

An Evidence Based Review:
Helmet Efficacy to Reduce Head Injury &
Mortality in Motorcycle Crashes

**Injury Control and Violence Prevention Committee
Eastern Association for the Surgery of Trauma**

Jana B.A. MacLeod, MD
Associate Professor of Surgery
Emory University School of Medicine/Grady Hospital
Atlanta, GA

J. Christopher DiGiacomo, M.D.
Director of Trauma
The Port Authority Heroes of September 11 Trauma Center
Jersey City Medical Center
Jersey City, New Jersey

Glen H. Tinkhoff, M.D.
Director of Trauma
Christiana Hospital
Christiana, Delaware

Introduction

In the United States in 2004, 3888 motorcyclists died in motorcycle crashes. The National Highway Traffic Safety Administration reported in 2004 that per mile traveled, the number of motorcycle deaths is about 27 times that of car occupant deaths. An important factor is that motorcyclists lack the protection of an enclosed vehicle when a crash occurs. Although motorcycle deaths had been declining since the early 1980s, they began to increase in 1998, and were 89% higher in 2004 than in 1997. Since the early 21st century motorcycle fatalities have continued to increase across all states. Motorcycle fatalities now account for approximately 10% of all motor vehicle crash fatalities.

Head injuries are common after motorcycle crashes and have been estimated to be the main cause in over 50% of the fatalities seen. In close to a third of these patients, the head injury was the sole organ system injured. While the vast majority of patient, estimated as high as 90% of patients, a head injury is present along with other injuries.

The use of protective headwear is documented back to Paleolithic pictographs and the earliest oral traditions, such as the Epic of Gilgamesh. It was intuitive even to our earliest ancestors that a hard shell would protect the head from injury. The modern age of motorcycle helmet laws dates to the 1930s with the World War I hero Lawrence of Arabia and British Neurosurgeon Hugh Cairns. Colonel T. E. Lawrence suffered a traumatic brain injury from a motorcycle crash in 1935, and subsequently died from his injuries. Dr. Cairns felt the injury might have been avoided if Colonel Lawrence had been wearing a protective crash helmet. Based on his research on head injuries and deaths among army motorcyclists during World War II, he concluded, "There can be little doubt that adoption of a crash helmet as a standard wear by all civilian motorcyclists would result in considerable savings of life, working time, and the time of hospitals." (Cairns H: Crash helmets. Br Med J 1946;2:322-324)

In the United States, an increasing recognition that helmet use is associated with reductions in fatalities without apparent harm increased the implementation of universal helmet laws. In response to the 1966 Federal Highway Act, which withheld federal funds

from states that did not enact a helmet law, Georgia became the first State to enact a mandatory universal motorcycle helmet law in 1967. By 1975, 47 of the 50 states had universal helmet laws. However, public and political concern over individual rights versus public safety opened a new debate. In the following years, political changes reversed and/or limited previous sanctions and grants that encouraged states to enact universal helmet laws which further eroded support for helmet laws. An increasing number of states either repealed their mandatory laws altogether or significantly reduced the laws to apply only to minors. At present only 20 states have universal helmet laws, another 26 require only partial coverage and 4 states have no helmet laws (Colorado, Illinois, Iowa and New Hampshire). , .

In this regard, the issue of how strong the evidence must be for a public safety intervention to be imposed by governing bodies needs to continually be addressed. Geoffrey Rose further elucidated this issue in his 1992 book, *Strategy of Preventative Medicine: Implementation of a public safety intervention depends on the consequences of making the wrong decision, whether positive or negative. A judgment must be made not only on the potential benefits, but also the potential harm the intervention could have. Dr. Rose suggested that it may be acceptable to impose an intervention even if the evidence supporting the benefit is incomplete if there is strong evidence that the intervention will do no harm. This is a part of the "prevention paradox", in that a successful preventive strategy may provide significant benefit to a population overall, yet yield little or limited benefit to the individual members of that population on a case by case basis. Varying views on the tally between public safety and personal rights continues to blur the debate. Universal helmet laws have been shown to be a strong indicator for helmets usage, On the contrary, partial coverage, where only young riders under the age of 21 years are mandated to wear a helmet, helmet use drops significantly and often with no difference to pre-law levels or no helmet law states.*

There has been a large volume of literature which has quantified the consequences of not wearing a helmet while riding a motorcycle. Motorcycle riding and registration is increasing, more states with universal helmet laws are introducing bills to repeal their laws, while debate continues on the personal advantages of helmet usage.

Therefore, we will review the scientific literature and summarize the evidence-based for the utility of helmet usage during a motorcycle crash. In particular, we will review the impact of usage of a helmet on overall mortality, head-injury related mortality and head injury after a motorcycle crash.

Statement of Problem

Motorcycles are a significant cause of injury-related fatality and disability. In particular, head injury is a common associated cause of death and long term disability after a motorcycle crash. Despite these facts there remains ongoing controversy as to the survival and disability advantages for riders who wear motorcycle helmets. In the public and legislative sectors there remains significant policy controversy resulting in a push to retain partial coverage helmet laws and to repeal universal helmet laws in many others.

Questions to be addressed:

- A. Do non-helmeted riders in comparison to helmeted riders have a higher or lower overall death rate after a motorcycle crash?
- B. Do non-helmeted riders in comparison to helmeted riders incur higher or lower rates of lethal head injury after a motorcycle crash?
- C. Do non-helmeted riders in comparison to helmeted riders incur higher or lower rates of non-lethal head injury or is the non-lethal head injury more or less severe after a motorcycle crash?
- D. Do geographical areas (i.e. aggregate states) that have universal helmet laws have a higher or lower death rate or head injury rate after motorcycle crashes as compared to areas without a universal helmet law?

Methods & Process

A computerized search of the world's literature was undertaken using PubMed, of the U.S. National Library of Medicine, extending back to 1990 using the key words:

helmet + (motorcycle OR crash) to present (2009). There were 507 citations identified. The abstract for each was reviewed, and 197 candidate papers having possible applicability to the guideline topic were retrieved and reviewed. General reviews, letters to the Editor, single case reports, and retrospective reviews of poor quality were excluded. This left 45 manuscripts which were felt to have sufficient merit to form the basis for the guidelines. The manuscripts were reviewed in detailed by the authors JM, GHT and JCD.

