TAC-MUARC Enhanced Crash Investigation Study (ECIS): Key findings

Associate Professor Michael Fitzharris, on behalf of the ECIS Investigators and the ECIS Team

Enhanced Crash Investigation Study (ECIS) Symposium
Melbourne (online)
Friday, 20 November 2020
Acknowledgement

The ECIS Investigators express their sincere gratitude to the injured drivers and families who participated in the study.

Drivers and families participated at an extremely challenging time in their lives. Being involved in a crash and admitted to hospital is traumatic, overwhelming and is a period of great uncertainty.

We are indebted to the drivers and their families who voluntarily gave their time and consented to participate in the study. This was done with the expectation that the lessons learnt will improve road safety in Victoria.

Our commitment to you is to work hard on ensuring that the findings are used to create the safest road transport system possible and to ensure every person gets home safely, every time.

Note: The conduct of the ECIS Case Study was approved by the research ethics committees of The Alfred Hospital Research Ethics Committee (HREC, Project: 249-14), The Royal Melbourne Hospital HREC (HREC, Project: 249-14), and the Monash University HREC (CF14/2329-2014001254). The conduct of the ECIS Control study was approved by the Monash University HREC (CF14/1930-2014000983).

For full detail and citation details, see ECIS Report 1, available at https://www.monash.edu/muarc [MUARC Report 343]
Rationale for ECIS

- Serious injury is associated with significant physical and mental health impacts for those involved

- The ripple effect of serious injury across the community is large

- The TAC has the legislative responsibility to reduce the incidence of crashes and to facilitate the post-crash care, rehabilitation and other assistance to all persons injured

- The TAC has committed to being the world’s leading social insurer, facilitating optimal recovery and maximising independence for the most seriously injured

- In *TAC 2020*, the TAC committed to the ambition of eliminating serious injury from Victorian roads

- ECIS was designed to provide the TAC and the Victorian Road Safety Partners insight into how crashes occur and to identify ways to reduce, and ultimately eliminate, serious injury
ECIS Objective

Through a forensic examination of 400 drivers involved in serious injury crashes, ECIS had the objectives of:

- Determining the factors associated with crash occurrence
- Determining the factors associated with injury severity
- Identifying measures that would be effective in preventing occupants of vehicles being seriously injured in the event of a crash, in addition to identifying crash prevention measures
ECIS structure and design

**ECIS Case Arm** (crash-involved drivers)
- 400 injured drivers, admitted to The Alfred or the Royal Melbourne Hospital
- Conducted over 28 months (August 2014 – December 2016)
- In the same period, 6654 drivers admitted to all Victorian hospitals and made a TAC Claim (ratio of 1:16)

**ECIS Control Arm** (non-crash drivers)
- 1536 drivers that safely navigated through one of 228 ECIS crash sites
- Completed a survey with vehicle speed recorded covertly
- Goal was to compare against ‘case’ drivers, to examine risk factors for being involved in a crash
ECIS Case Arm: Crash investigation

- Our Research Nurses obtained participation from the driver or their family following admission to The Alfred or the Royal Melbourne

  “I was heading out with my boyfriend and ….”

- Our team inspected the vehicle and the scene, obtained all possible information, and reconstructed the crash

- Synthesised each crash to determine presence or absence of factors across the human, vehicle and road environment that contributed to crash occurrence and injury severity
ECIS Control Arm: Measuring speed and estimating risk

- Objective was to estimate ‘risk’ of crash involvement
- Vehicle speed measured on same week day, within a 30-minute window of the ECIS crash
- 1536 drivers completed a detailed survey, from 4629 surveys sent via the TAC (33.2% response rate)
- Survey responders were travelling on-average slightly faster than non-responders
Injury severity metrics: defining ‘serious’ injury

- Multiple measures of injury severity, including length of stay, ICU admission, discharge destination were collected
- Injuries were coded according to the AAAM Abbreviated Injury Scale (AIS)
- ECIS adopted MAIS 3+ as the definition of ‘serious injury’

