TRAFFIC INJURY PREVENTION
2025, VOL. 26, NO. 1, 61–75
https://doi.org/10.1080/15389588.2025.2451572

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NHTSA crash investigation sampling system (CISS) is unreliable, inaccurate and does not estimate serious injury in motor vehicle crashes

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ABSTRACT

Objective: Errors and inaccuracies are documented in the 2017–2022 CISS (Crash Investigation Sampling System) field data managed by NHTSA on serious injury in motor vehicle crashes in the US.

Methods: All CISS cases of serious, non-fatal injury to 3–5 and 6–12 year old (yo) children were downloaded from the NHTSA website. Each case was summarized for the: 1) case identification by year, PSU and number, 2) case weighting factor and domain, 3) vehicle make, model and model year and 4) age, seating position and maximum injury severity (MAIS) to the child. Crashes with serious injury are in domains 02, 05 and 08 depending on the age of the vehicle. There were several cases with unusually high weighting factors (casewgt) in comparison to others in the groups. The sources of the high case weights were identified.

Results: There were 8 cases with MAIS 3–6 injury to 3–5 yo children. The weighted sum was 3,538.8 estimated national incidence for 6 years. Case #5 had a weight of 2,223.3, which was 63% of the sum. There were 8 cases with MAIS 4–6 injury to 6–12 yo children. The weighted sum was 5,817.9. Case #9 had a weight of 5,199.6, which was 89% of the sum. There were 18 cases with MAIS 3 injury to 6–12 yo children. Case #22 had a weight of 1,264.5 and case #25 937.8, representing 52% of the sum. The high case weights were traced to errors in the domain due to incorrect injury severity and vehicle age. NHTSA has been aware of the domain errors and unusually high case weights since 2012. They have not corrected the errors in high case weights. They have ignored the effects of errors in the CISS and NASS-CDS data on serious injury. The data errors lead to unrealistic and inaccurate estimates of serious injury. There are other problems with CISS and NASS-CDS.

Conclusions: There are pervasive errors in the CISS crash selection procedure, domains and case weights that make estimates of serious injury unreliable. There is no quality control to correct the data errors. CISS cases are incomplete and limited in comparison to the earlier NASS-CDS.

CISS sampling procedure is incorrect by relying on vehicle age for case selection. NASS-CDS sampling relied on occupant injury severity. CISS and NASS-CDS incorrectly handle multi-vehicle crashes. A complete review and revision of CISS and NASS-CDS is needed to correct errors so the databases are compatible from the 1980s to today. NHTSA needs to disclose information about the revised NASS-CDS and CISS files. The online NASS-CDS and CISS files are incorrect and inadequate to estimate serious injury in motor vehicle crashes.

CISS sampling frequencies rely on 2011 NASS-CDS, which is not relevant to serious injury crashes today. The 2011 NASS-CDS did not investigate older vehicles. CISS under-samples serious injury in older vehicles where race, gender and SES are important factors. CISS and NASS-CDS are not representative samples of serious injury in US crashes.

ARTICLE HISTORY
Received 6 December 2024
Accepted 4 January 2025

KEYWORDS
CISS; NASS-CDS; crash data; injury databases; child injury

Introduction

NHTSA rulemaking depends on accurate estimates of injuries in motor vehicle crashes to conduct benefit analyses and set priorities. They developed an in-depth evaluation of field accidents in the 1970s with NCSS (National Crash Severity Study) to provide a national estimate of crash injuries based on a stratified, probability sample of crashes (Ricci 1979). NHTSA later developed NASS-CDS (National Automotive Sampling System - Crashworthiness Data System) with improved in-depth investigation of several thousand crashes in the US per year (Shelton 1991; Fleming 2010). National estimates are calculated by applying a weighting factor to each case, which is the product of inverse probabilities of selection in the three-stage sampling process (Radja 2012). In 2015; NHTSA claimed a further improved field data collection procedure was needed and they embarked on CISS with implementation online in 2017. NHTSA continues to ask for budget increases to expand CISS (Federal Register 2022; GAO 2015).

The government, industry and researchers depend on the field data to describe the risks for serious injury by crash type, restraint use, occupant demographics and other factors.

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NHTSA claims CISS is nationally representative of injuries in motor vehicle crashes (Federal Register 2022; NHTSA 2023). However, the accuracy of estimates depends on the adequacy of the sampling methods and accuracy of the case weights for national estimates.

The author undertook an in-depth analysis of child injuries in the 2017–2022 CISS to explore current field experiences with serious injury to young children. He also wanted to examine CISS cases to see improvements in the case files and representativeness of the findings. The analysis led to troubling findings of systemic errors in the sampling methods and inaccuracies in the procedures to weight cases. This editorial provides an overview of the findings, pointing out issues that make CISS unreliable and inaccurate for estimating serious injuries in motor vehicle crashes in the US. The issues are systemic and apply to the CISS and NASS-CDS databases.

Methods

All serious injury crashes were identified involving 3–5 year old (yo) and 6–12 yo children in the 2017–2022 CISS (Crash Investigation Sampling System). CISS investigates towaway crashes involving light vehicles using a stratified three-stage sample of primary sampling units (PSU), police jurisdictions (PJ) and police accident reports (PAR) as described in reports by Zhang et al. (2019a,2019b,2019c, 2024) and Radja et al. (2019, 2022).

CISS was searched at NHTSA (https://crashviewer.nhtsa.dot.gov/CISS/SearchFilter) for 3–5 years old (yo) and 6–12 yo children seriously injured, but not killed in vehicle crashes. Each case was downloaded and summarized. CISS selects cases for investigation based on the domain of the crash, which is determined by the KABCO rating of the most severely injured occupant and the vehicle age (Zhang et al. 2019a,2019b,2019c, 2024; Radja et al. 2019, 2022). The injury rating is from the police report and depends on the officer's evaluation on-scene and with follow-up in the hospital, when conducted. The KABCO rating and vehicle age define the domain of the crash for serious injuries. The domain is used with other adjustments to determine the case weight for national estimates.

The KABCO rating is used by the police to assess occupant injury (Sherman et al. 1976; DOT 2012; Zhang et al. 2019a,2019b,2019c, 2024). The police report lists occupant injury severity as K: killed or fatally injured, A: incapacitating, suspected serious injury, B: non-incapacitating, suspected minor injury, C: possible injury, O: no apparent injury and U: unknown.

Table 1 shows the domains for crashes investigated by CISS. The domains are an expansion of strata used in NCSS and NASS-CDS to select and group crashes. A crash is placed in a domain based on the maximum KABCO level of injury and the age of the vehicle (DOT 2012; Zhang et al. 2019a, 2024). Fatal crashes are in domain 01, irrespective of vehicle age. They are K in the KABCO rating and F in MAIS. All cases in this study should be A level serious injuries. Serious injuries are MAIS 3–6 in hospital records, based on the maximum abbreviated injury scale AIS (https://www.aaam.org/).

An A level serious injury should be in domains 02, 05 or 08 depending on vehicle age (≤4 years old, 5–9 years old and ≥10 years old), unless there is a fatality of another occupant. However, serious injury A level crashes can be in domains 03, 06 or 09 based on the hierarchical selection procedure in CISS (Zhang et al. 2024; pg. 4). For example, in multi-vehicle crash, a vehicle ≤4 year old sets the domain even if the injury in the vehicle is less severe than the injury in another, older vehicle. The hierarchy makes no sense. It differed from the hierarchy used by NASS-CDS (Radja 2016; Zhang and Chen 2013). The incorrect case sampling and domain are a reason several of the cases in this sample of seriously injury to children have unusually high case weights. The hierarchy then proceeds to mid-age vehicles 5–9 years old and lastly older vehicle ≥10 years old.

CISS procedure for crash selection is incorrect. It depends on vehicle age for selecting a domain, not injury severity (Zhang et al. 2024; Table 1, 4#x00029;. The CISS hierarchy for case selection is wrong and leads to a database not focused on serious injury, as seen in the sample of serious injury to 3–12 yo children in this study. NASS-CDS relied on occupant injury severity by placing a case in a strata (Radja 2016; Table 3-1, 5–8). The NASS-CDS hierarchy was sensible for an injury database. CISS and NASS-CDS incorrectly handle multi-vehicle crashes. Both databases lead to unusually high case weights for some crashes with serious injury, which can be seen in this and other studies.

Definitions: The following terms and definitions are used in this study:

- Case vehicle has the occupant with serious injury (MAIS 3+) that is the focus of the CISS cases studied here. In a multi-vehicle crash, the other vehicle may have occupant injuries of lesser, similar or greater severity.
- Case weight error is defined as an unusually (or unrealistically) high casewgt that is more than 3 sd (standard deviation) above the average of other case weights in the sample of serious injury.
- An inaccurate case weight is defined as an unusually high case weight that biases the average properties of the sample from that of the other cases without the unusually high case weight. The unusually high case weight distorts calculations of proportions for the sample, such as, percent seatbelt use, percent alcohol-drug use, percent female drivers, percent crashes on a

Table 1. CISS domains based on KABCO and vehicle age (DOT 2012; Zhang et al. 2019a, 2024).