Over the past decades, the volume of literature supporting helmet usage prevents, and ethically so, any randomized control trials or even controlled trials of helmet usage. Therefore the most robust studies published in the last 20 years are predominantly prospective and retrospective epidemiological studies. As there are no Class I studies to review, the studies we did review do not vary across the classes of evidence in a useful manner. Therefore, we categorized the articles in this review by study design. There are prospective cohort and cross-sectional studies. However, the majority of the studies are retrospective: either before-after cross-sectional studies of helmet law changes or cross-sectional studies of helmeted in comparison to non-helmeted riders. Finally, we also identified case-control studies.

Recommendations

Level I:

All motorcyclists should wear motorcycle helmets when riding motorcycles to reduce the incidence of head injury and severe head injury after a crash.

NB: This statement was made a Level recommendation despite a lack of Class I data because of the volume of consistent Class II data, including robust prospective data, to support this finding without any methodologically similar data to refute it.

Level II:

·All motorcyclists should wear motorcycle helmets when riding motorcycles to improve overall survival and reduce head injury-related mortality after a crash.

·Mandatory universal motorcycle helmet laws should be introduced or re-enacted to reduce mortality and head injury after a crash.

Scientific Foundation

The evidence reviewed here which assesses the effectiveness of helmets for motorcyclists comes from the following 45 study designs:

- 1) Prospective Cohort study of motorcycle riders (1)
- 2) Prospective Cross-sectional studies that compare helmeted riders with non-helmeted riders for different outcomes. (4)
- 3) Retrospective Before-After Cross-sectional studies where outcomes of motorcycle crashes are compared before and after either the repeal of or the enactment of a mandatory universal helmet law. (20)
- 4) Case-control studies of motorcycle riders (3)
- 5) Retrospective Cross-sectional studies that compare helmeted riders with non-helmeted riders across different outcomes. (16)
 - a. Comparison of mortality between states with helmet laws and states without helmet laws. (2)

The outcomes reported included any one or more of the following: mortality, head injury related mortality, prevalence of head injury and prevalence of severe head injury.

- A. Do non-helmeted riders in comparison to helmeted riders have a higher or lower overall death rate after a motorcycle crash?

Two prospective cross-sectional studies showed a reduction in mortality in for helmeted riders in comparison to non-helmeted riders with an odds ratio of 0.40 and 0.22 respectively (Ouellet JV and Kelly P). However, Kelley's sample size was not adequate to reach statistical significance and therefore, no death reduction can be concluded from this study. Nine retrospective cross-sectional studies reported mortality as an outcome but 2 showed no reduction (Brandt M &

Offner P) while 7 showed reductions that varied from a maximal odds ratio estimate of 0.29 (Nakahara S) to a minimal odds ratio estimate of 0.84 (Croce MA). Of the studies that showed a mortality reduction only 3 were adjusted for rider and/or environmental factors (Croce MA, Nakahara S & Hundley JC).

There were five studies that compared crashes before and after helmet law repeal. Two of the studies showed an increase in fatality after repeal of the helmet law, 26% and 30% increases respectively (Kyrychenko SY & Ho EL). However, two further studies had nonsignificant increases in the odds of death: OR of 1.08 (per 10,000 motorcycle registrations, O'Keeffe T) and OR: 1.01 (per 1000 crashes, Bledsoe GH). Interestingly, though Bledsoe did not show an overall reduction in mortality, there was a significant increase in riders who were blood alcohol positive at the time of the crash who were also not wearing a helmet after the repeal as compared to before (14.2% versus 33.6%, OR:2.37, $p<0.05$).

There were twelve studies that compared crashes before and after helmet law establishment or re-enactment. Auman and colleagues showed close to a halving of the relative risk of fatality after the law was re-enacted (RR: 0.51, 9.3 fatalities per 10,000 motorcycle registrations to 4.7 fatalities per 10,000 registrations). Another five studies showed relative risks that reflected statistically significant mortality reductions from 0.57 to 0.81 (Mock CN, Muelleman RL, Fleming NS, Ferrando J & Kraus JF). One study, Chiu WT, showed no change in mortality over the study period (4.0%).

- B. Do non-helmeted riders in comparison to helmeted riders incur higher or lower rates of lethal head injury after a motorcycle crash?

The relative risk of head injury related mortality was reduced by more than half after the enactment of a helmet law in Texas from 6.8 fatalities to 3.1 fatalities per 10,000 motorcycle registrations (RR:2.19, $p<0.05$, Fleming NS). In

Pennsylvania after the repeal of the helmet law, the head injury related death rate per 10,000 motorcycle registrations increased by 36.9% (1.6 to 2.2 fatalities per 10,000 registrations, $p < 0.05$, Mertz KJ).

- C. Do non-helmeted riders in comparison to helmeted riders incur higher or lower rates of non-lethal head injury or severity of non-lethal head injury after a motorcycle crash?

All 25 of the studies which had prevalence of a nonfatal head injury as an outcome had a significantly lower incidence for helmeted riders, for after re-enactment or before repeal of a helmet law.

The one prospective cohort studied that followed motorcycle riders to determine the incidence of head injury associated crashes showed that non-helmeted riders sustained a head injury at more than twice the rate of helmeted riders (4.7% vs. 1.9%, Lin MR). Three studies showed an odds of a head injury after a crash to vary from 2.3 times to 4.4 times higher for non-helmeted riders as compared to helmeted riders ($p < 0.05$, Conrad P, LaTorre G & Kelly P). Ouellet JV showed an odds of sustaining a serious injury to be 3.5 times higher ($p < 0.05$) for non-helmeted riders.

Retrospective studies confirm the consistent findings of the prospective studies that head injury is uniformly more frequent and more severe when sustaining a crash without a helmet. The magnitude of the increased prevalence of a head injury after a non-helmeted crash is as high as 4.3 times to a low of 1.7 times higher than after a helmeted crash in 9 retrospective cross-sectional studies. However, for severe head injuries, most commonly defined as an AIS score of 2 or greater, the magnitude of the estimate is uniformly larger. For three retrospective studies, the odds of a severe head injury was 18.1 (12.5-25.3), 4.4 (2.58-7.37) and 3.7 (1.9-7.3) respectively (Javouhey E, Christian WJ & Rowland J). Lin JW and colleagues showed a 41% increase in trauma-induced brain

hemorrhage, including sub-arachnoid, subdural and epidural hematomas when a rider was non-helmeted during a crash.

The case-control studies showed an adjusted odds ratio of 0.26 (0.14-0.48 and 0.41 (0.21-0.81) which represents a significant protective effect of wearing a helmet in reducing the incidence of a head injury after a motorcycle crash (Tsai YJ & Gabella B).

In 4 retrospective studies where universal motorcycle helmet laws were enacted, the incidence of non-lethal head injury decreased from 29% up to reductions of 63%.

