



Comparison of HIC and BrIC head injury risk in IIHS frontal crash tests to real-world head injuries

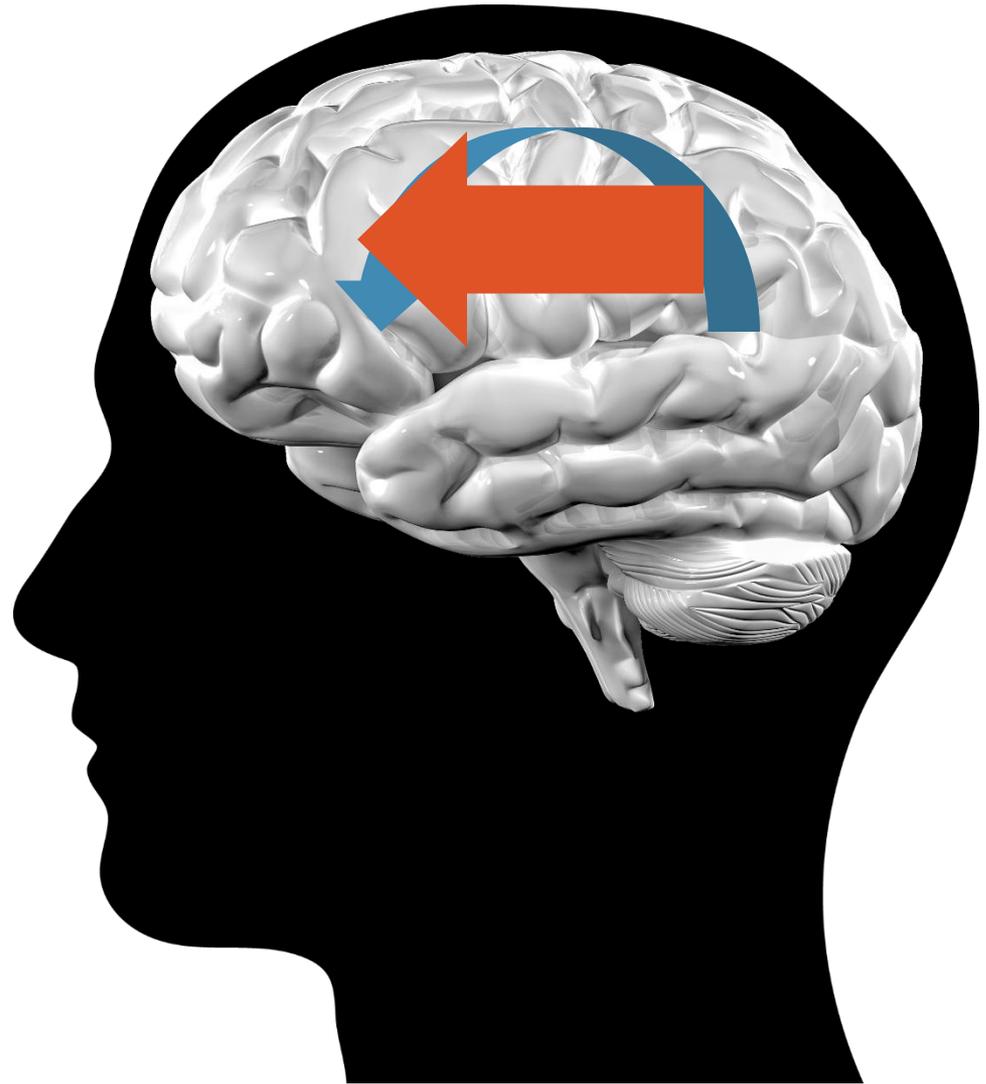
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Background

- ▶ In crash tests of modern vehicles, **HIC** typically indicates low head injury risk despite incidence of real-world head injuries from direct impact.
- ▶ **BRIC** is a new head injury criteria intended to compliment HIC in identifying head injuries.



