

## **APPENDIX A: ELASTICITY EFFECTS**

For presenting elasticity effects, we consider a subset of independent variables that were found to be significant in the proposed model including Senior driver, Male driver, Vehicle age  $\leq 3$  years old, Light truck (pickup, van), Rollover, Steering air bag deployed, Driver side impact, Speed limit  $\geq 50$ mph, and Dark. The elasticity effects analysis for all injury severity levels are illustrated in table A.1 through A.9. In table A.10, we demonstrate the elasticity effects of the body regions not included in Table 3 of the manuscript.

**Table A.1 Elasticity Effects Analysis for Senior Driver**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Senior driver	Head	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
		Serious injury	---	---	---	---	---
	Face	No injury	-5.19	-4.86	-3.90	-3.28	-2.82
		Minor injury	28.34	29.05	31.52	33.75	35.73
		Moderate injury	53.83	55.44	61.22	66.40	66.74
	Neck	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
	Abdomen	No injury	-3.23	-3.45	-3.49	-3.59	-3.75
		Minor injury	22.11	23.26	26.06	28.32	31.06
		Moderate injury	32.69	34.34	38.18	41.64	46.35
	Thorax	No injury	-18.78	-18.29	-17.63	-16.79	-16.31
		Minor injury	41.70	42.87	45.83	49.32	50.74
		Moderate injury	88.09	89.58	93.61	97.24	101.63
	Spine	No injury	-4.96	-4.68	-4.35	-3.99	-3.78
		Minor injury	22.58	21.11	20.13	19.10	17.79
		Moderate injury	36.92	34.72	33.78	32.17	30.20
	Lower extremity	No injury	-7.08	-7.03	-6.76	-6.29	-6.04
		Minor injury	11.95	13.38	15.09	17.84	20.07
		Moderate injury	25.57	27.29	30.78	34.12	38.67
	Upper extremity	No injury	-11.01	-10.97	-10.73	-10.18	-10.11
		Minor injury	16.75	17.89	19.42	21.80	23.09
		Moderate injury	40.41	42.06	45.55	48.90	52.82

**Table A.2 Elasticity Effects Analysis for Male Driver**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Male driver	Head	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
		Serious injury	---	---	---	---	---
	Face	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Neck	No injury	1.85	1.89	1.80	1.73	1.71
		Minor injury	-57.22	-56.28	-56.42	-56.76	-58.05
	Abdomen	No injury	3.25	3.45	3.45	3.52	3.67
		Minor injury	-22.69	-23.76	-26.27	-28.34	-31.09
		Moderate injury	-32.30	-33.64	-36.62	-39.67	-43.73
	Thorax	No injury	6.51	6.29	6.01	5.66	5.52
		Minor injury	-16.11	-16.42	-17.22	-18.15	-18.73
		Moderate injury	-27.76	-27.95	-28.91	-29.73	-31.10
	Spine	No injury	7.45	7.01	6.47	5.93	5.67
		Minor injury	-34.33	-32.10	-30.42	-28.96	-27.17
		Moderate injury	-53.10	-49.89	-47.99	-45.73	-43.52
	Lower extremity	No injury	13.98	13.78	13.08	12.03	11.59
		Minor injury	-24.23	-26.86	-29.95	-34.79	-39.30
		Moderate injury	-48.75	-51.51	-56.56	-62.11	-69.41
	Upper extremity	No injury	8.67	8.60	8.34	7.85	7.82
		Minor injury	-13.83	-14.67	-15.76	-17.43	-18.49
		Moderate injury	-29.59	-30.56	-32.57	-34.62	-37.25