<table>
<thead>
<tr>
<th>AIS SEVERITY</th>
<th>AIS SEVERITY DESCRIPTOR</th>
<th>MAIS CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 1</td>
<td>Minor</td>
<td>MAIS 1</td>
</tr>
<tr>
<td>AIS 2</td>
<td>Moderate</td>
<td>MAIS 2</td>
</tr>
<tr>
<td>AIS 3</td>
<td>Serious</td>
<td></td>
</tr>
<tr>
<td>AIS 4</td>
<td>Severe</td>
<td></td>
</tr>
<tr>
<td>AIS 5</td>
<td>Critical</td>
<td></td>
</tr>
<tr>
<td>AIS 6</td>
<td>Maximal</td>
<td>MEAS 3+</td>
</tr>
</tbody>
</table>
ECIS crashes and involved road users

- **400** ECIS Drivers
- **523** Other road users involved
- **17** Died
- **548** Hospitalised
- **358** Minor or Uninjured
- **393** Number of crashes

**August 2014 – December 2016**

Timeframe of crashes
Crashes included drivers of all ages from across Victoria.
Injury severity was high, especially in crashes in regional Victoria.
Injury severity differed by crash type; so too did length of medical care.
Crash occurrence: Driver-based contributing factors

- All [393]:
  - Performance failure: 86.5%
  - Health and driver state: 41.7%
  - Non-compliant behaviour: 56.2%

- Lane Departure [199]:
  - Performance failure: 81.4%
  - Health and driver state: 54.8%
  - Non-compliant behaviour: 52.3%

- Across Path [117]:
  - Performance failure: 94.0%
  - Health and driver state: 22.2%
  - Non-compliant behaviour: 82.9%

- Rear Impact [68]:
  - Performance failure: 88.2%
  - Health and driver state: 39.7%
  - Non-compliant behaviour: 26.5%
### Driver performance failures contributed to crash occurrence

<table>
<thead>
<tr>
<th>Error</th>
<th>Percent of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail to see traffic signs / signals</td>
<td>6.1%</td>
</tr>
<tr>
<td>Fail to see hazard / not look</td>
<td>11.5%</td>
</tr>
<tr>
<td>Judgement error</td>
<td>16.3%</td>
</tr>
<tr>
<td>By other driver</td>
<td>21.6%</td>
</tr>
</tbody>
</table>

### Behaviour - Driving Task

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Percent of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inappropriate gap</td>
<td>5.9%</td>
</tr>
<tr>
<td>Driving adverse to conditions</td>
<td>18.6%</td>
</tr>
<tr>
<td>Unsafe action</td>
<td>25.7%</td>
</tr>
</tbody>
</table>

### Inattention

<table>
<thead>
<tr>
<th>Inattention</th>
<th>Percent of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside vehicle</td>
<td>11.7%</td>
</tr>
<tr>
<td>Self / inward focus (thoughts)</td>
<td>15.3%</td>
</tr>
<tr>
<td>Activities in vehicle</td>
<td>5.6%</td>
</tr>
<tr>
<td>Passenger interactions</td>
<td>5.1%</td>
</tr>
<tr>
<td>Technology (phone use)</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

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**Error** more prominent in Across Path (70.1%) and Rear Impact (70.6%) crashes than Lane Departure (49.2%)

- Lane Departure: vehicle control (31.7%); judgement error (16%)
- Across Path: fail to see (20%); judgement error (18%)
- Rear Impact: fail to see (20%); judgement error (10%)

**Behaviours** more prominent in Rear Impact (55.9%) crashes than Across Path (41.0%) and Lane Departure (41.2%)

- Lane Departure: drive adverse to conditions (26%); unsafe act (20%)
- Across Path: unsafe act (36%)
- Rear Impact: inappropriate gap (32%); unsafe act (23%)

**Inattention** highest in Rear Impact (54.4%) crashes with Lane Departure (50.8%) similar, then Across Path (41.9%)

- Lane Departure: thoughts (18%); outside (10%); activity in veh. (7%)
- Across Path: thoughts (14%); outside (12%); passenger (7%)
- Rear Impact: outside (13%); passenger (7%); phone (6%)
Health and driver state factors contributed to crash occurrence

<table>
<thead>
<tr>
<th>Health Factor</th>
<th>Percent of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute / Transient Illness</td>
<td>5.6%</td>
</tr>
<tr>
<td>Medical (Physical) Condition</td>
<td>14.5%</td>
</tr>
<tr>
<td>Mental Health / Psych Distress</td>
<td>12.2%</td>
</tr>
<tr>
<td>Self-harm</td>
<td>0.5%</td>
</tr>
<tr>
<td>Effects Prescribed Medication</td>
<td>6.6%</td>
</tr>
<tr>
<td>Benzodiazapines</td>
<td>2.0%</td>
</tr>
<tr>
<td>Opioid/narcotic analgesics</td>
<td>2.8%</td>
</tr>
<tr>
<td>Driver State</td>
<td>25.5%</td>
</tr>
<tr>
<td>Drowsy</td>
<td>17.6%</td>
</tr>
<tr>
<td>Fell asleep</td>
<td>7.9%</td>
</tr>
</tbody>
</table>

