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Novelty helmet use and motorcycle rider fatality

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Abstract

Objectives—To compare the risk of fatal injury across helmet types among collision-involved motorcyclists.

Methods—We used data from a cohort of motorcyclists involved in police-reported traffic collisions. Eighty-four law enforcement agencies in California collected detailed information on helmet and rider characteristics during collision investigations in June 2012 through July 2013. Multiply-adjusted risk ratios were estimated with log-binomial regression.

Results—The adjusted fatal injury risk ratio for novelty helmets was 1.95 (95% CI 1.11–3.40, *p* 0.019), comparing novelty helmets with full-face helmets. The risk ratios for modular, open-face, and half-helmets, compared with full-face helmets, were not significant.

Conclusions—A more complete understanding of the inadequacy of novelty helmets can be used in educational and law enforcement countermeasures to improve helmet use among motorcycling populations in California and other US states. Law enforcement approaches to mitigating novelty helmet use would seem attractive given that novelty helmets can be visually identified by law enforcement officers with sufficient training.

Keywords

Traffic collision; Motorcycle; Helmets; Fatality

1. Introduction

Motorcycle helmets are designed to protect against head and brain injury during traffic collisions. Modern helmets are constructed of a thick layer of expanded polystyrene covered with a thin shell of plastic or similar material. Softer foam material is added to improve fit and comfort and to reduce noise. The layer of polystyrene, or liner, is usually one inch or more in thickness and is designed to absorb and redistribute energy from impacts to the head. The shell's role is to keep the liner in place and to provide anchoring points for the helmet strap, wind visor, or other accessories.

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California has had a universal motorcycle helmet law in effect since the early 1990's. Several types of helmets are currently in wide use in the state. These include: full-face helmets, modular helmets, open-face helmets, half-helmets, and novelty helmets. Full-face helmets provide full coverage of the head, including the chin. Modular helmets resemble full-face helmets, but have a chin bar that can swing up to expose the face and chin. Open-face helmets cover the majority of the head but lack a chin bar. Half-helmets only cover the top of the head, and differ from open-face helmets in that they leave the base of the skull vulnerable and leave more of the face exposed.

Novelty helmets provide coverage similar to that of half-helmets but, unlike other helmet types, they do not have an expanded polystyrene liner to absorb impact energy in the event of a collision (Fig. 1). Consequently, they weigh approximately two-thirds less than most other helmets. The use of novelty helmets is common in California (Tsui et al., 2013) and other U.S. states with universal helmet laws (NHTSA, 2014). Most state helmet laws specify that a helmet meeting the Federal Motor Vehicle Safety Standard 218 (DOT standard) must be worn during the operation of a motorcycle (Federal Motor Vehicle Safety Standard No. 218, 1973). Helmets meeting the DOT standard are labeled with a "DOT" sticker; however, many novelty helmets possess fraudulent "DOT" stickers. Samples of novelty helmets tested by the National Highway Traffic Safety Administration largely failed to meet the DOT standard (NHTSA, 2007). Enforcing this standard in California is challenging because California courts have ruled that California Highway Patrol officers are not qualified to determine helmet quality, and assert that any helmet with a "DOT" label meets the requirements of the state helmet law (Tsui et al., 2013). This ruling applies to the California Highway Patrol only, but most law enforcement agencies in the state infrequently cite riders wearing novelty helmets.

A significant body of literature has confirmed that, overall, motorcycle helmet use is highly effective in preventing and reducing the severity of head and brain injuries (Liu et al., 2004). Studies have also shown that helmets reduce the risk of fatality among collision-involved motorcyclists (Norvell and Cummings, 2002; Kraus et al., 1994; Erhardt et al., 2016; Crompton et al., 2010).

The study of novelty helmets has proven difficult. Police officers generally record helmet presence with a binary indicator (yes/no) during collision investigations. Most studies of helmet effectiveness have used this indicator of helmet use for analysis. Generally, police departments in the U.S. use their state's standardized collision report forms when investigating traffic collisions. We collected the standardized forms for each state and found that only one state, Pennsylvania, routinely collections information on motorcycle helmet type as well as the usual yes/no status. We recognize that some studies, such as those based in emergency departments, have acquired detailed helmet information, but tend to have limited sample sizes (Brewer et al., 2013; Hitosugi et al., 2004; Yu et al., 2011). Because legal helmet types and novelty helmets are usually collapsed into one, less specific, "helmeted" category, the protective effects of novelty helmets are not well understood. Studies using a binary helmet use variable are likely to underestimate the protectiveness of legitimate motorcycle helmets.

