Furthermore, perceptions of enforcement, crash risk, social norms and disapproval and negative personal and emotional affect have a mediating influence between personality and expectations to drive at up to 10km/h above the speed limit in the following twelve months, with only one exception observed (the relationship between neuroticism and expectations to drive at up to 10km/h above the speed limit was not mediated by perceptions of enforcement).

The results of this study have provided valuable information on how personality and factors beyond legal sanctions might be used in efforts to deter any initial involvement in illegal driving behaviour, as well as respond to drivers who have already performed illegal driving behaviours in the past, and in some cases have accumulated lengthy driving histories. If drivers at greatest risk, by reason of the personality traits they possess or the perceptions they express can be persuaded to take on responsible driving habits, the community is given the best opportunity possible to have access to a safe road network.

Chapter Eleven: Discussion and conclusions

This chapter provides a discussion and draws conclusions to the research presented in this thesis. The chapter starts with an overview of the frameworks that guided the research and reviews the broad thesis aims. Next, each of the three studies are summarised, including a brief overview of results, and comparisons drawn to existing research. Following this, key themes from the research are discussed. The chapter then moves to considering the strengths and limitations of the research overall, including areas where future research may be advantageous. Finally, this chapter provides a discussion on the overall implications of the research before finishing with some thoughts on the broader context of improved safety on the roads.

11.1 Frameworks that guided the research

The research reported in this thesis was guided overall by the Safe System Approach, Haddon's Matrix and deterrence theory. The Safe System Approach to road safety identifies safe road users as one essential ingredient to a safe road network, alongside safe roads, safe vehicles and safe speeds (e.g. Australian Transport Council, 2011; Organisation for Economic Co-operation and Development, 2008; United Nations Road Safety Collaboration, 2010).

Haddon's Matrix (Haddon, 1972, 1980) conceptualises risk factors for crashes and recognises the role of road users' attitudes and behaviours at the pre-crash phase (Mohan et al., 2006). Deterrence Theory (e.g. Hucklesby, 2004; Muncie, 2004) complements both the Safe System approach and Haddon's Matrix. Drawing upon these existing frameworks, a newly developed conceptual model, described in chapter three, provided the overarching framework for this thesis, and proposed a number of pathways in which deterrence may operate in relation to driver behaviour.

First, the model encapsulated the already well-established relationship between illegal driving behaviour and infringements. In other words, if drivers perform an illegal driving behaviour, they may receive an infringement. Furthermore, the model also proposed that the relationship between illegal driving behaviour and infringements operates in the opposite direction, and that deterrence may impact this relationship. In other words, drivers are aware infringements operate and so may change their behaviour to avoid receiving an

infringement. The influence of infringements on illegal driving behaviour was investigated in studies one and three.

Second, the model included a relationship between illegal driving behaviour and crashes. Taking this relationship into account, in addition to the relationship already noted above, the conceptual model proposed relationships between: a) infringements and deterrence of illegal driving behaviour; and b) illegal driving behaviour and crashes. It is this relationship, specifically that infringements may impact illegal driving behaviour, and subsequently influence crash risk, that was assessed in study two.

Finally, the model included a relationship between crashes and illegal driving behaviour (i.e. drivers may change their driving behaviour after a non-fatal crash). However, exploration of this relationship was beyond the scope and aims of this thesis.

Given the complexities of study three, which examined factors beyond legal sanctions, this study was also guided by a more detailed conceptual model. This model (introduced in chapter three) combined personality, perceptions of potential deterrents (enforcement, crash risk, social norms and disapproval, and negative personal and emotional affect) and behavioural expectations. Further discussion on how this conceptual model was applied is covered in the Section 11.3.3 of this chapter.

11.2 Broad aims of the research

Guided by the theoretical frameworks outlined above, the thesis had three broad aims:

- 1) To assess whether receiving an infringement for a driving offence has the desired effect of deterrence
- 2) To assess whether perceptions in relation to illegal driving behaviour have a deterring influence
- 3) To determine whether potential deterring factors differ depending on driver characteristics

To address these aims, two data sources were used:

- 1) Administrative data: consisting of a series of separate VicRoads data sets. These contained information from Victoria on licensing (full licence history), infringements (records of any traffic infringement notices for driving offences that a driver had received) and crashes (information on all police reported crashes).

- 2) Online survey: designed as part of this thesis, to collect information on personality, perceptions towards four potentially deterring factors (enforcement, crash risk, social norms and disapproval, negative personal and emotional affect) and expectations to perform illegal driving behaviours. Data were collected from 5,108 licensed drivers in Victoria, Australia.

In order to address the aims, three separate, but closely related studies were undertaken. The following section provides discussion on each of the three studies.

11.3 Summary of studies undertaken, key findings and contributions to road safety

11.3.1 Study One – The deterring influence of traffic infringements upon future driver behaviour, as evidenced by subsequent traffic infringements

11.3.1.1 Overview of study

Study one was focused on the deterring influence of traffic infringements, as evidenced by a reduction in subsequent driver offending behaviours in the twelve months that followed an infringement. This study answered two key research questions:

- 1) Do driver and offence characteristics, including gender, age at first licence, years licensed, licence type, demerit points and offence type have a relationship with the length of time to next offence, within twelve months?
- 2) Is time to next offence within twelve months associated with the number of previous offences a driver has?

The study examined the entire licence history of drivers considered in the analysis, using a *time to event* analysis methodology, to determine the length of time between infringements, and whether this time changed based on previous offence type, number of previous offences and driver characteristics. The VicRoads licensing and infringements data sets were used, with the two data sets linked by driver licence number.

Study one is valuable for enhancing understandings of the effectiveness and limitations of the current enforcement system and penalty system in Victoria, Australia. In particular, the study examined to what extent to which the current system successfully deters the performance of further illegal driving behaviours after a driver has been infringed. The study therefore explored the concept of *specific deterrence*, which as explained in chapter three is

focussed on deterring individuals after they have already come to the attention of enforcement authorities.

11.3.1.2 Key findings

Time to reoffending in the twelve months that followed an infringement was longer for females than males, but only following the first and second offences. Drivers who were licensed at a younger age or who had held their licence for a shorter length of time had a shorter time to reoffence in comparison to drivers first licensed at an older age or drivers who had held their licence for a longer period of time. Demerit points were found to have a relationship with time to reoffending: receiving a higher number of demerit points appeared to have a deterrent effect on reoffending amongst new offenders, with longer time to reoffending when a greater number of demerit points were given to drivers following their first offence. This pattern did not continue for drivers with multiple previous offences: when accumulated demerit points were examined, the time to reoffending was actually shorter for drivers with a higher number of accumulated demerit points.

Analysis results also suggested that drivers with extensive offending histories became increasingly difficult to deter. Whilst around 27 per cent of drivers reoffended within one year of their first offence, the proportion rose to around 43 per cent for drivers following the fifth offence. The pattern of accumulated demerit points and shorter time to reoffending provided further evidence of this.

11.3.1.3 Comparisons to previous research

The patterns that emerged in study one showed both consistencies and differences with existing research that has examined driver behaviour. Detailed comparisons to existing research were provided in the discussion contained in the journal paper included in chapter five. Comparisons with one study in particular deserve further mention here.

The current research sought to build upon the work of Haque (1990). As was discussed in chapter five, a number of changes have taken place in road laws and enforcement approaches in Victoria in the thirty-years since Haque's study was undertaken. Thus, the current study sought to provide understandings on traffic reoffending in the current Victorian context of laws, their enforcement and associated penalties. It was in drawing

comparisons to the Haque (1990) study that perhaps the most interesting results of the current research emerged.

Whilst Haque (1990) found that a greater number of accumulated demerit points had a positive effect on deterrence from further traffic offending, the current research found evidence that suggested the opposite. Drivers with a higher number of accumulated demerit points had a shorter time to further offending, suggesting they were not being successfully deterred. This is not to say that demerit points lead to drivers engaging in further traffic offending, but rather represent a group of drivers with greater risk-taking propensity.

Unfortunately, it was not possible to conclude whether the differences between the Haque (1990) study and the current research were due to changes in patterns of deterrence (i.e. it becoming more difficult to deter drivers) or rather methodological differences, in terms of factors such as length of follow up and the groups of drivers who were eligible for inclusion.

Despite this, study one of this PhD provides valuable information about traffic offending and deterrence in the current road law enforcement environment in Victoria, Australia. In particular, it was evident that the current system is working well for drivers with few offences, but is failing to have a meaningful impact on those with more extensive offending histories. This points to a group of drivers for whom greater focus needs to be given if deterrence is to be achieved. This is therefore in some ways consistent and in some ways inconsistent with the overall thesis framework, which proposed that if infringements were achieving deterrence further offending would not be observed.

11.3.2 Study Two – The deterring influence of traffic infringements upon future driver behaviour, as evidenced by subsequent crash involvement

11.3.2.1 Overview of study

Study two was focussed on examining the deterring influence of traffic infringements upon subsequent crash involvement. This study addressed two key research questions:

- 1) Is there an association between receiving an infringement for a driving offence and subsequent crash involvement?

- 2) Are driver and offence characteristics associated with subsequent patterns of crash involvement in the period following an infringement for a driving offence being received?

The study applied an innovative research design, the case-case-time-control study design, which is an extension of the case-crossover design previously applied to examine the traffic infringement and crash relationship (Davis et al., 2018; Redelmeier, Tibshirani and Evans; 2003; Walter and Studdert, 2015). The VicRoads licensing, infringements and crash data sets were used, with all three linked by driver licence number.

Like study one, study two is also valuable for enhancing understandings of the effectiveness and limitations of current laws, enforcement and associated penalties in Victoria, this time by examining crash involvement in the period that follows a driver receiving a traffic infringement. Thus, study two also explored the concept of *specific deterrence*.

11.3.2.2 Key findings

Results of study two suggested that there is an association between receiving an infringement for a driving offence and subsequent crash involvement. Overall, the odds of receiving an infringement in the month prior to a crash were 35 per cent higher than receiving an infringement in the same month the year prior when no crash had occurred, for the case group, adjusted for change over time in the control group (OR = 1.35, 95% CI 1.17 – 1.57). These results showed that not only was there an association, but that this association went in the opposite direction of what would be expected if deterrence was operating. Had deterrence been operating, we would have expected to see a lower odds of infringement in the one-month period just prior to a crash. This is therefore not consistent with the overall thesis framework, which proposed that if infringements were achieving deterrence, crash risk would be reduced.

A number of sub-analyses were undertaken in relation to gender, age, area of residence, specific offence types and number of demerit points. Each of these analyses showed that the odds of receiving an infringement in the one-month prior to a crash occurring were greater, consistent with the overall result of there being no evidence of deterrence operating.

Existing research has suggested that drivers may experience “gamblers fallacy”, where they believe that the chances of being apprehended within quick succession of a previous offence are small (Pogarsky & Piquero, 2003). Thus, the results of study two may suggest that in the period that followed drivers receiving an infringement for a traffic offence, their subsequent driving patterns were risky, as they possibly believed the chance of a further infringement was small. This risky driving behaviour may have resulted in a crash. It is not possible to conclude whether “gamblers fallacy” underlies the patterns observed however.

Indeed, these results should not be taken to suggest that receiving an infringement for a driving offence is a risk factor for crashes. Perhaps a more plausible explanation is that which was suggested by Walter and Studdert (2015). They proposed that infringements likely reflect a period of risky driving behaviour, and that during this period, the degree of risk is particularly strong, such that infringements are unable to achieve deterrence.

Finally, it is possible that drivers were involved in a crash before they even received their infringement in the mail. Of course, deterrence can only take effect if an individual knows they have received an infringement.

11.3.2.3 Comparisons to previous research

Study two built upon three existing studies in particular, these being the case-crossover studies that explored the relationship between infringements and crashes, undertaken by Redelmeier, Tibshirani and Evans (2003), Walter and Studdert (2015) and Davis et al. (2018). The results in the current research were consistent with the results identified by Walter and Studdert (2015) and Davis et al. (2018). Those two studies, along with the current research each found that the odds of being involved in a crash in the month after receiving a traffic sanction were greater when compared with the same one-month period in the year prior. On the other hand, Redelmeier, Tibshirani and Evans (2003) found the opposite. In the one-month period that followed a driver receiving a sanction for a driving offence, their risk of crash was lower than in a comparable one-month period the year prior.

It is not clear what factors may have contributed to the different results that were uncovered by Redelmeier, Tibshirani and Evans (2003) when compared to the current research and the two studies undertaken by Walter and Studdert (2015) and Davis et al. (2018). One possible difference is that whilst Redelmeier, Tibshirani and Evans (2003)

included only fatal crashes, the other studies, including the current research did not exclusively focus on fatal crashes.

The current research builds on the existing body of literature by demonstrating application of the case-case-time-control study design, thereby controlling for factors that were not controlled for in previous studies using the case-crossover study design. This is particularly important given enforcement patterns can change over time, and such changes may increase or decrease the risk of being apprehended.

11.3.3 Study Three – The influence of personal characteristics and perception towards possible deterrence, upon self-reported expectations of future traffic offending

11.3.3.1 Overview of study

The third study undertaken as part of this PhD research examined factors beyond infringements that may deter illegal driving behaviour. A conceptual model was developed that included a number of pathways, based upon the existing body of literature. The theoretical model proposed that perceptions towards potential deterrents (enforcement, crash risk, social norms and disapproval and negative personal and emotional affect) may have a mediating influence on the relationship between personality, as measured by the Big Five Model (agreeableness; conscientiousness; extraversion; neuroticism; openness) and expectations an individual has to perform an illegal driving behaviour. Direct pathways between factors were also included in the theoretical model. The study addressed four key research questions:

- 1) Does personality have an influence on expectations to speed in the following twelve months?
- 2) Does personality have an influence on perceptions towards potential deterrents in relation to speeding in the following twelve months?
- 3) Are there factors beyond legal sanctions that may influence expectations to speed in the following twelve months?
- 4) Do perceptions towards potential deterrents have a mediating influence on the relationship between personality and expectations to speed in the following twelve months?

This study has value in enhancing understandings of factors beyond the traditionally used legal sanctions that are administered to drivers who behave illegally on the roads. Additionally, the study also has value in showing how personality may influence these factors.

An online survey was developed and used to collect data for study three. Whilst descriptive statistics were provided in chapter nine for all six offence types (drink driving; drug driving; driving up to 10km/h above the speed limit; driving at more than 10km/h above the speed limit; using a handheld mobile phone whilst driving; failing to stop at a red light), a mediated regression analysis was only undertaken for *speeding at up to 10km/h above the speed limit* (termed speeding for the remainder of this section). This was the most prevalent offence type identified in the data set. The summary here will focus on the modelling results, rather than the results in the descriptive chapter.

11.3.3.2 Key findings

Significant correlations were observed between all Big Five personality traits and expectations to speed in the twelve-months that followed. Scoring relatively high on extraversion, agreeableness, conscientiousness, and openness were associated with lower expectations drive at up to 10km/h above the speed limit in the following twelve months. Comparatively, scoring relatively high on neuroticism was found to be associated with higher expectations to drive at up to 10km/h above the speed limit in the following twelve months.

Personality was also found to have a significant relationship with perceptions of the potential deterrents (enforcement, crash risk, social norms and disapproval, negative personal and emotional affect). Drivers scoring relatively high on agreeableness and conscientiousness in particular expressed perceptions that were consistent with deterrence from both legal and non-legal sanctions. Conversely, drivers scoring highly on neuroticism expressed perceptions that were not consistent with deterrence from both legal and non-legal sanctions.

Factors other than legal sanctions were also found to be associated with lower expectations to speed in the twelve months that followed. Of the four perceptions variables that were examined (perceptions of enforcement, crash risk, social norms and disapproval and

negative personal and emotional affect), perceptions of social norms and disapproval were found to have the strongest correlation ($r=-0.72$, $p<.001$) with expectations to speed in the following twelve months. The remaining two perceptions variables that related to non-legal sanctions (perceptions of crash risk ($r=-0.50$, $p<.001$) and perceptions of negative personal and emotional affect ($r=-0.51$, $p<.001$)) had correlations that were similar in strength to perceptions of enforcement ($r=-0.49$, $p<.001$) when their relationship to expectations to speed was examined. Thus, the results suggest that there factors other than legal sanctions that may have a relationship with drivers' expectations to speed.

Finally, it was found that perceptions towards the four potentially deterring factors examined did have a mediating influence on the relationship between personality and expectations to speed in the following twelve-months in a number of cases. Specifically, the relationship between extraversion and expectations to speed was completely mediated by all four perceptions factors. The relationships between agreeableness and expectations to speed and conscientiousness and expectations to speed were partially mediated by all four perceptions factors. The relationship between openness and expectations to speed was completely mediated by three of the perceptions factors examined. The fourth (perceptions of enforcement) partially mediated the openness and expectations to speed relationship. Finally, in terms of the relationship between neuroticism and expectations speed, two of the perceptions factors (crash risk and negative personal and emotional affect) partially mediated the relationship, one perceptions factor (social norms and disapproval) completely mediated the relationship and one perceptions factor (enforcement) was non-significant.

Overall, these results suggest there is evidence associations exist between personality, perceptions towards the potential deterrents and drivers' expectations to speed in the twelve months that follow.

11.3.3.3 Comparisons to previous research

The results of study three support the existing literature in a number of ways. First, as was proposed by Nagin and Paternoster (1993), research may be enhanced by combining theories of crime and offending together. This was indeed the case in the current research. The research could have taken one of two approaches. First, relationships between the Big-

Five personality traits and expectations to speed could have been examined in isolation. Second, relationships between the four perceptions towards potential deterrent factors (perceptions of enforcement, crash risk, social norms and disapproval and negative personal and emotional affect) and expectations speed could have been examined in isolation.

Had such approaches been taken, the results that emerged would not have provided the insights that were generated by combining the two perspectives together. By only including personality (and excluding the perceptions factors) the process through which each trait is related to expectations to speed would have been missed. By including only perceptions towards the potentially deterring factors (i.e. excluding personality), the research would have missed how different personality traits influence these perceptions, which then go on to influence expectations to speed. By combining both personality and perceptions towards the potential deterrents, richer understandings emerged.

The results of this research also support the existing research that has examined personality and attitudes towards road safety expressed by drivers (e.g. Lucidi, 2014; Machin and Sankey, 2008; Mallia et al., 2015; Steinbakk et al., 2019; Ulleberg and Rundmo, 2003; Zhang et al., 2018). Previous research used different personality scales and examined different sets of attitudes and perceptions to the current study, making direct comparisons difficult. What is consistent across all studies is that the attitudes and perceptions that drivers hold mediate the relationship between personality and driving behaviour or expectations of driving behaviour. This again provides support for combining multiple theories and perspectives together, given such an approach increases levels of understanding in relation to driver behaviour.

11.4 How have the three studies addressed the thesis theoretical framework and aims?

The summaries above provided a brief overview of the results that emerged from the three studies undertaken as part of this PhD, based on the research questions each sought to address, as well as how they fit within the existing body of literature. What is also important to examine is the extent to which the findings have supported the proposed relationships in the overall thesis conceptual framework, the study three conceptual model and also how the overall thesis aims have been addressed. To reiterate, the thesis aims were: 1) To assess whether receiving an infringement for a driving offence has the desired effect of

deterrence; 2) To assess whether perceptions in relation to illegal driving behaviour have a deterring influence; and 3) To determine whether potential deterring factors differ depending on driver characteristics. Aim one was addressed in studies one and two and aim two was addressed in study three. Aim three was addressed in all studies.

The results that emerged in study one, where some groups of drivers were found to be deterred following a traffic infringement (e.g. female drivers, drivers licensed at an older age and drivers who had held a licence for a considerable period of time) whilst others were found to be not deterred (e.g. newly licensed drivers) address aims one and three. In other words, the study assessed both whether receiving an infringement for a driving offence has the desired effect of deterrence and whether potentially deterring factors differ depending on driver characteristics. This study also addressed the relationship proposed in the thesis conceptual framework that connected infringements and illegal driving behaviour, and whether deterrence was operating to influence this relationship. The outcome was that infringements do have the desired effect of deterrence, but that this deterrent effect was only evident amongst some groups of drivers.

The results that emerged in study two, where the odds of receiving an infringement in the one-month period prior to a crash were greater than in a comparable one-month period the year prior, with this pattern observed across numerous driver characteristic groups (e.g. males, drivers of all groups) also indicates that aims one and three were addressed. This study also addressed the relationship that was proposed in the thesis conceptual framework, where infringements may deter illegal driving behaviour, which in turn may influence risk of crash involvement. The results suggest a lack of evidence to be able to conclude that infringements for traffic offences do have a deterring influence (aim one), with to some extent patterns differing based on driver characteristics (e.g. significant results for males, but not for females (aim three)). It is important to re-emphasise that this does not mean infringements lead to further infringements and subsequently crashes. Rather, these results suggest that, for some drivers, the desired outcome of infringements (i.e. safer patterns of driving behaviour) are not being achieved. For these drivers, it is important to consider other options that may have the potential to influence their driving behaviour and encourage deterrence from further traffic offending.

The results that emerged for study three, where perceptions in relation to illegal driving behaviour (perceptions of enforcement, crash risk, social norms and disapproval and negative personal and emotional affect) were all found to have a deterring effect addressed aim two. Specifically, study three showed that perceptions of both legal and non-legal sanctions have the potential to influence deterrence. When these perceptions were considered as mediating variables between personality and expectations of speeding behaviour in the following twelve months, as was proposed in the conceptual model developed for this study, some drivers were found to express perceptions not consistent with deterrence. This result therefore addresses aim three. Thus, it could be concluded that perceptions do have a deterring effect, but that this deterring effect is only observed in some groups of drivers (e.g. drivers scoring relatively high on personality traits such as agreeableness and conscientiousness). In addition to examining the pathways in the conceptual model developed specifically for this study, the study also enabled further exploration of the pathways between infringements and illegal driving behaviour and how deterrence may operate to influence this relationship.

Thus, taken together, all three aims were successfully addressed and all proposed relationships in the conceptual models were successfully examined in one or more of the studies conducted. In addressing these aims and examining the relationships in the conceptual models, important insights into deterrence and driving behaviour have been uncovered. The results have potential implications for road safety policy and enforcement. These implications are explored in the section that follows.

11.5 What are the potential implications of the results from the three studies?

Having explored the key results of each of the three studies, a number of key themes emerge. These key themes are: 1) No single factor can successfully achieve deterrence amongst *all groups* of drivers; 2) there is a group of drivers for whom deterrence seems particularly difficult to achieve; 3) drivers appear to go through risky driving periods, and these periods present an opportunity for intervention; and 4) when considering new interventions that could be introduced, it is important to think broadly, rather than rely on legal sanctions. Each of these themes are outlined below and discussion is provided on their implications for road safety.

11.5.1 No single factor can successfully achieve deterrence amongst all drivers

The results of this PhD research demonstrated that there is no single factor (e.g. infringements, concern about being involved in a crash, concern about experiencing negative emotions) that can successfully achieve deterrence amongst *all* drivers. The current sanctioning system that operates in Victoria, Australia, similar to that in many other jurisdictions globally, focusses on the use of legal sanctions (most commonly traffic infringements with varying levels of severity) to respond to the performance of illegal driving behaviours. The research in this thesis provides evidence to suggest that this uniform approach may not consistently provide the outcomes that are desired, in relation to both general and specific deterrence.

The existing ways of sanctioning illegal driving behaviours seem to be based on the implicit assumption that all drivers respond to sanctions, or the threat of sanctions, in the same way. The results presented in thesis provide evidence that this is not the case. Factors such as age, gender, years licensed, the number of previous driving offences, and indeed the personality traits of drivers were found to have a significant association with successful or unsuccessful deterrence. This is consistent with existing research, where it has been found that driving behaviour varies according to a range of driver characteristics (e.g. age and gender) (e.g. Brown et al., 2017; Guo et al., 2017; Jonah, 1990; Lucidi et al., 2019).

If progress is to be made in reducing the incidence of serious injuries and deaths as a result of road crashes that have illegal driving behaviour as a contributing factor, it is important to ensure countermeasures are tailored to driver groups, based upon what we know about deterrence. To some extent Victoria already has a system in place that operates under a model where high-risk groups are identified and responded to accordingly.

For example, young drivers (or more generally those on probationary licences) are subject to different conditions and punishments than are drivers who hold full licences. These include, for example, limits on peer passenger numbers, greater restrictions on the types of behaviours that are permissible (e.g. a BAC of zero must be adhered to; no mobile phone use of any nature – i.e. even if through a hands-free system) and lower thresholds of demerit points that can be accrued before a licence is suspended (VicRoads, 2019g).

Victoria, and other jurisdictions may find value in expanding this model to other groups of drivers.

It may be effective to have additional conditions on drivers in the short period that follows a traffic infringement, given there was evidence of high risks of recidivism and crashes for some driver groups, in the period following an infringement. These strategies may decrease the chances of crashes occurring for these high-risk drivers (e.g. by not allowing them to consume any alcohol at all or use a mobile phone in any way) and in instances where deterrence cannot be achieved, minimise harm if they do crash (e.g. by having limits in place for the number of passengers in their vehicle).

Education programs that are tailored to particular groups of drivers may also have value in influencing driver behaviour. These could act through a general or specific deterrence perspective. General deterrence could be achieved through the use of media and advertising campaigns. These are already in place in Victoria, and target a number of offence types, including drink driving, drug driving, speeding, mobile phone use, as well as specific road user groups such as motorcycle riders and young drivers (Transport Accident Commission, 2020b). Continued use of such campaigns, broadening the offence types and driver groups being targeted (e.g. older drivers, people driving for work), may assist with general deterrence across a wide range of drivers.

In terms of specific deterrence, for drivers who do come to the attention of enforcement authorities for performing an illegal driving behaviour, value may be found in raising awareness of the potential consequences of illegal driving behaviours. This could include, for example, the provision of written material or compulsory completion of an education program. Drivers who are found to have performed drink driving and drug driving offences in Victoria are currently required to complete a driver education/rehabilitation program (VicRoads, 2020c, 2020d). Indeed, the effectiveness of driver rehabilitation programs in achieving deterrence from recidivist drink driving has been established in existing research. For example, Ferguson et al (2001) examined the *Under the Limit* drink driving rehabilitation program and found that repeat drink drivers who attended the program showed higher levels of willingness to change their drink driving behaviour, and indeed showed lower levels of further drink driving behaviour. Similarly, Mazurski et al (2011) examined the *Sober Driver Program* and found that drivers who completed this program had lower rates of recidivism

when compared to a group of drivers who had not. There may be capacity to expand such programs to a wider range of offence types, to ensure no opportunities for intervention are lost. For example, drivers who receive an infringement for a low-level speeding offence or a mobile phone offence could also be required to undertake some form of education. This could include the completion of a short online module that must be completed by drivers, providing them with information about the possible consequences of their actions (e.g. risk of crash and serious injury). The results of the current research showed drivers' perceptions of enforcement and of crash risk had correlations with behavioural expectations that were of similar strength. Thus, given much focus is already on promoting the risks of enforcement (and increasing awareness of enforcement) in efforts to achieve deterrence, further deterrence may be achieved by giving more attention to the risks of crash.

Existing research has shown that driver education programs can be beneficial. For example, a study of young drivers in the United States who attended a driver education program mandated by a court showed greater knowledge in relation to risky driving behaviours and perceived there to be higher levels of risk associated with the performance of such behaviours (Lanning, Melton & Abel, 2018). Similarly, a study that examined older drivers found that those who attended an educational program focussed on safe driving practices showed higher levels of self-regulation in their on-road behaviour than the levels identified before they completed the program (Stalvey & Owsley, 2003). Another study, focussed on recidivist drink drivers who undertook a rehabilitation program in Queensland, Australia, found that those who attended the program reported being motivated to change their drink driving behaviour (Freeman et al., 2005).

