

Appendix 1: Unweighted count of spinal and head injury by belt use and crash type based on 18 years of NASS-CDS (1994-2011).

	Crash Type					Total
	Front	Side	Rear	Rollover	Other	
Front outboard occupant	37,867	17,170	4,745	9,638	637	87,574
MAIS 0+F	35,975	16,361	4,438	9,190	595	81,950
MAIS 3+F	4,193	2,846	196	2,422	176	11,069
MAIS 4+F	1,631	1,721	127	1,514	126	5,732
Spine injury						
MAIS 4+ (SCI)	112	102	23	112	7	409
AIS 3+	500	369	59	632	57	1,804
AIS 4+ (SCI)	120	109	24	114	9	435
AIS 3 Fx-dislocation	344	245	29	489	46	1,266
Head injury						
MAIS 4+	625	891	68	702	62	2,631
AIS 3+	2,577	3,768	274	2,930	307	10,974
AIS 4+	1,203	1,766	131	1,385	152	5,183
Belted front outboard occ	29,174	13,408	4,049	6,345	424	60,969
MAIS 0+F	27,877	12,822	3,805	6,077	391	58,366
MAIS 3+F	2,248	1,670	109	995	63	5,405
MAIS 4+F	720	932	62	498	38	2,366
Spine injury						
MAIS 4+ (SCI)	50	42	11	39	1	155
AIS 3+	230	162	31	281	21	767
AIS 4+ (SCI)	53	43	12	40	1	163
AIS 3 Fx-dislocation	162	112	16	228	20	561
Head injury						
MAIS 4+	282	462	38	235	16	1,085
AIS 3+	1,160	1,927	150	962	106	4,504
AIS 4+	541	892	78	425	49	2,079
Unbelted front outboard occ	7,570	3,183	542	3,078	195	23,855
MAIS 0+F	7,030	2,982	485	2,906	186	20,956
MAIS 3+F	1,801	1,062	79	1,374	108	5,269
MAIS 4+F	855	724	60	985	84	3,183
Spine injury						
MAIS 4+ (SCI)	56	55	10	70	3	232
AIS 3+	248	197	21	331	32	965
AIS 4+ (SCI)	60	60	10	71	4	247
AIS 3 Fx-dislocation	168	129	8	245	26	660
Head injury						
MAIS 4+	329	391	28	457	44	1,469
AIS 3+	1,364	1,683	120	1,935	194	6,174
AIS 4+	635	798	51	950	101	2,968

Appendix 2: Annual count of spinal and head injury by belt use and crash type based on 18 years of weighted NASS-CDS (1994-2011).

	Crash Type				
	Front	Side	Rear	Rollover	Total
Belted	716,324	341,730	113,549	125,680	1,529,453
MAIS 0+F	695,953	329,497	107,975	119,817	1,481,473
se	67,760	41,863	18,098	17,516	150,588
MAIS 3+F	10,097	6,771	313	5,166	24,065
se	1,143	1,169	69	1,043	3,196
MAIS 4+F	1,981	2,778	168	1,922	7,406
se	291	566	43	204	1,038
Spine injury					
MAIS 4+ (SCI)	87	82	38	130	390
se	17	17	23	36	70
AIS 3+	1,062	589	102	1,301	3,355
se	278	147	35	258	548
AIS 4+ (SCI)	93	82	40	132	407
se	20	17	23	36	74
AIS 3 Fx-dislocation	925	496	60	1,146	2,848
se	270	147	20	231	498
Head injury					
MAIS 4+	756	1,275	103	811	3,194
se	158	258	26	149	410
AIS 3+	3,294	5,039	302	2,620	12,549
se	665	823	74	258	1,585
AIS 4+	1,301	2,236	149	1,173	5,419
se	222	401	44	180	694
Unbelted	122,035	40,335	9,319	29,514	430,429
MAIS 0+F	116,144	38,461	8,650	27,777	384,539
se	21,651	5,832	1,463	5,469	46,020
MAIS 3+F	7,826	3,892	190	5,236	20,488
se	1,886	842	56	1,428	4,417
MAIS 4+F	2,814	2,289	138	3,416	10,341
se	803	499	53	962	2,422
Spine injury					
MAIS 4+ (SCI)	136	124	13	194	537
se	39	21	7	54	108
AIS 3+	795	545	32	1,419	3,309
se	264	108	9	593	964
AIS 4+ (SCI)	142	128	13	195	558
se	38	21	7	54	108
AIS 3 Fx-dislocation	599	407	7	1,131	2,565
se	224	104	2	536	852
Head injury					
MAIS 4+	887	1,195	87	1,346	4,198
se	282	269	43	327	903
AIS 3+	3,808	5,223	425	5,440	17,760
se	881	1,027	271	1,301	3,461
AIS 4+	1,552	2,376	173	2,721	8,148
se	437	459	105	600	1,610

