Rates of Bicycle Helmet Use in an Affluent Michigan County

LOUIS B. JACQUES, MD

Dr. Jacques is Assistant Professor, Department of Family Medicine, School of Medicine, Wayne State University, 4201 St. Antoine, UHC 4J, Detroit, MI 48201, telephone 313-543-7770. Tearsheet requests to him.

Synopsis

Bicycle helmet use in the United States has remained low despite clear demonstration of its beneficial effect on reducing the incidence of serious head injury. Several interventions have been reported, with variable results and costs. Much of the recent literature has focused on child cyclists and on demographic factors associated with helmet use.

This paper reports on helmet use by children and adults in a sample of 652 riders in an affluent southeast Michigan region, chosen to minimize the effect of previously recognized socioeconomic negative predictors that are not readily changed by intervention. Subjects were classified by age, sex, location, riding surface, type of bicycle, child bicycle seat use, child bicycle trailer use, and helmet use by companions.

Overall helmet use was 24 percent; infants and toddlers had the highest rate of helmet use at 61 percent, followed by adults at 26 percent and school-aged children at 17 percent. The strongest predictor of helmet use in all age categories was the presence of a helmeted companion. Adult helmet use was also positively predicted by riding in the street and by riding a racing-type bicycle. The use of a city-type bicycle negatively predicted helmet use. For non-adults, female sex and the use of a child seat or trailer were positive predictors. Fostering peer pressure to increase helmet use may be an effective yet relatively inexpensive way to achieve the goal of widespread use of bicycle helmets.

BICYCLE-ASSOCIATED injuries account for an estimated 600,000 emergency room visits yearly in the United States and an estimated 50,000 emergency room visits yearly in Canada (*1–4*) with approximately 0.2 percent of the injuries resulting in death in both countries. In the United States about half of these reflect trauma experienced by children. Several recent studies demonstrate that 70–80 percent of bicycle-related deaths are due to head injury, with pubescent males being at particularly high risk (*5,6*). A recent Harris poll commissioned by Bicycling magazine suggests that 83 million American adults rode a bicycle at least once during the past year (*7*). Factoring in child cyclists, the total number of cyclists easily exceeds 100 million. Since the costs associated with attempts to alter the behavior of half the national population would be enormous, strategies that can lead to optimal allocation of resources by further defining persons at higher risk of injury are valuable.

Although loss of control of the bicycle is the most common circumstance leading to bicycle-related injuries of children, the majority of fatal bicycle accidents involve collision with a motorized vehicle of some kind (*8*). In spite of data indicating that bicycle helmet use can decrease the incidence of serious head injury by 85 percent (*4*), current observations confirm that the use of bicycle helmets remains low unless mandated by law (*2,3,9–14*). Estimates of children's helmet use ranged from 2–5 percent, and overall helmet use hovered around 10 percent in several baseline studies from the late 1980s. Later reports have shown higher overall use of helmets, ranging from 15 percent to 35 percent in some samples (*2,3,9,12*). This proportion remains far below the goal of 50 percent cited in "Healthy People 2000" (*15*). A 1990 middle-school intervention in Oakland County, MI, site of this study, did not include observational findings (*16*). The results of interventional studies have demonstrated inconsistent success in increasing helmet use rates (*3,10,14*).

Factors previously shown to have a positive correlation with helmet use by children are white race, high family income, female sex, riding on a bicycle path, riding on weekends, riding with helmeted companions, and riding a geared bicycle

(*2,3,9,12*). Parental level of education is positively associated with helmet ownership but not with helmet use by children (*11*).

Methods

Several observed characteristics of child and adult cyclists and their equipment were examined with the goal of finding predictors of helmet use. To minimize the effect of low family income, a known negative predictor for helmet use, the sample was taken from a population with a high median family income.