The **objective** of this study is to compare head injury risk based on HIC and BRIC in IIHS moderate and small overlap front crash tests with real-world head injury rates in similar frontal crashes.

Moderate overlap



Small overlap



Calculating real-world head injury rates

Frontal crashes

- ▶ NASS-CDS study
- ▶ Good rated IIHS moderate overlap
- ▶ Model years 2004 – 2012
- ▶ No rollover, no underride

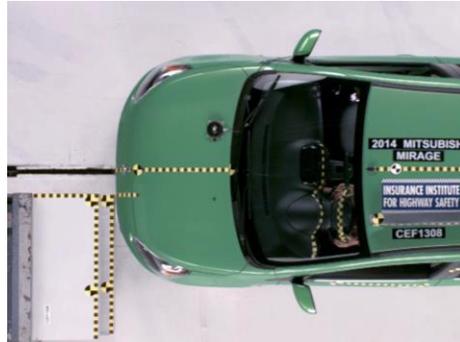
Vehicle categories (photographic evidence)

- ▶ Damage extent: equal or greater than IIHS tests
- ▶ Configuration: small or moderate overlaps
- ▶ Identify head injuries and possible sources

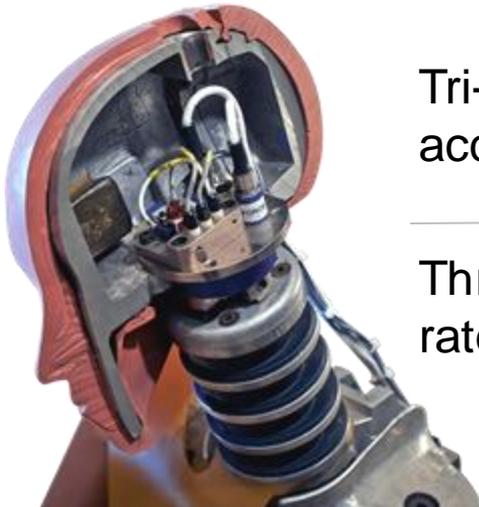
Estimating head injury risk from crash tests

Two head injury metrics based on different injury mechanisms

17 moderate overlap



122 small overlap



Tri-axial linear
accelerometer array

$$HIC = \left\{ \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t) dt \right]^{2.5} (t_2 - t_1) \right\}_{max}$$

