

An Evaluation of Spinal Cord Injury (SCI) Associated with Motor Vehicle Crashes including Rollovers

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HARBORVIEW
INJURY PREVENTION
& RESEARCH CENTER



Traumatic Spinal Cord Injury

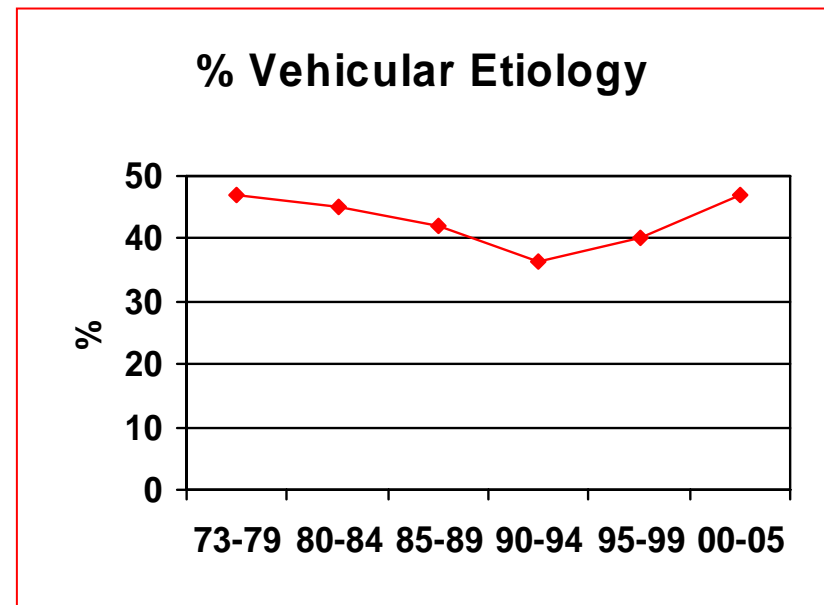
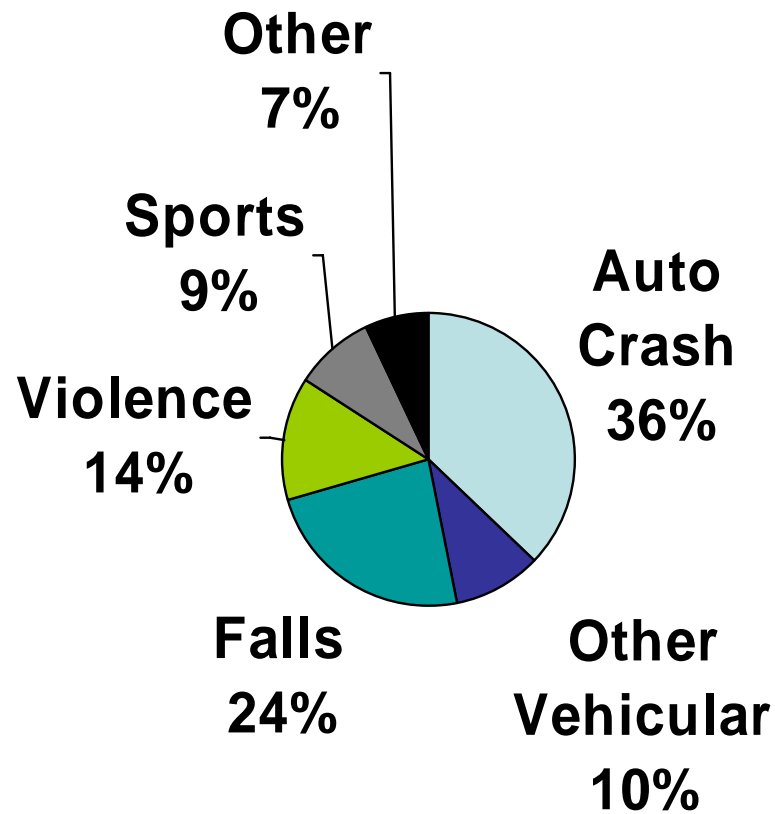
- 11,000 new cases annually in US
- 260,000 persons in US living with chronic SCI
- Primary data source: National SCI Statistical Center
 - non-random sample of US SCI cases treated at 14 SCI Model Systems
 - Summary of data at:
<http://www.spinalcord.uab.edu/show.asp?durki=21446>

Neurologic Classification

- Injury Level
 - Lowest cord level unaffected by SCI
- Completeness of injury
 - **Complete injury** (50% of all injuries): no motor or sensory signals pass through the injured segment
 - **Incomplete injury**: some signals pass
 - Some sensation below injury level
 - May have some motor below level

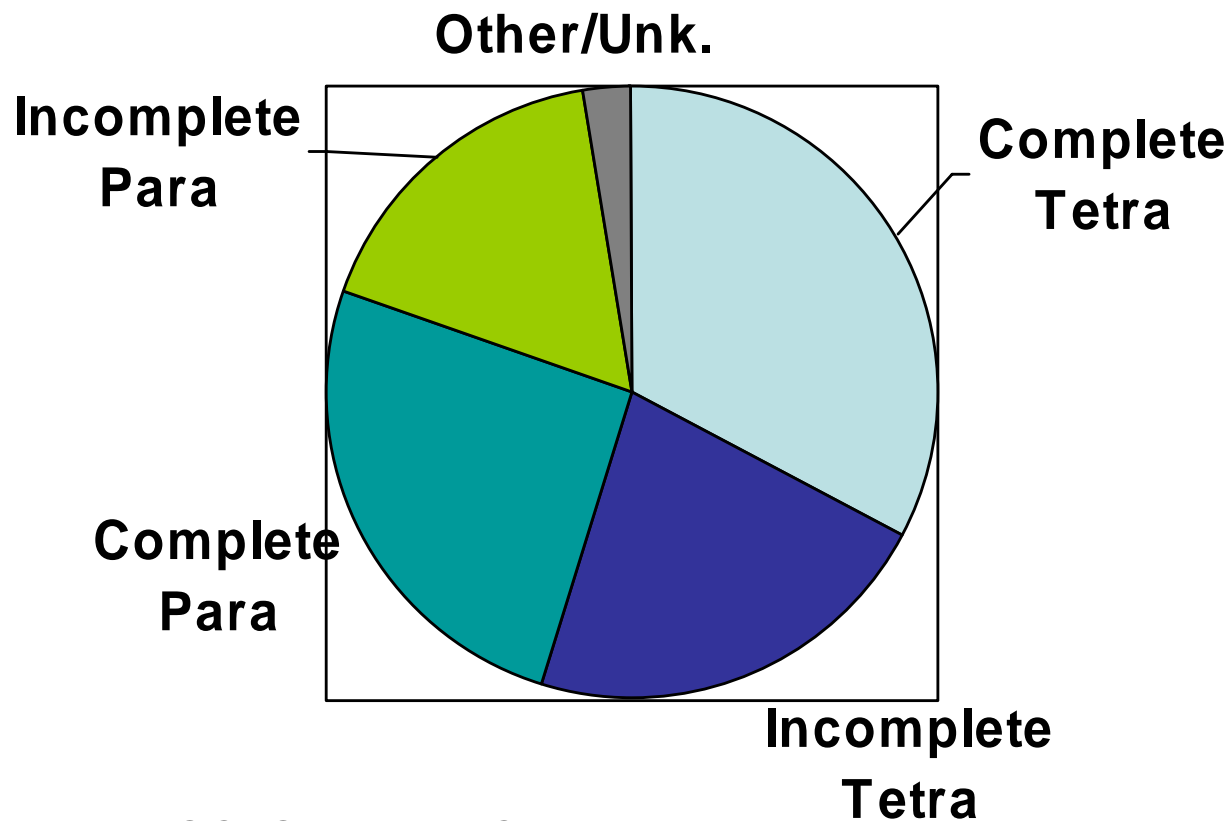
Greater impairment (higher level; complete injury) causes greater disability, more medical complications, and reduced life expectancy

Etiology: 2000-2005



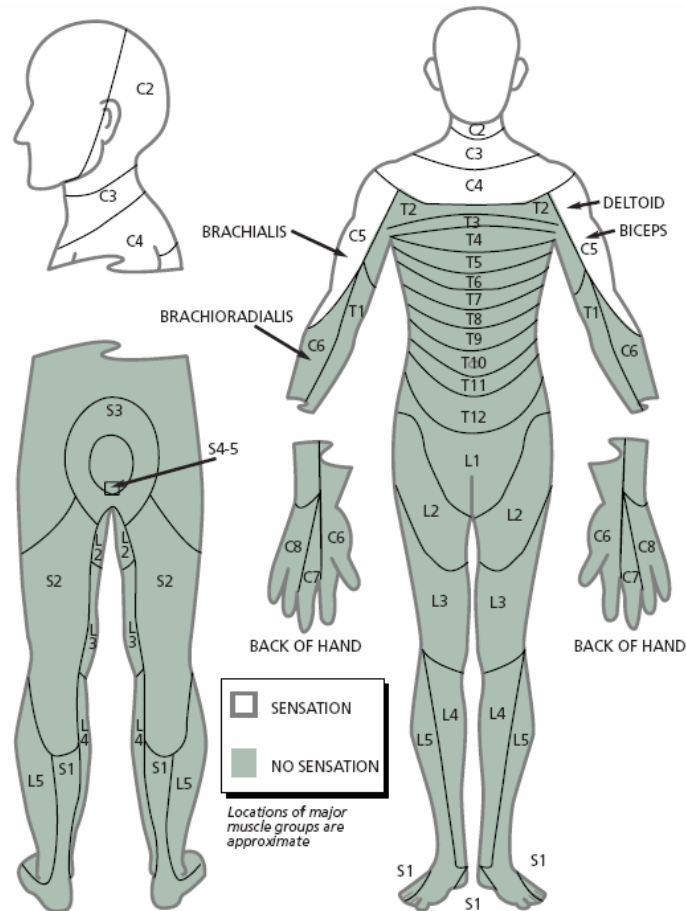
•source: National SCI Statistical Center

