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Novelty helmet use and motorcycle rider fatality

Thomas M. Rice[a,*], Lara Troszak[a], Taryn Erhardt[a], Roger B. Trent[b], Motao Zhu[c]

[a] University of California Berkeley, United States
[b] Health Surveillance Analysis, Gridley, CA, United States
[c] Ohio State University, United States

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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.

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.

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

* Corresponding author at: Safe Transportation Research & Education Center, 2614 Dwight Way #7374, Berkeley, CA, 94720-7374, United States.
E-mail address: tomrice@berkeley.edu (T.M. Rice).

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

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