Vol 25 No 3, 2014

Journal of the Australasian College of Road Safety

Formerly RoadWise – Australia's First Road Safety Journal

Special Issue: Marking the anniversary of the UN Decade of Action

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His Excellency General the Honourable Sir Peter Cosgrove AK MC (Retd)
Governor-General of the Commonwealth of Australia

Message for the Australasian College of Road Safety Journal

Too many Australian families have been touched by tragedy through road accidents. I commend the Australasian College of Road Safety for its commitment to ensuring all Australian road users—pedestrians, cyclists, drivers, riders, and passengers—travel safely on our nation's roads.

By bringing together people with a broad range of expertise and experience to raise awareness and promote new initiatives, the Australasian College of Road Safety undoubtedly saves lives and prevents injuries.

I am very proud to be Patron of the Australasian College of Road Safety, and look forward to working with this impressive association during my term as Governor-General.

Let us all strive to make Australian roads safer.

Peter Cosgrove
26th June 2014

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Contents

Peer-reviewed papers

Contributed articles

Cover image

The Third anniversary of the United Nations Decade of Action has seen many developments to improve road safety globally through the five pillars of: Road Safety Management; Safer Roads and Mobility; Safer Vehicles; Safer Road Users; and Post-Crash Response.
For further information go to www.decadeofaction.org.

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The aim of the *Journal of the Australasian College of Road Safety* is to provide a medium for expression of views and debate on all facets of the study of road safety. Articles are accepted from a variety of disciplines, such as health and medicine, road and automotive engineering, education, law, behavioural sciences, communication, history, management, and urban and traffic planning. Interdisciplinary approaches are particularly welcome.

The College encourages interested persons and organisations to submit articles, photographs or letters for publication. Published letters would normally show the name of the writer and the state or territory of residence. The journal provides the opportunity for researchers to have their work submitted for peer review, in order to improve the quality of their research papers. However, peer review cannot guarantee the validity of research nor assure scientific quality. The publisher reserves the right to reject submissions or, with approval of the author, to edit articles. No payment is offered for articles published.Material in this journal may be cited with acknowledgement of the full reference, including the author, article title and the year and volume of the journal. For permission to reprint articles, please contact the Journal Managing Editor.

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Submissions to the journal, and any queries or comments about journal content, should be addressed to the Managing Editor. Inquiries regarding journal subscriptions, changes of address and back issues should be addressed to the Finance and Administration Officer.
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Messages may be left on voicemail when the office is unattended.

From the President

Dear ACRS members,

Recently at a discussion group where business leaders had outlined their road safety activities, the coordinator asked how much of their activities were encouraged or driven by the UN Decade of Action on Road Safety program. The general view was that most of their programs were driven by their own recognition that they could reduce trauma in their workplace by applying their systems approach to workplace safety to their road transport activities.

I mention this as we coming up to the three year review of the Decade of Action program, which has been a focus for government agencies and researchers in Australia, for Aid Agencies and others overseas, but perhaps not so much for business.

However, when I look back over the past three years there has been an increased level of interest, and activity for the UN program, perhaps not specifically or directly attributable to that program but influenced by it.

At the College we have definitely ramped up our information services, encouraged more direct collaboration between researchers and other professionals, encouraged the national government to have a more specific safe systems policy, broadened our membership base including businesses and have plans for further outreach and improved networking not only in Australasia, to assist in the reduction of unnecessary road trauma. You will read of more of the UN's program in the Journal.

I hope that the three year review will help us all accelerate our actions so we can confidently help to achieve the goals to arrest road trauma.

Our last Journal with the specific focus on the various world NCAP related programs has been widely circulated and very well received as a comprehensive status report on these important programs.

In this issue fleet, trucking, rollover and data collection are key topics as well as the regular reports.

We are pleased to welcome the following members to their new roles on the Executive Committee: Co Vice-President and ACT Chapter Representative Eric Chalmers; Treasurer and Queensland Chapter Representative Dr Kerry Armstrong; New South Wales (Sydney) Representative David McTiernan; and Committee Members Professor Narelle Haworth and Dr Marilyn Johnson. We extend our thanks to the outgoing members for their contribution: Professor Barry Watson; Ms Liz de Rome; and Dr Teresa Senserrick. The Executive Committee for 2014 are listed in this edition of the Journal, and we look forward to the input from the new directors. I encourage you to contribute where you can and in particular to participate in your own Chapter activities.

Lauchlan McIntosh AM FACRS
ACRS President

Diary

7 – 11 September 2014
21st World Congress on Intelligent Transport Systems
Detroit, Michigan
United States of America
https://www.its-australia.com.au/events/21st-world-congress-detroit-2014/

10 – 11 September 2014
Road Safety 5 International Conference: Improving Road Safety Together to Save Lives
Manila, The Philippines
http://roadsafety-5conference.com/Homepage

18 - 19 September 2014
Occupational Safety in Transport Conference
Crowne Plaza, Surfers Paradise
Gold Coast, Queensland
http://ositconference.com/

5 – 8 October 2014
The 2nd International Conference on Law Enforcement and Public Health (LEPH2014)
Free University, Amsterdam, The Netherlands
http://www.lephcon.com.au/

14 October 2014
Police Family Liaison Following Road Death and Serious Injury
Solihull, Birmingham (UK)
http://www.brakepro.org/take-part/calendar-of-brake-events/2-uncategorised/189-police-family-liaison-following-road-death-and-serious-injury

19 – 21 October
Research Driving Efficiency
ANZ Stadium, Sydney Olympic Park, Australia
http://www.26arrbconference.com.au/

12 – 14 November 2014
Australasian Road Safety Research, Policing and Education Conference
Melbourne, Australia
http://rsrpe2014.com.au

17 – 19 November 2014
1st International Road Federation Asia Regional Congress
Bali Nusa Dua Convention Center
Bali, Indonesia
http://www.irfnews.org/event/1st-asia-regional-congress

4 – 10 May 2015
3rd United Nations Global Road Safety Week: Focussed On Children and Road Safety

The 2014 Executive Committee

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Marking the third anniversary of the United Nations Decade of Action

Road safety finds itself at a cross roads. During the first three years of the Decade of Action for Road Safety 2011-2020, much has been achieved. Countries have built road safety management capacity; improved the safety of roads and vehicles; enhanced the behaviour of road users; and strengthened post-crash care. Still, much work needs to be done to scale up implementation of the known solutions and thereby save millions of lives.

2015 will be a not-to-be-missed opportunity to add further impetus and a renewed sense of urgency to the Decade of Action. In May the international community will mark the Third United Nations Global Road Safety Week on children and road safety, and in November the Government of Brazil will host the Second High-Level Global Conference on Road Safety. The latter event, which is expected to convene ministers and other senior officials from transport, health, interior and foreign affairs from all countries, will be the occasion to review progress in the Decade of Action to date and develop a road map for the next five years. In 2015, Governments will also decide on new development goals for the world. Road safety is given due consideration in the preparatory debates.

Launched on 11 May 2011 by governments across the world, the Decade of Action seeks to save five million lives.

It is through the concerted efforts of governments, civil society and all road users that the legacy of this Decade of Action will be one of a world in which safe and sustainable transport is considered a right for all.

Dr Etienne Krug
Director, WHO Department of Violence and Injury Prevention and Disability

Ten times the population of Australia will be killed and seriously injured in road crashes by 2030

A total of 265 million people will be killed and seriously injured on the world's roads between 2015 and 2030. That is 265 million children, brothers, sisters, mums and dads – more than 10 times the population of Australia. The United Nations is currently shaping the post-2015 Sustainable Development Goals that will shape global action worldwide for the next 15 years. Halving road deaths by 2030 must be one of those targets and you can help by voting for better transport and roads and highlighting road safety as a priority issue at http://vote.myworld2015.org/.

In Australia recent work by the Australian Automobile Association AusRAP programme highlighted that 39% of Australian national highways are only rated one or two-star - where five-star is the safest. Worldwide more than 50% of roads assessed by iRAP are also in the lowest two-star rating categories. With research showing that the cost of death and serious injury per kilometre travelled is halved for each incremental improvement in star rating the potential for safer roads to save many lives is clear. The savings to the health, long-term care, insurance, legal and emergency response sectors are significant; making this investment cost effective when viewed from a whole of government, whole of community perspective.

With the great improvements in vehicle safety thanks to ANCAP we are now driving 4 and 5-star cars on 1 and 2-star roads in Australia. Setting and achieving targets for no one or two-star roads by 2020 (like the Netherlands Government) or four-star national highways (like the New Zealand Government) will rapidly and sustainably reduce the impact of road trauma on our communities. The vaccines for roads exist and all that is missing is the coordinated scale of response to make a difference.

Rob McInerney
CEO of the international Road Assessment Programme
www.irap.org

Road safety: A message from Senator Alex Gallacher, Senator for South Australia – Co-chair of the Parliamentary Friends of Road Safety

Above: Senator Alex Gallacher

The Hon. Darren Chester MP and I have taken the opportunity to form the Parliamentary Friends of Road Safety.

The group has four main objectives:

1. Elevate with the Federal Parliament greater awareness of road safety.
2. Inform Federal Parliamentarians of the need for continual improvement in road safety outcomes.
3. Inform Federal Parliamentarians of the national and international initiatives with potential to improve road safety outcomes.
4. Ensure the Federal Members of Parliament are aware of the enormous social and economic cost of failing to continually prioritise improved road safety outcomes.

The group has been able to attract over 40 parliamentarians to be founding members of the group.

This will allow an opportunity for organisations to present their thoughts to law makers from across the country.

The group has already been involved in supporting Fatality Free Friday where the group was able to organise many federal parliamentarians to sign the pledge.

The issue of Road Safety has been part of our nation for generations. Unfortunately, we still have an extremely high number of Australians dying on our roads or being catastrophically injured. The numbers in recent times have been on a downward trend, despite our population increasing effectively increasing the number of road users.

Since 1989 there has been a steady decline in road fatalities through interventionary forces such as Random Breath Testing, Standards and Speed policies, fixed speed cameras, random drug testing, vehicle impounding and p-plate restrictions.

Vehicle safety standards is another contributing factor that has helped decrease the fatalities and catastrophic injuries on our roads, and I am positive that future cars will be built smarter with increased safety design features to work in conjunction with driver assistance mechanisms to assist drivers on our roads, such as Emergency (Auto) Braking Technology. This is to build on successful driver assistance mechanisms like Electronic Stability Control, Traction Control and ABS.

However, we still need to proceed to the next stage and continue the downward trend. Since 1925, there have been over 180,000 deaths on Australian roads, and unfortunately in 2013 we lost 1,193 people on our roads. The annual economic cost of road crashes in Australia is estimated to be at $27 billion, but what is even more devastating is that children grow up without parents, brothers, sisters. The health cost is also significant. According to a BITRE report in 2006, there were 4,619 people who suffered a disability after a crash and in that same year 36,204 people were admitted to hospital. A further 216,500 people were treated for road crash injuries but thankfully were not admitted to hospital. The figures are alarming.

So what is next?

That is a question for not just policy makers but the general public. One thing that is certain is that there is no silver bullet approach. Small gains are crucial, but we need to keep certain issues on the forefront of the public's mind, because their concerns will drive action.

I can identify some options for policy makers to consider, especially in Australia, such as better road design and engineering, undergrounding electricity poles, controlled right hand turns at major intersections and widespread implementation of Emergency (Auto) Braking Technology.

We also have many fantastic organisations and special interest groups that are continually thinking strategically to decrease road fatalities and injuries.

Some strategies will be popular, some will not, but the community needs to have a greater buy-in regarding road safety. Our successes to-date have predominantly been on the enforcement side of things, but the future reduction in road fatalities will cost taxpayers money. The only way to achieve a buy-in is through public discussion driving public policy.

In the meantime, Governments need to continually alleviate known problems on existing roads, by funding programs such as the National Blackspot Programme, the Roads to Recovery Programme, along with the now weakened Financial Assistant Grants for councils and now the former Local Road Funding for South Australia that are and were vitally important to reaching our desired goal of safer roads.

The Decade of Action and the National Road Safety Strategy are ways that can bring these platforms to the forefront of debate and action.

Decade of Action Forum: Vote for road safety as a post-2015 priority

Above: Andrew McKellar, Executive Director, AAA

As part of a global 'Week of Action' for the UN's post-2015 public vote on future priorities, the Road Safety Fund co-organised a high level Forum to call for urgent action to save lives around the world. The Decade of Action Policy and Donor Forum, held in Melbourne, called for road safety to be included in the new 'post-2015' goals for global development currently being debated at the United Nations.

The goal of the UN's Decade of Action, launched in 2011, is to save five million lives and prevent fifty million serious injuries. But this objective will not be achieved unless funding, coordination and political support is increased significantly, the Forum heard.

The Forum was hosted by the RACV and co-organised by the AAA, the Commission for Global Road Safety, the Road Safety Fund and the FIA Foundation. The Forum brought together governments, NGOs and automobile clubs, and the private sector from across Australia and Asia/Pacific, as well as global institutions including the Asian Development Bank, World Bank, World Health Organization and UNESCAP. The event was part of a global 'Week of Action' to encourage participation in the UN's global 'My World' vote, which has already seen two million people cast votes for their priorities in the next global development goals.

Above: Saul Billingsley, Director General, FIA Foundation

In addition to the post-2015 agenda the Forum also focused on the need for new funding sources to support post-2015 implementation. The role of the private sector in supporting and funding global road safety was a main focus. A session brought together speakers and panellists from companies including WorleyParsons and Hyder Consulting to discuss their motivations for investing in road safety, both as an internal HSE issue and as a CSR or philanthropic mission. A panel of NGOs, including Save the Children, AIP Foundation, Global Road Safety Partnership and the International Road Assessment Programme, discussed effective methods for securing and retaining corporate support for road safety programmes. A side-meeting also reviewed the potential for social/development impact bonds to finance road safety improvements, particularly in the road infrastructure sector.

A high-level opening session heard from Josh Frydenberg MP, the Parliamentary Secretary to the Australian Prime Minister, on the importance of domestic and international road safety to the Australian Government. Professor Peter Choong, President of Australia's Orthopaedic Association, vividly described the human and economic costs of road traffic injuries, both in Australia and across the Asia/Pacific region. In a video message, Lord Robertson of Port Ellen, Chairman of the Commission for Global Road Safety, emphasised the urgency of persuading governments to support a road safety target in the post-2015 goals, a point endorsed by Brian Gibbons, Deputy President of the FIA, who described the campaigning of the FIA's auto clubs to promote the UN's 'My World' survey.

Movie actress and Global Road Safety Ambassador Michelle Yeoh was a keynote speaker at the Forum and was also in Melbourne to begin filming a new documentary on road safety. She told delegates about some of the road traffic victims she has met during her fact-finding missions in Asia.

"I've seen the parents anxiously tending to their son in an intensive care unit in Delhi, or sleeping in the hallway of a Hanoi hospital outside the trauma ward where their daughter lies injured. There is a universal language of pain and grief that follows in the wake of a road traffic crash, and these often very poor families have no one to speak up for them. But now we have an unprecedented chance to make their voices heard. By voting for 'better roads and transport' in the UN's global My World survey, we can ensure that road safety gets onto the radar of policymakers at the UN and around the world."

The Australian State of Victoria was recognised at the Forum for political commitment to road safety over many decades; an example that must be replicated elsewhere. HRH Prince Michael of Kent, cousin of HM The Queen and Patron of the Commission for Global Road Safety, presented his prestigious 'Decade of Action' Award to the State of Victoria in recognition of its achievements in road safety. Previous recipients of the Decade Award include former Mayor of New York Michael Bloomberg for his multi-million dollar philanthropic support for road safety.

Presenting the Decade Award to the State of Victoria, HRH Prince Michael said: "Victoria is a worthy winner of my 'Decade of Action' Award for 2014. The State is leading by example with an innovative approach which is saving lives. My Award also recognises the constant striving for further improvement that characterises the Victorian, and the Australian, approach to road safety.

"This bold vision must be replicated globally. Over the course of the next 18 months the international community will finalise the post-2015 sustainable development goals and begin designing means of implementation. We must all do what we can to ensure that road safety is an integral part of this process. This global epidemic of road traffic injuries requires urgent action."

Victoria serves as a global exemplar for road safety policy making: The Transport Accident Commission has pioneered an innovative financing model which accounts for the social, health and economic costs of road traffic injuries; VicRoads has conducted vital work in enhancing safe road infrastructure, exporting its expertise throughout the Asia Pacific region; Victoria Police has played an important role in effectively implementing and enforcing road safety initiatives across the state over many decades; and the Accident Research Centre at Monash University has made a major global contribution to the academic and practical development of the 'Safe Systems' approach. HRH Prince Michael also praised Australia for its global support for road safety, including contributing funding to the World Bank's Global Road Safety Facility and advocating at the UN for road safety to be part of the post-2015 agenda.

Mr Colin Jordan, Managing Director and CEO of RACV and member of the Commission for Global Road Safety opened the Forum, welcoming HRH Prince Michael of Kent and Michelle Yeoh to Melbourne. "I am pleased to welcome Prince Michael, Michelle Yeoh and the other international road safety campaigners and experts to Australia, and I am particularly proud that Victoria can showcase and share our successful campaigns to the world," he said.

Also recognised at the Forum, other leading organisations received Awards from HRH Prince Michael, they included: 'Stars on Cars', which was created in South Australia as an education programme on vehicle safety features when consumers consider a new car purchase and to increase awareness of the safety ratings published by the Australasian New Car Assessment Program (ANCAP); The Malaysian Institute of Road Safety Research (MIROS), which has helped create safer roads, vehicles and road users and reduced road deaths and injuries in Malaysia and other Southeast Asian nations; and the International Road Assessment Programme (iRAP) which has a vision of a world free of high risk roads. iRAP is a world leader working in over 70 countries to ensure safe road infrastructure. Vehicle safety was a major theme, with Global NCAP holding its annual meeting at the event, and a separate workshop on 'Fatality Free Roads' reviewing the future potential of road and vehicle active safety technologies and telematics to work together.

The Decade Forum follows the UN General Assembly's new Resolution passed in April 2014, which encourages Governments to consider the inclusion of road safety in the new global development goals. Australia was one of the Member States which co-sponsored the Resolution which underlines the call for increased global support for road safety. Over 1.2 million people lose their lives on the roads each year and tens of millions are injured with road crashes the number one killer of young people aged 15-29 worldwide. The UN resolution also encourages donors to consider supporting the Road Safety Fund, co-managed by the FIA Foundation and the World Health Organization.

For inclusion in the new Post-2015 Development Goals, the Commission has recommended a global fatality reduction target of 50% by 2030, as measured from the 2007-2010 baseline data provided by World Health Organization's Global Status Report on Road Safety 2013. This would be consistent with the current goal of the UN Decade of Action for Road Safety, to 'stabilise and then reduce' global road traffic fatalities by 2020.

The campaign is also encouraging people to vote for 'better roads and transport' at the UN's 'MY World' survey for the public globally to vote on their post-2015 priorities:

To vote at MY World visit http://walksafe.myworld2015.org

UN Global Road Safety Week: Focus on children and road safety

On 10 April 2014, the United Nations General Assembly (UNGA) issued a new resolution - "Improving global road safety". The UNGA requested the World Health Organization (WHO) and the United Nations regional commissions assist in organising the Third UN Global Road Safety Week in 2015.

WHO and the UN regional commissions are pleased to announce that the Week will be held 4 - 10 May 2015 and the theme will be children and road safety. The Week will draw attention to the urgent need to better protect children and generate action on the measures needed to do so.

The resolution also announced that the Government of Brazil will host the inter-Ministerial conference on road safety in late 2015 that will provide the mid-term monitoring point of the UN Decade of Action for Road Safety.

Left: Colin Jordan, Managing Director and CEO of RACV and member of the Commission for Global Road Safety opened the forum

Left: The Hon. Josh Frydenberg MP, Parliamentary Secretary to the Prime Minister, spoke at the event

Above: L to R Prince Michael of Kent, Deputy Premier of Victoria Peter Ryan MP and Global Road Safety Ambassador, Michelle Yeoh

College news

Head Office News

Chapter reports

ACT and Region Chapter

Annual General Meeting

The Chapter held its Annual General Meeting on 7 May 2014.

Executive Election

The four office bearers and the current members of the executive committee agreed to continue in their respective roles for 2014-15.

Executive:

Eric Chalmers
President and National Executive Representative

Keith Wheatley
Secretary

Steve Lake
Treasurer

Members:

Eddie Wheeler, Linda Cooke, Geoff Davidson, Claire Howe, Laurelle Tunks, Melissa Weller and Chris Lazzari.

Future Directions

It was agreed that the Chapter should aim to run two half day seminars in the next 12 months, with the option of presenting some short breakfast/lunchtime presentations. The Chapter will work to hold an annual local road safety forum; a one day seminar with presentations from all stakeholders on what road safety activities are taking place in the coming months/years. There was some discussion on potential topics ranging from motorcycling, truck safety, and child pedestrians, through to a "grant application" writing workshop.

In the second half of 2014 a seminar on vulnerable road users will be held and a presentation on motorcycling undertaken in conjunction with the Motorcycle Riders Association ACT.

Vulnerable Road Users Inquiry

The ACT Legislative Assembly Standing Committee on Planning, Environment and Territory and Municipal Services has completed its Inquiry into Vulnerable Road Users. The report may be viewed at http://www.parliament.act.gov.au/in-committees/standing_committees/Planning,-Environment-and-Territory-and-Municipal-Services/inquiry-into-vulnerable-road-users/reports?inquiry=450639

The Chapter will hold a seminar on this topic to enable the recommendations of the report to be discussed within the community.

Queensland Chapter

The Queensland Chapter held its December quarterly seminar and Chapter meeting on Tuesday, 3 December 2013. The seminar "*Bridging the gap between Systems thinking and the Safe Systems Approach: Research requirements for safer road systems*" was presented by Associate Professor Paul Salmon, University of Sunshine Coast. Paul is an Associate Professor in Human Factors and Ergonomics with over 12 years experience in applied Human Factors research across a range of safety critical domains, including road safety, defence, workplace safety, aviation, emergency management, rail transport and outdoor education.

Another quarterly seminar and Chapter meeting was held on Tuesday 4 March 2014. The seminar "*The need for a road safety target in the new Millennium Development Goals*" was presented by Mr Rob McInerney, CEO, iRAP. Rob McInerney is the Chief Executive Officer for the international Road Assessment Programme (iRAP), a registered charity with the vision for a world free of high-risk roads.

The Queensland Chapter AGM was held on 12 May 2014. The Executive for the Queensland Chapter duly elected at the AGM were: Chair – Dr Kerry Armstrong; Deputy Chair Dr Mark King; Secretary/Treasurer Ms Veronica Baldwin; Committee members – Ms Lisa-Marie O'Donnell (QPS); Ms Nerida Leal (DTMR); Mr Joel Tucker (RACQ); Professor Barry Watson; Dr James Freeman; and Dr Ioni Lewis (CARRS-Q).

The quarterly seminar and Chapter meeting was held on Tuesday 3 June 2014. The seminar "*Understanding aggressive driving on our roads: where are we and where to next?*" was presented by Dr Alexia Lennon, Senior Lecturer, CARRS-Q. Dr Alexia Lennon joined CARRS-Q in 2004 and is currently Senior Lecturer and Course Coordinator of the Graduate Certificate and Graduate Diploma in road safety. Since becoming an academic, Alexia has developed several areas of research interest including vulnerable road users, in particular child passengers and older pedestrians, speeding, and aggressive driving.

Other news

2014 National Trucking Industry Award winners

Outstanding Contribution to the Australian Trucking Industry

Award sponsors: BP Australia, NTI and Volvo Trucks

David Simon, Simon National Carriers, Toowoomba, QLD

David Simon began loading and unloading trucks for his family's company, Simon National Carriers, in 1984 before succeeding his father as the Managing Director in 1988. He has been a director of the Queensland Trucking Association since 2002 and joined the board of the Australian Trucking Association in 2003. David has just stepped down following his second term as Chairman of the ATA, where he represented the industry through his positions on the NHVR project implementation board, the HVCI reform board, and as an observer to the Standing Council on Transport and Infrastructure. In early 2013, David delivered a televised address at the National Press Club where he discussed the state of the industry and how governments can improve road funding and planning.

National Professional Driver of the Year

Award sponsors: BP Australia, NTI and Volvo Trucks

Tom Scotney, Hardy's Haulage, Warwick, QLD

With just two employers during his 33 years of truck driving, Tom has shown enormous commitment to the road transport industry. He is often seen assisting other road users and younger drivers in the industry. His work ethic is beyond reproach, and he makes a point of being impeccably attired every day. In the last 10 years, Tom has travelled more than 6.3 million kilometres without receiving a fine. He is not afraid to stop other people if he sees them doing a job in an unsafe manner and encourages those around him to adopt safer practices. Tom was recognised as the 2013 NatRoad Professional Driver of the Year.

Trucking Industry Woman of the Year

Award sponsor: Cummins South Pacific

Lynne Jack, Griffin Motors, Newcastle, NSW

Lynne first entered the trucking industry working for her father's Volvo dealership in administration and the spare parts department. She took over the running of the business in 1984 and was elected as a member of the Volvo Dealer Council six years later. A founding member of the Newcastle and Hunter Road Transport Awareness Day, Lynne has assisted in raising more than $1.4 million for charity through this yearly event. Lynne also assists at the Hunter TAFE to provide heavy vehicle and plant apprentices with hands-on experience and access to mentors within the industry.

TruckSafe John Kelly Memorial Award to recognise excellence in the TruckSafe program

Award sponsor: Austbrokers AEI Transport Insurance Brokers

Directhaul, Berrimah, NT

Starting as a single tanker operation out of Katherine in the early 80s, today Directhaul specialises in bulk fuel and oil deliveries across remote locations across central and north Australia, as well as parts of Queensland, Western Australia and South Australia. TruckSafe accredited since 1998, Directhaul operates a fleet of more than 90 road-train rated prime movers and 290 trailers and dollies, with an average prime mover age of 3 years. Directhaul's highest priority is providing its customers with exceptional service in the safest manner possible.

National Training Excellence Award

Award sponsor: Driver Education Centre of Australia (DECA)

Toll Mining Services, Newburn, WA

During a safety review in December 2012, the Toll Mining Services management team concluded that providing rollover training to drivers was just an administrative control – the lowest level on the risk control hierarchy. This conclusion led to the decision to introduce engineering controls including a comprehensive rollout of ABS, EBS, mobile tracking data and driver state sensor technologies throughout the fleet, as well as speed limiting all units to 90km/h. Drivers were provided with extensive training on the new equipment, with all fuel drivers also receiving defensive driving training. Toll Mining Services expects to complete the rollout across all its sites within the next year.

Don Watson Memorial Award for conspicuous achievement in furthering the industry's objectives

Tim Wedlock, Austbrokers AEI Transport Insurance Brokers, Gordon, NSW

As the Managing Director of AEI Transport Insurance Brokers, Tim Wedlock has spent 27 years of experience providing insurance broking services to the transport and logistics industry. He is a strong supporter of the industry and advocates improving industry safety through risk management procedures, particularly the TruckSafe accreditation program. AEI Transport Insurance Brokers have sponsored the TruckSafe John Kelly Memorial Award since its inception in 2011.