For this study, we collected detailed data on helmet and rider characteristics during police investigations of motorcycle collisions in California during a one-year period. Collisions were included without regard to injury occurrence or severity. As a result, we were able to examine the protectiveness of the five most commonly used types of motorcycle helmets. Specific objectives of the analysis were (1) to estimate fatality risk ratios comparing motorcycle helmet types and (2) identify effect modification by various rider and collision characteristics.

2. Methods

We used data from a cohort of motorcyclists involved in police-reported traffic collisions to estimate fatality risk ratios for the five primary motorcycle helmet types in use in California.

2.1. Data

The California Highway Patrol (CHP) and 83 county or municipal law enforcement agencies in California collected detailed information on helmet and rider characteristics of motorcyclists involved in collisions between June 2012 and July 2013. The aim of CHP was to collect data on every motorcycle collision in the state that they investigated. Local agencies committed to collect data on all collisions or, in many cases, a subset of collisions in their jurisdiction. For example, in one large urban agency, only two of the eight divisions participated. Information was collected using a supplemental data collection form at the time of each traffic collision investigation, regardless of motorcyclist injury status. For each motorcycle occupant, reporting officers filled out the supplemental form through a secure website. The form data fields included helmet type, helmet retention, helmet damage, lane-splitting status, body region injured, speed of the motorcycle, and speed of the surrounding traffic. Officers could provide estimates of speed as a point estimate or a range. Additionally, we obtained, redacted, and abstracted information from the corresponding traffic collision reports. Finally, we linked the collision report data and the supplemental form data and converted it into a rider-level data set.

For the present analysis, we used data on 7255 helmeted motorcycle riders who had both a supplemental data form and a linked police collision report. We excluded 66 riders under the age of 18 years because of concerns that young riders may be more susceptible to brain injury than adults and because the incidents involving young riders were much more likely to take place in unusual environments (e.g., non-paved roadways). The resulting data set consisted of 7189 motorcycle riders.

2.2. Variables

Investigating officers indicated body regions injured (head, neck, torso, and arm/leg) and survival status on the supplemental data form if they identified injuries or if the officer was informed of an injury by emergency medical staff. In addition, overall injury severity for each motorcycle riders was coded on the standard police report. We used both sources to determine the fatality status of each rider. We constructed a motorcycle type classification from the motorcycle make and model information from the collision reports and by referencing motorcycle manufacturer and dealer web sites. We used age as a continuous

variable and categorized as 18–24, 25–34, 35–44, 45–54, 55–64, and 65 or older. We categorized motorcycle speed in miles per hour (MPH) as not moving, 1–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80–89, and 90 or greater. The investigating officer's determination of rider culpability was abstracted from the collision report.

2.3. Statistical analysis

We used log-binomial regression to estimate fatality risk ratios for each helmet type compared with full-face helmets. We included rider age and sex as covariates. The following covariates were considered individually and retained if their overall *p* was 0.15 or less or if they altered any helmet type coefficient by 10% or more: elevated blood alcohol content, motorcycle speed, operator vs passenger status, motorcyclist culpability, motorcycle type, motorcycle brand, collision type, state highway collision occurrence, and weekend occurrence. These variables were selected for consideration because they seemed likely to be associated with both helmet type and fatality risk. We used directed acyclic graphs to facilitate the identification of potential confounders. Operator status, motorcycle brand, and motorcycle type were rejected; all other variables were included in the model. We modeled age and motorcycle speed as continuous, quadratic, and categorical. Each of these models produced nearly identical helmet risk ratios. The categorical model was selected to facilitate interpretation. We considered effect measure modification by including product terms between the helmet type variable and selected covariates. We used standard regression diagnostics to check for overly influential data points. All data management and analysis was implemented with Stata 14 software (StataCorp, 2014).

3. Results

The data sample included 6837 operators and 352 passengers involved in 6708 collisions. Males comprised 95% of motorcycle riders (Table 1). Rider ages ranged from 18 to 86 years, with a mean of 38. Of all operators, 81% were properly licensed and 86% were determined to be at fault. Two-thirds of riders were wearing a full-face helmet (68%), followed by half-helmets (15%), open-face helmets (9%), modular helmets (4.4%), and novelty helmets (3.9%). A majority of motorcycles were Sport (38%), Cruiser (27%), or Touring (11%).