Appendix 3: Spinal and head injury rates for belted and unbelted front-seat occupants and seatbelt effectiveness by crash type based on 18 years of weighted NASS-CDS (1994-2011).

Injury Rates	Crash Type				
	Front	Side	Rear	Rollover	Total
Front Outboard Occupants					
MAIS 3+F	2.181%	2.907%	0.432%	6.986%	2.371%
se	0.332%	0.541%	0.093%	1.519%	0.386%
MAIS 4+F	0.585%	1.385%	0.263%	3.582%	0.943%
se	0.125%	0.285%	0.069%	0.738%	0.179%
MAIS 4+ (SCI)	0.030%	0.056%	0.046%	0.218%	0.051%
se	0.008%	0.009%	0.019%	0.057%	0.009%
Spine AIS 3+	0.227%	0.305%	0.123%	1.855%	0.356%
se	0.051%	0.057%	0.035%	0.514%	0.071%
Spine AIS 4+ (SCI)	0.032%	0.057%	0.048%	0.220%	0.054%
se	0.009%	0.009%	0.019%	0.056%	0.010%
Spine AIS 3 Fx-dislocation	0.183%	0.242%	0.065%	1.556%	0.287%
se	0.000%	0.054%	0.021%	0.455%	0.060%
MAIS 4+ head	0.197%	0.667%	0.161%	1.440%	0.389%
se	0.046%	0.128%	0.048%	0.185%	0.063%
Head AIS 3+	0.853%	2.785%	0.608%	5.364%	1.593%
se	0.163%	0.483%	0.250%	0.884%	0.249%
Head AIS 4+	0.343%	1.248%	0.270%	2.582%	0.712%
se	0.074%	0.217%	0.105%	0.364%	0.111%
Relative rate: Head v Spine					
MAIS 4+	6.7	11.9	3.5	6.6	7.6
AIS 3+	3.8	9.1	5.0	2.9	4.5
AIS 4+	10.6	21.7	5.7	11.8	13.2

Appendix 3 (cont): Spinal and head injury rates for belted and unbelted front-seat occupants and seatbelt effectiveness by crash type based on 18 years of weighted NASS-CDS (1994-2011).

