

Bicycling Rates and the Prevalence of Bicycle Helmet Usage in Wisconsin

Christian W. Schmidt, MS; Traci R. Snedden, PhD, RN; Kristen M. Malecki, PhD, MPH; Ronald E. Gangnon, PhD; Shoshannah I. Eggers, PhD; Marty S. Kanarek, PhD, MPH

ABSTRACT

Introduction: Bicycles are a source of transportation, recreation, and exercise throughout the world. Bicycling is associated with both health and environmental benefits but also poses a risk of injury. The use of bicycle helmets has been shown to reduce morbidity and mortality associated with cycling. It is unknown if helmet use differs across Wisconsin geographic areas and sociodemographic groups.

Methods: Data were obtained from the Survey of the Health of Wisconsin (SHOW). Bicycle use and helmet use frequency were determined from a self-administered questionnaire that contained questions specific to preventative health behaviors. Descriptive statistics summarized overall bicycle ridership. Chi-square and Student *t* tests were performed to assess relationships between bicycle and helmet use across geographic categories and sociodemographic groups.

Results: Differences between sex, race or ethnicity, and education level were found to be associated with bicycle ridership and the frequency of helmet use. Men were significantly more likely to report riding a bicycle and never wearing a helmet. Individuals from urban communities reported always wearing a helmet more often than rural communities. Higher education levels were associated with higher levels of bicycle and helmet use. Race or ethnicity was not associated with bicycle ridership but was associated with differences in helmet use frequency.

Conclusion: Nearly half of those who ride bicycles in Wisconsin report never wearing a helmet. Since bicycle ridership and helmet use were found to be associated with a number of sociodemographic characteristics, any solution should consider the role of equity when attempting to increase ridership or helmet use.

BACKGROUND

Bicycles are a popular source of recreation, exercise, and transportation throughout the United States and the world. Cycling is related to many health cobenefits pertaining to physical activity

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Author Affiliations: Department of Population Health Sciences, University of Wisconsin School of Medicine and Public Health, University of Wisconsin-Madison, Madison, Wis (Schmidt, Malecki, Gangnon, Eggers, Kanarek); School of Nursing, University of Wisconsin-Madison, Madison, Wis (Snedden); Department of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai, New York, NY (Eggers).

Corresponding Author: Christian Schmidt, 610 Walnut St, 707 WARF Building, Madison, WI 53726; phone 651.829.1542; email cwschmidt@wisc.edu.

and improved environmental air quality.^{1,2} However, it is also a common mechanism of trauma in the United States. In 2009, bicycle-related injuries accounted for nearly 600,000 emergency department visits, 20,000 hospital admissions, and 630 fatalities in the United States.³ The majority of bicycle-related injuries affect the extremities, followed by injuries to the head, face, or spine.⁴ The injuries to the head, face, or spine accounted for nearly 50% of all hospitalizations, having more significant morbidity and mortality than injuries of the extremities.³ It is believed that many of these injuries can be reduced by the use of bicycle helmets. A meta-analysis of the effects of bicycle helmets on injuries found that helmets reduced overall head injury by 48%, traumatic brain injuries by 53%, and facial injuries by 23%.⁵ Helmet usage also was found to reduce serious head injuries and the total number of cyclists that were seriously injured or killed by 60% and 34%, respectively.⁵

Despite the health benefits of cycling and the protective effects of bicycle helmet use, usage rates vary dramatically across the United States and other countries. Some studies have found that trip length—in both time and distance—was strongly associated with helmet use, where cyclists going on a longer trip were more likely to use a helmet.^{6,7} Cyclists who reported not wearing a helmet on short trips stated that they trusted their bicycling ability and did not think they would be injured on their trip.⁸ The path used while cycling also affects helmet usage, where cyclists who ride on roads with traffic were more likely to report wearing a helmet than those on the sidewalk or a bicycle path.⁹ Other characteristics associated with helmet usage in adults are education, income, and age, where, higher levels of education, higher income levels, and older age were associated with increased helmet usage.¹⁰

