

Helmet Use in North Carolina Following a Statewide Bicycle Helmet Law

Final Project Report for the North Carolina Governor's Highway Safety Program



**Libby Thomas
William W. Hunter
John R. Feaganes
Robert D. Foss**

**University of North Carolina
Highway Safety Research Center**

December 2002

**Helmet Use in North Carolina
Following a Statewide Bicycle Helmet Law**

**Final Project Report
for the
North Carolina
Governor s Highway Safety Program**

**Libby Thomas
William W. Hunter
John R. Feaganes
Robert D. Foss**

**University of North Carolina
Highway Safety Research Center
Chapel Hill, NC**

December 2002

EXECUTIVE SUMMARY

In anticipation of legislation, and to provide background information prior to this proposed legislation, the North Carolina Governor's Highway Safety Program sponsored a 1999 statewide survey of bicycle helmet use. These data were used to estimate a baseline, pre-law helmet wearing rate as well as gather other information on bicyclist characteristics as they related to helmet use tendencies.

In the spring and summer of 2002, approximately six months following the effective date of the mandatory helmet use law, the University of North Carolina Highway Safety Research Center (HSRC) repeated the statewide observational survey. We employed the same methodology and sampling locations used in 1999 in order to obtain comparable, post-law estimates of helmet use and again evaluate bicyclist characteristics related to use. We altered age groupings slightly for the 2002 survey to reflect the ages affected by the law as it was written. When we performed the survey in 1999, proposed legislation suggested that the law would affect those 13 years of age and under. When legislation was passed in 2001, the law mandated use by those ages 15 and under.

Survey results indicate that helmet use has increased by a modest amount compared with use estimated from the 1999 survey. Statewide helmet use estimated from the probability sample of on-street locations was 24% for helmet use (includes correct and incorrect use) in 2002 compared to 18% in 1999. Statewide, correct use of helmets was estimated at 20% in 2002 compared to 14% in 1999. Helmet use was again lowest in the Coastal Plain, which showed no increase over the 1999 level (total use estimated at 9% from on-street locations), followed by the Piedmont region (25%), with highest use in the Mountain region (46%). As in 1999, observed helmet wearing rates were higher at greenways (55%) and mountain biking locations (89%) compared to on-road locations (30% on collector streets; 19% on local streets; unweighted data). Factors correlated positively with helmet use include use of gloves, use of road bikes, use of backpacks, riding in the mountain region, being female, and riding on weekends. Factors negatively correlated with helmet use include not using gloves or backpacks; use of child, or other adult bikes; riding in the coastal plain; being male; and riding on weekdays.

As in the 1999 survey, adults had higher observed helmet use rates than children. Despite being covered by the statewide helmet law, helmet use observed at on-street locations by those ages zero to 15 years was approximately 16% while that for ages 16 and up was nearly 30% (unweighted data for helmet use). School aged children (six to 15 years) had the lowest helmet use of any age group. Additionally, larger gains in helmet use were shown by adults than by children targeted by the law. Bicycle helmet use by children, zero to 18 years of age (combined for analyses due to the change in age groupings), increased from 12% during the 1999 survey to 16% during the 2002 survey (unweighted percentages from on-street locations). Adult (ages 19 years and up) helmet use increased from 27% in 1999 to 32% in 2002 (also unweighted values).

As expected from the above comparisons, statistical analyses indicate that the law failed to generate a differential increase in helmet use by children ages zero to 15 years, mandated to wear helmets, compared with those ages 16 and above and not covered by the law. Although the

difference in helmet use between surveys (1999 pre-law and 2002 post-law) was significant, it is clear that the helmet requirement has had little effect on increasing helmet use by children thus far. Increases in helmet use among both children and adults may simply be due to an upward trend over time unrelated to the law. It is also possible that the law has had a small effect in increasing helmet use among children, but that parents and other adults (perhaps to model good behavior) are also wearing helmets at a higher rate in response to the law. An increase in adult use attributable to the law would be a positive benefit. But the relatively modest increases among both children and adults indicate that much greater effort in promoting proper helmet use and enforcement of the helmet law is needed to obtain the bicycling safety improvement among children desired from this law.

The relationships of other bicyclist characteristics indicated by this study to be negatively correlated with helmet use provide insight for targeting helmet promotion and enforcement campaigns. Efforts should be focused particularly in the coastal plain and to a lesser extent, the Piedmont. An effort should be made to reach more casual adult riders, which may be reflected by those lacking specialized gear such as riding gloves, road bikes, and backpacks. Children and adults riding casually in neighborhoods, where we saw the lowest helmet use among all the location types in both survey years, should also be a primary focus of helmet use campaigns. Additionally, male bicyclists appear to use helmets significantly less frequently than do females. Males also comprise nearly 80% of cyclists observed during both surveys, as well as more than 80% of bicyclists involved in reported crashes with motor vehicles in North Carolina from 1997 - 1999. These data suggest that an additional focus on persuading male bicyclists to use safety helmets is warranted.