Injuries	Crash Type				
	Front	Side	Rear	Rollover	Total
MAIS 3+F					
Belted	1.451%	2.055%	0.290%	4.311%	1.624%
se	0.164%	0.355%	0.063%	0.871%	0.216%
Unbelted	6.738%	10.118%	2.198%	18.852%	5.328%
se	1.624%	2.189%	0.648%	5.142%	1.149%
Belt eff	78.5%	79.7%	86.8%	77.1%	69.5%
MAIS 4+F					
Belted	0.285%	0.843%	0.156%	1.604%	0.500%
se	0.042%	0.172%	0.040%	0.171%	0.070%
Unbelted	2.423%	5.951%	1.595%	12.297%	2.689%
se	0.691%	1.298%	0.607%	3.462%	0.630%
Belt eff	88.3%	85.8%	90.3%	87.0%	81.4%
MAIS 4+F (SCI)					
Belted	0.013%	0.025%	0.035%	0.109%	0.026%
se	0.003%	0.005%	0.021%	0.030%	0.005%
Unbelted	0.117%	0.322%	0.155%	0.698%	0.140%
se	0.033%	0.055%	0.086%	0.195%	0.028%
Belt eff	89.3%	92.3%	77.4%	84.4%	81.2%
AIS 3+ spine					
Belted	0.153%	0.179%	0.095%	1.086%	0.226%
se	0.040%	0.045%	0.033%	0.215%	0.037%
Unbelted	0.684%	1.418%	0.369%	5.108%	0.861%
se	0.227%	0.281%	0.101%	2.134%	0.251%
Belt eff	77.7%	87.4%	74.4%	78.7%	73.7%
AIS 4+ spine (SCI)					
Belted	0.013%	0.025%	0.037%	0.110%	0.027%
se	0.003%	0.005%	0.022%	0.030%	0.005%
Unbelted	0.122%	0.334%	0.155%	0.702%	0.145%
se	0.033%	0.054%	0.086%	0.195%	0.028%
Belt eff	89.1%	92.5%	76.0%	84.4%	81.1%
AIS 3 fx-disl.					
Belted	0.133%	0.151%	0.056%	0.957%	0.192%
se	0.039%	0.045%	0.018%	0.193%	0.034%
Unbelted	0.515%	1.058%	0.081%	4.071%	0.667%
se	0.193%	0.269%	0.018%	1.929%	0.222%
Belt eff	74.2%	85.8%	31.1%	76.5%	71.2%
MAIS AIS 4+ head					
Belted	0.109%	0.387%	0.095%	0.677%	0.216%
se	0.023%	0.078%	0.024%	0.124%	0.028%
Unbelted	0.763%	3.107%	1.010%	4.845%	1.092%
se	0.243%	0.700%	0.500%	1.176%	0.235%
Belt eff	85.8%	87.5%	90.6%	86.0%	80.3%
AIS 3+ head					
Belted	0.473%	1.529%	0.280%	2.186%	0.847%
se	0.096%	0.250%	0.069%	0.215%	0.107%
Unbelted	3.278%	13.579%	4.911%	19.585%	4.619%
se	0.758%	2.671%	3.129%	4.683%	0.900%
Belt eff	85.6%	88.7%	94.3%	88.8%	81.7%
AIS 4+ head					
Belted	0.187%	0.679%	0.138%	0.979%	0.366%
se	0.032%	0.122%	0.040%	0.150%	0.047%
Unbelted	1.336%	6.177%	2.003%	9.795%	2.119%
se	0.377%	1.194%	1.208%	2.161%	0.419%
Belt eff	86.0%	89.0%	93.1%	90.0%	82.7%
Relative rate: Head v Spine					
MAIS 4+					
Belted	8.7	15.6	2.7	6.2	8.2
Unbelted	6.5	9.7	6.5	6.9	7.8
AIS 3+					
Belted	3.1	8.6	3.0	2.0	3.7
Unbelted	4.8	9.6	13.3	3.8	5.4
AIS 4+					
Belted	14.1	27.2	3.7	8.9	13.3
Unbelted	10.9	18.5	12.9	14.0	14.6

Appendix 4: Contact sources for AIS 4+ spinal injury by crash type based on 18 years of weighted NASS-CDS (1994-2011).