		Injury				
KABCO	K	A	B	C	O	U
	killed	suspected serious, incapacitated	suspected minor, not incapacitated	Possible injury	no apparent injury	Unknown injury
Vehicle Age (yr)			Domain			
≤4	01	02	03	03	04	–
5–9	01	05	06	06	07	–
≥10	01	08	09	09	10	–

freeway, and other characteristics of the sample of serious injury. Inaccurate case weights make the calculations of standard errors inaccurate.

- A domain error refers to a case vehicle placed in a domain that is not consistent with the severity of occupant injury and vehicle age. For example, the case of a seriously injured (MAIS 3) child in 10 year old vehicle is in domain 03 because of a collision with a new vehicle with minor injury (MAIS 1) to the driver. The case weight is determined by the domain for the newer vehicle with a minor injury, leading to an unusually high case weight in comparison to other cases with serious injury to children.
- NHTSA may have correctly followed their CISS case selection procedure but the case vehicle can be in the incorrect domain due to the convoluted logic of selecting the domain by vehicle age and not the most severely injured occupant in multi-vehicle crashes. There were several older vehicles with serious injury (A-level) placed in a domain with a newer vehicle and minor injury (B, C level). They are referred to as domain errors in this study.
- Incorrect procedure is a wrong (invalid) hierarchy of case selection that is not based on occupant injury severity.
- Representative means the weighted sample quantifies the incidence and risk for serious injury and death in the US within 10% of the actual counts. An unrepresentative sample means the weighted data provides an invalid estimate of serious injury and death.
- Unreliable means the removal of one case with unusually high case weight drastically alters the average properties of the sample of serious injury. The unusually high case weight influences the sample averages from that of the other cases. This means the estimates do not converge on the same average with and without the unusually high case weight crash.
- Multi-vehicle crashes mishandled means a crashes is put in a domain with minor or no injury when the case vehicle has an occupant with serious injury, leading to an unusually high case weight.
- There are flaws in the CISS and NASS-CDS databases that give the same case weight to both vehicles in a multi-vehicle crash. There is no expectation that the crash frequencies are the same and there is no expectation that the injuries to occupants in the vehicles are the same severity. Each vehicle should have its own case weight in a multi-vehicle crash.

Results

Table 2 summarizes all cases of serious-critical injury (MAIS 3+) to 3–5 yo children in the 2017–2022 CISS. There were 8 cases with vehicles ranging from 2 to 18 years old. All children were in rear seats and they experienced MAIS 3–4 injuries in the crashes. The case year, PSU and number are listed with the case weight (casewgt) and domain. The total case weight was 3,538.8 for 6 years of crash data. Case #5 had a high weight. It was 2,223.3. The high weight represents 63% of the case weight sum. It is an outlier and appears to be an error, since it is in domain 03, which is for a minor injury in a newer vehicle (≤4 years old) crash. The KABCO rating is incorrect and the vehicle age is incorrect. Case #3 has a high weight, but it is in the correct domain. It is unclear what led to the high case weight. The weighted data gives an estimated 590 ± 954 serious-critical injuries per year to 3–5 yo children in US crashes. The estimate is heavily influenced by the outlier weights for cases #5 and #3. Table 2 includes information on fatal crashes. The average vehicle age is 16.2 ± 5.5 years old, which is significantly older than the serious injury cases. Fatal crashes in CISS are a census, since all fatalities are sampled. Serious injury crash are not a census, but a probability sample based on sampling frequencies not validated with real-world injuries in the US.

Table 3 summarizes all cases of critical injury (MAIS 4+) to 6–12 yo children in the 2017–2022 CISS. There were 8 cases with vehicles ranging from 4 to 15 years old. Most children were in rear seats and they experienced MAIS 4–6 injuries. The total case weight was 5,817.9. Case #9 had a very high case weight. It was 5,199.6. It is in the wrong domain. Domain 09 is for possible injury in an older vehicle. The very high case weight represents 89% of the case weight sum. It is an outlier due to the incorrect domain 09. The high case weight is unrealistic in comparison to other cases in the group. Case #16 is listed with a C level injury to the child but is in domain 02. It is in the correct domain, but with an incorrect C level injury. The weighted data gives an estimate of 970 ± 2,073 critical injuries per year to 6–12 yo children in US crashes. The estimate is heavily influenced by the outlier weight for case #9. Table 3 shows the average vehicle age is 11.1 ± 7.1 years old in fatal crashes.

Table 4 summarizes all cases of serious injury (MAIS 3) to 6–12 yo children in the 2017–2022 CISS. There were 18 cases with vehicles ranging from 2 to 25 years old. Most children were in rear seats. The total case weight was 4,202.0, which is oddly lower than the sum of case weights for MAIS

Table 2. Cases with 3–5 yo serious-critical injury (MAIS 3+) in 2017–2022 CISS.

Case	Case Information					Case Vehicle	Veh	Child			
#	Year	PSU	No	casewgt	dom	MY, Make, Model	Age	Loc	Age	MAIS	KABCO
		Serious-Critical Injury									
1	2017	19	113	148.5	01	2008 GMC Acadia	9	2L	5	3	A
2	2017	20	046	39.1	02	2014 Nissan Altima	3	2L	5	3	A
3	2018	20	111	887.3	08	2000 Merc Mountaineer	18	–	3	3	A
4	2019	11	077	113.9	02	2016 Mazda CX5	3	2L	4	3	A
5	2019	11	113	2,223.3	03	2011 Toyota RAV4	8	2L	3	4	C
6	2019	59	048	73.7	02	2017 Chevy Cruze	2	2L	3	3	A
7	2020	26	134	24.5	02	2018 Honda Accord	2	2R	3	3	A
8	2021	26	093	28.5	05	2014 Ford Explorer	7	2R	3	3	A
			total	3,538.8		avg	6.5		3.6	3.1	
						sd	5.4		0.9	0.4	
	Fatalities (n = 979.1 wgt, n = 10 unwgt)					avg	16.2		4.0	4.7	
						sd	5.5		0.9	1.1	

Notes: PSU: primary sampling unit, casewgt: case weight multiplier, dom: domain.
2L: left 2nd row, 2R: right 2nd row, –: unknown, avg: average, sd: standard deviation.

Table 3. Cases with 6–12 yo critical injury (MAIS 4+) in 2017–2022 CISS.

Case	Case Information					Case Vehicle	Veh	Child			
#	Year	PSU	No	casewgt	dom	MY, Make, Model	Age	Loc	Age	MAIS	KABCO
		Critical-Severe Injury									
9	2017	24	061	5,199.6	09	2002 Saturn SL	15	2R	6	4	A
10	2018	26	088	59.2	05	2009 Toyota Venza	9	2M	9	6	A
11	2019	21	038	94.0	05	2014 Scion xB	5	2L	7	5	A
12	2019	21	086	10.7	02	2015 GMC Terrain	4	2L	10	4	A
13	2020	48	068	182.2	03	2011 Honda Pilot	9	2L	6	4	A
14	2021	30	092	69.6	02	2017 Nissan Versa	4	1R	12	5	A
15	2022	14	063	154.8	02	2018 Mazda3	4	1R	11	4	A
16	2022	23	019	47.8	02	2018 Ford Escape	4	2L	12	4	C
			total	5,817.9		avg	6.8		9.1	4.5	
						sd	4.0		2.5	0.8	
	Fatalities (n = 901.2 wgt, n = 10 unwgt)					avg	11.1		8.8	4.1	
						sd	7.1		2.1	1.4	

Notes: see footnote Table 2, 1 R: right-front passenger, 2 M: middle 2nd row.

Table 4. Cases with 6–12 yo serious injury (MAIS 3) in 2017–2022 CISS.

Case	Case Information					Case Vehicle	Veh	Child			
#	Year	PSU	No	casewgt	dom	MY, Make, Model	Age	Loc	Age	MAIS	KABCO
		Serious injury									
17	2017	13	021	154.2	02	2014 Honda Crosstour	3	2L	10	3	C
18	2017	28	026	81.1	02	1992 Jeep Wrangler	25	2R	7	3	A
19	2017	32	013	474.0	01	2003 Chevy Suburban	14	2L	7	3	A
20	2018	11	035	125.5	01	2000 Toyota Camry	18	2L	7	3	A
21	2018	12	035	449.7	01	2002 Toyota 4-Runner	16	2R	6	3	C
22	2018	13	008	1,264.5	03	1998 Ford Expedition	20	3R	10	3	C
23	2018	26	099	45.7	02	2016 Toyota 4-Runner	2	2M	8	3	A
24	2018	30	001	215.0	08	1999 Pontiac Grand Prix	19	2M	11	3	A
25	2018	32	004	937.8	06	2000 Ford E-Van	18	1R	12	3	U
26	2020	21	041	11.4	02	2017 Nissan Rogue	3	2R	12	3	A
27	2020	21	123	40.8	01	2002 Mercedes M	18	2R	8	3	A
28	2020	73	055	34.2	08	1998 Ford F-series	22	2L	6	3	A
29	2021	19	100	47.5	05	2015 Jeep Willys	6	2L	10	3	A
30	2021	21	165	111.2	05	2016 Toyota Camry	5	1R	12	3	A
31	2021	22	083	47.5	08	2009 Kia Sorento	13	2R	6	3	A
32	2021	26	159	14.5	02	2020 Kia Rio	1	2M	6	3	A
33	2021	32	040	109.0	01	2006 Ford F-series	15	2L	11	3	A
34	2022	73	109	38.4	01	2017 Ford F-150	5	2R	9	3	A
			total	4,202.0		avg	12.4		8.8		
						sd	7.8		2.3		

Notes: see footnote Tables 2 and 3, 3 R: right 3rd row.