In one study in which the motorcycle law was repealed, the incidence of hospitalizations for head injury increased by 42%, from 15.4 to 21.9 per 10,000 motorcycle registrations ($p < 0.05$) (Mertz KJ).

- D. Do geographical areas (i.e. aggregate states) that have universal helmet laws have a higher or lower death rate or head injury rate after motorcycle crashes as compared to areas without a universal helmet law?

Two studies compared regions with and without helmet laws. Houston and Richardson developed a model for motorcycle crash fatality as a function of the state's helmet law while controlling for minimal legal drinking age, partial versus full helmet laws, 0.08 Blood Alcohol Concentration Law, roads with maximum speed limit of 65, daily temperature, daily percent precipitation, gender, age, per capita income, per capita alcohol consumption and population density. Their results showed 1.3 fewer fatalities per 10,000 motorcycle registrations in helmet law states that can be attributed in their model to the presence of the helmet law. Further, Coben and colleagues using hospital discharge data from 33 states calculated a relative risk 0.65 ($p < 0.05$), and 0.72 ($p < 0.05$), respectively for severe head injury and fatalities in states with universal helmet laws as compared to states without universal helmet laws.

Study Limitations

The main limitation of these uncontrolled and observational studies involves the collection and incorporation in the analysis of potential confounders for the outcomes studied. The wearing of helmets is associated with multiple factors, many of which have also been shown to be associated with the incidence and severity of crashes. Rider factors include alcohol consumption, seat position on the motorcycle (driver versus passenger), age, and gender. There are also environmental factors such as weather, time of day; other policy factors such as speed limits and DUI laws; and other intrinsic motorcycle factors such as the size and type of motorcycle itself (the potential kinetic energy of the crash) also contribute to motorcycle crash occurrence and severity and ultimately crash consequences for the rider. Unfortunately, many of these factors are not easy to reliably measure on a crash to crash basis and therefore, only 9 studies at least in part adjusted for at least a portion of these factors. There were other studies that stratified the study group by various factors but did not control for them in their analysis. But the majority of the studies did not control for any potential confounders. A second methodological concern is selection bias. The subjects in these studies were not selected randomly, except for the one cohort study that chose the students randomly. There were missing data and no studies had information on those “not chosen” in order to confirm that they were the same as those included in the study.

A large number of the studies reported fatalities and prevalence of head injuries as a rate, a function of either the number of motorcycle registrations or the number of crashes. This eliminates the misinterpretation of changes in absolute fatalities that reflect changes in the number of riders or the number of riders who crash. However, changes in registrations may not be an accurate denominator to reflect the active riders who are engaging in motorcycle usage and therefore, may obscure difference. Perhaps vehicle miles driven are a better

denominator for this purpose for the same reason it is used in motor vehicle collision fatality rates. A good example is in the study by Bledsoe et al, where registrations decreased and thereby crashes decreased but the fatality rate increased. However, perhaps because of the decreases, the absolute increase appears minimal and statistically not significant.

The variation in helmet usage in these studies was substantial. Internationally, Conrad et al., in Indonesia reported helmet usage as high as 89% while LaTorre et al in Italy reported only a 12% rate of helmet usage. Nationally, in America, Brandt et al, reported in their study from Michigan a prevalence of 80.5% of riders wearing a helmet during a crash while a study conducted in Illinois by Kelly and colleagues reported a 14.6% prevalence of helmets in riders involved in crashes. Without nonrandom selection of these studies, the variation in helmet usage can also impact the results obtained.

The studies reviewed here discuss only the use of helmets or not. However, the issue of misuse as noted by Peek-Asa in his 1999 study in Thailand can also be a major factor in post-crash injury. Further study is required to better understand and to quantify this problem. Further, in these studies we did not explore in depth the impact of partial helmet laws, though the studies by Houston DJ and Tsai SY attempted to address this issue. Interestingly, Houston and Richardson found that partial helmet laws showed no improvement in outcomes over states with no helmet laws.

Summary

- A. The use of motorcycle helmets decreases the overall death rate of motorcycle crashes as compared to non-helmeted riders.
- B. The use of motorcycle helmets decreases the incidence of lethal head injury in motorcycle crashes as compared to non-helmeted riders.

- C. The use of motorcycle helmets decreases the severity of non-lethal head injury in motorcycle crashes as compared to non-helmeted riders.
- D. Mandatory universal helmet laws reduce mortality and head injury in geographical areas with the law as compared to areas without it.

References

1. Croce MA, Zarzaur BL, Manotti LJ & Fabian TC. Impact of motorcycle helmets and State Laws on Society's Burden: A National Study. *Annals of Surgery*. 2009. 250: 390-394.
2. Goslar PW, Crawford NR, Petersen SR, Wilson JR & Harrington T. Helmet use and Associated Spinal Fractures in motorcycle crash Victims. *Journal of Trauma, Injury, Infection and Critical Care*. 2008. 53: 469-471.
3. Mertz KJ & Weiss HB. Changes in Motorcycle-related Head Injury Deaths, Hospitalizations, and Hospital Charges Following Repeal of Pennsylvania's Mandatory Motorcycle Helmet Law. *American Journal of Public Health*. 2008. 98(8):1464-1467.
4. Houston DJ & Richardson LE. Motorcycle Safety and the Repeal of Universal Helmet Laws. *American Journal of Public Health*. 2007. 97(11):2063-2069.
5. Coben JH, Steiner CA & Miller TR. Characteristics of motorcycle-related hospitalizations: Comparing states with different helmet laws. *Accident Analysis and Prevention*. 2007. 39:190-196.
6. O'Keefe T, Dearwater ST, Gentilello LM, Cohen TM, Wilkinson JD & McKenney MM. Increased Fatalities after Motorcycle Helmet Law Repeal: Is it all because of lack of helmets? *Journal of Trauma, Injury, Infection and Critical Care*. 2007. 62:1006-1009.