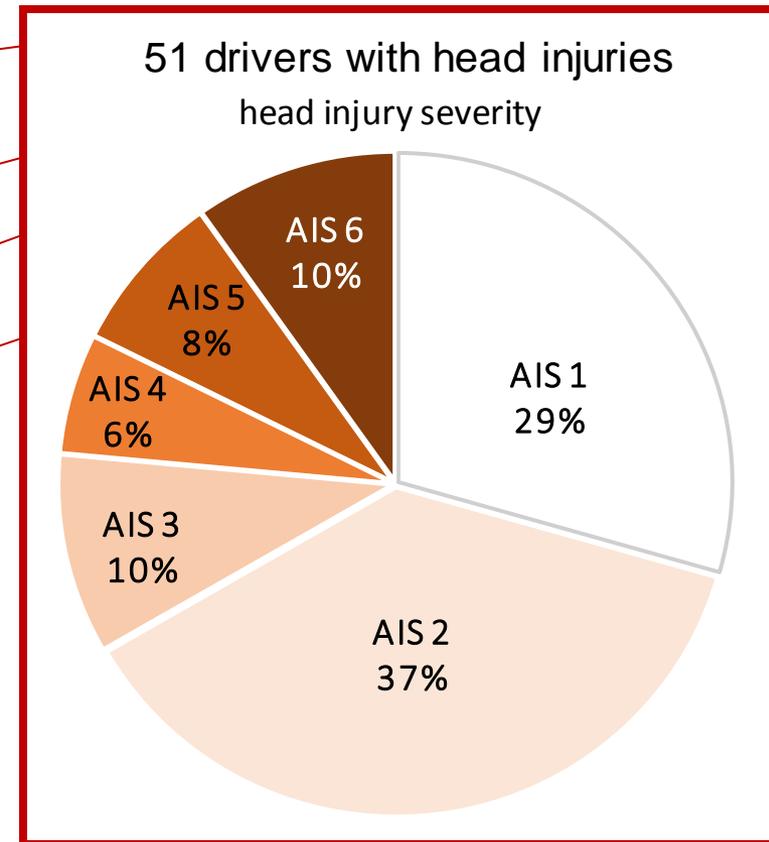
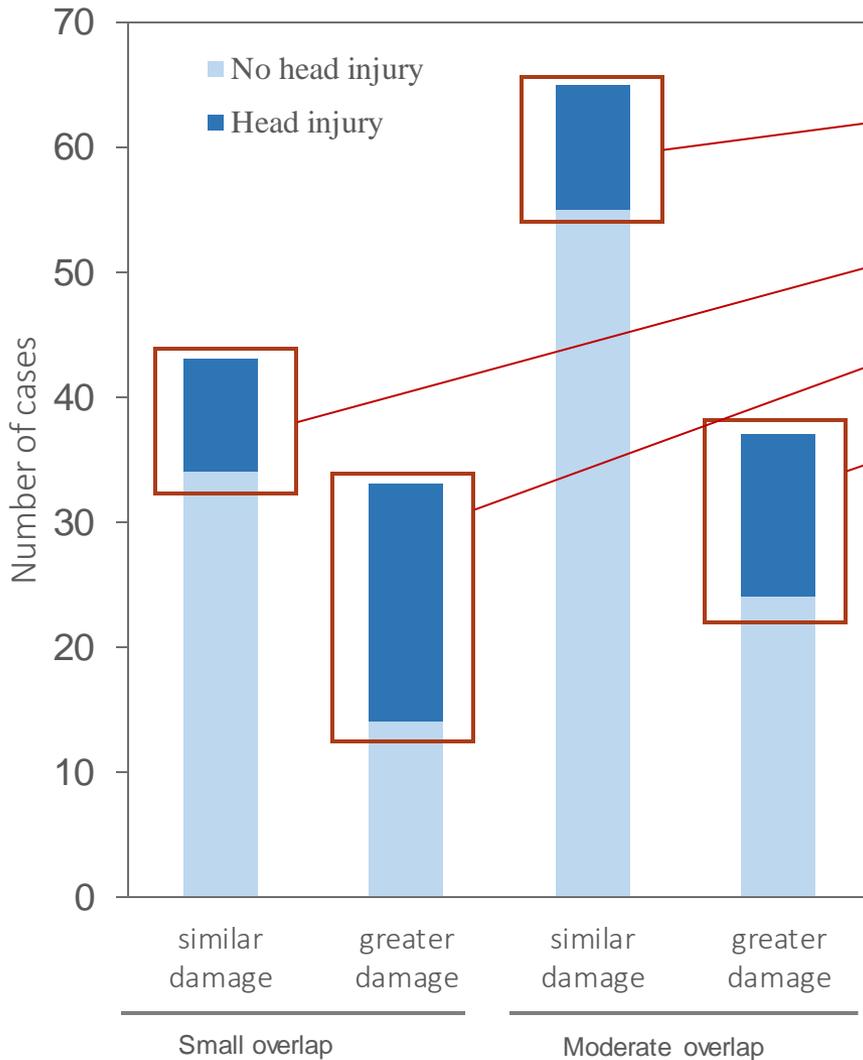
Three angular
rate sensors

$$BrIC = \sqrt{\left(\frac{\omega_x}{\omega_{xC}}\right)^2 + \left(\frac{\omega_y}{\omega_{yC}}\right)^2 + \left(\frac{\omega_z}{\omega_{zC}}\right)^2}$$