Vehicular Etiology: Level of Injury



•source: National SCI Statistical Center

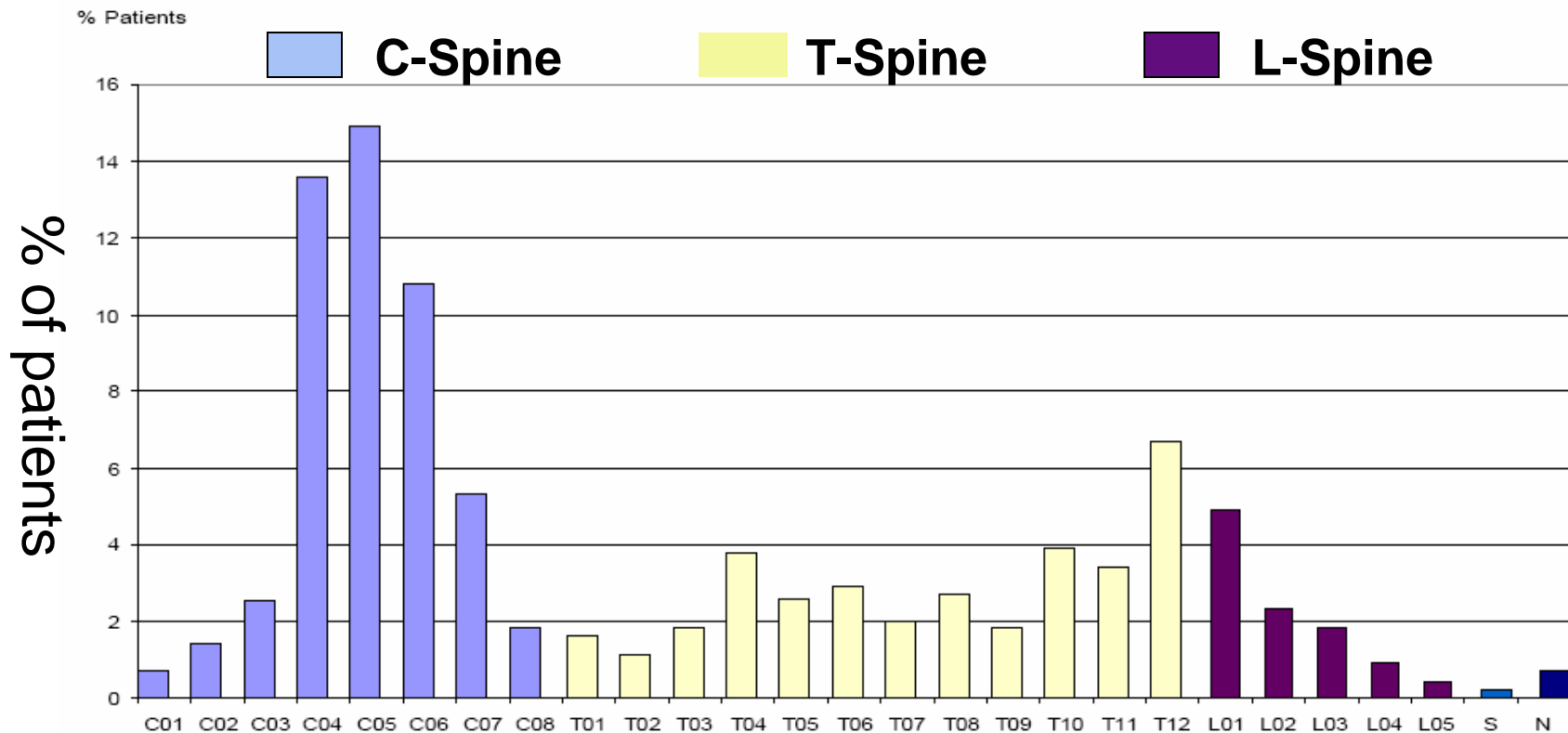
Case with Most Common Attributes



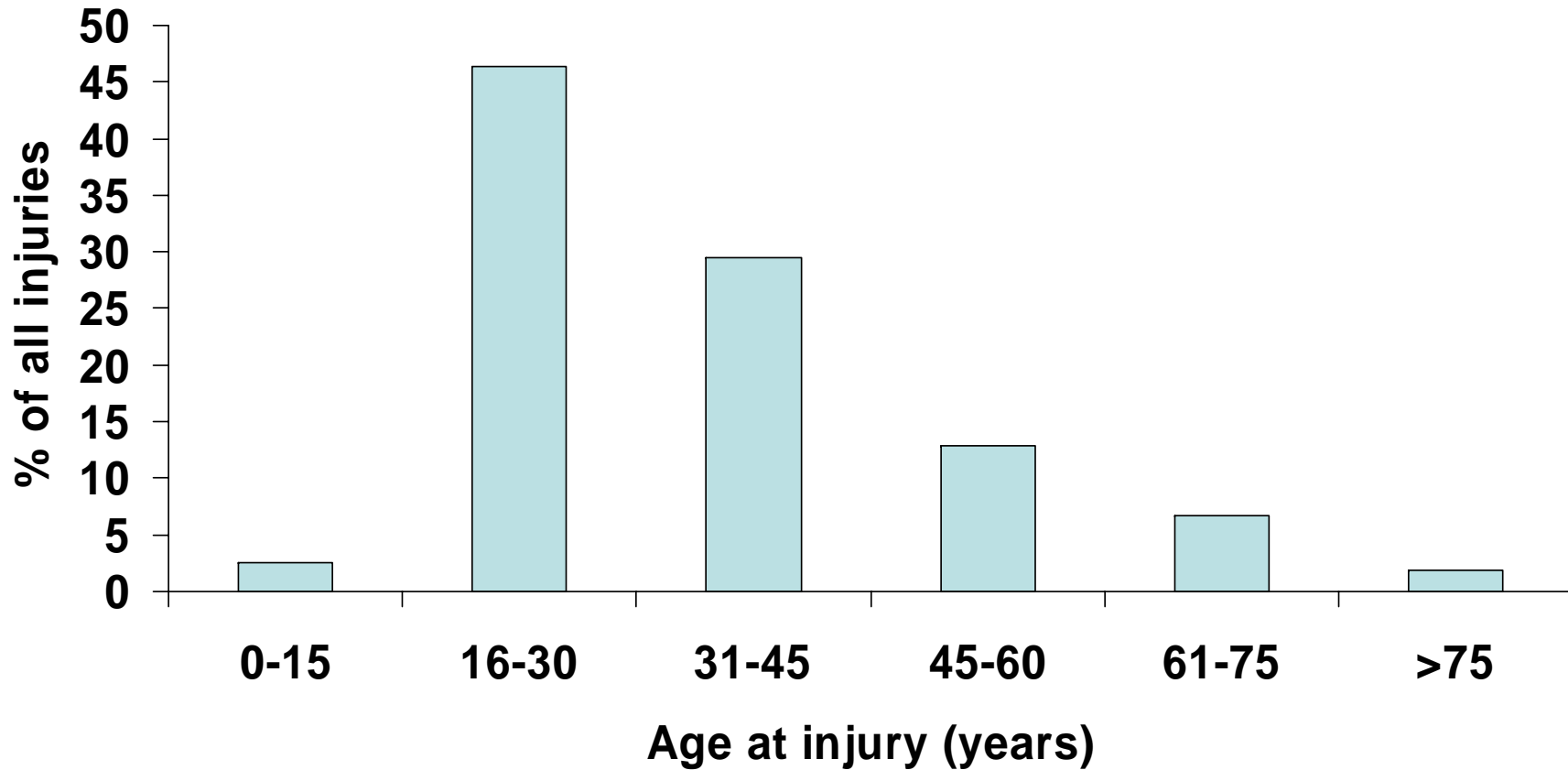
- 19 y/o white male; auto collision
- C4-C5 vertebral fracture-dislocation
- C5 neurological level; complete injury (loss all movement and sensation below that level)