4–6 injury. Case #22 has a weight of 1,264.5. It is in the incorrect domain. Domain 03 is for newer vehicles with B, C level minor injury. The KABCO rating is C. It should be A. Both vehicle age and injury severity are incorrect. Case #25 has a weight of 937.8 and is in the wrong domain. Domain 06 is for a mid-year vehicle with B, C level injury. The E-van was 18 years old. The KABCO was unknown. The two cases represent 52% of the case weight sum. They are outliers in comparison to the other case weights. There were two other cases (#17 and #21) with incorrect KABCO ratings for the child's injury. The weighted data gives an estimated 700 ± 1,176 serious injuries per year to 6–12 yo children in US crashes. The estimates indicate more critical than serious injuries in 6–12 yo children in US crashes. This is nonsense and defies what is known from hospital data showing lower incidence of life-threatening (MAIS 4+) than serious (MAIS 3) injuries.

Table 5 shows six cases out of 34 with errors in the domain due to miss-classification of injury severity and vehicle age. The errors can lead to very high case weights. The domains for this study should be 02, 05 or 08 depending on vehicle age or domain 01, if another occupant was fatally injured (Table 1). The domain in the CISS file and the actual domain for the case vehicle are shown. The six cases with domain and vehicle age errors represent 17.6% of the sample of serious injury crashes with 3–12 yo children. The total weight of the 34 cases was 13,558.7. Four of the cases (#5, #9, #22 and #25) have very high case weights.

Table 5. Case vehicle in incorrect domain and high case weight for 3–12 yo serious injury (MAIS 3–6) in 2017–2022 CISS.

Case	Case Information					Case Vehicle		Veh	Injury		Other Vehicle		Veh	Injury	
#	Year	PSU	No	Casewgt	Dom^	Dom^^	MY, Make, Model	Age	MAIS	KABCO	Dom^^^	MY, Make, Model	Age	MAIS	KABCO
	Incorrect Case Vehicle Domain														
5	2019	11	113	2,223.3	03	05	2011 Toyota RAV4	8	4	C	–	2018 Nissan Rogue	1	U^	C
9	2017	24	061	5,199.6	09	08	2002 Saturn SL	15	4	A	–	2016 Yamaha 750 cc	1	U^^	–
13	2020	48	068	182.2	03	08	2011 Honda Pilot	9	4	A	03	2017 GMC Suburban	3	1	C
18	2017	28	026	81.1	02	08	1992 Jeep Wrangler	25	3	A	03	2015 VW Jetta	2	2	A
22	2018	13	008	1,264.5	03	08	1998 Ford Expedition	20	3	C	03	2014 Honda CR-V	4	1	C
25	2018	32	004	937.8	06	08	2000 Ford E-Van	18	3	U	06	2013 Nissan Altima	5	2	B
	Other High Case Weight														
3	2018	20	111	887.3	08	08	2000 Merc Mountaineer	18	3	A	–	2004 Chevy Silverado	14	U^^	–
19	2017	32	013	474.0	01	01	2003 Chevy Suburban	14	3	A	–	1984 Ford F-series	33	U^^	–
21	2018	12	035	449.7	01	01	2002 Toyota 4-Runner	16	3	C	–	none			

Dom^: domain listed in CISS, Dom^^: domain for case vehicle, DOM^^^: domain for other vehicle in crash.
U^: Unknown if injured, not treated, U^^: occupant not summarized in CISS, –: unknown, none: single vehicle crash.

They total 9,625.2 and represent 71.0% of the weighted sum of all cases. The four cases overwhelm the other 28 cases in any analysis of proportions for national estimates of characteristics of serious injury to 3–12 yo children. An incorrect domain can lead to an incorrect case weight, which can be a very high. The case weight is related to the inverse of the injury severity. In 5 of the cases, the domain was incorrect based on the vehicle age. The vehicles were catalogued as newer than they were. This also influences the weighting factor. Cases #13 and #18 have the wrong domain, but a low case weights. It is unclear why they are low.

There were three other high case weights (Table 5). Case #3 was in the correct domain. It is unclear why the weight is 887.3. The other two crashes involved fatal injury to another occupant and were correctly in domain 01. The cases had higher weights than the average of 97.9 ± 51.1 for ten fatal cases with 3–5 yo children and 90.1 ± 97.0 for ten fatal cases with 6–12 yo children. The reason for the high case weights is unclear.

Table 5 includes the other vehicle in multi-vehicle crashes and lists its age and the maximum injury. In several cases, the injury was not investigated and the CISS file does not summarize occupants in the other vehicles. In all cases, the maximum injury in the other vehicle was lower or matched that in the case vehicle. The domain for the other vehicle is shown, when the injury was known. It is unclear what domain should be used with unknown injury (U), so the domain is left blank for the other vehicle. Zhang et al. (2019a) includes occupants with injury of unknown severity in domains with B and C level injuries. It is my understanding police report U unknown when it is unclear if the occupant is injured or injury is not reported. Wang (2023) stated unknown (U) represents injured unknown severity, unknown if injured or not reported. This could place U unknown in the B or C domains. It seems U unknown if injured or not reported belong in O domains when the officer sees no injury or has no report on the occupant.

Six cases have KABCO errors that list serious-severe injury (A level and MAIS 3–4) as C or U level injury in the police report (Tables 2–5). Each of the 3–12 yo children was seriously injured (A level). The CISS investigator was aware of the MAIS in the case vehicle based on hospital records. The actual MAIS severity should be used to correct errors in the police reported KABCO rating, so the case vehicle is weighted for the correct domain. The hospital record of MAIS is medically diagnosed and overrides the police rating with KABCO. The CISS investigator was aware of the occupant injury severity and case vehicle age, yet there are errors in the CISS data.

Discussion

NHTSA is aware of unusually high case weights

NHTSA has been aware of unusually high case weights in NASS-CDS since 2012. They know the high case weights distort national estimates of factors influencing serious injury in US crashes. Brumbelow and Farmer (2013) used 2000–2010 NASS-CDS to study real-world injuries associated with Hybrid III sternal deflections in frontal crash tests. They used Logistic regression to model the probability of AIS ≥ 3 injury as a function of maximum sternal deflection in the Hybrid III. The probability curves relied on weighted data, but there were cases with large weighting factors (high casewgt) that unrealistically influenced injury risks. They excluded the cases with incorrect injury ratings from the police accident report (PAR) from the analysis.

IIHS contacted NHTSA about the problem (Brumbelow and Farmer 2013). According to Barbara Rhea from NHTSA on March 23, 2012; the high weights occur when the police officer codes an injury severity (or leaves it blank) and later revises the code after the case has been selected for the NASS-CDS sample. Cases with no serious injury have low sampling likelihood but higher weighting factors to represent

the greater number of crashes in the population. When one of these sampled crashes actually involves serious injury, the weighting factor is much larger than other cases with serious injury, as seen in Tables 2–5. The CDS procedure samples a greater proportion of crashes with serious injury than minor injury crashes. NHTSA claimed there was no way to adjust the case weight after sampling occurred. This is nonsense and leads to errors that persist in the NASS-CDS and CISS databases and distort national estimates. NHTSA has been aware of the problem with high case weights and has done nothing since 2012.

Samaha et al. (2013) studied the opportunities for injury reduction in frontal crashes by structural engagement, vehicle class and occupant age. They addressed overly influential (high) NASS case weights. The high case weights distorted the statistics. They used a mean case weight in place of the very high weight based on the assumption that the case weights were normally distributed.

Brumbelow (2019) studied frontal crash injury risks for restrained drivers in vehicles with a "good" vehicle rating by age, impact configuration and delta V from the vehicle EDR. They found two sources for inflated (very high) case weights. First, police reports can include errors that are discovered during the investigation or are corrected by the police after CISS stratification has occurred. For example, an officer may indicate that an occupant did not require hospitalization when they were admitted. If the case is included in the NASS-CDS sample, the resulting weighting factor is much higher than similar cases with hospitalized occupants. He found 3% of the sample had coded values that did not match the definition of the stratum assigned to the crash.