**Acute:** Lane Departure (6%); Across Path (4%); Rear Impact (6%)

**Medical:** Lane Departure (18%); Across Path (6%); Rear Impact (18%)

**Mental health conditions and/or psychological distress:** Lane Departure (17%); Across Path (8.5%); Rear Impact (6%)

**Adverse effects of prescribed medication** more common in Lane Departure (10%) than Rear Impact (4.4%) with few in Across Path (1.7%)

**Driver state** more common in Lane Departure crashes (37%), including drowsy (23%) and fell asleep (14%)
- Across Path: drowsy (12%); fell asleep (0%)
- Rear Impact: drowsy (15%); fell asleep (4%)
Non-compliant behaviour contributed to crash occurrence

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Across Path</th>
<th>Rear Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail to yield</td>
<td>10.7%</td>
<td></td>
</tr>
<tr>
<td>Disregard instruction</td>
<td>13.7%</td>
<td></td>
</tr>
<tr>
<td>Exceed speed limit</td>
<td>26.2%</td>
<td></td>
</tr>
<tr>
<td>- Exceed 1-5 km/h</td>
<td>9.7%</td>
<td></td>
</tr>
<tr>
<td>- Exceed 6-9 km/h</td>
<td>6.1%</td>
<td></td>
</tr>
<tr>
<td>- Exceed 10+ km/h</td>
<td>10.4%</td>
<td></td>
</tr>
<tr>
<td>Alcohol &amp;/or illicit present</td>
<td>19.1%</td>
<td></td>
</tr>
<tr>
<td>- Alcohol (BAC)</td>
<td>11.2%</td>
<td></td>
</tr>
<tr>
<td>- Illicit drugs</td>
<td>12.7%</td>
<td></td>
</tr>
<tr>
<td>Traffic light / sign</td>
<td></td>
<td>1%</td>
</tr>
</tbody>
</table>

Exceed speed limit was the most prominent single factor but differed across crash type
- Lane Departure: 34%
- Across Path: 22%
- Rear Impact: 13%

More prominent in MAIS 3+ crashes (36.6%)
- Lane Departure: 40%
- Across Path: 36%
- Rear Impact: 14%

Alcohol &/or other drugs more common in Lane Departure (29%) compared to Across Path (8%) and Rear Impact (10%)
- Lane Departure: Alcohol (17.6%); Illicit (19.6%)
- Across Path: Alcohol (4.3%); Illicit (4.3%)
- Rear Impact: Alcohol (5.9%); Illicit (7.4%)
Driver factors: Travel speed was associated with crash involvement

- **Question:** What is the association between travel speed and crash risk?
- **Case:** Control analysis of 146 crashes (247 drivers cf. 1039 drivers; ratio: 4.2)
- **Key finding:** Robust relationship exists between travel speed and crash risk
  - Increased crash risk with exceeding the speed limit
  - Safety benefit travelling below the speed limit

**FAST FACT:**
“Only a little bit over” matters: exceeding the speed limit by 3 km/h is associated with a 25% increase in crash risk (OR: 1.25, 95% CI: 1.18 - 1.32)

<table>
<thead>
<tr>
<th>TRAVEL SPEED RELATIVE TO SPEED LIMIT (KM/H)</th>
<th>OR</th>
<th>95% CI LOWER</th>
<th>95% CI UPPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15</td>
<td>0.33</td>
<td>0.25</td>
<td>0.44</td>
</tr>
<tr>
<td>-10</td>
<td>0.48</td>
<td>0.40</td>
<td>0.58</td>
</tr>
<tr>
<td>-5</td>
<td>0.69</td>
<td>0.63</td>
<td>0.76</td>
</tr>
<tr>
<td>0</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>1.44</td>
<td>1.31</td>
<td>1.59</td>
</tr>
<tr>
<td>10</td>
<td>2.09</td>
<td>1.72</td>
<td>2.53</td>
</tr>
<tr>
<td>15</td>
<td>3.01</td>
<td>2.26</td>
<td>4.01</td>
</tr>
</tbody>
</table>