An important component of any education campaign would also be to ensure they are able to capture the attention of those drivers most at risk (e.g. male drivers, inexperienced drivers).

11.5.2 There are groups of drivers for whom deterrence seems particularly difficult to achieve

Unfortunately, some research suggests that seeking to change driver behaviour through education is not always effective. Lonero (2008) suggested that using scare tactics to encourage safe driving has minimal effectiveness and is an outdated means of influencing driving behaviour. Furthermore, in a study undertaken by Tuokko et al. (2007) of older

drivers, it was suggested that there were significant differences between males and females, and that any educational programs and materials should take this into account.

These potential gaps in the effectiveness of education programs in changing driver behaviour may be particularly relevant for some groups of drivers, as evidenced by the results from the current research. Patterns emerged in the research which indicated that deterrence is particularly difficult to achieve in some drivers. Perhaps two of the most obvious were based on: a) personality traits of drivers; and b) drivers with extensive traffic offending histories.

As demonstrated in study three, drivers scoring relatively high on neuroticism, and relatively low on agreeableness, conscientiousness, openness and extraversion expressed perceptions and behavioural expectations inconsistent with deterrence from speeding. These results are relevant from both a general and specific deterrence perspective. As was proposed in chapter ten, driver education programs would perhaps find value in designing their content around specific personality traits and the ways in which individuals scoring highly on each trait respond best. Such an approach is consistent with the suggestion from Tuokko et al. (2007), who proposed that education programs need to take differences in groups of drivers into account.

The second group of drivers for whom unique strategies may be particularly important, is those with extensive traffic offending histories. Despite receiving multiple traffic infringements, some drivers appeared to be resistant to changing their behaviour. Among these drivers, there is a trajectory of continued offending, in some cases accumulating multiple infringements within a short period of time. This was particularly true for drivers who were newly licensed.

As study one showed, the proportion of drivers reoffending within one year increased with each subsequent offence (27% reoffended following their first offence; 33% following their second offence; 37% following their third offence; 40% following their fourth offence; 43% following their fifth offence). If the experience of receiving multiple traffic infringements, as well as potentially experiencing non-legal consequences such as social disapproval has not deterred these drivers, it may be unrealistic to expect that education is the missing piece of

the puzzle. These drivers present a particular challenge on how they may be most effectively deterred.

Whilst this research explored personality, showing it as a factor that may influence perceptions and driving behaviour expectations, low levels of self-control are another factor contributing to some drivers finding it particularly difficult to regulate their driving behaviour (e.g. Keane, Maxim & Teevan, 1993; Meldrum, Boman & Back, 2019; Nagin & Paternoster, 1993; Nagin & Pogarsky, 2001; Piquero, Gomez-Smith & Langton, 2004). The concept of low self-control being a central factor to the performance of criminal behaviour was devised by Gottfredson and Hirschi (1990), as part of the General Theory of Crime. Repeat offending drivers may lack the required self-control to change their driving behaviour, and continued infringements and other legal sanctions are perhaps unlikely to change this behaviour, given their patterns of illegal driving have become deeply entrenched.

Given the potential gaps in knowledge of how to formulate effective education programs, the evidence suggesting that some drivers are resistant to changing their behaviour, even after receiving multiple traffic infringements, and the role that personality and low self-control may be playing in preventing these drivers from changing their behaviour, other options must be explored. Enforcement technology perhaps appears to be a viable option for recidivist traffic offenders. There are already many technological options available to improve driver compliance. These include, for example, alcohol interlock devices (e.g. Fitzharris et al., 2015) and speed limiting devices (such as intelligent speed assistance systems with intervening functionality) (e.g. van der Pas et al. 2009), which can be fitted to specific vehicles. New enforcement and compliance assistance technologies should be embraced as they become available, particularly for repeat traffic offenders.

11.5.3 Drivers go through risky driving periods, and these periods present an opportunity for intervention

Closely related to the point made above, but deserving of its own discussion, is the evidence to suggest that some drivers go through particularly risky periods, where the performance of illegal driving behaviours as well as crash occurrence is intensified. This increased period of risk perhaps points to a time window where further interventions may prove valuable.

Walter and Studdert (2015), suggested that licence suspension could be used as a version of 'flash incarceration', thus removing drivers' opportunity for offending when they are at a period of heightened risk. It is unlikely however that licence suspension would be accepted by the community, particularly for minor offences, such as exceeding the speed limit by only a few km/h. Furthermore, suspending licences does not always stop drivers from continuing to drive (e.g. McCartt, Geary & Berning, 2003; Parrish & Masten, 2014), and therefore the risk they pose may not be removed.

Other options that do not remove the opportunity for individuals to drive, but rather focus on encouraging safe driving behaviour may be effective. Furthermore, they are more likely to also gain community support, which is an important quality of all strategies that seek to deter illegal behaviour.

One such strategy could be the application of double demerit points for any further offences in the one-year period that follows a driver receiving a traffic infringement. Such a system is already in place in Queensland, Australia (Queensland Government, 2020). This may encourage drivers to adhere to the traffic laws, out of concern that they may otherwise be subject to punishments of an increased severity.

In an evaluation of the use of double demerit points during long weekends and holidays periods in Western Australia, Batani (2004) reported that the per hour infringement rate was 15 per cent lower than in a comparable period where double demerit points were not in use. Crashes also decreased by 11 per cent and fatal crashes decreased by 20 per cent, when compared with periods where double demerits points were not in force. Furthermore, in an analysis of crashes where speed was a contributing factor, a reduction of 40 per cent was observed when compared to a period where double demerits were not in place. A 52 per cent reduction was also observed in fatal crashes involving speed, when compared to a time period where double demerits were not in force. Similarly, fatal crashes where alcohol was a contributing factor decreased by 54 per cent in double demerit point periods (Batani, 2004). The results of Batani's research provide strong support as to the effectiveness of using double demerit points in a general driver population. If such a system was implemented for individual drivers, a similar evaluation to that undertaken by Batani would be essential.

It is notable that the results of the current research provided limited evidence for demerit points working for drivers once they have accumulated multiple previous offences. Thus, whilst success may be experienced by using double demerit points for drivers who have a smaller number of previous offences (i.e. no more than two), additional strategies would likely be required for drivers who have extensive offending histories.

Indeed, other conditions could be placed on drivers' licences for a period after they have received an infringement. For example, irrespective of the offence type, drivers could be required to have a BAC of zero at all times when driving during this one-month period. Other conditions could also be explored, but the focus of any strategy would need to be towards *encouraging safe driving practices* during this particularly risky period.

Another alternative could be a system that provides incentives for safe driving behaviour. Thus, rather than handing down harsher punishments if a driver does reoffend, a sustained period of good driving behaviour (e.g. twelve months) may see drivers rewarded with discounted registration or free licence renewal. However, to create fairness in such a system, discounts would also need to be made available to drivers who have a clean driving history (thereby potentially also creating a general deterrence effect), rather than just drivers who change their driving behaviour. Ensuring that drivers are aware of the potential outcomes of driving offences is essential for achieving behaviour change.

11.5.4 Interventions should be broader than just legal sanctions

There is no doubt that the vast majority of drivers have an awareness that the performance of risky and illegal driving behaviours violates traffic laws. When drivers perform illegal driving behaviours, it may be a result of lacking an awareness of the potential consequences; a belief they will not be subject to the legal consequences or be involved in crash; or alternatively a choice (i.e. they are willing to take the risk and pay the price for their offending if they are apprehended or involved in a crash). To ensure a more holistic approach to preventing aberrant driving, and to deter drivers who do not respond to legal sanctions, it may be time to look towards other remedies to deal with the road offending problem. Whilst legal sanctions, including traffic infringements, continue to have a place in responding to the performance of illegal driving behaviours, they should not be used in isolation, given these sanctions do not achieve deterrence for all drivers.

This thesis demonstrates that perceptions of potential non-legal consequences of illegal driving behaviour, such as crash risk, going against social norms and experiencing disapproval and negative personal and emotional affect were significantly associated with lower expectations of performing illegal driving behaviour (specifically, low-level speeding). These results suggest that non-legal sanctions have the potential to deter the performance of illegal driving behaviours. This is consistent with existing research (e.g. Baum, 1999; Freeman et al., 2006; Freeman et al., 2016; Freeman & Watson, 2009; Grasmick & Bursik, 1990; Grasmick & Green, 1980; Green, 1989; Homel, 1998; Loxley & Smith, 1991; Nagin & Pogarsky, 1001; Piquero & Paternoster, 1998; Freeman et al., 2010; Jones et al., 2005; Watson, 2004; Bradford et al., 2015). Greater success may be achieved if the non-legal consequences of illegal driving behaviour are emphasised to drivers. Once again, this would need to occur through the use of education and advertising campaigns. The key message is that in addition to legal sanctions, drivers place themselves at risk of many *other consequences* when they perform illegal driving behaviours (crashes, social disapproval, negative emotions). Similarly, embracing a system that incentivises good driving behaviour, rather than relying on punishing bad driving behaviour, may be effective in achieving safe driving practices. Is it notable that all the suggestions made above could be implemented into the current system of responding to illegal driving behaviour. In other words, there is no need to completely overhaul how illegal driving behaviours are responded to, but rather think about how new strategies might be implemented into the system that is already in place in Victoria.

11.6 Strengths of the research

In the thesis chapters that reported on the three studies, strengths were highlighted. In addition to these, there are a number of strengths that relate to the PhD research program more broadly and demonstrate the contribution the research makes to road safety. These strengths relate to the size and type of data sets used, the complementary nature of the three studies and the use of exclusively Victorian data. Further details about each of these strengths are provided below.

11.6.1 Large data sets were used

The data sets used across all three studies were large, meaning that a considerable number of drivers were considered in each study. In studies one and two, the data used was population-based, with all Victorian drivers who met the selection criteria being included. The use of large population data sets meant that the studies had greater statistical power and were able to pick up more subtle effects. Additionally, the use of population based administrative data, where all drivers who met the criteria for inclusion were ultimately included in the analysis, meant that participation bias was not introduced into the research.

11.6.2 Different sources of data were used

The use of administrative and as well as self-report survey data provided the advantages of two different data types. Advantages of administrative data include the ability to link data sets to increase the range of analyses that can be undertaken (e.g. Drake & Jonson-Reid, 1999; Smith et al., 2011), the large number of records often contained in these types of data sets (e.g. Connelly et al., 2016; Drake & Jonson-Reid, 1999; Kapteyn & Ypma, 2007; Windle, 2010) as well as the relatively high levels of accuracy the data sets usually provide, given they are held for official purposes, and are not subject to participation or reporting bias (e.g. Bowling, 2005; Fulton-Kehoe et al., 2007; Groves, 2006).

On the other hand, the advantages of using online surveys for data collection include enabling the researcher to access a wide range of people, compared to using face-to-face methods (e.g. Couper, 2000; Granello & Wheaton, 2004; Hardré et al., 2007; Lazar & Preece, 1999) and they enable sensitive questions to be asked that might not be suitable for asking face-to-face (Granello & Wheton, 2004). Unlike administrative data, survey data collection enables researchers to collect the exact information they require, given they develop the data collection tool, rather than use an existing data source. *More detailed* information can also be collected to understand an issue. Therefore, using an online survey meant subjective information could be collected, alongside the objective information the administrative data sets provided.

By using two different types of data, the range of research questions and breadth of analyses that could be undertaken was greatly enhanced. For example, in studies one and two, the interest was specifically on the deterring influence of traffic infringements. Using official administrative data was most appropriate as this ensured a high degree of

confidence that the full infringement history of drivers was being considered. There was no reliance on drivers to recall all infringements they had received in their driving career. There was also no risk of drivers potentially omitting information because they did not have a clear memory of events or they were reluctant to provide full details of their infringement history because these were not socially desirable. However, the administrative data did not enable an examination of many of the factors that may underlie patterns of driver offending, such as personality (e.g. Dahlen & White, 2006; Ulleberg & Rundmo, 2003) and perceptions (e.g. Nagin, 1998; Paternoster et al. 1982; Paternoster et al., 1983a; Saltzman et al., 1982). Self-report survey data filled this gap.

In study three, the design of a self-report survey provided the opportunity to collect data that would provide a rich source of information on a broader range of factors and enabled an examination on their relationship to driver behaviour – research that could not be achieved using administrative sources of data. As a result of the rich data sets used, the PhD research contained in this thesis was able to consider driver behaviour from *multiple perspectives*.

11.6.3 Each of the studies conducted complement one another

The third strength of this research is closely related to that described above. Whilst three separate studies were reported on in this thesis, each is complementary to the others and together they provide a comprehensive picture of factors that may act as deterrents to the performance of risky behaviours on Victorian roads. A conceptual model provided the overarching framework for this thesis, and proposed a number of pathways by which deterrence may operate. As noted, studies one and two considered the deterring influence of traffic infringements in relation to the two outcomes that they arguably most seek to achieve – 1) the performance of further illegal driving behaviour; and 2) involvement in a crash. However, as existing research has shown, infringements do not operate in a vacuum and therefore there are likely many other factors, beyond legal sanctions, that may play a role in successful (and unsuccessful) deterrence (e.g. Akers, 1990; Anderson, Chiricos, & Waldo, 1977; Bishop, 1984; Cochran et al., 1998; Gibbs, 1979; Jacob, 1980; Mann et al., 2016; Meier & Johnson, 1977; Nagin & Pogarsky, 2001; Piliavin et al., 1986; Piquero & Tibbetts, 1996; Sherman, 1993; Silberman, 1976; Vinglis, 1990; Williams & Hawkins, 1986). Thus, study three provided broader understandings of traffic offending that were not

explored in studies one and two, by considering an expanded model of deterrence and taking a more subjective approach.

11.6.4 The research offers important insights for the Victorian jurisdiction

Finally, the research in this thesis was based on data exclusively from the jurisdiction of Victoria, Australia. The three studies provide a comprehensive picture of factors that may be associated with both the successful and unsuccessful deterrence of drivers on Victorian roads. The results presented therefore provide invaluable lessons for road safety in Victoria.

11.7 Limitations of the research

Whilst the PhD research had many strengths, like all research projects it also had limitations that need to be acknowledged. Whilst limitations have been highlighted for individual studies in the chapters that report on their findings, there are some limitations that relate to the study program overall. The following section will explore these limitations, but more importantly provide a discussion around how these limitations may have had an influence upon the validity and reliability of the results provided.

11.7.1 Profile of drivers included in the administrative data sets

The first limitation relates to the age of drivers in the data sets and date range of the available data. The VicRoads data sets that were used for studies one and two only contained data for drivers born on or prior to 31st December 1974. Based on this date of birth and the date range at which data were available in the data extraction (crash data available through to 2015 and infringements and licensing data available through to 2016), only drivers aged 40 years and above were able to have their full driving history examined. Furthermore, changes in the way in which licensing data was held meant that a complete licence history was only available from 8th July 1994.

There are two ways in which this may have influenced the validity of the results presented in studies one and two. Relating to study one only, given this study sought to examine drivers' complete history of infringements, the date range meant the minimum age that drivers could possibly have been licensed was 19.5 years. This is 1.5 years older than the minimum age of 18 years at which drivers are able to obtain a licence in Victoria, Australia. This no doubt had an influence on the group of drivers who were included in the study. A considerably higher number of females were included in the sample than what we would

ordinarily expect to see in the Victorian driver population of this age. It is possible that males in the older age groups may have received their licence at 18 years of age. They were therefore not captured in the data set used. Females may have been relatively more likely to receive their licence at an older age, as driving was traditionally seen as a male endeavour (e.g. Berger, 1986; Siren & Hakamies-Blomqvist, 2005). As a result, the inclusion of a larger proportion of females, as well as drivers who were not licensed at the age of 18 years impacts the generalisability of the sample to all drivers in Victoria, or indeed to all drivers in jurisdictions beyond Victoria. However, this does not affect the internal validity of the results (which are broken down by *age at licence*); the results still provide important understandings on patterns that may influence deterrence and driver behaviour. The key limitation is that this study *does not provide insights into drivers who obtained their licence at the age of 18 years*.

11.7.2 Age of drivers included in the administrative data sets

The use of data limited to drivers born on or prior to 31st December 1974 (aged 40 years and above) also meant that the group of drivers included in studies one and two were over 20 years older than other drivers who would have also have been driving on Victorian roads at the time the data was extracted (i.e. a (relatively) older driver cohort was selected).

Existing research has shown that younger drivers (e.g. Donmez, Boyle & Lee, 2010; Ferguson, 2003; Groeger, 2006; McKnight & McKnight, 2003; Prato et al., 2010; Russell, Vandermeer & Hartling, 2011; Scott-Parker, Watson & King, 2009) and older drivers (e.g. Charlton et al., 2006; Devlin & McGillivray, 2016; Dickerson et al., 2019; Eby et al., 2012; Eby et al., 2018; Hill et al., 2020; Karthaus & Falkenstein, 2016; Li et al., 2019; Molnar et al., 2013; Molnar et al., 2018; Owsley et al., 2001; Shimada et al., 2015) face a unique set of challenges when driving (e.g. Doroudgar et al., 2017; Kurali, Gyi & Mansfield, 2017; Simons-Morton et al., 2020; Zhao, Yamamoto & Kanamori, 2020).

It is possible that drivers in younger age groups would respond in a different manner to receiving a traffic infringement. This means that results presented in studies one and two are not generalisable beyond the age group of drivers considered, both inside and outside of the Victorian jurisdiction. However, the results of this research still provide important understandings about offending and deterrence in the age group that was examined.

11.7.3 Analyses limited to the data variables available

A third limitation, affecting all three studies is that the analyses were limited to the variables that were available in the data sets used. It is likely that there are many unmeasured variables that also had an effect on the results. For example, factors such as relationship issues and divorce (e.g. Kposowa & Breault, 2009; Lagarde et al. 2004; Legree et al., 2003; McMurray, 1970), financial stress (e.g. Cunningham & Regan, 2016; Norris et al., 2000), employment stress (e.g. Carty, Stough & Gillespie, 1998; Hartley & El Hassani, 1994; Norris et al., 2000; Rowden et al., 2011; Rowland et al., 2007; Smith, 2016) and health issues (e.g. Cunningham & Regan, 2016; Legree et al., 2003; Rowden et al., 2011) have all been identified as having an influence on patterns of driving behaviour.

The VicRoads data sets did not provide any opportunity to control for these factors. Given the administrative nature of these data sets, the inclusion of personal information beyond factors such as age, sex and postcode of residence is very limited. This omission is of particular relevance to study two, where the use of the case-case-time-control study looked at drivers' infringement in two short 30-day time periods twelve months apart. Drivers may have been experiencing difficult personal circumstances in one of these time periods, meaning their receipt of an infringement or involvement in a crash may have been related to this personal stress, which in turn may have lowered the degree to which they were deterred.

The survey was designed to address many of these issues, collecting data on factors such as education level attained and employment status. However, the nature of survey research still means that limits have to be placed on the type of data that is collected. Asking individuals to provide personal information such as experience of relationship issues, financial stress, housing stress/living situation, concerns around employment and health information would have created barriers for the research. In particular, online surveys are particularly susceptible to non-completion, with individuals starting the survey, but stopping prior to reaching the end (Sue & Ritter, 2012b) and also lower response rates (e.g. Bech & Kristensen, 2009; Couper, 2000; Kwak & Radler, 2002; Miller et al., 2002; Shih & Zitao, 2008). For this reason, including too many invasive questions was avoided as much as possible. Had all these additional questions been included, not only would the survey have become unacceptably lengthy, their inclusion would have likely limited the number of

complete responses, and also introduced participation bias into the study. Many individuals would likely not have felt comfortable providing this personal information and may have opted not to take part and not to complete the survey after these questions were presented.

11.7.4 Data sets were unable to fully capture deterrence and offending

A fourth limitation of the research relates to the extent to which the data sets used were able to fully capture deterrence and offending. Whilst the three studies were complementary to one another, they did not all consider the same group of drivers. This may therefore leave gaps in our understanding of the factors that may most effectively achieve deterrence.

As noted, studies one and two provided insight into the deterring influence that receiving a traffic infringement had upon further driver offending and subsequent crash involvement. Study three was able to provide understandings of a broader range of potentially deterring factors and their relationship to expectations of one particular illegal driving behaviour. Unfortunately, the use of (administrative) VicRoads data in studies one and two meant that it was not possible to take into account the role that *perceptions* towards potential deterrents may have had on the results. Similarly, the exclusive use of self-report data in study three meant that there was no way to verify a driver's performance of traffic offences (either prior to the survey or in the months that followed). Thus, the conclusions that were able to be drawn in each individual study are not as complete as those that would be drawn if a single cohort was examined using administrative and (linked) survey data. There were three primary factors that prevented such an analyses from being undertaken in the current research.

First, in order to match drivers' survey responses to their full driving history, consent would need to have been collected from drivers and they would also have been required to provide their driver licence number details. Some drivers would have been reluctant to provide this information, which may have meant finding a large and representative sample would have been further complicated. Indeed, existing research has examined prescription opioid and benzodiazepine use amongst individuals injured in a road crash, linking TAC claims data (TAC claims database), prescription drug use data (pharmaceutical benefits scheme (PBS) database) and government subsidised health service use data (Medicare

benefits schedule (MBS) database) together. Of the 10,998 individuals who were invited to be included in the research, only 738 (7%) provided consent (Berecki-Gisolf et al., 2016). This study provides evidence that the proportions of individuals who are willing to enable researchers to link data held about them from multiple sources is very low. This means the conduct of a data linkage study as part of this PhD research would likely have been very difficult to achieve.

Second, a Qualtrics survey panel was used to recruit study participants. The use of survey panels means that personal details or potentially identifiable information cannot be collected, given Qualtrics owns the rights to these survey panels. Thus, an alternative method for collecting the survey data would have needed to be found.

Finally, as noted, the VicRoads data extraction that was available for this research only contained data for drivers aged 40 years and older, whereas the survey contained data for drivers of all ages. Having a matched sample would have meant drawing further constraints on the group of drivers who were eligible to take part in the survey.

11.7.5 Constraints had to be drawn on the sub-analyses that could be undertaken

A fifth limitation of the research is that, whilst a series of sub-analyses was undertaken, (e.g. on factors such as age, gender, years licensed, licence type, residing in a metropolitan or regional area), there are many more variables that also have the potential to provide valuable information on how deterrence may vary between different groups of drivers. The confines of a PhD research program means that limits have to be drawn on the breadth and depth of the analyses that can be undertaken. Decisions were made on which factors would be most appropriate to undertake sub-analyses, with those ultimately chosen based on their potential to provide valuable information on as wide a group of drivers as possible, given they covered large groups such as age, gender and licence type.

For example, the VicRoads licensing data set contains information on drivers who have opted to extend their demerit point period. For these drivers, rather than have their licence suspended because they have reached the allowable demerit point threshold, they opt to continue driving, but risk losing their licence for double the length of time if they reoffend in the twelve-months this demerit point extension is in place (VicRoads, 2020e). Undertaking further analyses on deterrence and offending amongst drivers who have opted to take an

extended demerit point period would have provided valuable information, but went beyond the scope of this PhD.

11.7.6 Used only data from Victoria, Australia

Whilst the use of Victorian data in all three studies was highlighted as a strength, as it provided specific understandings relevant to Victoria, it is also important to note that this may also be seen as a limitation. It is unclear the extent to which the results are applicable to other jurisdictions, both in Australia and internationally. All results should be interpreted with caution when applied to other jurisdictions. Researchers and policy makers should consider similarities and differences between their jurisdiction and the Victorian jurisdiction, particularly in terms of road traffic law enforcement, but also driving population and road network differences, when evaluating the results reported in this thesis.

11.8 Areas for future research

The limitations of this research indicate there are many questions that remain unanswered with regard to deterrence and illegal driving behaviour. As such, there are a number of avenues for future research that may prove viable in further exploring deterrence and driver behaviour. These are outlined below.

11.8.1 Repeat analyses on a younger cohort of drivers

First, future research may repeat the analyses in studies one and two on a younger cohort of drivers, and also include drivers who obtained their licence at the legal age of 18 years. Such an analysis would enable an examination of whether the patterns observed amongst older drivers also hold true for a younger group of drivers. Such research could be undertaken not only within the Victorian jurisdiction, but in other jurisdictions both in Australia and internationally. The research would have great value in indicating whether substantially different strategies are needed for drivers of different age groups, to address illegal driving behaviour.

11.8.2 Exploration of different research approaches

Second, in order to deal with some confounding factors, future research may be approached differently. For example, in study two, it may be an option to use multiple control periods. The odds ratio calculated with different control periods would enable an examination of whether there was perhaps another factor influencing the results during one

single control period, or if the results are consistent across all control periods. For example, an odds of 1.35 in one control period (as was the result in the current research), but odds ratios of 0.85 and 0.70 in two other control periods may potentially point to the 1.35 odds ratio being an anomaly, and an unmeasured factor (e.g. an extensive enforcement campaign) influencing the results.

For study three, rather than collect survey data at one single point in time, data could be collected longitudinally. If survey participants were willing to provide their contact details (e.g. an email address), the survey could be resent to them at regular intervals. The data could then be examined to determine if their responses on key measures remain consistent or if there is evidence of changed patterns over time. Changes may signify other life events having an influence on a driver's patterns of behaviour, and thus controls put in place to account for this. It is important to note that a limitation of this study would be that long periods of follow-up may be required. This is an issue faced by prospective cohort studies (e.g. Levin, 2006). Whilst a retrospective cohort study could be used, a limitation would be that it would rely on drivers to correctly recall different life experiences (e.g. Levin, 2006).

Such a study would be valuable given recent research by Truelove et al., (2020) examined the stability of perceptions towards legal and non-legal sanctions by collecting data from drivers at two time points, three months apart. They found that there were indeed fluctuations in the perceptions drivers expressed at the two different time points, with the greatest difference observed in relation to certainty of apprehension. It was therefore concluded that longitudinal research presents greater reliability when examining the deterring effect of perceptions on driving behaviour (Truelove et al., 2020).

It is important to note that whilst the study designs outlined above are alternative examples that may help to reduce confounding, it is unlikely they will completely remove it. There would still likely be a number of unknown factors contributing to the results that emerge.

11.8.3 Data linkage study

Another option for future research would be a large data linkage study that links survey and administrative data together. This would assist in providing an even more comprehensive picture of deterrence and driving behaviour than this PhD was able to.

Whilst the limitations section highlighted some difficulties that would likely have been encountered in the current research if an attempt had been made to develop a single data set to undertake all three studies, building such a data set would not necessarily be out of reach in the future.

Such a study would need to start off with the collection of survey data from a sample of drivers, asking them the same questions on personality, perceptions towards potential deterrents and expectations to perform illegal driving behaviours, as were asked in the current study. Additionally, drivers would need to provide their licence number, and consent would need to be sought to ensure drivers agree the researchers can access their full licence history, including any infringements they had ever received. In order for the behavioural expectations to be corroborated with actual patterns of driving behaviour, the data extract would need to be obtained one year after completion of the survey.

The VicRoads licensing, infringements and crash data sets would then be merged with the survey data. Such a study would have the potential to provide a more comprehensive picture of traffic offending than was possible using separate data sets and driver samples, as was the approach in the research reported on in this thesis. A study of this nature would be of great benefit not only in the Victorian jurisdiction, but also in other jurisdictions in Australia and internationally.

11.8.3 Apply to conceptual model to other offence types and jurisdictions

Fourth, this PhD research saw the development of a detailed conceptual model and comprehensive survey to collect data on personality, perceptions towards potential deterrents for a range of different offence types and driver's expectations to perform these illegal driving behaviours. The pathways for this model were examined for driving up to 10km/h above the speed limit in this thesis. The results of this modelling provided valuable information on the factors that may see drivers both successfully and unsuccessfully deterred for speeding behaviour.