The second source occurs because of the assumption in the NASS-CDS sampling procedure that hospital admission is associated with a police-reported A-level incapacitating injury (Brumbelow 2019). Hospitalization occurs only for occupants with A level injury. In NASS-CDS, there is a unique stratum for occupants with A level injury who are not hospitalized. There is no unique stratum for occupants with B, C, O or U injuries who are hospitalized. Cases where the injury was not incapacitating on the police report are weighted up to 100 times greater than those with A level injuries. Four percent (4%) of the sample involved hospitalized occupants without an A level injury by the police. Overall, they found a selection of cases often includes a small number with very high weights compared to others with similar injury outcome. The high weight cases dominate the weighted results and obscure meaningful findings. Brumbelow's (2019) sample included 184 cases with AIS ≥ 3 injury. Four cases accounted for 41% of the weighted sum.

Brumbelow and Jermakian (2021) studied injury risks and crashworthiness benefits for females compared to males in frontal crashes with airbag deployment. They used regression analysis with the weighted sample. The sampling weights were adjusted lower for cases that were mis-stratified or where a driver was hospitalized without a police-reported incapacitating A injury. These cases accounted for 6% of sample. NHTSA is aware of unrealistically high case weights in samples of serious injury (MAIS 3+) in NASS-CDS and CISS. They know the high case weights distort national estimates making calculations unrealistic, incorrect and unreliable. NHTSA has done nothing about the problems. NHTSA has not informed the public of the problems caused by high case weights. NHTSA has not corrected the errors in the CISS and NASS-CDS databases available online. NHTSA has ignored the problem. Brumbelow (2023) studied contributing factors and crash test relevance for lower extremity injury in female drivers. He addressed high case weights by capping them at the 99.5th percentile value. There are other examples where researchers capped or substituted high case weights.

There were at least 6 cases with problems in the domain, case weight and entries in the CISS cases (Table 5). There are other cases with high weighting factors that cannot be explained by the available information. The weighting factors are so high, that estimates of national incidence cannot be accurate or reliable. The author raised concerns about CISS case weight errors with NHTSA on 12-5-24 in an email with subject heading "unusually high case weights." Multiple emails have resulted in no NHTSA review of cases for errors or corrections to case weights. NHTSA has merely sidestepped the question of errors in the data and ignored the problem. Their inaction is irresponsible.

Errors in police reports are well known

Police officers list occupant injury severity using KABCO (Sherman et al. 1976; DOT 2012). Farmer (2003) found anomalies between police reported KABCO and hospital reported MAIS. For example, 49% of drivers coded by police as having incapacitating injuries (A) had only minor injuries (MAIS 1). The overstatement of injury severity was less frequent in male (44%) and elderly (37%) drivers than in female (53%) and nonelderly (50%) drivers. He did not address children. Taylor et al. (2024) found police accurately reported minor injuries (B-C), but inaccurately reported serious injuries (A). Police under-reported injury severity compared to trauma registry data. The KABCO had a higher degree of specificity classifying minor injuries (79.3%) but substantially underestimated seriously injured patients with a sensitivity of 49.9%. Burdett (2014) found law enforcement officers rated serious injuries (A, incapacitating) accurately in only 33% of occupants. The inaccuracies depended on alcohol use, gender, vehicle type and lighting conditions. He also found law enforcement officers had difficulty assessing injuries to body regions. NHTSA is aware that errors in the police accident report (PAR) cause errors in the CISS and NASS-CDS domain (stratum) and weighting factor, but they have taken no steps to resolve the problems in over 12 years.

NAS (2021) discussed methods to improve the accuracy of police reported KABCO ratings by regression adjustments, but no amount of adjustment can correct fundamental errors in the police report. The CISS crash investigator is in the best position to know what is correct and what is not. NHTSA need to have corrected the file elements that influence the case weight before a CISS case was finalized. CISS cases need to involve a correction of the KABCO ratings from the police report once hospital records of MAIS are known to the investigator. This should be done before the

quality control review of the case and should include modifications of the case weighting factor before the data is published. NHTSA never corrected errors in case weights in NASS-CDS and CISS. The errors have persisted for more than 12 years in NASS-CDS, yet they were aware of many studies showing poor correlation between serious injuries (MAIS 3+) and the KABCO rating given by the police.

Other errors have been reported in police reports. Viano and Parenteau (2018) compared seatbelt use in police reports with NASS-CDS investigator determined seatbelt use. For serious injury (MAIS 3), the police reported 72.6% belt use compared to 64.6% determined by the NASS-CDS investigator. For severe-to-fatal injury (MAIS 4+F), the police reported 52.3% belt use and the investigator found 44.4%. For fatalities (F), the police reported 46.1% belt use and the investigator found 41.8%. The authors found 13–18% error in police reported seatbelt use. The police often rely on self-reported belt use, which overestimates actual belt wearing, and they do not always conduct in-depth investigation of the vehicle, seatbelt and occupant injury to reach a conclusion of belt use. The police generally over-report seatbelt use in motor vehicle crashes.

KABCO or KACBO

In this study, the injury severity errors in the police report involve the officer listing an A level injury in the crash as a C level possible injury or U unknown. The officer did not determine the injury was A level (serious MAIS 3+), but they knew it was not minor (B level). They opted to classify it as possible injury (C level). The officers rated the A level injuries as C or U in 21.4% of the 34 cases. This is a relatively high fraction. Some of the problems with domain errors and high case weights is related to the KABCO classification of occupant injury by the police. The KABCO rating is perceived as a descending rank of injury severity. That perception may be incorrect. Some police officers rank injury severity as KACBO.

The KABCO literature uses different definitions for B and C level injuries. Sherman et al. (1976) refers to F as fatal injury, A as incapacitating injury, B as non-incapacitating, evident injury, C as possible injury and O as no injury. The National Safety Council (NSC 1996) and American National Standards Institute, Inc. (ANSI) refer to K as fatal, A incapacitating injury where an occupant cannot walk at the scene, B non-incapacitating, evident injury and C possible injury that is reported or claimed that cannot be classified as A or B.

The Department of Transportation DOT (2012) refers to K as fatal, A as suspected serious injury, B as suspected minor injury, C as possible injury that is not A or B, O as no apparent injury. ANSI (2017) updated the manual for classification of crashes listing K as fatal injury, A as suspected serious injury, B as suspected minor injury, C as possible injury and O as no apparent injury. Some police officers seem to interpret the severity of injury as KACBO, where C is intermediate between A serious incapacitating injury and B minor injury. KABCO misclassifications lead to an incorrect domain in NASS-CDS and CISS. NHTSA needs to clarify this area of contradiction with state police agencies, because rating A level injury as C or U has enormous effects on CISS and NASS-CDS case weights.

CISS case weight errors have enormous influence on national estimates

The 34 cases of serious injury to 3–12 yo children have a national estimate of 13,558.8 serious-critical injuries in 2017–2022. The annual estimate is 2,161,8 ± 2,260.3 serious injuries per year, based on estimates for each of the six years. The average case weight is 398.8 ± 961.6. The high standard deviation is due to several cases with extremely high case weight in comparison to the others in the sample. If the four cases with very high case weight (#5, #9, #22 and #25) are removed from the sample, the average case weight is 131.8 ± 180.7. This is 67.1% lower than the 398.8 average.

If the case weights for the four very high cases (#5, #9, #22 and #25) are replaced by the 131.8 average for the other cases, the sample has a sum of 4,458.0 serious-critical injuries in 2017–2022. This drops the annual estimate to 645.0 ± 694.8 serious injuries per year. This is 71% lower than the average with the high case weights included. The difference in the estimates cannot be overlooked or ignored, as NHTSA has done for more than 10 years with NASS-CDS. The question is whether the estimate of serious injury to 3–12 yo children is closer to 2,161.8 ± 2,260.3 per year or 645.0 ± 694.8 per year. Another question is whether neither estimate is accurate.

High case weights lead to erroneous policies and priorities

Takhounts et al. (2019) found a high risk for serious brain injury (AIS 3+) to the driver in 20 deg PDOF frontal crashes. The finding is counter-intuitive because there is no A-pillar head impact in a far-side oblique crash because the driver moves toward the center of the vehicle interior. Prasad et al. (2024) evaluated head injuries in 330–30 deg PDOF (principle direction of force) crashes in 10 deg increments using 1997–2011 NASS-CDS. They found the risk for AIS 3+ head injury was 0.45% in 20 deg frontal crashes, but the risk was 0.17–0.21% in the six other frontal directions from 330-10 and 30 deg PDOF. There was a spike in the risk at 20 deg PDOF due to one case (2004-08-169) with 1,522.5 casewgt.