Table of Contents

	Page
Executive Summary	i
Background	1
Methods	1
Results	3
Observed helmet use by location type	3
Misuse of helmets	6
Statewide and regional estimates of helmet use	8
Helmet use by children and adults	9
Effects of the law and other factors	10
Discussion	16
Acknowledgments	18
References	19
Appendix A	20
Appendix B	22

Background

On October 1, 2001, the state of North Carolina began mandating approved safety helmet use by bicyclists 15 years and under riding on public roadways and other public thoroughfares. In anticipation of legislation, and to provide background information prior to this proposed legislation, the North Carolina Governor's Highway Safety Program sponsored a 1999 statewide survey of bicycle helmet use. These data were used to estimate a baseline, pre-law helmet wearing rate as well as gather other information on bicyclist characteristics as they related to helmet use tendencies.

In the spring and summer of 2002, approximately six months following the effective date of the mandatory helmet use law, the University of North Carolina Highway Safety Research Center (HSRC) repeated the 1999 spring and summer, statewide survey. We employed the same methodology and sampling locations in order to obtain comparable, post-law estimates of helmet use and again evaluate bicyclist characteristics related to use.

Methods

In order to replicate as closely as possible the survey as performed in 1999, the same probability sample was used. This sample was stratified into the three geographic regions of the state, with the number of cities to be selected per region pre-established for a total of 26 cities. The number of cities per region was based on proportion of regional population to statewide population, but adjusted to achieve a minimum of four cities for the region with the smallest population (the mountain region). The cities were selected randomly, but with a probability of selection weighted according to population. Four cities were selected from the mountain region, six from the coastal plain, and sixteen from the Piedmont. Due, however, to sampling with replacement, Charlotte was selected four times and Greensboro, twice, resulting in 12 different Piedmont cities, 22 different cities overall.

Larger towns and cities could not be sampled in their entirety. As in 1999, two types of on-street sampling locations were visited in order to maximize the types of bicyclists seen. We visited the same two school-based neighborhoods in cities of less than 60,000 population, or the same four neighborhoods in cities of 60,000 or greater population. The same maps developed for the 1999 survey were used for sampling collector routes, defined as roads connecting local or neighborhood streets. (For more details of the sample and methodology, see Hunter, Foss, Stutts, Perriello, and Tolbert, 1999.) Observations were made by a pair of data collectors while driving through the selected neighborhoods and collector streets. Streets in both the selected neighborhoods and the collector routes were driven once on a weekend and once on a weekday, for approximately two hours each, recording data on every bicyclist observed.

Observations were also made at a majority of the same greenways and mountain biking trails as in 1999. Some of the trails visited in 1999 were no longer being used, and a few were dropped due to our having made few observations there in 1999. Trail locations were sampled from a stationary position by walking to an appropriate site. These locations were not part of the

probability sample (in either year), but provided additional information about helmet use in North Carolina.

The same observations were performed as in 1999, and included data on helmet use (yes, no, or misused), estimated age, gender, bicycle type, and presence of a backpack or bicycling gloves. We also made an effort to record type of misuse for every misuse case observed. Location, date, time, weather, observer, site type, and other identifying information were recorded for each collection location. The only difference in 2002 is that two age groups were altered slightly in order to distinguish children up to age 15 - those covered by the law as it was actually written. In 1999 we could only estimate the age groups that would be affected by any subsequent law. The legislation that had been introduced prior to the first survey included children age 13 and under. When the helmet law was actually passed in 2001, the affected ages included children up to age 15. The age groups were as follows:

1999 survey - 0 - 5, 6 - 13, 14 - 18, 19 - 30, 31 - 50, and 51+ years

2002 survey - 0 - 5, 6 - 15, 16 - 18, 19 - 30, 31 - 50, and 51+ years

As in 1999, HSRC staff and two outside two-person teams performed the data collection. The two outside teams covered the Asheville and Brevard communities and the Charlotte area communities (Charlotte, Gastonia, Mint Hill, Statesville, and Shelby), while HSRC staff collected data in the remaining 15 cities (see Appendix A for a complete list of sampled cities and results by city). Data collectors received an updated version of the 1999 training manual and training in data collection techniques. Data collection began April 26 and was completed on August 10, 2002.

We estimated statewide and regional helmet use rates using the probability sample of on-road locations (collector and neighborhood [local] streets). For these estimates, observations were weighted according to the probability of selection (by the number of cities selected in a region, by city population/regional population, and by the number of observations). Logistic models of combined data from 1999 and 2002 were used to analyze the associations of bicyclist characteristics (including location variables) with helmet use ('any helmet use' which included correct and incorrect use) as the dependent variable. There is greater confidence in 'any helmet use' than in 'correct helmet use' since some misuse may have gone unnoticed. Hereafter, helmet use will imply any use, including incorrect use of helmets, unless specifically noted otherwise. We also used logistic modeling to assess the effect of the statewide helmet law on helmet use. Using logistic regression, we were able to control for the effects of the other variables. Due to the slightly different make-up of age categories between 2002 and 1999, age groups were combined into three groups for the purposes of these analyses as well as other between survey years comparisons. The three youngest age groups from both years were combined into a 0 - 18 group; 19 - 30 year-olds comprised the second age group, and the two eldest adult groups of 31 - 50 and 51+ were combined into one group. A variable was also created to indicate whether the observed cyclist was covered by the helmet law or not (based on observed age and year of survey).