Figure 1. Bicycle Ridership

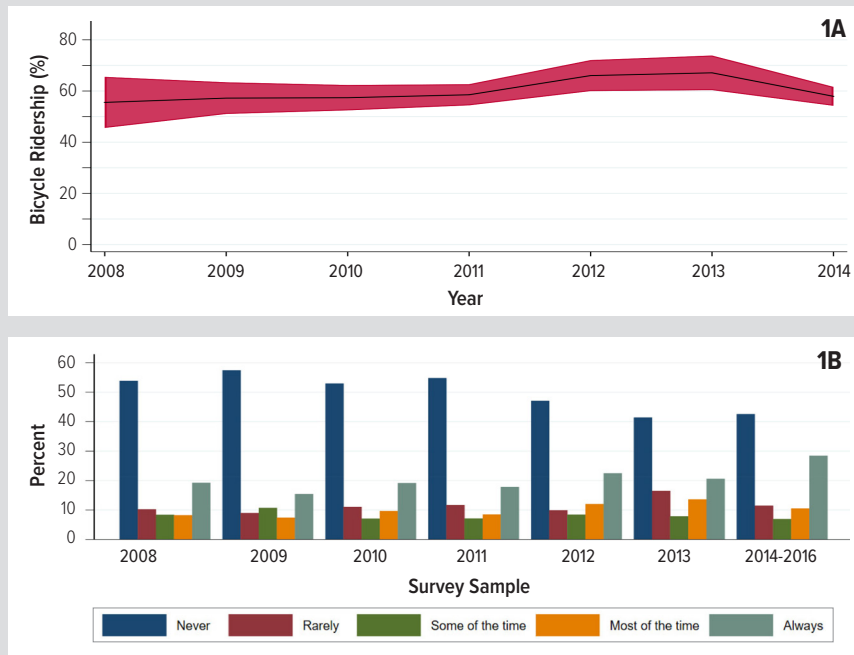


Figure 1A: Ridership over time with the estimates corresponding 95% confidence interval.
Figure 1B: Bicycle helmet usage frequency over time.

Many studies have examined helmet usage outside the United States or focused solely on urban centers of the US coasts, limited municipalities, or school districts. Few studies have examined helmet use in a statewide adult population that includes both urban and rural residents. Using data from the Survey of the Health of Wisconsin (SHOW), and coupled with SHOW's unique sampling methodology, the results of this study narrow the gap of knowledge concerning helmet usage in the Midwestern United States.

METHODS

Data were collected by the Survey of the Health of Wisconsin (SHOW)—an annual research survey that gathers information on the health and health determinants of representative samples of the general population in Wisconsin.¹¹ SHOW has been conducted through the University of Wisconsin School of Medicine and Public Health since 2008 in order to provide a statewide demographic and geographic representation of participants. Data are collected under a Certificate of Confidentiality obtained from the US Department of Health and Human Services.

Analysis was performed on samples collected between 2008 and 2016. Due to changes in the sampling methodology during the 2014-2016 sample, conclusions about the 2008-2013 and 2014-2016 samples are drawn independently, despite their unequal lengths, to maintain the accuracy of the weighting techniques. Study details have been discussed previously by Nieto et al.¹¹ The University of Wisconsin-Madison Health Sciences Institutional Review Board approved the study protocol and informed consent documents. Additional information can be obtained from the Survey Protocol and Manual of Operations downloadable from <http://www.show.wisc.edu/protocol>.

Variables

Rates of bicycle ridership and helmet use were determined per a self-administered questionnaire. Bicycle usage was determined from the respondents who indicated they ride a bike. Helmet use frequency was reported on a 5-point Likert-type scale including "Always," "Most of the time," "Some of the time," "Rarely," and "Never."

Categorization for urban, suburban, or rural setting was determined from rural-urban commuting area (RUCA) codes. RUCA codes utilize measures of urbanization, population density, and daily commuting in determining and assigning codes for communities.¹² A location is considered urban if it is part of the core of a metropolitan area, whereas suburban locations are urban areas not part of the core metropolitan area, and rural locations consist of large, small, and isolated rural locations.