**Table A.3 Elasticity Effects Analysis for Vehicle Age  $\leq 3$  Years Old**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Vehicle age $\leq 3$ years old	Head	No injury	5.64	5.40	4.43	3.82	3.29
		Minor injury	-33.42	-33.60	-38.63	-41.99	-46.84
		Moderate injury	-37.70	-38.15	-43.26	-47.42	-52.05
		Serious injury	-41.04	-40.55	-45.48	-48.19	-53.61
	Face	No injury	5.89	5.36	4.42	3.63	3.22
		Minor injury	-32.66	-32.48	-36.14	-37.63	-41.11
		Moderate injury	-50.42	-49.70	-54.85	-59.35	-61.82
	Neck	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
	Abdomen	No injury	1.26	1.33	1.36	1.38	1.45
		Minor injury	-8.95	-9.33	-10.48	-11.28	-12.43
		Moderate injury	-12.31	-12.73	-14.15	-15.23	-16.99
	Thorax	No injury	2.13	2.05	1.98	1.86	1.82
		Minor injury	-5.32	-5.42	-5.72	-6.01	-6.19
		Moderate injury	-8.98	-9.01	-9.49	-9.75	-10.28
	Spine	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Lower extremity	No injury	5.44	5.35	5.18	4.75	4.59
		Minor injury	-9.58	-10.63	-11.97	-13.84	-15.58
		Moderate injury	-18.56	-19.32	-22.00	-23.93	-27.45
	Upper extremity	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---

**Table A.4 Elasticity Effects Analysis for Light Truck (Pickup, Van)**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Light truck (pickup, van)	Head	No injury	3.29	3.23	2.53	2.19	1.79
		Minor injury	-19.32	-19.89	-21.87	-23.97	-25.29
		Moderate injury	-21.80	-22.84	-24.42	-27.13	-27.86
		Serious injury	-24.70	-25.03	-26.94	-28.41	-30.34
	Face	No injury	3.24	3.02	2.39	1.98	1.68
		Minor injury	-17.90	-18.18	-19.48	-20.46	-21.38
		Moderate injury	-29.55	-30.24	-31.79	-33.38	-33.82
	Neck	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
	Abdomen	No injury	1.93	2.05	2.05	2.08	2.15
		Minor injury	-13.74	-14.36	-15.86	-17.00	-18.41
		Moderate injury	-18.79	-19.54	-21.34	-22.79	-24.88
	Thorax	No injury	7.22	6.95	6.64	6.20	5.99
		Minor injury	-18.59	-18.86	-19.74	-20.65	-21.05
		Moderate injury	-29.54	-29.64	-30.70	-31.13	-32.32
	Spine	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Lower extremity	No injury	4.61	4.54	4.33	3.96	3.76
		Minor injury	-8.20	-9.06	-10.09	-11.63	-12.90
		Moderate injury	-15.47	-16.27	-18.06	-19.53	-21.71
Upper extremity	No injury	9.24	9.13	8.86	8.25	8.14	
	Minor injury	-15.28	-16.13	-17.26	-18.88	-19.78	
	Moderate injury	-29.61	-30.34	-32.32	-33.69	-35.82	

**Table A.5 Elasticity Effects Analysis for Rollover**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Rollover	Head	No injury	-13.97	-13.62	-11.19	-10.14	-8.77
		Minor injury	77.55	78.51	92.35	104.13	118.36
		Moderate injury	101.00	103.46	115.96	135.74	150.64
		Serious injury	107.28	112.90	124.55	146.88	155.55
	Face	No injury	-9.82	-9.02	-7.29	-6.08	-5.26
		Minor injury	61.51	62.36	69.08	75.17	80.84
		Moderate injury	104.82	105.36	123.59	143.60	125.51
	Neck	No injury	-1.61	-1.65	-1.62	-1.58	-1.56
		Minor injury	49.76	49.10	50.90	51.88	53.18
	Abdomen	No injury	-2.63	-2.80	-2.84	-2.93	-3.08
		Minor injury	18.16	19.05	21.36	23.23	25.60
		Moderate injury	26.31	27.57	30.77	33.78	37.80
	Thorax	No injury	-9.09	-8.79	-8.49	-8.06	-7.87
		Minor injury	21.57	22.02	23.29	24.73	25.47
		Moderate injury	40.31	40.67	42.80	44.59	47.02
	Spine	No injury	-10.24	-9.60	-8.81	-8.14	-7.62
		Minor injury	42.79	39.46	37.81	35.66	33.39
		Moderate injury	70.33	65.80	65.33	63.49	59.71
	Lower extremity	No injury	-6.71	-6.65	-6.41	-5.96	-5.75
		Minor injury	11.41	12.73	14.35	16.92	19.13
		Moderate injury	24.04	25.58	28.95	32.30	36.73
	Upper extremity	No injury	-25.09	-24.96	-24.57	-23.57	-23.53
		Minor injury	35.86	38.41	41.87	47.61	50.45
		Moderate injury	100.27	104.35	115.54	127.55	141.66