The most common collision type was Overturned, which indicates collisions in which the motorcyclist lost control of the vehicle and “laid it down.” When combined with Hit Object collision, 51% of riders were involved in single-vehicle collisions. The most common multiple-vehicle collision types were Sideswipe (20%) and Rear-end (19%).

The most commonly used motorcycles included Harley-Davidson (26%), Honda (17%), Yamaha (16%), and Suzuki (15%). The motorcycles were traveling at a wide range of speeds at the time of collision. A small number were stopped (2.6%) or traveling at 80 MPH or greater (2.0%). A slight overrepresentation of collisions on Fridays and Saturdays was observed.

The injuries reported by the investigating police officer are shown in Table 2. Among the 7189 motorcycle riders, 2.9% were fatally injured, 16% were severely injured, and 40%

suffered Other Visible injuries. Injured body regions included head (15%), neck (9%), torso (27%), and extremities (66%).

Rider age varied across helmet types (Table 3). Among riders wearing full-face helmets, 26% were aged 18–24 years, compared with 9%, 6%, and 6% of riders wearing open-face, half-helmets, and novelty helmets, respectively.

The occurrence of head injury was greatest for users of novelty helmets (25%) and half-helmets (19%), followed by modular helmets (17%), open-face helmets (16%), and full-face helmets (15%).

Helmet type also varied greatly by motorcycle type. Riders of cruisers and touring motorcycles accounted for almost all the novelty helmet use. For example, 8% of Cruiser riders wore a novelty helmet, compared with 0.4% of Sport motorcycle riders. Motorcycle brand was also strongly related to helmet choice. A majority of novelty helmets use involved riders of Harley-Davidsons and Other (uncommon or custom) brands. Ten percent of Harley-Davidson riders used a novelty helmet, compared with less than 2% for riders of each of the other common brands – BMW, Ducati, Honda, Suzuki, Kawasaki, Yamaha, and Triumph.

Users of novelty helmets had a significantly higher average risk of death due to injury than users of other helmet types (Table 4). The estimated risk of death was greatest for novelty helmet users (5.4%), followed by users of modular helmets and half-helmets (3.1% each), open-face helmets (2.8%), and full-face helmets (2.4%). The adjusted fatal injury risk ratio for novelty helmets was 1.95 (95% CI 1.11–3.40, $p = 0.019$), comparing novelty helmets with full-face helmets. The RR's for the other helmet types were not significant. Age was significantly associated with death risk ($p = 0.001$). Adjusted RR's for riders aged 55–64 years and 65 years or older were 2.36 (95% CI 1.49–3.73) and 2.07 (95% CI 1.06–4.03), respectively, comparing the risk of death with that of riders aged 25–34 years.

Motorcycle speed was also strongly associated with fatal injury ($p < 0.001$). Death risk was less than 1% for riders traveling at 29 MPH or slower. Death risk increased for higher speeds and was markedly higher for speeds of 80–89 MPH (13%) and 90 MPH or greater (27%). The adjusted RR's for these two speed categories were 17.3 (95% CI 7.90–38.0) and 33.7 (95% CI 16.35–69.5), respectively.

The estimated helmet type risk ratios did not vary significantly by the potential effect modifiers we examined, including age ($p = 0.355$), alcohol use ($p = 0.898$), state highway collision status ($p = 0.829$), and motorcyclist culpability ($p = 0.560$). We had insufficient data to evaluate potential effect modification by rider sex, motorcycle speed, and collision type.

4. Discussion

In this study, we found that novelty motorcycle helmets were associated with a significantly higher risk of death among motorcyclists involved in traffic collisions in California. The fatality risks for riders using full-face, modular, open-face, and DOT half-helmets were not significantly different. Riders wearing novelty helmets were found to be almost twice as

likely to die from their injuries as riders who were wearing full-face helmets after accounting for multiple personal and collision characteristics.

We also found that advanced age was predictive of fatal injury. Riders in age categories 45–54, 55–64, and 65 or greater were all significantly more likely to die from their injuries than younger riders.

Collision speed was also identified as a strong predictor of fatal injury. The risk of death increased with the speed of the motorcycle at the time of collision. High (and illegal) motorcycle speeds were associated with strikingly high risks of death for motorcycle riders. For example, one out of eight riders traveling 80–89 MPH at collision initiation died from their injuries.