During a 4 weeks' period in early summer 1992, 652 bicycle riders were observed in Oakland County, MI, where the 1989 median household income was $43,407, according to 1980 U.S. Census data (*17*). The study was not publicized. Observation areas were chosen by dividing the eastern half of the county into thirds (north, central, south) and targeting known areas of high bicycle use in each region, such as bicycle paths, regional parks, and schools, as well as suburban neighborhoods, city streets, and rural roads. A total of 15 sites were sampled. The average median household income for the sample locations was $43,804, consistent with that of the county as a whole (1989 median household income, U.S. Census data) (*17*).

As noted by others, the risk of multiple counting of some persons could not be completely controlled, but it was minimized (*2*). Measures taken to avoid counting riders more than once included varying the time and place of the observations, ignoring riders recognized as previously counted, and limiting the observation period to a maximum of 2 hours. With the exception of a bicycle path that was sampled on a weekend afternoon and on a weekday evening, no site was sampled more than once. Cyclists were not stopped or interviewed.

Within the sampling period at each site, all bicycle riders and occupants of bicycle-mounted child seats and bicycle trailers were entered as subjects. Observations were made on sunny days with moderate temperatures. All data were collected by the author, who is a board-certified family physician and an experienced bicyclist. The riders were entered consecutively, allowing subsequent retrieval of information about groupings of riders. The sampling instrument was a half-page checkoff form organized by variable. Information was recorded as to the date and time of day, site location, and type of surface, that is, sidewalk, road, or path. Path was defined as any paved or unpaved nonsidewalk surface not permitting motor vehicles, and it included dedicated bike paths, fields, and wooded areas. All paths sampled in this study were easily accessed by paved roadways.

Table 1. Characteristics of the observed sample of 652 persons

Variable	*Number*	*Percent*
Sex:		
Male	430	66
Female	203	31
Undetermined	19	3
Age:		
Adult	418	64
School-age child	212	33
Infant-toddler	22	3
Surface:		
Sidewalk	48	7
Street	168	26
Path	436	67
Location:		
Urban	10	2
Suburban	452	69
Rural-undeveloped	190	29
Adult bicycle type (418 persons):		
Racing	108	26
Mountain	249	60
City	56	14
Tandem[1]	4	1
Tricycle	1	<1
Infant-toddler bicycle transportation (22):[2]		
Bicycle child seat	18	83
Bicycle trailer	4	17

[1]Four adult riders on 2 tandem bicycles.
[2]All school-age children by definition rode their own bicycle. These were not subclassified further by type.

Bicycle Type

A road or racing bike was defined by down-turned or "aero" handlebars with double or triple chainring (front gear) and rear derailleur; city bikes had upright handlebars with single or multiple speed gearing without aggressive tire tread; mountain bikes had straight or upright handlebars, small frame size relative to rider size, double or triple chainring, rear derailleur and "knobby" tire tread. A tandem is an in-line bicycle built for two, and can be further classified as a road or mountain tandem. Adult tricycles were also included.

Riders were characterized by sex, with a third "undetermined" category for those, mostly infants and toddlers, whose sex could not be determined at the observation distance of approximately 2–20 meters. Age was divided into three categories: toddler-infant, child, and adult. A rider appearing to be post-pubescent was defined as an adult; any rider in a child bicycle seat or bicycle trailer was defined as a toddler-infant. A pre-adult rider on an individual bicycle was defined as a child. This delineation is consistent with the method of previous authors (*3*). Adult riders were further characterized by the type of

Table 2. Use of helmet by 418 adult bicyclists

Variable	Number helmeted	Percent use	χ^2	df	P value
Sex	...	...	0.532	1	NS
Male	72 of 264	27	...	...	...
Female	37 of 154	24	...	...	...
Adult bike type[1]	...	...	24.196	2	<.005
Racing	40 of 108	37	...	...	...
City	1 of 56	2	...	...	...
Mountain	64 of 249	26	...	...	...
Location	...	...	4.319	2	NS
Urban	2 of 10	20	...	...	...
Suburban	53 of 236	22	...	...	...
Undeveloped, rural	54 of 172	31	...	...	...
Weekend rider	...	...	5.844	1	<.025
Yes	94 of 326	29	...	...	...
No	15 of 92	16	...	...	...
Surface	...	...	18.669	2	<.005
Roadway	47 of 114	41	...	...	...
Sidewalk	6 of 29	20	...	...	...
Pathway	56 of 219	26	...	...	...
Helmeted companion	...	...	78.675	1	<.005
Yes	53 of 82	65	...	...	...
No	56 of 336	17	...	...	...

