

ORIGINAL ARTICLE

Effects of state helmet laws on bicycle helmet use by children and adolescents

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Objective: To evaluate the effectiveness of state helmet laws in increasing the use of bicycle helmets by children and adolescents under age 16.

Setting: United States.

Methods: A cross sectional study of factors associated with the likelihood of helmet use by children and adolescents. Data were derived from a national random digit dial telephone survey of bicycle riders. A multiple logistic regression analysis was used to quantify the independent effect of the state helmet laws on helmet use.

Results: Helmet use was systematically related to the presence of state helmet laws (odds ratio 2.65; 95% confidence interval (CI) 1.29 to 5.44). The increase in the average probability of helmet use attributable to state helmet laws was 18.4% (95% CI 17.8% to 19.0%).

Conclusions: State helmet laws significantly increase helmet use by children and play an important part in any comprehensive effort designed to achieve this goal.

According to the US Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System, an estimated 45 000 children under age 16, the age group affected by most state helmet laws, were treated in US hospital emergency departments for bicycle related head injuries in 1998.¹ In addition, an estimated 224 children under age 16 died from bicycling injuries in 1997² and most of these deaths resulted from head injuries.³

Although head injuries are among the most serious sustained by bicyclists,^{4,5} they are also among the most preventable. Research has shown that helmet use substantially reduces both the likelihood and severity of head injury.^{6–8} Such findings have spurred a number of efforts to increase the use of helmets, ranging from community based educational and outreach programs to state and local laws requiring that bicyclists wear helmets.^{9–13}

As of November 2001, 19 states and the District of Columbia have enacted legislation requiring the use of helmets by children.^{14–15} Twelve of the state laws apply only to children under the age of 16; one (the California law) requires helmets by children under age 18. The remaining laws apply to younger children (for example, from under age 15 to under age 12). Helmet use laws have also been enacted in over 50 localities outside of states having laws, but these localities account for only a small proportion of the US population.

None of the state laws requires the use of helmets by adults. Nor are the laws rigorously enforced.⁹ Five states have either no provision for enforcement or limit enforcement to verbal warnings. The remaining states allow for small fines, usually no more than about \$25 to \$50, but typically waive the fine if the violator can prove purchase of a helmet within a specified time.^{14–16}

Two of the state laws and several local laws have been shown to increase helmet use by children.^{17–22} Helmet laws have also been shown to increase helmet use in Australia and New Zealand.^{23–24} However, there has been no nationwide evaluation of their effectiveness in the US, even though some of these laws have been in effect since the early 1990s. The purpose of this article is to fill this information gap by evaluating the nationwide impact of state helmet laws on helmet use by children under age 16.

METHODS

Survey procedures

Data used in the analysis are from a 1998 national telephone survey of US bicyclists conducted by Yankelovich Partners. The survey employed a single stage, list assisted random digit dial sample design and was intended to provide a national probability sample of about 1000 bicycle riders in the US who had used their bicycle at least once during the previous year.²⁵

The survey was conducted during August 1998 and collected information about the characteristics of riders and their bicycle and helmet use. A maximum of five attempts was made to obtain an answered call for each telephone number included in the survey. When households were reached, respondents were asked how many household members had ridden a bicycle at least once during the last year. If there was more than one rider, one was selected randomly to be interviewed. If the selected rider was under age 16, a parent or guardian was asked to respond on the child's behalf.

Analytic procedures

SUDAAN software was used in the statistical analysis. Variance estimation was based on Taylor linearization methods.²⁶ All reported results reflect weighted data.

A univariate comparison of the characteristics of the children under age 16 who *always or almost always* wore helmets with the characteristics of those who did not was conducted as a preliminary evaluation of possible factors associated with helmet use. Crude odds ratios (OR), with 95% confidence intervals (CI), were calculated.

A cumulative logistic regression model, which can be used to examine the relationship between a series of explanatory variables and a dependent variable that is ordinal in nature,^{26–27} was used to estimate the adjusted impact of the laws on the likelihood of helmet use. In this case, the dependent variable represented four "frequency of helmet use" categories, including whether the bicyclist wore a helmet: (1) always or almost always, (2) more than half the time, (3) less than half the time, or (4) never or almost never.