2014 award winners: L-R Brian 'spud' Murphy, Tom Scotney, Tim Wedlock, Lynne Jack, Geoff Massey and David Simon

Book Review

Eliminating serious injury and death from road transport: a crisis of complacency

Published: December 11, 2013 by CRC Press
Content: 199 Pages | 24 Illustrations

Author(s): Ian Ronald Johnston, Carlyn Muir, Eric William Howard

This new book explores why societies and their elected leaders view road safety as a relatively (minor) problem. It examines the changes in the culture of road use that need to occur if this public health problem is to be effectively resolved.

Over the last 40 years there has been a reduction in the deaths and injury rates in Australia such that it is reasonable to say that over 100,000 lives have been saved had we not made a lot of changes to the way we drive, the cars we drive and the roads we drive on. Regrettably we have slipped from being in the best of the top ten in the world to the lower end of the top twenty when it comes to road trauma rates. A total of 33,900 people die or are seriously injured on Australian roads every year.

Major General Michael Jeffery AC CVO MC, as Governor General, speaking about road safety in 2006 said; “Take the mortality rate alone - if a similar statistic applied to Australians in battle, the public outcry would galvanise the country into action.”

Professor Ian Johnston, the lead author of the book, was awarded a Medal of the Order of Australia in 2007 for service to the transport industry, particularly the promotion of road safety through the Monash University Accident Research Centre, to maritime safety, and to a range of professional industry organisations. His co-authors Dr Carlyn Muir and Eric Howard have complementary experience in road safety governance and management.

They make the point that we focus too often on specific illegal behaviours like drink driving and speed, spending time blaming the victim, while we forget that most crashes, particularly non-fatal crashes are not caused by deliberate wrong doing. They say; “Rather, they (crashes) are far more commonly the result of a simple mistake, a lapse in attention or an error of judgement made by an imperfect human being.”

They have written the book not (so much) for the traffic safety professional but primarily for the intelligent layman - for that surprisingly large proportion of the population who have been ‘touched by the road toll’, for road crash victim support groups, and for media editors and transport and public health reporters, for politicians, for senior staff in traffic safety agencies and for road, traffic, and vehicle engineers.

"These are the many groups of people who need to understand why complacency rules, why a constituency for a truly safe road transport system needs to arise, why it should be embraced, and why they should become leaders in its development."

There is discussion on the changing role of the car and road transport in modern society, why communities think about traffic safety in the way that they do and includes case studies from the media, from advertising and from traffic safety public policy failures to illustrate the conclusions around the context in which public policy is set.

While writing for the layman there is ample scientific background with good recognition of the social and political issues and the potential to build a better case for action using public health examples.

Road safety is something of a dry subject but the book attempts to dispel many of the myths that currently drive societies' (misguided) view of traffic safety - the bad behaviour myth and the official myth that everything that can be done is being done - and how these myths limit progress in reducing death and serious injury.

Using supporting personal stories, in considerable detail, the dry engineering/political impacts are brought to the reader to build a compelling case for change.

There is hope and a plan. The authors suggest moving away from a focus on the three E's (Engineering, Enforcement, and Education) to the Six C's:

1. Constituency - Governments, lobby groups, champions, professional and community bodies
2. Committed leadership - Political and professional leaders, Professional scientific messages
3. Climate of safety - Developing a cooperative duty of care as in the workplace
4. Capacity building - Develop recognition of a safe system approach throughout all aspects of the planning, design, and operation of the transport system
5. Cooperation and coordination - effective management across the disparate agencies whose policies and practice influence on safety outcomes cannot be overemphasised; and
6. Courageous patience - too many die and are injured unnecessarily on our roads. We accept as a society that no one should die in workplaces, on trains or in planes. We need a similar community view that we can design, build and operate a road traffic system where people do not die or are injured. Automation and technology to help is emerging rapidly.

This book, a must read for the newly formed Friends of Road Safety Group in the Federal Parliament and many others, contributes well to a conversation and action plan happening around the world in this decade. The United Nations' Decade of Action for Road Safety 2011-2020, aims to reduce road deaths and injuries across the world.

Review by

Lauchlan McIntosh AM FACRS
President, Australasian College of Road Safety

3M-ACRS Diamond Road Safety Award

Applications are being called for the 2014 3M-ACRS Diamond Road Safety Award.

The 3M-ACRS Diamond Road Safety award calls for any road safety practitioner from the public or private sectors to submit highly innovative, cost-effective road safety initiatives/programmes which they have recently developed that stand out from standard, everyday practice and deliver significant improvements in road safety for the community.

An individual team leader from the winning project will receive a trip to the USA to attend the 45th ATSSA Annual Convention and Traffic Expo in 2015 at Tampa and to 3M Global Headquarters in Minnesota USA. This individual will also present on their winning entry and international trip at the following ACRS Road Safety Conference in 2015.

The winning entry will be announced in the latter part of 2014, when all eligible members of the winning project will be presented with the 3M-ACRS Diamond Road Safety Award.

For further information go to: http://acrs.org.au/awards/

Peer-reviewed papers

Measuring non-fatal road trauma: using police-reported and hospital admission-based data to monitor trends and inform policy

by Rebecca J Mitchell[1], Mike R Bambach[1], Raphael H Grzebieta[1] and Ann M Williamson[1]

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Abstract

Road trauma identified using hospital admission records or police-reported crashes are susceptible to changes in policy and resourcing. This research compares temporal trends in police, hospital and linked police-hospital records for non-fatal road trauma for road users by injury severity during 2001 to 2009 in New South Wales, Australia. Hospital records showed significantly increasing injury trends for motorcyclists and pedal cyclists (6.3% and 5.5%) and significantly decreasing trends for motor vehicle occupants and pedestrians (1.7% and 2.2%) per year whereas, for police-reported crashes, there were significant decreases for pedal cycle, motor vehicle and pedestrian casualties (1.5%, 3.8% and 5.2%), and a significant increase for motorcyclists (1.8%) per year. Differences in the annual percent change over time between hospital and police-reported crashes are evident which may influence policymaking. Policy makers should endeavour to review road casualty trends from a range of data collections to inform policy development regarding road safety.

Keywords

Road trauma, Data linkage, Policy, Injury severity, Police data, Hospital data

Introduction

Police reports of road traffic crashes are commonly used to measure performance in reducing road trauma-related mortality and morbidity in many countries, including Australia [1-4]. While reducing the number of fatalities on the road has been a focus in Australia, policy initiatives are also aiming to reduce the incidence of serious injuries following road trauma [5]. To be able to monitor trends of serious injury over time, mechanisms to monitor the incidence of serious injury are required. Previous research has shown that only monitoring police-reported road crashes can under-enumerate the number of road crashes [2, 6-8], particularly for certain crash types, such as vehicle-cyclist collisions [9]. In addition, when attempting to identify individuals who have been seriously injured in a road traffic crash, police have been found to misclassify injury severity [1, 7, 10].

Other data collections, such as hospital admission or trauma registries, can provide information on injuries following road traffic crashes [2, 4, 11], including information on those crashes that are not captured by police, but these data collections contain little to no detail regarding the crash circumstance. Injury severity estimates can be calculated from hospital administrative data collections [12, 13], negating the need to solely rely on police-identified injury severity estimates.

In addition to monitoring temporal trends in road trauma, information on the number, incidence and circumstances of road traffic crashes are used by policy makers to determine the magnitude of road trauma, to identify the causal and contributory factors involved in road crashes, and to identify priorities for road safety. This information is also used in the evaluation of countermeasures and to inform the development of road safety policy [14].

Policy makers need to be aware of changing trends in the incidence of non-fatal road trauma to assist in guiding policy development aimed at reducing road traffic-related injury morbidity. Whether similar temporal trends in non-fatal road trauma are able to be derived using data from different data collections collecting information on road trauma and commonly applied road-related denominator data for each road user or for different levels of injury severity is yet to be examined in New South Wales (NSW). This research aims to examine the use of police-reported, hospital admission, and linked police-hospital admission records to report on non-fatal road trauma for road users by injury severity to inform policy.

Method

A retrospective analysis of road trauma-related injuries identified in police-reported, hospital admission and linked police-hospital admission records during 1 January 2000 to 31 December 2009 was conducted. Ethics approval was obtained from the NSW Population and Health Services Research Ethics Committee (2010/10/273) and was ratified by the University of NSW Human Research Ethics Committee (HREC 11125).

Data collections

The Admitted Patient Data Collection (APDC) includes information on all inpatient admissions from all public and private hospitals, private hospital day procedures and public psychiatric hospitals in NSW. The APDC contains information on patient demographics, source of referral, diagnoses, external cause(s), hospital separation type (e.g. discharge, death) and clinical procedures. Diagnoses and external cause codes are classified using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM) [15]. Any APDC records with the separation coded as death (i.e. died in hospital) were excluded. Road trauma on public roadways were identified using the ICD-10-AM principal external cause code for each road user category: pedestrian (ICD-10-AM: V01-V06, V09), pedal cyclist (ICD-10-AM: V10-V18, V19), motorcyclist (ICD-10-AM: V20-V28, V29) and motor vehicle occupant (ICD-10-AM: V30-V38, V40-V48, V50-V58, V60-V68, V70-V78, V39, V49, V59, V69, V79, V86) and a ICD-10-AM 4th character identification of 'traffic' for each road user (i.e. occurred on a public roadway). There were 91,952 individuals who sustained an injury during a traffic crash in the hospital admission data collection.

The CrashLink data collection contains information on all police-reported road traffic crashes where a person was unintentionally fatally or non-fatally injured, or at least one motor vehicle was towed away and the incident occurred on a public road in NSW. Information pertaining to the crash and conditions at the incident site; the traffic unit or vehicle; and the vehicle controller and any casualties resulting from the crash; are recorded. Each individual is identified as being non-injured, injured or killed (died within 30 days). No information on injury severity is available. Individuals who were non-injured or killed were excluded. Road users were identified using the traffic unit group (i.e. pedestrian, pedal cyclist, motorcyclist or motor vehicle occupant). There were 236,538 individuals who sustained an injury during a traffic crash in the police-reported data.

Data linkage

The APDC was linked to the police-reported crashes in CrashLink by the Centre for Health Record Linkage (CHeReL). The CHeReL uses identifying information (e.g. name, address, date of birth, gender) to create a person project number (PPN), for each unique person identified in the linkage process. The record linkage used probabilistic methods and was conducted using *ChoiceMaker* software [16]. A successful link was defined as when the PPN matched in both data collections, and the admission date in the APDC was on the same day or the next day as the crash date in CrashLink. Upper and lower probability cut-offs started at 0.75 and 0.25 for a linkage and were adjusted for each individual linkage to ensure false links are kept to a minimum. Record groups with probabilities in between the cut-offs were subject to clerical review. There were 51,737 individuals who were included in both the police and hospital admission data collections. The overall linkage rate for road trauma recorded by the police to road traffic-related hospital admissions (i.e. the linkage of APDC records to CrashLink) was 56.3%.

Injury severity

Injury severity was calculated directly from the ICD-10-AM injury diagnosis codes, using the probability of survival for each individual code, termed a Survival Risk Ratio (SRR). The SRR for an ICD code is the proportion of survivors among all cases with that ICD-coded injury. The procedure has been compared with the Abbreviated Injury Scale (AIS) and has proved equivalent or superior in assessing mortality risk [12, 17, 18]. In a separate study using the APDC for all land transport trauma, the hospital records for 109,843 individuals were used to generate SRRs for all ICD-10 injury codes during 2001 to 2007 [13]. These data represent a census of all land transport trauma in NSW during the period, and for each ICD injury (ICDi) the SRR was calculated from Equation 1.

$$SRR_{ICD_i} = \frac{Number\ of\ individuals\ with\ injury\ ICD_i\ that\ survived}{Total\ number\ of\ individuals\ with\ injury\ ICD_i} \quad (1)$$

There is no specific measure against which different severity levels in the International Classification of Disease Injury Severity Score (ICISS) may be compared. Dayal et al [19] have suggested ICISS levels to define minor, moderate and serious injury. A similar approach was adopted for this study, with four levels of injury severity identified (i.e. minor, moderate, serious, and severe) (Table 1).

Table 1: Injury severity levels used for the International Classification of Disease Injury Severity Score (ICISS)

Injury severity	ICISS range	% of records in APDC[1]	Examples of common injuries in range
Minor	1.0 – 0.993	20.4	External abrasions, contusions, lacerations
Moderate	0.992 – 0.966	45.5	Fracture of minor bones, dislocations, minor organ contusions
Serious	0.965 – 0.855	27.3	Fracture of major bones/ribs, organ lacerations, spine fractures
Severe	0.854 – 0.0	6.9	Major organ/vessel damage, major brain/spinal cord damage

[1]Admitted Patient Data Collection.

Data management and analysis

All analyses were performed using SAS version 9.2 [20]. The three non-fatal injury data collections (i.e. hospital, linked police-hospital and police) were disaggregated by injury severity, road user type and year of crash to analyse temporal trends in road traffic crashes. Three commonly used denominators were used to calculate incidence rates by per 100,000 population per year; by per 10,000 vehicle registrations per year; and by per 10,000 licence holders per year. The total population, number of registered vehicles and number of driver licences are provided in Table 2.

Annual population numbers for NSW were derived from the Australian Bureau of Statistics (ABS) annual Australian demographic statistics [21]. Direct standardisation was used to age-standardise population rates, using the Australian population in 2001 as the standard population [22]. Ninety-five percent confidence intervals (95%CI) were calculated assuming a Poisson distribution [23]. The number of registered vehicles and licence holders were derived from the Transport for NSW annual statistical reports [24]. Trends in incidence rates were indexed to the year 2001 by dividing the rate in each year by the 2001 rate, in order to generate plots of trends over time. Because of over-dispersion, negative binomial regression was used to examine the statistical significance of changes in the trend over time of the annual rates of road crash casualties, road crash casualties by injury severity, and road crash casualties by type of road user [25].

Table 2: Number of records in the police and hospital linked data and number of vehicle registrations, licences and population in NSW by year, 2001-2009

	Hospital data	Linked police and hospital data	Police reported data	Vehicle registrations		Licences		Population
				Motor vehicles	Motor cycles	Motor vehicles	Motor cycles	
Year	n	n	n	n	n	n	n	n
2001	9,068	5,352	29,913	3,647,300	90,000	3,761,324	395,493	6,605,719
2002	9,144	5,302	28,447	3,734,300	94,400	3,837,582	404,924	6,651,745
2003	9,208	5,478	27,208	3,838,900	99,300	3,917,080	400,370	6,689,526
2004	9,269	5,379	26,323	3,949,256	105,289	3,939,409	405,661	6,730,149
2005	9,557	5,696	25,209	4,012,351	111,253	3,983,326	413,667	6,783,912
2006	10,293	5,944	25,439	4,097,516	120,827	4,048,742	425,441	6,856,782
2007	9,726	5,456	25,845	4,177,115	133,512	4,137,742	438,846	6,958,448
2008	9,451	5,236	24,048	4,273,025	146,583	4,181,259	460,997	7,059,690
2009	9,540	5,155	24,106	4,354,278	162,076	4,240,536	480,503	7,126,947

Sources for denominator data: Australian Bureau of Statistics, 2009. Australian demographic statistics, Sept 2009. Catalogue no 3101.0. ABS, Canberra and NSW Centre for Road Safety, 2010. Road traffic crashes in New South Wales: Statistical statement for the year ended 31 December 2009. Roads and Traffic Authority, Sydney.

Results

Overall, the largest declining rate trend for road crash casualties during 2001 to 2009 was shown per 10,000 vehicle registrations using the police-reported data, with the trend estimated to decrease significantly by 4.7% per year (p<0.0001; 95%CI for the decrease 4.1% to 5.4%). This compares to a decrease of 4.0% per year (p<0.0001; 95%CI for the decrease 3.4% to 4.5%) using per 10,000 licences as the denominator and a decline of 3.4% per year (p<0.0001; 95%CI for the decrease 2.9% to 3.9%) using per 100,000 population denominator. Hospital admissions data did not show the same rate of decline for road casualties per 100,000 population as shown in police-reported data, with an estimated 0.1% decrease in admissions (p=0.7; 95%CI for the decrease -0.4% to 0.6%). The linked police-hospital data also showed a declining trend, but the decrease was not as high as police-reported data, with an estimated decrease of 0.9% per year (p<0.0001; 95%CI for the decrease 0.5% to 1.3%) (Figure 1).

For road trauma-related hospital admissions in the APDC, rates of moderate and serious injury per 100,000 population increased from 2001 to a peak in 2006, after which they declined, resulting in an estimated 0.9% increase per year for serious injury (p=0.007; 95%CI for the increase 0.2% to 1.5%) and an estimated annual decrease of 0.3% for moderate injury (p=2.61). Compared to 2001 levels, the serious injury rates in the linked police-hospital data were similar to those in the hospitalisation data (estimated 0.7% increase per year, p=0.041; 95%CI for the increase 0.03% to 1.3%). However, the rates for severe injury were slightly higher in the linked police-hospital data than in the hospitalisation data alone, for moderate injury slightly lower, and for minor injury substantially lower (Figure 2).

The trends in road crash casualty rates for each road user type varied per 100,000 population. Motorcycle and pedal cycle casualty rates calculated using the hospitalisation data increased by 6.3% per year (p<0.0001; 95%CI for the increase 5.5% to 7.0%) and 5.5% per year (p<0.0001; 95%CI for the increase 4.3% to 6.7%), respectively. Motor vehicle and pedestrian rates decreased by 1.7% per year (p<0.0001; 95%CI for the decrease 1.3% to 2. 1%) and 2.2% per year (p<0.0001; 95%CI for the decrease 1.6% to 2.8%), respectively. The trends were similar for road casualty rates using the linked police-hospital data for all road user classes except pedal cyclists. The rate trends were different for casualties using police-reported data, which indicated decreases in pedal cycle (estimated decrease of 1.5% per year, p=0.014; 95%CI for the decrease 0.3% to 2.6%), motor vehicle (estimated decrease of 3.8% per year, p<0.0001; 95%CI for the decrease 3.3% to 4.4%) and pedestrian casualty rates (estimated decrease of 5.2% per year, p<0.0001; 95%CI for the decrease 4.6% to 5.9%) and an overall increase of 1.8% per year (p=0.005; 95%CI for the increase 0.6% to 3.1 %) in motorcycle casualty rates (Figure 3).

Discussion

Despite advances, road trauma accounts for an estimated 1.3 million deaths annually worldwide and is projected to become the third leading cause of the burden of disease by 2030 [26]. In Australia, although the road toll has been decreasing, the burden of road trauma remains significant at around 1,400 deaths and 32,500 serious injuries each year [27]. In Australia, the economic cost of road trauma has been estimated at AUD$27 billion [28]. In order to identify where gains can be made to reduce this cost by reducing the rate of road casualties, information on road casualty trends over time are required. Overall, a declining trend in road casualties was found in NSW, with the strength of the decline varying, depending on which data collection was used to estimate the incidence rate. While three different denominator data were used to examine casualty trends over time, there were no substantial differences in overall road trauma trends using each of these denominators. These similar trends provide impetus that the denominators selected are able to provide a consistent reflection of road casualty trends in NSW to inform policy decision making.

This study identified that incidence rates calculated using police-reported data showed a substantially greater declining trend compared to rates calculated using the hospitalisation data and the linked police-hospital data. Based on an examination of the non-linked records between the police and hospitalisation data, it appears that 75% of police-reported data consisted of individuals with only minor injuries (i.e. individuals identified as being injured by police who were not admitted to hospital). It appears that the larger declining trend in police-reported casualty rates over the study period compared to the hospitalisation data might result from either a real decline in the number of casualties with minor injuries, and/or a reduction in reporting to police and/or police attendance at crash scenes, and/or a reduction in the identification of 'injured' individuals by police. Unfortunately, the relative contribution of these effects could not be ascertained. However, it is clear that 'minor injury', represented by the majority of the police-reported records, appears to be influenced by temporal changes unrelated to experience of road trauma. Similarly, in New Zealand [4] temporal trends (1988–2001) in police-reported traffic crashes, where 80% of casualties were estimated to have minor injuries, indicated substantially greater declines than found when hospitalisation data was examined. Implications for policy makers are that minor injury following road trauma appears to be influenced by artefact and temporal trends of minor road trauma and may not reflect actual incidence of minor injury.

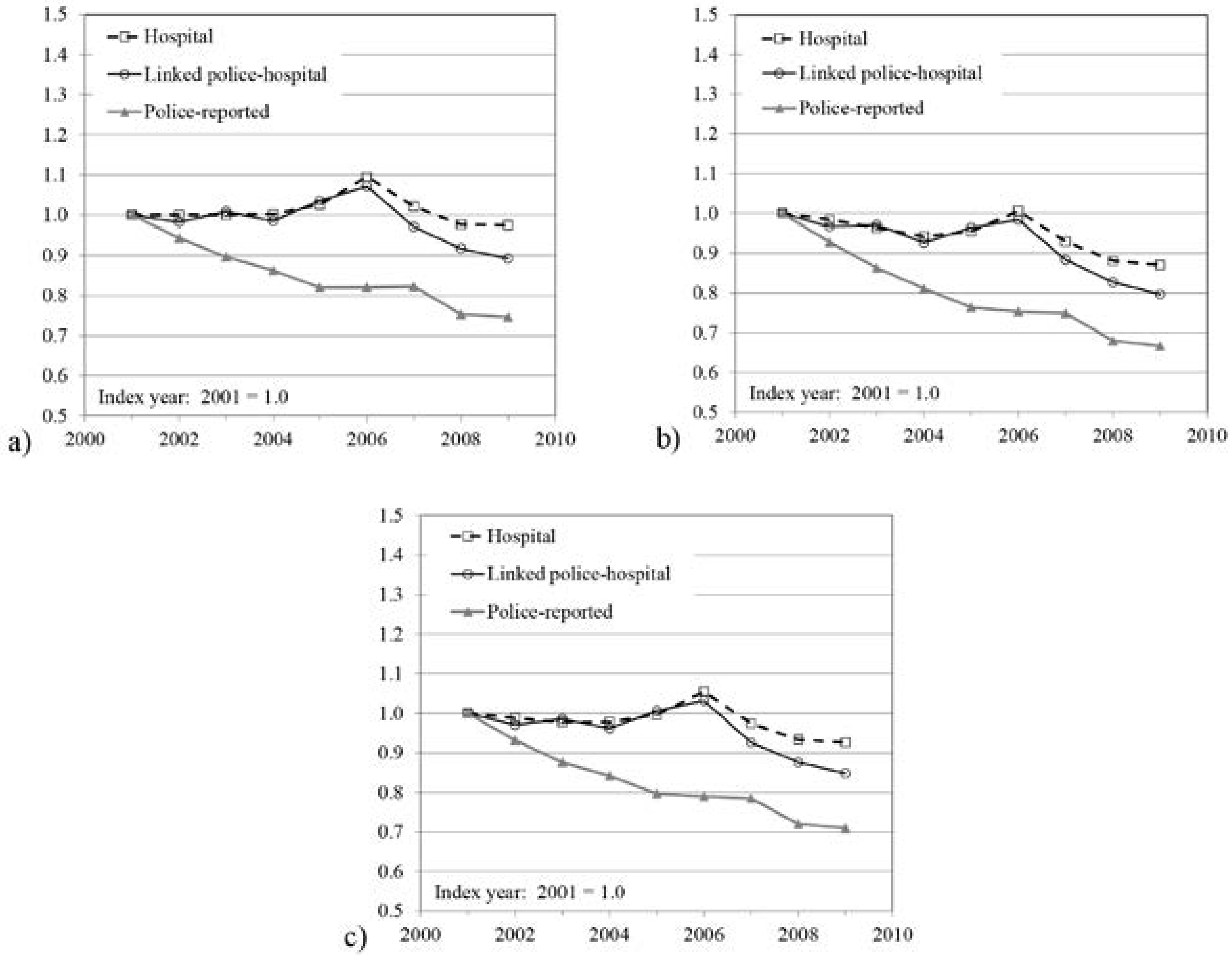

Figure 1: Trends in rates of road crash casualties in the hospitalisation, police-reported and linked police-hospital data collections; a) per age-adjusted 100,000 population, b) per 10,000 registrations, c) per 10,000 licences

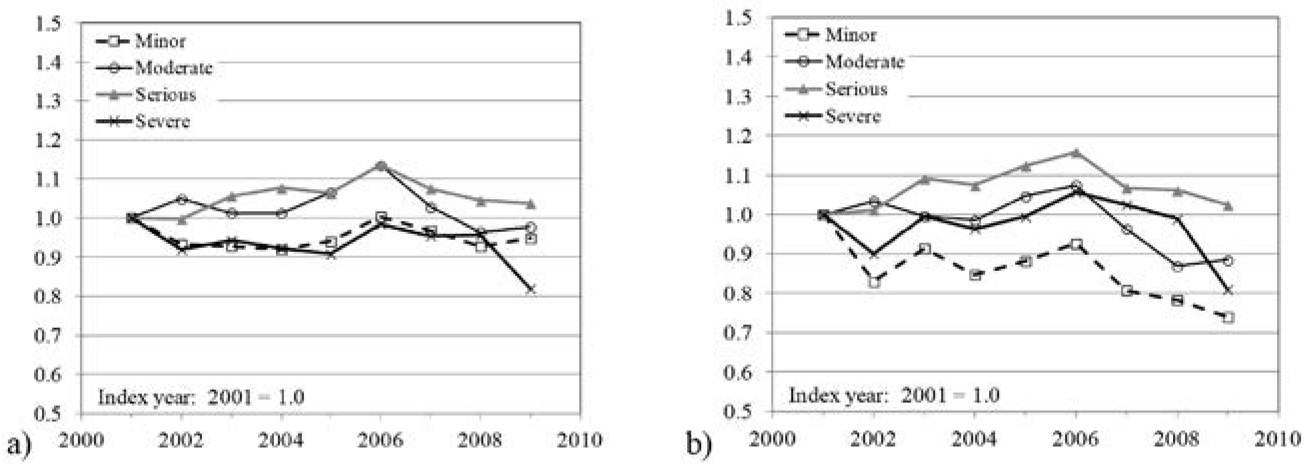

Figure 2: Trends in rates of road crash casualties per age-adjusted 100,000 population by injury severity, in the data collections; a) hospitalisation, b) linked police-hospital data