The success of this study highlights that the conceptual model that was developed and the survey that was designed may prove valuable for use in the conduct of further research. Such research would enable an examination of whether the significance of pathways in the conceptual model hold true for other offence types. Indeed, by examining multiple offence

types, the results may enable a determination of whether the significant pathways identified in the current research and the influence of the potentially mediating factors (perceptions towards the potential deterrents) differ based on offence type. Future research can also use the conceptual model and apply it in other jurisdictions, to determine if the same pathways remain true, even where approaches to enforcement may differ.

11.9 Conclusions

The three research studies reported on in this thesis have advanced the existing knowledge on deterrence and driver behaviour, specifically in Victoria, which in turn may provide valuable understandings for other jurisdictions within Australia and internationally. The results provide evidence to suggest that different groups of drivers respond in different ways to potential deterrents. The research shows that, despite legal sanctions, in particular infringements, being the primary way in which illegal driving behaviours are penalised, promoting the non-legal consequences of illegal driving behaviour to drivers, including the risk of crash and injury and the potential for social disapproval and experience of negative emotions may be beneficial, given some drivers are not deterred by legal sanctions. A system that seeks to strike a balance between the advantages of legal and non-legal consequences may achieve great success in responding to illegal driving behaviours.

An important component of the safe system framework is that humans are prone to error, and that the system, in terms of vehicles, roads and speeds, should be 'forgiving', such that these errors do not result in the incidence of serious injuries and deaths (e.g. Elvik, 2010; Larsson, Dekker & Tingvall, 2010; McTiernan et al., 2010). Whilst advancements in vehicle safety technology, such as lane keep assist and auto emergency braking have undergone rapid development in recent years, and road designs have improved, as long as people are in control of vehicles, enhanced vehicle safety technology and improved roads can only achieve so much. People must ultimately take responsibility and ensure they monitor their behaviour whilst driving on the roads.

Perhaps one day, there will be a time when driver behaviour ceases to have an influence on road safety. Great progress is being made on the development and introduction of automated vehicles, both in Australia (e.g. Dosen, Aroozoo & Graham, 2017; Kaye et al., 2019; Sun et al., 2017) and internationally (e.g. Elliott, Keen & Miao, 2019; González-

González, Nogués & Stead, 2019), including in relation to community acceptability (e.g. Becker & Axhausen, 2017; Cunningham et al., 2019; Kyriakidis, Happee & de Winter, 2015; Liljamo, Liimatainen & Pöllänen, 2018; Piao et al., 2016). Unfortunately, full implementation of such an advanced vehicle fleet will not be achieved within the short or even medium-term. We therefore must accept that humans, and the decisions they make on the roads will continue to be a factor that contributes to the incidence of road trauma for the foreseeable future. Fortunately, the results that are presented in this thesis provide valuable understandings on infringements, deterrence and driver behaviour. A strong knowledge base is the first step towards reducing road trauma and enhancing safety on the roads for all road users.

References

- Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis and Prevention*, 38(2), 215-224. <https://doi.org/10.1016/j.aap.2005.07.004>
- ACT Government Justice and Community Safety Directorate. (2011). *Road Safety Strategy 2011-20*. Canberra, Australia: ACT Government. https://justice.act.gov.au/sites/default/files/2019-08/ACT_Road_Safety_Strategy_2011-2020.pdf. Retrieved 28 November 2020.
- af Wåhlberg, A., Barraclough, P., & Freeman, J. (2017). Personality versus traffic accidents; meta-analysis of real and method effects. *Transportation Research Part F: Traffic Psychology and Behaviour*, 44, 90-104. <https://dx.doi.org/10.1016/j.trf.2016.10.009>
- Ahlin, E., Zador, P., Rauch, W., Howard, J., & Duncan, G. (2011). First-time DWI offenders are at risk of recidivating regardless of sanctions imposed. *Journal of Criminal Justice*, 39(2), 137-142. <https://doi.org/10.1016/j.jcrimjus.2011.01.001>
- Ajzen, I. (2005). From intentions to actions. In: *Attitudes, Personality and Behavior. Second Edition*. Berkshire, United Kingdom: Open University Press. pp. 99-116.
- Ajzen, I. (2011). The theory of planned behavior. In: P. Van Lange, A. Kruglanski, W. Arie & E. Higgins (Eds.). *SAGE Social Psychology Program: Theories of Social Psychology. Volume One*. London, UK: Sage Publications, pp. 438-459.
- Akers, R. (1990). Rational choice, deterrence and social learning theory in Criminology: the path not taken. *Journal of Criminal Law and Criminology*, 81(3), 653-676.
- Akers, R., & Sellers, C. (2004). Deterrence and rational choice theories: Classical criminology and the deterrence doctrine. *Criminological theories: Introduction, Evaluation, and Application*. California, USA: Roxbury Publishing Company. pp. 17-43.
- Alavi, H., Keleher, S., & Nieuwesteeg, M. (2014). Quantifying the contribution of low-level speeding to trauma in Victoria. *Proceedings of the 2014 Australasian Road Safety Research, Policing and Education Conference*, 12-14 November, Grand Hyatt Melbourne. https://acrs.org.au/files/arsrpe/full-paper_2113.pdf
- Allen, S., Murphy, K., & Bates, L. (2017). What drives compliance? The effect of deterrence and shame emotions on young drivers' compliance with road laws. *Policing and Society*, 27(8), 884-898. <https://doi.org/10.1080/10439463.2015.1115502>
- Anderson, L., Chiricos, T., & Waldo, G. (1977). Formal and informal sanctions: a comparison of deterrent effects. *Social Problems*, 25(1), 103-114. <https://doi.org/10.2307/800471>

- Anstey, K., Eramudugolla, R., Ross, L., Lautenschlager, N., & Wood, J. (2016). Road safety in an aging population: risk factors, assessment, interventions, interventions, and future directions. *International Psychogeriatrics*, 28(3), 349-356.
<https://doi.org/10.1017/S1041610216000053>
- Anstey, K., Windsor, T., Luszcz, M., & Andrews, G. (2006). Predicting driving cessation over 5 years in older adults: Psychological well-being and cognitive competence are stronger predictors than physical health. *Journal of the American Geriatrics Society*, 54(1), 121-126. <https://doi.org/10.1111/j.1532-5415.2005.00471.x>
- Ashbridge, M., Brubacher, J., & Chan, H. (2013). Cell phone use and traffic crash risk: a culpability analysis. *International Journal of Epidemiology*, 42(1), 259-267.
<https://doi.org/10.1093/ije/dys180>
- Ashbridge, M., Mann, R., Cusimano, M., Trayling, C., Roerecke, M., Tallon, J., Whipp, A., & Rehm, J. (2014). Cannabis and traffic collision risk: findings from a case-crossover study of injured drivers presenting to emergency departments. *International Journal of Public Health*, 59(2), 395-404. <https://doi.org/10.1007/s00038-013-0512-z>
- Ashbridge, M., Poulin, C., & Donato, A. (2005). Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada. *Accident Analysis & Prevention*, 37(6), 1025-1034. <https://doi.org/10.1016/j.aap.2005.05.006>
- Australian Bureau of Statistics (2017). *2071.0 - Census of Population and Housing: Reflecting Australia - Stories from the Census, 2016 – Educational qualifications in Australia*. Canberra, Australia: Australian Bureau of Statistics.
<https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2071.0~2016~Main%20Features~Educational%20Qualifications%20Data%20Summary%20~65>. Retrieved 1 December 2020.
- Australian Bureau of Statistics. (2018). *Household use of information technology*. Canberra, Australia: Australian Bureau of Statistics.
<https://www.abs.gov.au/statistics/industry/technology-and-innovation/household-use-information-technology/latest-release>. Retrieved 19 November 2020.
- Australian Bureau of Statistics. (2020a). *National, state and territory population*. Canberra, Australia: Australian Bureau of Statistics.
<https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/mar-2020>. Retrieved 25 November 2020.
- Australian Bureau of Statistics. (2020b). *Education and Work, Australia*. Canberra, Australia: Australian Bureau of Statistics.
<https://www.abs.gov.au/statistics/people/education/education-and-work-australia/may-2020>. Retrieved 26 November 2020.
- Australian Bureau of Statistics. (2020c). *Retirement and retirement intentions, Australia*. Canberra, Australia: Australian Bureau of Statistics.

<https://www.abs.gov.au/statistics/labour/employment-and-unemployment/retirement-and-retirement-intentions-australia/2018-19#key-statistics>. Retrieved 1 December 2020.

Australian Government Department of Infrastructure and Regional Development. *Road Safety*. Canberra, Australia: Department of Infrastructure and Regional Development. <https://infrastructure.gov.au/roads.safety/>. Retrieved 24 March 2018.

Australian Institute of Health and Welfare (AIHW). (2020). *National Drug Strategy Household Survey 2019. Drug Statistics Series no. 32. PHE 270*. Canberra, Australia: AIHW. <https://www.aihw.gov.au/getmedia/3564474e-f7ad-461c-b918-7f8de03d1294/aihw-phe-270-NDSHS-2019.pdf.aspx?inline=true>

Australian Transport Council. (2011). *National Road Safety Strategy 2011-2020*. Canberra, Australia. Department of Infrastructure, Transport, Regional Development and Communications. https://www.roadsafety.gov.au/sites/default/files/2019-11/nrss_2011_2020.pdf. Retrieved 25 November 2020.

Babor, T., Higgins-Biddle, J., Saunders, J., & Monteiro, M. (2001). *The Alcohol Use Disorders Identification Test: Guidelines for use in primary care. Second Edition*. Geneva, Switzerland: World Health Organization. <https://www.who.int/publications/i/item/audit-the-alcohol-use-disorders-identification-test-guidelines-for-use-in-primary-health-care>. Retrieved 19 November 2020.

Bachman, R., Paternoster, R., & Ward, S. (1992). The rationality of sexual offending: Testing a deterrence/rational choice conception of sexual assault. *Law and Society Review*, 26(2), 343-372. <https://doi.org/10.2307/3053901>

Bagaric, M., & Alexander, T. The capacity of criminal sanctions to shape the behaviour of offenders: Specific deterrence doesn't work, rehabilitation might and the implications for sentencing. *Criminal Law Journal*, 36(3), 159-172.

Barbone, F., McMahon, A., Davey, P., Morris, A., Reid, I., McDevitt, D., & MacDonald, T. Association of road-traffic accidents with benzodiazepine use. *The Lancet*, 352(9137), 1331-1336.

Barenbaum, N., & Winter, D. (2008). History of modern personality theory and research. In: O. John, R. Robbins & L. Pervin (Eds.). *Handbook of Personality: Theory and Research*, 3rd Edition. New York, USA: Guilford Publications, 3-26.

Baron, R., & Kenny, D. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173-1182.

Barraclough, P., af Wåhlberg, A., Freeman, J., Watson, B., & Watson, A. (2016). Predicting crashes using traffic offences: A meta-analysis that examines potential bias between

- self-report and archival data. *PloS One*, 11(4).
<https://doi.org/10.1371/journal.pone.0153390>
- Batani, C. (2004). *Evaluation of the trial period for double demerits legislation in Western Australia*. [Conference Presentation]. 2004 Safety Research, Policing and Education Conference. Perth, Australia. <https://acrs.org.au/files/arsrpe/RS040060.pdf>
- Bates, L., Darvell, M., & Watson, B. (2017). Young and unaffected by road policing strategies: Using deterrence theory to explain provisional drivers' (non)compliance. *Australian & New Zealand Journal of Criminology*, 50(1), 23-38.
<https://doi.org/10.1177/0004865815589824>
- Bates, L., Scott-Parker, B., Darvell, M., & Watson, B. (2017). Provisional drivers' perceptions of the impact of displaying P plates. *Traffic Injury Prevention*, 18(8), 820-825.
<https://doi.org/10.1080/15389588.2017.1322697>
- Bates, L., Soole, D., & Watson, B. (2012). The effectiveness of traffic policing in reducing traffic crashes. In Prenzler, T, editor. *Policing and Security in Practice: Challenges and Achievements*. Basingstoke, United Kingdom: Palgrave Macmillan Publishing, pp. 90-109.
- Baum, S. (1999). Self-reported drink driving and deterrence. *The Australian and New Zealand Journal of Criminology*, 32(3), 247-261.
<https://doi.org/10.1177/00486589903200304>
- Bech, M., & Kristensen, M. (2009). Differential response rates in postal and web-based surveys among older respondents. *Survey Research Methods*, 3(1), 1-6.
<https://doi.org/10.18148/srm/2009.v3i1.592>
- Becker, F., & Axhausen, K. (2017). Literature review on surveys investigating the acceptance of automated vehicles. *Transportation*, 44, 1293-1306.
<https://doi.org/10.1007/s11116-017-9808-9>
- Bedard, M., Guyatt, G., Stones, M., & Hirdes, J. (2002). The independent contribution of driver, crash, and vehicle characteristics to driver fatalities. *Accident Analysis & Prevention*, 34(6), 717-727. [https://doi.org/10.1016/S0001-4575\(01\)00072-0](https://doi.org/10.1016/S0001-4575(01)00072-0)
- Ben-Ari, O-T., & Yehiel, D. (2012). Driving styles and their associations with personality and motivation. *Accident Analysis & Prevention*, 45, 416-422.
- Berecki-Gisolf, J., Hassani-Mahmooei, B., Collie, A., & McClure, R. (2016). Prescription Opioid and Benzodiazepine use after road traffic injury. *Pain Medicine*, 17(2), 304-313.
<https://doi.org/10.1111/pme.12890>
- Berger, M. (1986). Women drivers!: the emergence of folklore and stereotypic opinions concerning feminine automotive behaviour. *Women's Studied International Forum*, 9(3), 257-263. [https://doi.org/10.1016/0277-5395\(86\)90061-0](https://doi.org/10.1016/0277-5395(86)90061-0)

- Berger, D., & Snortum, J. (1986). A structural equation model of drinking and driving: alcohol consumption, social norms, and moral commitments. *Criminology*, 42(1), 139-153.
<https://doi.org/10.1111/j.1745-9125.1986.tb00380.x>
- Bidjerano, T., & Dai, D. (2007). The relationship between the big-five model of personality and self-regulated learning strategies. *Learning and Individual Differences*, 17(1), 69-81. <https://doi.org/10.1016/j.lindif.2007.02.001>
- Bishop, D. (1984). Legal and extralegal barriers to delinquency. *Criminology*, 22(3), 403-419.
<https://doi.org/10.1111/j.1745-9125.1984.tb00307.x>
- Bland, J., & Altman, D. (2000). The odds ratio. *British Medical Journal*, 320(7247), 1468.
<https://doi.org/10.1136/bmj.320.7247.1468>
- Blomberg, R., Peck, R., Moskowitz, H., Burns, M., & Fiorentino, D. (2005). *Crash risk of alcohol involved driving: a case-control study*. Connecticut, USA: Dunlap & Associates, Inc
- Blows, S., Ameratunga, S., Ivers, R., Lo, S-K., & Norton, R. (2005). Risky driving habits and motor vehicle driver injury. *Accident Analysis & Prevention*, 37(4), 619-624.
<https://doi.org/10.1016/j.aap.2005.03.003>
- Blows, S., Ivers, R., Connor, J., Ameratunga, S., & Norton, R. (2003). Does periodic vehicle inspection reduce car crash injury? Evidence from the Auckland Car Crash Injury Study. *Australian and New Zealand Journal of Public Health*, 27(3), 323-327.
<https://doi.org/10.1111/j.1467-842X.2003.tb00401.x>
- Blows, S., Ivers, R., Connor, J., Ameratunga, S., Woodward, M., & Norton, R. (2005a). Marijuana use and car crash injury. *Addiction*, 100(5), 605-611.
<https://doi.org/10.1111/j.1360-0443.2005.01100.x>
- Blows, S., Ivers, R., Connor, J., Ameratunga, S., Woodward, M., & Norton, R. (2005b). Unlicensed Drivers and Car Crash Injury. *Traffic Injury Prevention*, 6(3), 230-234.
<http://doi.org/10.1080/15389580590969175>
- Blows, S., Ivers, R., Woodward, M., Connor, J., Ameratunga, S., & Norton, R. (2003). Vehicle year and the risk of car crash injury. *Injury Prevention*, 9(4), 353-356.
<https://doi.org/10.1136/ip.9.4.353>
- Borkenstein, R., Crowther, R., & Shumate, R. (1974). The role of the drinking driver in traffic accidents (the Grand Rapids study). *Blutalkohol*, 11(Suppl), 1-131.
- Bouffard, J., Niebuhr, N., & Exum, M. (2016). Examining specific deterrence effects on DWI among serious offenders. *Crime & Delinquency*, 63(14), 1923-1945.
<https://doi.org/10.1177/0011128716675359>

- Bowling, A. (2005). Mode of questionnaire administration can have serious effects on data quality. *Journal of Public Health*, 27(3), 281-291.
<https://doi.org/10.1093/pubmed/fdi031>
- Bradburn, M., Clark, T., Love, S., & Altman, D. (2003). Survival analysis part II: multivariate data analysis – an introduction to concepts and methods. *British Journal of Cancer*, 89(3), 431-436. <https://doi.org/10.1038/sj.bjc.6601119>
- Bradburn, M., Clark, T., Love, S., & Altman, D. (2003). Survival analysis part III: multivariate data analysis – choosing a model and assessing its adequacy of fit. *British Journal of Cancer*, 89(4), 605-611. <https://doi.org/10.1038/sj.bjc.6601120>
- Bradford, B., Hohl, K., Jackson, J., & MacQueen, S. (2015). Obeying the rules of the road: Procedural justice, social identity, and normative compliance. *Journal of Contemporary Criminal Justice*, 31(2), 171-191.
<https://doi.org/10.1177/1043986214568833>
- Braithwaite, J. (1989). *Crime, Shame and Reintegration*. Cambridge, UK: Cambridge University Press.
- Braver, E. (2003). Race, Hispanic origin, and socioeconomic status in relation to motor vehicle occupant death rates and risk factors among adults. *Accident Analysis & Prevention*, 35(3), 295-309. [https://doi.org/10.1016/S0001-4575\(01\)00106-3](https://doi.org/10.1016/S0001-4575(01)00106-3)
- Briscoe, S. (2004). Raising the bar: can increased statutory penalties deter drink drivers? *Accident Analysis and Prevention*, 36(5), 919-929.
<https://doi.org/10.1016/j.aap.2003.10.005>
- Brown, S. (1998). Associations between peer drink driving, peer attitudes towards drink driving, and personal drink driving. *Journal of Applied Social Psychology*, 28(5), 423-426. <https://doi.org/10.1111/j.1559-1816.1998tb01713x>
- Brown, S., Esbensen, F., & Geis, G. (2015) Deterrence and rational choice theories of crime. In: *Criminology: Explaining Crime and its context*. 9th Edition. New York, USA: Taylor and Francis.
- Brown, S., Finn-Aage, E., & Geis, G. (2015). Deterrence and Rational Choice Theories of Crime. In: *Criminology: Explaining Crime and Its Context. Ninth Edition*. New York, USA: Routledge. pp. 153-209.
- Brown, T., Ouimet, M., Eldeb, M., Tremblay, J., Vingilis, E., Nadeau, L., Pruessner, J., & Bechara, A. (2017). The effect of age on the personality and cognitive characteristics of three distinct risky driving offender groups. *Personality and Individual Differences*, 113, 48-56. <https://doi.org/10.1016/j.paid.2017.03.007>

- Brownell, M., & Jutte, D. (2013). Administrative data linkage as a tool for child maltreatment research. *Child Abuse & Neglect*, 37(2-3), 120-124.
<https://doi.org/10.1016/j.chiabu.2012.09.013>
- Bunce, D., Young, M., Blane, A., & Khugpath, P. (2012). Age and inconsistency in driving performance. *Accident Analysis & Prevention*, 49, 293-299.
<https://doi.org/10.1016/j.aap.2012.01.001>
- Bureau of Infrastructure, Transport and Regional Economics (BITRE). (2011). *Fatal road crashes in Australia in the 1990s and 2000s: Information Sheet 41*. Department of Infrastructure, Transport, Regional Development and Communications.
https://www.bitre.gov.au/sites/default/files/is_041.pdf. Retrieved 25 November 2020.
- Bureau of Infrastructure, Transport and Regional Economics (BITRE). (2014). *Road Safety – Modelling a Global Phenomenon. (Report 141)*. Canberra, Australia: Department of Infrastructure, Transport, Regional Development and Communications.
https://www.bitre.gov.au/publications/2014/report_141. Retrieved 14 March 2018.
- Bureau of Infrastructure, Transport and Regional Economics (BITRE). (2019). *Yearbook 2019: Australian Infrastructure Statistical Report*. Canberra, Australia: Department of Infrastructure, Transport, Regional Development and Communications.
https://www.bitre.gov.au/sites/default/files/documents/BITRE_2019_YEARBOOK.pdf. Retrieved 25 November 2020.
- Bureau of Infrastructure, Transport and Regional Economics (BITRE). (2020). *Road trauma Australia – Annual Summaries*. Canberra, Australia: Department of Infrastructure, Transport, Regional Development and Communications.
https://www.bitre.gov.au/publications/ongoing/road_deaths_australia_annual_summaries. Retrieved 25 November 2020.
- Cacioppo, J., & Patrick, W. (2008). *Loneliness: human nature and the need for social connection. First Edition*. New York, USA: W.W. Norton & Co.
- Cameras Save Lives (2019). *Fines and penalties*. Melbourne, Australia: State Government Victoria. <https://www.camerassavelives.vic.gov.au/fines-penalties>. Retrieved 27 November 2020.
- Cameras Save Lives (2020). *Camera types*. Melbourne, Australia: State Government Victoria. <https://www.camerassavelives.vic.gov.au/how-cameras-work/camera-types>. Retrieved 26 November 2020.
- Cameron, M., Haworth, N., Oxley, J., Newstead, S. Le, T. (1993). *Evaluation of Transport Accident Commission Road Safety Television Advertising. Report No. 52*. Melbourne, Australia: Monash University Accident Research Centre.
https://www.monash.edu/_data/assets/pdf_file/0019/216514/muarc052.pdf. Retrieved 1 December 2020.

- Carty, M., Stough, C., & Gillespie, N. (1998). The psychological predictors of work accidents and driving convictions in the transport industry. *Safety Science Monitor, Volume 3, Road Safety Article 4*.
- Caspi, A., Chajut, E., Saporta, K., & Beyth-Marom, R. (2006). The influence of personality on social participation in learning environments. *Learning and Individual Differences*, 16(2), 129-144. <https://doi.org/10.1016/j.lindif.2005.07.003>
- Castle, J. (2003). Maximising research opportunities: secondary data analysis. *Journal of Neuroscience Nursing*, 35(5), 287-290. <https://doi.org/10.1097/01376517-200310000-00008>
- Cestac, J., & Delhomme, P. (Eds.). *European road users' risk perception and mobility – The SARTRE 4 survey*. IFSTTAR. https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/projects_sources/sartre4_final_report.pdf. Retrieved 25 November 2020.
- Chamorro-Premuzic, T., Furnham, A., & Lewis, M. (2007). Personality and approaches to learning predict preference for different teaching methods. *Learning and Individual Differences*, 17(3), 241-250. <https://doi.org/10.1016/j.lindif.2006.12.001>
- Chandraratna, S., Stamatiadis, N., & Stromberg, A. (2006). Crash involvement of drivers with multiple crashes. *Accident Analysis and Prevention*, 38(3), 532-541. <https://doi.org/10.1016/j.aap.2005.11.011>
- Charlton, J., Oxley, J., Fildes, B., Oxley, P., Newstead, S., Koppel, S., & O'Hare, M. (2006). Characteristics of older drivers who adopt self-regulatory driving behaviours. *Transportation Part F: Traffic Psychology and Behaviour*, 9(5), 363-373. <https://doi.org/10.1016/j.trf.2006.06.006>
- Chen, H., Cohen, P., & Chen, S. (2010). How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics – Simulation and Computation*, 39(4), 860-864. <https://doi.org/10.1080/03610911003650383>
- Chihuri, S., Li, G., and Chen, Q. (2017). Interaction of marijuana and alcohol on fatal motor vehicle crash risk: a case-control study. *Injury Epidemiology*, 4(1). <https://doi.org/10.1186/s40621-017-0105z>
- Ch'ng, C.W., Fitzgerald, M., Gerostamoulos, J., Cameron, P., Bui, D., Drummer, O., Potter, J., & Odell, M. (2007). Drug use in motor vehicle drivers presenting to an Australian, adult major trauma centre. *Emergency Medicine Australasia*, 19(4), 359-365. <https://doi.org/10.1111/j.1742-6723.2007.00958.x>
- Chraif, M., Anitei, M., Burtaverde, V., & Mihaila, T. (2016). The link between personality, aggressive driving, and risky driving outcomes – testing a theoretical model. *Journal*

- of Risk Research, 19(6), 780-797.
<https://dx.doi.org/10.1080/13669877.2015.1042500>
- Christensen, K., Doblhammer, G., Rau, R., & Vaupel, J. (2009). Ageing populations: the challenges ahead. *The Lancet*, 374(9696), 1196-1208.
[https://doi.org/10.1016/s0140-6736\(09\)61460-4](https://doi.org/10.1016/s0140-6736(09)61460-4)
- Cicchino, J. (2017). Effectiveness of forward collision warning and autonomous emergency braking systems in reducing front-to-rear crash rates. *Accident Analysis & Prevention*, 99, 142-152. <https://doi.org/10.1016/j.aap.2016.11.009>
- Cicchino, J. (2018). Effects of blind spot monitoring systems on police-reported lane-change crashes. *Traffic Injury Prevention*, 19(6), 615-622.
<https://doi.org/10.1080/15389588.2018.1476973>
- Clapham, C., & Nicholson, J. (2014). *The Concise Oxford Dictionary of Mathematics. Fifth Edition*. Oxford, UK: Oxford University Press.
<https://doi.org/10.1093/acref/9780199679591.001.0001>
- Clark, T., Bradburn, M., Love, S., & Altman, D. (2003). Survival analysis part 1: basic concepts and first analyses. *British Journal of Cancer*, 89(2), 232-238.
<https://doi.org/10.1038/sj.bjc.6601118>
- Classen, S., Nichols, A., McPeck, R., & Breiner, J. (2011). Personality as a predictor of driving performance: an exploratory study. *Transportation Research Part F: Traffic Psychology and Behaviour*, 14(5), 381-389. <https://doi.org/10.1016/j.trf.2011.04.005>
- Cobanoglu, C., Warde, B., & Moreo, P. (2001). A comparison of mail, fax, and web-based survey methods. *International Journal of Market Research*, 43(4), 441-452.
<https://doi.org/10.1177/147078530104300401>
- Cochran, J., Wood, P., Sellers, C., Wilkerson, W., & Chamlin, M. (1998). Academic dishonesty and low self-control: an empirical test of a general theory of crime. *Deviant Behavior*, 19(3), 227-255. <https://doi.org/10.1080/01629625.1998.9968087>
- Cole, P. (1979). The evolving case-control study. *Journal of Chronic Diseases*, 32(1-2), 15-27.
[https://doi.org/10.1016/0021-9681\(79\)90006-7](https://doi.org/10.1016/0021-9681(79)90006-7)
- Cole, A., Friedlander, D., & Trinh, Q. (2018). Secondary data sources for health services research in urologic oncology. *Urologic Oncology: Seminars and original investigations*, 36(4), 165-173. <https://doi.org/10.1016/j.urolonc.2017.08.008>
- Connelly, R., Playford, C. J., Gayle, V., & Dibben, C. (2016). The role of administrative data in the big data revolution in social science research. *Social Science Research*, 59, 1-12.
<https://doi.org/10.1016/j.ssresearch.2016.04.015>

- Couper, M. (2000). Web surveys: a review of issues and approaches. *Public Opinion Quarterly*, 64(4), 464-494.
- Cox, D. (1972). Regression models and life tables. *Journal of the Royal Statistical Society: Series B (Methodological)*, 34(2), 187-202. <https://doi.org/10.1111/j.2517-6161.1972.tb00899.x>
- Cunningham, M., Regan, M. (2016). The impact of emotion, life stress and mental health issues on driving performance and safety. *Road Transport and Research*, 25(3), 40-50.
- Cunningham, M., Regan, M., Horberry, T., Weeratunga, K., & Dixit, V. (2019). Public opinion about automated vehicles in Australia: Results from a large-scale national survey. *Transportation Research Part A: Policy and Practice*, 129, 1-18. <https://doi.org/10.1016/j.tra.2019.08.002>
- Dahlen, E., & White, R. (2006). The Big Five factors, sensation seeking, and driving anger in the prediction of unsafe driving. *Personality and Individual Differences*, 41(5), 903-915. <https://doi.org/10.1016/j.paid.2006.03.016>
- Daigneault, G., Joly, P., & Frigon, J-Y. (2002). Previous convictions or accidents and the risk of subsequent accidents of older drivers. *Accident Analysis and Prevention*, 34(2), 257-261. [https://doi.org/10.1016/S0001-4575\(01\)00014-8](https://doi.org/10.1016/S0001-4575(01)00014-8)
- Dalla Valle, L., & Kennett, R. (2015). Official statistics: data integration for enhanced information quality. *Quality and Reliability Engineering International*, 31(7), 1281-1300. <https://doi.org/10.1002/qre.1859>
- Dana, D. (2001). Rethinking the puzzle of escalating penalties for repeat offenders. *The Yale Law Journal*, 110(5), 733-783. <https://doi.org/10.2307/797607>
- Darke, S., Kelly, E., & Ross, J. (2004). Drug driving among injecting drug users in Sydney, Australia: prevalence, risk factors and risk perceptions. *Addiction*, 99(2), 175-185. <https://doi.org/10.1046/j.1360-0443.2003.00604.x>
- Datta, T., Schattler, K., & Datta, S. (2000). Red light violations and crashes at urban intersections. *Transportation Research Board*, 1734(1), 52-58. <http://dx.doi.org/10.3141/1734-08>
- Davey, J., Freeman, J., Palk, G., & Lavelle, A. (2008). The self-reported impact of legal and non-legal sanctions on drug driving behaviours in Queensland: A study of general motorists and convicted offenders. In *Proceedings Australasian Road Safety Research, Policing and Education Conference 2008*, 416-425. Adelaide, South Australia.

