Effectiveness of a State Law Mandating Use of Bicycle Helmets among Children: An Observational Evaluation

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In spring 1999, the authors evaluated the effectiveness of a 1997 Florida law requiring helmet use by all bicyclists younger than age 16 years. Sixty-four counties in Florida had enacted the bicycle helmet-use law, while the other three counties had opted out. Using a cross-sectional study design, the authors conducted unobtrusive observations at bicycle racks at public elementary schools statewide. Florida children riding bicycles in counties where the state helmet-use law was in place were twice as likely to wear helmets as children in counties without the law. In counties where the state law was in place, 16,907 (79%) of 21,313 riders observed wore a helmet, compared with only 148 (33%) of 450 riders in counties where no such law was in place (crude prevalence ratio = 2.4, 95% confidence interval: 2.1, 2.8). Helmet use by children of all racial groups exceeded 60% under the law. No significant difference in use by gender was found. These data support the positive influence of a law on bicycle helmet use among children. The data reinforce the Healthy People 2010 objective that all 50 states adopt such a law for children in order to increase helmet use and consequently reduce brain injury. Am J Epidemiol 2001;154:1072–6.

bicycling; child; craniocebral trauma; head protective devices; legislation; safety

More than 70 percent of US children aged 5–14 years—approximately 28 million children—ride bicycles (1). In 1998, 194 US children aged 5–14 years were killed while riding a bicycle; at least 125 of those children died of traumatic brain injuries (2). Of the 100,000 children who incur a nonfatal injury to the head or face while riding bicycles each year, an estimated 20,000 sustain a traumatic brain injury (3).

Bicycle helmets prevent up to 85 percent of head injuries and 88 percent of serious brain injuries (4, 5). For every bicycle helmet sold, an estimated $395 is saved in direct medical costs and other costs (6). Despite such demonstrated effectiveness, a 1994 survey reported that only about half of US children owned a bicycle helmet, and only 25 percent wore one every time or nearly every time they rode (1). Helmet-use legislation can be an important and effective part of a multifaceted bicycle helmet-use program for children (5). Since 1987, 18 states, the District of Columbia, and more than 80 cities have enacted such laws or ordinances, covering approximately 49 percent of US children younger than age 15 years. Laws will take effect in two other states by March 1, 2002 (7).

Evidence of the effectiveness of such laws has been based on studies that used either observational methods (for local studies) or telephone surveys (for statewide surveys). The sentinel study using observational methods was conducted in Howard County, Maryland, in 1990. It showed one of the most impressive increases in helmet use following adoption of a law to date: from 4 percent to 47 percent (8). Although observational studies are considered preferable to telephone surveys, they are relatively resource-intensive and thus have been applied only to local or county jurisdictions. Local findings may not be generalizable to larger populations, because of the relative socioeconomic homogeneity of a single county. Statewide surveys would be more representative of the entire national population.

Two statewide surveys have been conducted by telephone. In Georgia, proxy-reported helmet use increased from 37 percent to 66 percent following the adoption of a state law (9). In Oregon, proxy use reported by telephone increased from 37 percent to 67 percent (10), although observations at 13 sites indicated that helmet use was 25 percent before the law took effect and 49 percent afterwards. Stronger evidence based on observational studies conducted statewide is needed to help reconcile such differences.

With statewide observational methods, one of the fundamental barriers to accurate ascertainment of population-based helmet use is the determination of the sampling frame. Because populations of riders from different geographic
areas are likely to differ in their exposure to traffic, trip duration, and pattern of helmet use, developing a probability sample based on exposure to bicycle-riding is challenging, if not impossible. A new look at study design was needed to overcome this limitation. Accordingly, we sought a site in which to survey all elementary schools across a state, rather than sample a supposedly representative population of riders.

Florida is an excellent site at which to study the effectiveness of a state law mandating use of bicycle helmets. Its warm climate affords year-round bicycling and thus relatively high exposure. It also has one of the highest numbers of children killed while bicycling in the nation. On the basis of a four-county 1991 study that indicated 15 percent helmet use, baseline helmet use in Florida appeared to be low, despite the implementation of a multifaceted intervention program (11).

On January 1, 1997, a state law (Florida Statutes 1996, Title XXIII, Chapter 316.2065) took effect mandating that all bicycle riders younger than age 16 years wear a helmet while riding (12). In the first year, law enforcement officers were authorized to issue verbal warnings and bicycle safety brochures to violators. After January 1, 1998, officials could issue a citation that carried a $15 fine. A provision to “opt out” of the state law provided a natural experiment in which to estimate its effectiveness. The law included a provision allowing a county to exempt itself from the legislation if its board of county commissioners, after holding a public hearing, passed an exemption ordinance before January 1, 1998 (12). Three counties (Brevard, Citrus, and St. Lucie counties), each with 112,000–640,000 residents, executed this provision to “opt out” of the law.