Level of Injury

- About 50% have tetraplegia (quadriplegia): impairment of upper and lower limbs



Age at Injury: Vehicular Etiology



Source: National SCI Statistical Center

Course of Care

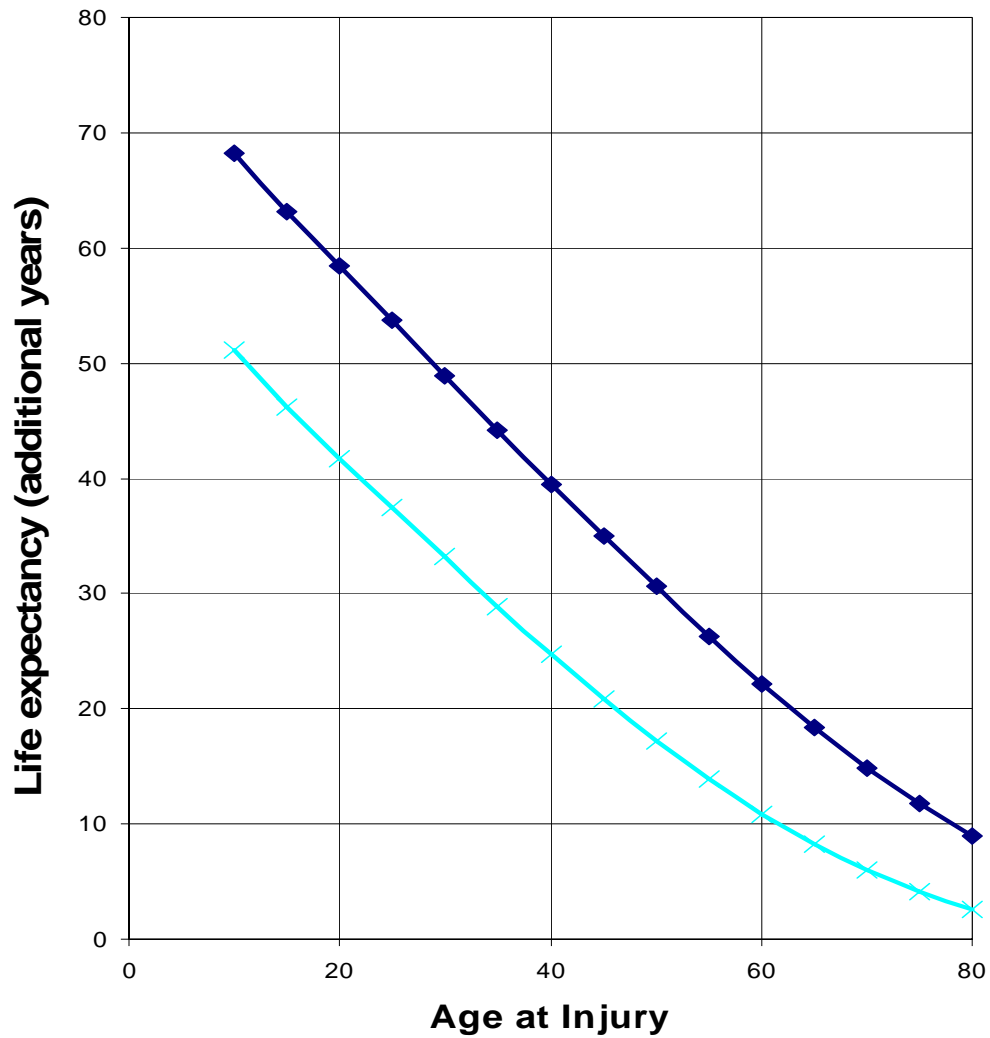
- Acute care:
 - Operative treatment of spinal fracture (66%)
 - Medical complications (respiratory failure, pneumonia, DVT, pressure ulcers, UTI's)
 - Mean LOS: 15 days
- Rehabilitation
 - Inpatient: Mean LOS: 40 days
 - Outpatient therapy
- Life-long care for secondary medical complications of SCI

Yearly Expenses and Lifetime Costs Per Patient (In 2006 US Dollars)

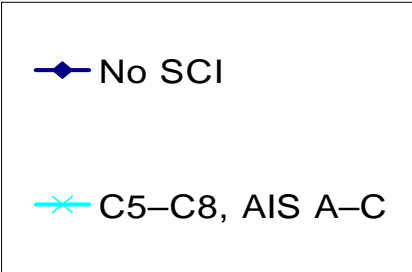
Injury Severity	First Year	Subsequent Years	Lifetime (if injury age 25)
C1-C4	\$741,425	\$132,807	\$2,924,513
C5-C8	\$478,782	\$54,400	\$1,047,189
Paraplegia	\$270,913	\$27,568	\$977,142

- Includes health care expenses and living expenses directly attributable to SCI.
- Excludes indirect costs such as lost wages, benefits, productivity (\$59,212 per year).

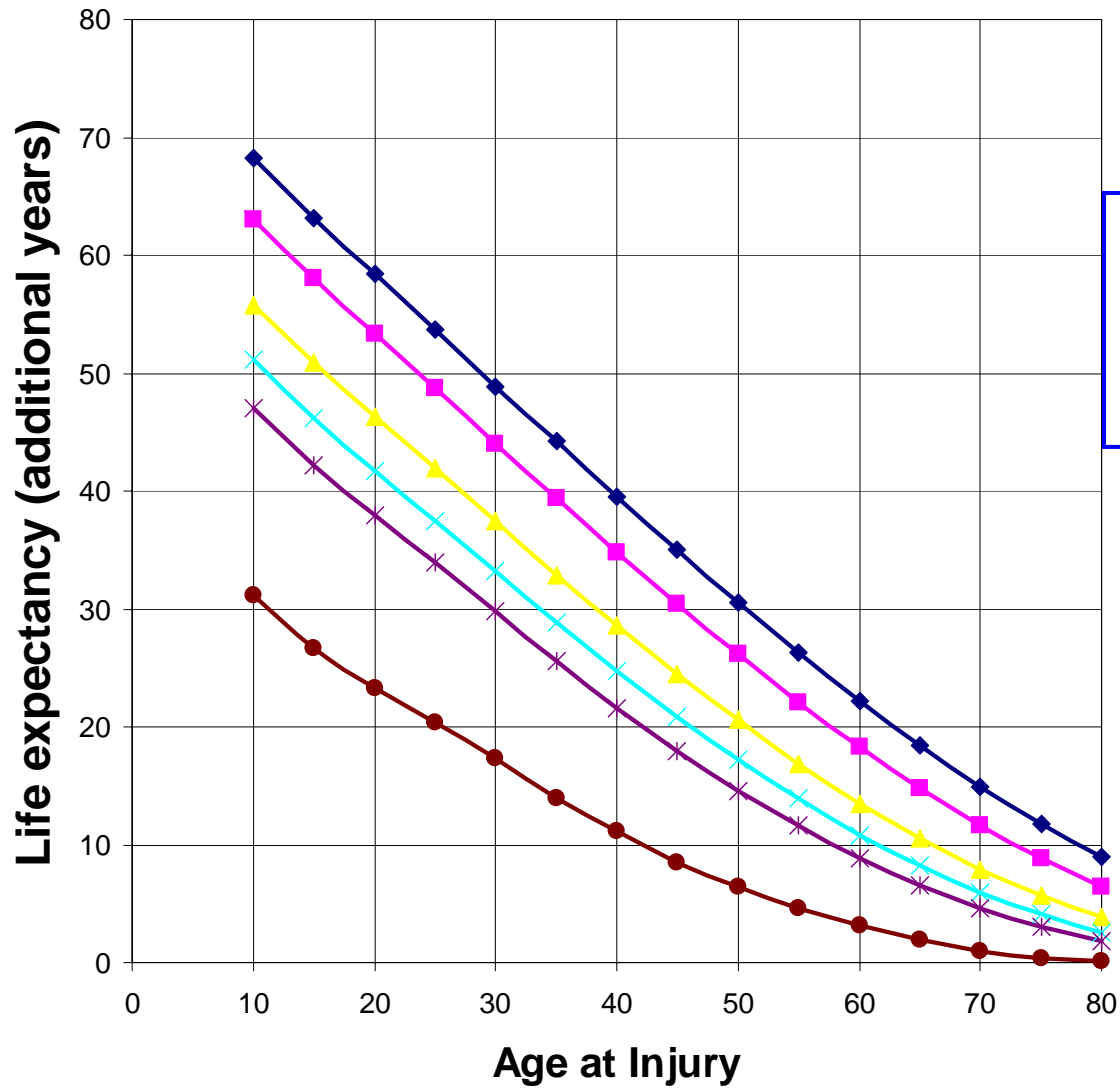
Source: National SCI Statistical Center



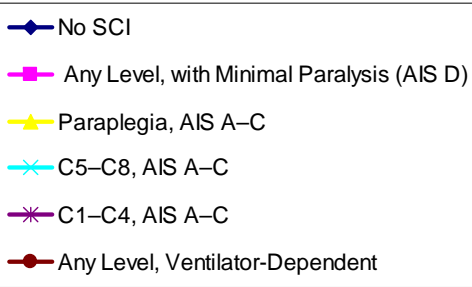
**Life Expectancy for
Persons with SCI who
Survive at Least One
Year Post-injury**



Source: National SCI Statistical Center



Life Expectancy for Persons with SCI who Survive at Least One Year Post-injury



Source: National SCI Statistical Center

Important Medical Complications of Chronic SCI

- Mortality
 - Pneumonia, sepsis
- Morbidity
 - Pressure ulcers, UTI's
- QOL
 - Bladder, bowel, sexual dysfunction, pain

Seattle CIREN Research

“Spinal Cord Injury and Auto Crashes:
Findings from Three United States
Databases” – submitted ???.....