The crash involved a 2000 BMW 3 Series that swerved left to avoid a deer in the road. The BMW lost control, contacted the left guardrail, crossed travel lanes and impacted the right guardrail with the right front. The vehicle was towed due to damage and the driver was transported to a medical facility. The right-front damage was minimal. The investigator determined a 13 km/h (8.1 mph) delta V for the right-front impact at 20 deg PDOF. The 33 yo male driver (178 cm, 95 kg) was lap-shoulder belted. The front airbags did not deploy but the tubular side airbags and seat airbags deployed. The driver experienced a small diameter (1–4 cm) intracerebral hematoma in the cerebrum, MAIS 4 brain injury. The investigator judged the injury was due to head impact on the left-side roof rail (confidence, probable).

When the high case weight crash was removed from the 20 deg PDOF sample, the risk for AIS 3+ head injury dropped to 0.16%. This is a 64% reduction in risk. There were 29 cases with a 20 deg PDOF. One case (3.4%) in the sample significantly distorted the risk calculation. Case 2004-08-169 was in stratum F, which is for crashes without a fatality or serious injury (Radja 2016, 5–7). The F strata is for minor injury B or possible injury C and has higher case weights than those in strata A, B, J or K, since the case weighting is the inverse of the injury severity. The case should have been in strata K because of an A level injury in a non-late model vehicle (≥5 year old) with the occupant transported for treatment. The one high-weight case led NHTSA to a wrong conclusion.

The very high case weight distorted the frontal crash risk calculations for AIS 3+ head injury by PDOF. The high risk at 20 deg PDOF erroneously led NHTSA to reach a priority for head protection. Prasad et al. (2024) showed the NHTSA analysis was misleading. The flaws in placing a crash in the wrong strata resulting in a high case weight are akin to putting the US in a panic over a new lethal virus, only to later find that the panic was unnecessary and there was no health threat because there was an error in the lab work on the blood sample. It would be unacceptable for a US agency not to inform the public that there was no threat. NHTSA needs to correct the high case weights for serious injury in CISS and NASS-CDS. They cannot ignore the problem.

Review of serious injury cases makes clear the high case weights are unrealistic

There were issues with CISS cases involving serious injury to 3–12 yo children that make national estimates unreliable, inaccurate and incomplete. Case #5 (1-11-2019-113-03) has a weighting factor of 2,223.3. It is in domain 03, which is for vehicles ≤4 years old with at least one non-incapacitated injury (B), possibly injury (C) or injury of unknown severity. It should be in domain 05. Case #5 involved an intersection impact to the left side of a 2011 Toyota RAV4 (case) by a 2018 Nissan Rogue. The case driver had MAIS 1 (minor) injury and the right-front passenger had no injury (MAIS 0). The 3 yo in the left 2nd row had MAIS 4 cerebral hematoma. It should have been in domain 05 because the vehicle was 8 years old and the rear occupant had an A level injury (MAIS 4). The domains with B, C or O injury (domains 03, 04, 06, 07, 09, 10) have higher weighting factors than domains with F fatal (01) or A level serious injury (02, 05 and 08).

The domain errors resulted in a very high and unrealistic case weight of 2,223.3. The other crashes in the sample of serious-critical injury to 3–5 yo children had an average case weight of 177.9 ± 311.8. The case weight for #5 was 6.5 standard deviations above the average for the other cases in the group. The relatively high standard deviation is due to case #13 with a 2000 Mercury Mountaineer. The driver had no injury (MAIS 0). There was no right-front passenger and the 3 yo child was unrestrained in the 2nd row and not in a child seat. The child had MAIS 3 cerebrum hematoma and vault fracture. The case was in domain 08 and the case weight was 887.3. Domain 08 involves an older model year vehicle with incapacitated (A) injury to at least one occupant. Case #13 involved an 18 year old vehicle and was in the proper domain. It is unclear what factors raised the case weight.

Case #9 (1-24-2017-061-09) has a weighting factor of 5,199.6. The injury was A level. It was in domain 09, which is for B, C level injury in an older vehicle (≥10 years old). Crashes with less severe injury have higher weighting factors than crashes with serious injury A (domains 02, 05 or 08) or fatalities F (domain 01). It should have been in domain 08 because the rear occupant had an A level injury (MAIS 4) and the vehicle was 15 years old.

Case #9 involved an intersection impact to the right side of a 2002 Saturn SL by a 2016 Yamaha 750 cc motorcycle. The Saturn was traveling on a two lane road. The motorcycle was on the same road traveling in the opposite direction. The Saturn made a left turn in front of the motorcycle resulting in a right-side impact of the Saturn, which spun 90 deg clockwise to rest. The case vehicle driver had MAIS 1 minor injuries and the right-front passenger had MAIS 2 rib fractures from the right door. The 6 yo male was in the right rear seat. He was in the vehicle lap-shoulder belts, not in a child seat. He experienced MAIS 4 liver laceration, reported by the police as A level injury. The injury source was the right-rear door armrest or panel.

NHTSA quality control review did not catch case errors

The quality-control, secondary review of CISS cases #5 and #9 did not correct the errors leading to an incorrect domain and weighting factor. The investigator was aware of MAIS 4 injury to the rear child in case #5, yet the KABCO rating was C. The investigator should have been aware of the MAIS 4 injury to the child in case #9. It had a case weight of 5,199.6, which is unrealistic for a MAIS 4 liver injury to a rear-seated child. It is incorrectly in domain 09, which is for B, C level injury in an older vehicle (≥10 years old). It should have been in domain 08 because the rear occupant had an A level injury (MAIS 4) and the vehicle was 15 years old. The other crashes in the sample of critical injury to 6–12 yo children had an average case weight of 88.3 ± 60.7. The case weight for case #9 was 84.5 standard deviations above the average for the other crashes in the group. This is an obvious and ridiculous error in the database. None of the errors shown in Table 5 were picked up and corrected during the secondary review of CISS cases.

CISS target samples rely on inaccurate data from 2011 CDS

The target sample allocation, estimated population and population percents used for CISS case selection are inaccurate for serious injury MAIS 3+ (see Table 1, Zhang et al. 2024). The "target percent of sample allocation" specifies the desired distribution of the sampled cases. For example, 5% in domain 01 means 5% of the sampled cases are selected from

crashes in domain 01. The "estimated population" is the expected population count for each domain estimated from 2011 CDS weighted data. The "population percent" column is the population distribution for each domain estimated from NASS-CDS.

CISS sampling frequencies were derived from the 2011 NASS-CDS (Zhang et al. 2024; page 4). The sampling procedure selects vehicles by injury severity and vehicle age based on weighted field data from the 2011 NASS-CDS. The 2011 NASS-CDS sampling and weighting were incorrect, so the CISS sampling and weighting are incorrect. NHTSA under-samples older vehicles. This is a critical deficiency in CISS and NASS-CDS.

For example, domain 08 assumes a population percent of 1.54%. This is unrealistically low for serious injury in older vehicles in the US. A review of FARS makes clear that more than 50% of fatalities occur in vehicles ≥10 years old (Viano 2023; Parenteau et al. 2022). Serious injury is overrepresented in older vehicles where driver age, race, ethnicity, gender and SES are important factors. Any comparison of domain 01 to domains 02, 05 and 08 shows that older vehicles are under-represented. The target population is 10% for domain 02 and 6% for domains 05 and 08. The percents are backwards. For fatal and serious injury, domain 08 should have a higher target population than for domains 02 and 05.

NHTSA's decision to sample more newer vehicles is flawed and lacks an understanding of real-world crash injuries where vehicle age is a surrogate for socio-demographic influences of driver age, gender and SES. It assures that CISS and NASS-CDS data are not representative of US crashes. For example, the case vehicle was ≥10 yo in 97.6% of fatal crashes with 3–5 yo children compared to 25.1% for serious injury crashes in the 2017–2022 CISS. The difference was statistically significant (χ^2 = 1,668, $p < 0.0001$). The difference is likely due to the CISS case selection procedure that under-sample older vehicles with serious injury. The reliance on the 2011 NASS-CDS sampling frequencies merely carries errors from 2011 forward to each year of CISS. Sampling errors persist in NASS-CDS and CISS.

NHTSA has done nothing to validate the CISS or NASS-CDS sampling frequencies against the distribution of hospital emergency department (ED) visits and admissions for injuries in motor vehicle crashes. This should have been a logical step that NHTSA took to ensure NASS-CDS and CISS sampling frequencies were consistent with real-world injuries. They should have mapped the KABCO ratings to ED visits and hospital admission. If it had been done, the errors in KABCO rating, domain and under-sampling of older vehicles would have been obvious.

A representative sample of older and newer vehicles is needed to describe serious injury crashes

A comparison of the average vehicle age for serious injuries and fatalities to 3–5 yo and 6–12 yo children in the 2017–2022 CISS shows the lack of representativeness of the CISS sample of serious injuries. Table 2 includes the average vehicle age for the unweighted cases with serious and fatal injury. The average vehicle is 16.2 ± 5.5 years old in fatal and 6.5 ± 5.4 years old in serious injury crashes. The difference is due to the sampling frequencies in CISS (and NASS-CDS) that result in a biased sample.