Abbreviations: CI, confidence interval; CPSC, Consumer Product Safety Commission; OR, odds ratio

Explanatory variables included the presence of a state law requiring helmet use in their state of residence, as well as various other characteristics of children and their households. The state law variable applies only to the 15 states that had helmet laws in effect at the time of the survey.

With the exception of a continuous variable representing the hours of bicycle use in an average month of riding, all of the explanatory variables were included as either dichotomous or polytomous variables.

The dichotomous variables included the child's gender, whether the child was under age 12, and whether the state of residence had a helmet law at the time of survey. All children under the age of 16 were assumed to be affected by the presence of a state helmet law, even if the specific state law applied only to younger children (for example, the West Virginia law applied only to children under age 15). However, the sensitivity of the statistical results to this assumption was also evaluated by specifying a polytomous variable that compared two categories of children from states with helmet laws (that is, the children covered by the laws and the older children not explicitly covered) against children from states without helmet laws. The polytomous variables included the child's geographic region of residence, the highest level of education attained by a household member, and household income.

The study's primary outcome measures included (1) the adjusted odds ratio associated with the state helmet law variable, and (2) the incremental increase in the average probability of helmet use (defined as a difference measure) attributable to the state helmet law variable.

RESULTS

A total of 11 468 numbers were called. Of this total, 3347 were successfully screened to determine whether a household member had ridden a bicycle during the prior year; 1069 households had riders and 2278 did not. Of the 1069 households with riders, interviews were completed with 1020.²⁵

Of the 8121 numbers not successfully screened, 4026 were households that refused to participate before the screener could be completed and another 364 were with households that did not complete the screener because of a language barrier. The remaining 3731 numbers remained unresolved after all call attempts; these numbers were either not answered, busy, or were answered by an answering machine on all attempted calls.

The response rate can be measured in two ways. Because the survey completed 1020 interviews with bicyclists, and successfully screened 2278 households that did not have bike riders, the response rate can be calculated as 43% of the 7737 numbers in which contact was made with a household. When the 3731 unresolved numbers are included, the *minimum* response rate was 29% [(1020+2278)/11 468]. (This rate is a minimum because some unknown proportion of the unresolved numbers are likely to have been businesses.)

Altogether 310 interviews collected information on helmet and bicycle use patterns of children under the age of 16 years. These observations represented an estimated 31.6 (95% CI 28.1 to 35.1) million children under age 16 and formed the basis for the analysis described in this article.

Selected characteristics of child riders are shown in table 1. Just over two fifths (40.9%) of the children surveyed resided in states with helmet laws.

Table 2 compares the characteristics of the children who *always or almost always* wore helmets (column 1) against those who did not (column 2), along with crude odds ratios. The univariate findings suggest that the children who always wore helmets were more likely to reside in states with helmet laws, to be younger (that is, under age 12), to live in northeastern or western states, and to be from households with higher incomes and higher levels of educational attainment.

Table 1 Descriptive characteristics of riders under age 16 years

Characteristics	No (%)	95% CI (%)
Age group (years)		
<12	215 (71.4)	65.7 to 77.1
12–15	95 (28.6)	22.9 to 34.3
Gender		
Male	175 (53.7)	47.3 to 60.1
Female	135 (46.3)	39.9 to 52.7
Helmet use		
Always or almost always	170 (59.1)	52.9 to 65.3
More than half the time	33 (9.9)	6.2 to 13.6
Less than half the time	30 (11.7)	7.2 to 16.2
Never or almost never	76 (19.3)	14.8 to 23.8
State helmet law		
Yes	125 (40.9)	34.6 to 47.2
No	185 (59.1)	52.9 to 65.4
Region		
Northeast	63 (22.2)	16.9 to 27.9
Midwest	73 (25.0)	19.4 to 30.6
South	117 (31.6)	26.0 to 37.2
West	57 (21.2)	15.6 to 26.8
Education*		
High school or less	93 (29.5)	23.6 to 35.4
Some college	77 (26.1)	20.4 to 31.8
College graduate	136 (44.4)	38.0 to 50.8
Household income (\$)		
<15000	22 (6.0)	3.3 to 8.7
15000 to <30000	67 (22.2)	16.6 to 27.8
30000 to <45000	56 (21.5)	15.9 to 27.1
≥45000	119 (50.3)	43.4 to 57.2

*Highest level attained by any household member.