- Davis, J., Casteel, C., Hamann, C., & Peek-Asa, C. (2018). Risk of motor vehicle crash for older adults after receiving a traffic charge: A case-crossover study. *Traffic Injury Prevention*, 19(5), 506-512. <https://doi.org/10.1080/15389588.2018.1453608>
- De Pauw, E., Daniels, S., Thierie, M.m & Brijs, T. (2014). Safety effects of reducing the speed limit from 90km/h to 70km/h. *Accident Analysis and Prevention*, 62, 426-431. <https://doi.org/10.1016/j.aap.2013.05.003>
- Devlin, A., & McGillivray, J. (2016). Self-regulatory driving behaviours amongst older drivers according to cognitive status. *Transportation Research Part F: Traffic Psychology and Behaviour*, 39, 1-9. <https://doi.org/10.1016/j.trf.2016.02.001>
- Diamantopoulou, K., Cameron, M., Dyte, D., & Harrison, W. (1997). The relationship between demerit points accrual and crash involvement. *Report Number 116*. Clayton, Victoria: Monash University Accident Research Centre. https://www.monash.edu/_data/assets/pdf_file/0017/217043/muarc116.pdf
- Di Bartolomeo, S., Valent, F., Sbrojavacca, R., Marchetti, R., & Barbone, F. (2009). A case-crossover study of alcohol consumption, meals and the risk of road traffic rules. *BMC Public Health*, 9(1), 316. <https://doi.org/10.1186.1471-2458-9-316>
- Dickerson, A., Molnar, L., Bedard, M., Eby, D., Classen, S., & Polgar, J. (2019). Transportation and aging: an updated research agenda for advancing safe mobility. *Journal of Applied Gerontology*, 38(12), 1643-1660. <https://doi.org/10.1177/0733464817739154>
- Digman, J. (1990). Personality structure: Emergence of the Five-Factor Model. *Annual Review of Psychology*, 41, 417-440.
- Dingus, T., Guo, F., Lee, S., Antin, J., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proceedings of the National Academy of Sciences of the United States of America*, 113(10), 2636-2641. <https://doi.org/10.1073/pnas.1513271113>
- Doecke, S., & Kloeden, C. (2014). The accuracy of determining speeding directly from mass crash data and using the NSW Centre for Road Safety Method. *Journal of the Australasian College of Road Safety*, 25(1), 35-41.
- Donmez, B., Boyle, L., & Lee, J. (2010). Differences in off-road glances: Effects on young drivers' performance. *Journal of Transportation Engineering*, 136(5), 403-409. [https://doi.org/10.1061/A\(ASCE\)TE.1943-5436.0000068](https://doi.org/10.1061/A(ASCE)TE.1943-5436.0000068)
- Doroudgar, S., Chuang, H., Perry, P., Thomas, K., Bohnert, K., & Canedo, J. (2017). Driving performance comparing older versus younger drivers. *Traffic Injury Prevention*, 18(1), 41-46. <https://doi.org/10.1080/15389588.2016.1194980>

- Dosen, I., Aroozoo, M., & Graham, M. (2017). *Automated Vehicles, Research Paper No. 7*. Parliamentary Library Information Service, Department of Parliamentary Services, Parliament of Victoria. Victoria, Australia.
<https://apo.org.au/sites/default/files/resource-files/2017-12/apo-nid123721.pdf>.
- Dowling, R. (2000). Cultures of mothering and car use in suburban Sydney: a preliminary investigation. *Geoforum*, 31(3), 345-353. [https://doi.org/10.1016/S0016-7185\(99\)00048-2](https://doi.org/10.1016/S0016-7185(99)00048-2)
- Drake, B., & Jonson-Reid, M. (1999). Some thoughts on the increasing use of administrative data in child maltreatment research. *Child Maltreatment*, 4(4), 308-315.
<https://doi.org/10.1177/1077559599004004004>
- Drummer, O., Gerostamoulos, J., Batzaris, H., Chu, M., Caplehorn, J., Robertson, M., & Swann, P. (2003). The incidence of drugs in drivers killed in Australian road traffic crashes. *Forensic Science International*, 134(2), 154-162.
[https://doi.org/10.1016/S0379-0738\(03\)00134-8](https://doi.org/10.1016/S0379-0738(03)00134-8)
- Drummer, O., Gerostamoulos, J., Batzaris, H., Chu, M., Caplehorn, J., Robertson, M., & Swann, P. (2004). The involvement of drugs in drivers of motor vehicles killed in Australian road traffic crashes. *Accident Analysis and Prevention*, 36(2), 239-248.
[https://doi.org/10.1016/S001-4575\(02\)00153-7](https://doi.org/10.1016/S001-4575(02)00153-7)
- Drummer, O., Kourtis, I., Beyer, J., Tayler, P., Boorman, M., & Gerostamoulos, D. (2012). *The prevalence of drugs in injured drivers*, 215(1-3), 14-17.
<https://doi.org/10.1016/j.forsciint.2011.01.040>
- Dubois, S., Mullen, N., Weaver, B., & Bédard, M. (2015). The combined effects of alcohol and cannabis on driving: Impact on crash risk. *Forensic Science International*, 248, 94-100. <https://doi.org/10.1016/j.forsciint.2014.12.018>
- Dupepe, E., Kicielinski, K., Gordon, A., & Walters, B. (2019). What is a Case-Control Study? *Neurosurgery*, 84(4), 819-826. <https://doi.org/10.1093/neuros/nyy590>
- Dykstra, C., Davis, J., & Conlon, E. (2020). Tactical and strategic driving behaviour in older drivers: The importance of readiness to change. *Accident Analysis and Prevention*, 141, 105519. <https://doi.org/10.1016/j.aap.2020.105519>
- Eby, D. (2011). Naturalistic Observation Field Techniques for Traffic Psychology Research. In B. Porter (Ed.), *Handbook of Traffic Psychology* (pp. 61-72). Oxford, United Kingdom: Elsevier.
- Eby, D., Molnar, L., Kostyniuk, L., Zakrajsek, J., Ryan, L., Zanier, N., St.Louis, R., Stanciu, S., Bogard, S., Demchak, D., DiGuseppi, C., Li, G., Mielenz, T., Strogatz, D., LeBlanc, D., Smith, J., Yung, R., Nyquist, L., Andrews, H., Betz, M., Hill, L., & Jones, V. (2018). The association between visual abilities and objectively-measured driving space,

- exposure, and avoidance among older drivers: a preliminary analysis. *Journal of the Australasian College of Road Safety*, 29(4), 39-45.
- Eby, D., Silverstein, N., Molnat, L., LeBlanc, D., Adler, G. (2012). Driving behaviors in early stage dementia: a study using in-vehicle technology. *Accident Analysis & Prevention*, 49, 330-337. <https://doi.org/10.1016/j.aap.2011.11.021>
- Economic Connections. (2017). Cost of road trauma in Australia 2015. *Report Prepared for the Australian Automobile Association*. Hall, Australian Capital Territory: Economic Connections Pty Ltd. https://www.aaa.asn.au/wp-content/uploads/2018/03/AAA-ECON_Cost-of-road-trauma-full-report_Sep-2017.pdf. Retrieved 15 September 2020.
- Elliott, D., Keen, W., & Miao, L. (2019). Recent advances in connected and automated vehicles. *Journal of Traffic and Transportation Engineering*, 6(2), 109-131. <https://doi.org/10.1016/j.jtte.2018.09.005>
- Elvik, R. (2008). Dimensions of road safety problems and their measurement. *Accident Analysis & Prevention*, 40(3), 1200-1210. <https://doi.org/10.1016/j.aap.2008.01.004>
- Elvik, R. (2010). Why some road safety problems are more difficult to solve than others. *Accident Analysis & Prevention*, 42(4), 1089-1096. <https://doi.org/10.1016/j.aap.2009.12.020>
- Evans, E., Grella, C., Murphy, D., & Hser, Y. (2010). Using administrative data for longitudinal substance abuse research. *The Journal of Behavioural Health Services and Research*, 37(2), 252-271. <https://doi.org/10.1007/s11414-008-9125-3>
- Factor, R. (2014). The effect of traffic tickets on road traffic crashes. *Accident Analysis and Prevention*, 64, 86-91. <https://doi.org/10.1016/j.aap.2013.11.010>
- Ferguson, S. (2003). Other high-risk factors for young drivers – how graduated licensing does, doesn't, or could address them. *Journal of Safety Research*, 34(1), 71-77. [https://doi.org/10.1016/S0022-4375\(02\)00082-8](https://doi.org/10.1016/S0022-4375(02)00082-8)
- Ferguson, M., Schonfeld, C., Sheehan, M., & Siskind, V. (2001). *The impact of the "Under the Limit" drink driving rehabilitation program on the lifestyle and behaviour of offenders*. Report prepared for the Australian Transport Safety Bureau. https://eprints.qut.edu.au/7947/1/Alc_Rehab_3.pdf. Retrieved 21 April 2021.
- Fitzharris, M., Liu, S., Peiris, S., Devlin, A., Young, K., Lenne, M., Bowman, D., Gatlof, J. (2015). *Options to extend coverage of alcohol interlock programs*. Research Report AP-R495-15. Sydney, Australia: Austroads.
- Flynn, R. (2012) Survival analysis. *Journal of Clinical Nursing*, 21(19-20), 2789-2797. <https://doi.org/10.1111/j.1365-2702.2011.04023.x>

- Foglia, W. (1997). Perceptual deterrence and the mediating effect of internalized norms among inner-city teenagers. *Journal of Research in Crime and Delinquency*, 34(4), 414-442. <https://doi.org/10.1177/0022427897034004002>
- Forrest, K., Bunker, C., Songer, T., Coben, J., & Cauley, J. (1997). Driving patterns and medical conditions in older women. *Journal of the American Geriatrics Society*, 45(10), 1214-1218. <https://doi.org/10.1111/j.1532-5415.1997.tb03772.x>
- Foss, R., & Goodwin, A. (2014). Distracted driver behaviors and distracting conditions among adolescent drivers: From a naturalistic driving study. *Journal of Adolescent Health*, 54(5), S50-S60. <https://doi.org/10.1016/j.jadohealth.2014.01.005>
- Freeman, J., Liossis, P., & David, N. (2006). Deterrence, defiance and deviance: an investigation into a group of recidivist drink drivers' self-reported offending behaviours. *The Australian and New Zealand Journal of Criminology*, 39(1), 1-19. <https://doi.org/10.1375/acri.39.1.1>
- Freeman, J., Liossis, P., Schonfeld, C., & Sheehan, M. (2005a). A preliminary investigation into the self-reported impact of a drink driving rehabilitation program on a group of recidivist drink drivers. *Road and Transport Research*, 14(3), 14-23.
- Freeman, J., Liossis, P., Schonfeld, C., Sheehan, M., Siskind, V., & Watson B. (2005b). Self-reported motivations to change and self-efficacy levels for a group of recidivist drink drivers. *Addictive Behaviors*, 30, 1230-1235. <https://doi.org/10.1016/j.addbeh.2004.10.007>
- Freeman, J., Liossis, P., Schonfeld, C., Sheehan, M., Siskind, V., & Watson B. (2006). The self-reported impact of legal and non-legal sanctions on a group of recidivist drink drivers. *Transportation Research: Part F: Psychology and Behaviour*, 9(1), 53-64. <https://doi.org/10.1016/j.trf.2005.08.005>
- Freeman, J., Szogi, E., Truelove, V., & Vingilis, E. (2016). The law isn't everything: The impact of legal and non-legal sanctions on motorists' drink driving behaviours. *Journal of Safety Research*, 59, 53-60. <https://doi.org/10.1016/j.jsr.2016.10.001>
- Freeman, J., Watling, C., Davey, J., & Palk, G. (2010). Perceptual deterrence versus current behaviours: A study into factors influencing drug driving in Queensland. *Road Transport and Research*, 19(3), 3-13.
- Freeman, J., & Watson, B. (2006). An application of Stafford and Warr's reconceptualization of deterrence to a group of recidivist drink drivers. *Accident Analysis & Prevention*, 38(3), 462-471. <https://doi.org/10.1016/j.aap.2005.11.001>
- Freeman, J., & Watson, B. (2009). Drink driving deterrents and self-reported offending behaviours among a sample of Queensland motorists. *Journal of Safety Research*, 40(2), 113-120. <https://doi.org/10.1016/j.jsr.2008.12.009>

- Fulton-Kehoe, D., Gluck, J., Wu, R., Mootz, R., Wickizer, T., & Franklin, G. (2007). Measuring work disability: what can administrative data tell us about patient outcomes. *Journal of Occupational and Environmental Medicine*, 49(6), 651-658. <https://doi.org/10.1097/JOM.0b013e318058a9e7>
- Gallo, J., Rebok, G., & Lesikar, S. The driving habits of adults aged 60 years and older. *Journal of the American Geriatrics Society*, 47(3), 335-341. <https://doi.org/10.1111/j.1532-5415.1999.tb02998.x>
- Gibbs, J. (1979). Assessing the deterrence doctrine: A challenge for the social and behavioral sciences. *The American Behavioral Scientist*. 22(6), 653-677. <https://doi.org/10.1177/000276427902200604>
- Goldberg, L. (1993). The structure of phenotypic personality traits. *American Psychologist*, 48(1), 26-34. <https://doi.org/10.1037/0003-066X.48.1.26>
- Goldenbeld, C., Reurings, M., Van Norden Y., & Stipdonk, H. (2013). Crash involvement of motor vehicles in relationship to the number and severity of traffic offenses. An exploratory analysis of Dutch traffic offenses and crash data. *Traffic Injury Prevention*, 14(6), 584-591. <https://doi.org/10.1080/15389588.2012.743125>
- González-Iglesias, B., Gómez-Fraguela, J., & Luengo-Martin, M. (2012). Driving anger and traffic violations: gender differences. *Transportation Research Part F: Traffic Psychology and Behaviour*, 15(4), 404-412. <https://doi.org/10.1016/j.trf.2012.03.002>
- González-González, E., Nogués, S., & Stead, D. (2019). Automated vehicles and the city of tomorrow: A backcasting approach. *Cities*, 94, 153-160. <https://doi.org/10.1016/j.cities.2019.05.034>
- Gonzalez, O., & MacKinnon, D. (2020). The measurement of the mediator and its influence on statistical mediation conclusions. *Psychological Methods*. <https://doi.org/10.1037/met0000263>
- Gottfredson, M., & Hirschi, T. (1986). The true value of lambda would appear to be zero: An essay on career criminals, criminal careers, selective incapacitation, cohort studies, and related topics. *Criminology*, 24(2), 213-233. <https://doi.org/10.1111/j.1745-9125.1986.tb01494.x>
- Gottfredson, M., & Hirschi, T. (1990). *A General Theory of Crime*. California, USA: Stanford University Press.
- Government of South Australia Department of Planning, Transport and Infrastructure. (2018). *Towards Zero Together – South Australia's Road Safety Action Plan 2019-2019*. Adelaide, Australia: Government of South Australia. https://dpti.sa.gov.au/_data/assets/pdf_file/0003/414579/MAC-DPTI_South_Australias_Road_Safety_Action_Plan_2018-019_visual_p12.pdf. Retrieved 28 November 2020.

- Government of Western Australia Road Safety Commission. (2009). *Road Safety Strategy To Reduce Trauma in Western Australia 2008-2020*. Perth, Australia: Government of Western Australia.
<https://www.rsc.wa.gov.au/RSC/media/Documents/About%20Us/Towards%20Zero/towards-zero-strategy.pdf>. Retrieved 28 November 2020.
- Granello, D., & Wheaton, J. (2004). Online data collection: strategies for research. *Journal of Counselling and Development*, 82(4), 387-393.
<https://doi.org/10.1002/j.1556-6678.2004.tb00325.x>
- Grasmick, H., & Bursik, R. (1990). Conscience, significant others, and rational choice: extending the deterrence model. *Law and Society Review*, 24(1990), 837-861.
- Grasmick, H., & Green, D. (1980). Legal punishment, social disapproval and internalization as inhibitors of illegal behaviour. *The Journal of Criminal Law and Criminology*, 71(3), 325-335. <https://doi.org/10.2307/1142704>
- Graziano, W., & Tobin, R. (2016). Agreeableness and the Five Factor Model. In: T. Widiger (Ed.), *The Oxford Handbook of the Five Factor Model*. Oxford University Press.
<https://doi.org/10.1093/oxfordhb/9780199352487.013.17>
- Green, D. (1989). Measures of illegal behaviour in individual-level deterrence research. *Journal of Research in Crime and Delinquency*, 26(3), 253-275.
<https://doi.org/10.1177/0022427889026003004>
- Greenberg, D. (1981). Methodological issues in survey research on the inhibition of crime. *The Journal of Criminal Law and Criminology*, 72(3), 1094-1101.
<https://doi.org/10.2307/1143277>
- Greenland, S. (1996). Confounding and exposure trends in case-crossover and case-time-control designs. *Epidemiology*, 7(3), 231-239. <https://doi.org/10.1097/00001648-199605000-00003>
- Grimes, D., & Schulz. (2002). Bias and causal associations in observational research. *The Lancet*, 359(9302), 248-252. [https://doi.org/10.1016/S0140-6736\(02\)07451-2](https://doi.org/10.1016/S0140-6736(02)07451-2)
- Griep, D. (1970). Propaganda and alternative countermeasures for road safety. *Accident Analysis and Prevention*, 2(2), 127-140. [https://doi.org/10.1016/0001-4575\(70\)90072-2](https://doi.org/10.1016/0001-4575(70)90072-2)
- Groeger, J. (2006). Youthfulness, inexperience, and sleep loss: the problems young drivers face and those they pose for us. *Injury Prevention*, 12(Suppl 1), i19-i24.
<https://doi.org/10.1136/ip.2006.012070>
- Groves, R. (2006). Nonresponse rates and nonresponse bias in household surveys. *The Public Opinion Quarterly*, 70(5), 646-675. <https://doi.org/10.1093/poq/nfl033>

- Guo, F. (2019). Statistical methods for naturalistic driving studies. *Annual Review of Statistics and Its Application*, 6(1), 309-328. <https://doi.org/10.1146/annurev-statistics-030718-105153>
- Guo, F., Klauer, S., Fang, Y., Hankey, J., Antin, J., Perez, M., Lee, S., & Dingus, T. (2017). The effects of age on crash risk associated with driver distraction. *International Journal of Epidemiology*, 46(1), 258-265. <https://doi.org/10.1093/ije/dyw234>
- Guo, F., Klauer, S., Hankey, J., & Dingus, T. (2010). Near crashes as crash surrogate for naturalistic driving studies. *Transportation Research Record: Journal of the Transportation Research Board*, 2147(1), 66-74. <https://doi.org/10.3141/2147-09>
- Haddon, W. (1972). A logical framework for categorizing highway safety phenomena and activity. *The Journal of Trauma*, 12(3), 193-207. <https://doi.org/10.1097/00005373-197203000-00002>
- Haddon, W. (1975). Reducing the damage of motor vehicle use. *Technology Review*, 77(8), 52-59.
- Haddon, W. Advances in the epidemiology of injuries as a basis for public policy. *Public Health Reports (1974-)*, 95(5), 411-421.
- Hakamies-Blomqvist, L., & Wahlström, B. (1998). Why do older drivers give up driving? *Accident Analysis & Prevention*, 30(3), 305-312. [https://doi.org/10.1016/S0001-4575\(97\)00106-1](https://doi.org/10.1016/S0001-4575(97)00106-1)
- Hallas, J., & Pottegard, A. (2014). Use of self-controlled designs in pharmacoepidemiology. *Journal of Internal Medicine*, 275(6), 581-589. <https://doi.org/10.1111/joim.12186>
- Hanowski, R., Perez, M., & Dingus, T. (2005). Driver distraction in long-haul truck drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 8(6), 441-558. <https://doi.org/10.1016/j.trf.2005.08.001>
- Hansen, B. (2015). Punishment and deterrence: evidence from drunk driving. *American Economic Review*. 105(4), 1581-1617. <https://doi.org/10.1257/aer.20130189>
- Haque, M. (1990). Evaluation of the demerit points system in deterring traffic offences. *Evaluation Review*, 14, 22-41. <https://doi.org/10.1177/0193841X9001400102>
- Harbaugh, C., & Cooper, J. (2018). Administrative databases. *Seminars in Pediatric Surgery*, 27(6), 353-360. <https://10.1053/j.sempedsurg.2018.10.001>
- Hardré, P., Crowson, H., Xie, K., & Ly, C. (2007). Testing differential effects of computer-based, web-based and paper-based administration of questionnaire research instruments. *British Journal of Educational Technology*, 38(1), 5-22. <https://doi.org/10.1111/j.1467-8535.2006.00591.x>

- Harron, K., Dibben, C., Boyd, J., Hjern, A., Azimaee, M., Barreto, M., & Goldstein, H. (2017). Challenges in administrative data linkage for research. *Big Data & Society*, 4(2), 2053951717745678. <https://doi.org/10.1177/2053951717745678>
- Hartley, L., & El Hassani, J. (1994). Stress, violations and accidents. *Applied Ergonomics*, 25(4), 221-230. [https://doi.org/10.1016/0003-6870\(94\)90003-5](https://doi.org/10.1016/0003-6870(94)90003-5)
- Hashimoto, R., Brodt, E., Skelly, A., & Dettori, J. (2014). Administrative database studies: goldmine or goose chase? *Evidence Based Spine Care Journal*, 5(2), 74-76. <https://doi.org/10.1055/s-0034-1390027>
- Hayes, A. (2013). The Simple Mediation Model. In: *Introduction to Mediation, Moderation, and Conditional Process Analysis*. New York, USA: The Guilford Press. pp. 85-122
- Hels, T., Lyckegaard, A., Simonsen, K., Steentoft, A., Bernhoft, I. (2013). Risk of severe driver injury by driving with psychoactive substances. *Accident Analysis and Prevention*, 59, 346-356. <https://doi.org/10.1016/j.aap.2013.06.003>
- Hendrie, D., & Miller, T. (2012). *Measuring the costs of road trauma and its longer-term consequences (RR-09-002)*. Monash Curtin Accident Research Centre. http://c-marc.curtin.edu.au/local/docs/MCRTLTC_FINAL.pdf. Retrieved 21 March 2017.
- Hernández-Díaz, S., Hernán, M., Meyer, K., Werler, M., & Mitchell, A. (2003). Case-crossover and case-time-control designs in birth defects epidemiology. *American Journal of Epidemiology*, 158(4), 385-391. <https://doi.org/10.1093/aje.kwg144>
- Hewson, C., Laurent, D., & Vogel, C. (1996). Proper methodologies for psychological studies conducted via the Internet. *Behavior Research Methods, Instruments and Computers*, 28(2), 186-191.
- Hill, L., Andrews, H., Li, G., DiGuseppi, C., Betz, M., Strogatz, D., Pepa, P., Eby, D., Merle, D., Kelley-Baker, T., Jones, V., Pitts, S. (2020). Medication use and driving patterns in older drivers: preliminary findings from the LongROAD study. *Injury Epidemiology*, 7(1), 38. <https://doi.org/10.1186/s40621-020-00265-y>
- Hofstede, G., & McCrae, R. (2004). Personality and culture revisited: linking traits and dimensions of culture. *Cross-Cultural Research*, 38(1), 52-88. <https://doi.org/10.1177/1069397103259443>
- Holdridge, J., Shankar, V., & Ulfarsson, G. (2005). The crash severity impacts of fixed roadside objects. *Journal of Safety Research*, 36(2), 139-147. <https://doi.org/10.1016/j.jsr.2004.12.005>
- Homel, R. (1988). *Policing and Punishing the Drinking Driver: A study of General and Specific Deterrence*. Springer, New York.