Hybrid III midsize male dummy

Real-world crash configurations and head injuries

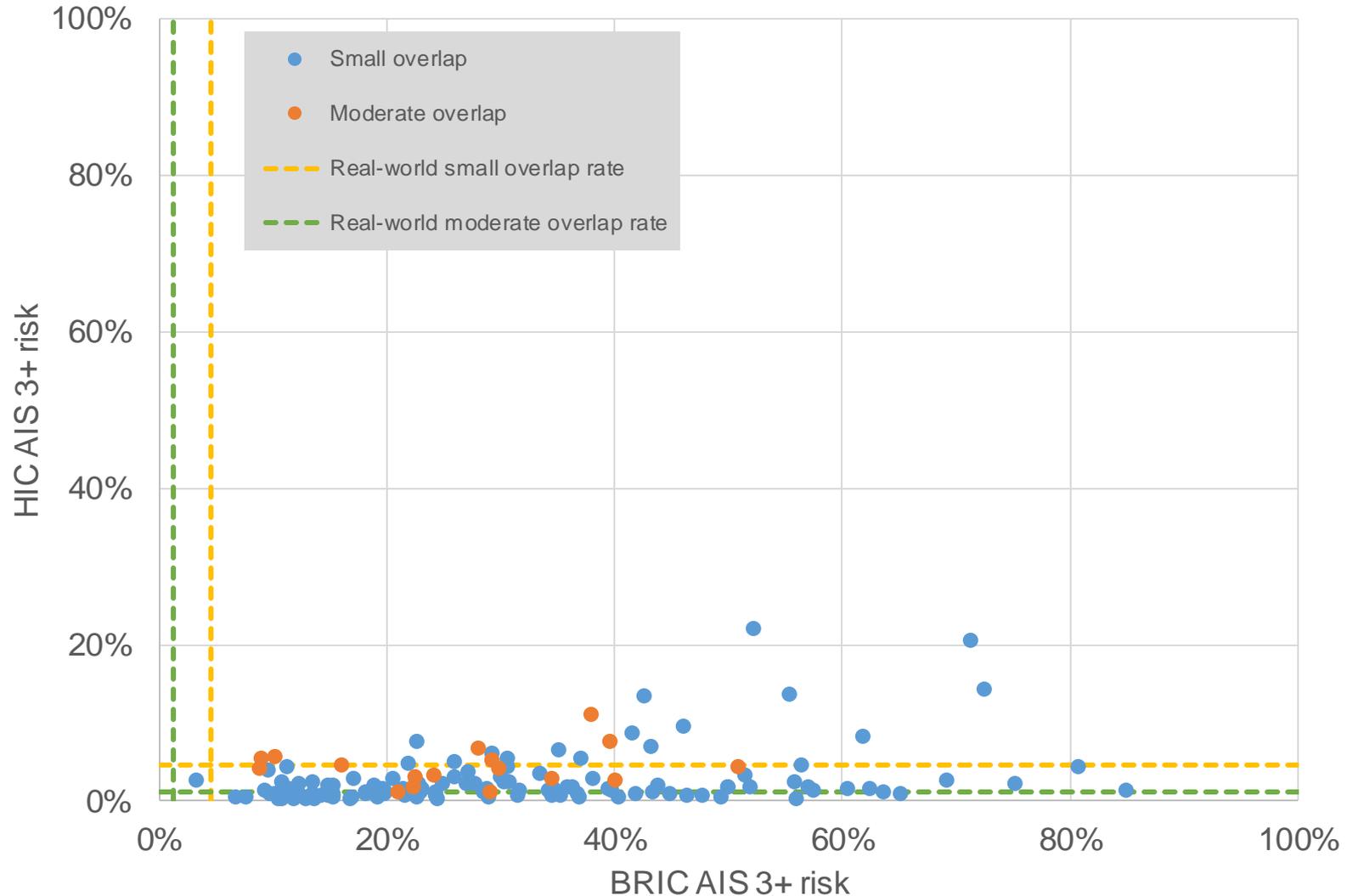
168 NASS cases of frontal crashes with equal or greater damage



