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Motorcycle helmet type and the risk of head injury and neck injury during motorcycle collisions in California

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ABSTRACT

The use of novelty motorcycle helmets is often prompted by beliefs that wearing a standard helmet can contribute to neck injury during traffic collisions. The goal of this analysis was to examine the association between helmet type and neck injury risk and the association between helmet type and head injury. Data were collected during the investigation of motorcycle collisions of any injury severity by the California Highway Patrol (CHP) and 83 local law enforcement agencies in California between June 2012 and July 2013. We estimated head injury and neck injury risk ratios from data on 7051 collision-involved motorcyclists using log-binomial regression. Helmet type was strongly associated with head injury occurrence but was not associated with the occurrence of neck injury. Rider age, rider alcohol use, and motorcycle speed were strong, positive predictors of both head and neck injury. Interventions to improve motorcycle helmet choice and to counteract misplaced concerns surrounding neck injury risk are likely to lead to reductions in head injury, brain injury, and death.

1. Introduction

Motorcycle collisions contribute significantly to preventable injury and death in the US. Nationally, 4668 fatalities and an estimated 88,000 non-fatal injuries resulted from motorcycle traffic collisions in 2013 (NHTSA, 2014b). In California, 453 motorcycle riders were killed and an additional 11,653 were non-fatally injured (SWITRS, 2013).

In an attempt to improve motorcycle collision outcomes, California and 18 other US states currently have universal motorcycle helmet laws which require all motorcycle riders to wear helmets that comply with US DOT safety standards. However, the use of non-compliant, or "novelty" motorcycle helmets is high in California (Tsui et al., 2013) and other states without universal helmet laws (NHTSA, 2014a).

Novelty helmets are lightweight helmets with no energy-absorbing liner and limited ability to protect against head injury. They are generally constructed of a thermoplastic or fiber composite shell, a retention strap, and soft foam inside the shell to improve fit. However, novelty helmets do not have an expanded polystyrene liner and do not meet the standards specified by Federal Motor Vehicle Safety Standard 218 (DOT), which establishes minimum construction and performance requirements (GPO, 2011). In 2007, the National Highway Traffic Safety Administration (NHTSA) conducted impact attenuation, penetration, and retention tests on various styles and brands of novelty helmet. With one exception in helmet retention, the seven novelty helmets tested failed in all three test categories (NHTSA, 2007).

A belief that motorcycle helmets cause neck injury because of increased mass often leads motorcycle riders to oppose helmet use or to wear a novelty helmet. A number of studies have investigated the association between helmet use and motorcyclist neck injury. A majority of these studies have found no association or have reported a protective effect (Liu et al., 2004). A Cochrane Collaboration review of motorcycle helmet literature concluded that most studies conducted to date have been suggestive of a neutral or protective helmet effect on neck injury risk, but that higher quality studies are needed to estimate the helmet-neck injury association (Liu et al., 2004). However, a small but frequently referenced group of studies have found some positive association between neck injury and helmet use (Krantz, 1985; Goldstein, 1986; Simpson et al., 1989).

The primary goal of this study was to estimate the association of motorcycle helmet type with occurrence of neck injury among adult riders of motorcycles involved in a traffic collision of any injury severity in California, while controlling for potential confounders. We used a significantly larger data set than has been used

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in previous studies and had access to detailed helmet type information, which is typically not collected during collision investigations and is not available in existing data sets.

2. Methods and procedures

The California Highway Patrol (CHP) and 83 local law enforcement agencies in California collected data during the investigation of motorcycle collisions between June 2012 and July 2013.

Officers were asked to complete a one-page supplemental form that included fields for body region injured, helmet style (full-face, modular, open-face, half-helmet), helmet retention, helmet damage, helmet certification labeling (DOT, Snell, ECE, none), and whether the officer believed the helmet met the DOT standard. Hard copies of police collision reports for each collision were also obtained, and data were abstracted.

We used data on 7535 motorcycle operators or passengers aged 15 or older who had both a corresponding supplemental data form and police collision report. Unhelmeted riders were excluded from the final analysis (330 [4.4%]). These riders were disproportionately in off-road or open desert environments, resulting in a collision type distribution which was notably different than that of helmeted riders. We excluded 154 riders with missing values on collision type (2.2%) from the regression model. Multiple imputation (Rubin, 1987; Schafer, 1999; Stuart et al., 2009) was used to address missing values on age, sex, or motorcycle speed for 583 riders (8.1%).