- Hong, R., & Paunonen, S. (2009). Personality traits and health-risk behaviours in university students. *European Journal of Personality*, 23(8), 675-696. <https://doi.org/10.1002/per.736>
- Horswill, M., & Helman, S. (2003). A behavioural comparison between motorcyclists and a matched group of non-motorcycling car drivers: factors influencing accident risk. *Accident Analysis & Prevention*, 35(4), 589-597. [https://doi.org/10.1016/s0001-4575\(02\)00039-8](https://doi.org/10.1016/s0001-4575(02)00039-8)
- Hucklesby, A. (2004). Sentencing and court processes. In: J. Muncie & D. Wilson (Eds.). *Student Handbook of Criminal Justice and Criminology*. Oxon, United Kingdom: Routledge-Cavendish. pp. 203-220.
- IBM Corp. (2017). IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.
- Ige, J., Banstola, A., & Pilkington, P. (2016). Mobile phone use while driving: Underestimation of a global threat. *Journal of Transport & Health*, 3(1), 4-8. <https://doi.org/10.1016/j.jth.2015.11.003>
- Imberger, K., Watson, A., & Kaye, S-A. (2019). The effect of sanctions on Victorian speeding drivers. *Journal of the Australasian College of Road Safety*, 30(4), 41-49.
- Isaksson-Hellman, I., & Lindman, M. (2018). Traffic safety benefit of a lane departure warning system. *International Journal of Automotive Engineering*, 9(4), 289-295. https://doi.org/10.20485/jsaeijae.9.5_289
- Jackson, J., Bradford, B., Hough, M., Myhill, A., Quinton, P., Tyler, T. (2012). Why do people comply with the law? Legitimacy and the influence of legal institutions. *British Journal of Criminology*, 52(6), 1051-1071. <https://10.1093/bjc/azs032>
- Jackson, J., & Roberts, B. (2015). Conscientiousness. In: T. Widiger (Ed.), *The Oxford Handbook of the Five Factor Model*. Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199352487.013.18>
- Jacob, H. (1980). Deterrent effects of formal and informal sanctions. *Law and Policy Quarterly*, 2(1), 61-80 <https://doi.org/10.1111/j.1467-9930.1980.tb00204.x>
- Jewell, N. (2003). *Statistics for Epidemiology*. Florida, USA: Chapman & Hall/CRC.
- John, O. (1990). The 'Big Five' factor taxonomy: dimensions of personality in the natural language and in questionnaires. In: L. Pervin (Eds.), *Handbook of Personality: Theory and Research*. New York: USA, Guilford Press. pp. 66-100.
- John, O., Donahue, E., & Kentle, R. (1991). *The Big Five Inventory – Versions 4a and 54*. Berkley, USA: University of California, Berkeley, Institute of Personality and Social Research.

- John, O., Naumann, L., & Soto, C. (2008). Paradigm shift to the integrative Big-Five trait taxonomy: History, measurement and conceptual issues: In: O. John, R. Robbins & L. Pervin (Eds.), *Handbook of Personality: Theory and Research. Third Edition*. New York: USA, Guilford Press. pp. 114-158.
- John, O., & Srivastava, S. (1999). The Big-Five trait taxonomy: History, measurement and theoretical perspectives. In: L. Pervin & O. John (Eds.), *Handbook of Personality: Theory and Research. Second Edition*. New York: USA, Guilford Press. pp. 102-138.
- Jonah, B. (1990). Age differences in risky driving. *Health Education Research*, 5(2), 139-149.
<https://doi.org/10.1093/her/5.2.139>
- Jonah, B. (1997). Sensation seeking and risky driving: a review and synthesis of the literature. *Accident Analysis and Prevention*, 29(5), 661-665.
[https://doi.org/10.1016/S0001-4575\(97\)00017-1](https://doi.org/10.1016/S0001-4575(97)00017-1)
- Jones, C., Donnelly, N., Swift, W., & Weatherburn, D. (2005). Driving under the influence of cannabis: The problem and potential countermeasures. *Crime and Justice Bulletin, Number 87*. New South Wales Bureau of Crime Statistics and Research.
<https://www.bocsar.nsw.gov.au/Publications/CJB/cjb87.pdf>
- Jones, P., & Elias, P. (2006). *Administrative data as a research resource: a selected audit*. Economic and Social Research Council.
<http://eprints.ncrm.ac.uk/452/1/Admin%2520Data%2520selected%2520audit%2520Dec06.pdf>. Retrieved on 28 November 2020.
- Kaplowitz, M., Hadlock, T., & Levine, R. (2004). A comparison of web and mail survey response rates. *Public Opinion Quarterly*, 68(1), 94-101.
<https://doi.org/10.1093/poq/nfh006>
- Kapteyn, A., & Ypma, J. (2007). Measurement error and misclassification: a comparison of survey and administrative data *Journal of Labor Economics*, 25(3), 513-551.
<https://doi.org/10.1086/513298>
- Karthaus, M., & Falkenstein, M. (2016). Functional changes and driving performance in older drivers: Assessment and interventions. *Geriatrics*, 1(2), 12.
<https://doi.org/10.3390/geriatrics1020012>
- Kaspi-Baruch, O. (2017). Big Five Personality and Creativity: The Moderating Effect of Motivational Goal Orientation. *The Journal of Creative Behavior*, 53(3), 325-338.
<https://doi.org/10.1002/jocb.183>
- Kaye, S-A., Buckley, L., Rakotonirainy, A., & Delhomme, P. (2019). An adaptive approach for trialling fully automated vehicles in Queensland Australia: A brief report. *Transport Policy*, 81, 275-281. <https://doi.org/10.1016/j.tranpol.2019.07.007>

- Keall, M., & Frith, W. (2004). Association between older driver characteristics, on-road driving test performance, and crash liability. *Traffic Injury Prevention*, 5(), 112-116. <https://doi.org/10.1080/15389580490435006>
- Keall, M., Frith, W., & Patterson, T. (2005). The contribution of alcohol to night time crash risk and other risks of night driving. *Accident Analysis and Prevention*, 37(5), 816-824. <https://doi.org/10.1016/j.aap.2005.03.021>
- Keane, C., Maxim, P., & Teevan, J. (1993). Drinking and driving, self-control, and gender: testing a general theory of crime. *Journal of Research in Crime and Delinquency*, 30(1), 30-46. <https://doi.org/10.1177/0022427893030001003>
- Kennedy, D. (2009a). Some implications of the subjectivity of deterrence. In: *Deterrence and Crime Prevention: Reconsidering the prospect of sanction*. Oxon, United Kingdom: Routledge. pp. 24-39.
- Kennedy, D. (2009b). Introduction. In: *Deterrence and Crime Prevention: Reconsidering the prospect of sanction*. Oxon, United Kingdom: Routledge. pp. 1-8.
- Klauer, S., Dingus, T., Neale, V., Sudweeks, J., & Ramsey, D. (2006). *The impact of driver inattention on near-crash/crash-risk: an analysis using the 100-Car Naturalistic Driving Study Data. DOT HS 810 594*. Washington DC, USA: U.S. Department of Transportation: National Highway Safety Administration. <https://vtechworks.lib.vt.edu/bitstream/handle/10919/55090/DriverInattention.pdf?sequence=1>. Retrieved 26 November 2020
- Klauer, S., Perez, M., & McClafferty, J. (2011). Naturalistic driving studies and data coding analysis techniques. *Handbook of Traffic Psychology* (pp. 73-85). Oxford, United Kingdom: Elsevier.
- Kloeden, C., McLean, A., & Glonek, G. (2002). *Reanalysis of travelling speed and the risk of crash involvement in Adelaide, South Australia*. Road Safety Research Report. CR207. Australian Transport Safety Bureau. http://www.atsb.gov.au/publications/2002/pdf/Speed_Risk_3.pdf
- Kloeden, C., McLean, A., Moore, V., & Ponte, G. (1997). *Travelling speed and the risk of crash involvement: Volume 1 – Findings*. Canberra, Australia: Federal Office of Road Safety. https://www.infrastructure.gov.au/roads/safety/publications/1997/pdf/Speed_Risk_1.pdf
- Kloeden, C., Ponte, G., & McLean, J. (2001). *Travelling speed and the risk of crash involvement on rural roads*. Canberra, Australian Capital Territory: Australian Transport Safety Bureau.
- Knol, M., Vandenbroucke, J., Scott, P., & Egger, M. (2008). What do case-control studies estimate? Survey of methods and assumptions in published case-control research.

- American Journal of Epidemiology*, 168(9), 1073-1081.
<https://doi.org/10.1093/aje/kwn217>
- Kowalski, K., Jeznach, A., & Tuokko, H. (2014). Stages of driving behaviour change within the Transtheoretical Model (TM). *Journal of Safety Research*, 50, 17-25.
<https://doi.org/10.1016/j.jsr.2014.01.002>
- Kposowa, A., & Breault, K. (2009). Motor vehicle deaths among men: marital status, gender and social integration. *International Journal of Men's Health*, 8(2), 129-142.
<https://doi.org/10.3149/jmh.0802.129>
- Kulig, T., Cullen, F., Wilcox, P., & Chouhy, C. (2019). Personality and adolescent school-based victimization: do the big five matter. *Journal of School Violence*, 18(2), 176-199.
<https://doi.org/10.1080/15388220.2018.1444495>
- Kuo, J., Charlton, J., Koppel, S., Rudin-Brown, C., & Cross, S. (2016). Modelling driving performance using in-vehicle speech data from a naturalistic driving study. *Human Factors*, 58(6), 833-845. <https://doi.org/10.1177/0018720716650565>
- Kurali, S., Gyi, D., & Mansfield, N. (2017). Driving a better driving experience: a question survey of older compared with younger drivers. *Ergonomics*, 60(4), 533-540.
<https://doi.org/10.1080/00140139.2016.1182648>
- Kuypers, K., Legrand, S.-A., Ramaekers, J., Verstraete, A., & Taffe, M. (2012). A case-control study estimating accident risk for alcohol, medicines and illegal drugs (Accident risk for different types of drugs). *PLOS One*, 7(8), e43496.
<https://doi.org/10.1371/journal.pone.0043496>
- Kwak, N., & Radler, B. (2002). A comparison between mail and web-based surveys: Response pattern, respondent profile, and data quality. *Journal of Official Statistics*, 18(2), 257-273.
- Kwok, C., Lloyd, D., & Yip, P. (2013). Ageing population scenarios: an Australian experience. *Journal of Populations Research*, 30(4), 335-345. <https://doi.org/10.1007/s12546-013-9114-0>
- Kyriakidis, M., Happee, R., & de Winter, J. Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transportation Part F: Traffic Psychology and Behaviour*, 32, 127-140. <https://doi.org/10.1016/j.trf.2015.04.014>
- Lacey, J., Kelley-Baker, T., Berning, A., Romano, E., Ramirez, A., Yao, J., Moore, C., Brainard, K., Carr, K., Pell, K., & Compton, R. (2016). Drug and alcohol crash risk: A case-control study. *Report No. DOT HS 812 355*. Washington, DC: National Highway Traffic Safety Administration. <https://rosap.nhtl.bts.gov/view/dot/1973>
- Lab, S. (2016). Specific deterrence and incapacitation. In: *Crime Prevention: Approaches, practices and evaluations*. New York, USA: Taylor and Francis, pp. 311-328.

- Lagarde, E., Chastang, J-F., Gueguen, A., Coeuret-Pellicer, M., Chiron, M., & Lafont, S. (2004). Emotional stress and traffic accidents: the impact of separation and divorce. *Epidemiology*, 15(6), 762-766. <https://doi.org/10.1097/01.ede.0000142140.77194.ad>
- Lam, L. (2003). Factors associated with fatal and injurious car crash among learner drivers in New South Wales, Australia. *Accident Analysis and Prevention*, 35(3), 333-340. [https://doi.org/10.1016/S0001-4575\(02\)00008-8](https://doi.org/10.1016/S0001-4575(02)00008-8)
- Langan, S., Benchimol, E., Guttman, A., Moher, D., Petersen, I., Smeeth, L., Sørensen, H., Stanley, E., & Von Elm, E. (2013). Setting the RECORD straight: developing a guideline for the reporting of studies conducted using observational routinely collected data. *Clinical Epidemiology*, 5(1), 29-31. <https://doi.org/10.2147/CLEP.S36885>
- Lanning, B., Melton, K., & Abel, N. (2018). The impact of a supplemental drivers' education program on teenage risk perception and driving behaviors. *Transportation Part F: Traffic Psychology and Behaviour*, 58, 442-451. <https://doi.org/10.1016/j.trf.2018.06.019>
- Larsson, P., Dekker, S., & Tingvall, C. (2010). The need for a systems theory approach to road safety. *Safety Science*, 48(9), 1167-1174. <https://doi.org/10.1016/j.ssci.2009.10.006>
- Lawton, R., Parker, D., Manstead, A., & Stradling, S. (1997). The role of affect in predicting social behaviors: the case of road traffic violations. *Journal of Applied Social Psychology*, 27(14), 1258-1276. <https://doi.org/10.1111/j.1559-1816.1997.tb01805.x>
- Lazar, J., & Preece, J. (1999). Designing and implementing web-based surveys. *The Journal of Computer Information Systems*, 39(4), 63-67.
- Lee, J., Young, K., & Regan, M. (2009). Defining driver distraction. In: M. Regan, J. Lee & K. Young (eds.). *Driver distraction: Theory, effects and mitigation*. Boca Raton, Florida, USA: CRC Press.
- Legree, P., Haffner, T., Psotka, J., Martin, D., & Medsker, G. (2003). Traffic crash involvement: experiential driving knowledge and stressful contextual antecedents. *Journal of Applied Psychology*, 88(1), 15-26. <https://doi.org/10.1037/0021-9010.88.1.15>
- Levin, K-A. (2006). Study design IV: Cohort studies. *Evidence-Based Dentistry*, 7, 51-52. <https://doi.org/10.1038/sj.ebd.6400407>
- Lewis, H. (1971). Shame and guilt in neurosis. *Psychoanalytic Review*, 58(3), 419.
- Li, J., Amr, S., Braver, E., Langenberg, P., Zhan, M., Smith, G., & Dischinger, P. (2011). Are current law enforcement strategies associated with a lower risk of repeat speeding citations and crash involvement? A longitudinal study of speeding Maryland drivers.

- Annals of Epidemiology*, 21(9), 641-647.
<https://doi.org/10.1016/j.annepidem.2011.03.014>
- Li, G., Andrews, H., Chihuri, S., Lang, B., Leu, C-S., Merle, D., Gordon, A., Mielenz, T., Strogatz, D., Eby, D., Betz, M., DiGuseppi, C., Jones, V., Molnar, L., & Hill, L. (2019). Prevalence of potentially inappropriate medication use in older drivers. *BMC Geriatrics*, 19(1), 260. <https://doi.org/10.1016/s12877-019-1287-8>
- Li, G., Brady, J., Chen, Q. (2013). Drug use and fatal motor vehicle crashes: A case control study. *Accident Analysis and Prevention*, 60, 205-210.
<https://doi.org/10.1016/j.aap.2013.09.001>
- Liljamo, T., Liimatainen, H., & Pöllänen, M. (2018). Attitudes and concerns on automated vehicles. *Transportation Part F: Traffic Psychology and Behaviour*, 59, 24-44.
<https://doi.org/10.1016/j.trf.2018.08.010>
- Linkov, V., Zaoral, A., Rezáč, P., & Pai, C-W. (2019). Personality and professional driver' behavior. *Transportation Research Part F: Traffic Psychology and Behaviour*, 60, 105-110. <https://doi.org/10.1016/j.trf.2018.10.017>
- Lonczak, H., Neighbors, C., & Donovan, D. (2007). Predicting risky and angry driving as a function of gender. *Accident Analysis & Prevention*, 39(3), 536-545.
<https://doi.org/10.1016/j.aap.2006.09.010>
- Lonero, L. (2008). Trends in driver education and training. *American Journal of Preventative Medicine*, 35(3S), S316-S323. <https://doi.org/10.1016/j.amepre.2008.06.023>
- Loxley, W., & Smith, L. (1991). Roadblock testing in Western Australia and the process of deterrence. *Australian Journal of Psychology*, 43(2), 101-106.
<https://doi.org/10.1080/00049539108259107>
- Lu, C. (2009). Observational studies: a review of study designs, challenges and strategies to reduce confounding. *International Journal of Clinical Practice*, 63(5), 691-697.
<https://doi.org/10.1111/j.1742-1241.2009.02056.x>
- Lucidi, F., Girelli, L., Chirico, A., Alivernini, F., Cozzolino, M., Violani, C., Mallia, L. (2019). Personality traits and attitudes toward traffic safety predict risky behaviour across young, adult and older drivers. *Frontiers in Psychology*, 10, 536.
<https://doi.org/10.3389/fpsyg.2019.00536>
- Lucidi, F., Mallia, L., Lazuras, L., & Violani, C. (2014). Personality and attitudes as predictors of risky driving among older drivers. *Accident Analysis and Prevention*, 72, 318-324.
<https://doi.org/10.1016/j.aap.2014.07.022>
- Lumley, T and Levy, D. (2000). Bias in the case-crossover study design: implications for studies of air pollution. *Environmetrics*, 11(6), 689-704.
[https://doi.org/10.1002/1099-095X\(200011/12\)11:6<689::AID-ENV439>3.0.CO2-N](https://doi.org/10.1002/1099-095X(200011/12)11:6<689::AID-ENV439>3.0.CO2-N)

- Lundman, R. (1986). One-wave perceptual deterrence research: Some grounds for the renewed examination of cross-sectional methods. *Journal of Research in Crime and Delinquency*, 23(4), 370-388. <https://doi.org/10.1177/0022427886023004004>
- Ma, C., Hao, W., Xiang, W., & Yan, W. (2018). The impact of aggressive driving behaviour on driver-injury severity at highway-rail grade crossings accidents. *Journal of Advanced Transportation*, 2018, 1-10. <https://doi.org/10.1155/2018/9841498>
- Ma, C., Yang, D., Zhou, J., Feng, Z., & Yuan, Q. (2019). Risk riding behaviors of urban e-bikes: A literature review. *International Journal of Environmental Research and Public Health*, 16(13). <https://doi.org/10.3390/ijerph16132308>
- Machin, M., & Sankey, K. (2008). Relationships between young drivers' personality characteristics, risk perceptions and driving behaviour. *Accident Analysis and Prevention*, 40(2), 541-547. <https://doi.org/10.1016/j.aap.2007.08.010>
- MacKinnon, D., Fairchild, A., & Fritz, M. (2007). *Mediation Analysis*. 58(1), 593–614. <https://doi.org/10.1146/annurev.psych.58.110405.085542>
- MacKinnon, D., Kisbu-Sakarya, Y., & Gottschall, A. (2013). Developments in Mediation Analysis. In: *The Oxford Handbook of Quantitative Methods in Psychology: Volume Two, Statistical Analysis*. Oxford, UK: Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199934898.013.0016>
- MacKinnon, D., Lockwood, C., Hoffman, J., West, S., & Sheets, V. (2002). A Comparison of Methods to Test Mediation and Other Intervening Variable Effects. *Psychological Methods*, 7(1), 83–104. <https://doi.org/10.1037/1082-989X.7.1.83>
- Maclure, M. (1991). The case-crossover design: a method for studying transient effects on the risk of acute events. *American Journal of Epidemiology*, 133(2), 144-153. <https://doi.org/10.1093/oxfordjournals.aje.a115853>
- Maclure, M., & Mittleman, M. (2000). Should we use a case-crossover design? *Annual Review of Public Health*, 21, 193-221.
- Males, M. (2009). Poverty as a determinant of young drivers' fatal crash risks. *Journal of Safety Research*, 40(6), 443-448. <https://doi.org/10.1016/j.jsr.2009.10.001>
- Mallia, L., Lambros, L., Violani, C., & Lucidi, F. (2015). Crash risk and aberrant driving behaviours among bus drivers: The role of personality and attitudes towards road safety. *Accident Analysis and Prevention*, 79, 145-151. <https://doi.org/10.1016/j.aap.2015.03.034>
- Mann, C. (2003). Observational research methods. Research design II: cohort, cross sectional, and case-control studies. *Emergency Medicine Journal*, 20(1), 54-60. <https://doi.org/10.1136/emj.20.1.54>

- Mann, H., Garcia-Rada, X., Hornuf, L., & Tafurt, J. (2016). What deters crime? Comparing the effectiveness of legal, social and internal sanctions across countries. *Frontiers in Psychology*, 7, 85. <https://doi.org/10.3389/fpsyg.2016.00085>
- Marshall, T. (2004). What is a case-control study? *International Journal of Epidemiology*, 33(3), 612-613. <https://doi.org/10.1093/ije/dyh055>
- Marshall, R., & Jackson, R. (1993). Analysis of case-crossover study designs. *Statistics in Medicine*, 12(24), 2333-2341.
- Mazurski, E., Withaneachi, D., & Kelly, S. (2011). *The NSW Sober Driver Program: recidivism rates and program parameters*. Paper presented to the Australasian Road Safety Research, Policing and Education Conference. Perth, Western Australia: November 6-9.
- McCartt, A., Geary, L., & Berning, A. (2003). Observational study of the extent of driving while suspended for alcohol impaired driving. *Injury Prevention*, 9, 133-137. <https://doi.org/10.1136/ip.9.2.133>
- McCrae, R., & Costa, P. (1995). Trait explanations in personality psychology. *European Journal of Personality*, 9(4), 231-252. <https://doi.org/10.1002/per.2410090402>
- McCrae, R., & John, O. (1992). An introduction to the five factor model and its applications. *Journal of Personality*, 60(Jun 92), 175-216.
- McEvoy, S., Stevenson, M., McCartt, A., Woodward, M., Haworth, C., Palamara, P., & Cercarelli, R. (2005). Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. *British Medical Journal*, 331(7514), 428-430. <https://doi.org/10.1136/bmj.38537.397512.55>
- McEvoy, S., Stevenson, M., & Woodward, M. (2006). Phone use and crashes while driving: a representative survey of drivers in two Australian states. *Medical Journal of Australia*, 185(11/12), 630-643. <https://doi.org/10.5694/j.1326-5377.2006.tb00734.x>
- McEvoy, S., Stevenson, M., & Woodward, M. (2007). The contribution of passengers versus mobile phone use to motor vehicle crashes resulting in hospital attendance by the driver. *Accident Analysis & Prevention*, 39(6), 1170-1176. <https://doi.org/10.1016/j.aap.2007/03.004>
- McKnight, AJ., & McKnight, AS. (2003). Young novice drivers: careless or clueless? *Accident Analysis & Prevention*, 35(6), 921-925. [https://doi.org/10.1016/S0001-4575\(02\)00100-8](https://doi.org/10.1016/S0001-4575(02)00100-8)
- McLaughlin, E. (2006). Deterrence. In: E. McLaughlin & J. Muncie (Eds.), *The SAGE Dictionary of Criminology. Second Edition*. London, United Kingdom: SAGE Publications. pp. 124-126.

- McMurray, L. (1970). Emotional stress and driving performance: the effect of divorce. *Behavioral Research in Highway Safety*, 1(2), 100-114.
- McTiernan, D., Turner, B., Wernham, R., & Gregory, R. (2010). Local government and the Safe System approach to road safety. *Research Report ARR 375*. Vermont South, Victoria, Australia: ARRB.
- Meesmann, U., Martensen, H., & Dupont, E. (2015). Impact of alcohol checks and social norm on driving under the influence of alcohol (DUI). *Accident Analysis & Prevention*, 80, 251-261. <https://doi.org/10.1016/j.aap.2015.04.016>
- Meier, R., & Johnson, W. (1977). Deterrence as social control: the legal and extralegal production of conformity. *American Sociological Review*, 42(2), 292-304. <https://doi.org/10.2307/2094606>
- Meldrum, R., Boman, J., & Back, S. (2019). Low self-control, social learning and texting while driving. *American Journal of Criminal Justice*, 44(2), 191-210. <https://doi.org/10.1007/s12103-018-9448-4>
- Meuleners, L., Fraser, M., Govorko, M., & Stevenson, M. (2017). Determinants of the occupational environment and heavy vehicle crashes in Western Australia: A case-control study. *Accident Analysis & Prevention*, 99(Part B), 452-458. <https://doi.org/10.1016/j.aap.2015.11.023>
- Miller, T., Miller-Kobayashi, M., Caldwell, E., Thurston, S., & Collett, B. (2002). Citizen surveys on the web: General population surveys of community opinion. *Social Science Computer Review*, 20(2), 124-136. <https://doi.org/10.1177/089443930202000203>
- Minor, W., & Harry, J. (1982). Deterrent and experiential effects in perceptual deterrence research: A replication and extension. *Journal of Research in Crime and Delinquency*, 19(2), 190-203. <https://doi.org/10.1177/002242788201900204>
- Mitchell, B. (2012). Crimes of misery and theories of punishment. *New Criminal Law Review: An International and Interdisciplinary Journal*, 15(4), 465-510. <https://doi.org/10.1525/nclr.2012.15.4.465>
- Mittleman, M., Maclure, M., & Robins, J. (1995). Control sampling strategies for case-crossover studies: an assessment of relative efficiency. *American Journal of Epidemiology*, 142(1), 91-98. <https://doi.org/10.1093/oxfordjournals.aje.a117550>
- Moan, I., & Rise, J. (2011). Predicting intentions not to “drink and drive” using an expanded model of planned behaviour. *Accident Analysis and Prevention*, 43(4), 1378-1384. <https://doi.org/10.1016/j.aap.2011.02.012>

- Mohan, D., Tiwari, G., Khayesi, M., & Muyia Nafukho, F. (2006). *Road traffic injury prevention training manual*. Geneva, Switzerland: World Health Organization. <https://apps.who.int/iris/handle/10665/43271>. Retrieved 28 November 2020.
- Molnar, L., Eby, D., Bogard, S., LeBlanc, D., & Zakrajsek, J. (2018). Using naturalistic driving data to better understand the driving exposure and patterns of older drivers, *Traffic Injury Prevention*, 19(Suppl 1), S83-S88. <https://doi.org/10.1080/15389588.2017.1379601>
- Molnar, L., Eby, D., Charlton, J., Langford, J., Koppel, S., Marshall, S., Man-Song-Hing, M. (2013). Driving avoidance by older adults: Is it always self-regulation? *Accident Analysis & Prevention*, 57, 96-104. <https://doi.org/10.1016/j.aap.2013.04.010>
- Montano, D., & Kasprzyk, D. (2008). Theory of Reasoned Action, Theory of Planned Behavior, and the Integrated Behavioral Model. In: K. Glanz, B. Rimer & K. Viswanath (eds.), *Health Behavior and Health Education: Theory, Research and Practice. Fourth Edition*. San Francisco, USA: Jossey-Bass. pp. 67-96.
- Moore, V., Dolinis, J., & Woodward, A. (1995). Vehicle speed and risk of severe crash. *Epidemiology*, 6(3), 258-262.
- Mooren, L., Grzebieta, R., & Job, S. (2014). Speed – the biggest and most contested road killer. *Journal of the Australasian College of Road Safety*, 25(1), 13-18.
- Moskowitz, H., & Fiorentino, D. (2000). *A review of the literature of the effects of low doses of alcohol on driving related skills*. Washington, DC: National Highway Traffic Safety Administration. <https://one.nhtsa.gov/people/injury/research/pub/Hs809028/Title.htm>. Retrieved 25 November 2020.
- Muncie, J. (2004). Contemporary Criminology, Crime and Strategies of Crime Control. In: J. Muncie & D. Wilson (Eds.), *Student Handbook of Criminal Justice and Criminology*. Oxon, United Kingdom: Routledge-Cavendish. pp. 3-20.
- Musselwhite, C., & Shergold, I. (2013). Examining the process of driving cessation in later life. *European Journal of Ageing*, 10(2), 89-100. <https://doi.org/10.1007/s10433-012-0252-6>
- Muthén, L., & Muthén, B. (1998-2017). *Mplus User's Guide*. Eight Edition. Los Angeles, CA: Muthén & Muthén.
- Nagin, D. (1998). Criminal deterrence research at the outset of the twenty-first century. *Crime and Justice*, 23, 1-42.
- Nagin, D. (2013). Deterrence in the twenty-first century. *Crime and Justice*, 42(1), 199-263. <https://doi.org.10.1086/670398>

- Nagin, D., & Paternoster, R. (1991). On the relationship of past to future participation in delinquency. *Criminology*, 29(2), 163-189. <https://doi.org/10.1111/j.1745-9125.1991.tb01063.x>
- Nagin, D., & Paternoster, R. (1993). Enduring individual differences and rational choice theories of crime. *Law and Society Review*, 27(3), 467-496. <https://doi.org/10.2307/3054102>
- Nagin, D., & Paternoster, R. (1994). Personal capital and social control: The deterrence implications of a theory of individual differences in criminal offending. *Criminology*, 32(4), 581-606. <https://doi.org/10.1111/j.1745-9125.1994.tb01166.x>
- Nagin, D., & Pogarsky, G. (2001). Integrating celerity, impulsivity, and extralegal sanction threats into a model of general deterrence: Theory and evidence. *Criminology*, 39(4), 865-892. <https://doi.org/10.1111/j.1745-9125.2001.tb00943.x>
- National Health and Medical Research Council. (2018). *National Statement on Ethical Conduct in Human Research*. Canberra, Australia: Commonwealth of Australia. <https://www.nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018>. Retrieved 16 November 2020.
- Newman, T., Browner, W., Cummings, S., & Hulley, S. (2013). Designing case control studies. In: *Designing Clinical Research. Fourth Edition*. Philadelphia, USA: Lippincott Williams & Wilkins. pp. 97-117.
- Norris, F., Matthews, B., Rias, J. (2000). Characterological, situational, and behavioural risk factors for motor vehicle accidents: a prospective examination. *Accident Analysis and Prevention*, 32(4), 505-515. [https://doi.org/10.1016/S0001-4575\(99\)00068-8](https://doi.org/10.1016/S0001-4575(99)00068-8)
- Northern Territory Government Department of Infrastructure, Planning and Logistics. (2018). *Road Safety Action Plan 2018-22*. Darwin, Australia: Northern Territory Government. https://roadsafety.nt.gov.au/_data/assets/pdf_file/0007/466675/Towards-Zero-Action-Plan-v18.1.pdf. Retrieved 28 November 2020.
- O'Brien, H., Callinan, S., Livingston, M., Doyle, J., & Dietze, P. (2020). Population patterns in Alcohol Use Disorders Identification Test (AUDIT) scores in the Australian population; 2007-2016. *Australian and New Zealand Journal of Public Health*. <https://doi.org/10.1111/1753-6405.13043>
- Office of the Road Safety Camera Commissioner. (2019). Annual Report 2018-2019. Melbourne, Australia: Office of the Road Safety Camera Commissioner. <https://cameracommissioner.vic.gov.au/publications/2018-19-annual-report>
- Organization for Economic Co-operation and Development. (2008). *Towards Zero: Ambitious Road Safety Targets and the Safe System Approach*. Paris, France: OECD Publishing.

https://www.oecd-ilibrary.org/transport/towards-zero_9789282101964-en.