An example shows the consequences of the CISS sampling bias. The seatbelt use of drivers in fatal crashes of 3–5 yo children is 79.8% based on weighted data (n = 832.7). The seatbelt use is 99.3% (n = 3,538.8) with serious injury. The difference is statistically significant (χ^2 = 607, $p < 0.0001$). The higher seatbelt use is not real, it is a result of under sampling older vehicles. The same is seen with 6–12 yo children.

Table 3 shows the average vehicle age was 11.1 ± 7.1 year old with a fatal 6–12 yo child compared to 6.8 ± 4.0 years old with serious injury. Seatbelt use by drivers was 42.5% (n = 766.6) in fatal and 100% (n = 5,606.5) in severe injury crashes involving 6–12 year old children. The difference is statistically significant (χ^2 = 3,463, $p < 0.0001$). Again, seatbelt use in fatal and serious injury crashes are not that different. Any real change is masked by the increase caused by selection bias in CISS.

The inclusion of a representative sample of older and newer vehicles is important to describe characteristics of serious injury crashes in the US. There were some at NHTSA and Academia pushing safety researchers to only use the latest field data on newer vehicles. They wanted to ignore older field data and deny the importance of comparing current to older data to show trends in automotive safety. CISS provides an incomplete picture of the frequency of seatbelt nonuse, child seat misuse, alcohol and drug use and other driver behaviors related to serious injuries, because it under-samples older vehicles.

A thought exercise shows the need for continuity in field data. It was developed during the study of fetal deaths (Viano and Parenteau 2023). Table 6 considers crashes involving all vehicle ages investigated from 1990 to 2008 and only newer vehicles (≤10 year old) from 2009 to 2025. It shows hypothetical counts and percents of seatbelt use. The 1990–2008 sample includes 80% seatbelt use in newer vehicles and 40% in older ones. The average use rate is 60.0 ± 28.3%. If data from 2009 to 2025 includes only newer vehicles and the same use rate exists as in 1990–2008; the belt use rate remains 80%. NHTSA can claim a 33% increase in seatbelt use. However, the new data does not include older vehicles with lower seatbelt use. If the experience with older vehicles is included, the belt use rate is 66.7 ± 23.1%. The combined data provides a clearer picture of seatbelt use and the standard deviation shows the uncertainty. NHTSA should not have stopped investigating serious injuries in older vehicles.

Table 6. Influence of stopping to investigate older vehicles (hypothetical analysis).

	Number belted				Percent belt use (%)		
Vehicle Age (yr)	1990–2008	2009–2025	1990–2025		1990–2008	2009–2025	1990–2025
0–9	80/100	160/200	240/300		80.0%	80.0%	80.0%
≥10	40/100	–	40/100		40.0%	–	40.0%
All	120/200	160/200	280/400		60.0%	80.0%	66.7%
				sd	28.3%		23.1%

Notes: sd: standard deviation.

NASS-CDS stopped investigating older vehicles in 2009

NHTSA made a mistake stopping the investigation of older vehicles (≥10 yo) in the 2009–2015 NASS-CDS (NHTSA 2009). CISS included older vehicles, but the proportion is too small to match real-world crashes in the US. NHTSA's decisions ruined the consistency of the field databases from the 1980s to today. It harmed the continuity of tracking trends in crash characteristics over decades of field crashes. NHTSA merely stopped investigating serious injury crashes with lower seatbelt use, because occupants in older vehicles have lower rates of seatbelt use.

Older vehicles are an important fraction of crashes in the US that involves a socio-demographic subset of the population race, gender, ethnicity and SES. The CISS sample of serious injuries does not include a field-relevant proportion of older vehicles. CISS sampling frequencies rely on 2011 NASS-CDS, where no older vehicles were investigated. It is unclear how NHTSA chose sampling frequencies for older compared to newer vehicles. For example, there was a phase-in of ESC (electronic stability control) from 2003 to 2009 MY (model year). The technology is remarkably effective and changed the crash types related to serious injury and death (Viano et al. 2024). It is unclear how the effect of ESC is accounted for in the CISS sampling frequencies.

Selection of the case domain

It was my understanding of NASS-CDS procedures that for crashes involving two or more vehicles, the vehicle with the greatest injury severity set the stratum (domain) in NASS-CDS (Radja 2016; Table 3-1, 5–8). The procedure in CISS is different for serious injury (Zhang et al. 2024; Table 1, 4). All fatalities are placed in domain 01, consistent with NASS-CDS. The remainder of domains are sorted by vehicle age and then occupant injury. NHTSA's decision to change the hierarchy of case selection in CISS undermines the usefulness of CISS data for the study of serious injury. The decision was wrong for an injury database. It makes no sense to select a domain based on vehicle age, if the database is for the study of injuries. The domain should depend on the most serious injury, as it did in NASS-CDS. That is why fatal injuries are in domain 01. If the newer vehicle sets the domain, vehicle age dictates the sample, which can have unusually high case weights for serious injury in an older vehicle, as occurred in this sample of serious injury to 3–12 yo children. That is why CISS is not representative of serious injury in US crashes.

For example, if a newer vehicle has a C level injury and another older vehicle in the crash has serious injury A level, the case weight for the older vehicle can be very large. The high case weight merely reflects a minor injury in a newer vehicle colliding with an older vehicle with serious injury. This may explain some of the very high case weights for crashes in the sample of 34 children with serious injury (Table 5). If true, it represents a fundamental flaw in CISS. Case selection should be based on injury severity. This also points to a weakness in not having a case ID for each vehicle in a multi-impact crash.

There is no reason to expect the same case weight for all vehicles in a collision. Each vehicle should have its own weight based on the injury outcomes in the vehicle and other factors. For example, a drunk driver speeding on the highway in a newer vehicle (≤ 4 years old) has a very different crash and injury risk than a family of four in an older vehicle (≥10 year old) driving below the speed limit back home from the movies. CISS gives the same case weight to both vehicles even if the drunk driver has minor injuries MAIS 1 and a child in the family vehicle has severe injuries MAIS 4. How CISS handles the case weighting and implications are unclear.

The domain errors for the six out of 34 crashes make the sample unrepresentative of serious injury to children in the US. NHTSA needs to correct CISS and NASS-CDS cases with MAIS 3+ injury. There seem to be several error types in selecting a domain and case weight. NHTSA needs to modify the domains based on the most severely injured occupant in the crash and then sort by vehicle age. This would allow a new case weight for the crash based on the vehicle with the most seriously injured occupant. The research community could treat the corrected data as a convenience sample for analysis of serious injury. The current CISS is not useful for the study of serious injury with the flaws in domain and outlier case weights. NHTSA should remove CISS and NASS-CDS from their website until high case weights are corrected for serious injury.

NASS-CDS and CISS serious injuries do not match hospital data

There are few studies comparing serious injury estimates from NASS-CDS and CISS with hospital ED and admitted patients. This is the way to judge the adequacy of the sampling protocol used by NHTSA. The author is unaware of any research done by NHTSA to show the validity of the procedures used to select NASS-CDS and CISS cases. Based on the under-sampling of older vehicles, the comparison to hospital records should be poor. Freeman and Leith (2020) estimated the number of cervical spine injuries in motor vehicle crashes in the US using NASS-CDS and compared them to the Nationwide Emergency Department Sample (NEDS) and Nationwide Inpatient Sample (NIS) hospital data. They found NASS-CDS under-estimated by 84% all types of cervical spine injuries in US hospital emergency departments. They concluded that NASS-CDS cannot be used to estimate the number of spinal injuries of any type or severity. Other comparisons like the Freeman, Leith study need to be made.

Case weighting procedure is incomprehensible

Researchers that analyze weighted CISS data on crash injuries in the US may not be aware of the distortion of results caused by extremely high case weights for serious injury. Researchers need to add an analysis step that reviews the case weights in the unweighted sample. Any case weight above 3 sd of the average for the other cases in the sample should be scrutinized for errors. It is best to impute the

average case weight for the non-outlier cases, use a median weight or some percentile case weight until NHTSA corrects the data.

NHTSA has the responsibility to correct the errors in NASS-CDS and CISS. They need to develop a case weight correction method based on errors between the KABCO and MAIS injury ratings, vehicle age, and other factors that influence case weight. They need to correct errors in sampling frequencies by matching CISS and NASS-CDS to hospital ED and admission data. They need to fix the selection of the newer vehicle in a crash setting the domain when the occupants have lower severity injuries than others in an older vehicle, if this is the procedure used by NHTSA in CISS and NASS-CDS.

The CISS weighting is summarized in the annual JKWGT file. The JKWGT file contains 32 columns of numbers with 24 JKWGT entries. Zhang et al. (2019a) defined the procedure to create a case weight as:

- calculate the base weights (the inverse of selection probabilities) at all three stages (PSU, PJ, and PAR).
- adjust the base weights for non-response at all three stages to correct potential non-response bias, a PAR is non-responding if the vehicle is unavailable for inspection, a PJ is non-responding or a PJ refuses to cooperate with the investigation.
- adjust the weights for duplicate PARs.
- calibrate the PJ and the PAR weights using the PSU level total PAR stratum counts to further correct potential non-response bias and coverage bias.
- calibrate case weights by benchmarking Census resident population counts and FARS crash counts.