Stephen P. Burns, MD, Christopher D. Mack, MS,
Robert P. Kaufman, BS, and Eileen Bulger, MD

Databases with SCI

	NSCID ('93-05)	CDS –('93-06) (unweighted)	CDS('93-06)	CIREN ('96-06)
# of Cases	3014	843	46,539	163
Annual # of Cases	~3700		~3300	

Databases with SCI

	NSCID ('93-05)	CDS –('93-06) (unweighted)	CDS –('93-06) (weighted)	CIREN ('96-06)
Age, mean (years)	35.1	39.1	41.3	39.7
Acute Care - LOS, mean (days)	18.1	7.8	6.5	8.8
Neurologic Classification				
Tetraplegia (%)	64.3	68.1	74.6	76.7
Paraplegia (%)	35.7	31.9	25.4	23.3
<i>Complete (%)</i>	<i>50.0</i>	<i>59.3</i>	<i>47.1</i>	<i>44.2</i>
<i>Incomplete (%)</i>	<i>48.8</i>	<i>36.7</i>	<i>46.1</i>	<i>51.5</i>
<i>Transient Paralysis (%)</i>	<i>1.2</i>	<i>3.9</i>	<i>6.7</i>	<i>4.3</i>

PDOF and ASI-SCI

PDOF Category	Occupants with ASI (%)	Occupants with SCI (%)
Non Horizontal (rollover)	2.519	0.252
Near Side	0.962	0.116
Far Side	0.764	0.090
Front	0.621	0.051
Back	0.458	0.067

Source: NASS-CDS

SCI in Rollover Collisions

Rollovers and Body Type

Rollover Type	Car/Van/Other (%)	SUV/Pickup (%)
None	95.03	81.60
1/4 turn	0.77	4.06
1/2 turn or greater	4.20	14.34

LTV body types were 3.7 times more likely to experience any degree of a rollover (1/4 turn or greater)

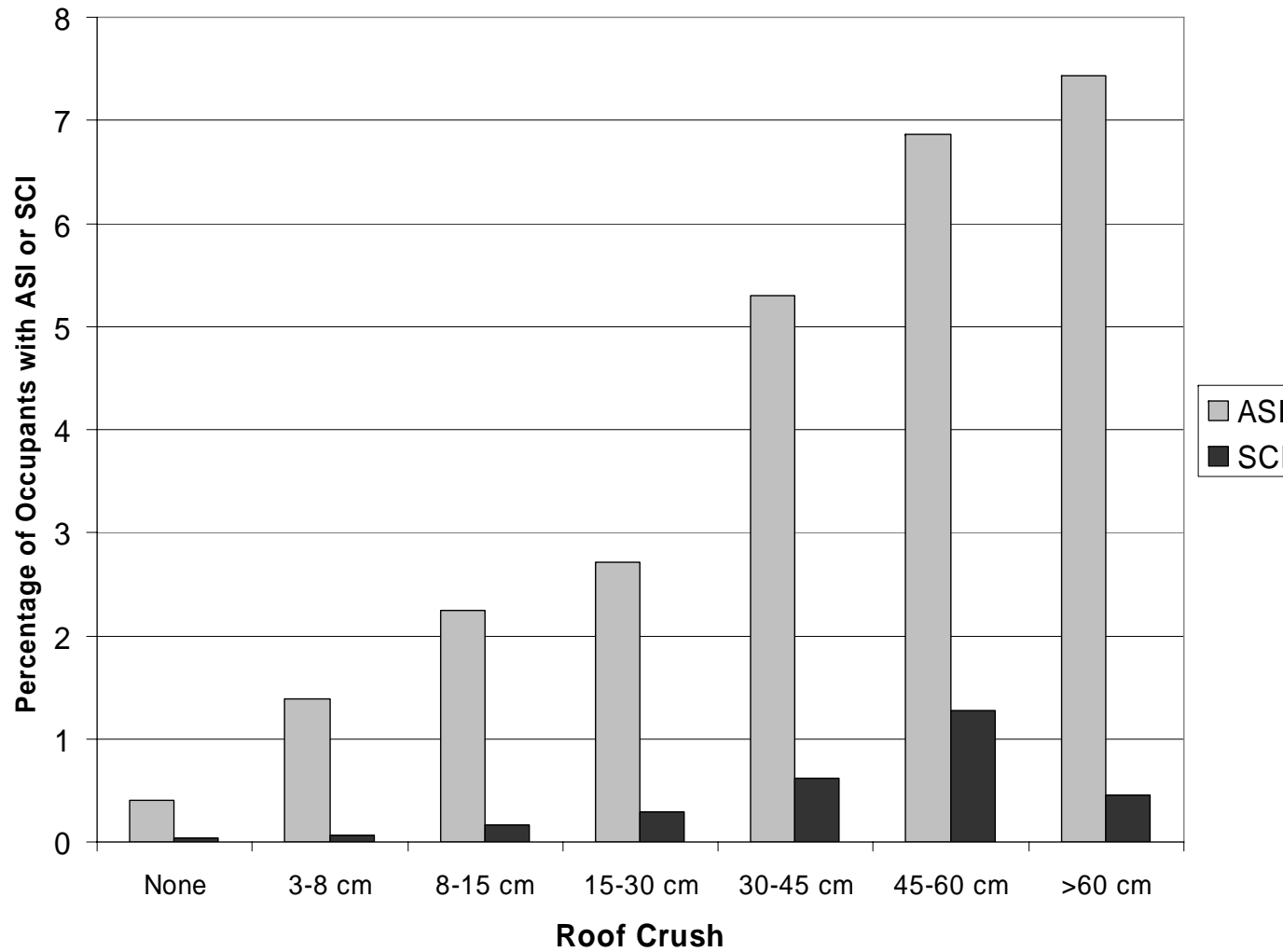
Source: NASS-CDS

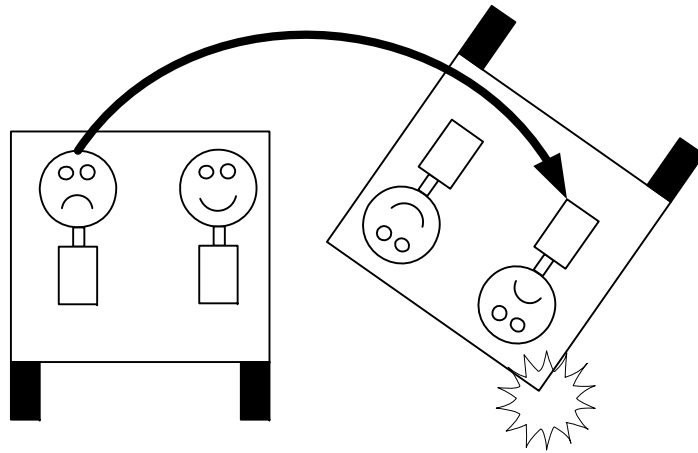
Rollover Types with ASI-SCI

		ASI (%)	SCI (%)
Rollover Type			
	None	0.492	0.0494
	1/4 turn	1.308	0.161
	1/2 turn or greater	2.773	0.269
Vehicle Body Type			
	Car/Van/Other	0.617	0.064
	SUV/Pickup	0.862	0.086

Source: NASS-CDS includes those in multiple crash events

Roof Crush and ASI-SCI

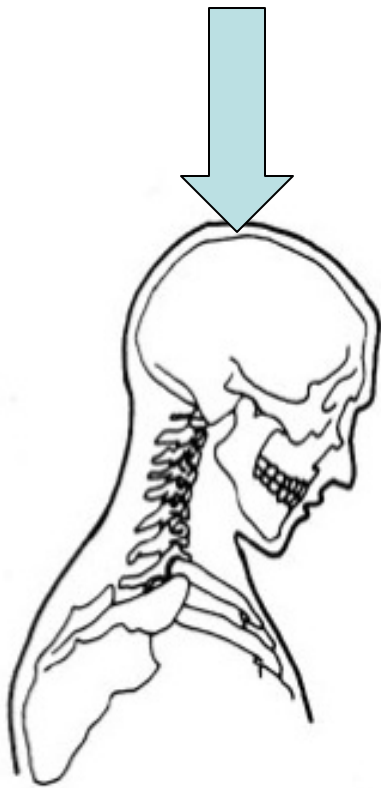




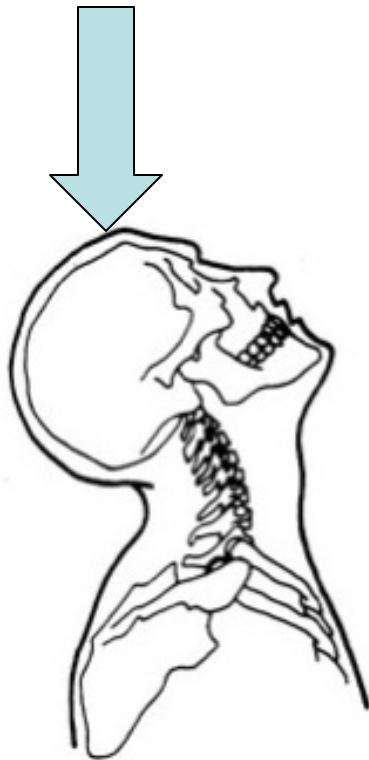
Other related research

- Outside of Arc, more severe injuries/death
 - Jehle D, Kuebler J, Auinger P. Risk of injury and fatality in single vehicle rollover crashes: danger for the front seat occupant in the "outside arc". Acad Emerg Med 2007;14:899-902.
- Roof was main contact points for severe head and neck injuries.
 - Hu J, Lee J, Yang K, King A. Injury patterns and sources of non-ejected occupants in trip-over crashes: a survey of NASS-CDS database from 1997 to 2002.