The results of the cumulative logistic regression analysis are presented in table 3. The regression model was based on 259 of the 310 survey observations. Thirty nine of the observations were lost because of missing data on the household income variable. As described below, the results of the analysis were not sensitive to these missing data.

The regression results are generally consistent with the univariate findings. Helmet use was greater for children under age 12, for those living in western states, from households with higher incomes, and for children from households in which one or more members had attended or graduated from college. Helmet use also increased with average monthly riding time.

Most noteworthy, for purposes of this analysis, helmet use was significantly higher in states with helmet use laws (OR 2.65; 95% CI 1.29 to 5.44), even when adjusted for demographic factors such as household income and education. Moreover, the helmet finding was not sensitive to modification of the definition of the helmet law variable. When it was respecified to compare two categories of children in states with helmet laws (that is, those covered by the laws and those not covered) against children from states without helmet laws, the resulting OR for children covered by the laws was 2.51 (95% CI 1.22 to 5.17). A more general sensitivity analysis also showed that the positive relationship between laws and the likelihood of helmet use was significant and strong regardless of the specification of the regression model. For example, when the income variable (which accounted for 39 of the 51 observations excluded from the analysis because of missing data) was dropped from the model, the adjusted OR for the helmet law variable was 2.28 (n=298, 95% CI 1.20 to 4.36).

In addition to estimating the OR associated with the state helmet law variable, the regression model enabled us to estimate directly the effect of the laws on the average probability of helmet use. Table 4 presents estimates under several conditions.

The probabilities shown in columns two and three of the first row show the average probability of *always or almost always*

Table 2 Selected descriptive characteristics of riders under age 16, by helmet use category

Variable	Wears helmet always or almost always		Crude OR (95% CI)
	Yes	No	
Age group (years) (n=309)			
≤12	79.1	60.9	2.43 (1.35 to 4.36)
12–15	20.9	39.1	1.0
Gender (n=309)			
Male	55.4	50.9	1.20 (0.72 to 2.02)
Female	44.6	49.1	1.0
State helmet law (n=309)			
Yes	51.3	26.2	2.99 (1.73 to 5.18)
No	48.7	73.9	1.0
Region (n=309)			
Northeast	27.3	14.9	0.88 (0.34 to 2.30)
Midwest	22.7	27.8	0.39 (0.16 to 0.96)
South	22.9	44.4	0.25 (0.11 to 0.57)
West	27.1	13.0	1.0
Education* (n=305)			
High school or less	16.8	47.4	1.0
Some college	30.2	20.4	4.17 (2.05 to 8.49)
College graduate	52.9	32.3	4.61 (2.48 to 8.57)
Household income (\$) (n=264)			
<15000	2.7	10.5	1.0
15000 to <30000	16.5	30.0	2.13 (0.71 to 6.35)
30000 to <45000	21.2	21.9	3.75 (1.25 to 11.25)
≥45000	59.6	37.7	6.12 (2.20 to 17.09)

*Highest level attained by any household member.