[1]The four riders of tandem bicycles were all helmeted. The lone adult tricycle rider was unhelmeted.
NOTE: *df* = degrees of freedom; NS = not significant.

Table 3. Use of helmets by 234 infants, toddlers, and school-age children

Variable	Number helmeted	Percent use	χ^2	df	P value
Sex[1]	...	...	2.031	1	NS
Male	24 of 164	15	...	...	...
Female	11 of 47	23	...	...	...
Location[2]	...	...	0.551	2	NS
Suburban	44 of 216	20	...	...	...
Undeveloped, rural	5 of 18	28	...	...	...
Weekend rider	...	...	0.728	1	NS
Yes	28 of 146	19	...	...	...
No	21 of 88	24	...	...	...
Surface	...	...	3.578	2	NS
Roadway	10 of 53	19	...	...	...
Sidewalk	1 of 19	5	...	...	...
Pathway	38 of 162	23	...	...	...
Transportation type	...	...	21.593	2	<.005
Own bicycle	36 of 212	17	...	...	...
Child seat	11 of 18	61	...	...	...
Trailer	2 of 4	50	...	...	...
Helmeted companion	...	...	81.443	1	<.005
Yes	26 of 32	81	...	...	...
No	23 of 202	11	...	...	...

[1]Sex was analyzed only for the school-age children, one of whose sex was undetermined. Sex was not analyzed for infants and toddlers because 18 of 22 were of undetermined sex.
[2]No nonadult riders were observed in urban areas.

bicycle ridden, based on observation of bicycle frame type, handlebar shape, gearing, and tire type (see box). Finally, the use or lack of use of a bicycle helmet was recorded.

Grouping of riders was determined by observation of the interaction between riders and by their proximity to one another. All riders were later categorized as to the presence or absence of a helmeted riding companion. This included lone riders, who by definition did not have a helmeted companion. In groups of three or more, the presence of one helmeted rider counted as a helmeted companion for all the other members of that rider's group.

Data Analysis

Bicyclists were divided into adult and nonadult categories for data analysis. Univariate testing of the dependent variable, personal helmet use, was performed by chi-squares. Stepwise multivariate regression, using computer software Minitab, version 8.2, was then performed on an IBM-compatible personal computer (*18*). As an additional measure of helmet use in groups, binomial probability of helmet use for group members was calculated for group sizes of two, three, four, six, and seven. (There were no groups of five in the sample.) The observed frequency of helmet use by group members was determined and compared with the predicted values. Because many of the groups contained both adults and nonadults, the binomial analysis was performed on the total sample.

Results

Characteristics of the sample population are summarized in table 1. Among adult riders, males constituted 71 percent of the racing bike riders, 46 percent of the city bike riders, and 63 percent of the mountain bike riders. Median group size was two with a range from one to seven. Of the riders, 254 rode alone. The racial composition was not specifically recorded, but minorities were informally noted to represent less than 5 percent of the sample.

Bicycle helmet use in the total sample was 24 percent (158 of 652). The percentages of helmet use for each of the observed characteristics are presented in table 2 for adults and in table 3 for infants, toddlers, and school-aged children. Univariate chi-square analysis of adult riders demonstrated statistically significant predictors ($P < 0.05$) of helmet use by type of bicycle ridden, weekend riding, street riding, and riding with a helmeted companion.