Injury Source	Crash Type				Total
	Front	Side	Rear	Rollover	
Belted					
Seatback	7%	12%	54%	4%	12%
Head restraint	0%	0%	20%	0%	2%
Airbag	4%	0%	0%	0%	1%
Seat belt	4%	0%	0%	12%	5%
Win/mirror/visor	3%	0%	0%	0%	1%
Steer wheel/column	24%	0%	0%	5%	7%
Front comp	1%	0%	0%	1%	0%
A-Pillar	0%	0%	0%	0%	2%
B-Pillar	0%	24%	0%	5%	6%
Other-Pillar	0%	0%	0%	0%	0%
Side window	0%	0%	0%	0%	0%
Side interior/door	4%	19%	0%	6%	7%
Roof/side rail/header	9%	4%	0%	56%	21%
Other components	31%	26%	26%	5%	17%
Other occupants	1%	3%	0%	1%	1%
Other vehicle/object	4%	8%	0%	0%	2%
Ground/environment	5%	4%	0%	4%	3%
Unknown	2%	0%	0%	3%	12%
Total	100%	100%	100%	100%	100%
Unbelted					
Seatback	1%	0%	9%	1%	1%
Head restraint	0%	0%	8%	0%	0%
Airbag	0%	0%	0%	0%	0%
Seat belt	0%	0%	0%	0%	0%
Win/mirror/visor	15%	3%	0%	5%	6%
Steer wheel/column	20%	2%	0%	1%	6%
Front comp	1%	0%	0%	0%	0%
A-Pillar	7%	3%	0%	0%	3%
B-Pillar	0%	5%	12%	0%	1%
Other-Pillar	0%	0%	0%	0%	0%
Side window	0%	1%	8%	0%	0%
Side interior/door	2%	41%	0%	2%	11%
Roof/side rail/header	6%	15%	4%	35%	18%
Other components	5%	1%	0%	2%	3%
Other occupants	0%	0%	0%	0%	0%
Other vehicle/object	14%	3%	0%	17%	11%
Ground/environment	18%	19%	51%	32%	25%
Unknown	11%	5%	9%	4%	15%
Total	100%	100%	100%	100%	100%

Appendix 5: Annual distribution of injuries to the cervical, thoracic and lumbar spine by crash type based on 18 years of weighted NASS-CDS (1994-2011).

	Crash Type				Total
	Front	Side	Rear	Rollover	
Spine injuries in front outboard occupants					
AIS unk	48	73	62	78	278
AIS 1	113,215	59,656	43,648	30,847	296,936
AIS 2	7,495	5,096	781	8,549	24,480
AIS 3	1,659	941	91	2,485	5,884
AIS 4+	276	218	58	334	1,046
se	75	34	24	86	193
total	122,693	65,985	44,640	42,294	328,625
C-Spine injuries in front outboard occupants					
AIS 1	69,939	36,905	27,539	18,594	183,893
AIS 2	2,521	1,415	228	2,347	7,277
AIS 3	1,087	806	56	1,802	4,251
AIS 4+	178	130	29	232	693
se	49	27	17	50	118
total	73,725	39,257	27,852	22,975	196,114
T-Spine injuries in front outboard occupants					
AIS 1	17,400	10,230	4,912	7,184	45,171
AIS 2	1,943	1,405	110	3,608	7,649
AIS 3	242	87	31	426	899
AIS 4+	77	88	29	94	319
se	21	22	12	43	77
total	19,661	11,810	5,081	11,312	54,038
L-Spine injuries in front outboard occupants					
AIS 1	25,915	12,558	11,228	5,109	68,010
AIS 2	3,031	2,276	443	2,602	9,561
AIS 3	330	49	5	257	735
AIS 4+	21	0	0	7	34
se	14	0	0	4	14
total	29,297	14,883	11,676	7,975	78,340
Rate AIS 4+ by spine region per AIS 4+ spine injury					
	Front	Side	Rear	Rollover	Total
C-spine	64.6%	59.7%	50.1%	69.5%	66.3%
se	17.7%	12.2%	29.2%	14.9%	11.3%
T-spine	27.9%	40.2%	49.9%	28.2%	30.5%
se	7.5%	10.1%	20.0%	12.9%	7.4%
L-spine	7.5%	0.1%	0.0%	2.2%	3.2%
se	5.0%	0.1%	0.0%	1.2%	1.3%

Appendix 6: Individual cases from NASS-CDS electronic files for AIS 4+ spinal injury to belted and unbelted front-seat occupants in rear impacts.