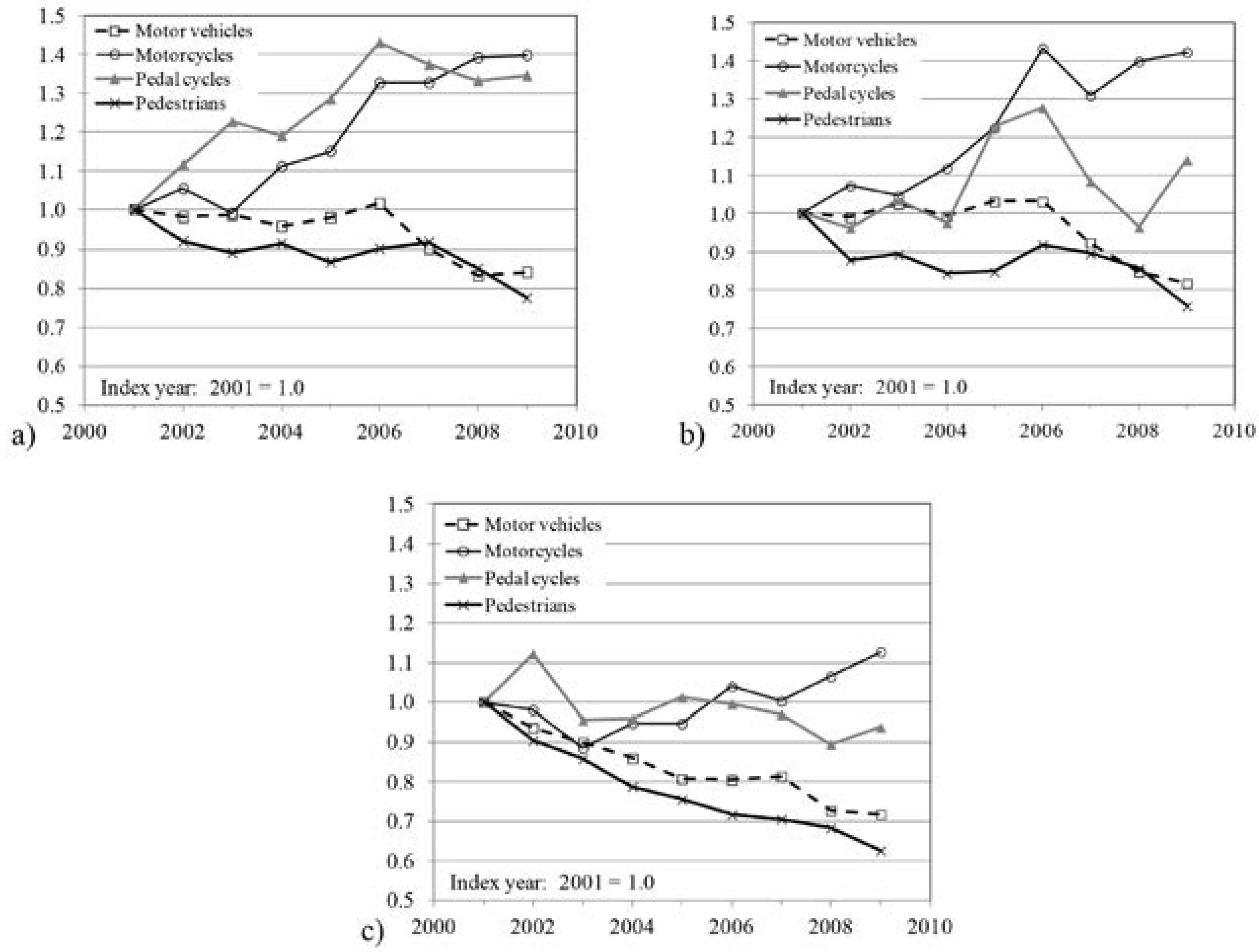

Figure 3: Trends in rates of road crash casualties per age-adjusted 100,000 population by road user class, in the data collections; a) hospitalisation, b) linked police-hospital data, c) police-reported data

It is difficult to explain with certainty the reason for the increase in the road casualty trend in 2006 and what this implies for the evaluation of the impact of road safety policy. This increase could be due to a real increase in road trauma and/or to changes in hospital admission policy or service delivery. It is likely that if there were changes in hospital admission policy there would be a decrease in minor injury admissions, with serious injuries remaining constant as these injuries would be likely to be admitted to hospital regardless of admission policies. However, this was not evident, as there was an increase in road casualties for every severity level and road user type. In addition, the 2006 peak for road casualties was also evident in other Australian states [27]. Therefore, the peak does not appear to be an artefact of the current analysis, but a real increase in casualties in that year.

The examination of trends over time by injury severity using the hospitalisation data and linked police-hospital data were similar, except for minor and, to some extent, moderate injury trends. As 66% of the hospitalisation data consisted of individuals with minor or moderate injury, it is likely that the divergence between the hospitalisation data and the linked police-hospital data trends result from the difference in the incidence of these injuries in each data collection. The decrease in minor injury in the linked police-hospitalisation data could be due to a decreasing tendency of reporting to police and/or police attendance at minor injury crashes, or an increasing tendency of hospitals to admit casualties with minor injuries. The relative contribution of these effects could not be ascertained with certainty. However, the impact of each of these conditions would have a different impact on policy making, for example if there was a decline in individuals reporting crashes or in police attending crashes, this would have implications for police-community liaison and police resourcing, respectively.

The examination of road casualties by type of road user found increasing casualty trends for pedal cyclists and motorcyclists and decreasing trends for motor vehicle occupants and pedestrians in the hospitalisation data.

Casualty trends in the linked police-hospital data were fairly similar to those identified using the hospitalisation data, except for pedal cyclists. However, using only police-reported data found decreasing casualty trends for pedal cyclists, motor vehicle occupants and pedestrians and an increasing trend for motor cyclists. Casualty trends for pedal cyclists appear to be the principal difference for road user types for all three numerator data collections. Pedal cyclists are known to be under-enumerated in police-reported crash data [9, 29, 30] and this appears to account for the diverging trends.

That only 56.3% of hospitalised road trauma on public roadways linked to police-reported crashes is of concern. Other research involving linkage between police-reported and hospitalised road trauma has found similar linkage rates [31-33]. In NSW, it appears that 43.7% of road trauma that involved individuals hospitalised was not reported to and/or recorded by police as a crash that involved an individual being injured. Reasons for non-identification by police of some road trauma involving hospitalisation are not clear, but could involve individuals not reporting a crash to police, or police not identifying individuals involved in a crash as injured, or police not attending crash scenes. It is also possible that some police records were not able to be successfully linked to hospitalisation records, due to absent or inaccurate information used for data linkage.

Policy makers need to be aware of the limitations of different data sources used to examine and report on road safety trends, particularly police-reported data sources and their under-enumeration of pedal cycle crashes. For policy makers, it is likely that hospitalisation data would be most useful to identify and examine serious injury trends (however no detailed information is available regarding the crash circumstances in these records), whereas police-reported crashes could be used as an overall estimate of the extent of road trauma (but no information is available on the injuries or treatment received). However, when estimating road trauma trends over time using police-reported crashes, it appears that a multiplying factor of at least 40% should be added to existing road trauma estimates to allow for under-enumeration of road trauma by police, particularly of the crashes that involve hospitalisation.

There are several limitations of the current study. The ICISS relies on the correct diagnosis and classification of injuries in the hospitalisation data, and validation of diagnosis coding was not conducted as part of this study. However, other research has identified that audits of diagnosis coding in hospitalisation data is of good to excellent quality [34]. The three denominator data commonly used in NSW, and used in this study may underestimate risk of a vehicle crash as they do not take into account the number of hours spent driving, the number of kilometres travelled, nor the number of individuals travelling in a vehicle. In fact not having ‘true’ exposure data for each type of road user, either the person-time risk (e.g. time spent cycling) or population at-risk (e.g. number of cyclists), is likely to underestimate the risk of injury over time. The lack of appropriate and reliable denominator data is a problem for calculating ‘true’ injury temporal trends. This is also an issue if trends between road users’ injuries are to be examined as the amount of time exposed on a roadway between road users will also differ. When using record linkage there is likely to be some degree of error in the data linkage process. In the current study, the CHeReL estimates the false positive rate for this linkage to be 0.4% (i.e. the proportion of false matches) and estimates the rate of false negatives at 0.5% (i.e. failure to identify matches).

Conclusions

It appears that the trends in road trauma casualty rates are influenced by a range of factors other than the incidence of injury, particularly minor and moderate injuries. Interpretation of non-fatal road casualty trends is likely to be influenced by the numerator data selected for review. Policy makers should endeavour to review road casualty trends from a range of data collections to inform policy development regarding road safety. This will ensure that any artefacts that might be present in one data collection, or if there are divergent trends for different types of road users between collections, will be able to be taken into account.

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References

1. Amoros, E., Martin, J., Chiron, M., and Laumon, B., Road crash casualties: characteristics of police injury severity misclassification. The Journal of Trauma, 2007. 62(2): p. 482-490.
2. Lyons, R.A., Ward, H., Brunt, H., Macey, S., Thoreau, R., Bodger, O., and Woodford, M., Using multiple datasets to understand trends in serious road traffic casualties. Accident Analysis & Prevention, 2008. 40(4): p. 1406-1410.
3. Department of Infrastructure and Transport, Road deaths Australia May 2012. 2012, Commonwealthh of Australia: Canberra.
4. Langley, J., Stephenson, S., and Cryer, C., Measuring road traffic safety performance: monitoring trends in nonfatal injury. Traffic Injury Prevention, 2003. 4: p. 291-296.
5. Transport for NSW, NSW Road Safety Strategy 2012-2021. 2012, Transport for NSW: Sydney.

6. Wilson, S., Begg, D., and Samaranayaka, A., Validity of using linked hospital and police traffic crash records to analyse motorcycle injury crash characteristics. Accident Analysis & Prevention, 2012. 49: p. 30-35.
7. Cryer, C., Westrup, S., Cook, A., Ashwell, V., Bridger, P., and Clarke, C., Investigation of bias after data linkage of hospital admissions data to police road traffic crash reports. Injury Prevention, 2001. 7: p. 234-241.
8. Moudon, A., Lin, L., Jiao, J., Hurvitz, P., and Reeves, P., The risk of pedestrian injury and fatality in collisions with motor vehicles, a social ecological study of state routes and city streets in King County, Washington. Accident Analysis & Prevention, 2011. 43: p. 11-24.
9. Langley, J., Dow, N., Stephenson, S., and Kypri, K., Missing cyclists. Injury Prevention, 2003. 9(4): p. 376-379.
10. UK Department for Transport, Linking police and hospital data on road accidents in England: 1999 to 2009 results. 2011, UK Department for Transport,: London.
11. Mitchell, R., Williamson, A., and Curtis, K., What is the potential of trauma registry data to be used for road traffic injury surveillance and informing road safety policy? Journal of Safety Research, 2011. 42: p. 345-350.
12. Stephenson, S., Henley, G., Harrison, J., and Langley, J., Diagnosis based injury severity scaling: investigation of a method using Australian and New Zealand hospitalisations. Injury Prevention, 2004. 10: p. 379-383.
13. Bambach, M., Mitchell, R., Grzebieta, R., Williamson, A., and Watson, W., Injury severity indicators and their impact on data linkage. 2012, Transport and Road Safety (TARS) Research, University of New South Wales: Kensington.
14. Horan, J.M. and Mallonee, S., Injury surveillance. Epidemiologic Reviews, 2003. 25: p. 24-42.
15. National Centre for Classification in Health, ICD-10-AM. Fifth ed. 2006, Sydney: National Centre for Classification in Health.
16. Choicemaker Technologies. Open Source Choicemaker Technology. 2011 [cited 2011 10/7/2011]; Available from: http://oscmt.sourceforge.net/.
17. Davie, G., Cryer, C., and Langley, J., Improving the predictive ability of the ICD-based injury severity score. Injury Prevention, 2008. 14: p. 250-255.
18. Willis, C., Gabbe, B., Jolley, D., Harrison, J., and Cameron, P., Predicting trauma patient mortality: ICD [or ICD 10 AM] versus AIS based approaches. ANZ Journal of Surgery, 2010. 80(11): p. 802.
19. Dayal, S., Wren, J., and Wright, C., Mapping injury severity scores against hospitalisation day stays for injury priority areas (excluding workplace injury). 2008, Public Health Intelligence, Health and Disability Systems Strategy Directorate, Ministry of Health: Wellington.
20. SAS Institute, SAS: statistical software, version 9.3. 2012, SAS Institute: Cary, North Carolina.
21. Australian Bureau of Statistics, Australian Demographic Statistics, Sept 2009. Catalogue no 3101.0. 2009, ABS: Canberra.
22. Australian Bureau of Statistics, 2001 Census Basic Community Profile and Snapshot. 2004, ABS: Canberra.
23. Dobson, A., Kuulasmaa, K., Eberle, E., and Schere, J., Confidence intervals for weighted sums of Poisson parameters. Statistics in Medicine, 1991. 10: p. 457-762.
24. NSW Centre for Road Safety, Road Traffic Crashes in New South Wales: Statistical Statement for the year ended 31 December 2009 2010, Roads and Traffic Authority: Sydney.
25. Armitage, P., Berry, G., and Matthews, J., Statistical Methods in Medical Research. Fourth Edition ed. 2002, Cornwell: Blackwell Science.
26. World Health Organization, The Global Burden of Disease 2004 update. 2008, World Health Organization: Geneva.
27. Henley, G. and Harrison, J., Trends in serious injury due to land transport accidents, Australia 2000-01 to 2007-08, in Injury Research and Statistics Series. 2011, Australian Institute of Health and Welfare: Canberra.
28. Australian Transport Council, The National Road Safety Strategy, 2011-2020. 2011, Australian Transport Council: Canberra.
29. Roads and Traffic Authority NSW, Traffic Accident Database System Data Manual. 2003, Roads and Traffic Authority, NSW: Sydney.
30. Amoros, E., Martin, J., and Laumon, B., Under-reporting of road crash casualties in France. Accident Analysis and Prevention, 2006. 38: p. 627-635.
31. Rosman, D. and Knuiman, M., A comparison of hospital and police road injury data. Accident Analysis & Prevention, 1994. 26(2): p. 215-222.
32. Alsop, J. and Langley, J., Under-reporting of motor vehicle traffic crash victims in New Zealand. Accident Analysis & Prevention, 2001. 33: p. 353-359.
33. Loo, B. and Tsui, K., Factors affecting the likelihood of reporting road crashes resulting in medical treatment to the police. Injury Prevention, 2007. 13: p. 186-189.
34. Henderson, T., Shepheard, J., and Sundararajan, V., Quality of diagnosis and procedure coding in ICD-10 administrative data. Medical Care, 2006. 44(11): p. 1011-1019.

Assessing cardiovascular associations to affective states in Australian truck drivers

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Abstract

Within this exploratory study, data is presented regarding occupational and lifestyle factors that contribute to cardiovascular disease and depression within the truck driving industry, and subsequently contribute to reduced road safety in Australia. The study assessed associations between mood parameters, heart rate variability (HRV) and blood pressure in the unstudied population of Australian truck drivers. A total of 35 heavy vehicle truck drivers were recruited from the local community. Electrocardiogram recordings were obtained during an active and baseline driving simulator task. HRV low and high frequency parameters were obtained from the ECG. Subjects completed the Profile of Mood States questionnaire and the Lifestyle Appraisal Questionnaire. Blood pressure was recorded before and after the study. Numerous mood states (anger-aggression, total mood disturbance score) were correlated to an increase in sympathetic activity ($p<0.05$). Diastolic blood pressure was positively correlated to a number of mood states, the most significant correlation being depression-dejection ($p<0.001$).

Keywords

Blood pressure, Cardiovascular disease, Depression, Heart rate variability, Truck driving

Introduction

The trucking industry plays a fundamental role in the affluence of Australia. A combination of long distances between industries and a low population density results in a heavy dependence upon road freight. Working conditions in the truck driving industry commonly involve both physiological and psychological demands. Intermittent work and rest cycles, loading and unloading of heavy freight [1], intense cabin vibrations, irregular meal schedules, occupational stress [1], monotonous driving conditions and the necessity of intense mental alertness [2], all contribute to impaired truck driver health. As a result of these occupational lifestyle factors, truck drivers potentially elevate their risk of many physiological and psychological health conditions such as diabetes [3], cancer [4], pain [1], sleep apnoea [5], cardiovascular disease (CVD) [2, 6], and affective disorders such as depression [7]. Between June 2010 and June 2011, 211 deaths resulted from 185 crashes involving heavy rigid or articulated trucks in Australia [8]. Despite accounting for only 2.47% of the total vehicles on Australian roads, heavy vehicles have been implicated in 17.96% of the fatal road accidents [9]. The economic implications of these accidents are significant, reportedly costing Australia approximately $2 billion each year [10]. It has also been shown that approximately one in every five individuals who are injured in the workplace in Australia is a truck driver [11]. This fatality rate is fourteen times that of all other occupational deaths in Australia [11].

Globally, CVD is the leading cause of premature death [12]. Cardiovascular disease [2], myocardial infarction and ischemic heart disease [6] have all been identified as serious health issues within the trucking industry. A study conducted by the National Transportation Safety Board [13] found that 9.2% of fatalities involving truck drivers in America involved some form of cardiac incident. Furthermore, a recent study found that in Australia, a collapse from heart disease accounts for as much as 15% of all crashes where the driver suddenly becomes ill [14]. High rates of obesity, sedentary lifestyles [15], cigarette smoking [15], hypertension [15], saturated fat and alcohol dependent behaviour [15] have all been consistently reported within this occupational field, and as such, contribute to the development of cardiovascular disease within the trucking industry.

Depression is a common affective disorder, which has been previously linked to the truck driving industry. A recent study conducted by Hilton and his team [7] found that 13.3% of Australian heavy vehicle truck drivers exhibited at least a mild form of depression (as measured by the Depression, Anxiety and Stress Scale) in comparison to the reported national rate of 11.6% [16]. Similarly, a study by da Silva-Junior and associates [17] found that 13.6% of the sample cohort of truck drivers (n=300) suffered from depression (as diagnosed through the section Major Depressive Episode in the Mini International Neuropsychiatric Interview). Supporting these findings, a study in 2007 found that 14.5% of truck drivers felt more depressed since beginning work within this occupation [18]. Recently, work stress has been heavily implicated as an independent predictor of depression [19]. As previously mentioned, truck drivers are frequently subjected to long hours, irregular work/rest cycles, isolation and intense occupational pressure. These common work stressors result in truck drivers being viewed as a depression vulnerable population. Additionally, the implication of long working hours in the development of depression has been further supported by a study conducted by Virtanen and colleagues [20], in which individuals who worked more than 11 hours per day were at a significantly increased odds ratio (OR) of developing depression (2.52 compared to 1.0). Depression has been consistently associated with a decrease in driver performance. A recent study conducted by Hilton and his team [7] found that severe and extremely severe depression in heavy vehicle truck drivers resulted in a significantly higher OR (4.4 and 5.0 respectively) for an accident or near miss. The study also found that self-reported performance at work was reduced by 5.7% in drivers experiencing severe depression when compared to those with no depressive symptoms. Supporting this, Blumash and associates [21] found that individuals with major depressive disorder exhibited marked decreases in steering reaction time and an increased number of crashes when compared to a control sample. These findings provide evidence for the detection and management of depression in heavy vehicle truck drivers in Australia.

Of concern is the scarcity of literature regarding depression in the trucking industry in Australia. Aside from the aforementioned study conducted by Hilton and associates [7], the rate of depression in Australian heavy vehicle drivers has been somewhat overlooked. Of further concern are the statistics regarding the adverse effects of depression on driver performance and the role of CVD in road accidents. Furthermore, the likelihood of seeking medical advice for the treatment of depression in Australia is worrisome, with a recent survey conducted by the Australian Bureau of Statistics [22] ascertaining that only 35% of Australian individuals who had suffered from a mental disorder in the previous 12-month period had accessed appropriate medical services. Despite a higher prevalence of depression amongst females when compared with males in Australia (14.5% and 8.8% respectively [22]), a seemingly entrenched social perception, which dissuades males from seeking medical advice, has resulted in significantly lower diagnostic rates of affective disorders among males [23]. Due to the extreme gender bias of the truck driving industry (97.5% male [24]), an underlying prevalence of undiagnosed affective disorders may be present, supporting the investigation of this health implication within this occupation.

Behavioural cardiology is a developing field of clinical practice based on the understanding that adversative lifestyle behaviours, emotive factors and chronic stress can collectively contribute to atherosclerosis and adverse cardiovascular events. The Australian Heart Foundation has recently identified depression as a modifiable biomedical risk factor for CVD, and has suggested that the link between depression and cardiovascular impairment warrants further investigation [25]. At present, there have been varying results regarding the impact of this disorder on cardiac activity and the development of cardiovascular disease. The present study aimed to assess the presence and effect of a number of adverse lifestyle and mood states on the cardiovascular system in order to identify possible behavioural and environmental factors within the Australian trucking community that may contribute to the development of CVD. By understanding and evaluating the presence and effect of depression and cardiovascular disease in the Australian truck driving community, we may be able to provide the foundation for the implementation of management procedures to reduce the effects of these disorders on driving ability, and thus, improve road safety within Australia.

Methods

Participants

A total of 35 heavy vehicle truck drivers were recruited from the local Sydney City community, aged between 18 and 69 inclusive. The ratio of males to females reflected the male dominance (97.5%) in the Australian trucking industry, with 33 males and 2 females being recruited to participate. Participants were recruited through local advertisement via a poster, recruitment though contacts established independently to this research, online forums and with the aid and endorsement of Australia Post Transport division and the Transport Workers Union. Participants were required to be employed as a truck driver, regularly driving a truck with a gross vehicle mass of over 4.5 tonne, not be consuming any prescription or non-prescription drugs (excluding tea, coffee and nicotine) and not be suffering from any chronic disease or illness. Participants were required to abstain from food for two hours, nicotine and caffeine for four hours, and alcohol for 12 hours prior to the study.

Procedure

Participants were tested between 9.30 am and 3 pm in order to negate the variations in heart rate between 8 - 9am and 4 – 8pm recently identified by Chen [26]. Furthermore, by ensuring participants abstained from consuming food for two hours prior to testing, the effect of the post-prandial blood pressure dip was negated. The study was conducted in a controlled laboratory environment, with auditory and visual interference being reduced as much as viably possible. Light sources were controlled, with laboratory blinds being drawn to reduce the impact of external light sources influencing physiological measurements. The study was comprehensively detailed to the subject upon arrival, with the opportunity for questions being presented. Upon confirmation of written consent, the study was commenced.

Blood pressure

Upon commencement of the study, three pre-study blood pressure (BP) readings were obtained. The volunteer was required to remain seated for five minutes prior to the BP readings being recorded, with a two minute seated interval between each of the measurements. In accordance with the National Heart Foundation of Australia BP guidelines [27] and the UTS HREC approved emergency protocol, a BP reading of greater than 160/100 mmHg resulted in the participant being excluded from the study. Furthermore, the participant was advised to seek urgent medical advice and the offer was made to escort the individual to the nearest medical facility. A participant with a pre-study BP reading greater than 140/90 mmHg but lower then 160/100 mmHg, whilst included in the study, was advised to consult their general practitioner regarding their elevated BP reading. Three post-study BP readings were also obtained, again in accordance with the National Heart Foundation of Australia BP guidelines [27] and the UTS HREC approved emergency protocol.

Lifestyle Appraisal Questionnaire

The Lifestyle Appraisal Questionnaire (LAQ) [28], a validated and clinically reliable questionnaire, was used to record demographic, lifestyle and psychological stress information from participants. The LAQ consists of two parts, with Part I consisting of 22 questions, with the highest obtainable score being 73. This information included family history of disease, smoking status, alcohol intake, exercise and diet regime, etc. The higher the score obtained from Part I of the LAQ, the greater the risk of developing a chronic illness later in life [28]. Part II of the LAQ consists of 27 items, and assessed an individual's "*cognitive appraisal of pressure and demands*" [28]. Following this, body mass index was objectively measured in the laboratory.

SmartData questionnaire

The SmartData questionnaire [29] provides demographical information regarding licensing, trucking history, employment status, nutrition, accident history and working conditions. This questionnaire was utilised as a basis for possible stratification of data, and to ascertain common conditions of truck driving in Australia. Following the administration of the SmartData questionnaire, the Likert Fatigue scale was completed.

Likert Fatigue Scale

The Likert scale is used to measure fatigue levels both prior and post the electrocardiogram (ECG) study [30]. The measure employs a rating scale of four points: not at all, slightly, moderately or markedly fatigued, and the participant circles the appropriate response. Fatigue has been shown to impact upon heart rate variability (HRV) and as such, this confounder is measured pre and post study to provide adequate information to allow for thorough identification of any areas of possible inter-individual variability.

Profile of Mood States Questionnaire

The Profile of Mood States questionnaire (POMS) [31] is composed of 65 items describing six mood subscales: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment. An overall measure of total mood disturbance is calculated for all six subscales by combining the scores obtained on the tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia and confusion-bewilderment scales minus the score on the vigor-activity scale. The POMS questionnaire is a subjective measurement of well-being, and is an assessment of an individual's mood state during the previous week, including the day of participation. This measurement is not used in this study to clinically diagnose depression in individuals, but rather, to elucidate mood states that may impact physiological parameters. This questionnaire is a well-validated, reliable, low cost, ergonomic psychometric tool.

Heart rate variability

Standardised attachment of a three-lead electrocardiogram was performed, with the active electrodes being positioned at the intercostal space between the fourth and fifth ribs, two centimetres laterally from each side of the sternum and the reference electrode being secured underneath the shoulder. Following this, the participant was asked to rest for five minutes, after which, the participant was seated in the driving simulator and after participating in the race format for ten minutes to familiarise themselves with program, were asked to complete the 'active' driving situation, in which they were engaged in a race meeting (Fuji Speedway) with other automatically generated cars whilst a concurrent twenty-minute ECG recording was obtained. The driver was then asked to rest for ten minutes. Following this, a baseline (control) recording was obtained, which involved the participant engaging in a twenty minute driving session, again on the Fuji Speedway, with the absence of other automobiles on the road whilst a concurrent twenty-minute ECG recording was taken. The driving simulator was employed in order to elicit a physiological stress response, and it should be noted that subjects were familiarised with the program prior to ECG recordings being obtained. Heart rate variability (HRV) data was then obtained from the R-R intervals of the ECG recordings using a non-parametric algorithm (Fast Fourier Transform) and used as a quantitative measurement of the sympathetic (Low Frequency HRV) and parasympathetic nervous systems (High Frequency HRV). HRV reactivity was obtained by calculating the increase from baseline to active states in the various HRV parameters.

Heart rate variability analysis

Initially, using the QRS detector, the pre-processing step of HRV analysis included band pass filtering to decrease power line noise, baseline wander, muscle noise and any other interference components. The pass band at approximately 5 – 30 Hz is sufficient to cover most of the frequency content of QRS complex [32]. After this pre-processing had occurred, a set of decision rules were applied to define if a QRS complex had occurred. The decision rules included the average heart beat period as well as the amplitude threshold, which were amended adaptively as the detection process continued. The fiducial point was selected to be the R-Wave, and the time at which the R-Wave occurs was logged. Post R-Waves identification, and time of R-Wave occurrence was determined, the HRV time series was derived. The R-R intervals were determined as the variances between successive R-Wave occurrence time periods. A power spectrum density (PSD) estimate was then used to calculate the R-R interval series. The PSD estimation is performed using the Fast Fourier Transform based Welch's periodogram method (Hann window was used). In the Welch's periodogram method, the HRV sample is separated into overlapping segments (50% overlap). The spectrum was then acquired by calculating the average spectra of these segments. This method reduces the amount of variance of the FFT spectrum. The frequency bands derived for short-term HRV recordings were low frequency (LF, 0.04 – 0.15 Hz) and high frequency (HF, 0.15 – 0.4 Hz). The absolute power values for each frequency band were derived through integration of the spectrum over the band limits.