7. Krychenko SY & McCartt AT. Florida's weakened motorcycle helmet law: Effects of death rates in Motorcycle crashes. *Traffic Injury Prevention*. 2006. 7:55-60.
8. Conrad P, Bradshaw YS, Lamsudin R, Kasniyah N & Costello C. Helmets, injuries and cultural definitions: Motorcycle injury in urban Indonesia. *Accident Analysis and Prevention*. 2006. 28(2): 193-200.
9. Ouellet JV & Kasantikul V. Motorcycle helmet effect on a per-crash basis in Thailand and the United States. *Traffic Injury Prevention*. 2006. 7:49-54.
10. Lin JW, Tsai SH, Tsai WC, Chiu WT, Chu SF, Lin CM, Yang MC & Hung CC. Survey of traumatic intracranial hemorrhage in Taiwan. *Surgical Neurology*. 2006. S2: 20-25.
11. Eastridge BJ, Shafi S, Minei JP, Culica D, McConnel C & Gentilello L. Economic impact of motorcycle helmets: from impact to discharge. *Journal of Trauma, Injury, Infection and Critical Care*. 2006. 60: 978-984.
12. Javouhey E, Guerin AC & Chiron M. Incidence and risk factors of severe traumatic brain injury resulting from road accidents: A population-based study. *Accident Analysis and Prevention*. 2006. 38: 225-233.
13. Bledsoe GH & Li G. Trends in Arkansas motorcycle trauma after helmet law repeal. *Southern Medical Journal*. 2005. 98:436-440.
14. Nakahara S, Chadbunchachai W, Ichikawa M, Tipsuntornsak N & Wakai S. Temporal Distribution of motorcyclist injuries and risk of fatalities in relation to age, helmet use, and riding while intoxicated in Khon Kaen, Thailand. *Accident Analysis and Prevention*. 2005. 37: 833-842.
15. Ho EL & Haydel MJ. Louisiana motorcycle fatalities linked to statewide helmet law repeal. *Journal of the Louisiana State Medical Society*. 2004. 156: 151-157.

16. Hundley JK, Kilgo PD, Miller PR, Change MC, Hensberry RA, Meredith JW & Hoth JJ. Non-helmeted motorcyclists: a burden to society? A study using the National Trauma Data bank. *Journal of Trauma Injury, Infection and Critical Care*. 2004. 57:944-949.
17. Ichikawa M, Chadbunchachai W & Marui E. Effect of the helmet act for motorcyclists in Thailand. *Accident Analysis and Prevention*. 2003. 35:183-189.
18. Servadei F, Begliomini C, Gardini E, Giustini M, Taggi F & Kraus J. Effect of Italy's motorcycle helmet law on traumatic brain injuries. *Injury Prevention*. 2003. 9:257-260.
19. Christian WJ, Carroll M, Meyer K, Vitaz T & Franklin GA. Motorcycle helmets and head injuries in Kentucky 1995-2000. *Journal of the Kentucky Medical Association*. 2003. 101:21-26.
20. Auman KM, Kufera JA, Ballesteros MF, Smialek JE & Dischinger PC. Autopsy study of motorcyclist fatalities: The effect of the 1992 Maryland motorcycle helmet use law. 2002. *American Journal of Public Health*. 92: 1352-1355.
21. LaTorre G, Bertazzoni G, Zotta D, Van Beech E & Ricciardi G. Epidemiology of accidents among users of two-wheeled motor vehicles. A surveillance study in two Italian cities. *European Journal of Public Health*. 2002. 12(2): 99-103.
22. Norvell DC & Cummings P. Association of helmet use with death in motorcycle crashes: A matched-pair cohort study. *American Journal of Epidemiology*. 2002. 156:483-487.
23. Brandt MM, Ahms KS, Corpron CA, Franklin GA & Wahl WI. Hospital cost is reduced by motorcycle helmet use. *Journal of Trauma, Injury, Infection and Critical Care*. 2002. 53(3): 469-471.
24. Lin MR, Hwang HF & Kuo NW. Crash severity, injury patterns, and helmet use in adolescent motorcycle riders. *J Trauma*. 2001. 50:24-30.

25. Ferrando J, Pasencia A, Oros M, Borrell C & Kraus JF. Impact of a helmet law on two wheel motor vehicle crash mortality in a southern European urban area. *Injury Prevention*. 2000. 6:184-188.
26. Chiu WT, Kuo CY, Hung CC & Chen M. The effect of the Taiwan Motorcycle helmet use law on head injuries. *American Journal of Public Health*. 2000. 90:793-796.
27. Tsai MC & Hemenway D. Effect of the mandatory helmet law in Taiwan. *Injury Prevention*. 1999. 5:290-291.
28. Peek-Asa C, McArthur DL & Kraus JF. The prevalence of non-standard helmet use and head injuries among motorcycle riders. *Accident Analysis and Prevention*. 1999. 31: 229-233.
29. Petridou E, Skalkidou A, Ioannou N & Trichopoulos D. Fatalities from non-use of seat belts and helmets in Greece: A nationwide appraisal. *Hellenic Road Traffic Police. Accident Analysis and Prevention*. 1998. 30: 87-91.
30. Peek-Asa C & Kraus JF. Estimates of injury impairment after acute traumatic injury in motorcycle crashes before and after passage of a mandatory helmet use law. *Annals of Emergency Medicine*. 1997. 29:630-636.
31. Rowland J, Rivara F, Salzberg P, Soderberg R, Maier R & Koepsell T. Motorcycle helmet use and injury outcome and hospitalization costs from crashes in Washington State. *American Journal of Public Health*. 1996. 86: 41-45.
32. Orsay E, Holden JA, Williams J & Lumpkin JR. Motorcycle trauma in the State of Illinois: Analysis of the Illinois Department of Public Health Trauma Registry. *Emergency Medicine*. 1995. 28:455-460.

33. Rutledge R & Stutts J. The association of helmet use with the outcome of motorcycle crash injury when controlling for crash/injury severity. *Accident Analysis and Prevention*. 1993. 25:347-353.
34. Kraus JF & Peek C. The impact of two related prevention strategies on head injury reduction among nonfatally injured motorcycle riders, California, 1991-1993. *Journal of Neurotrauma*. 1995. 12:873-881.
35. Panichaphongse V, Watanakajom T & Kasantikul V. Effects of law promulgation for compulsory use of protective helmets on death following motorcycle accidents. *Journal of the Medical Association of Thailand*. 1995. 78:521-525.
36. Mock CN, Maier RV, Boyle E, Picher S & Rivara FP. Injury Prevention strategies to promote helmet use decrease severe head injuries at a level I trauma center. *Journal of Trauma*. 1995. 39: 29-35.
37. Tsai YJ, Wang JD & Huang WF. Case-control study of the effectiveness of different types of helmets for the prevention of head injuries among motorcycle riders in Taipei, Taiwan. *American Journal of Epidemiology*. 1995. 42(9): 974-81.
38. Gabella B, Reiner KL, Hoffman RE, Cook M & Stallones L. Relationship of helmet use and head injuries among motorcycle crash victims in El Paso County, Colorado, 1998-1990. *Accident Analysis and Prevention*. 1995. 27:363-369.
39. Kraus JF, Peek C, McArthur DL & Williams A. The effect of the 1992 California Motorcycle helmet use law on motorcycle crash fatalities and injuries. *Journal of the American Medical Association*. 1994. 272: 1506-1511.
40. Fleming NS & Becker ER. The impact of the Texas 1989 motorcycle helmet law on total and head-related fatalities, severe injuries and overall injuries. *Medical Care*. 1992. 30:832-845.