Analysis

Results are reported as weighted means, and statistical analyses were performed using SAS version 9.4 (Cary, North Carolina). Chi-square and Fisher exact tests were used to analyze correlations between helmet use and potential use frequency predictors where appropriate. Student *t* tests were performed to identify differences between the means of bicycle and helmet use for different subpopulations.

RESULTS

Bicycle Ridership

As seen in Figure 1a, the overall mean bicycle ridership in the 2008-2014 sample was 60% (SE 1.4%). The 2014-2016 sample estimated bicycle ridership at 58% (SE 1.8%). In both samples, males were significantly more likely to ride a bicycle than females, with 13.9% higher ridership in the 2008-2013 sample (95% CI, 9.1%-18.7%) and 11.7% higher ridership in the 2014-2016 sample (95% CI, 5.5%-17.9%). In the 2008-2013 sample, non-Hispanic whites were 18.9% (95% CI, 8.7%-29.2%) more likely to ride a bicycle than non-Hispanic blacks or African Americans and 15.7% (95% CI, 3.8%-27.5%) more likely in the 2014-2016 sample. There was a significant difference between participants in urban and rural settings in 2008-2013, with urban residents reporting an 8.2% (95% CI, 2.7%-13.8%) higher ridership than rural residents. Participants with an income of $\geq 400\%$ of the federal poverty level (FPL) reported the highest ridership rates; and those whose income was $< 100\%$ FPL reported the second-highest ridership in both samples. The largest difference in ridership came from those $\geq 400\%$ FPL and 100% to 199% FPL, with an 11.5% difference in the 2008-2013 sample (95% CI, 4.4%-18.6%) and 14.5% difference in the 2014-2016 sample (95% CI, 7.1%-21.9%).

Analysis of the 2008-2013 sample for the relationship of education level and bicycle ridership revealed significantly lower levels

of bicycling in those with a high school-level education or less than those with some college education or an associate's degree (-8.8%; 95% CI, -14.7% to -2.9%), those with a bachelor's degree (-18.7%; 95% CI, -25.6% to -11.9%), and those with post-graduate education (-20.8%; 95% CI, -29.2% to -12.3%). Additionally, there were significantly lower rates of bicycle ridership between those with some college education or an associate's degree and those with either a bachelor's degree (-9.9%; 95% CI, -16.3% to -3.6%) or some post-graduate education (-12.0%; 95% CI, -20.0% to -3.9%). The 2014-2016 sample revealed similar trends. Those with a high school education or less were significantly less likely to ride than those with a bachelor's degree (-20.4%; 95% CI, -30.8% to -10.1%) and those with post-graduate education (-19.6%; 95% CI, -29.6% to -10.0%). There were also significant differences between those with some college or an associate's degree and those with a bachelor's degree (-15.2%; 95% CI, -24.7% to -5.7%) and those with post-graduate education (-14.5%; 95% CI, -23.5% to -5.4%).

Helmet Use Frequency

Over the entire sample, those who reported "never wearing a helmet" comprised the largest helmet use frequency group, averaging approximately 51% in the 2008-2013 sample (Table 1) and 43% in the 2014-2016 sample (Table 2). Those who reported always wearing a helmet were the next-largest subgroup, with 19% of the 2008-2013 sample and 28% of the 2014-2016 sample.

Similar to overall bicycle use, participants' sociodemographic traits correlated with different helmet use frequencies (Tables 1 and 2). In 2008-2013, the rate of males who reported never wearing a helmet was 9.4% (95% CI, 2.5%-16.3%) higher than females, and females were 6.2% (95% CI, 0.9%-11.5%) more likely than males to report always wearing a helmet.