Results

Significance testing was conducted using a standard confidence interval of 95%. Correlation analysis identified a number of statistically significant associations between BP and LAQ scores (Table 1). Pre-study systolic BP was positively correlated with both P1 ($r = 0.34$, $p = 0.049$) and P2 ($r = 0.39$, $p = 0.02$) of the LAQ. This positive correlation was also identified for pre-study diastolic BP with respect to P1 ($r = 0.47$, $p = 0.004$) and P2 ($r = 0.38$, $p = 0.024$) of the LAQ. Additionally, an increase in post-study systolic BP was associated with increased P1 ($r = 0.43$, $p = 0.009$) and P2 scores ($r = 0.46$, $p = 0.006$).

A number of statistically significant correlations between pre-study diastolic BP and the scores from the POMS questionnaire were identified. Those who presented with high pre-study diastolic BP readings, also reported higher tension-anxiety ($r = 0.34$, $p = 0.043$), fatigue-inertia ($r = 0.35$, $p = 0.038$), total mood disturbance ($r = 0.38$, $p = 0.023$) and the most significan association; depression-dejection ($r = 0.43$, $p = 0.009$) scores.

Table 1. Blood pressure associations with Lifestyle Appraisal Questionnaire

		r	p
Pre-study systolic BP	**LAQ P1**	0.34	0.049
	LAQ P2	0.39	0.020
Pre-study diastolic BP	**LAQ P1**	0.47	0.004
	LAQ P2	0.38	0.024
Post-study systolic BP	**LAQ P1**	0.43	0.009
	LAQ P2	0.46	0.00

The regression analysis for pre-study diastolic BP had an overall significance ($F = 2.42$, $df = 9, 25$, $p = < 0.039$, $R = 0.68$, $R^2 = 0.47$, Adjusted $R^2 = 0.27$) for nine variables (age, BMI, LAQ P1, LAQ P2, tension-anxiety, anger-aggression, fatigue-inertia, depression-dejection, TMD) together accounting for 46% of the variance in pre-study diastolic BP. The regression analysis for post-study systolic BP was significant ($F = 3.9$, $df = 4,30$, $p = < 0.011$, $R = 0.59$, $R^2 = 0.34$, Adjusted $R^2 = 0.26$) for four variables (age, BMI, LAQ P1 and LAQ P2) together accounting for 34% of the variance in post-study systolic BP. The individual variable that was most predictive of post-study systolic BP variability was LAQ P2 ($p = 0.03$).

A statistically significant positive correlation was identified between LF HRV measured during the active phase and anger-aggression ($r = 0.38$, $p = 0.03$) (Table 2). A significant positive correlation between HF and anger-aggression ($r = 0.42$, $p = 0.001$) and a negative correlation with the vigor-activity score ($r = -0.36$, $p = 0.004$) was also identified. HF reactivity showed a positive correlation with the anger-aggression subscale ($r = 0.38$, $p = 0.023$) and was negatively correlated with vigor-activity ($r = -0.34$, $p = 0.048$). No significant correlations were identified between POMS mood subscale scores and HRV data during the passive phase of testing.

Table 2. Mood disturbance associations with HRV during an active task

HRV parameter	POMS mood subscale	r	p
LF (ms^2) (Active)	**Anger-agression**	0.38	0.03
	Vigor-activity	-0.31	0.07
	TMD	0.32	0.07
HF (ms^2) (Active)	**Anger-agression**	0.42	0.01
	Confusion-bewilderment	0.32	0.06
	Vigor-activity	-0.36	0.04
	TMD	0.33	0.06

Discussion

Although no previous literature has addressed the links between part 1 of the LAQ and BP measurements, the present study identified a positive correlation between adverse lifestyle factors and pre/post-study SBP and pre-study DBP. Collectively, it can be assumed that an individual engaging in a number of undesirable lifestyle habits, such as those assessed in part 1 of the LAQ, is likely to have high BP. High SBP and DBP have been strongly associated with an increased CVD risk [33], and as such, addressing these adverse lifestyle factors that contribute would be beneficial in reducing BP in truck drivers.

Part 2 of the LAQ assesses an individual's cognitive appraisal of pressures and life demands over the previous eight weeks [28]. It is used to assess an individual's own assessment of the psychological pressures they are experiencing, and produces a raw score from which their levels of perceived stress can be determined. It is widely accepted that there is a significant positive correlation between psychological stress and BP [34]. The present study supports these findings, with pre and post-study SBP, and pre-study DBP found to be positively associated with perception of stress in the truck drivers. A number of mechanisms for this increase in BP, as a result of psychological stress, have been suggested. Individuals who experience prolonged periods of psychological stress have been shown to present higher circulating levels of cortisol, an essential glucocorticoid that controls catecholamines and a number of vasoactive agents that regulate vasculature tone [35]. Cortisol acts to enhance SNS activity by increasing the sensitivity of adrenergic receptors to catecholamine activation [36]. Furthermore, it has been suggested that due to the ability of cortisol to shift fluid from intracellular to extracellular compartments of the kidney, circulating blood volume may increase as a result, thereby increasing BP [37]. The hippocampus is the negative feedback mechanism for the control of circulating cortisol. Consistently elevated cortisol levels, such as those seen in times of prolonged and cumulative stress, reduce the hippocampal neuronal integrity, causing dysregulation of the HPA-axis [38]. This altered function of the HPA-axis has been directly linked to elevations in BP [38].

A number of studies found strong positive correlations between anxiety and BP [39]. The present study supports these findings to some degree, with pre-study DBP found to be positively correlated to Tension-anxiety scores attained from the POMS questionnaire. Unlike previous studies, however, no correlation was found between SBP and Tension-anxiety in the sample studied. This could be attributed to the predominantly male sample of the present study, as it has been reported that men will often underreport symptoms and severity of anxiety in surveys in which they are asked to assess their own psychological health [40]. The Tension-anxiety scores attained from the present sample (12.8 ± 5.4) were comparable to the normative values (12.9 ±6.8) [31]. Despite, this, due to the disinclination of men to report anxiety symptoms accurately on surveys, the true incidence of anxiety disorders within this cohort may actually be significantly higher.

The link between fatigue and BP has been comprehensively investigated numerous times. A recent study found that individuals who scored high on the Epworth Sleepiness Scale (ESS) displayed an increased casual SBP and DBP, when compared with those who attained low ESS scores [41]. Furthermore, short sleep durations, an occupational condition that is often reported by truck drivers, has been consistently associated with an increased risk of hypertension [42]. The present study supports these findings, with a positive correlation identified between pre-study DBP and Fatigue-inertia. The mechanisms by which fatigue influences BP can be attributed to the natural diurnal pattern of BP changes. With the onset of sleep and actual sleep, BP progressively decreases until an individual awakens [43]. This awakening is accompanied by a rapid increase in BP [42]. Sleeping fewer hours per night, as is reported by a large percentage of truck drivers would therefore act to increase average 24-hour BP, an issue in truck drivers. Overall, it should be noted that the Fatigue-Inertia mean score reported from participants in the present study was 2.6 points higher than the reported normative scores, which may suggest that fatigue is an issue within the Australian truck driving industry.

There have been a number of studies that have examined the links between depression and BP. While some found a positive association between depressive symptoms and BP [44], others identified a negative correlation [45]. It should be noted, however, that the inverse relationships found to be associated with depression were generally identified in geriatric populations [45]. The present study found that of all the POMS subscales, Depression-dejection scores had the strongest positive correlation with higher pre-study DBP. Furthermore, there was a trend towards significance with post-study SBP and higher Depression-dejection. As the present truck driver study sample had a highest individual age of 57, results parallel prevalent literature that suggest BP is positively correlated with depression in samples aged >65 years. This finding supports the initial hypothesis of the study, which stated that depression would be linked to increases in blood pressure. A number of mechanisms have been proposed to justify the increase in BP associated with depression and depressive symptoms. An increase in SNS activity, resulting in an exaggerated cardiovascular reactivity response, is one prominent theory [46]. Also, HPA axis dysregulation resulting in variable hypersecretion of cortisol has been hypothesised to result from depression [47]. It should also be noted that individuals within the present study presented an average

Depression-Dejection score of 3.2 points higher than the reported normative, indicating that this condition may be of concern within this industry.

The present study identified a positive correlation between low frequency (LF) (sympathetic activity) HRV during the active driving phase, and the Anger-aggression subscale of the POMS questionnaire. In previous studies, anger has been shown to have a positive relationship with LF activity, indicating an increased sympathetic outflow and sympathetic dominance, which has been identified as a predictive factor for the development of CVD [48]. It has been suggested that the increase in LF HRV in individuals exhibiting anger and aggression can be attributed to the sympatho-adrenal system, which, when experiencing high levels of anger or aggressive behaviour, is over-stimulated, resulting in sympathetic dominance [49]. Furthermore, it has been observed that the application of norepinephrine to the paraventricular hypothalamic nucleus resulted in increases in circulating corticosteroids and glucose [50]. It has been hypothesised that the close physical proximity of the hypothalamic regions involved in defence and those that stimulate the sympatho-adrenal system, may provide evidence for a functional interaction between the neural mechanisms for anger and aggression, and the sympatho-adrenal control of the body at the hypothalamic level [51].

Conclusion

A number of psychological states were assessed in relation to blood pressure. Psychological stress was associated with an increase in BP. This finding parallels the literature, which suggests that psychological stress increases the levels of circulating cortisol, thereby increasing vasoconstriction and blood volume, resulting in elevated BP [35]. Within the present study, fatigue was also positively correlated to BP. This finding is well supported by the current literature [42]. Depression was also found to be associated with an increase in DBP. Although current literature has debated the impacts of depression on BP, the present study suggests that this negative mood state may be associated with an increase in BP, and may subsequently result in an increased cardiovascular risk. The psychological health of Australian truck drivers has been somewhat overlooked, with only one study having assessed the psychological wellbeing of this cohort [7]. The Hilton study [7] assessed the prevalence of depression, anxiety and stress-related mood impairment within Australian truck drivers, although no comparisons were made to cardiovascular health. The present study assessed a more comprehensive range of mood states within this industry, including depression, anger, psychological stress, anxiety, confusion and fatigue. Findings from the present study suggest that a number of these negative mood states (psychological stress, tension-anxiety, depression-dejection and fatigue-inertia) are correlated to alterations in BP. As such, the identification and managements of these mood states would improve both the psychological and cardiovascular health of individuals within this industry.

There is also varying evidence regarding the effects of a number of mood states on autonomic activity (as assessed by HRV analysis). The current study identified positive associations between LF HRV (sympathetic activity) and anger. In previous studies, anger has been shown to have a positive relationship with LF activity, indicating an increased sympathetic dominance, which has been identified as an indicator for the development of cardiovascular impairment [48].

Collectively, the findings from the present study provide a novel perspective on the physiological and psychological health of Australian truck drivers. The present study is the first assess to the effects of certain lifestyle and mood states on cardiac parameters (such as BP and HRV) in the cohort of Australian truck drivers. The present study addressed the gaps in research by assessing a number of mood states and their relationships with cardiac parameters. The study found that multiple lifestyle and mood parameters (BMI, psychological stress, anger and depression) were associated with altered cardiovascular function. Elucidating from previous literature, reducing the incidence of these factors would work to reduce both CVD and depression, in turn, increasing driver performance, thereby improving road safety in Australia. These findings also suggest that the improved awareness and management of these factors in the male dominated truck driving industry would improve both the short term psychological and long term cardiovascular health of these individuals, in turn, reducing the socioeconomic burden associated with these affective disorders and cardiovascular disease in Australia. Considering that heavy vehicle accidents reportedly cost Australia approximately $2 billion each year [10], improving the psychological profile of these individuals would, in turn, reduce the effects of disorders such as depression on driving ability. Furthermore, identifying depression as a contributing factor to impaired cardiovascular function would provide the foundation for the management of this disease within the Australian truck driving industry. Road safety in Australia is a vital aspect of this industry that requires a holistic approach. By incorporating both physiological and psychological management schemes, the safety gains in terms of improved driver ability, and reduction in both absenteeism and cardiovascular related road crashes, would be beneficial.

References

1. Koda S, Yasuda N, Sugihara Y, Ohara H, Udo H, Otani T, et al. Analyses of work-relatedness of health problems among truck drivers by questionnaire survey. Sangyo Eiseigaku Zasshi. 2000;42(1):6-16.

2. Hartvig. P, Midttun, O. Coronary Heart Disease Risk Factors in Bus and Truck Drivers. International archives of occupational and environmental health. 1983;52:353-60.

3. Siu SC, Wong KW, Lee KF, Lo YYC, Wong CKH, Chan AKL, et al. Prevalence of undiagnosed diabetes mellitus and cardiovascular risk factors in Hong Kong professional drivers. Diabetes Research and Clinical Practice. 2012;96(1):60-7.

4. Young E, Kreiger N, Purdham J, Sass-Kortsak A. Prostate cancer and driving occupations: could whole body vibration play a role? International archives of occupational and environmental health. 2009 Apr;82(5):551-6.

5. Moreno CR, Carvalho FA, Lorenzi C, Matuzaki LS, Prezotti S, Bighetti P, et al. High risk for obstructive sleep apnea in truck drivers estimated by the Berlin questionnaire: prevalence and associated factors. Chronobiology international. 2004;21(6):871-9.

6. Robinson CF, Burnett CA. Truck drivers and heart disease in the United States, 1979-1990. American Journal of Industrial Medicine. 2005;47:113-9.

7. Hilton MF, Staddon Z, Sheridan J, Whiteford HA. The impact of mental health symptoms on heavy goods vehicle drivers' performance. Accident Analysis and Prevention. 2009;41(3):453-61.

8. Bureau of Infrastructure Transport and Regional Economics. Fatal heavy vehicle crashes Australia quarterly bulletin. In: Department of Infrastructure and Transport, editor. Canberra, ACT: Australian Government; 2011. p. 1-8.

9. Department of Infrastrcuture Transport Regional Development and Local Government. Road Deaths Australia 2008 Statistical Summary. Canberra ACT2009

10. Bureau of Infrastructure Transport and Regional Economics. Cost of road crashes in Australia 2006. Canberra, ACT2009

11. Safe Work Australia. Work-related traumatic injury fatalities, Australia 2008-092011.

12. Ignarro LJ, Balestrieri ML, Napoli C. Nutrition, physical activity, and cardiovascular disease: an update. Cardiovascular research. 2007;73(2):326-40.

13. National Transportation Safety Board. Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-to-the-Driver Heavy Truck Crashes. Wastington, D. C.: National Transportation Safety Board1990: Report No. SS-90-01.

14. VicRoads. Heart disease. 2012 [04/02/2012]; Available from: http://www.vicroads.vic.gov.au/Home/Licences/Medicalreview/HeartConditions.htm.

15. Korelitz JJ. Health Habits and Risk Factors Among Truck Drivers Visiting a Health Booth during a Trucker Trade Show. American journal of health problems. 1993;8(2):117-23.

16. World Health Organisation. Mental Health - Depression. 2009 [20/02/2012]; Available from: http://www.who.int/mental_health/management/depression/definition/en/.

17. da Silva-Junior FP, De Pinho RS, De Mello MT, De Bruin VM, De Bruin PF. Risk factors for depression in truck drivers. Social Psychiatry and Psychiatric Epidemiology. 2009;44(2):125--9.

18. Wong WC, Tam S.M., Leung PW. Cross-border truck drivers in Hong Kong: their psychological health, sexual dysfunctions and sexual risk behaviors. Journal of Travel Medicine. 2007;14(1):20-30.

19. Wang J. Work stress as a risk factor for major depressive episode(s). Psychological medicine. 2005;35(6):865-71.

20. Virtanen M, Stansfeld SA, Fuhrer R, Ferrie JE, Kivimski M. Overtime Work as a Predictor of Major Depressive Episode: A 5-Year Follow-Up of the Whitehall II Study. PloS one. 2012;7(1):30719.

21. Bulmash EL, Moller HJ, Kayumov L, Shen J, Wang X, Shapiro CM. Psychomotor disturbance in depression: assessment using a driving simulator paradigm. Journal of affective disorders. 2006;93(1-3):213-8.

22. Australian Bureau of Statistics. National Survey of Mental Health and Wellbeing: Summary of results. Canberra, ACT2007

23. Klint T, Weikop P. Monoamine transporters as continuing targets for drug discovery in depression. Drug Discovery Today: Therapeutic Strategies. 2004;1(1):111-6.

24. Australian Government. Truck Drivers - Statistics. 2012 [12/02/12]; Available from: http://joboutlook.gov.au/Pages/occupation.aspx?search=keyword&tab=stats&cluster=&code=7331.

25. Australian Heart Foundation. Cardiovascular Disease and Depression Strategic Research Program. 2008 [27/04/2012]; Available from: http://www.heartfoundation.org.au/research/funding/pages/strategic-research.aspx.

26. Chen HY. Circadian Patterns of Heart Rate Turbulence, Heart Rate Variability and Their Relationship. Cardiology Research. 2011;2(3):112-8.

27. National Blood Pressure and Vascular Disease Advisory Committee. Guide to management of hypertension: National Heart Foundation of Australia2010

28. Craig A, Hanock K, Craig M. The lifestyle appraisal questionnaire: A comprehensive assessment of health and stress. Psychology & Health. 1996;11:331-43.

29. Kavanagh D. SmartData Questionnaire Package. 2007.

30. Lal SK, Craig A. Driver fatigue: electroencephalography and psychological assessment. Psychophysiology. 2002;39(3):313-21.

31. McNair D, Lorr M, Droppelman L. Manual for the Profile of Mood States. San Diego, CA: Educational and Industrial Testing Service; 1971.

32. Pahlm O, Sornmo L. Software QRS detection in ambulatory monitoring--a review. Medical & biological engineering & computing. [Review]. 1984 Jul;22(4):289-97.

33. Franklin SS, Gustin Wt, Wong ND, Larson MG, Weber MA, Kannel WB, et al. Hemodynamic patterns of age-related changes in blood pressure. The Framingham Heart Study. Circulation. 1997;96(1):308-15.

34. Carroll D, Phillips AC, Der G, Hunt K, Benzeval M. Blood pressure reactions to acute mental stress and future blood pressure status: data from the 12-year follow-up of the West of Scotland Study. Psychosomatic medicine. 2011;73(9):737-42.

35. al'Absi M, Arnett DK. Adrenocortical responses to psychological stress and risk for hypertension. Biomedicine & pharmacotherapy. 2000;54(5):234-44.

36. Davies AO, Lefkowitz RJ. Regulation of beta-adrenergic receptors by steroid hormones. Annual review of physiology. 1984;46:119-30.

37. Kaplan NM. Clinical Hypertension. Baltimore: Williams & Wilkins; 1990.

38. McEwen BS. Plasticity of the hippocampus: adaptation to chronic stress and allostatic load. Annals of the New York Academy of Sciences. 2001;933:265-77.

39. Ginty AT, Carroll D, Roseboom TJ, Phillips AC, de Rooij SR. Depression and anxiety are associated with a diagnosis of hypertension 5 years later in a cohort of late middle-aged men and women. Journal of human hypertension. 2013;27(3):187-90.

40. Australian Institute of Health and Welfare. Australia's health 2008. Canberra: AIHW2008: Cat. no. AUS 99.

41. Goldstein IB, Ancoli-Israel S, Shapiro D. Relationship between daytime sleepiness and blood pressure in healthy older adults. American journal of hypertension. 2004;17(9):787-92.

42. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. Hypertension. 2006;47(5):833-9.

43. Hermida RC, Ayala DE, Portaluppi F. Circadian variation of blood pressure: the basis for the chronotherapy of hypertension. Advanced drug delivery reviews. 2007;59(9-10):904-22.

44. Hughes JW, Stoney CM. Depressed mood is related to high-frequency heart rate variability during stressors. Psychosomatic medicine. 2000;62(6):796-803.

45. Ng TP, Feng L, Niti M, Yap KB. Low blood pressure and depressive symptoms among Chinese older subjects: a population-based study. The American journal of medicine. 2010;123(4):342-9.

46. Jonas BS, Franks P, Ingram DD. Are symptoms of anxiety and depression risk factors for hypertension? Longitudinal evidence from the National Health and Nutrition Examination Survey I Epidemiologic Follow-up Study. Archives of family medicine. 1997;6(1):43-9.

47. Vreeburg SA, Hoogendijk WJ, van Pelt J, Derijk RH, Verhagen JC, van Dyck R, et al. Major depressive disorder and hypothalamic-pituitary-adrenal axis activity: results from a large cohort study. Archives of general psychiatry. 2009;66(6):617-26.

48. Virtanen R, Jula A, Salminen JK, Voipio-Pulkki LM, Helenius H, Kuusela T, et al. Anxiety and hostility are associated with reduced baroreflex sensitivity and increased beat-to-beat blood pressure variability. Psychosomatic medicine. 2003;65(5):751-6.

49. Hoch F, Werle E, Weicker H. Sympathoadrenergic regulation in elite fencers in training and competition. International journal of sports medicine. 1988;9 Suppl 2:S141-5.

50. Siviy SM, Kritikos A, Atrens DM, Shepherd A. Effects of norepinephrine infused in the paraventricular hypothalamus on energy expenditure in the rat. Brain research. 1989;487(1):79-88.

51. Stoddard SL, Bergdall VK, Townsend DW, Levin BE. Plasma catecholamines associated with hypothalamically-elicited flight behavior. Physiology & behavior. 1986;37(5):709-15.

Seriously injured occupants of passenger vehicle rollover crashes in NSW

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Abstract

This study uses linked police-reported road crash and hospitalisation datasets to establish the patterns of serious injury sustained by occupants of passenger vehicle rollover crashes in New South Wales, 2001 to 2011. A total of 10,876 casualties were identified that were injured in crashes where rollover was the primary event. The injury patterns are compared with in-depth rollover crash investigations using United States data, where injury mechanisms were identified in an effort to establish rollover crash test protocols and identify appropriate areas for vehicle improvements to ameliorate serious injuries. The aim of the present study is to establish similarities between patterns of serious injury to the head, spine and thorax between Australia and the United States, such that the lessons learned with regards to injury mechanisms, test protocols and vehicle performance requirements may be shared and used to improve vehicle rollover crashworthiness in both countries. General descriptors of rollover crash incidence, characteristics and determinates of serious injury in NSW are also reported.

Keywords

Rollover, Serious injury, Injury mechanisms, Rollover crashworthiness

Introduction

Rollover crashes are known to be relatively rare, yet particularly injurious events. Studies of Australian road fatalities have shown that one in every three to four vehicle fatalities involved a rollover of the vehicle [1]. Such studies have shown that head, spine and thoracic injuries feature highly as causes of death amongst fatally injured rollover occupants [2]. However, detailed studies of injury mechanisms resulting from rollover crashes have not been reported in Australia, and retrospective rollover investigations have concentrated on fatal crash cases [1-3]. This is partly due to the fact that vehicle rollovers cannot be identified in hospital data (wherein injury data are available), while injury data are not available in police-reported road crash data (wherein vehicle rollovers can be identified).

While the incidence of rollover fatalities has been reported to be substantial, vehicle performance testing for rollover crashworthiness in the Australasian New Car Assessment Program (ANCAP) is not scheduled to begin until 2014 [4]. The vehicle performance will be measured with a quasi-static roof crush test; however such a test has been noted as insufficient in replicating real-world crashes since the dynamic response of the roof, the kinematics of the occupant and the performance of the vehicles' safety features such as side and curtain airbags are not assessed [5]. In an effort to improve the understanding and assessment of the rollover performance of vehicles, a consortium of university and industry partners in both Australia and the United States (US) established a research program to develop a dynamic rollover occupant protection (DROP) crash test protocol [6]. Aside from the possible application of a consumer new car assessment protocol, a valid rollover crash test protocol will be an important research tool for understanding injury potential in rollover crashes, developing occupant protection systems, and thereby assisting in reducing road trauma related to this crash mode.

An important step in the development of a protocol is the identification of an Anthropomorphic Test Device (ATD) capable of replicating the injury mechanisms, for which accurate real-world data of relevant injury mechanisms are required. Due to the aforementioned difficulty of sourcing such detailed rollover crash data retrospectively in Australia, the authors previously used data from the US National Automotive Sampling System (NASS) Crashworthiness Data System (CDS). Rollover crash occupants relevant to the DROP protocol were identified, being contained (not ejected) and restrained (wearing a seatbelt) occupants in single-vehicle rollover crashes where no impacts with objects occurred either before, during or after the rollover. The major injury mechanisms were identified in these studies for the head [7], spine [8] and thorax [9]. Research is currently ongoing with regards to an appropriate ATD and DROP protocol that is capable of replicating these injury mechanisms, using a dynamic test apparatus that has been commissioned at the NSW CrashLab (UNSW Jordan Rollover System) [5,6]. Similar apparatuses have been established in the US at the Center for Injury Research [10] and the University of Virginia [11].

An important consideration for Australian researchers and ANCAP is that the injury mechanisms identified from US data are relevant to Australian conditions. The aim of the present study is to establish similarities between patterns of serious injury to the head, spine and thorax between Australia and the US, such that the lessons learned with regards to injury mechanisms, test protocols and vehicle performance requirements may be shared and used to improve vehicle rollover crashworthiness in both countries. A retrospective study of linked police-reported road crash and hospitalisation data identified occupants of rollover crashes and the injuries sustained. The characteristics of general rollover crashes (termed 'rollover crashes') were established in order to describe the overall rollover crash problem in NSW. A subset of occupants in these crashes were then identified that were seat-belted, non-ejected and in rollovers with no additional impacts (termed 'pure rollovers'). These are occupants specifically relevant to rollover crash testing and their injury patterns may be directly compared with the US studies [7-9], which only considered such occupants. Implications for rollover crash testing in Australia are discussed.

Methods

Data collections

The Admitted Patient Data Collection (APDC) includes information on all inpatient admissions from all public and private hospitals, private day procedures, and public psychiatric hospitals in NSW. The APDC contains information on patient demographics, source of referral, diagnoses, external cause(s), separation type and clinical procedures. Diagnoses and external cause codes are classified using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM) [12]. Ethics approval was obtained from the NSW Population and Health Services Research Ethics Committee and was ratified by the UNSW Human Research Ethics Committee.

