



Motorcycle Safety

A Trauma Surgeon's Perspective

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Disclosure

- I have nothing to disclose
- No political or financial attachments
- I do take care of injured patients



Motorcycle Safety



- Injury Severity Score
- Oklahoma roads
- Injury patterns
- What do I see
- Helmets
 - Pre and post helmet law repeal
- Motorcycle training
- Conclusion

What is the Injury Severity Score and Abbreviated Injury Scale?



Region	Injury Description	AIS	Square Top Three
Head and Neck	Cerebral contusion	3	9
Face	No Injury	0	
Chest	Flail chest	4	16
Abdomen	Minor liver injury	2	25
	Major spleen injury	5	
Extremity	Femur fracture	3	
External	No Injury	0	
Injury Severity Score			50

AIS Score	Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Un-survivable

Example adapted from: www.east.org



- What do we see at OUHSC
 - This is not entire state

Data from July1, 2009 – June 30, 2010

	Helmeted	Non-helmeted
Total Accidents	56	135
Mortality (in hospital)	4 (7%)	15 (11%)
Average ISS : Lived	17	13
Average ISS: Died	26	35

State of Oklahoma



- Based on 2009 data
 - Available from Oklahoma Highway safety Office
 - Total Accidents: 1636
 - Fatal Accidents: 105
 - Youngest Accident Victim: 4
 - Youngest fatality: 18

Oklahoma



Age	Number of Accidents	Number fatal	% Fatal	
<u>21-30</u>	395	26	6.5	
<u>31-40</u>	319	31	9.7	
<u>41-50</u>	371	22	5.9	
<u>51-60</u>	297	16	5.3	
<u>61-99</u>	99	6	6	
<u>Total</u>	987	101	10.2	

What types of injuries

- What do I see
 - Patients with and without personal protective equipment
 - Older patients
 - Don't ride on Coumadin!
- Studies on injury patterns



Types of Injuries

- Motorcycle-Related Injuries: Effect of Age on Type and Severity of Injuries and Mortality
 - *Talving et al,*
 - Injury patterns from 13 trauma centers in LA county
 - 6,530 admissions for motorcycle crashes (MCC)
 - Mortality
 - Overall : 3.2%
 - 19 – 55 YOA: odds ratio of 2.3 (95% CI 1.08 – 4.93, p=0.03)
 - Over 55 YOA: odds ratio: 3.28 (95% CI 1.36 – 7.93, p=0.05)
 - Contradicts smaller studies of older age being protective
 - Major cause of death was head trauma

Talving et al

TABLE 1. Motorcycle Collisions: Incidence of Injury Severity Score >15 and >25 According to Age Group

ISS	Age Group (yr)	Percent	n	OR (95% CI) ^a	p ^a
>15	≤18	23.5	116/493	1.00	—
	19–55	30.3	1,704/5,627	1.41 (1.14–1.75)	0.02
	>55	36.2	144/398	1.84 (1.38–2.47)	<0.001
>25	≤18	6.5	32/493	1.00	—
	19–55	12.3	693/5,627	2.02 (1.40–2.92)	<0.001
	>55	13.8	55/398	2.31 (1.46–3.65)	<0.001

^a Age ≤18 yr used as reference for comparison.
p values derived from chi-square test or Fisher exact test.

TABLE 2. Motorcycle Collisions: Incidence of Severe (AIS Score ≥3) Head, Chest, Abdomen, and Extremity Injuries According to Age Group

Body Area (AIS Score ≥3)	Age Group (yr)	Percent	n	OR (95% CI) ^a	p ^a
Head	≤18	15.8	78/493	1.00	—
	19–55	15.5	874/5,627	0.98 (0.76–1.26)	0.87
	>55	21.4	85/398	1.45 (1.03–2.03)	0.04
Chest	≤18	15.0	74/493	1.00	—
	19–55	24.7	1,398/5,627	1.86 (1.44–2.39)	<0.001
	>55	33.2	132/398	2.81 (2.03–3.88)	<0.001
Abdomen	≤18	8.7	43/493	1.00	—
	19–55	8.7	492/5,627	1.00 (0.72–1.39)	0.99
	>55	7.3	29/398	0.82 (0.50–1.34)	0.43
Extremity	≤18	27.0	133/493	—	—
	19–55	33.2	1,870/5,627	1.35 (1.10–1.66)	0.005
	>55	26.1	104/398	0.96 (0.71–1.29)	0.78

^a Age ≤18 yr used as reference for comparison.
p values derived from chi-square test or Fisher exact test.