Prior to this study, the effectiveness of the law was estimated by other investigators using two different methods. First, direct observations were conducted in one jurisdiction, Duval County, which includes Jacksonville. There, in addition to the law, the intervention included helmet-use education and helmet distribution. Helmet use increased from 13 percent 1 year before the law took effect to 73 percent 16 months after it took effect (13). Second, a statewide telephone survey conducted in 1997 indicated, by proxy report, that about 47 percent of children always wore a helmet while riding a bicycle (14).

The present observational study was conducted for two reasons. First, we wished to determine the generalizability of the high prevalence of helmet use noted in Duval County. Second, the Florida Department of Health needed school-specific data in order to know where to target its public health prevention efforts.

MATERIALS AND METHODS

Study population

In spring 1999, the Florida Department of Health conducted 1-day observations of bicycle helmet use at all Florida public elementary schools that included at least kindergarten through grade 5, where there was no school policy prohibiting children from riding bicycles to school and where school authorities anticipated that at least one child would ride to school. The principal of each eligible school was recruited, and most agreed to participate. The study design was reviewed by federal authorities and was determined to have no considerations pertaining to research on human subjects that would require informed consent, since the behaviors to be observed were publicly displayed and would be recorded anonymously.

After reviewing the survey instructions, school officials (usually the school principal, but sometimes a physical education teacher, school nurse, drug-abuse resistance education officer, or other school staff member) conducted unobtrusive observations of bicycle helmet use by students during 1 day of a 4-month period in spring 1999. A cross-sectional, static-group comparison design was selected because of resource limitations. They recorded helmet use once for each student, either while the student rode up to the bicycle rack at school in the morning or while he/she rode away from it in the afternoon. No attempt was made to identify whether helmets were being worn correctly. The gender and race (White, Black, other) of each child were recorded, but no attempt was made to identify Hispanic ethnicity because of concern about misclassification.

Statistical analyses

The possibility that within-school clustering might influence the results was tested using SUDAAN software (15), with the school district analyzed as the primary sampling unit. The resulting design effect was less than unity, indicating that variances calculated under a simple random-sample assumption using SAS software were larger (and thus more conservative) than those produced by cluster analysis. Thus, the unit of analysis was the observed rider, not the school. Statistical significance for the analysis was tested using Pearson’s $\chi^2$ test, with $p$ values less than 0.05 being considered statistically significant. In addition, we present crude and adjusted prevalence ratios for gender and race obtained by means of Cochran-Mantel-Haenszel statistics.

RESULTS

Of the 1,407 elementary schools in the 67 counties comprising the Florida public school system, 1,064 schools from 55 counties met the inclusion criteria. Among these 1,064 eligible schools, 1,015 schools from 55 counties returned completed observational surveys of helmet use (a 95 percent response rate). Of these schools, 66 had no bicycle riders on the survey date. An additional 385 riders from 11 schools had missing values for gender or race and were excluded. Thus, the final sample was composed of 21,763 children from 938 schools in 53 counties. Of these children, 21,313 lived in one of 50 counties where the state helmet-use law was in place and 450 (2.1 percent) lived in one of the three counties that were exempt from the law.

The demographic profile of children residing in the 50 counties with a helmet-use law was compared with that of children residing in the three counties exempt from the law (table 1). There was no difference in gender distribution
between the two types of counties. However, the racial distribution differed between children from counties with a helmet-use law and those from counties without one (p = 0.001). Measures of socioeconomic status were similar between the two types of counties.

Bicycle helmet use was 78 percent among all children observed. In counties where a state law was in place, 16,907 (79 percent) of 21,313 riders wore a helmet, compared with 148 (33 percent) of 450 riders in counties that were exempt from the state law (p = 0.001; table 2). In counties where the state law was in place, about twice as many boys rode a bicycle as girls, but their helmet use was not substantially different from that of girls (79 percent use for boys vs. 81 percent use for girls). Regardless of gender, where a law was in place, more White riders (83 percent) than Black riders (62 percent) wore bicycle helmets (p = 0.001). In counties that were exempt from the state law, 31 percent of boys and 37 percent of girls wore a helmet (p = 0.23). Regardless of gender, in counties where no helmet-use law existed, 38 percent of White children and 12 percent of Black children wore a helmet (p = 0.001).

Children living in counties with a law were 2.4 times more likely to wear a bicycle helmet than children in counties exempt from the law (95 percent confidence limits: 2.1, 2.8). The adjusted prevalence ratio in counties with a law versus those without a law, controlling for gender and race, was 2.3 (95 percent confidence limits: 2.0, 2.6). Thus, neither gender nor race confounded the relation between helmet use and the existence of a state law. All three of the counties exempt from the law were in the lowest quartile of helmet use.

**DISCUSSION**

This study provides further support for the value of a helmet-use law in influencing children to wear a bicycle helmet while riding to school. The overall value of 78 percent for observed helmet use is the highest known prevalence of helmet use for a large, general population of children or adults in the United States. Thus, the results of the postlaw Duval County observational study (13) are consistent with those of our statewide observational study. Notably, a greater-than-twofold difference in helmet use existed between counties that had a helmet-use law and those that did not. This difference remained the same after data were controlled for gender and race. This suggests that the state law was a more important determinant of helmet use than a child’s gender or race. Helmet use exceeded 60 percent for all gender/race strata in counties where the state law was in place. Although this value was somewhat lower than the state mean, it was higher than that obtained by other investigators using similar methods elsewhere in the United States (8–10). On the basis of these findings, the Florida Department of Health was able to target those communities with the lowest helmet use for further intervention.