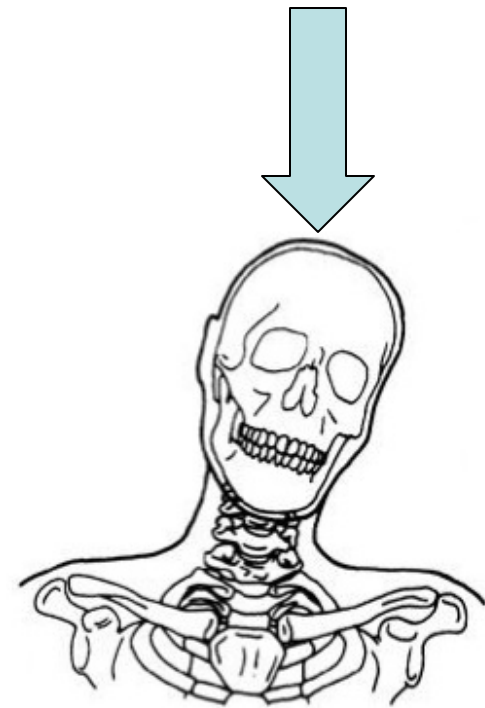
Roof Crush and SCI



Compression - Flexion



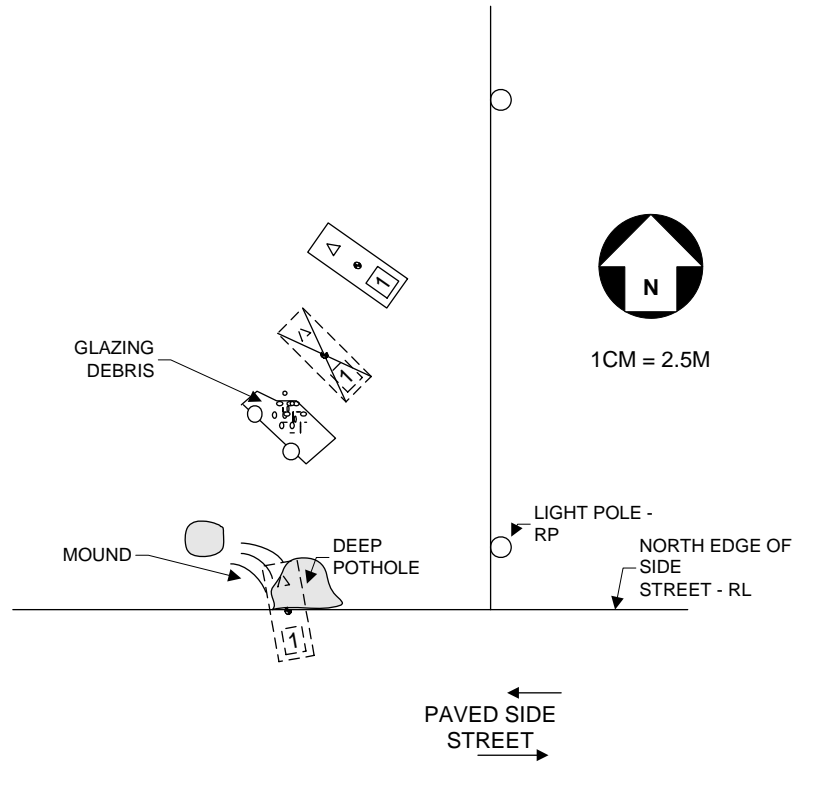
Compression - Extension



Compression - Lateral Bending

CIREN Case Reviews with ASI & SCI

Rollover CIREN Case Reviews with ASI-SCI



2000 Sport Utility Vehicle

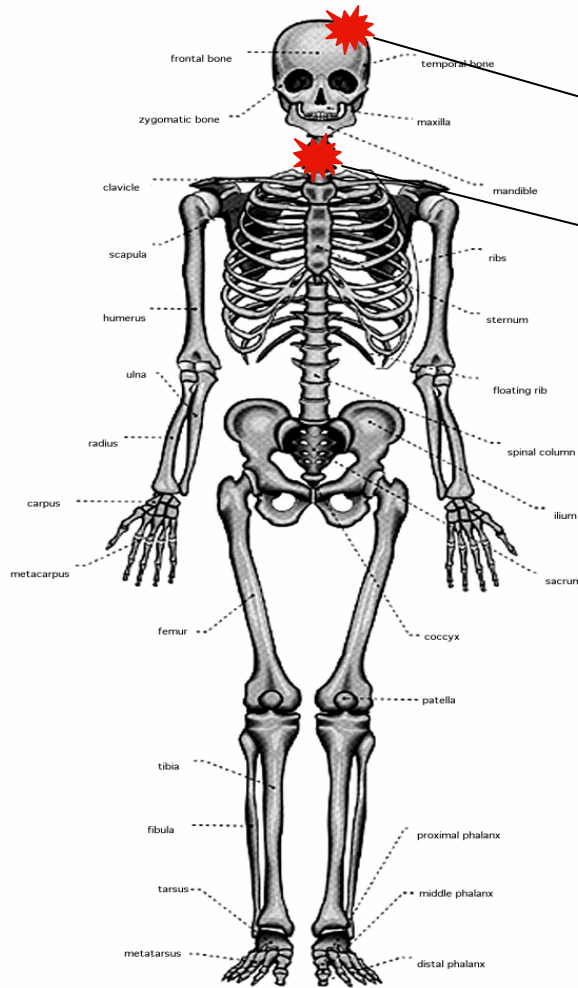




Front Right Passenger
Lap/shoulder restrained
20's yrs. – Male

(A belt restrained driver, and two other belt restrained passengers in second row had minor injuries and did not qualify for CIREN criteria)

Injuries



AIS 2 – Head

AIS 4 – C-spine fractures and Spinal Cord Injury

Case Review

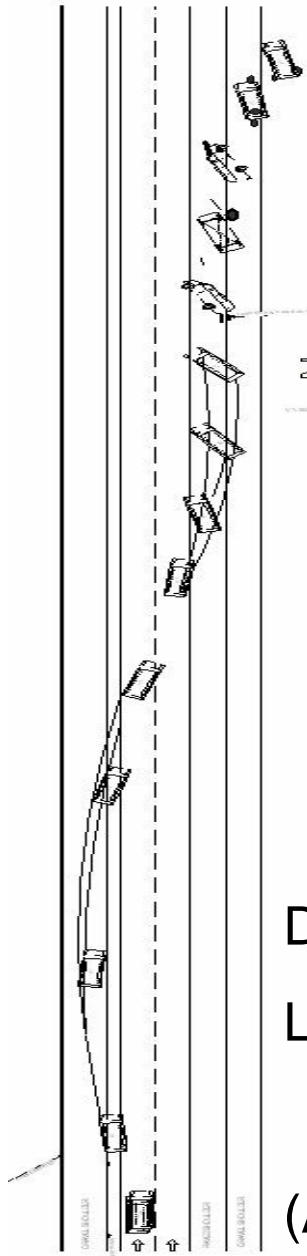


2006 Large Van



Driver - 50 yr. old, Male
Lap/Shoulder belt restrained

(Also front right restrained passenger with minor injury)



