

AutoTriage: predicting traumatic brain injury (TBI) in road traffic collisions using vehicle sensors

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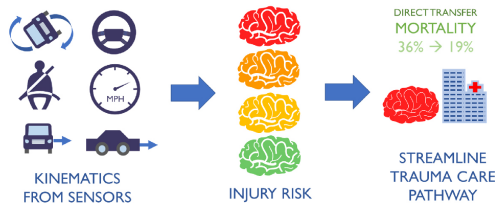
Dr Mazdak Ghajari, Dr Phil Martin, Prof David Sharp, Prof Mark Wilson

Abstract

Road traffic collisions (RTCs) are a major cause of traumatic brain injury (TBI) [1-2]. We demonstrate a relationship between collision dynamics that can be recorded by in-vehicle sensors and traumatic brain injury severity and type in historic collision data. The relationship between sensor-recorded parameters and injury could automatically inform the emergency services to time-critical TBI, aiming to reduce mortality and improve patient outcomes.

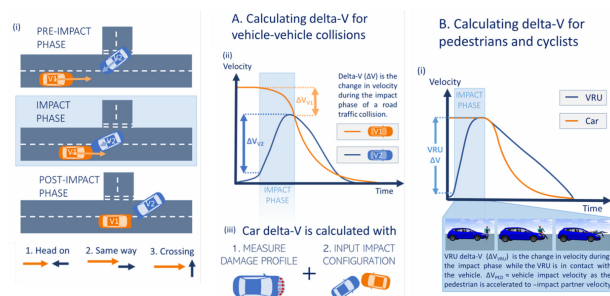
Introduction

There are an estimated 34 million TBIs in RTCs each year [2]. However, the relationship between road traffic collision dynamics and traumatic brain injury risk for different road users is unknown. Direct transfer to neurosurgical provision reduces mortality and improves outcomes [3]. Relating collision dynamics to TBI outcome could inform how routinely fitted automatic collision notification systems alert the emergency services to time-critical TBIs [4]. Automatically and rapidly identifying those that require neurosurgical care and ensuring they are transported directly to a centre with neuro-specialist provisions could improve patient outcomes.



Methods

We investigated TBI prevalence in 2,065 collisions from Great Britain's Road Accident In-depth Studies (RAIDS) database involving 5,374 subjects (2013–20). We developed a novel free-text search tool to classify TBI in free-text using the Mayo classification system [5]. We report prevalence of key TBI types. We extended our results nationally using 1 million police-reported RTC casualties. RAIDS detail facilitates vehicle collision dynamics understanding and change in velocity ('delta-V') estimation for a subset of in-depth collision data. We modelled the relationship between delta-V (magnitude and direction) on TBI (severity and type) with multivariate logistic regression and stratified k-fold cross-validation.



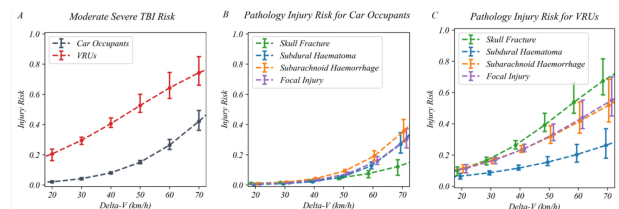
Results

Five hundred and ninety-five subjects sustained a traumatic brain injury (20.2% of 2940 casualties), including 315 moderate-severe and 133 mild-probable injuries. Key pathologies included skull fracture (179, 31.9%), subarachnoid haemorrhage (171, 30.5%), focal brain injury (168, 29.9%) and subdural haematoma (96, 17.1%) [6]. Extrapolating from the in-depth data we estimate that there are 20,000 traumatic brain injury casualties (5,000 moderate-severe) annually on Great Britain's roads.

Existing, widespread vehicle sensor dynamics measurements can be used to predict specific, time-critical traumatic brain injuries, with the potential to automatically triage injury.

	TOTAL	PEDESTRIANS	CYCLISTS	SCOOTERS	CAR PASSENGERS	CAR DRIVERS	ALL ROAD USERS
ALL SUBJECTS	5374	144	112	267	3992	369	262
RAIDS SUBJECTS	2940	144	112	267	3992	369	262
ALL TBI	595	69	43	67	385	31	5
MODERATE-SEVERE	315	52	29	46	166	15	7
MILD-PROBABLE	59	17	14	21	31	16	0
SKULL FRACTURE	179	17	8	10	153	5	3
SUBARACHNOID HAEMORRHAGE	171	25	26	27	92	8	3
FOCAL BRAIN INJURY	168	32	13	25	80	13	5
SUBDURAL HAEMATOMA	96	17	8	10	53	5	3

Higher delta-V increased the risk of moderate-severe brain injury for all road users. The four key pathologies were not observed below 8 km/h delta-V for pedestrians/cyclists and 19 km/h delta-V for car occupants (higher delta-V threshold for focal injury in both groups). Accounting for delta-V, pedestrians/cyclists had a 6-times higher likelihood of moderate-severe brain injury than car occupants. Car occupants exposed to a higher lateral delta-V component had a greater prevalence of moderate-severe brain injury, particularly subarachnoid haemorrhage. Multivariate logistic regression models created using total delta-V value and whether lateral delta-V was dominant had the best prediction capabilities (area under the receiver operator curve as high as 0.95).



Discussion

We address a key knowledge gap in the understanding of how collision dynamics relate to specific types of TBI pathology in varying types of road users. We described TBI prevalence and model the relationship of injuries to collision dynamics (delta-V). Moderate-severe TBI risk increased with delta-V and was significantly higher in VRUs for a given delta-V. The results have the potential to influence trauma care directly by informing the development of advanced automatic collision notification systems that are increasingly being fitted in new vehicles. Vehicle sensors can record delta-V, opening the door to real-time distinct injury risk alerts in post-crash care.

Conclusion

The new relationships presented connect widely available collision dynamics and distinct brain injury types and severities. The ability to identify time-critical injury in real-time using widely available sensors can support existing post-crash care. Early notification of high-risk scenarios can enable quicker activation of the highest level of emergency service response.

Bio



Dr Claire E Baker is an EPSRC Doctoral Prize Research Fellow (Research Associate) in HEAD Lab. She completed her interdisciplinary PhD in Design Engineering under the CDT Neurotechnology umbrella, funded jointly by EPSRC and industry partner TRL. She collaborates closely with Imperial Medicine and the NHS.

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