A primary strength of our analysis is the use of helmet type information that is more detailed than the information that is usually available for study. Almost all motorcycle collision studies in the US use a binary indicator for helmet use (yes/no). Our data set had a five-level helmet variable which allowed us to compare outcomes across the five helmet types most commonly used in California. We also had data on whether the officer believed the helmet to be DOT-compliant. The information on half-helmets and the DOT compliance variables allowed us to identify novelty helmet with reasonable confidence. Our method of identifying novelty helmets was conservative and most likely resulted in DOT-compliant half-helmets being incorrectly placed in the “novelty” category and far fewer novelty helmets being mixed in with the DOT-compliant half-helmets. If this happened, the result would be an unbiased estimate of the protectiveness of novelty helmets and a slight underestimation of the protectiveness of DOT-compliant helmets.

We also benefited from a larger sample size than most studies with helmet type information. Most studies based in emergency departments, for example, will assemble samples of several hundred motorcyclists. Our sample numbered more than 7000 and allowed for the more precise estimation of risk ratios and better simultaneous control of multiple potential confounders.

The protective effects of motorcycle helmets have been studied in considerable detail over many years. Numerous studies have found that helmeted motorcyclists have significantly better outcomes than unhelmeted motorcyclists. A Cochrane review by Liu et al. (2008) reported that higher quality studies found notable reductions in the risk of death attributable to helmet use (pooled OR 0.58, 95% CI 0.50–0.68). More than half the studies of fatality that were examined found protective effects that were not statistically significant due mostly to inadequate study sizes. Overall, the studies were found to be “consistent in their findings, suggesting a protective effect.”

Two of the more rigorous studies that we have reviewed are Anderson and Kraus (1996) and Norvell and Cummings (2002). Using similar data and matched-cohort methods, they reported fatality risk ratios (for helmet use) of 0.61 (95% CI 0.54–0.70) and 0.65 (95% CI 0.58–0.72), respectively. These studies benefited from large sample sizes and a favorable study design.

More recently, Wiznia et al. (2016) studied the outcomes of almost 1000 injured motorcycle riders who presented at a Level 1 trauma center in Connecticut. Unhelmeted riders (66%) were twice as likely to suffer head injury (58% vs 31%, $p < 0.001$) and were almost twice as likely to die from their injuries (adjusted OR 1.89, 95% CI 1.02–3.45).

The protectiveness of motorcycle helmets against fatal injury is not a new development. Several older studies have produced results similar to those found in most current studies. In an earlier paper (Rice et al., 2016), we reanalyzed data from the Hurt Study (Hurt et al., 1981), a study of 900 motorcyclists involved in collisions in Los Angeles in the late 1970's. We found that unhelmeted motorcyclists were more than twice as likely to die from their injuries (RR 2.27, 95% CI 1.35–3.85) than helmeted riders after controlling for age, sex, and motorcycle speed.

Crompton et al. (2010) used data from the National Trauma Data Bank to examine injury outcomes among 35,000 collision-involved motorcyclists from 2003 to 2006. They reported that 6.2% of un-helmeted motorcyclists suffered a fatal injury compared with 3.5% of helmeted motorcyclists.

Most prior research on motorcycle helmet effectiveness by helmet type has compared full-face, open-face, or half-helmets, without specific identification of novelty helmets. For example, Yu et al. (2011) studied 906 injured motorcycle riders treated at a Taiwan trauma center. They estimated that riders wearing a half-helmet had twice the odds of suffering head injury than riders wearing a full-face helmet (OR 2.57, 95% CI 1.50–4.40).

More recently, Sung et al. (2016) reported that full-face and open-face helmets reduced the occurrence and severity of head injuries in Korea, whereas half-helmets did not.

And Hitosugi et al. (2004), in a Tokyo study of fatally injured motorcyclists, found that those using open-face helmets were more likely to have suffered severe head and neck injuries than were those using full-face helmets.

The published literature reveals few studies that have differentiated novelty helmets from other helmet types. Kerns and McCullough (2009) interviewed and photographed the helmets of injured motorcycle operators at a Baltimore Maryland trauma center. They found that 13 of 26 (50%) of persons using novelty helmets received a head or brain injury of any severity compared with 22 of 96 (23%) of persons using DOT-compliant helmets. These counts result in an unadjusted RR of 2.18 (95% CI 1.28–3.71), comparing novelty helmet use to DOT-compliant helmet use.