Race and ethnicity were also strongly related to the frequency of helmet use. In the 2008-2013 sample, non-Hispanic whites were 20.0% (95% CI, 6.8%-33.1%) less likely to report never wearing a helmet than non-Hispanic blacks or African Americans. Non-Hispanic "other" race or multiracial participants were less likely to report never wearing a helmet than non-Hispanic whites (-19.3%; 95% CI, -35.4% to -3.2%), non-Hispanic blacks or African Americans (-39.3%; 95% CI, -59.3% to -19.2%), or Hispanics of any race (-27.8%; 95% CI, -50.6% to -4.9%). In the 2014-2016 sample, non-Hispanic whites reported never wearing a helmet significantly less than Hispanics of any race (-29.1%; 95% CI, -42.3% to -15.8%). Additionally, race and ethnicity correlated with how often participants reported always wearing a helmet. In 2008-2013, the rate of non-Hispanic blacks or African Americans who reported always wearing a helmet was significantly lower than non-Hispanic whites (-17.1%; 95% CI, -21.8% to -12.4%) and non-Hispanic other or multiracial participants (-33.1%; 95% CI, -51.0% to -15.1%). In the same sample, non-Hispanic other or multiracial participants reported always wearing a helmet at a significantly higher level than those of Hispanic ethnicity (24.7%; 95% CI, 4.6%-44.9%). In the 2014-2016 sample, those of Hispanic ethnicity reported always wearing a helmet at significantly lower levels than non-Hispanic whites (-25.8%; 95% CI, -33.1% to -18.5%),

non-Hispanic blacks or African Americans (-21.4%; 95% CI, -39.7% to -3.0%), and non-Hispanic other or multiracial participants (-20.0%; 95% CI, -32.3% to -7.6%).

In both samples, urban-rural categorizations were related to helmet use. Participants in rural communities reported the highest levels of never wearing a helmet—13.3% (95% CI, 5.0%-21.5%) and 21.8% (95% CI, 12.7%-30.9%) higher than those who live in urban settings and 13.6% (95% CI, 0.9%-26.4%) and 14.3% (95% CI, 8.2%-20.4%) higher than those from suburban communities, respectively. In 2008-2013, urban participants reported an 11.5% (95% CI, 6.3%-16.7%) higher frequency of always wearing a helmet vs those from rural communities. The 2014-2016 sample supported this; rural participants reported significantly lower levels of always wearing a helmet than those from urban (-21.4%, 95% CI, -29.3% to -13.6%) and suburban communities (-17.0%; 95% CI, -23.1% to -10.8%).

Helmet use frequency increased with income in both samples. Participants with an income \geq 400% FPL were significantly more likely to report always wearing a helmet than those with incomes of < 100%, 100% to 199%, 200% to 299%, and 300% to 399% FPL. The greatest difference was found between those with an income \geq 400% FPL vs those with an income of 100% to 199% FPL in the 2008-2013 sample (15.0%; 95% CI, 9.0%-20.9%) and between \geq 400% FPL and < 100% FPL in the 2014-2016 sample (28.2%; 95% CI, 20.1%-36.3%).

Participants with the highest incomes were also the least likely to report never wearing a helmet. Specifically, those \geq 400% FPL reported significantly lower levels than those < 100% and 100% to 199% in both samples, in addition to those 200% to 299% and 300% to 399% FPL in the 2014-2016 sample. In both samples, the largest variation occurred between those \geq 400% FPL and < 100% FPL (-16.4%; 95% CI, -28.3% to -4.5% and -28.3%; 95% CI, -43.0% to -13.5%, respectively).

Education level was associated with bicycle helmet use as well. In the 2008-2013 sample, a significantly higher proportion of those with a high school education or less reported never wearing a helmet than those with some college or an associate's degree (12.5%; 95% CI, 4.0%-21.0%), those with a bachelor's degree (28.5%; 95% CI, 19.8%-37.3%), and those with post-graduate education (42.8%; 95% CI, 32.9%-52.7%). Having some college or an associate's degree was associated with higher levels of never wearing a helmet than having a bachelor's degree (16.1%; 95% CI, 7.8%-24.3%) or post-graduate education (30.3%; 95% CI, 20.9%-39.8%). Additionally, having only a bachelor's degree was associated with a higher rate of never wearing a helmet than having post-graduate education (14.3%, 95% CI, 4.6%-24.0%).