Table 3 Logistic regression results: factors associated with helmet use, for riders under age 16

Variable	Coefficient	SE	p Value	Adjusted OR (with 95% CI)
Intercept 1	-2.435	0.6925	<0.01	0.09 (0.02 to 0.34)
Intercept 2	-1.880	0.6924	<0.01	0.15 (0.04 to 0.59)
Intercept 3	-1.079	0.6634	0.10	0.34 (0.09 to 1.25)
Age group (years)				
<12	0.700	0.294	0.02	2.01 (1.13 to 3.59)
12–15*	0	0		1.0
Gender				
Male	0.195	0.292	0.50	1.21 (0.68 to 2.15)
Female*	0	0		1.0
State helmet law				
Yes	0.973	0.367	<0.01	2.65 (1.29 to 5.44)
No*	0	0		1.0
Riding hours per month	0.0079	0.0028	<0.01	1.008 (1.002 to 1.014)
Region				
Northeast	-0.823	0.519	0.11	0.44 (0.16 to 1.21)
Midwest	-0.522	0.484	0.28	0.59 (0.23 to 1.53)
South	-1.101	0.435	0.01	0.33 (0.14 to 0.78)
West*	0	0		1.0
Education				
High school or less*	0	0		1.0
Some college	1.105	0.329	<0.01	3.02 (1.58 to 5.76)
College graduate	1.268	0.553	0.02	3.55 (1.20 to 10.53)
Household income (\$)				
<15000*	0	0		1.0
15000 to <30000	0.896	0.512	0.08	2.45 (0.90 to 6.69)
30000 to <45000	1.488	0.524	<0.01	4.43 (1.58 to 12.38)
≥45000	1.734	0.462	<0.01	5.66 (2.29 to 14.00)

*Reference category.

using a helmet for two independent categories of riders: those from states with helmet laws (where the average probability was 72.3%) and those from states without laws (where the average probability was 49.6%). Overall, the average probability was substantially higher in states with helmet laws than it was in states without laws. However, because these estimates did not control for other differences between the two categories of riders, they do not reflect the independent effect of the state laws on helmet use. For example, household incomes

and education levels, which were positively correlated with helmet use, were somewhat higher in the states with helmet laws. Consequently, income and education explained part of the difference in the average probabilities of helmet use.

The independent effect of the state laws on the average probability of helmet use can, however, be estimated by pooling all riders into a single category and allowing only the helmet law variable to change. This effect is estimated by comparing, from the first column of table 4, the probabilities

Table 4 Average probability of always or almost always using a helmet, for riders under age 16; values are % (SE)

Condition for estimating average probability of helmet use	Average probability of always or almost always using a helmet, by rider category		
	All riders	Riders from states with helmet laws	Riders from states without laws
Helmet laws as they existed at time of 1998 survey	58.6 (1.5)	72.3 (1.9)	49.6 (1.8)
Assuming all states had helmet laws	69.9 (1.2)	72.3 (1.9)	68.3 (1.6)
Assuming no states had helmet laws	51.5 (1.4)	54.2 (2.2)	49.6 (1.8)

in rows two and three. If, hypothetically, all states had helmet laws, the expected average probability of helmet use would have been 69.9%; conversely, if no states had helmet laws, the expected average probability would have been 51.5%. Thus, the *difference* in the average probabilities attributable to the helmet law variable was 18.4% (95% CI 17.8% to 19.0%).

DISCUSSION

The results of this analysis suggest that state helmet laws have significantly increased the likelihood of helmet use by children. Moreover, the effect has been substantial as well as statistically significant. If the increase in the average probability of helmet use associated with state laws were aggregated over the entire US population of riders under age 16, the estimated effect would be to add about 18.4% of all child riders to the category of helmet users.

Despite the strength of the statistical findings, the results need to be interpreted with some caution. The relatively low response rate, and the fact that some interviews could not be completed because of a language barrier, suggest that the results may be subject to some selection bias. The results are also subject to recall bias. Although the survey questions were, for the most part, factual in nature (for example, age, gender), some required information about past behavior. Additionally, in some cases, parents or guardians responding for their children may not have been fully aware of their children's helmet use patterns.

The results may also be subject to reporting bias. The helmet use estimates were self reported rather than observed, and could therefore be overstated.²⁸ However, the potential effects of reporting bias were minimized to the extent possible both in the design of the survey questions and the choice of outcome measure. For example, instead of limiting the responses of parents to a "yes" or "no" when asked about whether their children used helmets, the survey allowed for gradations in estimated helmet use. Second, respondents were not alerted to the main focus of the survey: helmet use. Rather, they were told that the study was about "how people use bicycles".