Roof Crush and Intrusion

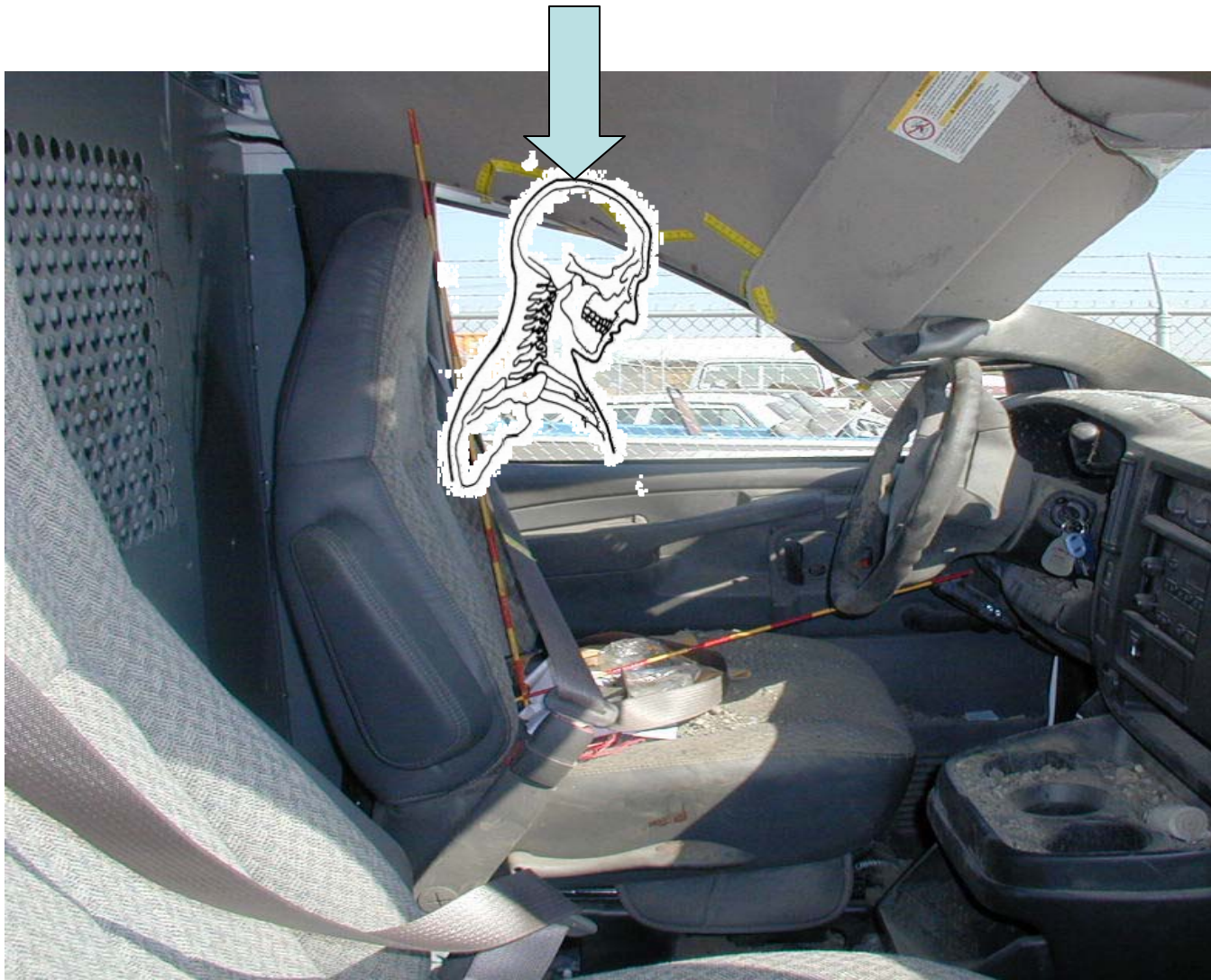


40cm/16inches roof Intrusion into driver position

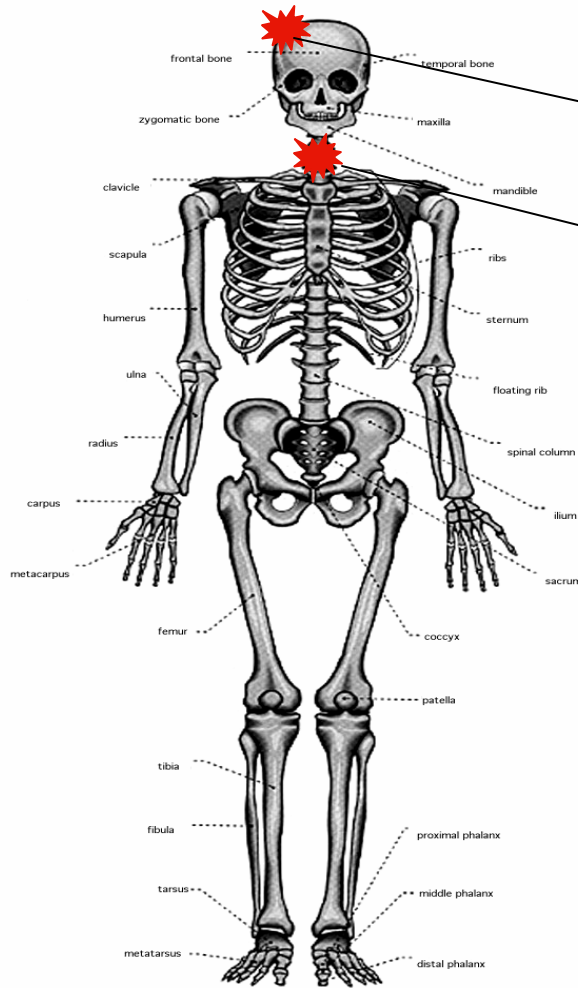
Contacts



Compression- Flexion



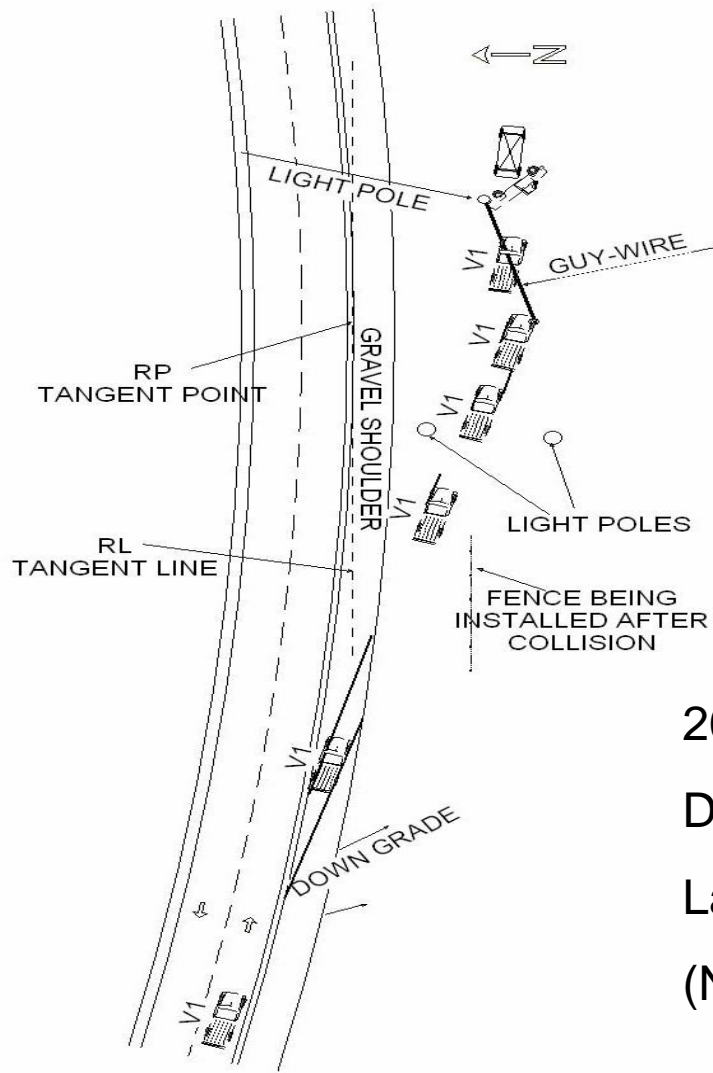
Injuries



AIS 1 – Head

AIS 3 – Multiple C-spine fractures

Case Review



2003 Compact Pickup Truck

Driver – 24 year old Male

Lap/shoulder restrained – Air bag deployed

(No other passengers in vehicle)

Roof Crush



Driver Seat Position - Intrusion

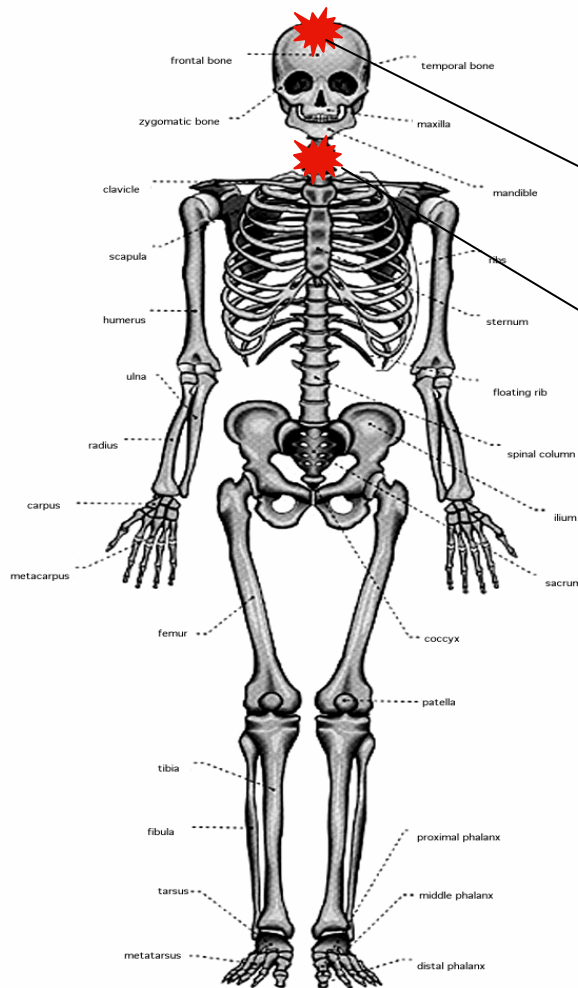


Roof Intrusion over driver 23 cm / 9 inches

Head Contacts



Injuries



AIS 1 –Head

AIS 5 – C-spine fractures and Spinal Cord Injury

Assessment of Costs due to SCI in Rollovers

Yearly Expenses and Lifetime Costs Matched to AIS coding

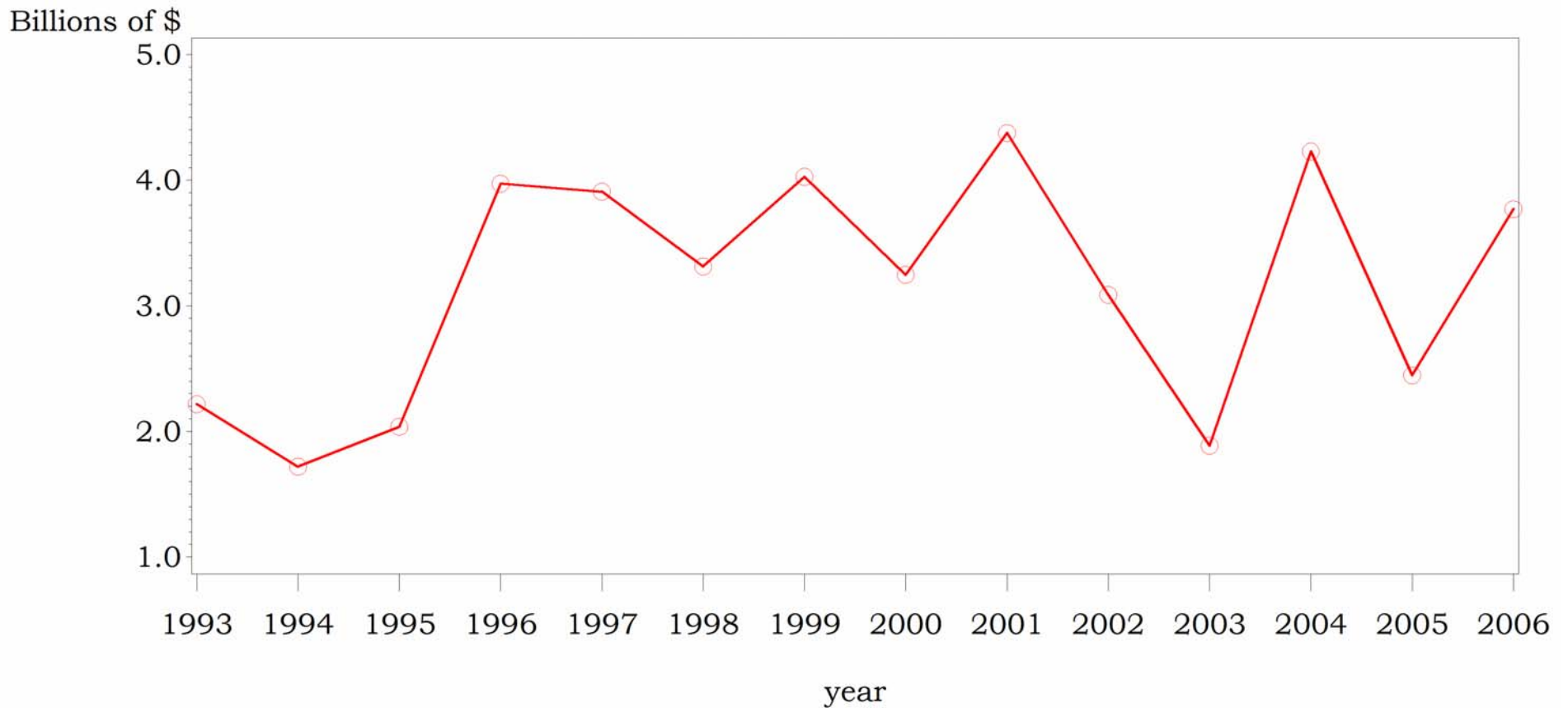
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**A.I.S.
SCI codes**



