In-depth road trauma analysis and the basis and evidence for crash prevention

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The advent of the motor vehicle brought with it unparalleled freedom of movement, enabling economic development and prosperity through the transportation of goods and services. On the other side of the ledger was – and remains so today – an immense cost: crashes resulting in death and injury to occupants of vehicles and other road users, as well as particulate and noise pollution. Driver behaviour was seen in large part to be the problem, solvable by education and enforcement; engineering solutions were recognised (hence, the 3 E's of road safety) but played a lesser role. This perspective shaped road safety policy across the world for many years.

Taking lessons from aviation safety and impact biomechanics, Haddon introduced a systematic approach to understand crashes in the late 1960's and early 1970's. Referred to as the *Haddon Matrix,* Haddon argued that human, vehicle, and environmental (HVE) factors all play a role in crash occurrence, injuries sustained, and post-crash recovery. While crash prevention was important, the elimination of death and injury once a crash occurs was imperative. Reduction and elimination of injury was to be achieved through improved 'crash packaging' (i.e., occupant protection) and the management of injury-causing energy through vehicle and infrastructure safety countermeasures. By understanding the factors associated with crash occurrence and injury severity, Haddon argued that the identification of countermeasures would follow. The systematic analysis of crash data was central to this objective.

While the more systems-based *Haddon Matrix* was frequently cited in road safety strategy documents, a 'road safety pillar' approach emerged. Managing driver behaviour remained central to road safety policy. It seemed as if the critical role of energy control and links between the pre-crash, crash, and post-crash sequence enunciated by Haddon were lost. Recognising this, and the long-term impairment associated with crashes, Tingvall introduced *Vision Zero.*

Vision Zero added an ethical layer to road safety policy whereby the loss of life and long-term impairment was an unacceptable trade-off for the mobility that the vehicle afforded. Designing, implementing, and managing a road transport system where serious injury is eliminated underpins *Vision Zero.* Acknowledging that drivers make errors and that the human body has a limited tolerance external energy before injury occurs are foundational principles of *Vision Zero.* The *Safe System* approach adopted in Victoria was inspired by, and largely based upon, *Vision Zero. The Safe System* approach – seen as *Safer Drivers, Safer Vehicles, Safer Roads, Safer Speed* — was seen to represent a framework for advocacy and analysis, and like *Vision Zero,* a way to understand the interaction between the system elements from which countermeasures that translates to safer travel could be identified.

Arguably a significant challenge has been how to effectively implement *Vision Zero* in practice. To facilitate this, Tingvall and colleagues developed both the *Multi-dimensional (SRA) Model of a Safe Road Transport System* and the *Integrated Safety Chain (ISC);* the former offering a way to understand the interdependencies across each element of the road transport system, and the latter being a model to define when — and how — to intervene in the crash sequence to either prevent the crash entirely, eliminate serious injury, and improve post-crash outcomes. Application of these tools requires a comprehensive understanding of factors associated with crashes and associated injury outcomes.

With this as background, this presentation will present an overview of the Transport Accident Commission (TAC) funded Enhanced Crash Investigation Study (ECIS) program conducted at the Monash University Accident Research Centre (MUARC).

The ECIS program was designed to 1. Provide the TAC with insight into how serious injury crashes occur, and 2. Identify 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. Data collection and analysis protocols were designed from the ground up. Hospitalised drivers (or their Next-of-kin) were enrolled to the program; each crash was meticulously examined and reconstructed. With the elimination of serious injury being a key road safety objective, the ECIS program was set within the *Vision Zero* context and the *Safe System* approach. The ECIS program was guided by the principle that understanding the factors associated with crash occurrence, the road users involved, and the type and severity of injuries sustained is fundamental to setting objective and defensible road safety policy.

This presentation will outline three key findings from the ECIS program. First, by using detailed crash data we demonstrate how *Vision Zero* works in practice. In doing so, we highlight the interdependence of *Safe Drivers*, *Safe*

Vehicles, and *Safe Roads* in creating an inherently safe road transport system; we show that speed is embedded within these three elements. These findings demonstrate that *Safe Drivers* are not supported by other elements of the system. The findings also demonstrate that by achieving total system alignment serious injury (MAIS 3+) can be avoided. The research highlights the importance of addressing all elements of the road transport system concurrently and that one element cannot be traded off against another.

Second, the presentation will demonstrate the critical role that energy – seen as travel speed and impact speed in the road transport system, play in shaping both crash risk and injury severity. This provides evidence for the perspective that speed is a critical regulator of safety of the road transport system. The data provides unequivocal evidence for matching speed limits to the surrounding road environment and the engineering limits of the vehicle to protect occupants from serious injury once a crash occurs.

Third, the presentation will highlight the principle of safety-by-design. With driver error being significantly more common in complex high-speed intersection locations where multiple adverse, or latent, features exist, it can be seen that road designers have a critical role to play in facilitating safe driver decisions.

To conclude, commentary will be given on the need to continuously collect and analyse detailed crash data to understand system performance, identify specific actions to address system gaps, and to monitor the impact of these actions over time. Finally, the point will be made that road safety policy actions may challenge the public and be received negatively in some sectors. Engaging the community with objective data and robust evidence drawn from local crashes represents a critical implementation step in seeking to achieve the ambition of *Vision Zero.*