The CrashLink data collection contains information on all police-reported road traffic crashes where a person was unintentionally fatally or non-fatally injured, or at least one motor vehicle was towed away and the incident occurred on a public road in NSW. Information pertaining to the crash and conditions at the incident site, the traffic unit or vehicle, and the vehicle controller and any casualties resulting from the crash are recorded. Each individual is identified as being non-injured, injured or killed (died within 30 days). Data were extracted for occupants of passenger vehicles (car/4WD/utility/van/light truck) in crashes for which the number of traffic units involved was one, the first impact type was identified as a vehicle rollover and the occupant was identified as either injured or killed. These occupants are hereafter termed ‘rollover casualties’. Contained and restrained occupants in rollovers for which no secondary collisions with objects occurred were identified where the crash record further indicated the occupant was wearing a seatbelt, was not ejected from the vehicle and the first object impacted was null. These occupants are hereafter termed ‘pure rollover casualties’. Data were extracted from both datasets from 1 January 2001 to 31 December 2011. To compare the incidence rate of casualties in the rollover crash mode with those in other modes, data were then extracted in a similar manner for all passenger vehicle crashes.

Data linkage

The APDC was linked to CrashLink by the Centre for Health Record Linkage (CHeReL). The CHeReL uses identifying information (e.g. name, address, date of birth, gender) to create a person project number (PPN), for each unique person identified in the linkage process. The record linkage used probabilistic methods and was conducted using ChoiceMaker software [13]. A successful link of the APDC with CrashLink was defined as when the PPN matched in both data collections, and the admission date in the APDC was on the same or next day as the crash date.

Injury identification

Two types of injury severity were considered; KSI and major injury. KSI refers to rollover casualties that were either killed or seriously injured. A seriously injured casualty was a casualty that was admitted to hospital, as identified by a hospital record that linked to the police-reported road crash record for that individual. Major injury refers to pure rollover casualties that sustained one or more head or spine injuries with an Abbreviated Injury Scale (AIS) score of 2 to 6 (AIS 2+), or thoracic injuries with an AIS score of 3 to 6 (AIS 3+). The major injury analysis was restricted to pure rollover casualties in order to make comparisons with the US data [7-9], which only considered such occupants. The time period for the US studies was 2000 to 2009, and injuries were coded to the AIS [14], thus the Australian injuries had to be converted to the AIS scheme such that severity levels matched. Major injury was identified as AIS 2+ for the head and spine (some skull fractures and vertebral fractures considered as major injury were scored as 2) and AIS 3+ for the thorax (where a score of 3 is the typical definition of a serious injury in the AIS). A map of head, spine and thoracic injuries from the ICD-10-AM to the AIS coding scheme was generated and used to convert the injuries coded in the hospital records (considering only the AIS2+ or AIS3+ injuries described above). This process involved manually identifying the closest AIS injury corresponding to each individual ICD-10-AM injury, for example lung contusion (ICD-10-AM S27.31) was matched to lung contusion NFS (AIS 441402.3). Where insufficient detail was provided, injuries were matched conservatively to the lowest AIS severity level.

Statistical analyses

Descriptive analyses of rollover casualties were performed using various variables available in the police-reported road crash records and shown in Table 1 (shown on page 35). Logistic regression analysis was then performed considering the outcome of KSI, for each variable individually (univariate analysis) and considering all variables (multivariate analysis). The method of purposeful selection was used in order to select the variables for the multivariate logistic regression model [15], where statistical significance and confounding were assessed at the 0.05 and 0.15 levels, respectively.

Results

Rollover crash casualties

A total of 10,876 rollover casualties were identified amongst police-reported road crashes in NSW between 2001 and 2011 (inclusive). Of these, 3,365 (31%) were identified as either killed or seriously injured (KSI), of which 454 were killed. The remaining casualties were either treated at an emergency department and subsequently not admitted to hospital, were treated by a general practitioner or other health professional, or were self-treated. The proportion of rollover casualties that were KSI is compared with other crash modes in Figure 1a, where the rate of KSI in rollovers is greater than the average of 27.4%, while less than the rates for multi-vehicle head-on collisions (43.9%) and single-vehicle fixed object collisions (37.2%). The proportion of total KSI casualties in all crash modes is depicted in Figure 1b, where single-vehicle rollovers accounted for 7.2% of all KSI casualties during the study period (n = 47,380).

The annual number of rollover casualties are plotted in Figure 2, where it is clear that numbers of rollover casualties have decreased substantially over the study period; casualties decreased from 1,197 to 723, KSI casualties decreased from 310 to 229 and fatalities decreased from 49 to 19. The location of rollover crashes resulting in casualties and KSI casualties is presented in Figure 3, where it is clear that rollover casualties predominantly occur in regional areas of NSW. This finding is also highlighted in Table 1 where 85.3% of rollover casualties occurred in rural areas. Of these rural crashes, around three quarters occurred in rural non-urban areas.

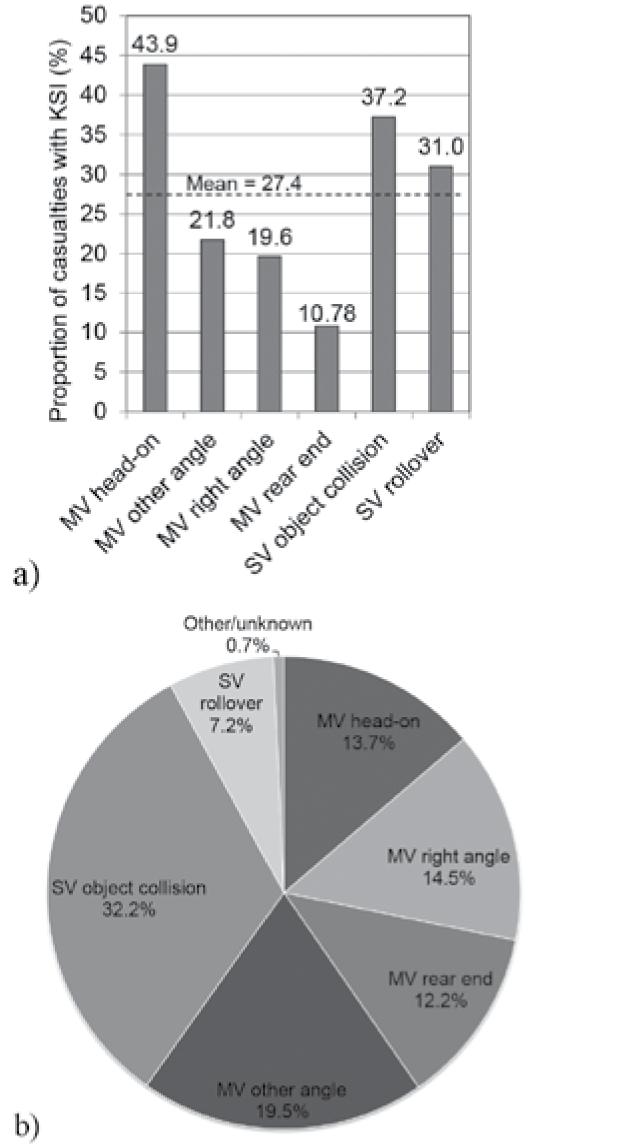


Figure 1. KSI casualties in all passenger vehicle crash modes, NSW 2001-2011. a) KSI rates, b) proportions of all KSI casualties (n = 47,380) (MV = multiple vehicle crashes, SV = single vehicle crashes)

Other descriptive results of note in Table 1 include: casualties were predominantly wearing a seatbelt (86.7%), were not ejected (96%), were seated in the front (87.1%) and were male (56.4%); the crashes predominantly did not involve a secondary object impact (91.6%), were in speed zones of 100km/h or more (63.4%), were in a car (57.9%), occurred in dry conditions (76.5%) in the daytime (59.4%) on a sealed roadway (81.2%), and did not occur at an intersection (91%) nor on highways or freeways (70.3%). The majority of crashes occurred on two-way undivided roads (79.4%). The driver was typically not driving with a BAC greater than 0.05g% (89.9%), while 32.3% of crashes were speeding-related and 10.6% were fatigue-related. The mean vehicle occupant age was 33 years.

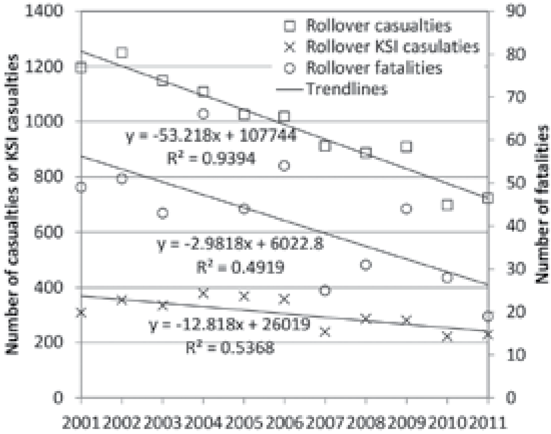


Figure 2. Temporal results, NSW 2001-2011

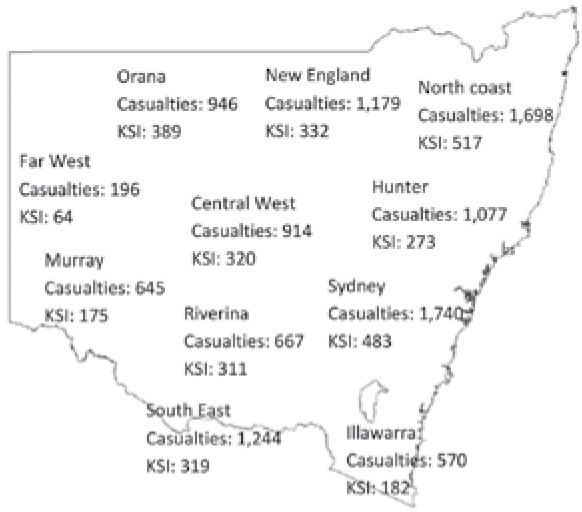
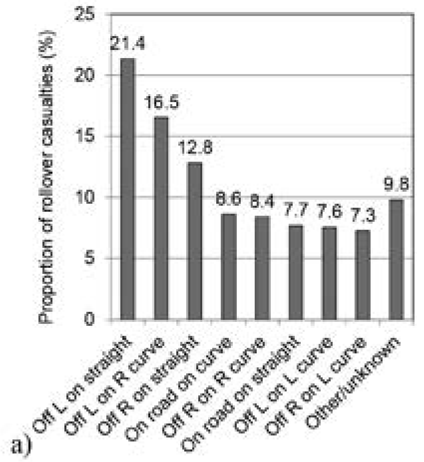


Figure 3. Location of rollover crashes, NSW 2001-2011

Factors involved in the initiation of the rollover crashes involving the 10,876 casualties were identified from the police-reported crash records and are summarised in Figure 4. Around three quarters of rollovers were run-off-road crashes, with the majority departing from the travelling lane (i.e. off the left side of the roadway). Embankments/cuttings were involved in 18.3% of rollover crashes, with ditches/drains/culverts and steep grades/crests also frequently involved, and these factors combined accounted for nearly one half of all rollover crashes. Other factors involved included avoiding an animal or vehicle, loose gravel on the shoulder or a rough surface, the driver was distracted or asleep/drowsy, and a tyre fault/failure.

The multivariate statistical results for the outcome of an occupant sustaining serious or fatal injury (KSI), and conditional upon the occupant being involved in a police-reported rollover crash where the police recorded that they were injured (casualty), are tabulated in Table 1. The results indicate that, assuming all other factors remain the same, the following factors were associated with increased odds of KSI (OR; 95% CI); ejection (3.15; 2.52-3.93), secondary fixed object impacts (1.70; 1.47-1.96), speed zones of 100km/h or more (1.35; 1.14-1.61), occupants aged above the mean of 33 years (1.52; 1.39-1.66), drivers with a BAC over 0.05 (2.22; 1.94-2.54), and crashes that occurred on sealed roadways (1.18; 1.05-1.31) and dry roadways (1.29; 1.16-1.43). Factors that were associated with reduced odds of KSI included wearing a seatbelt (0.56; 0.49-0.64) and crashes that occurred at an intersection (0.78; 0.66-0.93).



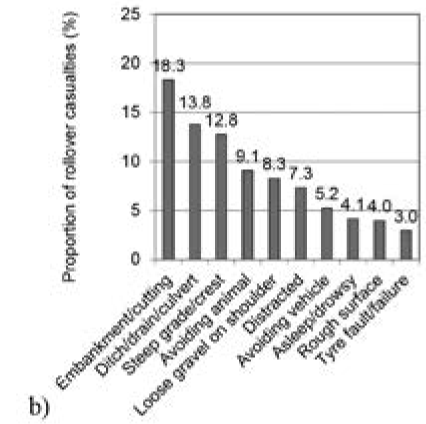
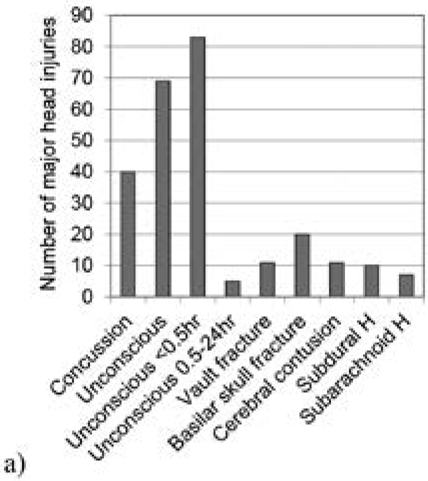


Figure 4. Proportion of rollover casualties amongst; a) rollover initiation locations and b) contributing factors to the rollover initiation (n=10,876), NSW 2001-2011

Pure rollover casualty major injuries and comparison with the US

Of the 3,365 rollover casualties that sustained KSI, 2,204 were identified as pure rollover casualties, and of these 450 sustained one or more major injuries. Of these, 227 pure rollover casualties sustained a total of 285 major head injuries (AIS 2+). Specific major head injuries are summarised in Figure 5a, where concussion and unconsciousness occurred most frequently, followed by fractures to the base of the skull and vault and brain injuries. The major injury results are compared with those identified amongst pure rollover occupants in the US study [7] in Figure 5b, where concussions and unconsciousness were excluded (n = 86 for the present study). It is noted that in the present study the ICD-10-AM code for 'unspecified intracranial injury' was used frequently, while this was not the case in the AIS-coded US study. These cases are included in Figure 5b.

A total of 198 pure rollover casualties sustained 351 major spine injuries (AIS 2+). These were predominantly vertebral fractures, and also included dislocations and spinal cord injuries. The frequency of injuries at the various levels of the spinal column are shown in Figure 6a, where fractures were sustained throughout the column, however predominantly in the lower cervical and upper thoracic spine (C5 to T4), with peaks also at C2 and T11/T12. Dislocations predominantly occurred at the C5/C6 levels, while spinal cord injury occurred in a small number of cases predominantly between C3 and C6. For comparison with the US pure rollover cases [8], the injury types were grouped and injuries to the level T4 were considered (n = 217 for the present study) (Figure 6b).



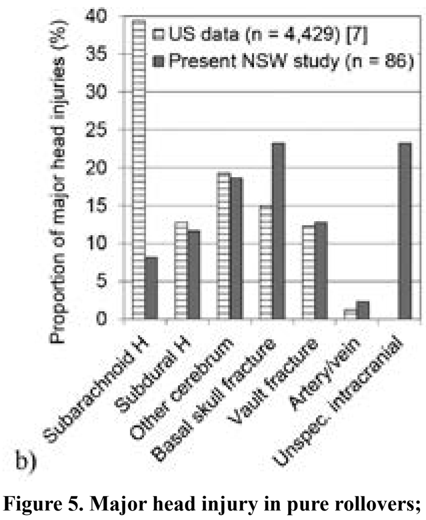


Figure 5. Major head injury in pure rollovers;
a) NSW, 2001-2011 and b) comparison with US data
(excludes concussions and unconsciousness) (H = haemorrhage)

Table 1. Descriptive and multivariate logistic regression results for rollover casualties, NSW 2001-2011

	Total rollover casualties		Rollover casualties not KSI		Rollover casualties KSI		Multivariate logistic regression Outcome = KSI			
	n	%	n	%	n	%	OR	CL_L	CL_U	p
Seatbelted	9431	86.7	6759	90.0	2672	79.4	0.56	0.49	0.64	<0.01
Not	1445	13.3	752	10.0	693	20.6	1			
Ejected	431	4.0	146	1.9	285	8.5	3.15	2.52	3.93	<0.01
Not	10445	96.0	7365	98.1	3080	91.5	1			
FO impact	918	8.4	534	7.1	384	11.4	1.70	1.47	1.96	<0.01
Not	9958	91.6	6977	92.9	2981	88.6	1			
Speed limit - 0-50	891	8.2	646	8.6	245	7.3	1			
60	1194	11.0	868	11.6	326	9.7				
70-90	1892	17.4	1365	18.2	527	15.7				
100-110	6899	63.4	4632	61.7	2267	67.4	1.35	1.14	1.61	<0.01
Vehicle - car	6297	57.9	4468	59.5	1829	54.4				
4WD	1772	16.3	1205	16.0	567	16.8				
light truck	2134	19.6	1390	18.5	744	22.1				
Ute	270	2.5	185	2.5	85	2.5				
Van	403	3.7	263	3.5	140	4.2				
Age > mean	4030	37.1	2583	34.4	1447	43.0	1.52	1.39	1.66	<0.01
≤ mean	6846	62.9	4928	65.6	1918	57.0	1			
Infringement	2	0.0	2	0.0	0	0.0				
Not	10874	100.0	7509	100.0	3365	100.0				
BAC ≥ 0.05	1095	10.1	540	7.2	555	16.5	2.22	1.94	2.54	<0.01
< 0.05	9781	89.9	6971	92.8	2810	83.5	1			
Front seated	9478	87.1	6549	87.2	2929	87.0				
Not	1398	12.9	962	12.8	436	13.0				
Male	6133	56.4	4080	54.3	2053	61.0				
Female	4743	43.6	3431	45.7	1312	39.0				
Intersection	975	9.0	721	9.6	254	7.5	0.78	0.66	0.93	0.01
Not	9901	91.0	6790	90.4	3111	92.5	1			
Metropolitan	1604	14.7	1162	15.5	442	13.1				
Rural	9272	85.3	6349	84.5	2923	86.9				
Curve	5508	50.6	3866	51.5	1642	48.8				
Not	5368	49.4	3645	48.5	1723	51.2				
Highway/freeway	3234	29.7	2220	29.6	1014	30.1				
Not	7642	70.3	5291	70.4	2351	69.9				
Sealed roadway	8831	81.2	6064	80.7	2767	82.2	1.18	1.05	1.31	0.01
Not	2045	18.8	1447	19.3	598	17.8	1			
Dry roadway	8322	76.5	5611	74.7	2711	80.6	1.29	1.16	1.43	<0.01
Not	2554	23.5	1900	25.3	654	19.4	1			
Daytime	6456	59.4	4562	60.7	1894	56.3				
Not	4420	40.6	2949	39.3	1471	43.7				

	Total rollover casualties		Rollover casualties not KSI		Rollover casualties KSI		Multivariate logistic regression Outcome = KSI			
	n	%	n	%	n	%	OR	CL_L	CL_U	p
Equipment fail	562	5.2	415	5.5	147	4.4				
Not	10314	94.8	7096	94.5	3218	95.6				
Speeding-related	3510	32.3	2418	32.2	1092	32.5				
Not	7366	67.7	5093	67.8	2273	67.5				
Fatigue-related	1151	10.6	710	9.5	441	13.1	1.24	1.15	1.42	<0.01
Not	9725	89.4	6801	90.5	2924	86.9	1			

KSI = killed or seriously injured (admitted to hospital), OR = odds ratio, CL_L = lower 95% confidence interval, CL_U = upper 95% confidence interval, FO = fixed object, BAC = blood alcohol content

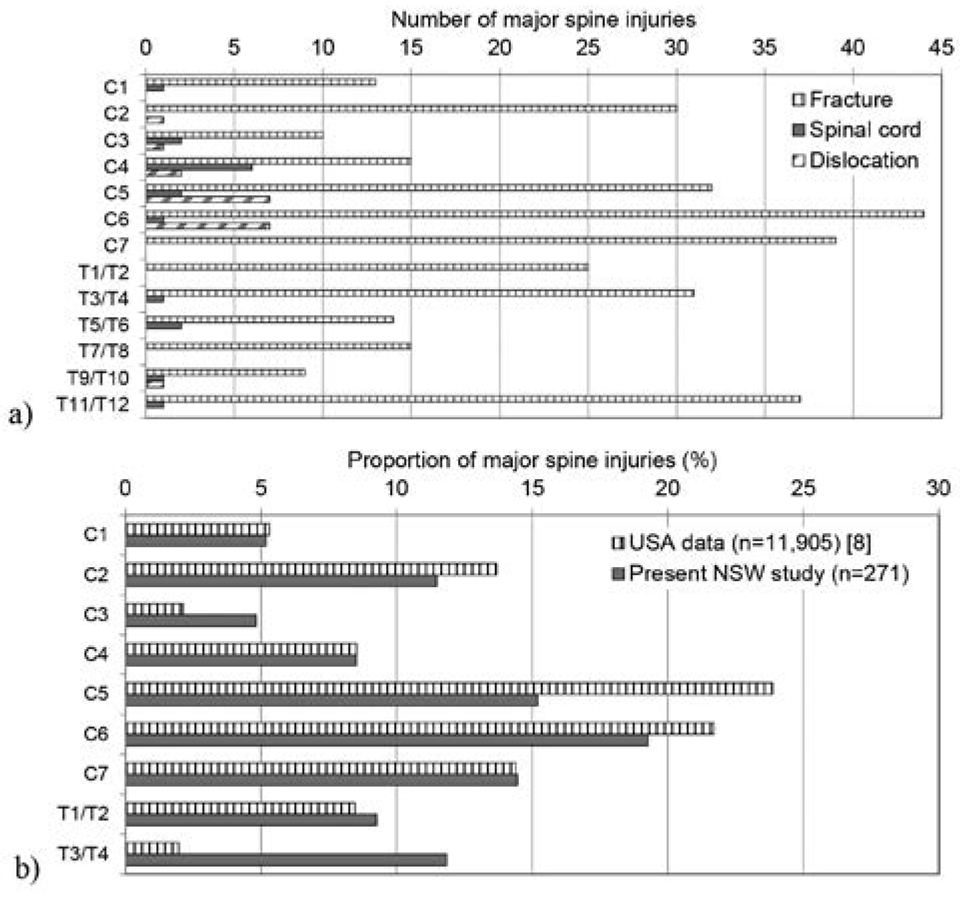


Figure 6. Major spine injury in pure rollovers; a) NSW, 2001-2011 and b) comparison with US data (C# = cervical spine vertebrae, T# = thoracic spine vertebrae)

A total of 86 pure rollover casualties sustained 98 major thoracic injuries (AIS 3+). These were predominantly lung contusions and fractures of the ribs (Figure 7a). The occurrence of contiguous injuries is also shown in Figure 7a, where pneumo/haemo/haemopneumothorax occurred in all cases of lung contusions, while major rib fractures occurred amongst only around one quarter of casualties with lung contusions. The major thoracic injury cases are compared with the US pure rollover cases [9] in Figure 7b.

Discussion

Around 7% of seriously injured passenger vehicle occupants in NSW resulted from rollover crashes during the study period. While this crash mode had a higher proportion of seriously injured occupants than the average of all crash modes, multi-vehicle head-on crashes and single-vehicle fixed object collisions had the highest rates. Around one in

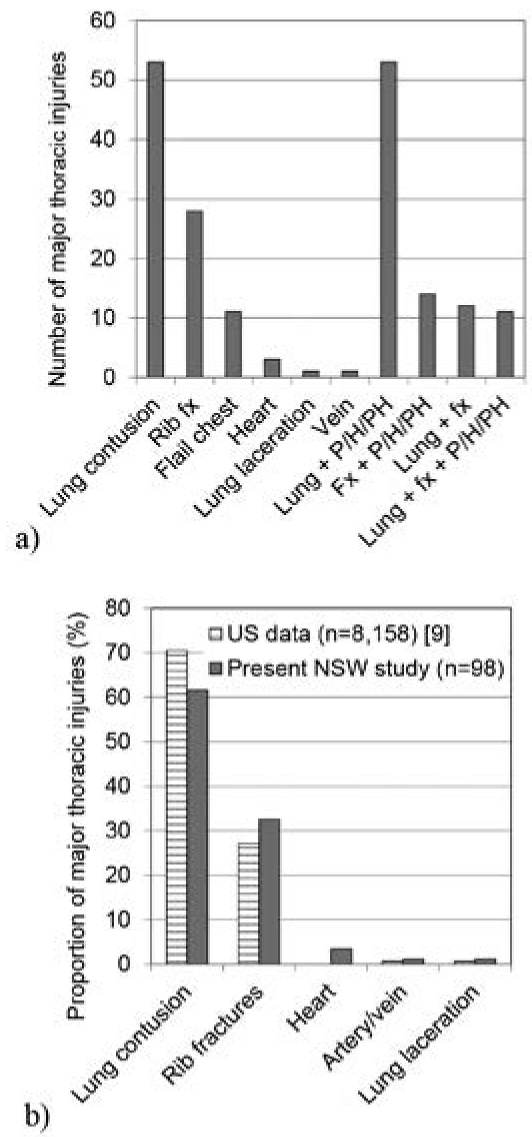


Figure 7. Major thoracic injury in pure rollovers; a) NSW, 2001-2011 and b) comparison with US data (fx = fractures, P/H/PH = pneumo/haemo/haemopneumothorax)

three rollover casualties were seriously injured or killed. These results indicate that while rollover crashes are relatively rare, they are particularly injurious crashes.

It should be noted that these results exclude other crash modes where the crash was initiated by a collision event (eg. with another vehicle or a fixed object), and the vehicle subsequently underwent a rollover event. In such cases the secondary rollover may have contributed to the occupants' injuries, thus the present study under-enumerates rollover-related occupant injuries. These crashes cannot be identified in CrashLink; regardless, in such cases it is very difficult to discern the relative contribution of the different crash modes to the occupants' injuries.

The temporal analysis indicated that the number of rollover casualties in NSW substantially decreased over the study period. This result was true for all levels of injury; casualties, KSI casualties and fatalities. This might result from vehicle improvements such as electronic stability control, which might reduce the incidence of rollovers, and structural and safety improvements such as stronger roofs and side/curtain airbags, which might reduce the incidence or severity of injuries during rollovers. This might also have resulted from improvements in the roadside environment such as shoulder sealing, roadside barriers and other general infrastructure improvements. It is also possible that occupant behaviour may have changed over the study period, such as less people not wearing a seatbelt, driving under the influence of alcohol/drugs and/or speeding.

The analysis of the location of rollover crashes indicated that they predominantly occurred in regional NSW (85.3%), and of these around three quarters occurred in non-urban regional areas. The typical rollover scenario was a vehicle on a two-way undivided road in a non-urban rural location that ran off the road and subsequently underwent a rollover. In nearly one half of cases an inclined surface was involved in the initiation of the rollover, including embankments, cuttings, ditches, drains, culverts, steep grades and crests. These results indicate that rollover is predominantly a regional problem in NSW and occurs infrequently in metropolitan areas. This indicates that roadway countermeasures to reduce rollover-related road trauma should be directed to regional NSW areas, and might include shoulder sealing and roadside barriers near slopes, for example.