41. Muelleman RL, Mlinek EJ & Collicott PE. Motorcycle crash injuries and costs: Effect of a re-enacted comprehensive helmet use law. *Annals of Emergency Medicine*. 1992. 21:266-272.
42. Braddock M, Schwartz R, Lapidus G, Baco L & Jacobs L. A population-based study of motorcycle injury and costs. *Annals of Emergency Medicine*. 1992. 21:273-278.
43. Offner PF, Rivara FP & Maier RV. The impact of Motorcycle helmet use. *Journal of Trauma Injury Infection and Critical Care*. 1992. 32(5): 636-642.
44. Shankar BS, Ramzy AI, Soderstrom CA, Dischinger PC & Clark CC. Helmet use, Patterns of Injury, Medical Outcome and Costs among Motorcycle Drivers in Maryland. *Accident Analysis and Prevention*. 1992. 24(4): 385-396.
45. Kelly P, Sanson T, Strange G & Orsay E. A prospective study of the impact of helmet usage on motorcycle trauma. *Annals of Emergency Medicine*. 1991. 20:852-856.

Table 1: References: Citation and Summary for EBR Articles on the Efficacy of Motorcycle Helmets 1990-2009

Prospective Cohort Studies:				
Class	Authors	Title	Citation	Summary
II	Lin MR Hwang HF Kuo NW	Crash severity, injury patterns, and helmet use in adolescent motorcycle riders	2001 Journal of Trauma 50:24-30	4,721 randomly selected junior college students in Taipei were followed prospectively for 20 months, during which time 1,284 were involved in 1,889 motorcycle crashes. 33% of the crashes the rider was wearing a helmet. Head injuries occurred in 4.7% of injured riders without a helmet compared to 1.9% of helmeted riders.
Prospective Cross-sectional Studies:				
Class	Authors	Title	Citation	Summary
II	Ouellet JV Kasantikul V	Motorcycle helmet effect on a per-crash basis in Thailand and the United States	2006 Traffic Injury Prevention 7:49-54	1,869 motorcycle crashes in Los Angeles and Thailand were prospectively investigated in detail. Approximately 6% of riders were killed at both locations and 20-25% were hospitalized. Non-helmeted riders were 2.5 times more likely to be killed and 3.5 times more likely to sustain a serious brain injury.
II	LaTorre G Bertazzoni G Zotta D Van Beeck E Ricciardi G	Epidemiology of accidents among users of two-wheeled motor vehicles. A surveillance study in two Italian cities.	2002 European Journal of Public Health 12(2):99-103.	Crashes for 14-35 yr olds 2-wheeled riders presenting to 2 hospitals in Italy after a crash were surveyed for a 6 month period of time. Injury and crash data was collected. 12% of the riders wore a helmet at the time of the crash. The risk of head injury is 4.35 times higher when not wearing a helmet.
II	Conrad P Bradshaw YS Lamsudin R Kasniyah N Costello C	Helmets, injuries and cultural definitions: Motorcycle injury in urban Indonesia.	1996 Accident Analysis and Prevention. 28(2): 193-200.	Prospective observational study of motorcycle riders in Indonesia. Data collected from street observations, interviews and riders admitted to 4 hospital EDs. 89% of drivers wore helmets but only 55% wore them correctly. Indonesia has a mandatory helmet law. The risk of a head injury was 0.41 for riders in a crash while wearing a helmet.
II	Kelly P Sanson T Strange G Orsay E	A prospective study of the impact of helmet usage on motorcycle trauma	1991 Annals of Emergency Medicine 20:852-856	Prospectively collected data of motorcycle crash victims presenting to emergency departments in 8 varying institutions across the State of Illinois, over a 7 month period. Only 14.6% of the 398 patients were wearing helmets at the time of the crash. The incidence of head injuries in the helmeted group was nearly three times that of the non-helmeted group (12.1% vs. 32.6%).
Retrospective Before-After Cross-Sectional Studies:				
Class	Authors	Title	Citation	Summary
II	Mertz KJ Weiss HB	Changes in Motorcycle-Related Head Injury Deaths, Hospitalizations, and Hospital Charges Following Repeal of Pennsylvania's Mandatory motorcycle	2008 American Journal of Public Health 98(8):1464-14667	Retrospective review of motorcycle-head related mortality and injuries comparing the pre-repeal period (2001-2) to the post repeal period (2004-5). There was a 32.8% increase in head injured related mortality and a 42.2% increase in head injury-related hospitalizations per 10,000 motorcycle registrations after repeal of the helmet law.