The current analysis adds to our understanding of the variable protectiveness of specific motorcycle helmet types with respect to fatal injury among motorcyclists involved in traffic collisions. Our findings underscore the strong role that helmet choice plays in overall outcome of motorcycle collisions. A more complete understanding of the inadequacy of novelty helmets can be used in educational and law enforcement countermeasures to improve helmet use among motorcycling populations in California and other US states. Law enforcement approaches to mitigating novelty helmet use would seem attractive given that

novelty helmets can be visually identified by law enforcement officers with minimal training.

This study also points to the utility of collecting detailed helmet information in the course of motorcycle safety research. The motorcycle helmet industry has undergone significant changes in recent years, and the offerings of helmet models and styles for use by motorcyclists are more numerous and more varied than ever before. Studies that further examine the protectiveness of existing and future helmet types will be needed.

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Fig. 1.
Bisectional view of full-face and novelty helmet construction.

Table 1

Characteristics, motorcycle riders involved in traffic collisions, California, 2012–2013.

Characteristic	No.	%
Sex (% male)	–	94.9
Operator of motorcycle (%)	–	95.1
Operator properly licensed (%)	–	80.7
Operator at fault (%)	–	85.8
Blood alcohol content ≥ 0.08 g/dL (%)	–	2.3
Rider was lane-splitting (%)	–	15.1
State highway collision (%)	–	62.6
Helmet Type		
Full-face	4,929	68.6
Modular	317	4.4
Half-helmet	1,050	14.6
Open-face	616	8.6
Novelty	277	3.9
Type of Collision		
Overturned	1,984	27.6
Sideswipe	1,454	20.2
Rear End	1,339	18.6
Hit Object	983	13.7
Broadside	829	11.5
Head-On	230	3.2
Other	218	3.0
Unknown	152	2.1
Motorcycle Type		
Sport	2,743	38.2
Cruiser	1,948	27.1
Touring	782	10.9
Dual Sport	405	5.6
Standard	192	2.7
Scooter	161	2.2
Other	68	0.9
Unknown	890	12.4
Motorcycle Brand		
BMW	257	3.6
Ducati	181	2.5
Harley-Davidson	1,899	26.4
Honda	1,211	16.8
Kawasaki	865	12.0
Suzuki	1,054	14.7
Yamaha	1,141	15.9

Characteristic	No.	%
Triumph	124	1.7
Other	378	5.3
Unknown	79	1.1
Motorcycle Speed		
Not moving	189	2.6
1–19 mph	738	10.3
20–29 mph	984	13.7
30–39 mph	1,492	20.8
40–49 mph	1,296	18.0
50–59 mph	874	12.2
60–69 mph	712	9.9
70–79 mph	346	4.8
80–89 mph	91	1.3
90+	48	0.7
Unknown	419	5.8
Day of Week		
Sunday	1,074	14.9
Monday	818	11.4
Tuesday	881	12.3
Wednesday	1,027	14.3
Thursday	978	13.6
Friday	1,119	15.6
Saturday	1,276	17.7
Total	7,189	100

Table 2

Injury outcomes, motorcycle riders involved in traffic collisions, California, 2012–2013.

Characteristic	No.	%
Injury Severity		
Fatal	206	2.9
Severe	1,169	16.3
Other visible	2,864	39.8
Complaint of pain	1,261	17.5
No injury	1,635	22.7
Unknown	54	0.8
Head injury		
Yes	1,089	15.1
No	6,100	84.9
Neck injury		
Yes	642	8.9
No	6,547	91.1
Torso injury		
Yes	1,931	26.9
No	5,258	73.1
Extremity injury		
Yes	4,742	66.0
No	2,447	34.0
Total	7,189	100

Table 3

Rider, motorcycle, and collision characteristics by helmet type, motorcycle riders involved in traffic collisions, California, 2012–2013.