While the extent of reporting bias is unknown, it should be noted that estimated use rates are not inconsistent with available data on the sales of helmets. Annual sales of bicycle helmets have ranged from about eight to 11 million annually since the mid-1990s. Assuming that helmets last on average five years, there would have been about 40 to 55 million helmets in use at the time when the survey was conducted. Based on the results of the full survey, including helmet use by adult riders, an estimated 48.5 (95% CI 44.8 to 52.2) million riders of all ages reported having helmets and using them at least some of the time; this included about 26.1 million children under age 16 and about 22.4 million older riders.

Furthermore, even if there was an upward bias in the reporting of helmet use, it would only affect a primary outcome measure, the estimated *difference* in the predicted rate of helmet use associated with the state law variable, if

respondents from states with helmet laws were more likely than respondents from other states to report helmet use.

Although we cannot determine the extent of reporting bias, there is no reason to believe it was substantial. The survey was not conducted by a governmental agency and, as noted above, respondents were not even told that the main focus was on helmet use. Furthermore, the survey was anonymous and respondents were not asked about the presence of helmet laws in their jurisdiction, a question that might have raised the likelihood of biased responses.

It should also be noted that at the time of the survey, there were about 50 local laws requiring helmet use outside of the states with state laws. These localities accounted for only about 7% of the US resident population in states without state helmet laws. However, to the extent that these local laws increased helmet use in states without state laws, the effect of the state laws would tend to be underestimated.

Finally, the major finding of this study—that state laws substantially increased the likelihood of helmet use—is supported by the results of two published pre-law and post-law studies conducted in Georgia and Oregon.^{17, 18} The laws in both states apply to children under age 16. The Georgia law became effective in July 1993; the Oregon law became effective in July 1994.

The Georgia study was based on an ongoing random digit dial telephone survey of parents of bike riders under age 16. It found that helmet use by children under 16 increased from 33% in the month before the law became effective to an average of about 52% during the five subsequent months. The attributable *difference* between the proportion of Georgia children using helmets during the pre-law and post-law time periods was 19%, almost identical to the 18.4% difference found nationally in the present study.

The Oregon study compared several methods of evaluating the pre-law and post-law change in helmet use. Most prominent were a statewide random digit dial telephone survey of parents of children who rode bicycles and an observational survey of riders in which observations of helmet use were made at 13 sites throughout Oregon.

The results of the telephone survey suggested that helmet use by children rose from 36.8% to 65.7% after the Oregon law was enacted, an attributable increase of 28.9% (65.7% minus 36.8%). The observational survey findings differed somewhat, indicating that helmet use increased from 24.5% to 49.3%, an attributable difference in helmet use of 24.8%—a difference that is generally consistent with the 18.4% difference found nationally in the present study.

It is difficult to make a strong generalization on the basis of a single empirical study. However, the results of this study, when considered within the context of the Georgia and Oregon studies, suggest that state helmet laws may add a sizable segment of all child riders, perhaps on the order of about 20%, to the category of helmet users.

Key points

- While head injuries are often serious, they are largely preventable.
- Nineteen US states and over 50 localities have child helmet laws.
- The analysis controlled for household demographics and rider characteristics.
- State helmet laws significantly increased the rate of helmet use
- State helmet laws increased average helmet use probabilities by almost 20%.
- Laws play an important part in increasing helmet use rates.
- Laws are more effective when combined with education and enforcement.

IMPLICATIONS FOR PREVENTION

An increase of this magnitude suggests that state helmet laws significantly increase the proportion of children who use helmets. However, it also reveals the potential limitations of helmet laws, especially if (as is generally the case) they are not rigorously enforced. Stronger enforcement at the local level presents a number of difficulties,⁸ but would likely improve the effectiveness of helmet laws and is encouraged by some.^{14–20} Helmet laws are also more likely to be effective when combined with comprehensive education and outreach programs.^{10–19–20} Nevertheless, the results of this analysis suggest that state helmet laws, even as they are now constituted and enforced, can still play an important part in getting children to wear helmets.

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