The same trend emerged in the 2014-2016 sample. Those with a high school education or less or some college experience or an associate's degree reported a higher rate of never wearing a helmet than those with a bachelor's degree (39.1%; 95% CI, 30.5%-47.7%; and 27.5%; 95% CI, 18.1%-36.9%, respectively) and those with post-graduate experience (47.6%; 95% CI, 39.7%-55.6%; and 36.0%; 95% CI, 27.2%-44.9%, respectively). Having some post-graduate education vs a bachelor's degree also correlated with significantly lower reported rates of never wear-

Table 1. Frequency of Helmet Use Based on Sociodemographic Traits (2008-2013)

Variable	N	Always (%, SE)	Most of the Time (%, SE)	Some of the Time (%, SE)	Rarely (%, SE)	Never (%, SE)
Overall	1661	19.34 (1.40)	10.06 (1.13)	8.26 (0.99)	11.51 (0.97)	50.83 (1.89)
Sex						
Male	806	16.61 (1.75)	10.51 (1.44)	7.22 (1.14)	10.71 (1.40)	54.95 (2.56)
Female	855	22.82 (2.04)	9.50 (1.28)	9.59 (1.38)	12.51 (1.34)	45.58 (2.41)
Age (mean, SE)	1661	47.37 (0.89)	43.64 (1.25)	42.19 (1.25)	40.00 (1.23)	41.31 (0.69)
Race						
Non-Hispanic white	1479	19.45 (1.40)	10.22 (1.25)	8.11 (1.04)	11.49 (1.09)	50.73 (1.99)
Non-Hispanic black or African American	67	2.35 (1.97)	5.17 (2.88)	8.47 (3.21)	13.29 (4.98)	70.72 (6.41)
Hispanic (any race)	43	10.67 (5.07)	20.16 (8.02)	6.20 (4.46)	3.75 (2.67)	59.22 (8.49)
Non-Hispanic other or multiracial ^a	70	35.41 (8.94)	4.76 (2.68)	12.52 (4.82)	15.83 (6.18)	31.47 (7.97)
Urban-rural classification						
Urban	857	23.28 (2.09)	9.73 (1.27)	8.20 (1.19)	11.67 (1.35)	47.13 (2.67)
Suburban	252	18.99 (3.63)	13.04 (3.89)	7.02 (1.71)	14.21 (1.85)	46.75 (5.61)
Rural	552	11.76 (1.63)	9.11 (2.03)	9.06 (2.28)	9.70 (1.53)	60.38 (3.28)
Income level						
<100% FPL	166	18.55 (4.78)	5.61 (2.61)	6.23 (2.47)	8.79 (2.86)	60.81 (5.47)
100%-199% FPL	267	8.93 (1.76)	6.63 (1.75)	10.37 (2.16)	14.27 (2.55)	59.79 (3.36)
200%-299% FPL	250	16.78 (2.78)	10.99 (2.93)	9.66 (2.12)	9.69 (2.22)	52.89 (4.24)
300%-399% FPL	282	21.94 (2.77)	9.95 (2.25)	4.43 (1.39)	12.99 (2.38)	50.68 (3.80)
400+% FPL	289	23.92 (2.47)	12.23 (1.79)	9.46 (1.60)	9.98 (1.80)	44.41 (2.64)
Education level						
High school or less	386	10.86 (1.90)	2.98 (0.98)	3.98 (1.07)	13.51 (2.24)	68.67 (3.24)
Some college or AA	630	13.75 (1.74)	8.34 (1.83)	9.74 (1.82)	11.96 (1.48)	56.20 (2.88)
Bachelor's degree	427	28.59 (2.57)	11.69 (1.83)	9.31 (1.71)	10.28 (1.72)	40.13 (3.06)
Post-graduate studies	218	31.56 (4.02)	24.13 (3.38)	9.27 (2.12)	9.18 (2.83)	25.86 (3.88)

Abbreviations: FPL, federal poverty level; AA, associate's degree.