TABLE 3. Motorcycle Collisions: Risk of Intracranial Injuries According to Age Group

Intracranial Injury	Age Group (yr)	Percent	n	OR (95% CI) ^a	p ^a
Epidural hematoma	≤18	1.2	6/493	1.00	—
	19–55	0.4	22/5,638	0.32 (0.13–0.79)	0.02
	>55	0.5	2/399	0.41 (0.08–2.04)	0.31
Subdural hematoma	≤18	1.4	7/493	1.00	—
	19–55	2.5	140/5,638	1.77 (0.82–3.80)	0.14
	>55	5.5	22/399	4.05 (1.71–9.59)	0.001
Subarachnoid hemorrhage	≤18	1.8	9/493	1.00	—
	19–55	3.2	179/5,638	1.76 (0.90–3.47)	0.10
	>55	7.0	28/399	4.06 (1.89–8.71)	<0.001
Brain contusion	≤18	4.1	20/493	1.00	—
	19–55	4.2	234/5,638	1.02 (0.64–1.63)	0.92
	>55	8.3	33/399	2.13 (1.20–3.78)	0.008

^a Age ≤18 yr used as reference for comparison.
p values derived from chi-square test or Fisher exact test.

Intrathoracic and Intra-abdominal Trauma



- *Jess F. Kraus, MPH, PhD, et al, 2002*
 - Included admissions and coroners records
 - Data from 1991 – 1992

Table 1 Anatomic Region with the Most Severe Injury in Fatally and Nonfatally Injured Motorcyclists, California, 1991-1992

Anatomical Region	Fatal		Nonfatal	
	No.	%	No.	%
Head	307	56.0	1,114	26.4
Neck ¹	0	0.0	12	0.3
Chest	175	32.0	405	9.6
Abdomen	30	5.5	198	4.7
Spine ²	17	3.1	155	3.7
Lower extremity	14	2.6	1,636	38.8
Upper extremity	5	0.9	513	12.2
Face	0	0.0	55	1.3
Unknown/unspecified	0	0.0	126	3.0
Total	548	100.1	4,214	100.0

¹ Includes soft tissue injury.

² Includes bone and cord.

Injury Patterns: Spine



- *Angus et al, 2002*
 - Data from UK
 - Data set from 1993 – 2000
 - Reported that in UK in 1998 24,969 MCC's

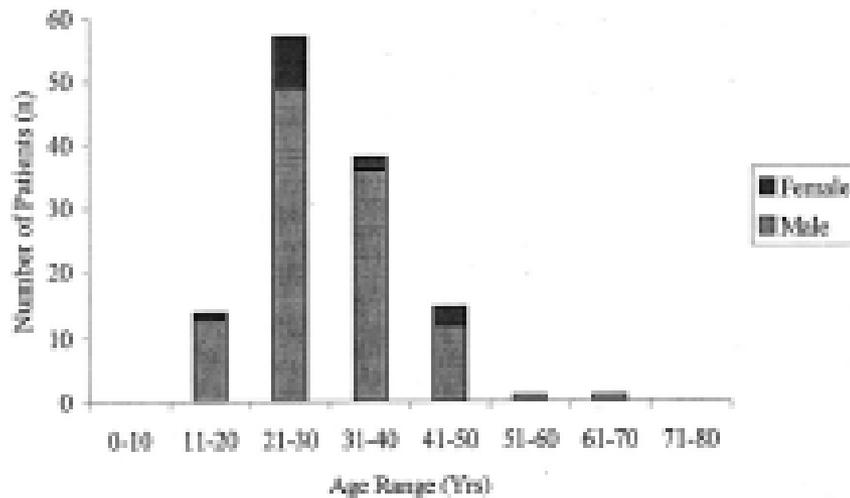


Fig. 1. Age and sex distribution.