Head injury and neck injury were indicated (yes/no) on the supplemental data form if any discernible injury to those regions was identified by the investigating officer or if the officer was informed of a head or neck injury by medical personnel at the scene or during investigative follow-up. We defined a novelty helmet as a half-helmet that the investigating officer did not believe met the DOT standard.

We estimated head and neck injury risk ratios using log-binomial regression models. The models included age categories, sex, alcohol use, motorcycle type, collision type, and roadway type as potential confounders. We modeled age and motorcycle speed as continuous, quadratic, and categorical. We found that the helmet risk ratios were nearly identical and selected the categorical model to facilitate interpretation. Stata software was used for data management and analysis (StataCorp, 2014).

3. Results

This motorcycling population had a broad age distribution with more than half (53%) being aged 35 years or older (Table 1). A large majority of riders were male (94%). Helmet types in use at the time of collision included full-face (68%), half-helmets (15%), and open-face (8.5%), modular (4.4%), and novelty (4.0%). A majority of riders suffered minor injuries – 'other visible' injuries (41%) or 'complaint of pain' injuries (24%). Of the 7205 riders, 641 (9%) suffered neck injury, 1089 suffered head injury (15%), and 202 died from their injuries (2.8%). Harley-Davidson was the most common motorcycle brand (26%), followed by Honda (17%), Yamaha (16%), and Suzuki (15%). Nearly one-fifth of the motorcyclists (19.2%) were improperly licensed.

Adjusted neck injury risk ratios for each helmet type were all close to 1 and no risk ratio was statistically significant (Table 2). For example, the risk ratio for half-helmet helmets compared with full-face helmets was 0.98 (0.79–1.21). Estimated risk ratios ranged from 0.89 to 1.11 (overall p 0.876).

Other characteristics were significantly associated with neck injury. Adjusted risk ratios for rider age showed a positive, monotonic trend ranging from 0.76 (95% CI 0.60–0.97) for the youngest riders to 1.65 (95% CI 1.17–2.32) for the oldest riders, each compared with riders aged 25–34 years. Motorcycle speed and the risk of neck injury were also significantly associated ($p < 0.001$). Adjusted risk ratios ranged from 1.41 (95% CI 0.96–2.07) for the 20–29 mph category, to 5.96 (95% CI 3.33–10.65) for the 90 + mph category. The neck injury risk ratio for having a BAC of 0.08 or greater was 1.65 (95% CI 1.14–2.38). The passenger risk ratio comparing motorcycle passengers to operators was not statistically significant (aRR 0.80, 95% CI 0.58–1.09). Additionally, most risk ratios for categories of collision type were not significantly distant from 1.

The adjusted risk of head injury, however, varied significantly across helmet type ($p < 0.001$, Table 3). Compared with full-face helmets, open-face (aRR 1.69, 95% CI 1.41–2.03), half-helmets (aRR 1.91, 95% CI 1.66–2.20), and novelty helmets (aRR 2.78, 95% CI 2.33–3.32) were associated with higher occurrence of head injury. The estimated head injury risk ratio comparing modular

Table 1
Characteristics of collision-involved motorcyclists.

Characteristic	No.	%
Age		
15–24	1457	20.2
25–34	1938	26.9
35–44	1173	16.3
45–54	1254	17.4
55–64	897	12.4
65+	286	4.0
Unknown	200	2.8
Gender		
Female	366	5.1
Male	6759	93.8
Unknown	80	1.1
Rider role		
Operator	6840	94.9
Passenger	642	8.9
Helmet type		
Full-face	4931	68.4
Half-helmet	1050	14.6
Open-face	616	8.5
Modular	317	4.4
Novelty	291	4.0
Neck injury		
No	6564	91.1
Yes	641	8.9
Head injury		
No	6116	84.9
Yes	1089	15.1
Most severe injury		
Fatal	202	2.8
Severe	1190	16.5
Other visible	2929	40.7
Complaint of pain	1716	23.8
No Injury	36	0.5
Unknown	1132	15.7
Motorcycle brand		
BMW	257	3.6
Ducati	181	2.5
Harley-Davidson	1901	26.4
Honda	1213	16.8
Kawasaki	867	12.0
Suzuki	1059	14.7
Yamaha	1145	15.9
Triumph	124	1.7
Other	378	5.2
Unknown	80	1.1
Properly licensed		
No	1382	19.2
Yes	5764	80.0
Unknown	59	0.8
Total	7205	100