	Helmet Type											
	Full-face			Modular			Open-face			Half-helmet		
	No.	%		No.	%		No.	%		No.	%	
Age Category												
15–24	1,273	25.8	52	16.4	55	8.9	60	5.7	16	5.8	1,456	20.3
25–34	1,587	32.2	70	22.1	79	12.8	156	14.9	46	16.6	1,938	27.0
35–44	757	15.4	45	14.2	112	18.2	191	18.2	67	24.2	1,172	16.3
45–54	665	13.5	68	21.5	143	23.2	288	27.4	90	32.5	1,254	17.4
55–64	391	7.9	44	13.9	154	25.0	265	25.2	42	15.2	896	12.5
65+	131	2.7	18	5.7	55	8.9	70	6.7	12	4.3	286	4.0
Unknown	125	2.5	20	6.3	18	2.9	20	1.9	4	1.4	187	2.6
Sex												
Female	240	4.9	17	5.4	52	8.4	46	4.4	10	3.6	365	5.1
Male	4,633	94.0	284	89.6	560	90.9	1,001	95.3	267	96.4	6,745	93.8
Unknown	56	1.1	16	5.0	4	0.6	3	0.3	0	0.0	79	1.1
Type of Collision												
Broadside	542	11.0	59	18.6	64	10.4	133	12.7	31	11.2	829	11.5
Head-On	157	3.2	16	5.0	20	3.2	19	1.8	18	6.5	230	3.2
Hit Object	634	12.9	39	12.3	95	15.4	160	15.2	55	19.9	983	13.7
Overtaken	1,324	26.9	65	20.5	173	28.1	335	31.9	87	31.4	1,984	27.6
Rear End	940	19.1	55	17.4	114	18.5	187	17.8	43	15.5	1,339	18.6
Sideswipe	1,090	22.1	62	19.6	106	17.2	164	15.6	32	11.6	1,454	20.2
Other	142	2.9	10	3.2	21	3.4	38	3.6	7	2.5	218	3.0
Unknown	100	2.0	11	3.5	23	3.7	14	1.3	4	1.4	152	2.1
Properly Licensed												
No	961	19.5	81	25.6	97	15.7	170	16.2	69	24.9	1,378	19.2
Yes	3,923	79.6	230	72.6	515	83.6	877	83.5	207	74.7	5,752	80.0
Unknown	45	0.9	6	1.9	4	0.6	3	0.3	1	0.4	59	0.8

Helmet Type												
	Full-face		Modular		Open-face		Half-helmet		Novelty		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Motorcyclist Culpable												
No	683	13.9	48	15.1	113	18.3	151	14.4	28	10.1	1,023	14.2
Yes	4,246	86.1	269	84.9	503	81.7	899	85.6	249	89.9	6,166	85.8
State Highway												
No	1,704	34.6	169	53.3	243	39.4	435	41.4	127	45.8	2,678	37.3
Yes	3,204	65.0	148	46.7	372	60.4	613	58.4	150	54.2	4,487	62.4
Unknown	21	0.4	0	0.0	1	0.2	2	0.2	0	0.0	24	0.3
Rider Role												
Passenger	197	4.0	7	2.2	48	7.8	90	8.6	10	3.6	352	4.9
Operator	4,732	96.0	310	97.8	568	92.2	960	91.4	267	96.4	6,837	95.1
Head Injury												
No	4,372	88.7	275	86.8	490	79.5	792	75.4	171	61.7	6,100	84.9
Yes	557	11.3	42	13.2	126	20.5	258	24.6	106	38.3	1,089	15.1
Injury Severity												
Fatal	122	2.5	10	3.2	17	2.8	35	3.3	22	7.9	206	2.9
Severe	752	15.3	54	17.0	97	15.7	197	18.8	69	24.9	1,169	16.3
Other Visible	1,910	38.8	119	37.5	247	40.1	458	43.6	130	46.9	2,864	39.8
Complaint of Pain	935	19.0	63	19.9	99	16.1	139	13.2	25	9.0	1,261	17.5
No Injury	1,170	23.7	70	22.1	151	24.5	213	20.3	31	11.2	1,635	22.7
Unknown	40	0.8	1	0.3	5	0.8	8	0.8	0	0.0	54	0.8
Motorcycle Type												
Cruiser	825	42.4	90	4.6	620	31.8	253	13.0	160	8.2	1,948	100
Other	18	26.5	8	11.8	22	32.4	11	16.2	9	13.2	68	100
Dual Sport	354	87.4	15	3.7	8	2.0	23	5.7	5	1.2	405	100
Standard	147	76.6	16	8.3	8	4.2	20	10.4	1	0.5	192	100
Scooter	78	48.4	12	7.5	29	18.0	37	23.0	5	3.1	161	100
Sport	2,576	93.9	78	2.8	34	1.2	43	1.6	12	0.4	2,743	100
Touring	285	36.4	38	4.9	245	31.3	154	19.7	60	7.7	782	100