Table 1 Regions Involved and Neurologic Injury

Region	No. (%)	Neurology	No. (%)
Cervical (excluding brachial plexus)	22 (17.4)	Complete	4 (18.2)
		Incomplete	1 (2.9)
		Transient	1 (2.9)
Thoracic	69 (54.8)	Complete	9 (13.0)
		Incomplete	4 (5.8)
		Transient	3 (4.3)
Lumbar	37 (29.4)	Complete	1 (2.7)
		Incomplete	0 (0.0)
		Transient	2 (5.4)

Accident Prevention

- Personal protective equipment
- Trend has been to repeal helmet laws



AMA Position statement



- **AMA Position In Support Of Voluntary Helmet Use [Share](#)**
- The American Motorcyclist Association (AMA), as part of a comprehensive motorcycle safety program to help reduce injuries and fatalities in the event of a motorcycle crash, strongly encourages the use of personal protective equipment, including gloves, sturdy footwear and a properly fitted motorcycle helmet certified by its manufacturer to meet the DOT standard.
- The AMA believes that adults should have the right to voluntarily decide when to wear a helmet. The AMA does not oppose laws requiring helmets for minor motorcycle operators and passengers, believing that many young motorcyclists and/or their passengers may lack the maturity to make an informed decision regarding the use of motorcycle helmets.
- (From AMA website, March, 2011)

California 1992 requiring helmets

- Kraus, et al
 - Reviewed accident data pre and post helmet law
 - Reported a significant reduction in fatalities

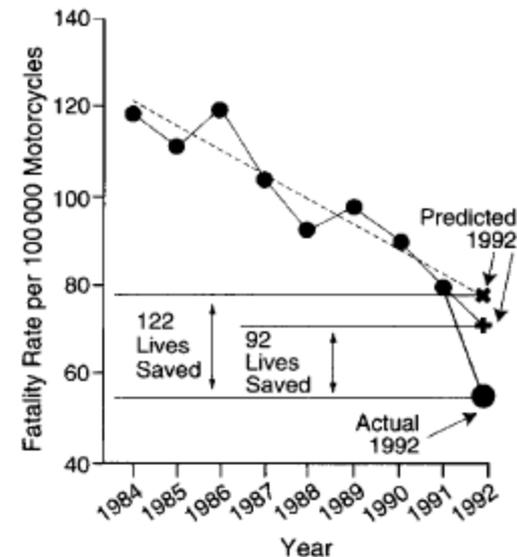
Table 1.—Fatalities and Injuries to Motorcyclists in California, 1991 and 1992

Fatality	1991 (Prelaw)	1992 (Postlaw)	% Change
Statewide			
All fatalities	523	327	-37.5
Drivers	457	306	-33.0
Passengers	66	20	-69.7
Fatality rate*	70.1	51.5	-26.5
Injured Rider Samples			
Fatal†	346	201	-41.9
Nonfatal‡	1969	1283	-34.8
Admitted	1483	927	-37.5
Emergency department only	486	356	-26.8

*Fatality rate per 100 000 registered motorcycles in California.

†Eleven California counties.

‡Twenty-eight hospitals in 10 California counties.



Fatality rate per 100 000 registered motorcycles in California, 1984 through 1992, and estimated prevented deaths in 1992.

Kraus et al



Table 2.—Percentage of Selected Driver, Crash, and Vehicle Factors in Motorcycle Crash Fatalities (Statewide and Fatal Sample) and Nonfatal Motorcycle Crash Injuries in California, 1991 and 1992

Factor	Statewide Fatalities		Fatal Sample*		Nonfatal Sample†	
	1991	1992	1991	1992	1991	1992
No.	523	327	346	201	1969	1283
Mean age, y	29.1	30.5	28.6	30.6‡	28.2	29.0‡
Helmeted, %§	22.3	83.1	21.5	80.1	28.6	83.9
Male, %	92.0	94.8	91.3	94.5	89.6	90.9
Driver, %¶	87.3	93.8‡	87.5	94.0‡	88.7	91.4‡
Multiple vehicle crash, %#	56.7	62.3	58.7	67.0‡	58.0	61.8
Owner, %#**	56.7	64.2‡	53.8	64.5‡	66.4	69.9‡
Valid motorcycle license, %#**	30.0	34.9	30.9	34.0	29.7	35.7
Died at scene, %	29.8	38.6‡	29.4	37.0	NA††	NA
Driver intoxicated, %**‡§§	37.5	32.1‡	34.0	27.5‡	41.4	28.5‡

*Eleven California counties.