		Helmet Law		
II	O'Keefe T Dearwater ST Gentilello LM Cohen TM Wilkinson JD McKenney MM	Increased Fatalities After Motorcycle Helmet Law Repeal: Is it all Because of lack of helmets?	2007 Journal of Trauma Injury, Infection, and Critical Care 63:1006-1009	Retrospective review of fatalities pre- and post-motorcycle helmet law repeal (July 1, 2000) in Miami-Dade County, Florida. Police crash and medical examiners records were reviewed for fatalities per registered motorcycle riders from 1997 to 2003. Motorcycle helmet usage in fatal crashes dropped from 80% to 33%. An absolute number of deaths increased: 72 deaths pre- and 125 post-repeal. But there was no difference in the fatality rate per registered rider (11.6 pre- to 12.5 deaths post-repeal per 10,000 motorcycle registrations, p=0.61).
II	Kyrychenko SY McCartt AT	Florida's weakened motorcycle helmet law: Effects of death rates in motorcycle crashes	2006 Traffic Injury Prevention 7:55-60	Retrospective review of police reported crashed 1998-2002 from the Florida Department of Highway Safety and Motor Vehicles. The helmet law was changed from universal to exclude riders 21 years and older with at least \$10,000 of Medical Benefit Insurance in mid 2000. Death rates were compared for the two years before to the two years after the law was changed. The death rate rose from 30.8 deaths per 1000 crashes to 38.8.
II	Bledsoe GH Li G	Trends in Arkansas motorcycle trauma after helmet law repeal	2005 Southern Medical Journal 98:436-440	Retrospective review of data from the Arkansas Department of Finance and Administration for motorcycle registrations, motorcycle crash data from the Arkansas State Police Highway Safety Office, and motorcycle fatality data for Arkansas from the Fatality Analysis Reporting System (FARS). The Arkansas helmet law was repealed in 1997. The study compares the 4 years before to the 4 years after the repeal. Fatalities per crash increased non- significantly from 41.9 to 42.2 per 1000 crashes but in the same period of time, crashes and fatalities per 1000 registered motorcycles decreased. The percentage of motorcycle fatalities not wearing a helmet increased from 47.0% to 78.2% after the repeal.
II	Ho EL Haydel MJ	Louisiana motorcycle fatalities linked to statewide helmet law repeal	2004 Journal of the Louisiana State Medical Society 156:151-157	In 1999 Louisiana repealed its universal motorcycle helmet law to exempt riders 18 and older with \$10,000 Health Insurance Policies. This is a retrospective review of 8,916 motorcycle crashes and 300 fatalities for 1994-2002, except 1999, combining data from NHTSA, Louisiana Highway Safety Commission, and a level I Trauma Registry. The fatality rate increased from 3.0% per collision to 3.7% after repeal. Helmet use decreased from 71.4% to 35% after repeal.
II	Ichikawa M, Chadbunchachai W Marui E	Effect of the helmet act for motorcyclists in Thailand	2003 Accident Analysis and Prevention 35:183-189	Retrospective analysis of Trauma Registry data comparing 2 years before to 2 years after enactment of a motorcycle helmet law in Thailand. 12,002 patients were reviewed, including 129 deaths. As compared to the pre-Law period, head injuries decreased 41.4% and motorcycle related deaths decreased 20.8%.
II	Servadei F Begliomini C Gardini E Giustini M Taggi F Kraus J	Effect of Italy's motorcycle helmet law on traumatic brain injuries.	2003 Injury Prevention 9: 257-260	Retrospective review of traumatic brain injuries at a regional neurosurgery referral center for one year before and after implementation of a universal motorcycle helmet law. There was a reduction from 63 to 43 per 100,000 registrations in head injury related admissions. There was also a 76% decrease in the diagnoses of traumatic subarachnoid hemorrhage, subdural hematoma, and epidural hematoma after the enactment of the law.
II	Christian WJ Carroll M Meyer K Vitaz T	Motorcycle helmets and head injuries in Kentucky 1995-2000	2003 Journal of the Kentucky Medical Association	Retrospective review of head injury and head injury severity after a motorcycle crash from a single level I trauma center from 1995-2000. Of note, Kentucky repealed their helmet law in 1998. A non-helmeted rider was 4.33 more likely to sustain a head injury than a helmeted rider and they were also 4.36 more likely to sustain a severe head injury than non-helmeted riders.

	Franklin GA		101:21-26	
II	Auman KM Kufera JA Ballesteros MF Smialek JE Dischinger PC	Autopsy study of motorcyclist fatalities : The effect of the 1992 Maryland motorcycle helmet use law	2002 American Journal of Public Health 92:1352-1355	Retrospective comparison of motorcycle fatalities in Maryland for the 33 months before and after implementation of a universal helmet law. 61.3% of fatalities occurred before the law was enacted and 38.7% after. The fatality rate per 10,000 registrations decreased from 9.3 to 4.7 per 10,000 motorcycle registrations in the 3 year period before and after the enactment.
II	Ferrando J Plasencia A Oros M Borrell C Kraus JF	Impact of a helmet law on two wheel motor vehicle crash mortality in a southern European urban area	2000 Injury Prevention 6:184-188	Retrospective study comparing the 2 year period before and after implementation of a universal motorcycle helmet law in Spain. Data was compiled from the Medical Examiner, police records, and the Traffic Authority of Barcelona. Annual fatalities decreased from 60 in the first year of the review to 32 in the last year, with the crash mortality rate decreasing from 6.9 to 5.2 per 1000 crashes. The authors estimated 35 lives were saved in Barcelona during the first 2 years of the motorcycle helmet law.
II	Chiu WT Kuo CY Hung CC Chen M	The effect of the Taiwan Motorcycle helmet use law on head injuries	2000 American Journal of Public Health 90:793-796	Retrospective study comparing motorcycle related head injuries seen at 56 major hospitals across Taiwan for one year before and after implementation of a universal helmet law, based on the Head Injury Registry of Taiwan. Total number of motorcycle related head injuries decreased 33%. In hospital death rates remained unchanged at 4.0%.
II	Tsai MC Hemenway D	Effect of the mandatory helmet law in Taiwan	1999 Injury Prevention 5:290-291	Retrospective review in 3 cities comparing 6 months before to 6 months after enactment of a mandatory motorcycle law in Taiwan. Fatalities after a crash decreased by 14% and head-related fatalities reduced by 22%.
II	Peek-Asa C Kraus JF	Estimates of injury impairment after acute traumatic injury in motorcycle crashes before and after passage of a mandatory helmet use law.	1997 Annals of Emergency Medicine 29:630-636	Retrospective review comparing 4790 non-fatally injured motorcycle riders for one year before and after enactment of the California mandatory motorcycle law, linking medical records to police reports. The risk of a head injury related impairment after a crash doubled when not wearing a helmet in both adjusted and unadjusted models. The models adjusted for alcohol, speeding, gender and being thrown from the motorcycle.
II	Kraus JF Peek C	The impact of two related prevention strategies on head injury reduction among nonfatally injured motorcycle riders, California, 1991-1993	1995 Journal of Neurotrauma 12:873-881	Retrospective review of non-fatally injured motorcycle riders before and after enactment of the California mandatory motorcycle helmet law of 1992. The law resulted in 85.6% of injured riders wearing a helmet. Head injuries decreased from 38.2% of the injuries seen before the enactment to 24.1% of the head injuries after the law was enacted.
II	Panichaphongse V Watanakajorn T Kasantikul V	Effects of law promulgation for compulsory use of protective helmets on death following	1995 Journal of the Medical Association of Thailand 78:521-525	Retrospective review comparing the 2 years before and after implementation of a motorcycle helmet law. Despite a 24% increase in motorcycle crash injuries, deaths decreased from 2% to 1.4%. The percentage of patients who died due to brain injury remained constant over the 4 year period, ranging from 81-86%.