Multivariate analysis of adult subjects demonstrated statistically significant positive prediction of helmet use for riding on a street, riding a racing bike, and having a helmeted companion. Riding a city bike was a strong negative predictor (table 4). For children, infants, and toddlers, riding in a child seat or trailer and riding with a helmeted companion were significant univariate predictors at the same level of significance (table 3). Multivariate analysis of nonadults demonstrated significant positive predictive value for riding with a helmeted companion, riding in a child seat or trailer, and female sex (table 5). Binomial expansion of the probability of helmet use by group members demonstrated strong grouping of helmeted and nonhelmeted riders compared with predicted values. Utility of data for groups of more than four riders is limited by few subjects in these categories but is included for completeness (table 6).

Discussion

The difficulties entailed in unobtrusive observational studies of bicycle helmet use are similar to those encountered in other observations, such as measures of seatbelt use (*19*). The practical requirements for observing moving vehicles lead to selection bias in choosing sites for sampling. Whereas one may determine the actual distribution of motor vehicles through State registration records and sample accordingly, such data are not available for bicycles. This consideration limits the application of these findings to the population as a whole.

The possibility of contamination of the sampled riders with riders living outside of Oakland County cannot be eliminated. Such crossover would likely come from Shelby Township or Sterling Heights, which border Oakland County on the east. Because the median household income of residents of Shelby

Table 4. Stepwise regression of adult helmet use predictors

	Step			
	1	*2*	*3*	*4*
Constant	*0.1667*	*0.2013*	*0.1590*	*.01326*
Helmeted companion	0.480	0.462	0.448	0.452
t	9.82	9.61	9.42	9.55
City bicycle type	...	−0.233	−0.214	−0.186
t	...	−4.15	−3.86	−3.28
Riding on street	...	...	0.156	0.141
t	...	...	3.68	3.29
Racing bicycle type	...	...	0.100	
t	...	...	...	2.25
s	0.397	0.389	0.383	0.381
R^2	18.82	22.06	24.54	25.45

$df = N - 2 = 416$ $P \leqslant 0.05$ for all t vales

NOTE: R^2 = coefficient of determination; t = test statistic; s = standard error of the estimate.

Table 5. Stepwise regression of predictors of school-age child-infant-toddler helmet use

	Step		
	1	*2*	*3*
Constant	*0.09845*	*0.08995*	*− 0.03642*
Helmeted companion	0.720	0.728	0.733
t	10.339	10.59	10.74
Infant-toddler age[1]..	...	0.41	0.38
t	...	2.66	2.49
Female sex	...	...	0.103
t	...	...	20.8
s	0.309	0.305	0.303
R^2	33.40	35.55	36.84

$df = N - 2 = 232$ $P \leqslant 0.05$ for all t values

[1]Infant-toddler age is equivalent to the use of a child seat or a trailer because those riders were defined as infants or toddlers.

NOTE: R^2 = coefficient of determination; t = test statistic; s = standard error of the estimate.

Table 6. Binomial probability of helmet use by group members (all subjects), P = 0.24 for individual persons

Number of riders helmeted	Group size 2			3			4			6			7		
	Predicted	Observed	(N)[1]	Predicted	Observed	(N)[1]	Predicted	Observed	(N)[1]	Predicted	Observed	(N)[1]	Predicted	Observed	(N)[1]
0	0.5776	0.7364	(95)	0.4390	0.4138	(12)	0.3336	1.0	(7)	0.1927	0		0.1465	0.50	(1)
1	0.3648	0.0542	(7)	0.4159	0.2758	(8)	0.4214	0		0.3651	1.0	(1)	0.3237	0	
2	0.0576	0.2090	(27)	0.1313	0.1724	(5)	0.1996	0		0.2882	0		0.3067	0	
3				0.0138	0.1379	(4)	0.0420	0		0.1214	0		0.1614	0	
4							0.0033	0		0.0287	0		0.0510	0	
5										0.0036	0		0.0097	0.50	(1)
6										0.0002	0		0.0010	0	
7													<0.0001	0	

[1](N) = number of groups.