Source: National SCI Statistical Center

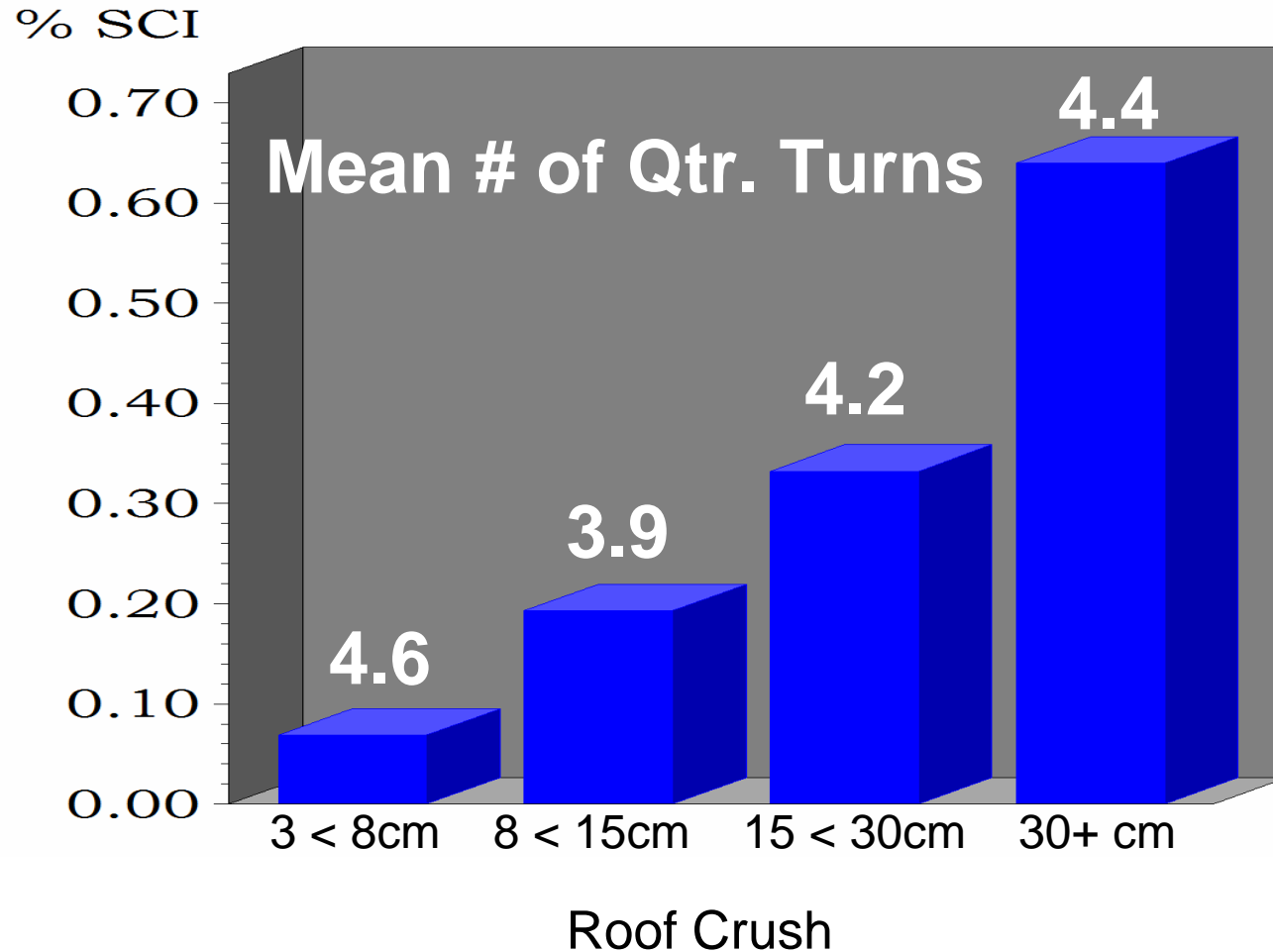
Annual Costs of SCI for All Crashes



Everybody -- Unbelted, Ejected, No Rollover, etc.

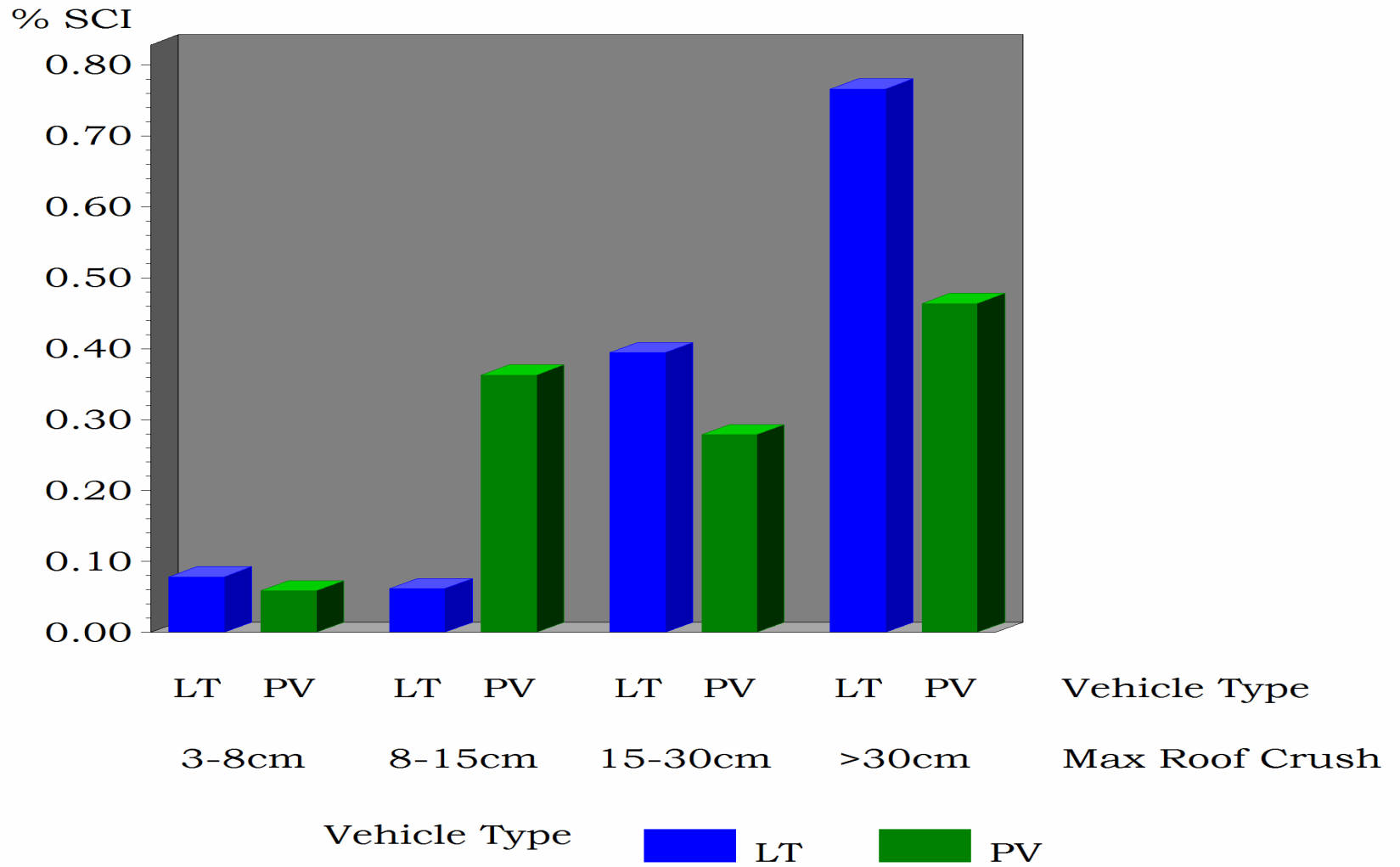
Source: NASS-CDS – Nationally all crashes involving SCI