†Twenty-eight hospitals in 10 California counties. January through September.

‡P<.05, 1992 vs 1991.

§Excludes unknown helmet use: statewide=57, fatal sample=44, and nonfatal sample=443.

||P<.01, 1992 vs 1991.

¶Excludes cases for whom ridership was unknown: nonfatal sample=144.

#Excludes cases with no crash report: statewide=four, fatal sample=three, and nonfatal sample=802.

**Driver only.

††NA indicates not applicable.

‡‡Statewide fatalities include only intoxication reported on the police report; fatal and nonfatal samples are reported from the autopsy report and the hospital record, respectively. Driver is intoxicated if blood alcohol level is greater than 17 mmol/L (79 mg/dL).

§§Excludes drivers not tested: fatal sample=51 and nonfatal sample=1638.

Kraus et al



Table 5.—Anatomical Region of Most Severe Injury in Fatally and Nonfatally Injured Motorcyclists in California, 1991 and 1992

Region	Fatal		Nonfatal*	
	1991 (Prelaw), No. (%)	1992 (Postlaw), No. (%)	1991† (Prelaw), No. (%)	1992‡ (Postlaw), No. (%)
Head	212 (61.3)	87 (43.3)	589 (30.7)	264 (20.8)
Neck‡	0 (0)	0 (0)	4 (0.2)	5 (0.4)
Chest	98 (28.3)	81 (40.3)	154 (8.0)	160 (12.6)
Abdomen	19 (5.5)	11 (5.5)	76 (3.9)	66 (5.2)
Spine§	4 (1.2)	13 (6.5)	70 (3.6)	46 (3.6)
Lower extremity	9 (2.6)	5 (2.5)	750 (39.1)	525 (41.4)
Upper extremity	1 (0.3)	0 (0)	221 (11.5)	174 (13.7)
Face	1 (0.3)	0 (0)	26 (1.4)	11 (0.9)
External	2 (0.6)	4 (2.0)	27 (1.4)	18 (1.4)
Total	346	201	1917	1269

*Excludes riders with injuries of unknown severity.

†January through September.

‡Includes only soft tissue.

§Includes injury to bone and cord.

Economic Impact of helmet use



- Eastridge et al, 2006
 - National Highway Transportation Safety Administration
 - 1994 – 2002

Table 1 Prehospital Course and Injury Severity of Patients Involved in Nonfatal Motorcycle Collisions

	n	Helmeted	Nonhelmeted	p Value
Require transport to emergency room	4,005	2,547 (73.3)	1,458 (78.6)	0.01
Discharge from scene	1,323	927 (26.7)	396 (21.4)	0.01
Total live patients	5,328			
Death at scene	297	135 (3.6)	162 (8.3)	0.001

Data were abstracted from NHTSA GES and are presented n (%).

Eastridge et al

- This data includes out of hospital cost:
- What is the cost to Oklahoma?

Table 3 Cost Analysis Algorithm for 197,608 Motorcycle Crash Riders

Data Element	With Helmet	No Helmet	Data Source
Riders in crashes (%)	65	35	NHTSA GES
Riders in crashes (n)	128,445	69,163	Derived
Crash riders requiring hospital transport (%)	73.3	78.6	NHTSA GES
Crash riders requiring hospital transport (n)	94,150	54,362	Derived
Crash rider transports requiring admission (%)	32.8	39.9	Literature Prospective Study ¹
Crash rider transports requiring admission (n)	30,881	21,690	Derived
Hospital charges per admission	\$32,098	\$36,163	NTDB
Total hospital charges	\$1,006,058,840	\$784,375,470	Derived
Charge/crash rider	\$7,837	\$11,340	Derived