> *'Bicycle helmet use remains low even in a sample of an affluent population for whom financial constraints to helmet purchase are minimized. As noted by others, 44 percent of children who own helmets do not wear them. It appears that attempts to increase helmet use by easing helmet availability will be limited by rider motivation.'*

Township ($47,930) and Sterling Heights ($46,470) is higher than that of Oakland County, their inclusion is not believed to undermine the premise of sampling an affluent population (*17*).

The overall helmet use of 24 percent is within a reasonable range compared with other published rates (*2,3,9,12*). Consistent with other reports, adult helmet use is significantly higher than that of school-age children (*2*). The very low level of helmet use in older, school-age children is consistent with previous reports which have noted that children in this age group are at increased risk for serious accidental injury (*8*). Direct adult supervision is reduced in cyclists in this age group compared with children in bicycle seats or trailers, who are de facto accompanied by an older rider, generally an adult. For infants and toddlers, helmet use is a passive activity and represents parental concern rather than toddler-infant attitudes toward helmet use. Because half of the adults, presumably the parents, accompanying helmeted infants-toddlers were themselves unhelmeted, it appears that parents have different behaviors regarding their personal head injury risk. Others have shown a relation between parental use and a child's helmet use (*14*).

The classification of location into sidewalk, road, and path stratified the risk of exposure to motor vehicular traffic; cyclists on bike paths may go for miles before encountering an at-grade intersection with motor vehicle traffic. Sidewalks permit a limited separation from motor traffic, while riding in the road exposes the cyclist to the greatest risk of encountering a motor vehicle. Since the majority of bicycle-related fatalities involve collisions with motor vehicles (*5,6,8*) in this sample, the group at greater risk appears to be taking the greater precaution.

The extensive use of helmets by riders of racing bikes may be a reflection of higher motivation in this group as a subset of the bicycling population observed in this sample, and possibly by perception of increased risk by individual riders. These riders generally ride on public roads and at higher speeds than others.

Mountain bikes, widely perceived as easier to ride compared with racing bikes, have become popular with recreational riders and now represent the largest growth segment of the bicycle industry. As the terrain encountered during sampling was not of a severity to mandate the use of a mountain bike, it is likely that the mountain bike riders in this study overrepresent the casual cyclist. A better representation of non-casual mountain bike helmet use patterns would necessitate observation of riders in more challenging and remote "off-road" terrain.

Since the largest risk of serious head injury is related to bicycle-motor vehicle accidents, the current sample nonetheless reflects a population of mountain bike riders with high-risk exposure. The city bikes as a group appeared to be older and less expensive than either the mountain or racing bikes. It is possible that riders who are more motivated or "dedicated" may be more likely to wear a helmet; they may also be more likely to buy a more expensive or "high-tech" bike. The low rate of helmet use in riders of city bikes may reflect this.

A followup study to examine mileage ridden (as a proxy for motivation) and the choice of bicycle and use or nonuse of a helmet is in progress. The consistency of helmet use or nonuse within individual groups is thought to be a reflection of peer or parental pressure, although this could be, instead, a reflection of the process by which riders select companions.

Conclusion

Lowering the financial burden of helmet ownership does not, by itself, lead to widespread helmet use. Bicycle helmet use remains low even in a sample of an affluent population for whom financial constraints to helmet purchase are minimized. As noted by others, 44 percent of children who own helmets do not wear them (*10*). It appears that attempts to increase helmet use by easing helmet availability will be limited by rider motivation. Though not definitive, the results of this study suggest that, among adults, casual riders may be less likely to wear helmets and may be a promising target for intervention. As a higher rate of helmet use was noted in cyclists with helmeted companions, the decision to wear a helmet may be more influenced by fellow riders than by a formal program directed at unhelmeted riders. Having helmeted cyclists "adopt" a nonhelmeted "buddy" may be a successful tactic at the grassroots level.