Percent SCI by Roof Crush Among Rollovers



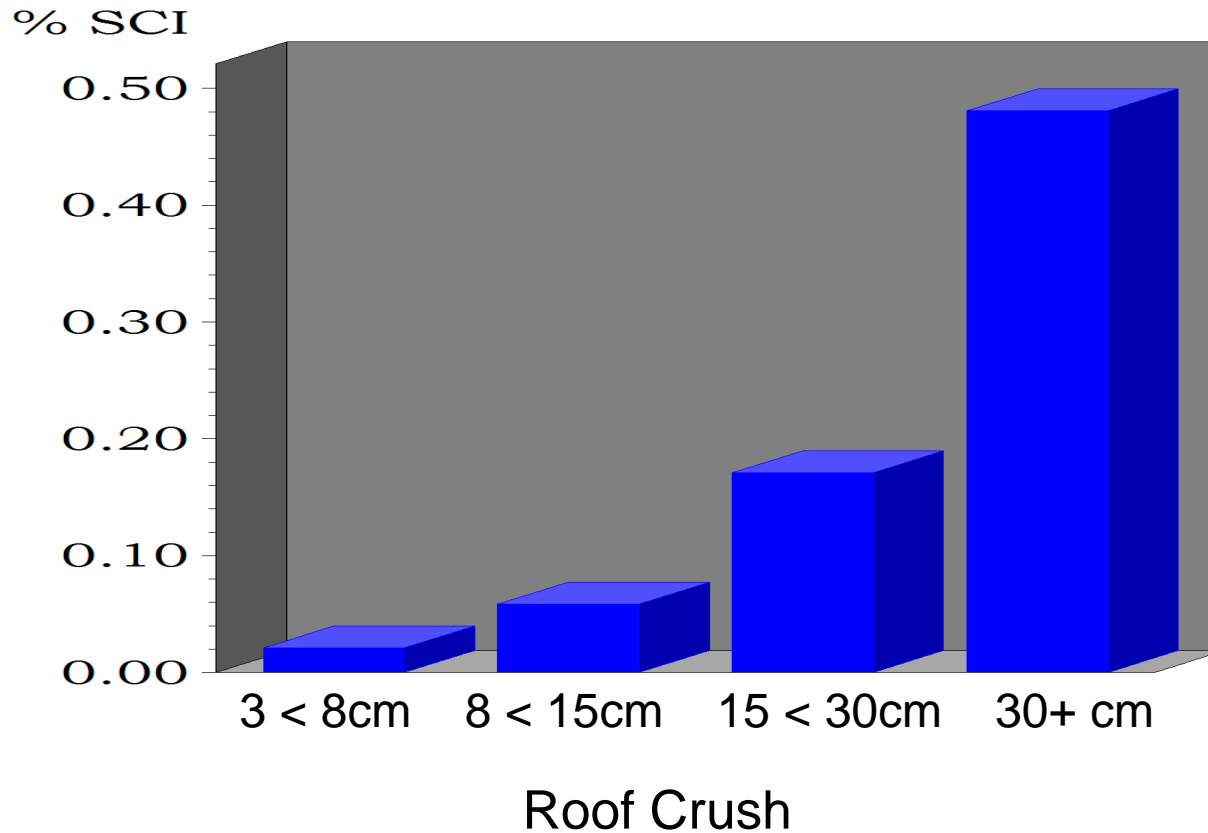
Source: NASS-CDS 1993-2006

Percent SCI by Roof Crush Among Rollovers by Body Type



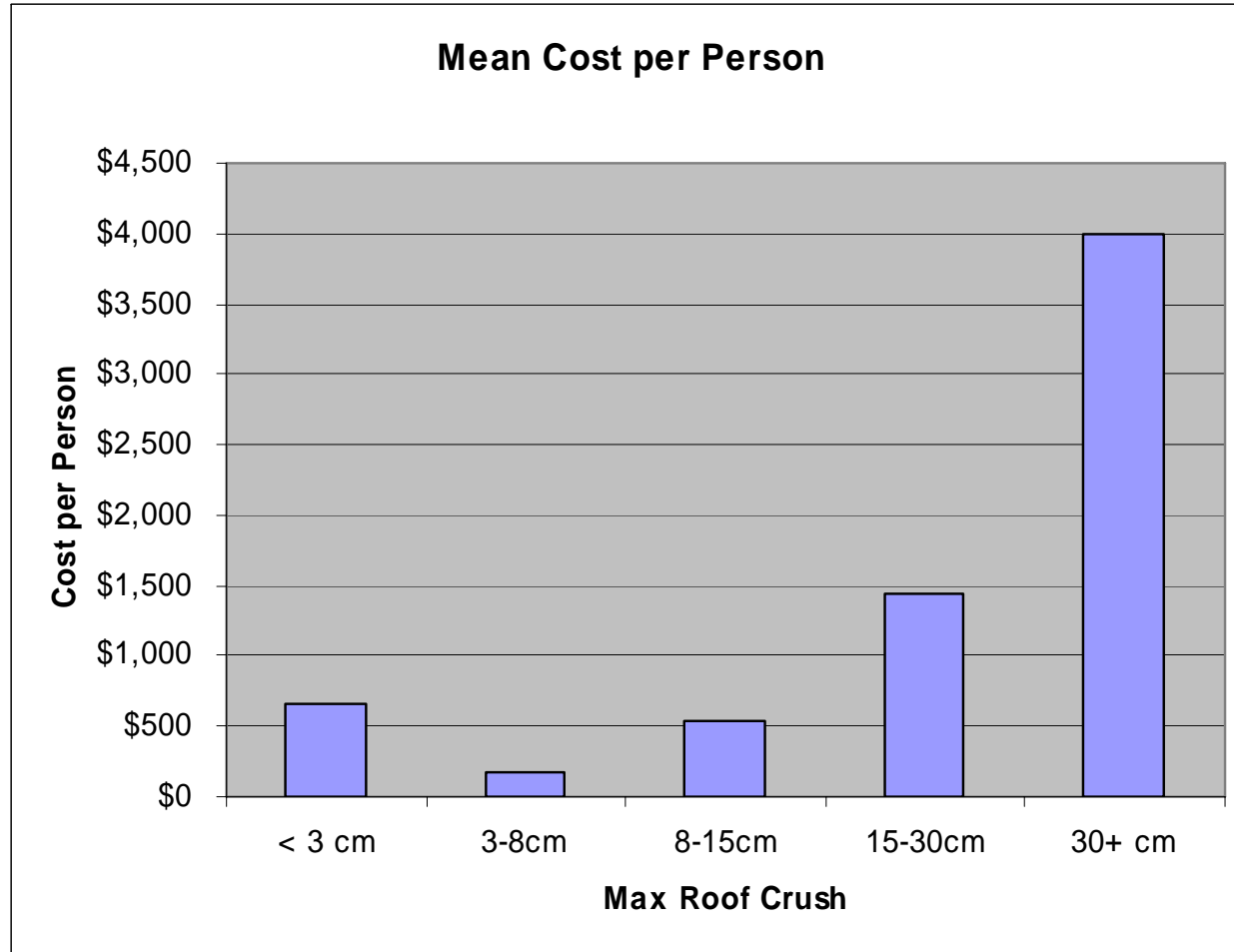
Source: NASS-CDS 1993-2006

Percent SCI by Roof Crush Among Belted Occupants



Source: NASS-CDS 1993-2006

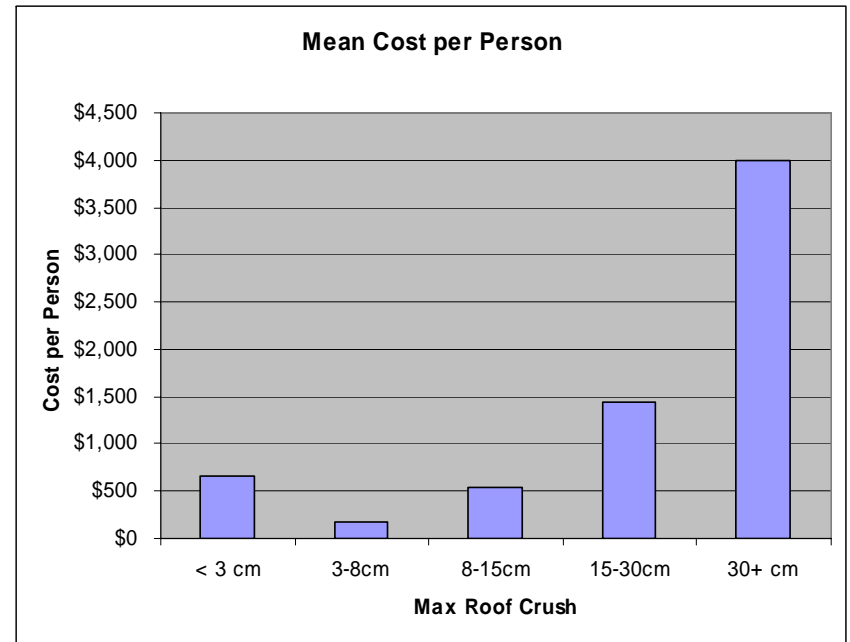
Mean Cost for SCI per Roof Crush for Belted Occupants



Source: NASS-CDS – Note: under count due to unknown restraint use for many

Minimize Roof Crush and Savings

- If roof crush were no higher than 30cm then total savings of **\$717,570,000** (1993-2006)
- Annual Savings **\$51,255,000**



Note: For belted occupants and undercount due to unknown restraint use for many

Thank you