Cost data from National Trauma Data Bank

- Hundley, et al
 - reviewed data from National Trauma Data Bank
 - 1994 – 2002

Table 1 Demographics, Outcome, and Injury Severity

	Helmet (n = 6756)	No Helmet (n = 3013)	p-Value
Demographics			
Male (%)	89.2	87.3	0.0071
Age (years)	34.6	34.0	0.0454
Hospital course			
ICU days	1.8	2.4	<0.0001
Ventilator days	1.4	1.8	<0.0001
LOS (days)	6.4	7.0	0.0036
Mortality (n)	4.25% (287)	7.07% (213)	<0.0001 (OR 1.71)
Injury scores			
ISS	12.0	14.2	<0.0001
RTS	7.3	6.6	<0.0001
GCS	13.9	12.5	<0.0001
Highest AIS by region			
Head	2.72	3.00	<0.0001
Face	1.32	1.32	NS
Neck	1.84	2.71	NS
Thorax	2.09	2.67	NS
Abdomen	2.27	2.26	NS
Spine	2.29	2.49	NS
Upper extremity	1.89	1.87	NS
Lower extremity	2.42	2.42	NS
Cervical spine injury	14.3%	14.8%	NS

All values are means unless otherwise specified.

p < 0.05 considered to be significantly different between groups.

ICU, intensive care unit; LOS, length of stay; N, number of patients; OR, odds ratio of NHM compared with HM; ISS, Injury Severity Score; RTS, Revised Trauma Score; GCS, Glasgow Coma Scale; AIS, Abbreviated Injury Score; NS, not significant (p > 0.05).

Hundley et al



Table 2 Charges and Principal Payment Source

	Helmet (n = 5484)	No Helmet (n = 2269)	p-Value	OR
Charges (mean)	\$32,113	\$34,564	0.0054	
Personal insurance (n)	72.5% (3975)	61.2% (1389)	<0.0001	0.60
Other (n)	27.5% (1509)	38.8% (880)	<0.0001	1.46
Medicaid	6.0% (329)	8.0% (181)	0.0228	1.45
Medicare	2.3% (125)	2.9 (66)	NS	1.25
Self Pay	19.2% (1055)	27.9% (633)	<0.0001	1.19

OR, odds ratio of NHM compared with HM.

Table 3 Discharge Disposition

	Helmet (n = 6569)	No Helmet (n = 2968)	p-Value	OR
Dead (n)	4.4% (287)	7.2% (213)	<0.0001	1.72
Home (n)	79.4% (5214)	72.9% (2154)	<0.0001	0.76
Rehabilitation (n)	12.4% (816)	15.6% (462)	<0.0001	1.32
Rehab hospital	10.8% (709)	13.1% (389)	0.0013	1.25
Nursing home	0.7% (44)	1.2% (35)	0.0143	1.77
SNF	1.0% (63)	1.3% (38)	NS	1.34
Other (n)	3.8% (252)	4.4% (129)	NS	1.14

p < 0.05 denotes significant difference between groups.

OR, odds ratio of NHM compared with HM; SNF, skilled nursing facility.

Table 4 Results by Alcohol/Drug Use and Helmet Use

	No Alcohol or Drugs			Alcohol or Drugs Present		
	Helmet (n = 2872)	No Helmet (n = 1096)	p-Value	Helmet (n = 1318)	No Helmet (n = 959)	p-Value
Demographics						
Male	88.0%	86.0%	NS	90.0%	89.9%	NS
Age (yrs)	35.0	34.2	NS	35.5	35.4	NS
Injury scores						
ISS	11.9	15.0	<0.0001	13.6	15.6	<0.0001
RTS	7.3	6.5	<0.0001	7.1	6.5	<0.0001
GCS	14.0	12.5	<0.0001	13.5	12.0	<0.0001
Hospital course						
ICU days	1.8	2.6	<0.0001	2.8	3.3	<0.0001
Vent days	1.6	2.0	<0.0001	2.3	2.7	0.0002
LOS (days)	6.3	7.5	<0.0001	8.0	8.1	NS
Charges	\$32,719	\$36,795	<0.0001	\$39,042	\$41,015	NS
Mortality (n)	4.18% (120)	8.03% (88)	<0.0001	4.40% (58)	6.57% (63)	0.0292

Mean unless otherwise specified.

ISS, Injury Severity Score; RTS, Revised Trauma Score; GCS, Glasgow Coma Scale; ICU, intensive care unit; LOS, length of hospital stay.