Retrieved 28 November 2020.

- Ouimet, M., Brown, T., Bédard, J-P., & Bergeron, J. (2010). Measurement of readiness to reduce driving speed: A pilot study. *Psychological Reports*, 107(3), 749-761. <https://doi.org/10.2466/13.20.PR0.107.6.749-761>
- Oulasvirta, A., Rattenbury, T., Ma, L., & Raita, E. (2012). Habits make smartphone use more pervasive. *Personal and Ubiquitous Computing*, 16(1), 105-114. <https://doi.org/10.1007/s00779-011-0412-2>
- Oviedo-Trespalacios, O., Haque, M., King, M., & Washington, S. (2016). Understanding the impacts of mobile phone distraction on driving performance: A systematic review. *Transportation Research Part C: Emerging Technologies*, 72, 360-380. <https://doi.org/10.1016/j.trc.2016.10.006>
- Overton, T., Rives, T., Hecht, C., Shafi, S., & Gandhi, R. (2015). Distracted driving: prevalence, problems and prevention. *International Journal of Injury Control and Safety Promotion*, 22(3), 187-192. <https://doi.org/10.1080/17457300.2013.879482>
- Owsley, C., Stalvey, B., Wells, J., Sloane, M., & McGwin Jr, G. (2001). Visual risk factors for crash involvement in older drivers with cataract. *Arch Ophthalmology*, 119(6), 881-887. <https://doi.org/10.1001/archophth.119.6.881>
- Parkin, K. (2017). *Women at the wheel: a century of buying, driving, and fixing cars*. Pennsylvania, USA: University of Pennsylvania Press.
- Parr, M., Ross, L., McManus, B., Bishop, H., Wittig, S., & Stavrinou, D. (2016). Differential impact of personality traits on distracted driving behaviors in teens and older adults. *Accident Analysis & Prevention*, 92, 107-112. <https://doi.org/10.1016/j.aap.2016.03.011>
- Parrish, K., & Masten, S. (2014). The problem of suspended and revoked drivers who avoid detection at checkpoints. *Traffic Injury Prevention*, 16(2), 97-103. <https://doi.org/10.1080/15389588.2014.909592>
- Paternoster, R., & Bachman, R. (2012). Perceptual Deterrence Theory. In: F. Cullen & P. Wilcox (Eds.), *The Oxford Handbook of Criminological Theory*. Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199747238.013.0033>.
- Paternoster, R., Saltzman, L., Chiricos, T., & Waldo, G. (1982). Perceived risk and deterrence: Methodological artifacts in perceptual deterrence research. *The Journal of Criminal Law and Criminology*, 73(3), 1238-1258. <https://doi.org/10.2307/1143192>
- Paternoster, R., Saltzman, L., Waldo, G., & Chiricos, T. (1983a). Perceived risk and social control: Do sanctions really deter? *Law and Society Review*, 17(3), 457-480. <https://doi.org/10.2307/2053589>

- Paternoster, R., Saltzman, L., Waldo, G., & Chiricos, T. (1983b). Estimating perceptual stability and deterrent effects: The role of perceived legal punishment in the inhibition of criminal involvement. *The Journal of Criminal Law and Criminology*, 74(1), 270-297. <https://doi.org/10.2307/1143322>
- Paternoster, R., & Simpson, S. (1996). Sanction threats and appeals to morality: Testing a rational choice model of corporate crime. *Law and Society Review*, 3(3), 549-584. <https://doi.org/10.2307/3054128>
- Pawlson, G., Scholle, S., & Powers, A. (2007). Comparison of administrative only versus administrative plus chart review data for reporting HEDIS hybrid measures. *The American Journal of Managed Care*, 13(10), 91-96.
- Peck, R., Gebers, M., Voas, R., Romano, E. (2008). The relationship between blood alcohol concentration (BAC), age, and crash risk. *Journal of Safety Research*, 39(3), 311-319. <https://doi.org/10.1016/j.jsr.2008.02.030>
- Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A., Jarawan, E., & Mathers, C. (Eds). (2004). *World report on road traffic injury prevention*. Geneva, Switzerland: World Health Organization. <https://www.who.int/publications-detail-redirect/world-report-on-road-traffic-injury-prevention>. Retrieved 28 April 2017
- Penmetsa, P., & Pulugurtha, S. (2016). Risk drivers pose to themselves and other drivers by violating traffic rules. *Traffic Injury Prevention*, 18(1), 1-7. <https://doi.org/10.1080/15389588.2016.1192284>
- Perry, A., & Baldwin, D. (2000). Further evidence of associations of Type A personality scores and driving-related attitudes and behaviors. *Perceptual and Motor Skills*, 91(1), 147-154. <https://doi.org/10.2466/pms.2000.91.1.147>
- Pervin, L. (1994). A critical analysis of current trait theory. *Psychological Inquiry*, 5(2), 103-113. https://doi.org/10.1207/s15327965pli0502_1
- Piao, J., McDonald, M, Hounsell, N., Graindorge, M., Graindorge, T., & Malhene, N. (2016). Public view towards implementation of automated vehicles in urban areas. *Transportation Research Procedia*, 14, 2168-2177. <https://doi.org/10.1016/j.trpro.2016.05.232>
- Piliavin, I., Gartner, R., Thornton, C., & Matsueda, R. (1986). Crime, deterrence and rational choice. *American Sociological Review*, 51(1), 101-119. <https://doi.org/10.2307/2095480>
- Piquero, A., & Paternoster, R. (1998). An application of Stafford and Warr's reconceptualization of deterrence to drinking and driving. *Journal of Research in Crime and Delinquency*, 35(1), 3-39. <https://doi.org/10.1177/0022427898035001001>

- Piquero, A., & Pogarsky, G. (2002). Beyond Stafford and Warr's reconceptualization of deterrence: personal and vicarious experiences, impulsivity and offending behaviour. *Journal of Research in Crime and Delinquency*, 39(2), 153-186.
<https://doi.org/10.1177/002242780203900202>
- Piquero, A., & Tibbetts, S. (1996). Specifying the direct and indirect effects of low self-control and situational factors in offenders' decision making: Toward a more complete model of rational offending. *Justice Quarterly*, 13(3), 481-510.
<https://doi.org/10.1080/07418829600093061>
- Pogarsky, G. (2002). Identifying "detractable" offenders: implications for research on deterrence. *Justice Quarterly*, 19(3), 431-451.
<https://doi.org/10.1080/07418820200095301>
- Pogarsky, G., & Piquero, A. (2003). Can punishment encourage offending? Investigating the "resetting effect". *Journal of Research in Crime and Delinquency*, 40(1), 95-120.
<https://doi.org/10.1177/0022427802239255>
- Porta, M (Ed.). (2008). Confounding. In: *A Dictionary of Epidemiology. Sixth Edition*. Oxford, UK: Oxford University Press.
- Prato, C., Toledo, T., Lotan, T., & Ben-Ari, O. (2010). Modeling the behaviour of novice young drivers during the first year after licensure. *Accident Analysis & Prevention*, 42(2), 480-486. <https://doi.org/10.1016/j.aap.2009.09.011>
- Qualtrics. (2020a). *Online Survey Software*. <https://www.qualtrics.com/au/core-xm/survey-software/?rid=ip&prevsite=en&newsite=au&geo=AU&geomatch=au>. Retrieved 1 December 2020.
- Qualtrics. (2020b). *Online Sample*. <https://www.qualtrics.com/au/research-services/online-sample/>. Retrieved 1 December 2020.
- Queensland Government. (2020). *Double demerit points*. Brisbane, Australia: Queensland Government. <https://www.qld.gov.au/transport/safety/fines/demerit/double>. Retrieved 3 December 2020.
- Queensland Government Department of Transport and Main Roads. (2015). *Safer Roads, Safer Queensland: Queensland's Road Safety Strategy 2015-21*. Brisbane, Australia: Queensland Government. <https://www.tmr.qld.gov.au/Safety/Road-safety/Strategy-and-action-plans>. Retrieved 28 November 2020.
- Rakauskas, M., Gugerty, L., & Ward, N. (2004). Effects of naturalistic cell phone conversations on driving performance. *Journal of Safety Research*, 35(4), 453-464.
<https://doi.org/10.1016/j.jsr.2004.06.003>

- Rammstedt, B., & John, O. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality*, 41(1), 203-212. <https://doi.org/10.1016/j.jrp.2006.02.001>
- Rauch, W., Zador, P., Ahlin, E., Howard, J., Frissell, K., & Duncan, G. (2010). Risk of alcohol-impaired driving recidivism among first offenders and multiple offenders. *The American Journal of Public Health*, 100(5), 919-924. <https://doi.org/10.2105/AJPH.2008.154575>
- Ravera, S., van Rein, N., de Gier, J., de Jong-van den Berg, L. (2012). A comparison of pharmacoepidemiological study designs in medication use and traffic safety research. *European Journal of Epidemiology*, 27(6), 473-481. <https://doi.org/10.1007/s10654-012-9689-3>
- Redelmeier, D., & Tibshirani, R. (1997a). Association between cellular telephone calls and motor vehicle collisions. *The New England Journal of Medicine*, 336(7), 453-458. <https://doi.org/10.1056/NEJM199702133360701>
- Redelmeier, D., & Tibshirani, R. (1997b). Interpretation and bias in case-crossover studies. *Journal of Clinical Epidemiology*, 50(11), 1281-1287. [https://doi.org/10.1016/S0895-4356\(97\)00196-0](https://doi.org/10.1016/S0895-4356(97)00196-0)
- Redelmeier, D., Tibshirani, R., & Evans, L. (2003). Traffic-law enforcement and risk of death from motor vehicle crashes: Case-crossover study. *The Lancet*, 361(9376), 2177-2182. [https://doi.org/10.1016/s0140-6736\(03\)13770-1](https://doi.org/10.1016/s0140-6736(03)13770-1)
- Regan, M., Young, K., Lee, J., & Gordon, D. (2009). Sources of driver distraction. In: M. Regan., J. Lee., & K. Young (Eds.), *Driver distraction: Theory, effects and mitigation*. Florida, USA: CRS Press, 249-279.
- Retting, R., Ulmer, R., & Williams, A. (1999). Prevalence and characteristics of red light running crashes in the United States. *Accident Analysis & Prevention*, 31(6), 687-694. [https://doi.org/10.1016/S0001-4575\(99\)00029-9](https://doi.org/10.1016/S0001-4575(99)00029-9)
- Retting, R., Williams, A., Preusser, D., & Weinstein, H. (1995). Classifying urban crashes for countermeasure development. *Accident Analysis & Prevention*, 27(3), 283-294. [https://doi.org/10.1016/0001-4575\(94\)00068-W](https://doi.org/10.1016/0001-4575(94)00068-W)
- Rhodes, N., & Pivik, K. (2011). Age and gender differences in risky driving: The role of positive affect and risk perception. *Accident Analysis & Prevention*, 43(3), 923-931. <https://doi.org/10.1016/j.aap.2010.11.015>
- Riendeau, J., Stinchcombe, A., Weaver, B., & Bédard, M. (2018). Personality factors are associated with simulated driving outcomes across the driving lifespan. *Transportation Part F: Traffic Psychology and Behaviour*, 54, 171-187. <https://doi.org/10.1016/j.trf.2018.01.022>

- Riley, G. (2009). Administrative and claims records as sources of health care cost data. *Medical Care*, 47(7, Supplement 1), S51-S55.
<https://doi.org/10.1097/MLR.0b013e31819c95aa>
- Risbey, T., Cregan, M., De Silva, H. (2010). *Social cost of road crashes*. Paper presented at the Australian Transport Research Forum 2010. Canberra, Australia.
https://www.bitre.gov.au/sites/default/files/sp_003_Risbey_Cregan_deSilva.pdf.
Retrieved 12 March 2017.
- Robinson, M., Gath, K., & Unsworth, N. (2017). The neurotic wandering mind: An individual differences investigation of neuroticism, mind-wandering, and executive control. *The Quarterly Journal of Experimental Psychology*, 70(4), 649-663.
<http://dx.doi.org/10.1080/17470218.2016.1145706>
- Robinson, E., Hull, L., & Petrides, K. (2020). Big Five model and trait emotional intelligence in camouflaging behaviours in autism. *Personality and Individual Differences*, 152.
<https://doi.org/10.1016/j.paid.2019.109565>
- Romano, E., Peck, R., & Voas, R. (2012). Traffic environment and demographic factors affecting impaired driving and crashes. *Journal of Safety Research*, 43(1), 75-82.
<https://doi.org/10.1016/j.jsr.2011.12.001>
- Roper, Y., Rowland, M., Chakich, Z., McGill, W., Nanayakkara, V., Young, D., et al. (2018). *Implications of Traffic Sign Recognition (TSR) Systems for Road Operators*. Research Report AP-R580-18. Sydney, Australia: Austroads.
https://austroads.com.au/publications/connected-and-automated-vehicles/ap-r580-18/media/AP-R580-18_Implications_of_Traffic_Sign_Recognition.pdf
- Rosenthal, J. (1996). Qualitative descriptors of strength of association and effect size. *Journal of Social Service Research*, 21(4), 37-59.
https://doi.org/10.1300/J079v21n04_02
- Ross, L. (1992). Are DWI sanctions effective? *Alcohol, Drugs and Driving*, 8(1), 61-69.
- Ross, L., Anstey, K., Kiely, K., Windsor, T., Byles, J., Luszcz, M., & Mitchell, P. (2009). Older drivers in Australia: trends in driving status and cognitive and visual impairment. *Journal of the American Geriatric Society*, 57(10), 1868-1873.
<https://doi.org/10.1111/j.1532-5415.2009.02439.x>
- Rowden, P., Matthews, G., Watson, B., & Biggs, H. (2011). The relative impact of work-related stress, life stress and driving environment stress on driving outcomes. *Accident Analysis and Prevention*, 43(4), 1332-1340.
<https://doi.org/10.1016/j.aap.2011.02.004>
- Rowden, P., Watson, B., Haworth, N., Lennon, A., Shaw, L., Blackman, R. (2016). Motorcycle riders' self-reported aggression when riding compared with car driving.

- Transportation Part F: Traffic Psychology and Behaviour*, 36, 92-103.
<https://doi.org/10.1016/j.trf.2015.11.006>
- Rowland, B., Wishart, D., Davey, J., & Freeman, J. (2007). The influence of occupational driver stress on work-related road safety: an exploratory review. *Journal of Occupational Health and Safety, Australia and New Zealand*, 23(5), 459-468.
- Russell, K., Vandermeer, B., & Hartling, L. (2011). Graduated driver licensing for reducing motor vehicle crashes among young drivers. *The Cochrane database of systematic reviews*, 10, CD003300. <https://doi.org/10.1002/14651858.CD003300.pub3>
- Sagberg, F. (2018). Characteristics of fatal road crashes involving unlicensed drivers or riders: implications for countermeasures. *Accident Analysis and Prevention*, 117, 270-275. <https://doi.org/10.1016/j.aap.2018.04.025>
- Salmon, P., Regan, M., & Johnson, I. (2005). *Human error and road transport: Phase one – Literature review*. Report No. 256. Clayton, Victoria, Australia: Monash University Accident Research Centre.
https://www.monash.edu/_data/assets/pdf_file/0010/216946/Human-Error-and-Road-Transport-Phase-One-A-framework-for-an-error-tolerant-road-transport-system.pdf
- Saltzman, L., Paternoster, R., Waldo, G., & Chiricos, T. (1982). Deterrent and experiential effects: The problem of causal order in perceptual deterrence research. *Journal of Research in Crime and Delinquency*, 19(2), 172-189.
<https://doi.org/10.1177/002242788201900203>
- Sandberg, T., & Conner, M. (2008). Anticipated regret as an additional predictor in the theory of planned behaviour: A meta-analysis. *British Journal of Social Psychology*, 47(4), 589-606. <https://doi.org/10.1348/014466607X258704>
- Sârbescu, P., & Maricutoiu, L. (2019). Are you a “bad driver” all the time? Insights from a weekly diary study on personality and dangerous driving behavior. *Journal of Research in Personality*, 80(), 30-37. <https://doi.org/10.1016/j.jrp.2019.04.003>
- Sarrazin, M., & Rosenthal, G. (2012). Finding pure and simple truths with administrative data. *JAMA*, 307(13), 1433-1435. <https://doi.org/10.1001/jama.2012.202>
- SAS Software. (2014). Version 9.4 for Windows. Cary, USA: SAS Institute Inc.
- Schleyer, T., & Forrest, J. (2000). Methods for the design and administration of web-based surveys. *Journal of the American Medical Informatics Association*, 7(4), 416-425.
<https://doi.org/10.1136/jamia.2000.0070416>
- Schmidt, W. (1997). World-wide web survey research: benefits, potential problems, and solutions. *Behavior Research Methods, Instruments and Computers*, 29(2), 274-279.
<https://doi.org/103758/BF03204826>

- Schneider, B., Carnoy, M., Kilpatrick, J., Schmidt, W., & Shavelson, R. (2007). *Estimating causal effects using experimental and observational designs*. Washington, DC: Governing Board of the American Educational Research Association. <https://www.aera.net/Portals/38/docs/Causal%20Effects.pdf>. Retrieved 30 November 2020.
- Schulz, K., & Grimes, D. (2002). Case-control studies: research in reverse. *The Lancet*, 359(9304), 431-434. [https://doi.org/10.1016/S0140-6736\(02\)07605-5](https://doi.org/10.1016/S0140-6736(02)07605-5)
- Schulze, H., Schumacher, M., Urmeew, R., Auerbach, K. (2012). *Final Report: Work performed, main results and recommendations*. Project Number: TREN-05-FP6TR-S07.61320-518404-DRUID. Germany: Federal Highway Research Institute. <https://www.oisevi.org/a/archivos/estudios-especificos/ong/Union-Europea-Druid-Final-Report.pdf>
- Scott-Parker, B., & Oviedo-Trespalacios, O. (2017). Young driver risky behaviour and predictors of crash risk in Australia, New Zealand and Colombia: Same but different? *Accident Analysis & Prevention*, 99(Pt A), 30-38. <https://doi.org/10.1016/j.aap.2016.11.001>
- Scott-Parker, B., Watson, B., & King, M. (2009). Understanding the psychosocial factors influencing the risky behaviour of young drivers. *Transportation Part F: Traffic Psychology and Behaviour*, 12(6), 470-482. <https://doi.org/10.1016/j.rtf.2009.08.003>
- Scott-Parker, B., Watson, B., King, M., & Hyde, M. (2012). The influence of sensitivity to reward and punishment, propensity for sensation seeking, depression, and anxiety on the risky behaviour of novice drivers: A path model. *British Journal of Psychology*, 103(2), 248-267. <https://doi.org/10.1111/j.2044-8295.2011.02069.x>
- Scott-Parker, B., Watson, B., King, M., & Hyde, M. (2013). A further exploration of sensation seeking propensity, reward sensitivity, depression, anxiety, and the risky behaviour of young novice drivers in a structural equation model. *Accident Analysis & Prevention*, 50, 465-471. <https://doi.org/10.1016/j.aap.2012.05.027>
- Sedgwick, P. (2012). What is recall bias? *British Medical Journal*, 344, e3519–e3519. <https://doi.org/10.1136/bmj.e3519>
- Šeibokaitė, L., Endriulaitienė, A., Markšaitytė, R., Žardeckaitė-Matulaitienė., & Pranckevičienė, A. (2014). Aggressiveness as proximal and distal predictor of risky driving in the context of other personality traits. *International Journal of Psychology and Behavioural Sciences*, 4(2), 57-69. <https://doi.org/10.5923/j.ijpbs.20140402.01>
- Shen, B., Qu, W., Ge, Y., Sun, X., & Zhang, K. (2018). The relationship between personalities and self-report positive behaviour in a Chinese sample. *PLoS ONE*, 13(1): e0190746. <https://doi.org/10.1371/journal.pone.0190746>

- Sherman, L. (1993). Defiance, deterrence, and irrelevance: a theory of the criminal sanction. *Journal of Research in Crime and Delinquency*, 30(4), 445-473. <https://doi.org/10.1177/0022427893030004006>
- Sherman, L., Strang, H., & Woods, D. (2000). *Recidivism Patterns in the Canberra Reintegrative Shaming Experiments (RISE)*. Canberra, Australia: Australian Institute of Criminology.
- Shih, T., & Xitao, F. (2008). Comparing response rates from web and mail surveys: a meta-analysis. *Field Methods*, 20(3), 249-271. <https://doi.org/10.1177/1525822x08317085>
- Shimada, H., Tsutsumimoto, K., Lee, S., Doi, T., Makizako, H., Lee, S., Harada, K., Hotta, R., Bae, S., Nakakubo, S., Uemura, K., Park, H., & Suzuki, T. (2015). Driving continuity in cognitively impaired older drivers. *Geriatrics & Gerontology International*, 16(4), 508-514. <https://doi.org/10.1111/ggi.12504>
- Silberman, M. (1976). Toward a theory of criminal deterrence. *American Sociological Review*, 41(3), 442-461. <https://doi.org/10.2307/2094253>
- Simons-Morton, B. (2017). Driving in search of analyses. *Statistics in Medicine*, 36(24), 3763-3771. <https://doi.org/10.1002/sim.7404>
- Simons-Morton, B., Gershon, P., O'Brien, F., Gensler, G., Klauer, S., Ehsani, J., Zhu, C., Gore-Langton R., & Dingus, T. (2020). Crash rates over time among younger and older drivers in the SHRP 2 naturalistic driving study. *Journal of Safety Research*, 73, 245-251. <https://doi.org/10.1016/j.jsr.2020.03.001>
- Sinelnikov, S., & Wells, B. (2017). Distracted driving on the job: Application of a modified stages of change model. *Safety Science*, 94, 161-170. <https://doi.org/10.1016/j.ssci.2017.01.007>
- Siren, A., & Hakamies-Blomqvist, L. (2005). Sense and sensibility. A narrative study of older women's car driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, 8(3), 213-228. <https://doi.org/10.1016/j.trf.2005.04.008>
- Siren, A., Hakamies-Blomqvist, L., & Lindeman, M. (2004). Driving cessation and health in older women. *Journal of Applied Gerontology*, 23(1), 58-69. <https://doi.org/10.1177/0733464804263129>
- Smith, A. (2016). A UK survey of driving behaviour, fatigue, risk taking and road traffic accidents. *BMJ Open*, 6(8), e011461. <https://doi.org/10.1136/bmjopen-2016-011461>
- Smith, A., Ayanian, J., Covinsky, K., Landon, B., McCarthy, E., Wee, C., & Steinman, M. (2011). Conducting high-value secondary dataset analysis: an introductory guide and resources. *Journal of General Internal Medicine*, 26(8), 920-929. <https://doi.org/10.1007/s11606-010-1621-5>

- Stafford, M., & Warr, M. (1993). A reconceptualization of general and specific deterrence. *Journal of Research in Crime and Delinquency*, 30(2), 123-135.
<https://doi.org/10.1177/0022427893030002001>
- Stalvey, B., & Owsley, C. (2003). The development and efficacy of a theory-based educational curriculum to promote self-regulation among high-risk older drivers. *Health Promotion Practice*, 4(2), 109-119.
<https://doi.org/10.1177/1524839902250757>
- Stanton, N., & Salmon, P. (2009). Human error taxonomies applied to driving: A generic driver error taxonomy and its implications for intelligent transport systems. *Safety Science*, 47(2), 227-237. <https://doi.org/10.1016/j.ssci.2008.03.006>
- Starkey, N., & Isler, R. (2016). The role of executive function, personality and attitudes to risks in explaining self-reported driving behaviour in adolescent and adult male drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 38, 127-136. <https://doi.org/10.1016/j.trf.2016.01.013>
- Steele, F. (2008). Multilevel models for longitudinal data. *Journal of the Royal Statistical Society: Series A (statistics in Society)*, 171(1), 5-19. <https://doi.org/10.1111/j.1476-985X.2007.00509.x>
- Steinbakk, R., Ulleberg, P., Sagberg, F., & Fostervold, K-I. (2019). Speed preferences in work zones: The combined effect of visible roadwork activity, personality traits, attitudes, risk perception and driving style. *Transportation Research Part F: Traffic Psychology and Behaviour*, 62, 390-405. <https://doi.org/10.1016/j.trf.2019.01.017>
- Stigson, H., Krafft, M., & Tingvall, C. (2008). Use of fatal real-life crashes to analyse a safe road transport system model, including the road user, the vehicle and the road. *Traffic Injury Prevention*, 9(5), 463-471.
<https://doi.org/10.1080/15389580802335240>
- Stiles, P., & Boothroyd, R. (2005). Ethical use of administrative data for research purposes. In J. Fantuzza & D. Culhane (Eds.), *Actionable Intelligence*. New York: Palgrave Macmillan. pp. 125-155.
- Studdert, D., Walter, S., & Goldhaber-Fiebert, J. (2017). Once ticketed, twice shy: Specific deterrence from road traffic laws. *Stanford Law School Working Paper*.
https://petrieflom.law.harvard.edu/assets/publications/Studdert_Deterrence_from_Traffic_Laws.pdf. Retrived 27 November 2020.
- Stutts, J., Feaganes, J., Reinfurt, D., Rodgman, E., Hamlett, C., Gish, K., & Staplin, L. (2005). Driver's exposure to distractions in their natural driving environment. *Accident Analysis and Prevention*, 37(6), 1093-1101.
<https://doi.org/10.1016/j.aap.2005.06.007>