Higher real-world head injury rates for small overlap crashes compared to moderate overlap

	Moderate overlap (10,027)	Small overlap (7,249)
Skull fracture		
Cases (weight)	2 (21.84)	3 (67.29)
Rate	0.2%	0.9%
AIS 3+		
Cases (weight)	7 (117.21)	10 (330.8)
Rate	1.2%	4.6%
AIS 4+		
Cases (weight)	5 (67.11)	7 (247)
Rate	0.7%	3.4%

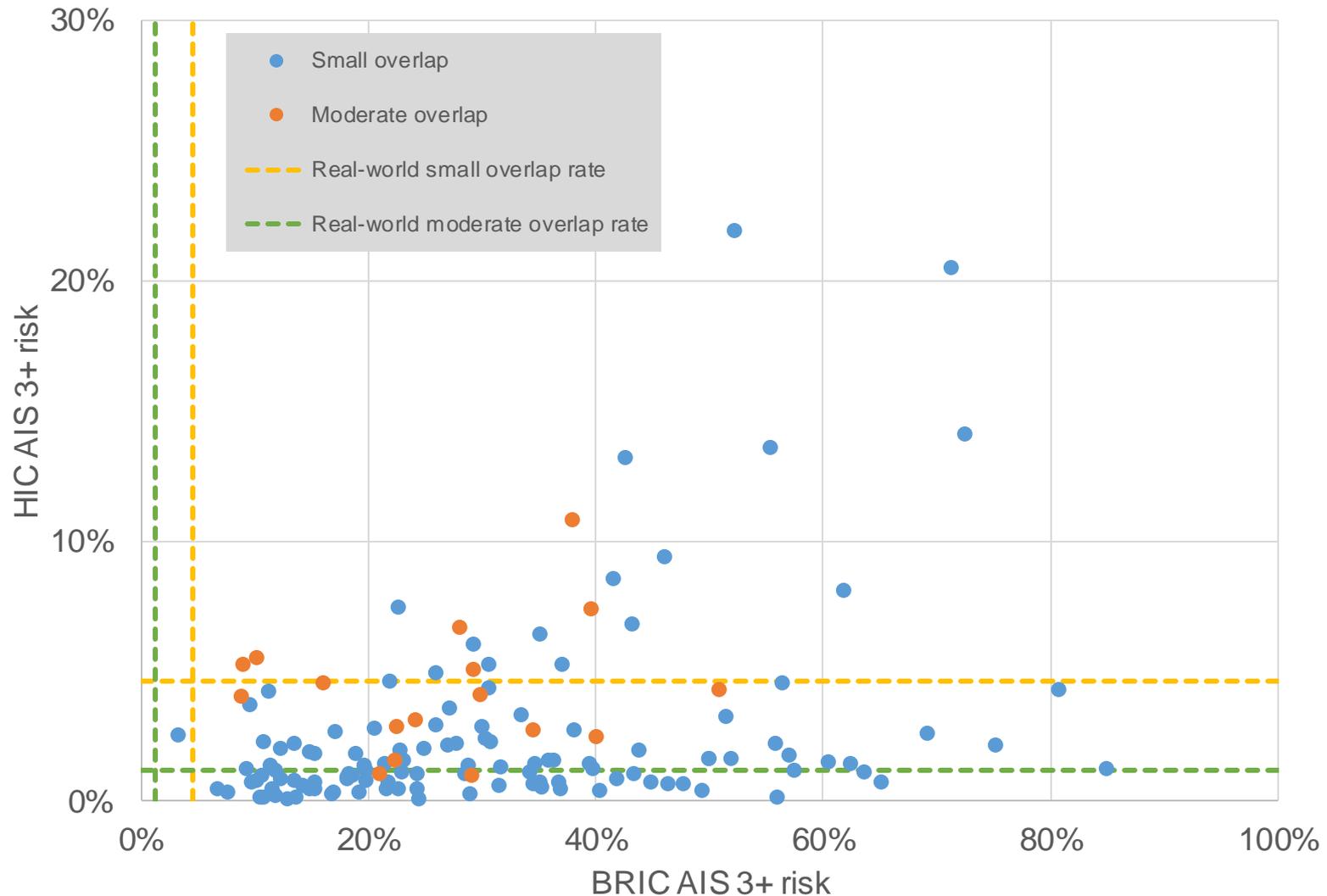
Crash test HIC and BRIC AIS 3+ head injury risk