Hundley et al

upon society. A summation by the US Supreme Court as cited by McSwain et al. succinctly summarizes this situation. "From the moment of injury, society picks the person up off the highway; delivers him to a municipal hospital and municipal doctors; provides him with unemployment compensation if, after recovery, he cannot replace his lost job, and if the injury causes permanent disability, may assume the responsibility for his and his family's subsistence. We do not understand a state of mind that permits the plaintiff to think only he himself is concerned."¹¹ Undoubtedly, the decision not to wear a helmet has far-reaching consequences that impact more than just the individual.



Non-standard Helmets

- Peek-Asa, et al
 - Reported on Sham helmets
 - Reported data after helmet law enacted

Table 2
Head injuries among injured motorcycle riders

	Non standard helmet indicated		No helmet		Standard helmet		Total	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Number	24	1.8	187	14.0	1124	84.2	1335	
<i>Fatal injury</i> ^a								
Yes	8	33.3	29	15.5	153	13.6	190	14.2
No	16	66.6	158	84.5	971	86.4	1145	87.8
<i>Head injury</i> ^b								
Yes	18	75.0	97	51.9	345	30.7	460	34.5
No	6	25.0	90	48.1	779	69.3	875	65.5
<i>Head injury AIS</i> ≥ 3 ^{c,f}								
Yes	15	62.5	70	37.4	245	21.8	330	24.7
No	9	37.5	117	62.6	879	78.2	1005	75.3
Average head Injury severity ^{d,f}	2.65		1.56		0.96		1.07	
Without head region ^{e,f}	15.8		10.4		14.4		13.6	

^a $\chi^2 = 7.77$, $P < 0.05$; χ^2 calculated using bogus versus no helmet and standard helmet.

^b $\chi^2 = 49.63$, $P < 0.0001$.

^c $\chi^2 = 49.63$, $P < 0.0001$.

^d $F[2,1326] = 21.94$, $P < 0.0001$.

^e $F[2,1326] = 11.6$, $P < 0.05$.

^f Excludes AIS severity 9 (unknown severity).

Repeal of helmet law



- Bledsoe et al
 - Reported 3 years before and 3 years after helmet law repealed
- Findings
 - Increased cost
 - Increased severity
 - Increased mortality

Table 1 Arkansas Statewide Data, 1995 to 1999

Year	Motorcycles		Fatalities	
	Registrations	Crashes	Helmeted	Nonhelmeted
1994	14,338	720	14	17
1995	17,195	651	10	10
1996	16,471	576	18	7
1997	14,311	571	12	11
1998	21,051	625	7	19
1999	22,428	647	4	20

did not differ significantly regarding age, gender, severity of injury, and length of stay (total or ICU). Financially, overall charges and reimbursements did not differ significantly over the 6-year study period (Table 4).

When comparing all nonhelmeted versus helmeted patients in the study, there were no differences regarding gender, age, or disposition on discharge (i.e., home, rehabilitation, or death). However, nonhelmeted patients had significantly worse injuries as measured by ISS, had higher

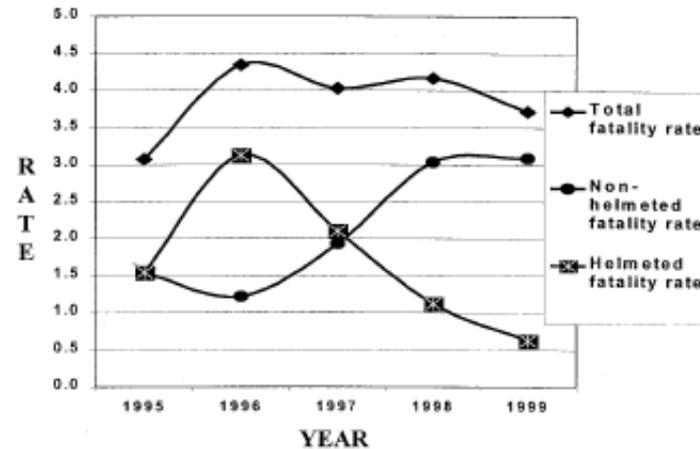


Fig. 1. Nonhelmeted and helmeted fatality rates per 100 crashes, 1995 to 1999.