Statistical model: Conditional logistic regression, age/sex adjusted, excludes alcohol/illicit drug
Matched: day of week, 30-minute crash window; vehicle/movement
Impact speed determines the severity of injuries sustained

- Probability of sustaining MAIS 3+ injury is strongly associated with impact speed
- Shows the limits of human body to withstand injury and the limits of the vehicle to protect drivers and occupants from serious injury; points to need to improve vehicle safety and reduce impact speeds

Statistical model used was logistic regression. Frontal model: adjusted for collision object, SVC/MVC.
Side impact model: impact speed only

FAST FACT:
29% of drivers attempted to avoid the crash by steering

FAST FACT:
45% of drivers failed to brake pre-crash. Those who braked (55%) did so for 1.3 seconds on average, reducing pre-crash travel speed by 31%
Injury severity also depends on the collision object

- Injury severity differs by the collision object
- Highlights the problem of vehicle incompatibility
- Demonstrates the harm associated with tree impacts and impacts with rigid objects
- Seat belt non-use was also associated with high injury severity
- Half of the ECIS drivers were trapped in their vehicle due to high levels of vehicle crush associated with high impact speeds

<table>
<thead>
<tr>
<th>Collision Object</th>
<th>MAIS 1</th>
<th>MAIS 2</th>
<th>MAIS 3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSENGER CARS</td>
<td>28.1%</td>
<td>32.4%</td>
<td>39.6%</td>
</tr>
<tr>
<td>Light/Small/Medium</td>
<td>31.9%</td>
<td>31.9%</td>
<td>36.2%</td>
</tr>
<tr>
<td>Large</td>
<td>20.0%</td>
<td>33.3%</td>
<td>46.7%</td>
</tr>
<tr>
<td>SPORTS UTILITY VEHICLE</td>
<td>17.8%</td>
<td>33.3%</td>
<td>48.9%</td>
</tr>
<tr>
<td>COMMERCIAL VEHICLE</td>
<td>15.4%</td>
<td>24.8%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Car-based utility</td>
<td>20.0%</td>
<td>20.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Utility / 4WD / Van</td>
<td>20.0%</td>
<td>20.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Truck / Bus</td>
<td>10.0%</td>
<td>30.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>ROADSIDE OBJECT</td>
<td>19.3%</td>
<td>33.6%</td>
<td>47.1%</td>
</tr>
<tr>
<td>Tree</td>
<td>9.9%</td>
<td>31.0%</td>
<td>59.2%</td>
</tr>
<tr>
<td>Pole</td>
<td>12.5%</td>
<td>41.7%</td>
<td>45.8%</td>
</tr>
</tbody>
</table>

Other object                      | 37.8%  | 33.3%  | 28.9%   |

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
At impact, the vehicle is the last line of defence: 5-stars matter

- Strong association between driver injury severity and ANCAP star rating
- Demonstrates the benefit of vehicle safety technology and that 5-stars matter

<table>
<thead>
<tr>
<th>YEAR OF MANUFACTURE</th>
<th>ANCAP 5-STAR</th>
<th>MAIS 3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014–2016</td>
<td>86.2%</td>
<td>17.2%</td>
</tr>
<tr>
<td>2011–2013</td>
<td>75.0%</td>
<td>35.0%</td>
</tr>
<tr>
<td>2006–2010</td>
<td>30.3%</td>
<td>45.5%</td>
</tr>
<tr>
<td>2001–2005</td>
<td>4.8%</td>
<td>51.9%</td>
</tr>
<tr>
<td>1996–2000</td>
<td>0.0%</td>
<td>58.6%</td>
</tr>
<tr>
<td>1991–1995</td>
<td>0.0%</td>
<td>48.1%</td>
</tr>
<tr>
<td>1990 and earlier</td>
<td>0.0%</td>
<td>51.6%</td>
</tr>
<tr>
<td>All</td>
<td>22.5%</td>
<td>47.0%</td>
</tr>
</tbody>
</table>
All vehicles have limits: the problem of high impact speed

- Majority of crashes occur at impact speeds above the ability of the vehicle to protect the driver from serious injury
- Based on the vehicle ‘safety envelope’ defined by impact speed. The threshold impact speed is linked to crash tests and differs by ANCAP safety rating, impact point and collision object