HIC: Prasad P, Mertz HJ. 1985. SAE Technical Paper 851246. Warrendale, PA: Society of Automotive Engineers.

BRIC: Takhounts EG, Craig MJ, Moorhouse K, McFadden J, Hasija V. 2013. Development of brain injury criteria (BrIC). Stapp Car Crash J. 57:243-66.

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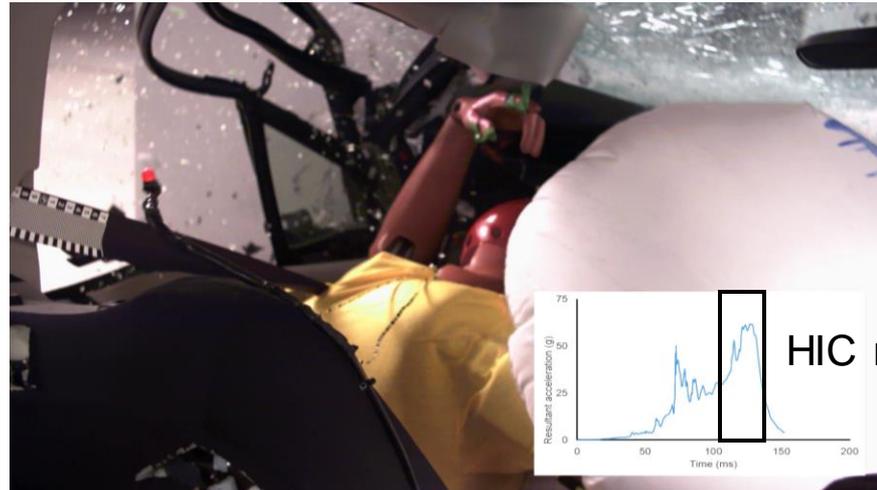
HIC-based head injury risk more closely reflects real-world rates than BRIC-based risks

	Moderate overlap		Small overlap	
	HIC	BRIC	HIC	BRIC
Average value	259	0.64	173	0.69
AIS 3+ risk	4.1%	27%	2.5%	32%
AIS 3+ real world rate	1.2%		4.6%	

BRIC correctly indicates that small overlap crashes have higher risks compared to moderate overlap observed in real-world rates

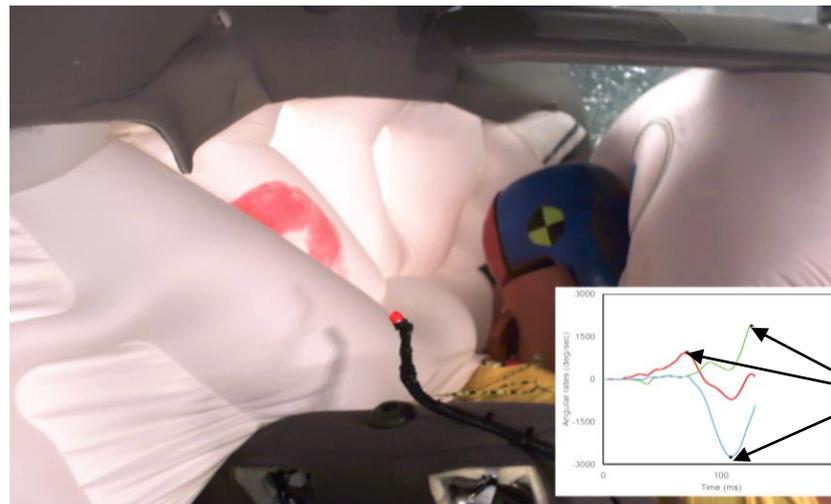
HIC identifies high injury risk with hard impacts while BRIC identifies high injury risk with airbag loading