- Sue, V., & Ritter, L. (2012a). Planning the online survey. In: *Conducting Online Surveys. Second Edition*. Los Angeles, USA: SAGE Publications.
<https://dx.doi.org/10.4135/9781506335186.n2>
- Sue, V., & Ritter, L. (2012b). Writing the survey questions. In: *Conducting Online Surveys. Second Edition*. Los Angeles, USA: SAGE Publications.
<https://dx.doi.org/10.4135/9781506335186.n4>
- Sugrue, M., Seger, M., Dredge, G., Davies, D., Ieraci, S., Bauman, A., Deane, A., & Sloane, D. (1995). Evaluation of the prevalence of drug and alcohol abuse in motor vehicle trauma in South Western Sydney. *Australian and New Zealand Journal of Surgery*, 65(12), 853-856. <https://doi.org/10.1111/j.1445-2197.1995.tb00575.x>
- Suissa, S. (1995). The case-time-control design. *Epidemiology*, 6(3), 248-253.
<https://doi.org/10.1097/00001648-199505000-00010>
- Suissa, S. (1998). The case-time-control design: further assumptions and conditions. *Epidemiology*, 9(4), 441-445. <https://doi.org/10.1097/00001648-199807000-00016>
- Sun, M., & Lipsitz, S. (2018). Comparative effectiveness research methodology using secondary data: A starting user's guide. *Urologic Oncology*, 36(4), 174-182.
<https://doi.org/10.1016/j.urolonc.2017.10.011>
- Sun, Y., Olaru, D., Smith, B., Greaves, S., Collins, A. (2017). Road to autonomous vehicles in Australia: an exploratory literature review. *Road and Transport Research: A Journal of Australian and New Zealand Research and Practice*, 26(1), 34-47.
- Sutin, A. (2015). Openness. In: T. Widiger (Ed.), *The Oxford Handbook of the Five Factor Model*. Oxford University Press.
<https://doi.org/10.1093/oxfordhb/9780199352487.013.16>
- Svensson, R., Pauwels, L., & Weerman, F. (2017). The role of moral beliefs, shame, and guilt in criminal decision making: An overview of theoretical frameworks and empirical results. In: W. Bernasco, J-L. Van-Gelder & H. Elffers. *The Oxford Handbook of Offender Decision Making*.
<https://doi.org/10.1093/oxfordhb/9780199338801.001.0001>
- Szogi, E., Darvell, M., Freeman, J., Truelove, V., Palk, G., Davey, J., & Armstrong, K. (2017). Does getting in the way with it count? An application of Stafford and Warr's reconceptualised model of deterrence to drink driving. *Accident Analysis and Prevention*, 108, 261-267. <https://doi.org/10.1016/j.aap.2017.08.006>
- Tackett, J., & Lahey, B. (2016). Neuroticism. In: T. Widiger (Ed.), *The Oxford Handbook of the Five Factor Model*. Oxford University Press.
<https://doi.org/10.1093/oxfordhb/9780199352487.013.14>

- Tangney, J., & Dearing, R. (2002). *Shame and Guilt. Second Edition*. New York, USA: Guilford Press.
- Taylor, D., MacBean, C., Das, A., & Rosli, R. (2017). Handheld mobile phone use among Melbourne drivers. *Medical Journal of Australia*, 187(8), 432-434.
<https://doi.org/10.5694/j.1326-5377.2007.tb01352.x>
- Tao, D., Zhang, R., & Qu, X. (2017). The role of personality traits and driving experience in self-reported risky driving behaviors and accident risk among Chinese drivers. *Accident Analysis & Prevention*, 99(Pt A), 228-235. <https://doi.org/j.aap.2016.12/009>
- Tasmanian Government Department of State Growth. (2016). *Towards Zero Tasmanian Road Safety Strategy 2017-2026*. Hobart, Australia : Tasmanian Government.
[https://www.transport.tas.gov.au/_data/assets/pdf_file/0017/142550/Towards Zero - Tasmanian Road Safety Strategy 2017-2026.PDF](https://www.transport.tas.gov.au/_data/assets/pdf_file/0017/142550/Towards_Zero_-_Tasmanian_Road_Safety_Strategy_2017-2026.PDF). Retrieved 28 November 2020.
- Tate, C. (2015). On the Overuse and Misuse of Mediation Analysis: It May Be a Matter of Timing. *Basic and Applied Social Psychology*, 37(4), 235–246.
<https://doi.org/10.1080/01973533.2015.1062380>
- Terer, K., & Brown, R. (2014). Effective drink driving prevention and enforcement strategies: approaches to improving practice. *Trends and Issues in Crime and Criminal Justice*, Number 472. Canberra, Australia: Australian Institute of Criminology.
<https://aic.gov.au/publications/tandi/tandi472>
- Teschke, K., Harris, M., Reynolds, C. C., Winters, M., Babul, S., Chipman, M., Cusimanu, M., Brubacher, J., Hunte, G., Friedman, S., Monro, M., Hui, S., Vernich, L., & Crompton, P. (2012). Route infrastructure and the risk of injuries to bicyclists: a case-crossover study. *American Journal of Public Health*, 102(12), 2336-2343.
<https://doi.org/10.2105/AJPH.2012.300762>
- Thake, C., Armstrong, K., Leal, N. (2011). The role of personality in predicting hooning-related driving behaviour. *Journal of the Australasian College of Road Safety*, 22(1), 40-45.
- Transport Accident Commission. (2017). Drink driving statistics.
<https://www.tac.vic.gov.au/road-safety/statistics/summaries/drink-driving-statistics>. Retrieved 25 November 2020.
- Transport Accident Commission (2020a). TAC Campaigns – Drug driving.
<https://www.tac.vic.gov.au/road-safety/tac-campaigns/drug-driving>. Retrieved 25 November 2020.
- Transport Accident Commission (2020b). TAC Campaigns. <https://www.tac.vic.gov.au/road-safety/tac-campaigns>. Retrieved 30 November 2020.

- Transport Accident Commission., VicRoads., Victoria Police., Victorian Department of Justice and Regulation., & Victorian Department of Health and Human Services. (2016). *Towards Zero 2016-2020 Road Safety Strategy and Plan*. Melbourne, Australia: Victoria State Government.
https://www.towardszero.vic.gov.au/_data/assets/pdf_file/0010/183556/STU_020_6_RS_STRATEGY_2016_web.pdf. Retrieved 28 November 2020.
- Transport for NSW. (2012). *NSW Road Safety Strategy 2012-2021*. Sydney, Australia: NSW Government.
https://roadsafety.transport.nsw.gov.au/downloads/road_safety_strategy.pdf. Retrieved 28 November 2020.
- Trimboli, L., & Smith, N. (2009). Drink-driving and recidivism in NSW. *Crime and Justice Bulletin, Number 135*. Sydney, Australia: NSW Bureau of Crime Statistics and Research. <https://www.bocsar.nsw.gov.au/Documents/CJB/cjb135.pdf>
- Trinh, Q. (2018). Understanding the impact and challenges of secondary data analysis. *Urologic Oncology, 36*(4), 163-164. <https://doi.org/10.1016/j.urolonc.2017.11.003>
- Truelove, V., Freeman, J., & Davey, J. (2019). “you can’t be deterred by stuff you don’t know about”: Identifying factors that influence graduated driver licensing rule compliance. *Safety Science, 111*, 313-323. <https://doi.org/10.1016/j.ssci.2018.09.007>
- Truelove, V., Freeman, J., Watson, B., Kaye, S-A., & Davey, J. (2020). Are perceptions of penalties stable across time? The problem of causal ordering in deterrence applied to road safety. *Accident Analysis & Prevention, 146*, 105746.
<https://doi.org/10.1016/j.aap.2020.105746>
- Tuokko, H., McGee, P., Gabriel, G., & Rhodes, R. (2007). Perception, attitudes, and beliefs, and openness to change: Implications for older driver education. *Accident Analysis and Prevention, 39*(4), 812-817. <https://doi.org/10.1016/j.aap.2006.12.002>
- Turner, J. (2020). Case-crossover studies. In Gellman, M (Ed.) *Encyclopaedia of Behavioural Medicine*. New York, USA: Springer. https://doi.org/10.1007/978-3-030-39903-0_991
- Tutt, D., Arms, J., Perera, C., & Bauer, L. (2001). Cannabis and road death: an emerging injury prevention concern. *Health Promotion Journal of Australia: Official Journal of Australian Association of Health Promotion Professionals, 12*(2), 159-162.
- Tyler, T. (2003). Procedural justice, legitimacy, and the effective rule of law. *Crime and Justice, 30*, 283-257.
- Tyler, T. (2006). Psychological perspectives on legitimacy and legitimation. *Annual Review of Psychology, 57*, 375.

- Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perceptions as predictors of risky driving behaviour among young drivers. *Safety Science*, 41(5), 427-442. [https://doi.org/10.1016/S0925-7535\(01\)00077-7](https://doi.org/10.1016/S0925-7535(01)00077-7)
- United Nations Road Safety Collaboration. (2010). *Global Plan for the Decade of Action for Road Safety 2011-2020*. Geneva, Switzerland: World Health Organization. https://www.who.int/roadsafety/decade_of_action/plan/en/. Retrieved 28 November 2020.
- Van Damme, A., & Pauwels, L. (2016). Why are young adults willing to cooperate with the police and comply with traffic laws? Examining the role of attitudes toward the police and law, perceived deterrence and personal morality. *International Journal of Law, Crime and Justice*, 46, 103-116. <https://doi.org/10.1016/j.ijlcrj.2016.04.002>
- van der Pas, J., Kessels, J., Veroude, B., & van Wee, B. (2014). Intelligent speed assistance for serious speeders: the results of the Dutch Speedlock trial. *Accident Analysis & Prevention*, 72, 78-94. <https://doi.org/10.1016/j.aap.2014.05.031>
- Van Elslande, P., Fournier, J.-Y., & Jaffard, M. (2012). Influence of cannabis on fatal traffic crashes detailed analysis. *Transportation Research Record*, 2281, 43-50. <https://doi.org/10.3141/2281-06>
- van Stralen, K., Dekker, F., Zoccali, C., & Jager, K. (2010). Case-control studies – An efficient observational study design. *Nephron Clinical Practice*, 114(1), c1-c4. <https://doi.org/10.1159/000242442>
- van Walraven, C., & Austin, P. (2012). Administrative database research has unique characteristics that can risk biased results. *Journal of Clinical Epidemiology*, 65(2), 126-131. <https://doi.org/10.1016/j.jclinepi.2011.08.002>
- Vereeck, L., & Vrolix, K. (2007). The social willingness to comply with the law: The effect of social attitudes on traffic fatalities. *International Review of Law and Economics*, 27(4), 385-408. <https://doi.org/10.1016/j.irle.2007.07.002>
- VicRoads. (2019a). *Acts, regulations & policies*. Melbourne, Australia: VicRoads. <https://www.vicroads.vic.gov.au/about-vicroads/acts-and-regulations>. Retrieved 26 November 2020.
- VicRoads. (2019b). *Purpose & values*. Melbourne, Australia: VicRoads. <https://www.vicroads.vic.gov.au/about-vicroads/overview-of-vicroads/purpose-aims-and-values>. Retrieved 26 November 2020.
- VicRoads. (2019c). *Fines*. Melbourne, Australia: VicRoads. <https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties/fines>. Retrieved 27 November 2020.

- VicRoads. (2019d). *Speed limit*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/a-to-z-of-road-rules/speed-limits> . Retrieved 27 November 2020.
- VicRoads. (2019e). *Mobile phones, technology & driving*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/safety-and-road-rules/driver-safety/mobile-phones-and-driving>. Retrieved 27 November 2020.
- VicRoads. (2019f). *Combined drink & drug-driving penalties*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties/combined-drink-and-drug-driving-penalties>. Retrieved 25 November 2020.
- VicRoads. (2019g). *P1 & P2 probationary licence restrictions*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/licences/your-ps/p1-and-p2-probationary-licence-restrictions>. Retrieved 1 December 2020.
- VicRoads. (2020a). *Victoria's road network*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/traffic-and-road-use/road-network-and-performance/victorias-road-network>. Retrieved 25 November 2020.
- VicRoads. (2020b). *About VicRoads*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/about-vicroads>. Retrieved 25 November 2020.
- VicRoads. (2020c). *Drink-driving penalties*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties/drink-driving-penalties>. Retrieved 25 November.
- VicRoads. (2020d). *Drug-driving penalties*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/safety-and-road-rules/road-rules/penalties/drug-driving-penalties>. Retrieved 25 November.
- VicRoads. (2020e). *About demerit points*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/licences/demerit-points-and-offences/about-demerit-points>. Retrieved 27 November 2020.
- VicRoads. (2020f). *Free Licence Scheme*. Melbourne, Australia: VicRoads.
<https://www.vicroads.vic.gov.au/licences/your-ps/free-licence-scheme>. Retrieved 20 November 2020.
- Victorian Department Environment, Land, Water and Planning. (2017). *Plan Melbourne 2017-2050. Metropolitan Planning Strategy*. Melbourne: Australia: State Government of Victoria.
https://www.planmelbourne.vic.gov.au/data/assets/pdf_file/0007/377206/Plan_Melbourne_2017-2050_Strategy.pdf

- Vincent, A., & Ross, D. (2001). Personalize training determine learning styles, personality types and multiple intelligences online. *The Learning Organization*, 8(1), 36-43. <https://doi.org/10.1108/09696470110366525>
- Vinglis, E. (1990). A new look at deterrence. In: R. Wilson & R. Mann (Eds.). *Drinking and driving: Advances in research and prevention*. New York, USA: Guilford Press, pp. 99-115.
- Voas, R., Torres, P., Romano, E., & Lacey, J. (2012). Alcohol-related risk of driver fatalities: an update using 2007 data. *Journal of Studies on Alcohol and Drugs*, 73(3), 341-350. <https://doi.org/10.15288/jsad.2012.73.341>
- Vollrath, M., Knoch, D., & Cassano, L. (1999). Personality, risky health behaviour, and perceived susceptibility to health risks. *European Journal of Personality*, 13(1), 39-59. [https://doi.org/10.1002/\(SICI\)1099-0984\(199901/02\)13:1<39::AID-PER328>3.0.CO;2-J](https://doi.org/10.1002/(SICI)1099-0984(199901/02)13:1<39::AID-PER328>3.0.CO;2-J)
- Waddell, J., Nissen, L., Hale, A., & Kyle, G. (2020). Using the big five inventory to evaluate the personality traits of Australian Pharmacists. *International Journal of Pharmacy Practice*, 28(3), 275-281. <https://doi.org/10.1111/ijpp.12597>
- Walter, S., & Studdert, D. (2015) Relationship between penalties for road traffic infringements and crash risk in Queensland, Australia: a case-crossover study. *International Journal of Epidemiology*, 44(5), 1722-1730. <https://doi.org/10.1093.ije/dyv148>
- Walton, G., Cohen, G., Cwir, D., & Spencer, S. (2012). Mere belonging: The power of social connections. *Journal of Personality and Social Psychology*, 102(3), 513-532. <https://doi.org/10.1037/a0025731>
- Wan, J., Wu, C., Zhang, Y., Houston, R., Chen, C., & Chanawangsa, P. (2017). Drinking and driving behaviour at stop signs and red lights. *Accident Analysis & Prevention*, 104, 10-17. <https://doi.org/10.1016/j.aap.2017.04.008>
- Wang, S., Linkletter, C., Maclure, M., Dore, D., Mor, V., Buka, S., & Wellenius, G. (2011). Future cases as present controls to adjust for exposure trend bias in case-only studies. *Epidemiology*, 22(4), 568-574. <https://doi.org/10.1097/EDE.0b013e31821d09cd>
- Wang, X., & McClung, S. (2012). The immorality of illegal downloading: The role of anticipated guilt and general emotions. *Computers in Human Behavior*, 28(1), 153-159. <https://doi.org/10.1016/j.chb.2011.08.021>
- Wang, Y., Qu, W., Ge, Y., Sun, X., & Zhang, K. (2018). Effect of personality traits on driving style: psychometric adaption of the multidimensional driving style inventory in a Chinese sample. *PLoS ONE*, 13(9): e0202126. <https://doi.org/10.1371/journal.pone.0202126>

- Watling, C., Palk, G., Freeman, J., & Davey, J. (2010). Applying Stafford and Warr's reconceptualization of deterrence theory to drug driving: can it predict those likely to offend? *Accident Analysis and Prevention*, 42(2), 452-458.
<https://doi.org/10.1016/j.aap.2009.09.007>
- Watson, B. (2004). How effective is deterrence theory in explaining driver behaviour: a case study of unlicensed driving. In: *Proceedings Road Safety Research, Policing and Education Conference*. Perth, Australia.
- Watson, B., Siskind, V., Fleiter, J., Watson, A., & Soole, D. (2015). Assessing specific deterrence effects of increased speeding penalties using four measures of recidivism. *Accident Analysis and Prevention*, 84, 27-37.
<https://doi.org/10.1016/j.aap.2015.08.006>
- Weatherburn, D., & Moffat, S. (2011). The specific deterrent effect of higher fines on drink-driving offenders. *British Journal of Criminology*, 51(5), 789-803.
<https://doi.org/10.1093/bjc/azr043>
- Weisberg, R. (2014). Meanings and measures of recidivism. *Southern California Law Review*, 87, 785-804.
- Wheeler, M., McGrath, M., Haslam, N. (2019). Twentieth century morality: The rise and fall of moral concepts from 1990-2007. *PLoS ONE*, 14(2): e0212267.
<https://doi.org/10.1371/journal.pone.0212267>
- Wierwille, W., Hanowski, R., Hankey, J., Kieliszewski, C., Lee, S., Medina, A., et al. (2002). *Identification and Evaluation of Driver Errors: Overview and Recommendations*. Report No. FHWA-RD-02-003. Virginia, USA: Federal Highway Administration.
<https://rosap.ntl.bts.gov/view/dot/922>
- Williams, K., & Hawkins, R. (1986). Perceptual research on general deterrence: a critical review. *Law Society and Review*, 20(4), 545-572. <https://doi.org/10.2307/3053466>
- Wilt, J., & Revelle, W. (2016). Extraversion. In: T. Widiger (Ed.), *The Oxford Handbook of the Five Factor Model*. Oxford University Press.
<https://doi.org/10.1093/oxfordhb/9780199352487.013.15>
- Windle, P. (2010). Secondary data analysis: is it useful and valid? *Journal of Perianesthesia Nursing: Official Journal of the American Society of PeriAnesthesia Nurses*, 25(5), 322-324. <https://doi.org/10.1016/j.jopan.2010.07.005>
- World Health Organization. (2013). *Global status report on road safety 2013: supporting a decade of action*. Geneva, Switzerland: World Health Organization.
https://www.who.int/violence_injury_prevention/road_safety_status/2013/en/. Retrieved 12 September 2017

- World Health Organization. (2014). *Global status report on alcohol and health 2014*. Geneva, Switzerland: World Health Organization.
https://apps.who.int/iris/bitstream/handle/10665/112736/9789240692763_eng.pdf
 Retrieved 25 November 2020.
- World Health Organization. (2015). *Global status report on road safety 2015*. Geneva, Switzerland: World Health Organization.
http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/.
 Retrieved 13 March 2017.
- World Health Organization. (2018). *Global status report on road safety 2018*. Geneva, Switzerland: World Health Organization.
<https://www.who.int/publications/i/item/9789241565684>. Retrieved 12 October 2020.
- World Health Organization. (2020). *Road traffic injuries. Factsheet*. Geneva, Switzerland: World Health Organization. <https://www.who.int/news-room/factsheets/detail/road-traffic-injuries>. Retrieved 25 November 2020
- Wright, K. (2005). Researching internet-based populations: advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services. *Journal of Computer-Mediated Communication*, 10(3).
- Wright, K., & Gudjonsson, G. (2007). The development of a scale for measuring offence-related feelings of shame and guilt. *The Journal of Forensic Psychiatry and Psychology*, 18(3), 307-316. <https://doi.org/10.1080/14789940701292810>
- Young, K., & Regan, M. (2007). Driver distraction: A review of the literature. In: I.J. Faulks, M. Regan, M. Stevenson, J. Brown, A. Porter & J. Irwin (Eds.). *Distracted driving*. Sydney, Australia: Australasian College of Road Safety, pp. 379-405.
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.469.4178&rep=rep1&type=pdf>
- Yu, J. (1994). Punishment celerity and severity: testing a specific deterrence model on drunk driving recidivism. *Journal of Criminal Justice*, 22(4). 355-366.
[https://doi.org/10.1016/0047-2352\(94\)90082-5](https://doi.org/10.1016/0047-2352(94)90082-5)
- Zein, S., & Navin, F. (2003). Improving traffic safety: A new systems approach. *Transportation Research Record: Journal of the Transportation Research Board*, 1830(1), 1-9. <https://doi.org/10.3141/1830-01>
- Zhang, L.-F. (2003). Does the big five predict learning approaches? *Personality and Individual Differences*, 34(8), 1431-1446. [https://doi.org/10.1016/S0191-8869\(02\)00125-3](https://doi.org/10.1016/S0191-8869(02)00125-3)
- Zhang, Y. (1999). Using the internet for survey research: a case study. *Journal of the American Society for Information Science*, 51(1), 57-68.
[https://doi.org/10.1002/\(SICI\)1097-4571\(2000\)51:1,57::AIC-ASI9>3.0.CO;2-W](https://doi.org/10.1002/(SICI)1097-4571(2000)51:1,57::AIC-ASI9>3.0.CO;2-W)

- Zhang, Q., Ge, Y., Qu, W., Zhang, K., & Sun, X. (2018). The traffic climate in China: The mediating effect of traffic safety climate between personality and dangerous driving behaviour. *Accident Analysis & Prevention*, 113, 213-223. <https://doi.org/10.1016/j.aap.2018.01.031>
- Zhao, Y., Yamamoto, T., & Kanamori, R. (2020). Study of older male drivers' driving stress compared with that of young male drivers. *Journal of Transport and Transportation Engineering*, 7(4), 467-481. <https://doi.org/10.1016/j.jtte.2018.10.011>

Appendix A: Monash University Human Research Ethics Committee (MUHREC) ethics approval certificate for studies one and two



Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number: 9868

Project Title: Deterring Risky Driving: Understanding the effect of infringements on subsequent aberrant driving and crashes

Chief Investigator: Dr Janneke Berecki-Gisolf

Expiry Date: 20/09/2022

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MUHREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Thank you for your assistance.

Professor Nip Thomson

Chair, MUHREC

CC: Assoc Professor Stuart Newstead, Dr Karen Stephan, Ms Hayley McDonald

List of approved documents:

Document Type	File Name	Date	Version
Supporting Documentation	Data Variables	09/08/2017	1

Appendix B: Monash University Human Research Ethics Committee (MUHREC) ethics approval certificate for study three



Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID: 19886
Project Title: The influence of personal characteristics and perceptions towards potential deterrents, upon self-reported traffic offending
Chief Investigator: Assoc Professor Janneke Berecki-Gisolf
Approval Date: 28/06/2019
Expiry Date: 28/06/2024

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MUHREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Ms Hayley McDonald, Dr Karen Stephan, Assoc Professor Stuart Newstead

List of approved documents:

Document Type	File Name	Date	Version
Supporting Documentation	Email Invitation	21/05/2019	1
Supporting Documentation	Risk Assessment 13743	27/05/2019	1
Explanatory Statement	Explanatory Statement - Project ID 19886	19/06/2019	1
Consent Form	Consent form in Qualtrics	19/06/2019	2
Questionnaires / Surveys	Driving patterns and actions surveyv6 19JUN19	19/06/2019	6

Appendix C: Example of invitation email sent to Qualtrics panel members inviting them to complete a survey

WHAT DOES A TYPICAL EMAIL INVITATION TO A SURVEY LOOK LIKE?

A New Survey is Available

Hi Katy,

Someone wants to know what you think...



145 SB

Award
Value

25 min

Time to
Complete

This survey won't be available for long. Act now if you're interested.

Take Your Survey

Can't open the link? You can copy the link below into your browser:

<http://s.cint.com/Survey/Start/f4fcc8c1-6383-92fb-c88d-fed740c5b71ddd>

After successfully completing this survey, it may take up to 5 business days to receive SBs in your account

If you cannot participate in this survey we would appreciate it if you could decline participation in this survey by clicking on the following link*: [Decline survey](#)

For any concerns or questions regarding your survey please contact: surveysupport@swagbucks.com.

To make sure our emails do not get sent to you Junk/SPAM inbox, please add surveys@swagbucks.com to your contacts list or address book.

Thank you in advance!

Appendix D: Explanatory statement included in survey used to collect data for study three



EXPLANATORY STATEMENT

Project ID: 19886

Project Title: The influence of personal characteristics and perceptions towards potential deterrents, upon self-reported traffic offending

Chief Investigator: Associate Professor Janneke Berecki-Gisolf

Department: Monash University Accident Research Centre

Phone: +61 3 9902 0358

Email: janneke.berecki-gisolf@monash.edu

Student Researcher: Hayley McDonald (**Contact Person**)

Phone: +61 3 9905 1859

Email: hayley.mcdonald@monash.edu

You are invited to take part in this study. Please read the explanatory statement below in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to **contact the student researcher, Hayley McDonald**, via the phone number or email address listed above.

What does this research involve?

The aim of this study is to examine factors that may have an influence on the manner in which Victorian licence holders drive. The study is interested in considering factors that may deter drivers from performing risky behaviours when operating a motor vehicle.

If you choose to take part in this study, you will be asked to complete a survey that will ask you questions about your driving patterns, how you feel about a range of different driving behaviours, your previous experiences when driving, as well as some information about yourself. It is anticipated the survey should take around 20-30 minutes to complete. Completion times may vary slightly, depending on the responses you provide to particular questions.

All responses that you provide will be anonymous. This means that all information you provide about your driving actions will not be able to be linked back to you.

Why were you chosen for this research?

You have been invited to participate in this research as you have developed a profile to complete online surveys. This survey has been identified as potentially relevant to you.

Consenting to participate in the project and withdrawing from the research

If you choose to participate in this project, you will be asked to answer 'yes' on the consent page that follows this explanatory statement. If you choose to participate, it is important that you understand that given all the responses you provide will be anonymous, it will not be possible to later withdraw from the study should you change your mind once you have completed the survey. If you decide that you no longer wish to participate in the study as you are completing the survey, please simply close your browser. The

responses that have already been entered by you will not yet be recorded and therefore it is possible to change your mind at this stage.

Possible benefits and risks should you choose to participate in this study

Accidents on Victorian roads lead to serious injuries and fatalities for many Victorian road users every year. If you choose to participate in this study, you will be providing the research team with valuable information that may lead to safer experiences for yourself and others when travelling on Victorian roads.

Whilst it is not expected that participating in this study poses any foreseeable risks for you, please note that there are some questions that ask about your experience in road accidents. If answering these questions about a previous road accident that you have been involved in causes you distress, you may like to contact your General Practitioner (GP), or one of the support organisations listed below.

Road Trauma Support Services Victoria (RTSSV)

Website: <https://rtssv.org.au>

Phone: 1300 367 797

Beyond Blue

Website: <https://www.beyondblue.org.au>

Phone: 1300 224 636

This survey also asks you questions about your use of alcohol and illicit drugs. If completing this survey causes you to become concerned about your level of use, please contact your General Practitioner (GP).

Additionally, this survey asks you some questions about your mental health. If you feel concerned about your mental health and wellbeing after answering these questions, please contact your General Practitioner (GP) or Beyond Blue (contact details above).

Payment

If you choose to complete this survey, you will be compensated the amount you agreed upon prior to clicking the link.