Note: threshold impact speed based on vehicle ANCAP star-rating, collision object and impact point on vehicle

<table>
<thead>
<tr>
<th>Crash severity</th>
<th>MAIS 1</th>
<th>MAIS 2</th>
<th>MAIS 3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>All crashes</td>
<td>30.0%</td>
<td>65.2%</td>
<td>81.5%</td>
</tr>
</tbody>
</table>
| Effect of speed zone and exceeding the speed limit
  - As speed limit increases, the proportion of crashes occurring within the engineered-in safety of the vehicle **reduced**
  - Exceeding the speed limit **exacerbated** this effect

Effect of ANCAP rating
- 5-star cars: 41.7% experienced impact speeds above the defined safety threshold
Achieving Vision Zero through the Safe System

- **Vision Zero** was introduced by Tingvall as a long-term policy ambition to eliminate serious injury.

- *The Vision Zero* model establishes design parameters and performance criteria to generate an **inherently safe system**, which once met results in the elimination of serious injury (MAIS 3+).

- Principles adopted in Australia as the **Safe System approach**.

- ECIS established performance criteria for Safe Drivers, Safe Vehicle and Safe Roads.

- A Safe System Failure Analysis was performed for each crash.

Crashes where Safe System performance criteria were met

**All crashes**
- Safe Driver(s) (All ECIS crashes)
  - All criteria met: 41.5% (163)
  - Driver state criteria not met: 13.2% (52)
  - Not compliant: 45.3% (178)
- Safe Vehicle(s) (All ECIS crashes)
  - All criteria met: 89.9% (353)
  - Failed criteria: 10.1% (40)
- Safe Road(s) (All ECIS crashes)
  - All criteria met: 74.0% (291)
  - Failed criteria: 26.0% (102)

**MAIS 3+ crashes**
- Safe Driver(s) (MAIS 3+ crashes)
  - All criteria met: 51.2% (165)
  - Driver state criteria not met: 11.2% (23)
  - Not compliant: 37.6% (77)
- Safe Vehicle(s) (MAIS 3+ crashes)
  - All criteria met: 95.1% (195)
  - Failed criteria: 4.9% (16)
- Safe Road(s) (MAIS 3+ crashes)
  - All criteria met: 81.0% (166)
  - Failed criteria: 19.0% (39)
Measuring safety performance through a Vision Zero lens

- Where the Safe Driver, Safe Vehicle, and Safe Roads criteria were met, no occupant was seriously injured (MAIS 3+)

- Compliant drivers were not supported by the ‘system’ as the proportion of vehicles meeting the Safe Vehicle and Safe Roads criteria was low
- In 35.9% of crashes, the Safe Driver, Safe Vehicle and Safe Roads criteria were not met

Findings highlight the significant need, and opportunity, to achieve reductions in serious injury, and demonstrates that eliminating serious injury is feasible
Safety performance and overlap differs by crash type

- Analysis highlights differences in the degree of overlap between the Safe Driver, Safe Vehicle and Safe Roads criteria across crash types.
- The lack of ‘system-level’ protection for Safe Drivers in Lane Departure crashes and Across Path crashes is evident.
- Failure to meet the criteria was associated with MAIS 3+ injury, a longer length of stay in hospital, the need for rehabilitation care, and higher costs to the TAC and the community.
- Demonstrates the need to improve all elements of the system.
Delivering insight

- ECIS highlights the highly injurious nature of crashes and the range of driver, vehicle and infrastructure-related factors that contribute to crash occurrence and serious injury.
- Driver performance factors, health and driver state, and non-compliance all played a role in crashes.
- ECIS showed that even for compliant drivers, the level of safety of the road transport system is insufficient to protect them from serious injury.
- Travel speed was shown to be strongly associated with crash risk.
- Impact speed was shown to be strongly associated with injury severity.
- By highlighting the complexity of crashes and factors associated with serious injury, ECIS shows that concurrent action in all three elements of the road transport system (Safe Driver, Safe Vehicle and Safe Roads) is required for reductions in serious injury to be achieved; this includes aligning speed limits with the inherent safety of the vehicle fleet and the road infrastructure, as well ensuring compliance with these speed limits.
Acknowledgements

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- We acknowledge the funding and logistical support provided by the Victorian Transport Accident Commission (TAC). In particular, we wish to thank the TAC Board and Mr Joe Calafiore (CEO) for supporting the study from the beginning.

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ECIS Team

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