Although not without controversy, laws mandating helmet use have been effective in raising rates of use (*13,20*). Precedent for legislating personal safety behavior exists regarding motorcycle helmet use and seatbelt use. Followup monitoring of seatbelt usage showed that the initial increase in use was followed by a significant decrease within a year after passage of the legislation (*19*). In contrast to motorcycle riders, bicycle riders are not generally subject to regulatory licensing and registration, and in large part are children with limited legal culpability. Unless actually riding with their children, parents have little ability to monitor and enforce actual helmet wearing. Adolescent behavior and response to parental directives are certainly problems that transcend bicycle helmet use. Bicyclists often ride in areas that are not routinely subject to police patrol rather than on public roadways. These factors lead to problematic long-term enforcement of helmet use laws. A better long-term solution would be to increase voluntary use. Further research into motivating factors will assist the development of cost-effective interventions.

References

1. Bicycle-related injuries—data from the National Electronic Injury Surveillance System. MMWR Morb Mortal Wkly Rep 36: 269–271, May 8, 1987.
2. Cushman, R., Pless, R., Hope, D., and Jenkins, C.: Trends in bicycle helmet use in Ottawa from 1988 to 1991. Can Med Assoc J 146: 1581–1585, May 1, 1992.
3. DiGuiseppi, C. G., Rivara, F. P., Koepsell, T. D., and Polissar L.: Bicycle helmet use by children. Evaluation of a community-wide helmet campaign. JAMA 262: 2256–2261, Oct. 27, 1989.
4. Thompson, R. S., Rivara, F. P., and Thompson, D. C.: A case-control study of the effectiveness of bicycle safety helmets. N Engl J Med 320: 1361–1367, May 25, 1989.
5. Nixon, J., Clacher, R., Pearn, J., and Corcoran, A.: Bicycle accidents in childhood. Br Med J 294: 1267–1269, May 16, 1987.
6. Simpson, A. H. R. W., Unwin, P. S., and Nelson, I. W.: Head injuries, helmets, cycle lanes, and cyclists. Br Med J 296: 1161–1162, Apr. 23, 1988.
7. Bicycling. Rodale Press, Emmaus, PA 18098, June 1992.
8. Selbst, S.M., Alexande, D., and Ruddy, R.: Bicycle-related injuries. Am J Dis Child 141: 140–144 (1987).
9. Weiss, B. D.: Trends in bicycle helmet use by children: 1985 to 1990. Pediatrics 89: 78–80, January 1992.
10. Towner, P., and Marvel, K.: A school-based intervention to increase the use of bicycle helmets. Fam Med 24: 156–158 (1992).
11. DiGuiseppi, C. G., Rivara, F. P., and Koepsell, T. D.: Attitudes toward bicycle helmet ownership and use by school-age children. Am J Dis Child 144: 83–91 (1990).
12. Weiss, B. D.: Bicycle helmet use by children. Pediatrics 77: 677–679 (1986).
13. Cote, T. R., et al.: Bicycle helmet use among Maryland children: effect of legislation and education. Pediatrics 89: 1216–1220, June 1992.
14. Pendergrast, R. A., Seymour Ashworth, C., DuRant, R. H., and Litaker, M.: Correlates of children's bicycle helmet use and short term failure of school-level interventions. Pediatrics 90: 354–358, September 1992.
15. Healthy people 2000, national health promotion and disease prevention objectives. DHHS Publication No. (PHS) 91–50212. U.S. Government Printing Office, Washington, DC, 1990.
16. Michigan Department of Public Health, Michigan Bicycle Helmet Advisory Committee: Increasing bicycle helmet use in Michigan. Lansing, March 1991.
17. Bureau of the Census: 1990 census of population and housing: summary social, economic, and housing characteristics: Michigan, 1990. CPH-5-24, U.S. Government Printing Office, Washington, DC, 1992.
18. Minitab Inc., 3081 Enterprise Dr., State College, PA 16801-3280.
19. Wagenaar, A. C., and Wiviott, M. B. T.: Effects of mandating seatbelt use: a series of surveys on compliance in Michigan. Public Health Rep 101: 505–513, September-October 1986.
20. Bader, M.: Helmets for child bicyclists. JAMA 263: 1914–1915, Apr. 11, 1990.