**Table A.6 Elasticity Effects Analysis for Steering Air Bag Deployed**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Steering air bag deployed	Head	No injury	-8.11	-8.06	-6.26	-5.60	-4.55
		Minor injury	47.62	48.94	55.05	61.75	65.40
		Moderate injury	54.17	57.53	59.94	68.58	69.27
		Serious injury	60.38	63.51	64.28	70.60	75.03
	Face	No injury	-11.73	-10.99	-8.55	-7.09	-5.76
		Minor injury	63.65	65.44	69.23	73.17	73.14
		Moderate injury	130.08	129.71	126.52	129.69	126.95
	Neck	No injury	-2.77	-2.86	-2.72	-2.66	-2.56
		Minor injury	85.42	85.06	85.24	87.32	87.20
	Abdomen	No injury	-8.18	-8.77	-8.68	-9.04	-9.24
		Minor injury	56.93	60.48	66.94	73.66	79.04
		Moderate injury	81.41	85.33	90.93	100.05	107.72
	Thorax	No injury	-19.51	-18.98	-18.02	-17.18	-16.43
		Minor injury	48.03	49.08	51.76	54.85	55.53
		Moderate injury	83.53	85.10	86.55	90.84	93.20
	Spine	No injury	-5.53	-5.23	-4.85	-4.47	-4.23
		Minor injury	25.47	23.84	22.70	21.66	20.15
		Moderate injury	39.47	37.68	36.46	35.08	32.95
	Lower extremity	No injury	-35.84	-35.83	-34.31	-32.16	-30.17
		Minor injury	62.79	70.50	81.40	95.57	105.62
		Moderate injury	123.05	131.80	137.28	153.51	160.36
	Upper extremity	No injury	-25.83	-25.83	-25.26	-24.15	-23.79
		Minor injury	41.02	43.89	48.56	54.76	58.00
		Moderate injury	88.79	92.31	94.98	101.01	103.59

**Table A.7 Elasticity Effects Analysis for Driver Side Impact**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Driver side impact	Head	No injury	-8.41	-8.23	-6.69	-5.97	-4.99
		Minor injury	47.19	47.67	55.36	61.87	67.59
		Moderate injury	57.59	60.12	66.92	77.53	81.59
		Serious injury	67.31	70.84	77.93	87.58	95.74
	Face	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Neck	No injury	-2.64	-2.68	-2.64	-2.53	-2.51
		Minor injury	81.41	79.74	82.76	83.30	85.43
	Abdomen	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Thorax	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Spine	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Lower extremity	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Upper extremity	No injury	-10.54	-10.47	-10.26	-9.70	-9.64
		Minor injury	16.17	17.23	18.66	20.83	22.03
		Moderate injury	38.26	39.58	43.21	46.34	50.35