The multivariate statistical results indicated that while not wearing a seatbelt, being ejected and secondary fixed object collisions occurred relatively infrequently, they were significantly associated with increased odds of KSI (Table 1). Occupants not wearing a seatbelt undergo large movements relative to the vehicle during rollover events, exposing them to injuries resulting from impacts with the vehicle interior, cargo and other occupants, or being fully or partially ejected from the vehicle. Vehicle ejection provides substantial opportunity for injury from contacts with the roadway and/or being crushed between the vehicle and the roadway. Increased odds of injury from not wearing a seatbelt and/or being ejected during a rollover have also been reported in studies of US data [16, 17]. Similarly, several authors have noted increased risk of injury from secondary fixed object collisions [18, 19].

Other factors associated with increased odds of KSI included increased age, which is a well known physiological result, and drivers who were either fatigued or had a BAC greater than 0.05g%. Fatigue and alcohol use have also been shown to increase the risk of injury in other crash modes [20, 21]. The association of KSI with higher speed zones (100km/h or greater) is likely a result of the fact that vehicles would likely be driving at higher speeds in these zones, resulting in greater crash kinetic energy which is well known to be related to injury outcome [21]. Additionally, sealed and dry roadways were associated with increased odds of KSI, a result which might be related to increased friction of the roadway resulting in a higher initial roll rate and consequently more severe rollover event, and/or an increased deceleration upon ground contact. A similar result was found in studies of US data, where dry roadways were associated with increased odds of major spine [8] and thoracic [9] injuries.

The analysis of major injuries sustained by pure rollover casualties in the head, spine and thorax body regions indicated that the results for Australian casualties closely matched those reported for US pure rollover casualties [7-9]. For the head, brain injury and haemorrhage accounted for the majority of major injuries, with the remaining attributed to fractures of the skull (base and vault). In comparison with the study of head injury in the US [7], a point of difference was in the incidence of subarachnoid haemorrhage. However, in the Australian data a substantial number of cases were coded as ‘unspecified intracranial injury’ while none were coded as such in the US data, which might account for some of this discrepancy. For the spine, fractures accounted for most of the major injuries and the level of injury correlated well with the US spine injury data [8]. Similarly, correlation of major thoracic injury with the US data [9] was evident, where lung contusions and rib fractures were predominant. In both the Australian and US studies lung contusions typically occurred in the absence of major rib fractures (77% and 69% of lung contusions, respectively). Overall, the differences between the proportions of particular injuries in the Australian and US data were (mean; standard deviation); head injuries (7.2%; 12.2%), spine injuries (3.0%; 3.7%) and thoracic injuries (3.8%; 3.5%); indicating close correlation between the two datasets.

The high level of correlation between major injury sustained by pure rollover casualties in both Australia and the US suggests that the injury mechanisms are similar between these casualties. The much more detailed crash investigations and reconstructions performed by the US NASS CDS afforded detailed studies of injury mechanisms and causation in these studies [7-9]. The spine fractures sustained by US pure rollover casualties resulted from interactions with the vehicle roof structure during vehicle inversion [8]. Detailed analysis of the spine fractures indicated a predominance of vertebral body fractures (typical to compression-based spine trauma), and lamina, pedicle, facet and transverse process fractures typically in the absence of spinous process fractures. These asymmetric fracture patterns indicated compression postero-laterally, which suggested an injury mechanism of compression with combined extension and/or lateral bending. These results led the authors to conclude that the predominant spine injury mechanism in pure rollovers was inverted impact with the roof structure while the head was orientated with lateral bending, and in around one third of cases this impact was further exacerbated by roof intrusion.

Major brain injuries sustained by US pure rollover casualties were predominantly to the cerebrum, including haemorrhages, haematomas and contusions [7]. Basal skull fractures without concomitant vault fractures typically result from impacts to the vertex of the head, producing predominantly axial loading, and were found to involve fracturing of the occipital condoyles without concomitant brain injury in the pure rollover cases. Basal skull fractures with concomitant vault fractures typically result from impacts to the side of the head creating a fracture of the vault that extends to the base of the skull, and were found to involve fracturing of the temporal bones that extended into the middle or anterior fossae in the pure rollover cases. Vault fractures in isolation were located in the frontal and parietal bones. Casualties with vault fractures (with or without basal skull fractures) mostly sustained concomitant brain injury, which led the authors to conclude that the principle brain injury mechanism was lateral and/or frontal loading to the head. Analysis of scalp injuries (as a proxy for head impact locations) indicated that nearly one half of head impacts occurred to the side of the head, while a further one third occurred to the front of the head, and typically resulted from contact with the roof structure or pillars. These results led the authors to conclude that the predominant head injury mechanism in pure rollovers was inverted impact with the roof structure and/or pillars while the head was orientated with lateral bending and/or extension, and in around two thirds of cases this impact was further exacerbated by roof intrusion.

The most common major thoracic injury sustained by US pure rollover casualties was a unilateral lung contusion (often in the absence of rib fractures), located on the side of the occupant adjacent to the vehicle door [9]. Lung contusions are well known to be a rate-dependant injury, and can occur in the absence of rib fractures when the ribs do not compress sufficiently to fracture, however compress the lung dynamically at a rate sufficient to contuse the lung. Major thoracic injuries predominantly resulted from direct contact with the interior door panel (57% of injuries) and in the absence of door intrusion (93% of injuries). These results led the authors to conclude that the predominant thoracic injury mechanism in pure rollovers was a result of the occupant moving laterally into the interior door panel.

These analyses of injury mechanisms led to the identification of several implications with regards to vehicle rollover performance requirements and crash test protocols that replicate and evaluate the potential for major injuries to the head, spine and thorax [7-9]. The head and spine studies identified the possibility of a lateral component to the inverted impact with the roof structure, which has implications for the selection of an appropriate ATD and injury assessment reference values (IARVs). The current neck injury criterion does not assess lateral bending loads [22] while the head injury criterion has not proven a reliable indicator of head injury in lateral impacts [23, 24]. There is a paucity of research on the applicability of the Hybrid III for lateral loads to the head and neck and associated IARVs, and some studies have questioned the validity of the Hybrid III neck for inverted loading [25,26]. Meanwhile, the Hybrid III does not measure lateral deflections of the chest which limits its applicability in assessing the thoracic injury mechanism of lateral impact with the door, in which case a side impact ATD might be more appropriate. However, validation of the head and neck of the EuroSid or WorldSid for the abovementioned inverted loadings has not been reported. Further research on the biofidelity of ATDs and associated IARVs for the identified rollover injury mechanisms is clearly required.

Additionally, roof intrusion was not associated with the thoracic injury mechanism and was a factor in around one third of spine injury and two thirds of head injury [7-9]. Since AIS3+ head, spine and thoracic injuries occur in roughly equal proportions in pure rollovers [7, 9]; roof intrusion is thus associated with only around one third of such injuries. Limiting roof intrusion by itself will therefore not reduce the majority of rollover-related injuries. These results indicate that improvements in vehicle restraints (i.e. seatbelts) and protective devices (i.e. padding, side and curtain air bags, etc.) will be required to assist in the amelioration of injuries. Moreover, assessing a vehicle's rollover crashworthiness using a quasi-static roof crush test will not address the majority of major injuries that occur in rollover crashes. The implications for the development of a rollover occupant protection test protocol are that the kinematics of the occupant (and associated impacts with interior components of the vehicle) and the vehicle performance need to be assessed dynamically, using an appropriately biofidelic ATD. Given the apparent correlation between injury patterns and mechanisms between rollover casualties in Australia and the US, it is reasonable to assume that such considerations are equally valid in both countries, and the development and implementation of a rollover crash test apparatus and protocol should proceed concurrently.

Limitations

There are a number of limitations of the study that should be noted. Not all crashes are reported to police, thus the casualties examined in the present study are under-enumerated and are a sample of all rollover casualties that occurred during the period. There may be discrepancies between the manner in which different police jurisdictions record different particulars of a crash. The designation of injured (casualty) in the police-reported crash data is subjective and not clearly defined, and is based on the discretion of the reporting police officer. The statistical method used determines associations with injury; however, it does not conclusively imply causality. There may be additional variables that are associated with injury that were not available in the data, of which notable examples include the vehicle speed and number of rolls. The probabilistic linkage method is not without possible linkage errors, however false positives and false negatives were estimated to be 0.4% and 0.5%, respectively. The sample sizes between the Australian and US data were substantially different, which reflects the substantially larger road user and rollover crash populations in the US.

Conclusions

This study identified 10,876 rollover casualties in NSW between 2001 and 2011, of which around one in three were seriously injured or killed. Rollover has been identified as primarily a regional problem in NSW, where casualties typically occurred on two-way undivided roadways in rural non-urban areas. Patterns of major injury to the head, spine and thorax were closely correlated between the present study and those of US data. Presuming this also indicates a correlation between injury mechanisms and causation, this suggests that strategies to reduce rollover-related road trauma may be aligned between the two countries. This includes techniques to measure and improve vehicle performance related to rollover, including the establishment of a dynamic rollover crash test protocol. Several recommendations for such a protocol have been identified and discussed, and it is envisaged that the development and implementation of a valid dynamic rollover crash test will help reduce road trauma related to this injurious crash mode.

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Abbreviations

AIS – Abbreviated Injury Scale

ANCAP - Australasian New Car Assessment Program

APDC - Admitted Patient Data Collection

ATD - Anthropomorphic Test Device

BAC – Blood Alcohol Content

DROP - Dynamic Rollover Occupant Protection

IARV - Injury Assessment Reference Value

ICD-10-AM - International Classification of Diseases, 10th Revision, Australian Modification

KSI – Killed or Seriously Injured

NASS CDS - US National Automotive Sampling System, Crashworthiness Data System

PPN – Person Project Number

References

1. Grzebieta, R.H., Young, D., McIntosh, A., Bambach, M., Fréchède, B., Tan, G., Achilles, T. Rollover Crashworthiness: The Final Frontier for Vehicle Passive Safety. Journal of the Australasian College of Road Safety 2009; 20(2):46-55.
2. Fréchède B.O., McIntosh A.S., Grzebieta R.H., Bambach M.R. Characteristics of single vehicle rollover fatalities in three Australian states (2000-2007). Accident Analysis & Prevention 2011; 43(3):804-812.
3. Young D., Grzebieta R.H., McIntosh A., Bambach A. & Frechede B. Diving vs Roof Intrusion: A Review of Rollover Injury Causation, International Journal of Crashworthiness 2007; 12(6): 609–628.
4. ANCAP Rating Road Map 2011 - 2017. Australasian New Car Assessment Program 2012.
5. Grzebieta R.H., McIntosh A.S., Bambach M.R., Young D.P. Dynamic Test Protocol To Assess Rollover Crashworthiness, Proc. Australasian Road Safety Research, Policing and Education Conference 2010, Canberra
6. Grzebieta R.H., Bambach M., McIntosh A., Digges K., Job S., Friedman D., Simmons K., Chirwa C., Zou R., Pintar F. and Mattos G. The Dynamic Rollover Protection (DROP) Research Program, Proc. 8th Int. Crashworthiness Conf. ICRASH 2012, Milan.
7. Mattos G., Grzebieta R., Bambach M.R. and McIntosh A.S. Head injuries to restrained occupants in single-vehicle rollover only crashes. Traffic Injury Prevention 2013; 14(4):360-368.
8. Bambach M.R, Grzebieta R., McIntosh A.S. and Mattos G. Cervical and thoracic spine injury from interactions with vehicle roofs in pure rollover crashes. Accident Analysis & Prevention 2013; 50:34-43.
9. Bambach M.R, Grzebieta R. and McIntosh A.S. Thoracic injuries to contained and restrained occupants in single-vehicle pure rollover crashes. Accident Analysis & Prevention 2013; 50:115-121.
10. Friedman D., Jordan A., Bish J., Carl N., Honikman T. Rollover roof test results for a production vehicle. Proc. of the IMECE 2004: ASME International Mechanical Engineers Congress and Exposition, California.
11. Kerrigan JR, Jordan A, Parent D, Zhang Q, Funk J, Dennis N, Overby B, Bolton J, Crandall J. Design of a dynamic rollover test system. SAE Int J Passenger Cars – Mechanical Systems 2011; 4(1):870-903.
12. National Centre for Classification in Health. ICD-10-AM, Fifth edition, Sydney: National Centre for Classification in Health, 2006.
13. Choicemaker Technologies, 2012. Open Source Choicemaker Technology: http://oscmt.sourceforge.net/
14. AAAM. Abbreviated Injury Scale (AIS). Association for the Advancement of Automotive Medicine, 1990.
15. Bursac, Z, Gauss, CH, Williams, DK and Hosmer, DW. Purposeful selection of variables in logistic regression. Source Code for Biology and Medicine 2008; 3:17.
16. Bahling G.S., Bendorf R.T., Kaspzyk G.S., Moffat E.A., Orlowski K.F., Stocke J.E. Rollover and drop tests – the influence of roof strength on injury mechanics using belted dummies. Paper no. 902314, Proceedings of the 34th Stapp Car Crash Conference, Orlando, Florida, 1990.
17. Funk, J.R., Cormier, J.M., Manoogian, S.J. Comparison of risk factors for cervical spine, head, serious, and fatal injury in rollover crashes. Accident Analysis & Prevention, 2012; 45:67-74.
18. Digges, K.H., Eigen, A.M., Dahdah, S. Injury patterns in rollovers by crash severity. Paper no. 355, Proc. of the 19th International Technical Conference on the Enhanced Safety of Vehicles (ESV), USA, 2005.
19. Bose D, Kerrigan JR, Foster JB, Crandall JR. Planar impacts in rollover crashes: significance, distribution and injury epidemiology. Ann Adv Automot Med. 2011;55.
20. Conner, J., Driver sleepiness and risk of serious injury to car occupants: population based case control study. British Medical Journal, 2002; 324:1125.
21. Singleton M, Qin H, and Luan J. Factors associated with higher levels of injury severity in occupants of motor vehicles that were severely damaged in traffic crashes in Kentucky, 2000-2001. Traffic Injury Prevention, 2004; 5:144-150.
22. NHTSA. NCAP Program Final Decision Notice, Federal Register 2008; 73(134): 40016-40050
23. Gennarelli TA, Pintar FA, Yoganandan N, Beuse N, Morgan R. Head injuries to nearside occupants in lateral impacts: epidemiological and full scale crash test analysis. International Research Council on Biomechanics of Injury (IRCOBI); September 18–20, 2002; Munich, Germany
24. McIntosh A, Kallieris D, Krabbel G, Mattern R, Svensson N, Ikels K. Head impact tolerance in side impacts. 15th Enhanced Safety of Vehicles, 1996, Australia.
25. Friedman D., Paver J.G., Caplinger J., Carlin F., Rohde D. Prediction of human neck injury in rollovers from dynamic tests using the Hybrid III dummy. IMECE 2008, USA.
26. Fréchède B.O., McIntosh A.S., Grzebieta R.H., Bambach M.R. Hybrid III ATD in inverted impacts: influence of impact angle on neck injury risk assessment. Ann. of Biomedical Engineering, 2009; 37:1403-1414.

Data foundations for relationships between economic and transport factors with road safety outcomes

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Abstract

Economic conditions and policies affect transport, resulting in road safety consequences. This paper describes the selection, acquisition, description and assessment of available, appropriate and suitable data for research of this topic.

Data on economic, transport, and road safety were collected and subjected to exploratory analysis and basic diagnostic tests, finding it to be generally suitable to support further analysis, with qualifications and limitations. Appropriate, and suitable data were found to support analysis of the relationships between economic and transport factors and road safety outcomes.

Simple regression models identified initial, basic relationships between four road safety outcomes and nine economic activity factors reinforcing the importance of these factors as determinants of road safety outcomes. Characteristics of the data dictated more sophisticated analysis is required to produce more reliable results. The data and initial information provides a solid foundation to base further investigations of relationships between economic and transport factors with road safety.

Keywords

Estimate, Fatality factor, Macroeconomics, Model, Road safety

Introduction

The need for people to travel and goods to be transported is described as a 'derived demand' meaning it is not an end in itself, but serves a more fundamental purpose. Transport is a necessary facilitating activity for industrial, community, commercial or other 'economic activity'. Travel generally results in crashes, with human, financial and other intangible consequences. Relationships between economic factors, transport factors and road safety outcomes have been investigated previously, but employing different methods and with varying results.

Many subsequent analyses can occur if economic factors can be related to road safety outcomes, so this work provides a foundation for further research, including:

- forecasting future safety outcomes;
- stimating the effect of changing economic conditions;
- stimating the effect of strategies and policy or program countermeasures; and
- assessing the effect of economic, transport, land use or social policies (such as taxation, or road pricing).

Before embarking on investigation of relationships, it is essential to understand the purposes of identifying relationships and the suitability of the data for the analysis. Both the analysis and the data must be 'fit for purpose'. This paper describes the selection, acquisition, description and assessment of available, appropriate and suitable data for further research of the economic influences on road safety, and some initial results.

The objectives of the early stages of this study include:

- identifying key findings relating from previous work regarding the association between changes in the economy and road crashes;
- describing the association between economic variables of the Western Australian economy and serious casualty crash outcomes; and
- preparing data and estimates suitable for further policy and forecasting analysis.

The following data were collected and used as the parameters in this study:

- economic factors (production, consumption, employment, fuel, etc.);
- transport system variables (vehicle kilometres travelled, speed camera use, etc.); and

- road safety outcomes (crashes, crash severity, crashes by road user).

This paper reports the following first stages of a larger, more comprehensive research project and includes:

- the description and review of data;
- diagnostic testing to ensure suitability of data;
- investigation of interrelationships within economic, transport and road safety data groups;
- initial investigation of relationships between and within economic and transport factors and road safety outcomes; and
- discussion and description of results.

This work is consistent with robust analysis producing sound conclusions, by recognising and dealing with three essential, distinct and complementary elements:

- a rationally based conceptual and analytical framework;
- the appropriateness and validity of data; and
- a valid statistical analytical method.

The first of these requires description and explanation beyond what is possible here, in order to provide a justifiable logical basis. Therefore this description based on theory and practice is to be described in further papers which are in preparation, although the concepts are based on previous literature.

Background

There are a great many measures representing economic factors which can be considered as explanatory variables in analyses. A review of aggregate models for road safety accidents (1) identified 14 studies which had considered various macro-economic and other factors in explaining road accidents. Additional transport, and road safety policy or other factors are also included in some studies. The most common factors found to be relevant were the amount of vehicle travel, vehicle population, income in its various forms and the percentage of young drivers. These studies were not entirely consistent in either the factors considered or the analytical methods used, with some studies reporting contradictory results with respect to certain parameters, such as fuel price.

Road safety measures which have been investigated more commonly include fatalities per vehicle or per vehicle mile travelled (VMT) and injury crashes per vehicle or per VMT (1). Economic factors have not so consistently been related to road safety outcomes but economic activity has been represented by disposable income, Gross National Product (GNP), industrial manufacturing, income and consumption with additional factors including unemployment size or rate and fuel costs (1).

The number of road fatalities has been positively correlated with per capita disposable income (2), as has fatal injury rates with gross domestic product (GDP) per capita (3), and GDP (4) (5). Unemployment rate has been correlated with reduced road fatality rates (5) (6) (7) (8) (9). An inverted U-shape relationship between national economic growth and road fatalities has been observed, with low income countries exhibiting high fatality rates compared with high income countries (11) (12) (13).

Analytical methodology has evolved from earlier simple methods to more sophisticated techniques and frameworks in more recent years. Initial research often uses ordinary least squares (OLS) linear regression (2) (3) (4) (5) with few variables, including time. Auto-Regressive Integrated Moving Average (ARIMA) (6) (7) and the more general Structural Time Series Modelling (STSM) (8) has been used to effectively account for autocorrelation between observations in a time series. Poisson and Negative Binomial forms of regression analysis have been used in a range of studies (9) (10) (11) (12) (13).

Sequential modelling frameworks have been developed based on motor vehicle travel as the major factor representing exposure to road crashes, to which the various analytical techniques could be applied, such as the ‘DRAG’ framework, from the French words for travel demand, accident frequency and severity. The DRAG concept combines separate functions of vehicle travel, crashes per unit vehicle travel and crash severity per crash (14). However, to describe the effect of economic factors, the framework is expanded to include the relationship with economic factors which affect the amount of vehicle travel. A revised DRAG model indicated that employment and real retail sales increase personal injury road accidents (15).

Results of all these studies support the hypothesis that economic factors can affect road safety outcomes, although intermediate stages are recognised which may be investigated independently, such as suggested by the DRAG concept. These previous studies suggest a wide variety of road safety outcomes may be related to economic factors and that various methodologies may be applied to analyse their relationships. There are inconsistencies between the analyses where different forms of relationships and different relevant factors were found. The most common economic factors which relate to road safety are reported to be economic activity (real GDP), population, disposable income, unemployment and transport (travel and vehicles). Some factors including industrial production, fuel consumption and fuel prices have been less commonly found to be related. Other factors have been postulated but not yet found to be related. The most common analytical techniques reported include single and multi-variable OLS linear regression, structural time series modelling (STSM), auto-regressive integrated moving average (ARIMA) and Poisson and Negative Binomial models.

It is also evident throughout the literature that the elements of data suitability and modelling which ensure valid results are, at best, not clearly described. In most cases, consistency with these requirements is not described at all, questioning the validity of the results (1). One of the most important unresolved issues is the choice of explanatory variable, for which no rational basis is often described, raising the question of whether spurious relationships have been developed and reported in the literature (16).

Data and methods

The initial data analysis is based on the proposition that economic activity is a driver of travel, which results in exposure to crashes. This essentially adds a travel generation element to a consolidated DRAG framework. The important distinctions within the DRAG framework are intended to be separated in later developments of the project. The overall relationships between economic factors and road safety outcomes reported here implicitly combine the individual DRAG elements.

Data selection

The research objectives defined the desirable range and preference for type of data. Data were collected from public and restricted sources for 16 economic factors, 12 transport system variables, and 15 road safety outcome measures, either quarterly or annually for the period from 1985 to 2009, shown in Table 1, some of which have been combined. Other scaled measures often used in road safety, such as fatalities per capita could be derived for further investigation or comparison. Commonly used measures of economic activity are real gross domestic product (GDP) or real gross national product (GNP). GNP however, is only estimated at the national level whereas we wish to use data for the State of Western Australia.

Thus, real gross state product (GSP) is the relevant similar measure. Various other factors, such as alcohol sales, could potentially be relevant to road safety, but were not available. Relevant transport variables were also collected, but are beyond reporting here. The categorisation of some factors, such as fuel sales and price is uncertain since they could be considered as economic or transport system factors.

Many measures have been used to describe road safety outcomes, each with advantages and weaknesses. Fatalities are probably the most common and reliable measure, but suffer from low frequencies which challenges the validity of statistical analysis. All suffer from definitional issues and data inaccuracies. While data are available for various crash outcomes, road safety effects and policy has more recently focussed on the number of people killed and seriously injured (KSI). KSIs is a preferred, but emerging metric, which is intended to reflect the major human cost of road safety as opposed to measurable or direct costs (17). The definition of KSIs alone is an important issue and the subject of considerable discussion regarding definitions and data collection and is therefore too complex to be discussed further here. KSIs are represented by the number of people reported to have been killed or hospitalised, based on Department of Health records. The validity of the hospitalisation statistic is fraught with many measurement issues, particularly regarding thresholds of severity of injury and definitional changes although the data series will be accepted as presented for analysis without further dwelling on these issues. Other measures are available but are generally not preferred by users. KSI crashes represent the number of crashes where people are killed or seriously injured, based on reports to Police.

The number of crashes is available for particular road user groups (passenger vehicles, trucks, motor cyclists, cyclists and pedestrians). Various other outcome measures are also available, including fatalities, and intermediate measures, such as vehicle kilometres travelled, and could be used for analysis if appropriate.

Initially, the data were summarised according to common introductory exploratory analysis describing the number of observations, mean, variation, and bounds, for both annual and quarterly data. The data were reviewed visually to identify the form of relationships, possible outliers, or other abnormalities. No major issues were identified. Seven of the annual parameters are available for less than the 25 year annual observations and one of the quarterly parameters is not available for the whole period. These limitations need to be taken into account during sophisticated analysis, but do not affect the introductory analysis.

Data assessment

In order to avoid model misspecification and misleading results several diagnostic tests are performed on the data to ensure that they are valid for analytical purposes. Tests for correlation, multicollinearity, normality and stationarity were conducted.

Within one of the groups (economic, transport and road safety) data may be subject to correlations which may affect the relationships with factors in other groups which needs to be taken into account. The correlations between economic factors show that most macro-economic factors are very closely related with correlation coefficients often nearing or exceeding 0.9. The correlations with petrol sales and unemployment are slightly less strong and negative for the latter, indicating that unemployment falls as other

Table 1. Summary of annual economic factors and road safety outcome measures

Parameter (1985-2009)	Mean	Standard Deviation	Lowest Observation	Highest Observation	Observations (annual/ quarter)	Metric (units)
Economic Factor						
Gross State Product	123448	30820	81442	180008	20/100	$ Million
Gross State Product /capita	65529	10147	50861	81317	20/100	$ Million
Gross State Income	20139	3368	15202	25748	18/100	$ Million
Gross State Income /capita	53902	13147	38300	81317	18/100	$ Million
Gross Disposable Income	45359	18474	24375	91729	20/100	$ Million
Industrial Value Added	115732	31333	73459	172437	20/100	$ Million
State Final Demand	21915	7783	12813	38775	25/100	$ Million
Net International Exports	4837	3213	1187	12646	22/88	$ Million
Retail Turnover	3873	1428	2030	6394	25/100	$ Million
Employment	878. 2	160.6	642.6	1179	25/100	No. of people
Unemployment	59.35	13.20	34.45	87.51	25/100	No. of people
Unemployment Rate	6.632	1.940	3.048	10.69	25/100	Percent
Population	1815775	229958	1436900	2269655	25/100	No. of people
Fuel Consumption	2594	521.7	1737.4	3506	25/100	Gigalitres
Petrol Sales	1805308	142359	1521956	1995565	25/100	Litres
Petrol Price	82.52	24.80	52.4	141.4	25/100	Cent/litre
Road Safety Outcome Measure						
Fatalities	207.3	23.24	163	247	25/100	Number
Crash - Total number	37439	2156	31914	41636	25/100	
KSIs	3752	570.8	2916	5016	25/100	
Crash - Passenger vehicle	35994	2096	30514	39794	25/100	
Crash - Heavy vehicle	2633	347.2	1949	3408	25/100	
Crash - Motorcycle	1222	221.0	929	1788	25/100	
Crash - Bicycle	701.8	138.6	544	1058	25/100	
Crash - Pedestrian	671.4	112.3	511	849	25/100	
Crash - Fatal	186.6	20.27	151	220	25/100	
Crash - KSI	2300	216.1	1678	2650	25/100	
Crash - Major property damage only	21090	3229	15702	27147	25/100	
Crash - Minor property damage only	7901	2163	3623	13437	25/100	
Road Injury - Motor vehicle	2598	531.6	1794	3713	25/100	
Road Injury - Bicyclist	569.6	156.1	265	841	25/100	
Road Injury - Pedestrian	376.3	48.78	292	449	25/100	

economic factors increase. The strong cross correlations suggest caution when developing multivariate relationships or mathematical models.