High HIC associated
with hard impact



HIC range during IP hit

High BRIC associated with
airbag contact



BRIC peaks during
Airbag loading

BRIC may not be correctly identifying most injurious crash events

Small overlap tests

	HIC			BRIC		
	airbag only	unrestrained motion	hard contact	airbag only	unrestrained motion	hard contact
minimum	39	54	42	0.3	0.53	0.47
average	163	172	205	0.66	0.77	0.72
maximum	527	426	651	1.24	1.07	0.89

Real-world crashes indicate 70% of AIS3+ brain injured occupants impacted a hard surface in the vehicle

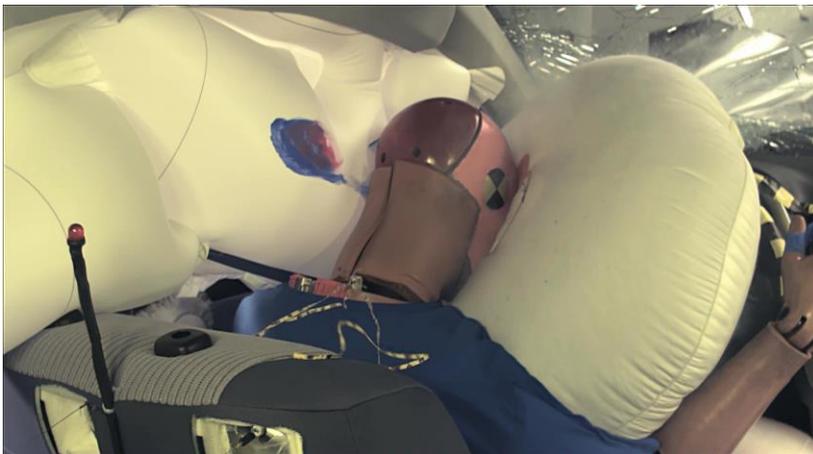
HIC is sensitive to restraint system changes where BRIC is insensitive

Kinematic improvement in head-to-airbag engagement

2013



2015



	Impact	HIC	BRIC
2013	Airbag then IP	283	0.60
2015	Airbag only	163	0.57

Conclusions

- ▶ BRIC estimates a much larger risk of brain injury than observed in real-world crashes of similar configurations.
 - BRIC correctly identifies higher risk for small overlap compared to moderate overlap crashes observed in real-world data
- ▶ Majority of BRIC measures are high in airbag-only head contact
 - real-world crashes indicate 70% of AIS3+ brain injured occupants impacted a hard surface in the vehicle
- ▶ HIC estimates a much closer risk of brain injury to that observed in real-world crashes of similar configuration.
 - HIC underestimates real-world skull fracture rates, likely because the majority of head injuries are occurring in more severe crashes than IIHS tests

Conclusions

- ▶ Lack of correlation between HIC and BRIC in crash tests suggest these metrics may provide different indications of injury
 - Kinematic events associated with BRIC raise concerns whether it correctly identifies the most injurious crash events
- ▶ From vehicles in this study, BRIC appears insensitive to vehicle design changes where HIC makes distinctions
 - Problematic for developing countermeasures which can reduce BRIC



Insurance Institute for Highway Safety
Highway Loss Data Institute

More information and links
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