Confidentiality

All responses that you provide when completing this survey will be anonymous. This means there will be no way for any person to link the responses you provide back to you. All results will be reported in aggregate form. This means your responses will be compiled with the responses provided by other individuals who choose to complete this survey.

Storage of data

Data from this survey will be stored on the secure Monash University server. Only members of the research team will have access to the data and a password will be required to gain this access. As per Monash University Human Research Ethics Committee (MUHREC) requirements, the data will be held for a minimum of five years and will be securely destroyed when it is no longer required.

Results

The results of this study will primarily be reported in a thesis to be submitted for examination for the degree of Doctor of Philosophy (PhD), that is currently being undertaken by the student researcher at the Monash University Accident Research Centre (MUARC). Results may also be presented at academic conferences

and submitted for publication to academic journals, both as part of the student researcher's course of study and following completion of the PhD. It is anticipated the results will be available in 2020.

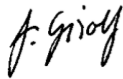
Complaints

Should you have any concerns or complaints about the conduct of this project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics Committee (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Room 111, Chancellery Building D,
26 Sports Walk, Clayton Campus
Research Office
Monash University, 3800

Phone: +61 3 9905 2052
Email: muhrec@monash.edu
Fax: +61 3 9905 3831

Regards,



Janneke Berecki-Gisolf

Appendix E: Survey used to collect data in Qualtrics for study three



Explanatory Statement

EXPLANATORY STATEMENT

Project ID: 19886

Project Title: The influence of personal characteristics and perceptions towards potential deterrents, upon self-reported traffic offending

Before commencing this survey, please download the Explanatory Statement via the link below. This document provides you with details about the research study, including the aims, how the data will be used and services you should contact should any issues arise.

Please save or print this document to enable you to refer back to it at any time whilst you are completing the survey or following completion of the survey.

Please click 'next' once you have read and understood the Explanatory Statement.

[Explanatory Statement Project ID 19886](#)

Consent Form

CONSENT FORM

Project ID: 19886

Project Title: The influence of personal characteristics and perceptions towards potential deterrents, upon self-reported traffic offending

Chief Investigator: Associate Professor Janneke Berecki-Gisolf

Student Researcher: Hayley McDonald

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project. I understand that if at any time whilst completing the survey I feel uncomfortable responding to the questions, I can simply close my browser and none of my responses will be recorded. I also understand that, given the survey is anonymous, I will be unable to withdraw my responses once I have completed the survey and my responses have been submitted.

I consent to the following:

	Yes	No
Completion of a survey asking me questions about my driving patterns, how I feel about a range of different driving behaviours, my previous experiences when driving, as well as some information about myself	<input type="radio"/>	<input type="radio"/>

Screening Questions

Do you currently hold or have you in the last 12 months held a Victorian probationary or full drivers' licence, which allows you to drive a car?

- ☐ Yes
- ☐ No
- ☐ Not Sure/Don't Know

In the last 12 months, have you driven on Victorian roads on at least one occasion?

- ☐ Yes
- ☐ No
- ☐ Not Sure/Can't Remember

Do you currently live in Victoria?

- ☐ Yes
- ☐ No
- ☐ Not sure/Don't Know

What is your age in years (eg. 52)?

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Do not wish to respond

Situational Factors

Thinking about the last three (3) months, how many kilometres (km) did you drive in a typical week?

- ☐ None at all
- ☐ 1 to 49 kilometres
- ☐ 50 to 99 kilometres
- ☐ 100 to 199 kilometres
- ☐ 200 to 399 kilometres
- ☐ 400 to 599 kilometres
- ☐ 600 to 799 kilometres
- ☐ 800 to 999 kilometres
- ☐ 1000 kilometres or more
- ☐ Don't know/Can't remember

Please indicate how much you agree or disagree with each of the following statements

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Don't Know
If I could not drive, this would impact my ability to get to the places I most regularly need to go to	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I could not drive, this would impact my level of independence	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I could not drive, this would put pressure on those closest to me as they would need to drive me around	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I could not drive, this would lead me to feel isolated	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I could not drive, this would not impact me as there are many other options to get around	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Legal Deterrence - Certainty

If I was to drive with an illegal BAC (Blood Alcohol Concentration), I'd worry that I would get caught by police

- ☐ Strongly agree
- ☐ Agree
- ☐ Somewhat agree
- ☐ Neither agree nor disagree
- ☐ Somewhat disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Do not wish to respond

If I was to drive after using illicit drug/s, I'd worry that I would get caught by police

- ☐ Strongly agree
- ☐ Agree
- ☐ Somewhat agree
- ☐ Neither agree nor disagree
- ☐ Somewhat disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Do not wish to respond

If I was to drive at up to 10km/h above the speed limit, I'd worry that I would get caught by police or a speed camera

- ☐ Strongly agree
- ☐ Agree
- ☐ Somewhat agree
- ☐ Neither agree nor disagree
- ☐ Somewhat disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Do not wish to respond

If I was to drive at more than 10km/h above the speed limit, I'd worry that I would get caught by police or a speed camera

- ☐ Strongly agree
- ☐ Agree
- ☐ Somewhat agree
- ☐ Neither agree nor disagree
- ☐ Somewhat disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Do not wish to respond

If I was to use a handheld mobile phone whilst driving, I'd worry that I would get caught by police

- ☐ Strongly agree
- ☐ Agree
- ☐ Somewhat agree
- ☐ Neither agree nor disagree
- ☐ Somewhat disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Do not wish to respond

If I was to drive through a red light, I'd worry that I would get caught by police or a red light camera

- ☐ Strongly agree
- ☐ Agree
- ☐ Somewhat agree
- ☐ Neither agree nor disagree
- ☐ Somewhat disagree
- ☐ Disagree
- ☐ Strongly disagree
- ☐ Do not wish to respond

Legal Deterrence - Severity

Loss of my licence for driving with an illegal BAC (Blood Alcohol Concentration) would have a significant negative impact on my life

- ☐ Strongly Agree
- ☐ Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor Disagree
- ☐ Somewhat Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ Do not wish to respond

Loss of my licence for driving after using an illicit drug/s would have a significant negative impact on my life

- ☐ Strongly Agree
- ☐ Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor Disagree
- ☐ Somewhat Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ Do not wish to respond

Receiving a fine and/or demerit points on my licence for driving at up to 10km/h above the speed limit would have a significant negative impact on my life

- ☐ Strongly Agree
- ☐ Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor Disagree
- ☐ Somewhat Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ Do not wish to respond

Receiving a fine and/or demerit points on my licence for driving at more than 10km/h above the speed limit would have a significant negative impact on my life

- ☐ Strongly Agree
- ☐ Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor Disagree
- ☐ Somewhat Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ Do not wish to respond

Receiving a fine and/or demerit points on my licence for using a handheld mobile phone whilst driving would have a significant negative impact on my life

- ☐ Strongly Agree
- ☐ Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor Disagree
- ☐ Somewhat Disagree
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ Do not wish to respond

Receiving a fine and/or demerit points on my licence for driving through a red light would have a significant negative impact on my life

- ☐ Strongly Agree
 - ☐ Agree
 - ☐ Somewhat Agree
 - ☐ Neither Agree nor Disagree
 - ☐ Somewhat Disagree
 - ☐ Disagree
 - ☐ Strongly Disagree
 - ☐ Do not wish to respond
-

Perceptions of personal/emotional effect

For each driving behaviour, please indicate how much of the time you think it is wrong

	Never wrong to do it	Rarely wrong to do it	Sometimes wrong to do it	Usually wrong to do it	Always wrong to do it	Do not wish to respond
Driving with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Driving through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The term 'shame' can be defined as 'a painful feeling of humiliation or distress caused by the consciousness of wrong or foolish behaviour'.

Thinking about this definition, would you feel shame if you.....

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The term 'guilt' can be defined as 'the fact of having committed a specified or implied offence or crime'

Thinking about this definition, would you feel guilt if you.....

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The term 'thrilling' can be defined as something 'causing excitement and pleasure; exhilarating'

Thinking about this definition, would you find it thrilling if you.....

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The term 'satisfaction' can be defined as 'fulfilment of one's wishes, expectations or needs, or the pleasure derived from this'

Thinking about this definition, would you feel satisfaction if you.....

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section Four: Perceptions of accident risk

I would be worried that I could have a crash if I.....

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I would be worried that I could injure myself or someone else if I.....

	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Perceptions of social disapproval

Thinking about the people who mean the most to you, how do you think they would respond if you.....

	Strongly Disapprove	Disapprove	Somewhat Disapprove	Neither Approve nor Disapprove	Somewhat Approve	Approve	Strongly Approve	Do not wish to respond
Drove with an illegal BAC (Blood Alcohol Concentration)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove after using an illicit drug/s	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at up to 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove at more than 10km/h above the speed limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used a handheld mobile phone whilst driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drove through a red light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Expectations of performing different driving behaviours

How likely do you think it is that you will drive with an illegal BAC (Blood Alcohol Concentration) in the next 12 months?

- ☐ Extremely likely
 - ☐ Moderately likely
 - ☐ Slightly likely
 - ☐ Neither likely nor unlikely
 - ☐ Slightly unlikely
 - ☐ Moderately unlikely
 - ☐ Extremely unlikely
 - ☐ Do not wish to respond
-

How likely do you think it is that you will drive after using an illicit drug/s in the next 12 months?

- ☐ Extremely likely
 - ☐ Moderately likely
 - ☐ Slightly likely
 - ☐ Neither likely nor unlikely
 - ☐ Slightly unlikely
 - ☐ Moderately unlikely
 - ☐ Extremely unlikely
 - ☐ Do not wish to respond
-

How likely do you think it is that you will drive at up to 10km/h above the speed limit in the next 12 months?

- ☐ Extremely likely
 - ☐ Moderately likely
 - ☐ Slightly likely
 - ☐ Neither likely nor unlikely
 - ☐ Slightly unlikely
 - ☐ Moderately unlikely
 - ☐ Extremely unlikely
 - ☐ Do not wish to respond
-

How likely do you think it is that you will drive at more than 10km/h above the speed limit in the next 12 months?

- ☐ Extremely likely
- ☐ Moderately likely
- ☐ Slightly likely
- ☐ Neither likely nor unlikely
- ☐ Slightly unlikely
- ☐ Moderately unlikely
- ☐ Extremely unlikely
- ☐ Do not wish to respond

How likely do you think it is that you will use a handheld mobile phone whilst driving in the next 12 months?

- ☐ Extremely likely
- ☐ Moderately likely
- ☐ Slightly likely
- ☐ Neither likely nor unlikely
- ☐ Slightly unlikely
- ☐ Moderately unlikely
- ☐ Extremely unlikely
- ☐ Do not wish to respond

How likely do you think it is that you will drive through a red light in the next 12 months?

- ☐ Extremely likely
- ☐ Moderately likely
- ☐ Slightly likely
- ☐ Neither likely nor unlikely
- ☐ Slightly unlikely
- ☐ Moderately unlikely
- ☐ Extremely unlikely
- ☐ Do not wish to respond

Previous Driving Behaviour - Performance of Behaviour

In the last 12 months, how often have you driven when you thought you may have an illegal BAC (Blood Alcohol Concentration)?

- ☐ Every trip
 - ☐ Most trips
 - ☐ Occasionally/Some trips
 - ☐ Rarely
 - ☐ Never
 - ☐ Do not wish to respond
-

In the last 12 months, how often have you driven after using an illicit drug/s?

- ☐ Every trip
 - ☐ Most trips
 - ☐ Occasionally/Some trips
 - ☐ Rarely
 - ☐ Never
 - ☐ Do not wish to respond
-

In the last 12 months, how often have you driven at up to 10km/h above the speed limit?

- ☐ Every trip
 - ☐ Most trips
 - ☐ Occasionally/Some trips
 - ☐ Rarely
 - ☐ Never
 - ☐ Do not wish to respond
-

In the last 12 months, how often have you driven at more than 10km/h above the speed limit?

- ☐ Every trip
 - ☐ Most trips
 - ☐ Occasionally/Some trips
 - ☐ Rarely
 - ☐ Never
 - ☐ Do not wish to respond
-

In the last 12 months, how often have you used a handheld mobile phone whilst driving?

- ☐ Every trip
 - ☐ Most trips
 - ☐ Occasionally/Some trips
 - ☐ Rarely
 - ☐ Never
 - ☐ Do not wish to respond
-

In the last 12 months, how often have you driven through a red light?

- ☐ Every trip
 - ☐ Most trips
 - ☐ Occasionally/Some trips
 - ☐ Rarely
 - ☐ Never
 - ☐ Do not wish to respond
-

Experience of being caught by police or a road safety camera

In the last 12 months, how many times have you been caught by police for driving with an illegal BAC (Blood Alcohol Concentration)?

- ☐ Never
 - ☐ Once
 - ☐ Twice
 - ☐ Three times
 - ☐ Four or more times
 - ☐ Do not wish to respond
-

In the last 12 months, how many times have you been caught by police for driving after using an illicit drug/s?

- ☐ Never
 - ☐ Once
 - ☐ Twice
 - ☐ Three times
 - ☐ Four or more times
 - ☐ Do not wish to respond
-

In the last 12 months, how many times have you been caught by police or a speed camera for driving at up to 10km/h above the speed limit?

- ☐ Never
 - ☐ Once
 - ☐ Twice
 - ☐ Three times
 - ☐ Four or more times
 - ☐ Do not wish to respond
-

In the last 12 months, how many times have you been caught by police or a speed camera for driving at more than 10km/h above the speed limit?

- ☐ Never
 - ☐ Once
 - ☐ Twice
 - ☐ Three times
 - ☐ Four or more times
 - ☐ Do not wish to respond
-

In the last 12 months, how many times have you been caught by police for using a handheld mobile phone whilst driving?

- ☐ Never
 - ☐ Once
 - ☐ Twice
 - ☐ Three times
 - ☐ Four or more times
 - ☐ Do not wish to respond
-

In the last 12 months, how many times have you been caught by police or a red light camera for driving through a red light?

- ☐ Never
 - ☐ Once
 - ☐ Twice
 - ☐ Three Times
 - ☐ Four or more times
 - ☐ Do not wish to respond
-

Previous accident involvement

In the last 3 years, how many road accidents have you been involved in as a driver or motorcycle rider?

This includes any road accidents where you were driving and:

- You or someone else was injured; AND/OR
- Your vehicle or someone else's vehicle was damaged (even if the damage was minimal); AND/OR
- Property was damaged; AND/OR
- You were at fault; AND/OR
- You were not at fault

Please only include accidents that happened on a public road (for example, do not include accidents where you may have been reversing into your driveway and you hit your letterbox)

- ☐ None
- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four
- ☐ Five
- ☐ Six or more (please specify number)
- ☐ Not sure/Can't remember
- ☐ Do not wish to respond
-

The next two questions ask about the road accident in which you were involved in the last 3 years.

If you responded in the previous question that you have been involved in two or more road accidents during this time, please answer the next two questions based on the one where the most serious injuries were received by a person. If none of your accidents have resulted in injuries, answer based on the one where there was the greatest level of damage to a vehicle or property.

Thinking about your road accident, was anyone injured?

Please select one response only. This means if more than one person was injured, select the response that reflects the person who was most seriously injured.

- ☐ No, the accident only resulted in damage to vehicles and/or property
- ☐ At least one person was injured, but no medical treatment was required
- ☐ At least one person was injured, requiring a visit to the doctor and/or first aid
- ☐ At least one person was injured, requiring them to be taken to a hospital emergency department
- ☐ Someone died
- ☐ Not sure/Can't remember
- ☐ Do not wish to respond
-

Still thinking about this same road accident, who do you believe was at fault?

- ☐ I was at fault
- ☐ Another driver was at fault
- ☐ Both myself and another driver were at fault
- ☐ Nobody was at fault
- ☐ Not Sure/Can't Remember
- ☐ Do not wish to respond
-

Self Control Questions

The following section presents a series of statements. Please indicate how strongly you agree or disagree each statement applies to you. Remember that all your responses are confidential.

	Strongly Disagree	Disagree Somewhat	Agree Somewhat	Strongly Agree
1. I often act on the spur of the moment without stopping to think	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. I don't devote much thought and effort to preparing for the future	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. I often do whatever brings me pleasure here and now, even at the cost of some distant goal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. I'm more concerned with what happens to me in the short run than in the long run	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. I frequently try to avoid things that I know will be difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. When things get complicated, I tend to quit or withdraw	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Strongly Disagree	Disagree Somewhat	Agree Somewhat	Strongly Agree
7. The things in life that are easiest to do bring me the most pleasure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. I dislike really hard tasks that stretch my abilities to the limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. I like to test myself now and then by doing something a little risky	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. Sometimes I will take a risk just for the fun of it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. I sometimes find it exciting to do things for which I might get in trouble	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. Excitement and adventure are more important to me than security	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Disagree	Disagree Somewhat	Agree Somewhat	Strongly Agree
13. If I had a choice, I would almost always rather do something physical than something mental	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. I almost always feel better when I am on the move than when I am sitting and thinking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15. I like to get out and do things more than I like to read or contemplate ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16. I seem to have more energy and a greater need for activity than most other people my age	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17. I try to look out for myself first, even if it means making things difficult for other people	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18. I'm not very sympathetic to other people when they are having problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Strongly Disagree	Disagree Somewhat	Agree Somewhat	Strongly Agree
19. If things I do upset people, it's their problem, not mine	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20. I will try to get the things I want, even when I know it's causing problems for other people	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. I lose my temper pretty easily	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. Often, when I'm angry at people, I feel more like hurting them than talking to them about why I am angry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23. When I am really angry, other people better stay away from me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24. When I have a serious disagreement with someone, it's usually hard for me to talk calmly about it without getting upset	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Personality questions

I see myself as someone who....

	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Strongly
1. Is talkative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Tends to find fault with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Does a thorough job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Is depressed, blue	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Is original, comes up with new ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Is reserved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Is helpful and unselfish with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. Can be somewhat careless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Strongly
9. Is relaxed, handles stress well	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. Is curious about many different things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. Is full of energy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. Starts quarrels with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. Is a reliable worker	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. Can be tense	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15. Is ingenious, a deep thinker	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16. Generates a lot of enthusiasm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Strongly
17. Has a forgiving nature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18. Tends to be disorganized	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19. Worries a lot	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20. Has an active imagination	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. Tends to be quiet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. Is generally trusting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23. Tends to be lazy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24. Is emotionally stable, not easily upset	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Strongly
25. Is inventive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26. Has an assertive personality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
27. Can be cold and aloof	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28. Perseveres until the task is finished	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
29. Can be moody	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
30. Values artistic, aesthetic experiences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
31. Is sometimes shy, inhibited	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
32. Is considerate and kind to almost anyone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Strongly
33. Does things efficiently	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
34. Remains calm in tense situations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
35. Prefers work that is routine	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
36. Is outgoing, sociable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
37. Is sometimes rude to others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
38. Makes plans and follows through with them	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
39. Gets nervous easily	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
40. Likes to reflect, play with ideas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Disagree Strongly	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Strongly
41. Has few artistic interests	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
42. Likes to cooperate with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
43. Is easily distracted	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
44. Is sophisticated in art, music or literature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Mental Health Questions

The following questions relate to how you have been feeling over the past 4 weeks. Select the response that best reflects your thoughts, feelings and behaviour.

In the past 4 weeks:

	None of the time	A little of the time	Some of the time	Most of the time	All of the time	Do not wish to respond
1. About how often did you feel tired out for no good reason?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. About how often did you feel nervous?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. About how often did you feel so nervous that nothing could calm you down?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. About how often did you feel hopeless?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. About how often did you feel restless or fidgety?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	None of the time	A little of the time	Some of the time	Most of the time	All of the time	Do not wish to respond
6. About how often did you feel so restless you could not sit still?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. About how often did you feel depressed?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. About how often did you feel that everything was an effort?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. About how often did you feel so sad that nothing could cheer you up?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. About how often did you feel worthless?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Alcohol Questions

The following questions are about alcohol consumption. Please remember all your answers are confidential.

How often do you have a drink containing alcohol?

- ☐ Never
- ☐ Monthly or less
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Do not wish to respond

For the following two questions, please use the diagram below. The first five drinks in the diagram are examples of one standard drink. The final drink, which is the full strength can or stubbie of beer contains 1.5 standard drinks.

Full Strength Beer 285ml 4.8% Alcohol	Low Strength Beer 425ml 2.7% Alcohol	Pre-mix Spirits 275ml 5% Alcohol	Wine 100ml 13.5% Alcohol	Spirits 30ml 40% Alcohol	Full Strength Beer Can or Stubbie 375ml 4.8% Alcohol
					

How many standard drinks do you have on a typical day when you are drinking?

- ☐ 1 or 2
- ☐ 3 or 4
- ☐ 5 or 6
- ☐ 7 to 9
- ☐ 10 or more
- ☐ Do not wish to respond

How often do you have six or more standard drinks on one occasion?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily
- ☐ Do not wish to respond

How often during the last year have you found that you were not able to stop drinking once you had started?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily
- ☐ Do not wish to respond

How often during the last year have you failed to do what was normally expected of you because of drinking?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily
- ☐ Do not wish to respond

How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily
- ☐ Do not wish to respond

How often during the last year have you had a feeling of guilt or remorse after drinking?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily
- ☐ Do not wish to respond

How often during the last year have you been unable to remember what happened the night before because you had been drinking?

- ☐ Never
- ☐ Less than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily
- ☐ Do not wish to respond

Have you or someone else been injured because of your drinking?

- ☐ No
- ☐ Yes, but not in the last year
- ☐ Yes, during the last year
- ☐ Do not wish to respond

Has a relative, friend, doctor, or other health care worker been concerned about your drinking or suggested you cut down?

- ☐ No
- ☐ Yes, but not in the last year
- ☐ Yes, during the last year
- ☐ Do not wish to respond

Illicit Drug Questions

Have you used any of the following illicit drugs in the last 12 months? Please select all that apply. Please remember all your responses are confidential.

- ☐ Cannabis/Marijuana
- ☐ Cocaine
- ☐ Heroin
- ☐ Amphetamine/Speed/Methamphetamine/Ice
- ☐ Ecstasy
- ☐ Other (Please Specify)
- ☐ I have not used any illicit drugs in the last 12 months
- ☐ Don't know/Can't remember
- ☐ Do not wish to respond

Thinking about your use of Cannabis/Marijuana in the last 12 months, how regularly did you use the drug?

- ☐ Monthly or less
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Don't know/Can't remember
- ☐ Do not wish to respond

Thinking about your use of Cocaine in the last 12 months, how regularly did you use the drug?

- ☐ Monthly or less
- ☐ 2- 4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Don't know/Can't remember
- ☐ Do not wish to respond

Thinking about your use of Heroin in the last 12 months, how regularly did you use the drug?

- ☐ Monthly or less
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Don't know/Can't remember
- ☐ Do not wish to respond

Thinking about your use of Amphetamine/Speed/Methamphetamine/Ice in the last 12 months, how regularly did you use the drug?

- ☐ Monthly or less
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Don't know/Can't remember
- ☐ Do not wish to respond

Thinking about your use of Ecstasy in the last 12 months, how regularly did you use the drug?

- ☐ Monthly or less
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Don't know/Can't remember
- ☐ Do not wish to respond

You noted you have used an 'other' type of illicit drug in the last 12 months. How regularly did you use this drug in the last 12 months? (If you noted you used more than one other type of illicit drug in the last 12 months, please answer based on the one you used most regularly)

- ☐ Monthly
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week
- ☐ Don't Know/Can't remember
- ☐ Do not wish to respond

Questions about you

Which area of Victoria do you live in?

- ☐ Melbourne Metropolitan area
- ☐ Regional area
- ☐ Don't know/Not sure
- ☐ Do not wish to respond

Are you currently studying?

- ☐ No
- ☐ Yes, full-time
- ☐ Yes, part-time
- ☐ Other (please specify)
- ☐ Do not wish to respond

What is your current employment status?

- ☐ Unemployed
- ☐ Employed full-time
- ☐ Employed part-time or casual
- ☐ Home duties
- ☐ Retired
- ☐ Disability pension
- ☐ Other (please specify)
- ☐ Do not wish to respond

What is the highest level of education that you have completed?

- ☐ Did not complete high school (Left school before Year 12 / Form 6)
- ☐ Completed high school (Completed Year 12 / Form 6)
- ☐ Completed an Apprenticeship / TAFE / Technical College
- ☐ Completed a University degree (Bachelor / Graduate / Post-Graduate)
- ☐ Other (please specify)
- ☐ Do not wish to respond

What type of licence(s) do you currently hold or have you held in the last 12 months?
Please specify as many as applicable.

- ☐ Car Probationary Licence
- ☐ Car Full Licence
- ☐ Heavy Vehicle (truck or bus) Licence
- ☐ Motorcycle Learner Permit
- ☐ Motorcycle Probationary Licence
- ☐ Motorcycle Full Licence
- ☐ Do not wish to respond

In the last 12 months, have you been unable to drive a car legally because your licence was...?
Please specify all that are applicable.

- ☐ Cancelled
- ☐ Suspended
- ☐ Disqualified
- ☐ Void
- ☐ Expired
- ☐ Surrendered
- ☐ No, my licence has not been subject to any of these conditions in the last 12 months
- ☐ Not Sure/Can't Remember
- ☐ Do not wish to respond

At what age did you obtain your first probationary drivers' licence (eg. 18)?

Appendix F: Personality trait each item in the Big Five Inventory seeks to measure

The Big Five Inventory is a 44-item personality scale that measures individuals on the five personality traits of extraversion, agreeableness, conscientiousness, neuroticism and openness (John, Donahue & Kentle, 1991; John, Naumann & Soto, 2008; John and Srivastava, 1999). As indicated in the thesis, each item is measured on a five-point scale of 1) Disagree strongly; 2) Disagree a little; 3) Neither agree nor disagree; 4) Agree a little; 5) Agree strongly. When scoring the scale, the nature of sixteen items means that they need to be reverse scored to accurately represent the trait they measure. Each of the 44-items are listed below, under the personality trait which they measure. Reverse coding is indicated where applicable.

Extraversion is measured using eight items:

- Is talkative
- Is reserved (reverse coded item)
- Is full of energy
- Generates a lot of enthusiasm
- Tends to be quiet (reverse coded item)
- Has an assertive personality
- Is sometimes shy, inhibited (reverse coded item)
- Is outgoing, sociable

Agreeableness is measured using nine items:

- Tends to find fault with others (reverse coded item)
- Is helpful and unselfish with others
- Starts quarrels with others (reverse coded item)
- Has a forgiving nature
- Is generally trusting
- Can be cold and aloof (reverse coded item)
- Is considerate and kind to almost everyone
- Is sometimes rude to others (reverse coded item)
- Likes to cooperate with others

Conscientiousness is measured using nine items:

- Does a thorough job
- Can be somewhat careless (reverse coded item)
- Is a reliable worker
- Tends to be disorganised (reverse coded item)
- Tends to be lazy (reverse coded item)
- Perseveres until the task is finished
- Does things efficiently
- Makes plans and follows through with them
- Is easily distracted (reverse coded item)

Neuroticism is measured using eight items:

- Is depressed, blue
- Is relaxed, handles stress well (reverse coded item)
- Can be tense
- Worries a lot
- Is emotionally stable, not easily upset (reverse coded item)
- Can be moody
- Remains calm in tense situations (reverse coded item)
- Gets nervous easily

Openness is measured using ten items:

- Is original, comes up with new ideas
- Is curious about many different things
- Is ingenious, a deep thinker
- Has an active imagination
- Is inventive
- Values artistic, aesthetic experiences
- Prefers work that is routine (reverse coded item)
- Likes to reflect, play with ideas
- Has few artistic interests (reverse coded item)
- Is sophisticated in art, music or literature