		motorcycle accidents		
II	Mock CN Maier RV Boyle E Pilcher S Rivara FP	Injury prevention strategies to promote helmet use decrease severe head injuries at a level I Trauma Center	1995 Journal of Trauma 39:29-35	Retrospective review of the Trauma Registry of a level I Trauma Center over 8 years comparing helmeted to non-helmeted motorcycle riders. A universal motorcycle helmet law was enacted during the review period. The mortality rate decreased from 10% before enactment of the helmet law to 6% after, and severe head injury decreased from 20% of crash admissions to 9%.
II	Kraus JF Peek C McArthur DL Williams A	The effect of the 1992 California Motorcycle helmet use law on motorcycle crash fatalities and injuries	1994 Journal of the American Medical Association 272:1506-1511	Retrospective review of all motorcycle fatalities for the year before and after implementation of a mandatory motorcycle helmet law, based on death certificates and police reports. There was a 37.5% decrease in absolute number of fatalities statewide during the first year after enactment, and with a decrease in the fatality ratio from 70.1 to 51.5 fatalities per 100,000 registrations in California.
II	Fleming NS Becker ER	The impact of the Texas 1989 motorcycle helmet law on total and head – related fatalities, severe injuries, and overall injuries.	1992 Medical Care 30:832-845	Retrospective review of all motorcycle fatalities in Texas from 1984 through 1990, with a helmet law being enacted in 1989. Overall mortality reduced from 12.1 to 9.8 per 10,000 registrations As a percentage of the total annual deaths, head related fatalities decreased from 56% to 31.5%.
II	Muelleman RL Mlinek EJ Collicott PE	Motorcycle crash injuries and costs : Effect of a reenacted comprehensive helmet use law	1992 Annals of Emergency Medicine 21:266-272	Retrospective review of one year before and after the re-enactment of the motorcycle helmet law in Nebraska. Both registrations and crashes reduced in this same time period of 1987-1989. The overall death rate dropped from 13 to 8 per 10,000 registrations. The frequency and severity of brain injury were similar for the two time periods.

Case Control Studies:

Class	Authors	Title	Citation	Summary
II	Norvell DC Cummings P	Association of helmet use with death in motorcycle crashes: A matched-pair cohort study	2002 American Journal of Epidemiology 156:483-487	Matched Pair Cohort Study using the NHTSA-FARS database for fatalities within 30 days of the crash that occurred from 1980-1998. 60.8% of the fatalities involved non-helmeted riders. The relative risk of death for a helmeted rider was estimated to be 0.61 compared to a non-helmeted rider, controlling for motorcycle and crash related variables, age, gender, and seat position.
II	Tsai YJ, Wang JD, Huang WF.	Case-control study of the effectiveness of different types of helmets for the prevention of head injuries among motorcycle riders in Taipei, Taiwan	1995 American Journal Of Epidemiology 42(9):974–81	Motorcycle riders crash admissions in 15 hospitals in Taipei, Taiwan from for 3 months in 1990. Cases were head injured motorcycle crash victims. Controls were motorcycle crash victims with injuries other than head. Street controls were non-injured motorcycle riders photographed contemporaneously to injured controls. Head Injury was involved in 41.5% of the 1,351 injuries during the study period.
II	Gabella B Reiner KL	Relationship of helmet use and head injuries	1995 Accident analysis	A county based study of head injury after motorcycle crashes determined by traffic accident reports and the Injury Epidemiology Program of Colorado. A case was a motorcycle rider with

	Hoffman RE Cook M Stallones L	among motorcycle crash victims in El Paso county, Colorado, 1998-1990	and Prevention 27:363-369	a head injury after a crash in a 2 year period of time from 1989-1990. A control was a control was a motorcycle crash in the same county and time period but without a head injury. Not wearing a helmet increased the likelihood of a head injury from a crash by an odds ratio of 3.34 relative to those riders wearing a helmet.
Retrospective Cross-sectional Studies:				
III	Croce MA Zarzaur BL Manotti LJ Fabian TC	Impact of motorcycle Helmets and State Laws on Society's Burden: A National Study	2009 Annals of Surgery 250:390-394	Retrospective review from 2002-2007 of National Trauma Data Bank. Helmeted trauma patients had lower odds of death as compared to non-helmeted: Adjusted odds ratio of 0.84 (95% CI: 0.76-0.93). N=75,644 Helmeted patients had better GCS scores.
III	Goslar PW Crawford NR Petersen SR Wilson JR Harrington T	Helmet Use and Associated Spinal Fractures in Motorcycle Crash Victims	2008 Journal of Trauma, Injury, Infection and Critical Care 53:469-471	Retrospective review of trauma registry of one Level I trauma center from July 1 st , 2002-June 30 th , 2005. Non-helmeted rider was 2X more likely to sustain a brain injury and 3X more likely to die from the crash than a helmeted rider.
III	Houston DJ Richardson LE	Motorcycle Safety and the Repeal of Universal Helmet Laws	2007 American Journal of Public Health 97(11): 2063-2069	Retrospective review of all 51 states from the NHTSA Fatal Accident Reporting System from 1975 -2004. Mortality was analyzed controlling for other rider and state factors that affect motorcycle-related mortality: demographic, social, traffic safety and population density across states. There was a 13.7% mortality reduction in states attributable to universal helmet law.
III	Coben JH Steiner CA Miller TR	Characteristics of motorcycle-related hospitalizations: Comparing states with different helmet laws.	2007 Accident Analysis and Prevention 39:190-196	A one year retrospective review of the Healthcare Cost and Utilization Project (HCUP) registry. The HCUP State Inpatient Database (SID) contains data from 33 states and captures ~80% of all hospital discharges in the US. 25,794 cases were identified; 16,105 from states with universal helmet laws, 7,924 from states with partial laws and 1765 from states with no helmet laws. Cases from states without universal helmet laws were 52% more likely to sustain the most severe forms of traumatic brain injury (RR: 1.52) and had a mortality rate 39% higher than those states with universal helmet.
III	Lin JW Tsai SH Tsai WC Chiu WT Chu SF Lin CM Yang CM Hung CC	Survey of traumatic intracranial hemorrhage in Taiwan	2006 Surgical Neurology S2:20-25	Retrospective review of 90,250 head trauma case admitted to the hospital in Taiwan, excluding dead on arrivals and outpatients over an 8 year period. 47% of all injuries were motorcycle related. Those not wearing a helmet had a 32.9% incidence of intracranial hemorrhage, compared to 25.2% for those who were. The chance of having an intracranial hemorrhage was 1.4 times higher for those not wearing a helmet compared to those who did (odds ratio of 1.40).
III	Eastridge BJ Shafi S Minei JP Culica D McConnel C Gentilello L	Economic impact of motorcycle helmets: from impact to discharge.	2006 Journal of Trauma Injury Infection and Critical Care 60:978-984.	Motorcyclists who crashed and found in NHTSA GES database for pre-hospital data and NTDB for hospital data from 1994 to 2002. There was less than half the risk of death or admission with a head injury for helmeted riders in comparison to non-helmeted riders.