Assessment of correlations between transport factors indicate many correlations with coefficients exceeding 0.8, although travel for different types of vehicle is less strongly correlated and motorcycle travel least strongly correlated. While there is a correlation between general transport factors with the policy factors of speed cameras and random breath tests, it is likely to be spurious since such measures are discretionary (subject to control by government and potentially subject to change at any time), so are unlikely to be structurally linked to other economic or transport factors.

Most road safety outcomes measures are not highly correlated. The numbers of passenger vehicle crashes are correlated with the total number of crashes since the majority of crashes involve cars. The numbers of property damage only crashes are correlated with both these factors for the same reason that the majority of crashes are minor. The number of KSIs is highly correlated with the number of people hospitalised since the number of fatalities is very small. The number of fatalities is correlated with the number of fatal crashes and other correlations also exist.

As groups, general economic factors are strongly correlated with transport factors. Road safety outcome measures as a group are not highly correlated with economic factors. Multicollinearity occurs when two or more predictors in a model are correlated and provide redundant information about the response which was tested by calculating variance inflation factors (VIF) for each predictor. The results indicate considerable multicollinearity between factors, so related factors should be used together cautiously in multivariable estimation. At the same time, there are sufficient differences between factors (such as the employment and fuel factors) to suggest valid multivariable models could be developed. Based on these results it is at least reasonable to include one economic activity factor, one fuel use factor, fuel price, and two employment factors in such estimations.

Normality (normal distribution of data) is a required attribute of data for many common statistical techniques, but not all. For the analysis of sensitivity and robustness, the Skewness and Kurtosis test, is employed to test normality. Almost all annual data, including the key road safety outcome measures reported below, and the majority of the quarterly data, were found to be normally distributed.

An important assumption often made when analysing time series data is that it is stationary, meaning the means and variances of the random error component of the data are constant over the period. Variables whose random error mean and variance changes over time are known as non-stationary or unit root variables. If the assumption is not true a resulting model may be misspecified and the results may be inappropriate. Time-series data can be conveniently described by the number of times it must be differenced to make it stationary. Stationarity of the selected main parameters was tested with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Optimum lag length is determined by Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SBIC), and Hannan and Quinn Information Criterion (HQIC). The results indicate that most of the variables are non-stationary in their levels. However, the stationarity property was found in the first difference of the variables. Therefore the time series nature of the variables needs to be respected during analysis.

Results of alternative analysis model forms

The availability and suitability of data and whether it is relevant to meet the research objective should be understood in the light of the issues described in the introduction and previous studies. Both the alternatives for the outcome measures and explanatory factors (or independent and dependent variables) need to be carefully considered, in conjunction with the data characteristics and quality. Subsequently the modelling commences with the simplest forms following the principle of Ockham's Razor, but with the potential to move towards more sophisticated techniques to take account of additional factors which may be relevant. In this case the investigation covered the most fundamental economic factor; economic activity, although even this is described in nine available forms which were considered against four alternative measures of road safety outcomes. While the available data extends to many more factors, it is beyond the scope of this paper to do more than describe the basic characteristics of relevant available data and explore the first of a potentially large number of alternative models.

In the first instance, relationships between economic activity and road safety factors were estimated using OLS regression. Alternative forms of model were initially investigated for key relationships followed by all economic activity parameters. These or similar model forms have been used in previous analyses, generally without justifying applicability. The forms reflect non-linearities in the data although many other forms may be valid and could be further investigated. Some forms suit further analysis such as multiplicative or additive effects of additional factors which could possibly be included in multivariable analysis. These assessments identify any preference of model form or economic activity for modelling.

Statistically valid models and closer fit to observations were preferred. Only models with statistically valid coefficients (P>0.95) were considered valid. Adjusted R^2 and root mean squared error (RMS Error) were used as the primary measures to compare the quality of fit between the observations and the estimation. These measures are not perfect however, particularly since transformations change the R2 value numerically, so direct comparison between models is not always possible. In general terms, simpler models are preferred over more sophisticated estimations unless an overriding rationale exists.

Alternative forms of model for estimation

Seven different forms of model were compared for the estimation of four key road safety outcome measures based on Gross State Product as the measure of economic activity:

Linear model	$y = b_0 + b_1.x$	[1]
Log - linear model	$y = b_0 + b_1.\ln(x)$	[2]
Linear - log model	$\ln(y) = b_0 + b_1.x$	[3]
Log - log model	$\ln(y) = b_0 + b_1.\ln(x)$	[4]
Exponent model 1	$y = b_1 . b_2^x$	[5]
Exponent model 2	$y = b_0 + {}_x{}^b1$	[6]
Log exponent model	$\ln(y) = b_0 + b_1{}^x$	[7]

The results of the alternative model forms are summarised in Table 2, which indicates that more complex models are often not statistically valid (P > 0.95) and do not consistently produce better explanations of the observations. Only the exponent model 1 [5] and the log exponent model [7] consistently produce valid models and the quality of the estimations from these models is consistently high. The normality of the data means transformations are not necessary to ensure validity of the estimations.

These models are illustrated together in Figure 1 which visually confirms the statistical measures and the high similarity between different model estimates, despite the non-zero axes overemphasising the degree of variation in the observations and hence the differences from the estimation. Similar graphs for other factors confirm little differences between the forms of models for estimations of other road safety outcomes based on economic activity.

Alternative explanatory economic activity factors

Estimates of road safety outcomes (KSIs) based on nine different measures of economic activity were compared and are summarised in Table 3. These results indicate that any of measures of economic activity produce valid models and the quality of the estimations from these models is consistently high. The similarity between the economic measures as explanatory variables is likely to be due to the high correlation between the factors. Many of these factors (e.g. retail turnover, industrial value added) are subcomponents of other factors (e.g. gross state product).

Table 2. Statistical comparison of alternative models forms

Relationship and Model	Valid Coefficients ($P>0.95$)	RMS Error	Adjusted R^2
Fatalities v GSP			
Linear model	-		
Log-linear model	-		
Linear-log model	-		
Log-log model	-		
Exponent model 1	b_1, b_2	21.65	.9886
Exponent model 2	-		
Log exponent model	b_0, b_1	.1082	.9996
KSIs v GSP			
Linear model	b_0, b_1	459.7	.4403
Log-linear model	b_0, b_1	.1211	.4240
Linear-log model	b_0, b_1	471.3	.4118
Log-log model	b_0, b_1	.1231	.4045
Exponent model 1	b_1, b_2	453.7	.9862
Exponent model 2	b_1	466.2	.9854
Log exponent model	b_0, b_1	.1209	.9998
Crashes v GSP			
Linear model	b_0, b_1	1763	.4002
Log-linear model	b_0, b_1	.0484	.3969
Linear-log model	b_1	1686	.4514
Log-log model	b_0, b_1	.0462	.4503
Exponent model 1	b_1, b_2	1776	.9977
Exponent model 2	b_1	1699	.9979
Log exponent model	b_0, b_1	.0484	1.000
KSI crashes v GSP			
Linear model	-		
Log-linear model	-		
Linear-log model	-		
Log-log model	-		
Exponent model 1	b_1, b_2	228.3	.9900
Exponent model 2	-		
Log exponent model	b_0, b_1	.1072	.9998

Note: Errors and R^2 are not comparable between models with different transformations

The results of these models are combined with the observed value of economic activity for each year to produce estimates of KSIs yearly as illustrated in Figure 2. This visually confirms the statistical measures and the high similarity between different explanatory variables, again despite the overemphasis resulting from the non-zero axes. In this figure, the number of KSIs annually are calculated based on the estimated relationship between the economic factor and KSIs then using the observed level of economic activity for each year.

Some particular issues need to be understood in the comparison of the alternative models shown in Table 2 and Figures 1 and 2. The best measure and model may be determined in the case when only a single explanatory variable is used, but this does not imply that the same variables, analytical techniques or models remain the most appropriate when multiple variables or transformations are applied.

All except the linear model involve transformations of at least one of the variables. However, results of statistical analyses are only directly comparable in terms of fit via the R-squared value if they involve the same transformation, or none. The lower statistical values of some models do not imply they are necessarily poorer representations of the data. As noted above, with models which use transformed data, the statistical measures are representative of the transformed data rather than the original data. The axes in Figures 1 and 2 are drawn with axes which are not at zero, in order to highlight the differences between the models, which are clearly very minor. If axes were extended to zero, the differences in the lines of each model would be indistinguishable. At the same time, if the axes were extended to zero it would also be clearer than the models closely represent the data, with small differences between the observations and any of the models, as indicated by the high R^2 values. The differences between the alternative models is best understood from the graphical representation rather than the statistical values.

Road safety outcomes are often reported against time, particularly annually. Trends over time may be reported based on OLS which will not necessarily adequately accommodate autocorrelation. Doing so also hides the nature of underlying factors which may be also be changing. One benefit of the assessment described here is to 'decouple' the estimate from time as a dependent variable, while still allowing estimations to be displayed against time.

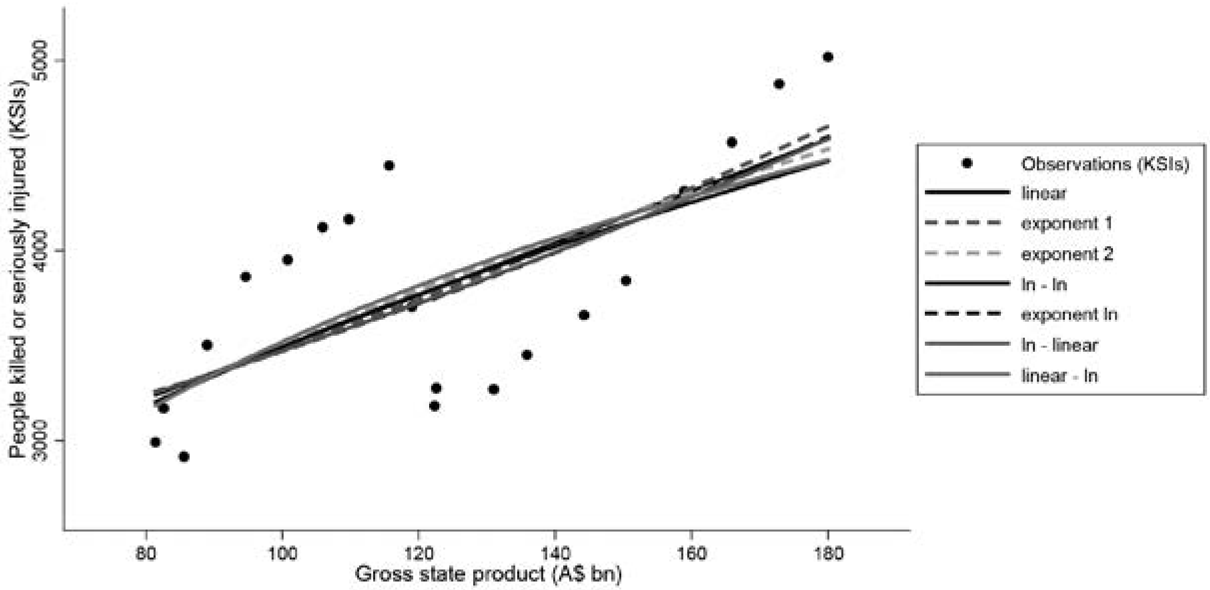

Figure 1. Graphed comparison of alternative forms of model

Table 3. Comparison of alternative economic activity as explanatory factors

Economic Activity Measure with model parameter		Coef.	Std. Err.	P>t (t test)	95% Conf. Interval low	high	RMS Error	Adjusted R-squared
Gross State Product	b_1	2420	272.6	0.000	1848	2993	453.7	.9862
(GSP)	b_2	1.000004	8.18e-7	0.000	1.000002	1.000005		
GSP per capita	b_1	1848.9	340.1	0.000	1134	2563	460.4	.9858
	b_2	1.000011	2.65e-6	0.000	1.000005	1.000017		
Gross State Income	b_1	2311	446.2	0.000	1365	3257	506.3	.9835
(GSI)	b_2	1.000026	9.17e-6	0.000	1.000006	1.00004		
GSI per capita	b_1	2540	284.7	0.000	1936	3143	441.4	.9874
	b_2	1.000008	1.90e-6	0.000	1.000004	1.000012		
Gross Domestic Income	b_1	2896	200.8	0.000	2474	3317	444.3	.9868
(GDI)	b_2	1.000006	1.28e-6	0.000	1.000003	1.000009		
Industrial Value Added	b_1	2525	269.9	0.000	1958	3092	461.9	.9857
(IVA)	b_2	1.000004	8.23e-7	0.000	1.000002	1.000005		
State Final Demand	b_1	2750	174.4	0.000	2389	3111	396.3	.9900
(SFD)	b_2	1.000014	2.51e-6	0.000	1.000009	1.000019		
Retail Turnover	b_1	2845	202.1	0.000	2427	3263	438.6	.9866
(RT)	b_2	1.00007	1.61e-5	0.000	1.000037	1.0001		
Net International Exports	b_1	3178	142.2	0.000	2881	3474	423.5	.9877
(NE)	b_2	1.00003	6.76e-6	0.000	1.00002	1.00005		

Discussion and conclusions

This introduction to a larger project which will involve further analysis followed a robust and thorough process to prepare and understand the suitability of data for the purposes of relating economic effects to road safety outcomes. Considerable amounts of relevant, appropriate and suitable data were found to be available to support the intended future analysis.

The assembled data was found to be suitable for the purpose based on visual assessments, descriptive statistics and statistical tests. Apart from minor issues, two important characteristics need to be taken into account when using the data. Collinearity between variables and groups of variables exist, so caution should be exercised when developing multivariate models. Much of the data is autocorrelated, (i.e. related over time) so attention should be given to respecting the time series nature of the data during further analysis.

Seven alternative forms of model for estimating relationships were investigated and found to produce similar results, but only an exponent model and a log transformed model were statistically valid in all four cases tested. Based on the similarity of the results of different

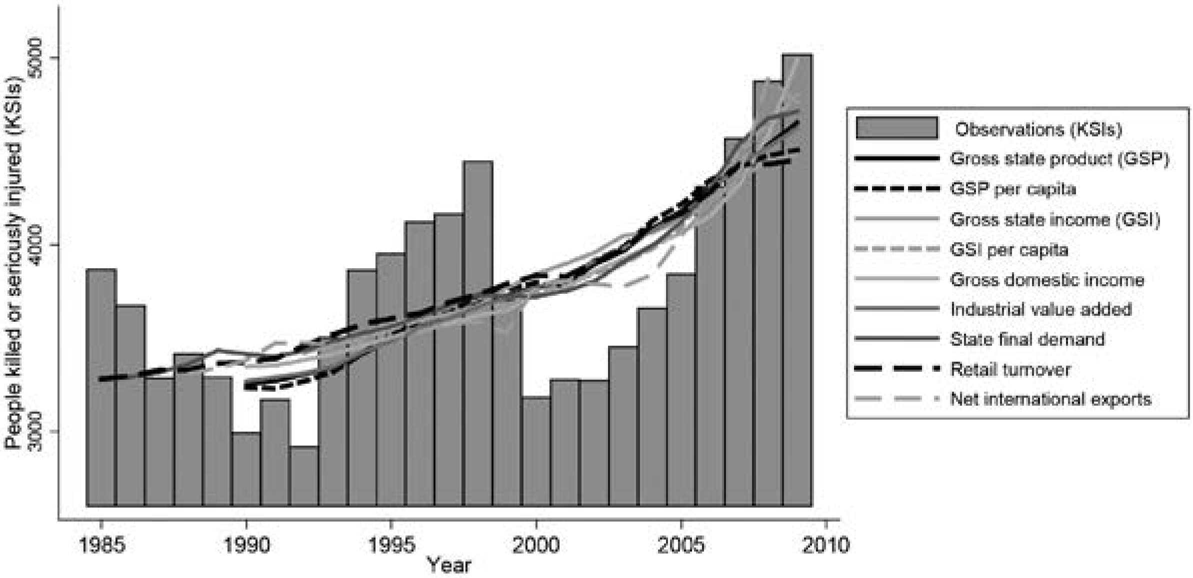

Figure 2: Estimate of people killed or seriously injured each year based on different measures of economic activity

forms of model, the exponent model 1 (equation [5]) is preferred due to statistical validity and consistency across estimates of all measures. Also, previous literature and the expectation that linearity has not been evident in many road safety outcomes over a longer period suggest linear models may not be appropriate. Compared to a linear model, the exponent model diverges at the extremities and the centre of the range which better matches the characteristics of the outcome variables being examined.

Nine alternative measures of economic activity were investigated and all found to be valid as explanatory variables, with each explaining a significant amount to the variation in the road safety outcome measures. Gross state product (GSP) is preferred as an explanatory variable due to it being a broad measure, frequently used, commonly understood and widely available. Consistent with previous studies economic activity has previously been positively correlated with increasing road safety measures (1) (2) (3) (4), however other studies have not directly compared different measures of economic activity.

Relationships were found between road safety outcomes and economic factors supporting the importance of considering these factors as relevant for understanding road safety outcomes and during investigation. While good levels of explanatory power have been found, other factors could be important in estimating road safety outcomes. Multivariate and other non-linear estimates may produce more informative results.

The data and initial information investigated in this study provides a solid foundation on which to base further investigations of relationships between economic and transport factors with road safety and subsequent investigations.

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References

1. Hakim S, Shefer D, Hakkert AS, Hocherman I. A critical review of macro models for road accidents. Accident Analysis & Prevention. 1991;23(5):379-400.
2. Zlatoper TJ. Determinants of motor vehicle deaths in the United States: A cross-sectional analysis. Accident Analysis & Prevention. 1991;23(5):431-6.
3. Van Beeck EF, Borsboom GJ, Mackenbach JP. Economic development and traffic accident mortality in the industrialized world, 1962-1990. International Journal of Epidemiology. 2000;29(3):503-9.
4. Granados JAT. Increasing mortality during the expansions of the US economy, 1900-1996. International Journal of Epidemiology. 2005;34:1194-202.
5. Gerdtham U-G, Ruhm CJ. Deaths rise in good economic times: Evidence from the OECD. Economics & Human Biology. 2006;4(3):298-316.
6. Wagenaar AC. Effects of macroeconomic conditions on the incidence of motor vehicle accidents. Accident Analysis & Prevention. 1984;16(3):191-205.
7. Reinfurt DW, Stewart JR, Weaver NL. The economy as a factor in motor vehicle fatalities, suicides, and homicides. Accident Analysis & Prevention. 1991;23(5):453-62.
8. Scuffham PA, Langley JD. A model of traffic crashes in New Zealand. Accident Analysis & Prevention. 2002;34(5):673-87.
9. Thoresen T, Fry T, Helman L, Cameron M. Linking economic activity, road safety countermeasures and other factors with the Victorian Road Toll. Monash University Accident Research Centre, 1992 Report 29.

10. Noland RB. Traffic fatalities and injuries: the effect of changes in infrastructure and other trends. Accident Analysis & Prevention. 2003;35(4):599-611.

11. Anbarci N, Escaleras M, Register C. Traffic fatalities and public sector corruption. KYKLOS. 2006;59(3):327–44.

12. Law TH, Noland RB, Evans AW. Factors associated with the relationship between motorcycle deaths and economic growth. Accident Analysis & Prevention. 2009;41(2):234-40.

13. Law TH, Noland RB, Evans AW. The sources of the Kuznets relationship between road fatalities and economic growth. Journal of Transport Geography. 2010.

14. Gaudry M. Un Abrege de DRAG, un Model de la Demande Routiere, des Accidents et de Leur Gravite, Applique au Quebec de 1956 a 1982. Montreal: Universite de Montreal, Centre de recherche sur le transports Ddse; 1986 November 1986. Report No.: Publication #698.

15. Tegnér GB, Lucassi VML. Time-series models for urban road traffic and accidents in Stockholm. TRANSEK Consultants; undated.

16. Oppe S. The development of traffic and traffic safety in six developed countries. Accident Analysis & Prevention. 1991;23(5):401-12.

17. Hughes BP, Newstead S, D’Elia A. Outcomes-Based National Road Safety Performance Measures. Australasian College of Road Safety National Conference; Melbourne, Australia 2011.

Contributed articles

United Nations Road Safety Collaboration (UNRSC)

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Establishing the UNRSC

Following the release of the World Report on Road Traffic Injuries in April 2004, the General Assembly passed a resolution, put forward by the Omani Ambassador to the United Nations, establishing the UN Road Safety Collaboration. The World Health Organisation was the UN agency assigned to chair the Collaboration. The objectives of this group are:

- To strengthen global and regional coordination on road safety through information exchange and multi-sectoral cooperation.
- To advocate and encourage demand and additional resources for road safety, including through major advocacy events.
- To support assessments of the magnitude of the road safety problem, harmonised data collection and research on risk factors implemented by its members along their own work programs and mandates, in a coordinated manner.
- To coordinate and support dissemination of documentation of good practices in prevention and road traffic injury reduction efforts in regions and countries developed by its members.
- To coordinate and support further development of guidelines for effective road safety interventions in the areas of prevention; risk management; limitation of consequences of crashes; sustainable management of road infrastructure and safety equipment; and appropriate legislative models; elaborated by its members.
- To coordinate and support further development of guidelines for appropriate legal and medical response to crashes.
- To coordinate promotion of individual and institutional capacity development on road safety implemented by its members.
- To coordinate efforts within the UN system and to encourage a culture of road safety within these organisations.

A key role of the UNRSC was to develop, and now to monitor, progress on the Global Plan for the Decade of Action for Road Safety.

In 2009, through the work of the Collaboration, the Russian Federation hosted the first Ministerial Conference on Road Safety. This forum enabled political leaders to come together and advance their ideas and commitments to road safety. Brazil has recently offered to host the Second Ministerial Conference in 2015.

The Collaboration has also been advocating to put road safety on the post-2015 Development Agenda, by calling for safe and sustainable transport to be included as a priority. The 68th Session of the UN General Assembly will consider this proposal in September, 2014.

The World Health Organisation (WHO) hosted the 19th Meeting of the UNRSC in New York on 8-9 April, 2014. More than 100 people attended representing around 40 UNRSC member governments, NGOs, foundations, private companies and universities including Lori Mooren from the University of NSW. Keynote speaker H.E. Mr A. Florencio Randazzo, Minister of Transport of Argentina, impressed the Collaboration; reporting remarkable progress on road safety in his country.

The Pillar 1 Road Safety Management Project Group, co-chaired by Ms Mooren and Marc Shotten of the World Bank is working towards documenting case studies in each Region, including Argentina, to inspire other countries in all Regions to make progress in the Decade of Action. This project will begin with a few countries seeking to outline the particular challenges and a number of ways that countries seek to address them. Argentina is an example of a Latin American country that has built a government and non-government collaboration for broad community participation in road safety. Senegal is an example of a West African nation that has a road safety program driven by an active NGO. Sweden is an example of a government led road safety approach that is trying to institute a cultural change in public attitudes to road safety. By documenting these differing approaches in differing circumstances the Project Group is offering countries at different stages of their road safety strategies to learn about ways to overcome barriers to road safety.

Pillar 2 Safer Roads and Mobility Project Group, chaired by Susanna Zammataro and Michael Dreznes, IRF, has four key focus areas for which they are developing guidance resources including: Successful integration of road safety into existing systems and policies; Road safety infrastructure management tools; ‘How To’ tips for road safety solutions in low and middle income countries; and ‘A model framework for road safety engineering capacity building’.

The Pillar 3 Safer Vehicles Project Group, chaired by Mr David Ward, FIA, is focused on harmonising international standards for safe vehicles and promoting the global new car assessment program. The Chair, advised the UNRSC that Global NCAP has written to the car manufacturers proposing a global voluntary agreement to apply the most important UN passenger car safety standards at the latest by 2020. These are:

Reg. 14	Seat belt anchorages
Reg. 16	Safety belts and restraint systems
Reg. 94	Occupant protection in frontal collision
Reg. 95	Occupant protection in lateral collision
GTR 8	Electronic stability control
GTR 9	Pedestrian protection

The Pillar 4 Safer People Project Group, chaired by Ms Gayle DiPietro, Global Road Safety Partnership, promotes development and use of the Collaboration guiding manuals, including on Speed Management, Drink Driving, Seatbelts and Pedestrian Safety. These are freely available at http://www.who.int/roadsafety/publications/en/.

The Pillar 5 Post Crash Response Project Group, chaired by Dr Margie Peden, WHO, is focused on developing strategies to advance timely medical and legal response to crash injury victims. These strategies include emergency retrieval, trauma treatment facilities, plus crash investigations and support for road injury victims and their families.

Two other Project Groups cover Monitoring and Evaluation, chaired by Dr Adnan Hyder, Johns Hopkins University; and Work Related Road Safety, chaired by Ms Awa Zarr, Laser International. These are cross-cutting Groups. The Monitoring and Evaluation Group assists to define performance indicators to enable good measurement of progress across the five main Pillars, as well as the Work Related Road Safety Project. The Work Related Road Safety Project Group aims to provide broad access to resources that can be used by employers that want to promote road safety across the five Pillars.

At the last UNRSC meeting, Dr. Etienne Krug, WHO, gave an overview of progress in the Decade of Action for Road Safety 2011-2020, highlighting the need to step up our actions in order to achieve the objectives of the Global Plan.

Participants discussed implementation of the new UN General Assembly resolution, “Improving global road safety”, which was passed on 10 April, 2014. During its formal adoption on 10 April 2014, the Russian Deputy Interior Minister, General Victor Kiryanov, the actress and ambassador Michelle Yeoh, as well as the Ambassadors to the UN of Brazil, Iceland, Israel, Jamaica, Monaco, Oman, South Africa, Syria, and the United States of America and representatives from Argentina and the United Kingdom

spoke in support of the resolution and stronger road safety action. The resolution endorses the offer of the Government of Brazil to host the Second Global Ministerial Conference on Road Safety in 2015; encourages the inclusion of road safety in the post-2015 development agenda; invites WHO to continue monitoring progress in the Decade of Action; and requests organisation of the Third UN Global Road Safety Week in 2015 on children and road safety.

The UN Road Safety Collaboration meets every six months. The next meeting will be held at WHO headquarters in Geneva on 6-7 October, 2014.