^aNot black or African American.**Table 2.** Frequency of Helmet Use Based on Sociodemographic Traits (2014-2016)

Variable	N	Always (%, SE)	Most of the Time (%, SE)	Some of the Time (%, SE)	Rarely (%, SE)	Never (%, SE)
Overall	932	28.49 (2.71)	10.54 (1.25)	6.93 (0.95)	11.46 (0.74)	42.59 (3.06)
Sex						
Male	447	25.38 (3.15)	9.87 (1.44)	7.10 (1.27)	11.73 (1.62)	45.93 (3.72)
Female	485	32.17 (3.05)	11.32 (1.52)	6.72 (1.53)	11.14 (1.02)	38.65 (3.19)
Age (mean, SE)	932	47.48 (0.88)	44.23 (1.02)	43.29 (2.14)	40.50 (2.24)	41.91 (1.15)
Race						
Non-Hispanic white	803	30.04 (2.80)	10.90 (1.23)	7.22 (1.05)	11.76 (0.60)	40.08 (3.03)
Non-Hispanic black or African American	42	25.60 (9.04)	2.78 (2.78)	2.81 (2.15)	8.82 (4.64)	60.00 (12.26)
Hispanic (any race)	35	4.23 (2.47)	10.37 (5.88)	8.32 (3.78)	7.95 (3.29)	69.13 (6.04)
Non-Hispanic other/ or multiracial ^a	50	24.21 (5.80)	11.46 (4.50)	4.53 (0.98)	12.12 (6.12)	47.68 (8.89)
Urban-rural classification						
Urban	519	34.89 (3.58)	12.57 (1.54)	5.67 (1.12)	11.22 (1.50)	35.64 (4.26)
Suburban	152	30.42 (2.58)	9.59 (1.63)	7.59 (2.36)	9.23 (1.04)	43.16 (2.53)
Rural	261	13.45 (1.80)	6.63 (1.19)	9.29 (1.54)	13.22 (0.87)	57.42 (1.81)
Income level						
<100% FPL	78	14.67 (3.09)	5.40 (1.56)	5.62 (2.67)	16.79 (4.86)	57.53 (6.34)
100%-199% FPL	136	16.93 (2.64)	11.01 (3.51)	6.22 (0.94)	12.77 (2.73)	53.07 (3.82)
200%-299% FPL	145	19.32 (4.12)	7.55 (2.38)	8.34 (2.69)	11.90 (3.82)	52.90 (5.18)
300%-399% FPL	115	16.81 (3.12)	11.51 (4.34)	10.67 (3.22)	11.63 (3.43)	49.37 (5.38)
400+% FPL	423	42.87 (2.76)	12.88 (1.70)	5.95 (1.01)	9.03 (1.73)	29.27 (4.07)
Education level						
High school or less	189	8.91 (1.73)	8.38 (2.88)	5.66 (1.74)	11.98 (2.44)	65.07 (3.52)
Some college or AA	311	20.66 (2.68)	7.94 (1.97)	5.95 (1.58)	11.99 (1.58)	53.46 (4.03)
Bachelor's degree	272	38.25 (3.43)	13.72 (1.84)	9.09 (1.73)	12.96 (1.67)	25.98 (2.60)
Post-graduate studies	160	55.14 (4.33)	13.48 (2.86)	6.96 (1.59)	6.99 (2.22)	17.44 (2.03)

Abbreviations: FPL, federal poverty level; AA, associate's degree.

^aNot black or African American.

ing a helmet (-8.5%; 95% CI, -15.0% to -2.1%).