Occupant # Vehicle #	Case #	MY	Make/Model	CDC	Delta V (mph)	Occ	Airbag	Age (yrs)	Gender	Height (in)	Weight (lb)	Region with max injury (other than spine)	MAIS	Source	AIS 4+ Head injury	2nd Row Max intrusion (in)	Factors	
Belted	1 1	2000-8-185A	1998	Hyundai Elantra	06BDEW6 12FDEW1	50 9	D N	26	F*	Unk	Unk	Head	6 F	Headrest	Yes	26	Seatback deformed forward by intrusion	
	1 2	2002-8-13E	1999	Jaguar X- Type	06BDEW3	14	RF N	54	F	Unk	Unk	Head	6 F	Headrest	Yes	12	Headrest	
	2 3	2002-11-61A	2000	Chrysler 300M	06BYEW6 12RDES1	Severe Unk	D N	48	F	67	291	Head	5 F	Headrest	Yes	18	Seatback w/rotation rearward	
	4 5	2002-12-115A	2001	Pontiac Montana	06BDEW2	14	D N	72	F	67	150					--		Seatback in an upright position
	5 6	2005-50-116B	1995	Saturn SL	06BYAW07 01FRMS03	52 Unk	D N	26	M	65	187					36		Head restraint w/seatback deformed forward by intrusion
	6 7	2006-49-120B	1997	Chevy Cavalier	06BDEW07	Unk	D N	44	F	60	207	Thorax (aorta)	6 F	Seatback	Yes	35		Seatback deformed forward by intrusion
	7 8	2006-12-224B	1999	Buick LeSabre	06BYEW06	23	D N	78	M	73	259					20		Seatback w/limited rotation rearward
	8 9	2008-48-231K	1998	Ford Mustang	06BDEW05	Severe	D N	54	F	66	303					8		Seatback w/rotation rearward
	9 10	2010-81-1B	2004	Chevy Impala	87BLAE09	Severe	D N	18	M	72	163	Head	6 F	Other left pillar	Yes	31		Other left pillar
	10 11	2010-11-240A	2010	Ford Focus	06BDAW07 00TFDW05	Severe Unk Unk	D N	57	M	73	212	Head	6 F	Headrest	Yes	27		Headrest deformed Seatback supported by intrusion
Unbelted	1 1	1997-73-120J	1996	Chevy Cavalier	26BDAW6 9999999	Severe 19	D N	55	M	Unk	249				Yes	28		Left B-pillar (seat supported upright by intrusion)
	2 2	1998-82-122J	1997	Honda Civic	06BDEW6	42	D N	26	M	74	165				Yes	19		Headrest w/seatback supported by intrusion
	3 3	2001-75-1B	1997	Subaru Legacy	06BDEW9 05RFW4 7	Severe 31	D N	57	M	69	165				Yes	5		Ground w/ejection
	4 4	2003-74-130B	1998	Mercury Mystique	99BD999 06BDEW6 40 00U9999	Unk	D N	44	M	68	229				Yes	12		Headrest w/seat supported by intrusion
	5 5	2006-49-99B	2000	Jeep Cherokee	06BDEW06	34	D Unk	23	F	60	207				Yes	2		Seatback supported by intrusion
	5 6	2006-50-105B	1998	Nissan Frontier	26BDEW99	24	RF Unk	41	F	64	158							Seatback deformed forward by intrusion
	6 7	2007-82-15B	1994	Geo Prizm	46BDAW06	Severe	D N	41	M	70	185	Head	6 F	Headrest	Yes	Severe		Rear header w/cab supporting seatback
	8 9	2007-41-205B	1999	Toyota Tacoma	06BLE999 11LFEW99	Severe Unk	D N	74	M	68	203				Yes	Severe		Headrest w/seatback supported by intrusion
	9 10	2009-73-85B	2004	Dodge Ram	26BDEW99 12FDEW99	Severe Unk	D Y	32	M	68	176	Whole body	6 F	Fire	Yes	Severe		Intrusion related

* Pregnant