We considered whether restricting site selection to public school property had biased our results. We chose to observe children only at school sites because we wanted to maxi-
mimize the number of elementary school children surveyed statewide. Furthermore, the time periods before and after school hours are particularly important to consider, because they are relatively hazardous; approximately 30 percent of all bicycle crashes among children occur while the child is riding to or from school (16). We chose to conduct observational surveys rather than rely on telephone, mail, or classroom surveys, because observations are generally acknowledged to be more accurate and conservative than other survey methods (17). Measuring helmet use on school property enhanced survey efficiency tremendously by enabling the task to be completed by only one adult observer at the place of work in a short period of time. The school-based method used here also virtually eliminated the possibility of double-counting the same child, a key threat to validity in observational surveys (17).

One key limitation of this study was our inability to control for the existence of school policies requiring bicycle riders to wear a helmet when riding to and from school. Some Florida schools had already adopted a policy requiring children to wear a helmet while bicycling to school lest they not be allowed to ride their bicycle home that day. If so, our choice to restrict observations to school sites may have produced a spurious association between the existence of a state law and helmet use. A school policy might be expected to increase helmet use among children riding to or from school but not affect helmet use at other times and places. We attempted to quantify this potential bias but could only ascertain the necessary information about the existence of a school policy for approximately one third of schools—too few to permit analysis. Meanwhile, we hypothesize that the coexistence of a law and a school policy might be synergistic. Indeed, a state law might be a necessary antecedent to a school policy, empowering reluctant school officials to adopt one. The specific influence of a school policy deserves further study.

Another key limitation of this study was imposed by its cross-sectional, observational design. Because the survey was conducted only once, we could not evaluate any change in helmet use associated with passage of the law or thereafter. The unobtrusive nature of the study prevented us from collecting data on age and other important rider variables. In addition, we made no attempt to measure any joint effectiveness of local bicycle-helmet giveaway and/or educational programs, which in Australia were demonstrated to increase helmet use in advance of a law (18). However, early experience in Duval County suggested that the law had a greater effect than helmet distribution or education (13). Furthermore, when a helmet giveaway and educational program were provided to all elementary school children in two Texas towns where no helmet-use law existed, change in helmet use was relatively small and unsustained (19).

We conclude that bicycle helmet-use laws can be powerful stimulants for behavioral change (9). This study showed that helmet use was twice as high in Florida counties where a law was enacted as in counties that opted out of the law. These data support the Healthy People 2010 objective recommending that all 50 states adopt a bicycle helmet-use law for children (20) in order to increase helmet use and consequently reduce traumatic brain injury.

### TABLE 2. Observed use of bicycle helmets among children in counties with and without a bicycle helmet use law, by gender and race, Florida, 1999

<table>
<thead>
<tr>
<th>Gender and race</th>
<th>Counties with a helmet law</th>
<th>Counties without a helmet law</th>
<th>( \chi^2 ) value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of riders</td>
<td>No. helmeted</td>
<td>Helmet use (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( % )</td>
</tr>
<tr>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>10,226</td>
<td>8,421</td>
<td>82.4</td>
</tr>
<tr>
<td>Black</td>
<td>1,972</td>
<td>1,200</td>
<td>60.9</td>
</tr>
<tr>
<td>Other</td>
<td>1,629</td>
<td>1,229</td>
<td>75.5</td>
</tr>
<tr>
<td>Subtotal</td>
<td>13,827</td>
<td>10,850</td>
<td>78.5</td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>5,571</td>
<td>4,718</td>
<td>84.7</td>
</tr>
<tr>
<td>Black</td>
<td>1,060</td>
<td>683</td>
<td>64.4</td>
</tr>
<tr>
<td>Other</td>
<td>855</td>
<td>656</td>
<td>76.6</td>
</tr>
<tr>
<td>Subtotal</td>
<td>7,486</td>
<td>6,057</td>
<td>80.9</td>
</tr>
<tr>
<td>Both genders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>15,797</td>
<td>13,139</td>
<td>83.2</td>
</tr>
<tr>
<td>Black</td>
<td>3,032</td>
<td>1,883</td>
<td>62.1</td>
</tr>
<tr>
<td>Other</td>
<td>2,484</td>
<td>1,885</td>
<td>75.9</td>
</tr>
<tr>
<td>Subtotal</td>
<td>21,313</td>
<td>16,907</td>
<td>79.3</td>
</tr>
</tbody>
</table>

* \( p < 0.05 \) for helmet use in counties with a law vs. counties without a law (Pearson \( \chi^2 \) test).
† The Pearson \( \chi^2 \) test was not performed because of small cell sizes.
ACKNOWLEDGMENTS

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REFERENCES