**Table A.8 Elasticity Effects Analysis for Speed Limit  $\geq$  50mph**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Speed limit $\geq$ 50mph	Head	No injury	-4.05	-3.99	-3.19	-2.80	-2.35
		Minor injury	23.48	24.11	27.15	30.05	32.92
		Moderate injury	27.65	28.92	31.77	35.88	38.06
		Serious injury	30.14	31.15	34.09	36.93	39.87
	Face	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Neck	No injury	-0.89	-0.91	-0.90	-0.86	-0.86
		Minor injury	27.46	27.23	28.11	28.30	29.18
	Abdomen	No injury	-1.62	-1.73	-1.75	-1.79	-1.88
		Minor injury	11.33	11.90	13.31	14.37	15.79
		Moderate injury	16.03	16.79	18.60	20.17	22.52
	Thorax	No injury	-5.14	-4.99	-4.81	-4.53	-4.42
		Minor injury	12.65	12.93	13.63	14.36	14.77
		Moderate injury	22.05	22.29	23.41	24.11	25.45
	Spine	No injury	-5.93	-5.60	-5.24	-4.79	-4.58
		Minor injury	27.33	25.55	24.42	23.13	21.67
		Moderate injury	42.30	40.27	39.81	37.92	36.32
	Lower extremity	No injury	-5.69	-5.65	-5.43	-5.01	-4.83
		Minor injury	9.83	10.99	12.32	14.38	16.20
		Moderate injury	19.96	21.17	23.92	26.40	30.09
	Upper extremity	No injury	-6.28	-6.25	-6.10	-5.74	-5.72
		Minor injury	9.96	10.60	11.41	12.63	13.35
		Moderate injury	21.64	22.42	24.34	25.97	28.32

**Table A.9 Elasticity Effects Analysis for Dark**

Variable	Body Region	Injury Severity Level	Year				
			2003	2006	2009	2012	2015
Dark	Head	No injury	-3.51	-3.44	-2.75	-2.40	-2.00
		Minor injury	20.51	21.08	23.71	26.17	28.35
		Moderate injury	23.62	24.57	26.88	30.14	31.78
		Serious injury	26.14	26.50	28.85	30.66	33.01
	Face	No injury	-3.73	-3.42	-2.73	-2.21	-1.89
		Minor injury	23.44	23.74	26.03	27.49	29.06
		Moderate injury	37.61	37.25	40.88	44.39	41.32
	Neck	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
	Abdomen	No injury	-1.70	-1.80	-1.83	-1.87	-1.96
		Minor injury	11.92	12.49	13.97	15.08	16.56
		Moderate injury	16.78	17.47	19.38	20.90	23.31
	Thorax	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Spine	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---
	Lower extremity	No injury	-4.44	-4.39	-4.22	-3.89	-3.74
		Minor injury	7.73	8.62	9.66	11.26	12.64
		Moderate injury	15.35	16.19	18.23	19.95	22.54
	Upper extremity	No injury	---	---	---	---	---
		Minor injury	---	---	---	---	---
		Moderate injury	---	---	---	---	---

**Table A.10 The Elasticity Effects Between Vehicle Types and Across All Crash Types  
by Body Region**

Body Region	Vehicle Type	Injury Level	Roadside departure	Any forward impact	Backward impact	Driver side impact	Head On	Rear end
Abdomen	Light truck	No Injury	---	1.79	1.26	---	4.80	---
		Minor Injury	---	-16.50	-20.06	---	-10.63	---
		Moderate Injury	---	-21.68	-25.32	---	-18.08	---
Face	Light truck	No Injury	---	1.77	1.14	---	4.72	---
		Minor Injury	---	-22.78	-27.73	---	-17.79	---
		Moderate Injury	---	-36.68	-43.30	---	-34.87	---
Lower extremity	Light truck	No Injury	5.66	3.87	2.46	---	9.41	2.48
		Minor Injury	-8.23	-10.49	-15.45	---	-4.03	-14.88
		Moderate Injury	-15.89	-17.86	-23.11	---	-14.44	-22.91
Upper extremity	Light truck	No Injury	10.42	---	---	9.05	15.20	6.82
		Minor Injury	-14.41	---	---	-17.28	-10.22	-21.62
		Moderate Injury	-29.06	---	---	-31.24	-28.97	-37.13