The procedure is incomprehensible. It is not possible to follow the steps and understand how high case weights are generated. The data relied upon for each step is unknown, not available or unclear. No examples are provided to show how each step changes the case weight. Fleming (2010) outlined the case weighting procedure for NASS-CDS. The steps are complex and hard to follow and no examples are given. The CISS procedure needs to be explained with examples of cases leading to high, average and low case weights.

It is not possible to assess the reasonableness of NHTSA's procedure to "create" a case weight and no validation is provided. When a case has an incorrect domain and a very high case weight, it creates an error in the database. It is also likely that very low case weights have errors in the data. This has not been analyzed. The weighting steps seem to deal with minutia when the initial sorting places a case in a domain for B or C level injury, when it is an A level injury. NHTSA (2023) has a fancy brochure about the crash reporting sampling system and claims their data establishes an estimate of the number of people annually injured in motor vehicle crashes. The statement is untrue for serious injury.

MAIS and death risks

Table 7 shows the maximum abbreviated injury severity (MAIS) for occupant injuries (Gennarelli and Wodzin 2006). The CISS file contains a summary of occupant injuries with the AIS level for each injury. It also provides the MAIS for the occupant based on the maximum injury severity in the hospital records. The risk of death for belted and unbelted occupants is shown by MAIS (Viano and Parenteau 2018). For a belted occupant, a MAIS 3 has a $2.99 \pm 0.50\%$ risk of death. A MAIS 4 has $17.4 \pm 3.4\%$ risk of death up to MAIS 6 with $99.7 \pm 13.6\%$ (note: the upper limit is 100%). Occupant deaths in motor vehicle crashes are listed as K (killed) in the KABCO rating and F (fatal) in MAIS. The CISS cases have fatalities with a range of MAIS in the occupant, from MAIS 1–6. The selection of injury cases need to mirror the probability of survival by MAIS and should be based on hospital records that are linked to crash selection frequencies. The current approach assumes a distribution based on invalid and unverified selection procedures that rely on NASS-CDS crashes selected for investigation in 2011. It is a recurring error. Wang (2023) reported the risk of fatality (K) by MAIS using 2017–2019 CISS. For example, the risk of death was 0.1872% with MAIS 3 injury.

Table 7. Maximum abbreviated injury Scale and risk of death for belted and unbelted occupants (Gennarelli and Wodzin 2006; Viano and Parenteau 2018).

%	Maximum Abbreviated Injury Scale (MAIS)						
Fatal	6	5	4	3	2	1	0
	Maximum	Critical	Severe	Serious	Moderate	Mild	None
Belted							
average	99.7	39.6	17.4	2.99	0.398	0.0250	0.0130
sd	13.6	9.5	3.4	0.50	0.057	0.0022	0.0097
Unbelted							
average	98.1	44.0	9.7	5.53	0.740	0.1670	0.0040
sd	20.2	11.6	1.8	1.57	0.188	0.0343	0.0025
Wang (2023)	91.2	0.0	0.0	0.1872	0.0	0.0169	0.0049

CISS is not an improvement over NASS-CDS

There is a lack of completeness in CISS cases as compared with NASS-CDS. Radja et al. (2019) claimed CISS was a major improvement over NASS-CDS in sample design, data collection technology and information infrastructure making CISS a nationally representative probability sample. NHTSA (2023) claimed CISS was a nationally representative sample with detailed investigation of passenger vehicle crashes and that it provides nationally representative data on fatal and nonfatal motor vehicle crashes for use in developing and evaluating federal motor vehicle safety standards and other safety countermeasures. This is similar to claims by others that CISS improved on the procedures in NASS-CDS (Zhang et al. 2019a, 2019b, 2019c, 2024; Radja et al. 2019, 2022). CISS cases are not an improvement over NASS-CDS.

CISS cases have degraded in quality, completeness and accuracy from NASS-CDS data. The representativeness depends on the selection criteria and case weight for each investigated crash. The case weight depends on the most severe injury in the police report, vehicle age and other factors. If there are errors in the case description of the injury severity and vehicle age, there are errors in the case weight and the sample is not representative. An extremely high case

weight overwhelms calculations of proportions in comparison to lower weight cases in a defined sample of seriously injured children. Unreliable data leads to unreliable results. NASS-CDS and CISS data users need to be aware and be cautious of case weights that are higher than 3 standard deviations (sd) of the other weights for seriously injured occupants in a defined group.

Degradation in the number and quality of photographs in CISS

There are other degradations in the quality, accuracy and completeness of CISS cases compared to the earlier NASS-CDS. For example, the number and quality of photograph in CISS cases are substantially reduced from what was available in NASS-CDS. Often the most-damaged area of the vehicle is inadequately shown and the interior around the most seriously injured occupant lacks contact mark delineation, photographs of witness marks, damage to components and perspective of the interior. Detailed photographs of the rear-seat area are limited or often skipped in CISS cases with serious injury. These issues occur more often with older vehicles (≥10 years old), as compared to NASS-CDS.

Case narrative lacks information

The CISS case narrative of the crash is significantly shorter and contains less information than was available in NASS-CDS. Often only a sentence or two is included describing the direction of travel of vehicles. The driver responsible for the crash is not defined, which is particularly relevant for intersection crashes with vehicles turning or passing through. The scene diagram is not coded with traffic controls at the intersection. The police report and on scene review should enable the investigator to define the responsible driver, violations of traffic controls and other relevant factors. NASS-CDS narratives often described the pre-crash vehicle movements, occupant injuries, extraction and transport. NASS-CDS cases contained relevant information. CISS narratives are inadequate and do not provide useful information.

Sources of injury are unclear

The source of injuries no longer includes a percent assurance from the investigator and often the source is vague with multiple entries that make injury causes ambiguous. NASS-CDS investigators were often experienced, retired police offices, whose determinations of injury sources were reasonably reliable. It is unclear what background CISS investigators have today or what limitations have been put on their time or expected work product, but CISS cases leave uncertainties in the causes for injuries. CISS case information is less reliable, less accurate and less complete than NASS-CDS cases. The quality control step or secondary review of CISS cases is inadequate.

NHTSA needs to translate different AIS codes linking NASS-CDS and CISS data

The Abbreviated Injury Scale has undergone many revisions since the early 1980s. Wang (2023; Table 1, 6) noted early NASS-CDS used AIS90 codes to describe injuries and their severity. He developed a translator for newer AIS codes. The 2000–2008 NASS-CDS used AIS98. The AIS code was updated to AIS05 and again later to AIS15. The severity of injuries in NASS-CDS and CISS should be translated to the latest AIS code so it is possible to study serious injury across decades of field data. It is unclear if the NHTSA translator is sufficient to update NASS-CDS files to AIS15 or the latest AIS code.

Conclusions

There are pervasive errors in the CISS crash selection procedure, domains and case weights that make estimates of serious crash injury unreliable. There is no quality control to correct the data errors. The online CISS and NASS-CDS files are inaccurate and need corrections for cases involving serious injury (MAIS 3+). A complete review and revision of the CISS and NASS-CDS is needed to correct errors so the databases are compatible from the 1980s to today. The revised data needs to be posted with clear statements on the scope of the revisions and measures taken to correct the data. The current online NASS-CDS and CISS files are incorrect and inadequate to estimate serious injury in motor vehicle crashes.

CISS sampling frequencies rely on 2011 NASS-CDS weighted data, which is not relevant to serious injury crashes more than 10 years later. The 2011 NASS-CDS did not investigate older vehicles. CISS under-samples serious injury in older vehicles where race, gender and SES are important factors. CISS is not a representative sample of serious injury crashes in the US. CISS cases are incomplete and limited in comparison to the earlier NASS-CDS.

This study concluded:

1. CISS has domain errors in 17.6% (6 out of 34 cases) of serious injury cases involving 3–12 yo children in the 2017–2022 data. The CISS hierarchy for case selection and domain placement is incorrect. It is based on vehicle age, not the maximum severity of injury (A, B, C, O level) in the case vehicle.
2. An incorrect domain can lead to an unrealistically high case weight for serious injury cases. This is particularly true when a serious injury (A-level) case is placed in a domain for possible injury (C-level) or unknown (U), which happens in some multi-vehicle crashes.
3. Four of 34 CISS cases with high weights represent 71% of the overall sample weight, leading to inaccurate national estimates of pediatric injury in motor-vehicle crashes.
4. CISS data estimates 2,161,8 ± 2,260.3 serious injuries per year to 3–12 yo children with the four high case

weights in NHTSA files. Adjusting the four high cases to the average case weight of the other 30, drops the estimate to 645.0 ± 694.8 serious injuries per year. This is a 71% lower estimate, an enormous difference. Which estimate is closer to the actual? NHTSA has done nothing to check and verify injury and fatality estimates. The inaccurate case weights make the calculations of standard errors inaccurate and unreliable.