III	Javouhey E Guerin AC Chiron M	Incidence and risk factors of severe traumatic brain injury resulting from road accidents: A population-based study.	2006 Accident Analysis and Prevention 38:225-33.	Motorcycle crashes were identified in a population based road trauma registry in France from 1996-2001 to determine risks for severe head injury. A non-helmeted rider had an 18 fold higher risk of having a severe head injury as defined by AIS of 2 or higher as compared to helmeted riders.
III	Nakahara S Chadbunchachai W Ichikawa M Tipsuntornsak N Wakai S	Temporal distribution of motorcyclist injuries and risk of fatalities in relation to age, helmet use, and riding while intoxicated in Khon Kaen, Thailand	2005 Accident Analysis and Prevention 37:833-842	Retrospective review of 9,552 patients injured in motorcycle crashes in Thailand and transferred to the regional Medical Center over 5 years. The case fatality rate was 0.25 for helmeted riders and 0.94 for non-helmeted riders. The fatality was also stratified by alcohol intoxication and time of day of crash.
III	Hundley JK Kilgo PD Miller P R Chang MC Hensberry RA Meredith JW Hoth JJ	Non-helmeted motorcyclists: a burden to society? A study using the National Trauma Data bank.	2004 Journal of Trauma Injury Infection and Critical Care 57:944-9.	Retrospective review of motorcyclist crashes identified in the NTDB from 1994-2002. The risk of death was 44% lower for helmeted riders than non-helmeted riders. 69.2% of all riders were listed as wearing a helmet.
III	Brandt MM Ahrns KS Corpron CA Franklin GA Wahl WI	Hospital cost is reduced by motorcycle helmet use.	2002 Journal of Trauma Injury Infection and Critical Care 53(3):469-71.	Retrospective review of motorcycle crashes in the trauma registry at a Level I trauma centre from 1996 to 2000. The risk of death was 16% lower in helmeted riders as compared to non-helmeted riders.
III	Peek-Asa C McArthur DL Kraus JF	The prevalence of non-standard helmet use and head injuries among motorcycle riders	1999 Accident Analysis and Prevention 31:229-233	Retrospective review comparing helmets which met the 1992 California Mandatory Helmet Use Law requirements to those which did not. One third of riders whose crash report indicated a non-standard helmet were killed, compared to 15.5% on non-helmeted riders and 13.6% of helmeted riders. Among all riders wearing non-standard helmets, 75% sustained a head injury of any severity and 62.5% sustained a head injury ≥ 3 . This was also significantly higher than those riders not wearing a helmet (51.9% and 37.4%) and those wearing a standard helmet (30.7% and 21.8%). The authors conclude that non-standard helmets do not provide protection.
III	Petridou E Skalkidou A Ioannou N Trichopoulos D	Fatalities from non-use of seat belts and helmets in Greece: A nationwide appraisal. Hellenic Road Traffic Police.	1998 Accident Analysis and Prevention 30:87-91	Retrospective analysis of all motorcycle crashes in Greece for 1985 and 1994. No motorcycle laws were in effect during either period, and helmet use rates were similar for two periods. In 1985, 3.5% of helmeted riders died in motorcycle crashes compared to 4.3% of unhelmeted riders. In 1994, 2.9% of helmeted riders died in motorcycle crashes compared to 5.1% for unhelmeted riders. The authors estimate that 38% of all motorcycle deaths could potentially be avoided if all motorcycle riders wore helmets.
	Rowland J	Motorcycle helmet use	1996	Retrospective review combining State crash information, hospital records, and death records

III	Rivara F Salzberg P Soderberg R Maier R Koepsell T	and injury outcome and hospitalization costs from crashes in Washington State	American Journal of Public Health 86:41-45	for 1989 in Washington State. There were 2,090 crashes with 59 fatalities (2.8%). Motorcycle riders who were hospitalized after a crash were 2.9 times more likely to be hospitalized with a head injury and 3.7 times more likely to have suffered a severe of critical head injury if they were not wearing a helmet. Non-helmeted riders had 1.62 times the risk of a fatal crash compared to helmeted riders.
III	Orsay E Holden JA Williams J Lumpkin JR	Motorcycle trauma in the State of Illinois: Analysis of the Illinois Department of Public Health Trauma Registry	1995 Annals of Emergency Medicine 28:455-460	Retrospective review of the Illinois Trauma Registry for 18 months comparing helmeted to unhelmeted motorcycle riders. Of the 1231, 18% were helmeted and 56% were not. 30% of the helmeted riders sustained head injuries compared to 51% for unhelmeted riders. The unhelmeted riders also had more severe head injuries.
III	Rutledge R Stutts J	The association of helmet use with the outcome of motorcycle crash injury when controlling for crash/injury severity	1993 Accident Analysis and Prevention 25:347-353	Retrospective analysis of the North Carolina State Trauma Registry over 3.5 years, comparing 892 patients. Helmet information was available for 460 (51.6%). Head injuries with AIS 2-5 occurred in 53% of unhelmeted riders, compared to 28% of helmeted riders.
III	Braddock M Schwartz R Lapidus G Banco L Jacobs L	A population-based study of motorcycle injury and costs.	1992 Annals of Emergency Medicine 21:273-278	Retrospective review of 112 motorcycle deaths in Connecticut over a two year period. The fatality rate for unhelmeted riders was 26.7 per 1000 crashes, compared to 7.9 for helmeted riders.
III	Offner PF Rivara FP Maier RV	The Impact of Motorcycle Helmet Use.	1992 Journal of Trauma Injury Infection and Critical Care 32(5):636-42.	Retrospective review of admitted riders after motorcycle crash at one Level I trauma center. The trauma registry identified the cases from 1985 to 1990. Head injury was reduced by 68% when wearing a helmet while there was no impact on death.
III	Shankar BS Ramzy AI Soderstrom CA Dischinger PC Clark CC	Helmet Use, Patterns of Injury, Medical Outcome and Costs among Motorcycle Drivers in Maryland.	1992 Accident, Analysis and Prevention 24(4): 385-96.	Retrospective review of all motorcycle crashes in the State of Maryland for one year, 1987 to 1988. Riders wore a helmet in 35% of the crashes.