In fact, the higher the participants' education level, the more likely they were to report always wearing a helmet. In both samples, those with post-graduate education or a bachelor's degree were significantly more likely to report always wearing a helmet than those with a high school education or less or those with some college education or an associate's degree. In the 2014-2016 sample, there were also significant differences between those with a high school education or less and those with some college education or an associate's degree (-11.8%, 95% CI, -18.0% to -5.5%) as well as between those with a bachelor's degree vs post-graduate education (-16.9%; 95% CI, -27.7% to -6.1%), with the higher education level more frequently reporting always wearing a helmet.

DISCUSSION

Wisconsin has a sizable bicycle-riding population, which our study estimates between 55% and 67% statewide. Historically, Wisconsin also has been ranked one of the most bicycle-friendly states by organizations such as The League of American Bicyclists.¹³ However, approximately half of bicycle riders report never wearing a helmet. These factors are influenced by sociodemographic characteristics such as sex, race and ethnicity, urban-rural categorizations, and education level. Because Wisconsin and the United States are both in the midst of an obesity epidemic—over 30% of Wisconsin adults are obese—interventions to increase bicycle ridership should be of interest with regard to public health.¹⁴

Despite the desirability of increasing bicycle ridership across Wisconsin, an equally important public health issue is the low rate of helmet use. Although the level seems to be decreasing over time, approximately half of the state's bicycle-riding population report never wearing a helmet. Additionally, it is evident that disparities in helmet use frequency exist between different subpopulations. Both of these factors prompt solutions.

One factor that has been shown to influence bicycle helmet usage is the presence of helmet-use legislation. A systematic review from Karkhaneh, et al determined

an odds ratio of 4.60 (95% CI, 2.87-7.36), where helmet usage increases more than 4 times after legislation was put into place.¹⁵ Currently, 21 states, along with the District of Columbia, have some sort of helmet-requirement law in place for minors.¹⁶ These laws require cyclists ranging from 11 years old and younger to 17 years old and younger to wear a helmet while riding a bicycle. However, no states currently have legislation that requires adults to wear a helmet while cycling, and legislation alone does not necessarily increase helmet usage. An important aspect of improving usage rates further is having some sort of enforcement or incentive program in place.¹⁵ For example, a longitudinal study done by Huybers, et al found that after all-age helmet legislation was put into place in Nova Scotia, helmet usage did not improve until police began issuing more tickets to noncompliant cyclists.¹⁷ The new program allowed citizens to forgo a fine or court appearance in exchange for attending an educational program delivered by health professionals, police officers, and injury survivors.

Different enforcement techniques have been developed to improve helmet usage, ranging from fines for nonadherence, to supplying helmets to minors at no cost, or giving incentives for wearing helmets. When designing such legislation and interventions, it is important to remember that sociodemographic characteristics affect helmet usage and to seek equitable solutions that will improve the health for all.¹⁸

Study Limitations

One limitation of this study arises from how the rates of bicycle use were defined by the SHOW study and the lack of other information pertinent to bicycle use, such as the purpose (eg, commuting or recreation), frequency of use, and length of trips. Instead, all bicycling activities are categorized similarly, despite the assumption that different activities may predispose certain individuals to greater risks where one may be more or less likely to wear a helmet. For example, those who participate in mountain biking may have different helmet use than those who ride only on roads or bicycle paths, or those who regularly commute via bicycle may have different use than those who rarely ride. Because the inherent risks of bicycling activities may be higher for certain individuals, this lack of other information may limit the effectiveness of any interventions.

Another study limitation is that the sample sizes pertaining to certain demographic groups are small due to a lower rate of overall bicycle ridership, which can make conclusions about them less precise and generalizable. Additionally, survey research can be affected by other biases, such as social desirability bias, recall bias, and differences in survey response rate by certain populations.

CONCLUSION

The low rates of bicycle ridership and helmet usage throughout Wisconsin are concerning to public health professionals. The findings of this study contribute knowledge specific to population-level demographic characteristics that affect helmet usage and serve as an important first step in reducing bicycle morbidity and mortality through improved helmet usage. Implementing public health initiatives and policy recommendations may help improve

rates of bicycling and helmet use; however, such policies must acknowledge the differences between population groups in order to reduce these disparities while also promoting equity.

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