	Helmet Type											
	Full-face			Modular			Open-face			Half-helmet		
	No.	%	No.	No.	%	No.	No.	%	No.	No.	%	Total
Unknown	646	72.6	60	6.7	84	9.4	75	8.4	25	2.8	890	100
Motorcycle Brand												
BMW	184	71.6	19	7.4	6	2.3	48	18.7	0	0.0	257	100
Ducati	163	90.1	7	3.9	4	2.2	6	3.3	1	0.6	181	100
Harley-Davidson	644	33.9	82	4.3	703	37.0	280	14.7	190	10.0	1,899	100
Honda	948	78.3	49	4.0	103	8.5	91	7.5	20	1.7	1,211	100
Kawasaki	735	85.0	48	5.5	36	4.2	31	3.6	15	1.7	865	100
Suzuki	958	90.9	32	3.0	35	3.3	20	1.9	9	0.9	1,054	100
Yamaha	931	81.6	34	3.0	80	7.0	75	6.6	21	1.8	1,141	100
Triumph	108	87.1	1	0.8	7	5.6	7	5.6	1	0.8	124	100
Other	206	54.5	28	7.4	72	19.0	52	13.8	20	5.3	378	100
Unknown	52	65.8	17	21.5	4	5.1	6	7.6	0	0.0	79	100
Total	4,929	100	317	100	616	100	1,050	100	277	100	7,189	100

Table 4

Unadjusted and adjusted fatality risk ratios, motorcycle riders involved in traffic collisions, California, 2012–2013.

Variable	Total	Fatal Injury (%)	RR ^a	95 CI ^b	p	aRR ^c	95 CI	p
Helmet Type								
Full-face	4,419	106 (2.4)	Ref.	–		Ref.	–	
Modular	258	8 (3.1)	1.30	0.64–2.62	0.477	1.04	0.51–2.15	0.910
Open-face	545	15 (2.8)	1.15	0.67–1.96	0.613	1.18	0.69–2.02	0.536
Half-helmet	959	30 (3.1)	1.30	0.87–1.95	0.192	1.07	0.70–1.64	0.756
Novelty	240	13 (5.4)	2.26	1.29–3.96	0.004	1.95	1.11–3.40	0.019
Rider age (years)								
15–24	1,333	30 (2.3)	0.96	0.60–1.52	0.017	0.98	0.62–1.53	0.001
25–34	1,788	42 (2.4)	Ref.	–		Ref.	–	
35–44	1,074	21 (2.0)	0.83	0.50–1.40		0.92	0.56–1.54	
45–54	1,141	33 (2.9)	1.23	0.79–1.93		1.56	0.98–2.49	
55–64	823	35 (4.3)	1.81	1.16–2.82		2.36	1.49–3.73	
65 or greater	262	11 (4.2)	1.79	0.93–3.43		2.07	1.06–4.03	
Rider Sex								
Male	6,089	165 (2.7)	1.29	0.61–2.72	0.511	0.98	0.47–1.98	0.928
Female	332	7 (2.1)	Ref.	–		Ref.	–	
Motorcycle Speed (MPH)								
Stopped	168	4 (2.4)	1.88	0.65–5.50	< 0.001	2.68	0.75–9.59	< 0.001
1–19	677	3 (0.4)	0.35	0.10–1.17		0.34	0.10–1.16	
20–29	935	7 (0.8)	0.59	0.25–1.41		0.60	0.25–1.44	
30–39	1,424	18 (1.3)	Ref.	–		Ref.	–	
40–49	1,234	33 (2.7)	2.12	1.20–3.74		2.10	1.18–3.74	
50–59	848	46 (5.4)	4.29	2.51–7.35		5.07	2.86–9.00	
60–69	673	23 (3.4)	2.70	1.47–4.98		4.27	2.18–8.37	
70–79	332	15 (4.5)	3.57	1.82–7.02		5.63	2.73–11.62	
80–89	86	11 (12.8)	10.12	4.94–20.74		17.3	7.90–38.0	
90+	44	12 (27.3)	21.58	11.08–42.0		33.7	16.35–69.5	
Total ^d	6,421	172 (2.7)	–	–		–	–	

^c Risk ratio adjusted for age, sex, elevated BAC, motorcyclist culpability, motorcycle speed, collision type, state highway status, and weekend collision status.

^d Regression model fitted to 6421 riders.

^a Unadjusted risk ratio.

^b Confidence interval.