Applying online fleet driver assessment to help identify, target and reduce occupational road safety risks

by Will Murray

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Visiting Fellow, Loughborough University and Centre for Accident Research and Road Safety – Queensland, will.murray@virtualriskmanager.net

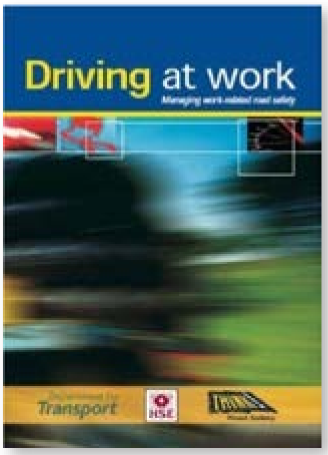
Introduction

This paper focuses on the application of online fleet driver assessment tools to help identify, target and reduce occupational road safety risks. It covers the principles of risk assessment, the uses of online tools, predictive validity analysis, intervention allocations and some suggested next steps.

Risk assessment

Driver risk assessment, monitoring and improvement is important to organisations requiring their people to travel - for a range of business, legal, financial and even societal reasons in the UK and globally. As a basic compliance-led start point in the UK, the soon to be re-launched Health & Safety Executive Guidance ‘INDG382 Driving at work: Managing work-related road safety’ says that: *organisations need to risk assess the safety of their drivers, vehicle and journeys*.

Essentially, risk assessment for any work-related driving activity should follow the same principles as those for any other work activity. It should identify and document the potential hazards; who might be harmed; and reasonable measures to support your drivers to protect themselves from harm.



A range of approaches are available for driver risk assessment, including combinations of in-vehicle assessments, psychometric tests and online assessments. Each is important, depending on the nature of the work and operating environment. Over the last 10 or so years, however, a growing number of online programs have been developed promising many benefits – particularly around costs compared to face to face assessments, reduced 'time off the tools' for employees and lower risks. Online tools allow everyone who drives on business - including car, van, occasional, two-wheeler, specialist, site vehicle and grey fleet drivers - to be included in a program that traditionally may have only catered for specialist commercial vehicle drivers.

With these developments in mind, the remainder of this article focuses on applying online fleet driver assessment to help identify, target and reduce occupational road safety risks.

Online assessments

Online assessment programs require drivers to log onto a secure internet portal and answer a series of questions, which will then generate a ranking. This is more often than not based on red, amber and green traffic lights sometimes known as a RAG rating to symbolise high, medium and low risk drivers which can be utilised:

- Pre-employment as part of recruitment pre-screening, at interview, during induction and as part of the new employee training process;
- For current staff as part of the permit to drive process; for selecting instructors and assessors; to evaluate training needs and review the success of training; and for post-collision investigation purposes; and
- In other ways such as to drive policy and process compliance; allocate company and hire cars; engage drivers in cash for car and own vehicle schemes; for high employee turnover operations; risk assessments for due diligence, insurance, underwriting and vehicle hire; as part of the business development process; and as a third party service to clients.

Depending on the background and origins of the online assessment supplier – typically in the driver training, vehicle leasing, insurance and behavioural sectors – the emphasis and content of the various assessment tools available will vary. Typically most of the available tools focus some attention on the exposure levels of the driver, the type of vehicle they drive and journeys they undertake, as well as testing combinations of their attitude, behaviour, knowledge and hazard perception. Interventions such as feedback, training, workshops or One-To-Ones will then be allocated on the basis of the risks identified.

RoadRISK assessment

As an example, at Interactive Driving Systems our online risk assessment tool, which was first developed through trials undertaken at the University of Huddersfield in the UK in 1998, is known as RoadRISK. Through its Profile, Defensive Driving and Feedback modules, which take about an hour to complete in total, RoadRISK covers each driver's personal exposure to risk, attitudes to safe driving and behaviour on the road. It has been evaluated in some detail through research undertaken at Edinburgh Napier and Loughborough universities based on large numbers of British Telecommunications (BT) drivers [1] and also through predictive validity analysis with many other organisations, including most recently the likes of Wal-Mart ASDA, Roche Australia [2], E.ON and Nestlé.

Predictive validity

Figure 1 shows the relationship between the RoadRISK assessment outcomes and the average driver claim rate for a large company car and van fleet with about 4,000 drivers. Participants identified as being at high risk on the assessment are the same drivers who have the highest collision rate. Although not perfect, this gives the organisation the opportunity to PREDICT who its most at-risk drivers are for targeting relevant next steps and interventions.

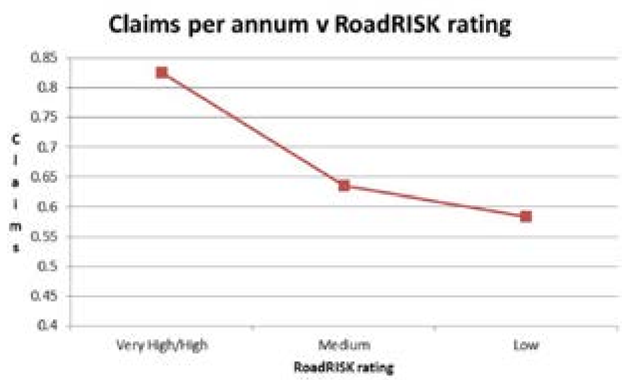


Figure 1. Predictive validity analysis for RoadRISK assessment

To give an indication of how online risk assessments have traditionally worked:

1. The 'RoadRISK: Driver Profile' is a 49 question review of each participant's personal risk exposure, the vehicle they drive and the journeys they make. As well as good practice, it also helps meet health and safety requirements for risk assessment in line with the HSE guidance mentioned above.

2. 'RoadRISK: Defensive Driving' is a 45 question assessment of participant attitude, behaviour, knowledge of the Highway Code and hazard perception on the road.

3. On completion, 'RoadRISK: Driver Feedback' reviews participant responses, providing good practice guidance and details of the next steps required as well as completion certificates.

Allocation of relevant driver safety improvement interventions

From such web-based driver assessment, outcomes data feeds into an online management information system, and recommendations are provided for interventions - such as those shown in Table 1 below.

Over the last 10 years, this approach has stood the test of time, and brought many positive benefits for the fleet industry. BT is a very good example, with its online RoadRISK assessment and engagement process touching over 80,000 employees since first being piloted in 2001. As its compliance has increased and programs have become more robust year on year, so BT's overall claim rate and costs have significantly reduced as can be seen in the following regression analysis (Figure 2).

Like many other similar organisations, BT has very successfully used its risk assessment program to drive organisational policy and process by working with its line managers and drivers to promote compliance, targeted interventions on the basis of risk and hence safer travel [3].

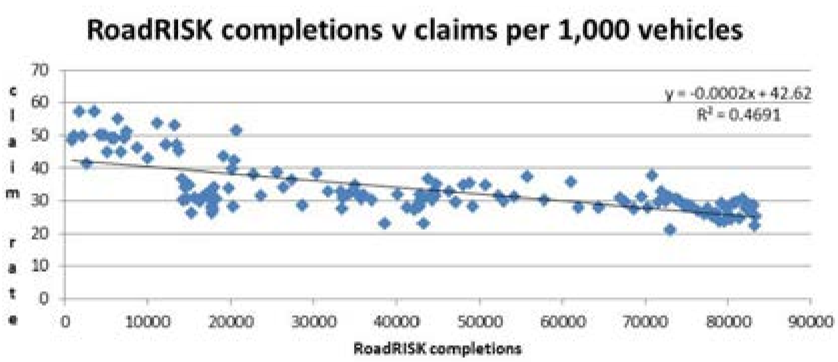


Figure 2. BT RoadRISK versus claims rate regression analysis

Table 1. Indicative risk based driver improvement interventions

Outcome	% of drivers	Typical interventions
At high risk	2 - 20	RoadRISK Profile and Defensive driving feedback Mandatory computer based training (CBT) Mandatory One-to-one with manager Mandatory group-based session In-vehicle session if required Relevant CBTs and communications as required
At medium risk	40 - 70	Profile and RoadRISK feedback Mandatory CBT One-to-one with manager if required Group-based session if required In-vehicle session if required Relevant CBTs and communications as required
At low risk	10 - 50	Profile and RoadRISK feedback Relevant CBTs and communications as required

Conclusion and next steps

Online driver risk assessment is only one part of a wider motor risk management system focusing on policy, compliance, leadership, mobility management, driver wellbeing, vehicle management, collision management and stakeholder engagement. It is, however, in many cases the glue that binds all these areas together.

Driver risk assessment, monitoring and improvement has many uses and benefits for organisations requiring their people to travel, and is evolving in several ways including focusing more on policy compliance and driver commitment, as well as through increasingly sophisticated online coaching modules for drivers and managers.

With technology and data converging, online risk assessment results are also being securely integrated with information from other sources such as collisions and claims, license checks, in-vehicle telemetry systems, fuel, tyres, observed violations, tachographs and training to provide an overall picture of each driver, and the organisations' risks from which highly cost effective driver and manager level interventions, such as coaching and One-To-Ones, can be developed on the basis of need.

As well as some peace of mind with regards to meeting the requirements of documents such as the UK HSE's 'Driving at work: Managing work-related road safety' guidance INDG382 and other basic legal requirements such as the Highway Code or Rules of the road, if used well online programs offer many other opportunities to drive road safety a long way down the road to compliance and beyond.

When reviewing the market for online driver risk assessment tools, it is advisable to look around, and discuss the options with your insurer, vehicle leasing and driver training suppliers. Most good suppliers will also: offer dedicated support; assist with business cases; supply details of their research and predictive validity analysis; be willing to set up detailed pilot studies; provide excellent references, case studies and benchmarks; and, have the capability to integrate the types of external data described.

References

1. Darby P, Murray W. and Raeside R. Applying online fleet driver assessment to help identify, target and reduce occupational road safety risks. Safety Science. 47, 2009, 436-442.
2. Murray W, White J and Ison S. Work-related road safety: A case study of Roche Australia. Safety Science. 50 (1), 2012, 129-137.
3. Wallington D, Murray W, Darby P, Raeside R and Ison S. Work-Related Road Safety: Case Study of British Telecommunications (12-1196). Paper presented at the 91st Annual Meeting of the Transportation Research Board, Washington, D.C., January 22-26, 2012.

www.virtualriskmanager.net/validation provides more detail about validation studies for online driver risk assessment tools.

Improving road safety through truck visibility

By Pippa Batchelor

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Introduction

The Global Decade of Road Safety aims to reduce road deaths ideally to zero by 2020. Adopting visibility markings on heavy vehicles as in Europe, US, Canada and China could help to prevent fatal incidents on Australian roads.

Research studies

A leading university study in Germany found that more than 95% of night time accidents from the rear or side of a truck could be reduced by using outline vehicle visibility markings [1]. A truck, defined as a vehicle over 7.5 tonne gross weight, with outline reflective markings is recognised earlier than an unmarked truck. Using this visual information, a road user can deduce the likely type of the vehicle ahead, proximity and probable speed, giving them the best chance and more time to manoeuvre safely [2].

There are several other studies that provide compelling results for the introduction of vehicle markings. The US introduced mandatory vehicle markings in December 1993 to all new heavy vehicles. A study commissioned by the National Highway Traffic Safety Administration assessed the effectiveness of these vehicle markings in reducing truck accidents, with the study area covering Florida and Pennsylvania. They concluded that tape reduced side and rear impacts by up to 44% in dark conditions. The paper found that the tape was effective in all adverse weather conditions (except fog). Additionally, the study estimated the number of fatalities that could be saved, as well as other injuries, if tape was applied to all heavy vehicles. This conclusion lead to the mandating of retrospective application of reflective markings to all heavy vehicles and their trailers in 1999 [3].

Schmidt-Clausen conducted an extensive study in Europe which monitored 1000 trucks with reflective markings applied. The study concluded that reflective contour

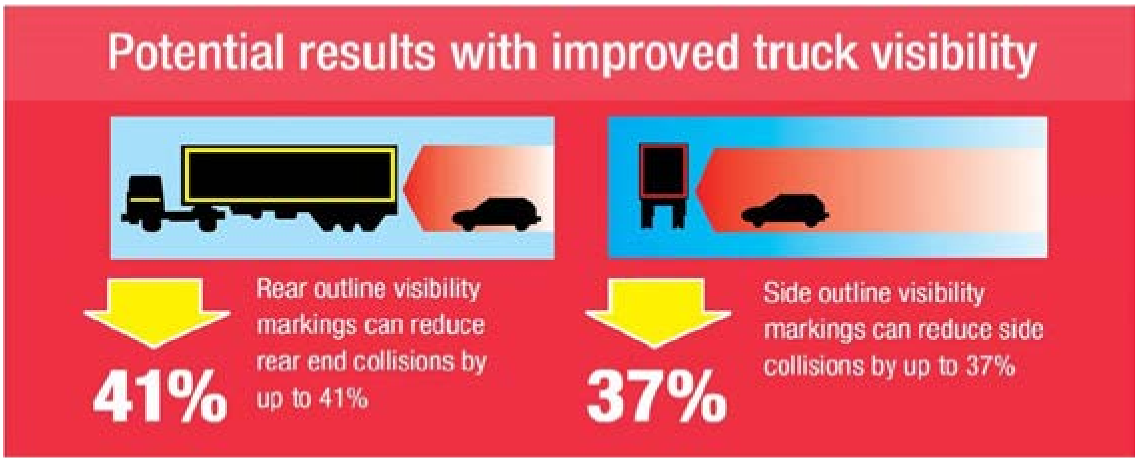

Figure 1. Reflective contour markings improve truck visibility

markings on a vehicle would on average reduce rear collisions into the truck by 44% and side collisions by 37% [1].

Australian best practice

Currently, ADR13/00 refers to the UNECE104 regulation for best practise vehicle marking. In order to be compliant with UNECE104, reflective tapes must be independently tested for photometric and physical performance. They are then awarded a unique identifier number which is printed (repeating) along the length of each tape. The regulation allows red, white and yellow tapes. Fluorescent yellow also fits into the yellow colour requirements and gives additional daytime visibility benefits. The Australian Trucking Association has produced a free Technical Advisory Procedure booklet which outlines these best practices for trucks. As a basic guide, the markings should cover at least 80% of the overall length of the vehicles and indicate its full outline. As a minimum, partial markings should be applied:

Benefits

Between July 2012 and June 2013 there were 192 incidents involving at least one heavy vehicle, which resulted in 231 fatalities on Australian roads. Of these, 132 fatalities involved multiple vehicles, at least one of which was a heavy vehicle. During the same period BITRE has reported that 38% of accidents occurred at night, suggesting that 50 fatalities were linked to incidents involving multiple vehicles at least one of which was classed as a heavy vehicle during hours of darkness. If the benefits seen in the US and European studies could be assumed to be true for Australian road environments, potentially nineteen fatalities could have been avoided during that period [4].

The cost of application of reflective vehicle marking tape is dependent on vehicle type but is in the range of $250 - $500 per vehicle if self-applied. A biannual study by the National Centre for Truck Accidents looks at incidents involving trucks every other year and the claims made through NTI. In the latest 2013 report they determined the average cost of a claim was over $118,000 AUD [5].

Australian research

Australia has some of the heaviest road transport configurations as well as some of the highest speed limits. Research from other countries shows potential crash reductions of relevant crash types from the use of conspicuity markings, and estimated cost-benefit ratios have been generally positive. There is a need for more research on the potential effectiveness of improved conspicuity markings for heavy vehicles in Australia, particularly with regard to cost-benefit ratios and the many variables to consider in such calculations. However, the available evidence suggests that a significant reduction in conspicuity-related crashes is possible with appropriate application of high quality conspicuity markings.

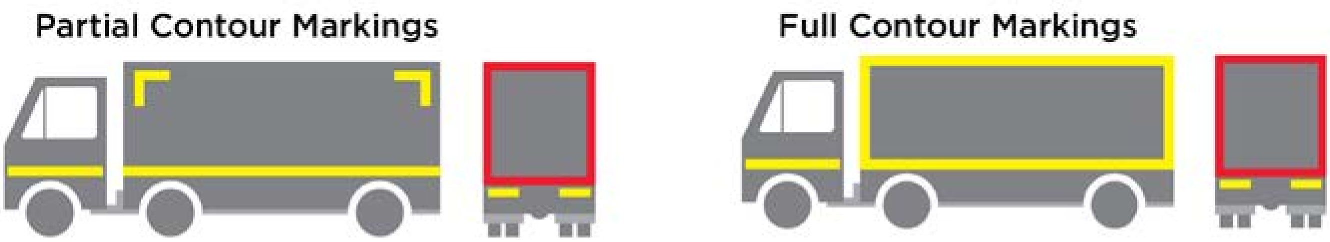

Figure 2. New mandatory markings for European Union countries under UN/ECE104

3M has joined together with the Victorian Transport Association to ascertain the benefits of high performance vehicle markings on heavy vehicles working on the Australian network. Murray Gouldburn and FBT Transwest are fully involved in the study to help determine how the Australian road transportation industry could further reduce the incident rates.

References

1. Prof. Dr.-Ing. H.-J. Schmidt-Clausen, Laboratory of Lighting Technology, Darmstadt University of Technology: Contour marking of vehicles, final report FO 76 / 00
2. LBI Unfallforschung Austria: Viewing Behaviour Survey / 2001
3. NHTSA Technical Report DOT HS809222. The Effectiveness of retroreflective tape on heavy trailers. March 2001.
4. BITRE, Road Deaths Australia Annual Report 2013.
5. Owen P. Driscoll - Major Accident Investigation Report 2013 – National Transport Insurance, National Centre for Truck Accident Research.

Photographs showing day and night images of an FBT Transwest tanker with high visibility reflective markings.

RACV takes a global approach to road safety

Victoria's actions and achievements were recognised by HRH Prince Michael of Kent when he presented the Decade of Action Award to Victorian Deputy Premier Peter Ryan at Parliament House, representing the State Government of Victoria, in May.

Prince Michael is Patron of the Commission for Global Road Safety and was in Melbourne to attend the Commission's 2014 Policy and Donor Forum. He created the award in 2012 in partnership with the Commission to showcase the most significant achievements made in support of the UN Decade of Action for Road Safety 2011-2020. The award states, "The State of Victoria has pioneered many road safety innovations that are new, admired and influencing road safety policy and practice around the world."

In light of these achievements, the following article provides some detail on the work being conducted by RACV in improving road safety.

Contact for correspondence: Robert Hogan, Manager Corporate Communications,
Royal Automobile Club of Victoria (RACV) Limited, 550 Princes Highway, Noble Park North, VICTORIA 3174, Tel: 03 9790 2620

The mission is straight forward: reduce the global loss of life and trauma associated with road crashes. It is a lofty objective but not surprising considering that almost 1.3 million people die every year on the world's roads, and another 50 million are injured. But, even with the United Nations and more than 100 countries committing to a universal strategy, the challenge is colossal.

The United Nations' Decade of Action for Road Safety 2011-2020 is the catalyst for the nonpartisan international effort to reduce the road toll. However, it is an objective that cannot be achieved by nations alone. International agencies, civil society and industry sector organisations and businesses have aligned with governments in the historic campaign. One of those organisations is RACV, a leader in promoting road safety and safe motoring practices.

Above: RACV Managing Director and CEO, Colin Jordan speaking at the Global Road Safety Commission's 2014 Policy and Donor Forum held at the RACV City Club Melbourne in May.

Led by Managing Director and Chief Executive Officer Colin Jordan, RACV has developed its own agenda to complement the UN Decade of Action program. As well as the Club's activities in Victoria and nationally, RACV and Mr Jordan have played significant roles internationally.

Mr Jordan is a former President of the Paris-based World Road Association, which has 120 member countries, and is a member of the distinguished 15-person Commission for Global Road Safety. He was strongly credentialled to host and chair the Commission's 2014 Policy and Donor Forum at the RACV City Club in May.

The invitation-only forum brought together 149 experts from across the broad spectrum of road safety and focused on a range of issues, including health, funding, safety and implementation. It was hosted by RACV and co-organised by the Australian Automobile Association (AAA), the Commission for Global Road Safety and the FIA (Fédération Internationale de l'Automobile) Foundation's Road Safety Fund.

Mr Jordan told the forum that the next 18 months would be critically important for road safety and the UN's Decade of Action. He highlighted four priorities in the quest to improve global road safety: building momentum toward the Global Ministerial Conference in Brazil at the end of 2015; securing the inclusion of a road safety target in the UN's post-2015 agenda; encouraging new sources of donor funds from the private sector and philanthropies; and ensuring that existing country donors, including Australia, maintain and even increase the scale and scope of their engagement.

However, he warned that to secure political support and financial commitments advocates for road safety must be able to measure the problems and demonstrate effective solutions.

While RACV is active in attempting to stem the global epidemic of road traffic injuries, the Club's programs are also achieving positive results at the local level in Victoria, which has become a world leader in road safety. Last year, the state recorded a record low 242 fatalities, equating to 4.24 deaths per 100,000 population. This figure is second only to the Australian Capital Territory in Australia.

RACV works with the Victorian Government on several projects but is calling for stronger targets and actions. An important role is monitoring the state Road Safety Strategy and Action Plan, which outlines a number of initiatives to improve road safety. An RACV report card charts the progress of these actions and highlights in which areas greater focus is needed.

RACV believes that everyone has a responsibility to contribute to making roads safer. It conducts a broad-based and vigorous program of encouraging its 2.1 million members to become involved and reaches out to specific groups in the community. At grassroots level, RACV urges members to contact their local Victorian Member of Parliament and ask what he or she will do to improve the safety of roads in their suburb, town or city.

The RACV website, www.racv.com.au, informs members of services available to them and also urges motorists to share responsibility for improving road safety. It is accessible to all motorists and offers road safety information, advises how RACV can help people using roads to be safe and discusses what individuals can do to contribute to safer travel on our roads.

RACV has developed guides and programs to enhance road safety awareness for all ages, from parents with children through to senior drivers.

Parents are urged to undertake their own research when buying child restraints and RACV provides detailed on-line guides to help ensure young people will be safe when travelling. The Child Restraint Evaluation Program (CREP), a partnership of five other organisations, provides test results that are an important guide to those responsible for selecting child seats, particularly as the latest CREP tests demonstrate that not all restraints meet the required safety standards.

CREP tests restraints in three categories: rear-facing restraints for babies up to six months and about 12 months; forward-facing restraints for young children aged six to 12 months to under four years; and booster seats for children four years and older.

Road trauma is the leading cause of unintentional-injury deaths for children aged 0-14 years and RACV has designed Street Scene specifically for this group. It is a program that provides educators free of charge for road safety sessions in primary schools. Information for parents complements the program.

Above: Students from St Anthony's Catholic Primary School Noble Park, one of the 250 schools involved in the RACV Street Scene Primary School Program.

Another free program aimed at young people is Transmission, for Victorian Year 9-12 students. Participants learn about road safety and use their imagination to create a community service announcement for television. The most outstanding design is professionally produced and aired on television. The program may be integrated into an existing component of study or be an extra-curricular activity.

There are other services for young drivers, including keys2drive, a national federally-funded education program that provides a free one-hour specialised lesson to learner drivers and their supervisor. RACV Drive School instructors are accredited to deliver the lessons. The keys2drive session provides an opportunity for the learner driver and their supervisor to learn together.

RACV also joined with other road safety agencies and stakeholders to deliver Fit to Drive, or F2D, an initiative for senior secondary students that aims to improve the safety of young drivers and their passengers. The program incorporates the notion that young people have the capacity to change attitudes in relation to risky driving and supports them to take ownership and responsibility for their own and their peers' safety.

A partnership with Victoria Police, the state fire services, VicRoads, TAC and the Department of Education and Early Childhood Development; F2D coordinates road safety resources and their delivery to students at secondary schools. The program started in 2001 at 18 secondary schools in Frankston and on the Mornington Peninsula and now has expanded across Melbourne and throughout Victoria.

At the next level, the P Drivers Project involves P-platers who complete surveys to connect and voice their opinions and experiences of being a new driver, and share some of the challenges they face. Many will also attend locally run group discussions and a session with a driving coach to help them be safer drivers. The project is one of the largest and most complex scientific research studies in the world undertaken in the area of driver education designed to improve the safety of new P-plate drivers. RACV is a member of the project's steering committee, along with VicRoads, Transport for NSW and the TAC.

RACV also has developed a range of resources for drivers at the other end of the age spectrum. A valuable introduction is Years Ahead, a free presentation for older road users to help them to remain safe on the road for as long as possible. Delivered by trained presenters to groups and clubs, Years Ahead covers road safety tips, choosing a safe vehicle, the importance of being fit to drive, the impact of health and medications on driving and planning for future mobility.

RACV acknowledges that dementia is an increasingly common disease and, supported by Alzheimer's Australia (Victoria), has produced Australia's first comprehensive guide to the issues surrounding driving and dementia. Developed for health professionals, carers, families, friends and people with the disease, *Dementia, Driving and Mobility Guide*, provides a summary of the key issues and describes what other mobility options exist for people who can no longer drive. As the incidence of dementia increases, the guide has been widely welcomed. More than 75,000 Victorians are living with dementia and it is estimated that about one-quarter of people aged 85 years and over will develop the disease.

All these programs are aimed at individuals but RACV also is committed to improving the safety of vehicles and roads. “Safer cars save lives,” says Colin Jordan.

RACV advocates that one of the most important features of any car is the level of protection offered to its occupants in a crash. To assist car buyers to make an informed choice, RACV, through its involvement in the Australasian New Car Assessment Program (ANCAP), has conducted vehicle crash testing and then published the results for more than 20 years. RACV specialist vehicle engineers attend the crashes and provide technical input to the assessments.

The crash tests are highly complex and technical and ANCAP assigns a one-to-five-star rating as an easy-to-understand measure of a vehicle’s occupant protection.

RACV promotes similar scrutiny of used cars and distributes Used Car Safety Ratings (USCR). Records from more than five million vehicles in police-reported crashes in Australia and New Zealand between 1996 and 2012 were analysed by Monash University’s Accident Research Centre to calculate ratings. Using that foundation, UCSR driver protection ratings continue to be recalculated based on the most recent data available. Models that cause lower injuries to unprotected road users are awarded a “Safe Pick” label.

As the features of cars become more sophisticated, buyers need to understand the function and benefits of new vehicle safety technologies. To assist this understanding, RACV offers all motorists online information and advice. The information is categorised into six detailed sections: airbags, brakes, lighting, neck and spine protection, seating and tyres.

Of course, motoring is an experience that involves not only people and vehicles, but roads as well. RACV advocates the crucial importance of safer roads in reducing trauma and is involved in the Australian Road Assessment Program (AusRAP), which maps risk, tracks performance, measures safer road investment plans and allocates star ratings for safety.

AusRAP aspires to help Australia become a nation free of high-risk roads. It is run by the Australian Automobile Association and state and territory motoring clubs. The program is part of the International Road Assessment Program and supports the Decade of Action for Road Safety 2011-2020.

An updated assessment of Victoria’s National Highway network was released this year.

RACV is a key player in improving road safety and has worked with the Victorian Government, other organisations and institutions to achieve the best outcomes for the community during the Decade of Action. These stakeholders have all contributed to Victoria’s position as a world leader in road safety.

Much has been achieved, both in Australia and internationally, but Colin Jordan believes that success in combating road trauma will come only from united local, national and global efforts. He says that reducing the occurrence and the burden of serious road-related injury will continue to be a fundamental priority for RACV.

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