Non-Helmeted and Helmeted Fatality Rates per 10,000 Registrations

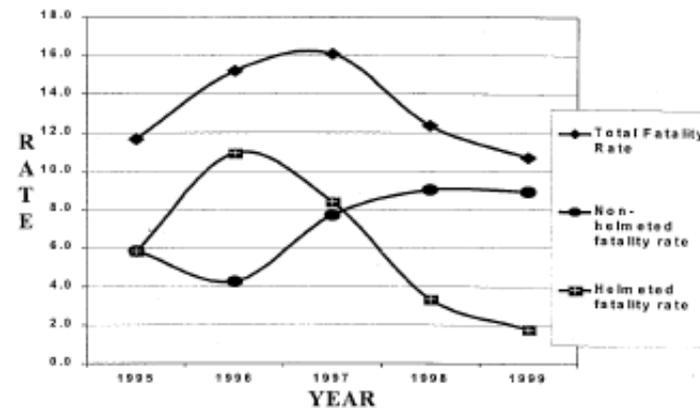


Fig. 2. Nonhelmeted and helmeted fatality rates per 10,000 registrations.

Miami-Dade county



- O'Keefe et al
 - 3 year period before and after repeal
 - Helmet law repealed in 2000
 - Found significant increase in mortality

O'Keefe et al

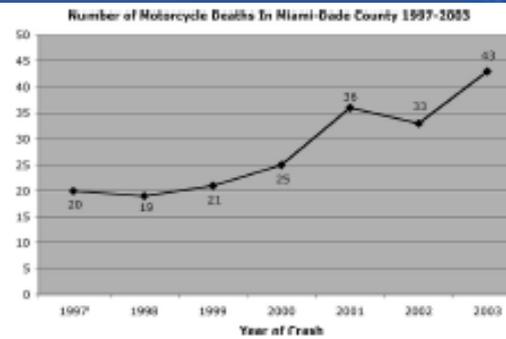


Fig. 1. Number of motorcycle fatalities in Miami-Dade County from 1997 to 2003.

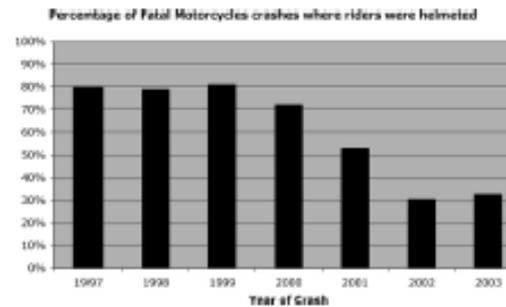


Fig. 2. Percentage changes in helmet use in fatal motorcycle crashes from 1997 to 2003.

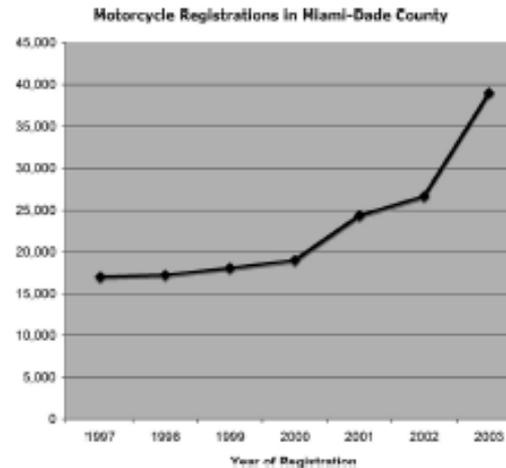


Fig. 3. Number of annual motorcycle registrations from 1997 to 2003.

Cochrane Review



- Liu, et al 2009.
 - Meta-analysis
 - Helmets reduce risk of death by 42%
 - Reduce risk of TBI by 69%

Cochrane review of Training Courses



- Kardamanidis et al, 2010
 - Few good studies on efficacy of training courses
 - World wide issue
 - Varied study design and varied results
 - Only 3 randomized trials
 - 2 randomized controlled trials showed benefit up to 2 years
 - Another Randomized controlled trial did not

Conclusions

- Helmets save lives and reduce injury
- Helmets reduced the additional burden of non-helmeted motorcyclists
- Uncertain if training programs decreases mortality or motorcycle accidents
 - It seems intuitively it would
- I don't know a thing about politics; only what they tell me!