5. NHTSA has been aware of unusually high case weights in NASS-CDS and CISS since at least 2012. They have done nothing to correct the errors, claiming they cannot make changes in domains and case weights. This is nonsense. Each year CISS continues the systemic problem of errors in the annual data. CISS weighted data is not representative of serious injury crashes in the US.
6. Researchers have used various methods to address high case weights by removing the cases with high weight, imputing the average weight from the other (lower weight) cases or imputing the 99.5 percentile case weight. They are aware that CISS and NASS-CDS case weight errors lead to unreliable estimates for serious injury incidence and risk.
7. NHTSA claims analysis of subsets of CISS data are not valid with small sample size. This ridiculous. If a small sample of data with one or more high case weights is not valid, a larger sample of cases with more high case weight errors cannot mysteriously be valid. The number of errors merely grows. CISS and NASS-CDS datasets are unreliable and incorrect for any national estimate.
8. CISS selects and investigates crashes based on sampling frequencies in the 2011 NASS-CDS. It is unclear how NHTSA picked the CISS sampling frequencies for older vehicles, when the 2011 NASS-CDS did not investigate older vehicles. Errors in the 2011 sampling frequencies are passed forward to CISS case selection. CISS under-samples older vehicles, where driver age, race, ethnicity, gender and SES are important factors in serious injury crashes.
9. In 2009, NASS-CDS stopped investigating vehicles ≥10 years old. NASS-CDS data after 2008 is not consistent with earlier field data and cannot be used to determine answers to questions about seatbelt use, alcohol-drug use, risk-taking behavior, etc., because the 2009-15 NASS-CDS excludes drivers in the lower SES strata that often use older vehicles. The exclusion of older vehicles makes it appear that road safety has improved, which seems like a self-serving reason NHTSA decided not to investigate a representative sample of serious injury crashes in the US.
10. CISS sampling errors are obvious. For example, 97.6% of fatal crashes with 3–5 yo children involve older vehicles (≥10 years old). This compares with 25.1% for serious injury crashes. The difference is statistically significant (χ^2 = 1,668, $p < 0.0001$). The difference is due to selection bias for newer vehicles. Older vehicles are a surrogate variable for demographic influences of race, gender and SES on serious injury crashes. If the correct proportion of older vehicles with serious injury had been sampled, the difference would diminish and serious injury cases would be more like fatal crashes in CISS.
11. Seatbelt use of drivers in fatal crashes of 3–5 yo children is 79.8% based on weighted data (n = 832.7). It is 99.3% (n = 3,538.8) with serious injury. The difference is statistically significant ($\chi 2 = 607$, $p < 0.0001$). The higher seatbelt use is not real, it is a result of under sampling older vehicles with serious injury to 3–5 yo children. CISS sampling, domain placement and weighting are obviously wrong.
12. A field relevant balance of older and newer vehicles is needed to account for the influences of alcohol-drug use, aggressive driving, lack of seatbelt use, lack of child seat use and other risky behaviors. More than 50% of deaths in FARS occur in vehicles 10 or more years old.
13. If the newer vehicle in a crash sets the domain in CISS, vehicle age dictates the case weight for serious injury in an older vehicle in a multi-vehicle crash. For example, if a newer vehicle has a C level injury and another, older vehicle, in the crash has serious injury A level, the case weight for the older vehicle is based on domain B, C. The case weight can be very large. This makes no sense.
14. There is a fundamental flaw in the CISS and NASS-CDS databases that gives the same case weight to both vehicles in a multi-vehicle crash. There is no expectation that the crash frequencies are the same for both vehicle and there is no expectation that the injuries to occupants in the vehicles are the same severity. Each vehicle should have its own case weight in a multi-impact crash.
15. Freeman and Leith (2020) found NASS-CDS under-estimated by 84% all types of cervical spine injuries in US hospital emergency departments. They concluded that NASS-CDS cannot be used to estimate the number of spinal injuries of any type or severity. The 2011 CDS sampling frequencies are wrong for serious injury.
16. NHTSA has not validated the sampling frequencies used in CISS from the 2011 NASS-CDS for serious injury against medical data on emergency department (ED) visits and hospital admissions. NHTSA has ignored the need to validate the sampling frequencies.
17. NHTSA sampling frequencies are invalid and need to be revised to match hospital admissions for serious injury.
18. NHTSA (2023) claims CISS estimates the annual number of people injured in motor vehicle crashes. This is untrue for serious injury crashes in the CISS and NASS-CDS files.
19. Under-sampling older vehicles means CISS cannot establish valid safety priorities for impaired driving,

restraint use and other crash characteristics. CISS sampling frequencies emphasize newer vehicles, which lack drivers prone to alcohol-drug use, not using seatbelts, not properly using child seats and risk-taking behaviors.

20. NHTSA acts as if CISS and NASS-CDS are free-standing datasets of traffic injuries. This view is untrue. Their databases need to be consistent with health data on traffic-related emergency department and hospital admissions for injury. This would provide a continuity of data across DOT and HHS. If NHTSA had done a consistency check of CISS with injuries in hospital admissions, they would have found that errors in the CISS and NASS-CDS data sampling and case weighting lead to injury numbers that are not consistent with hospital data.
21. NHTSA should compare vehicle age, restraint use, impaired driving and other behaviors between the census data in FARS and the sampled crashes in CISS and NASS-CDS. This study would demonstrate a lack of comparability because of sampling and weighting errors. This is an evaluation NHTSA should have done years ago to check the validity of their methods of collecting serious injury data.
22. The quality and completeness of CISS cases have degraded from the earlier NASS-CDS. The number of photographs, crash narrative, injury source confidence and other elements are noticeably worse in CISS than NASS-CDS.
23. NHTSA continues to ask for more money to expand CISS data collection. Collecting a greater number of errors will not benefit the motoring public. OMB (Office of Management and Budget) should decline to support more dollars for CISS, until the procedures leading to errors and lack of representativeness of sampling frequencies are corrected in the existing NASS-CDS and CISS files and in future data collection. Their in-depth investigation procedures need improvements.
24. It is likely that other problems exist in the NASS-CDS and CISS sampling frequencies, domains and case weighting that influence national estimates for serious injury. NHTSA needs to adopt a practice of self-critical analysis of their methods and procedures for field data collection. None of the NHTSA reports include critical analyses showing their methods and procedures are accurate and relevant to hospital records of serious injuries from motor-vehicle crashes in the US. They have not conducted internal database comparisons of FARS with NASS-CDS and CISS to show consistency of the sampling and weighting methods and results. A recent study shows NASS-CDS estimates of fatalities are not consistent with the census count in FARS (Viano 2025).
25. NHTSA erroneously focused on a serious AIS 3+ head injury risk in 20 deg PDOF frontal impacts. An evaluation of 1997–2011 NASS-CDS found a spike at 0.45% risk for AIS 3+ head injury in 20 deg PDOF. The risk was 0.17–0.21% in 330-10 and 30 deg PDOF in 10 deg increments. The spike in risk was due to a very high case weight for one crash out 29 at 20 deg PDOF. Removal of the high weight case dropped the risk to 0.16%, which is in-line with the risk in six other frontal directions. NHTSA reached an incorrect conclusion for head protection because of flaws in the domain and case weighting for one serious injury case in NASS-CDS. The case was in domain F, which is for B or C level injuries. AIS 3+ injuries are A level.
26. Unusually high case weight errors have an enormous influence on national estimates of serious injury. NHTSA should remove CISS and NASS-CDS from their website until the case weight issues are corrected. NHTSA should not continue to ignore the problem of unusually high case weights. CISS and NASS-CDS estimates of serious injury are unreliable and inaccurate.
27. The high case weight problem may be occurring with MAIS 1–2 injuries (minor-moderate injury) where a KABCO rating of O (no injury) would lead to higher case weights than a B (minor injury) or C (possible injury) injury rating. This possibility has not been investigated. There are some very low case weights for A level injuries that also have not been investigated. The online files for NASS-CDS and CISS need to include clear calculations leading to a case weight.
28. NASS-CDS used AIS90, AIS98 and AIS05 for different data collection years. CISS uses AIS15. The coding of injury severity in NASS-CDS should be translated to the latest AIS (AIS15) so serious injury can be tracked across decades of field data. NHTSA has a translator but it is unclear it is sufficient to update NASS-CDS to AIS15 or the latest code.

Acknowledgements

The author has no conflicts of interest. There was no funding for the research. The field data is available from NHTSA: https://crashviewer.nhtsa.dot.gov/CISS/SearchFilter. The Tables in this study provide a summary of the CISS crashes involving serious injury to 3–12 year old children. The author appreciates helpful conversations with Mr. Matthew Brumbelow, IIHS, and Dr. Priya Prasad, retired Ford Motor Co. Their perspectives were important.

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