Results

The statewide observed sample distributions were very similar to those from the 1999 survey (Table 1). We saw fewer riders overall in 2002, but this result probably reflects differences in weather and temperatures between the two sample periods, as well as a slightly earlier start date in 2002 (before local schools were out). Additionally, some Charlotte neighborhoods which were inadvertently re-sampled in 1999 were not sampled twice in 2002. We also visited fewer trail locations in 2002 due to trails being closed or to a low number of observations in 1999.

The greatest population difference in bicyclist characteristics (other than helmet use) between surveys was in Bicycle Type. Six percent more *child bikes* were observed in 2002 than in 1999, 1% more *road bikes* were observed, while 3% fewer *mountain bikes*, and 4% fewer *other adult bikes* were observed. The levels of the remaining variables - Region, Location Type, Age Group, Glove Use, Backpack Use, and Part of Week - were within one to three percentage points of 1999 levels.

Observed helmet use by location type

Across the state, observed helmet use by Location Type and year is shown in Table 2. Helmet use in 2002, which includes both correct and incorrect helmet use, was again lowest overall on *local streets* (19%), higher on *collector streets* (30%), with substantially higher use on *greenways* (55%) and *mountain biking trails* (90%). Correct helmet use observed in 2002 was 16% on *local streets*, 27% on *collector streets*, 52% on *greenways*, and 88% on *mountain biking trails*.

Table 2. Observed helmet use by location type and year - total sample (unweighted data).

Location Type	% Any Helmet Use		% Correct Helmet Use		Sample n	
	1999	2002	1999	2002	1999	2002
Local Streets	16	19	13	16	1116	848
Collector Streets	25	30	22	27	592	513
Greenways	42	55	37	52	404	369
Mountain Biking trails	84	90	80	88	336	219
Total N					2448	1949

Table 1. Total sample distributions of observed bicyclist characteristics for 1999 and 2002
 (Frequencies are given, followed by percentage of yearly observations in parentheses.)

	1999	2002
Statewide	2448	1949
<i>Coast</i>	685 (28)	497 (25)
<i>Piedmont</i>	1549 (63)	1245 (64)
<i>Mountains</i>	214 (09)	207 (11)
Location Type		
<i>Local streets</i>	1116 (46)	848 (44)
<i>Collector streets</i>	592 (24)	513 (26)
<i>Greenways</i>	404 (16)	369 (19)
<i>Mtn. Biking trails</i>	336 (14)	219 (11)
Age Group		
0 - 5	104 (04)	42 (02)
6 - 13	557 (23)	n/a
6 - 15	n/a	648 (33)
14 - 18	404 (17)	n/a
16 - 18	n/a	156 (08)
0 - 18 combined	1065 (45)	846 (44)
19 - 30	653 (27)	504 (26)
31 - 50	552 (23)	462 (24)
51+	108 (05)	125 (06)
Gender		
<i>Male</i>	1936 (80)	1500 (77)
<i>Female</i>	486 (20)	444 (23)
Bicycle Type		
<i>Mountain</i>	1477 (61)	1134 (58)
<i>Road</i>	230 (10)	212 (11)
<i>Other adult</i>	219 (09)	88 (05)
<i>Child's (small wheels)</i>	482 (20)	503 (26)
Glove Use		
<i>Yes</i>	396 (17)	320 (17)
<i>No</i>	2001 (83)	1584 (83)
Backpack use		
<i>Yes</i>	358 (15)	278 (15)
<i>No</i>	2053 (85)	1619 (85)
Part of week		
<i>Weekend</i>	1327 (54)	1044 (54)
<i>Weekday</i>	1121 (46)	905 (46)

Figure 1 shows observed helmet use by age group at the different types of riding locations in 2002. Teens, 16 to 18 years, an age group not covered by the helmet law, had among the lowest observed helmet use at all types of sites except for off-road *mountain biking trails* (16% on *local streets*; 14% on *collector streets*; 43% on *greenways*; and 100% of a relatively small sample at *mountain biking trails*.) School-aged children, from 6 to 15 years and covered by the helmet law, also exhibited low helmet use at on-street locations (14% on *local streets*; 19% on *collector streets*) with higher percentages at *greenways* and *mountain biking* locations (59% and 75%, respectively). The youngest aged children (0 to 5 years) also wore helmets less frequently than adults (other than the 51+ group) when observed on *local streets* (21%) and *collector streets* (33%). Adults 31 to 50 years used helmets most often at on-street locations (31% on *local*, 42% on *collectors*) followed by adults 19 to 30 years (25% on *local*, 40% on *collectors*), while the oldest age group (51+ years) used helmets less frequently (24% on *local streets*, 16% on *collectors*). Teens and older adults (51+ years) were also observed to wear helmets less frequently on *collector streets* than on *local streets*. All age groups wore helmets 60% of the time or more at *mountain biking trails* and at least 43% of the time at *greenways*.

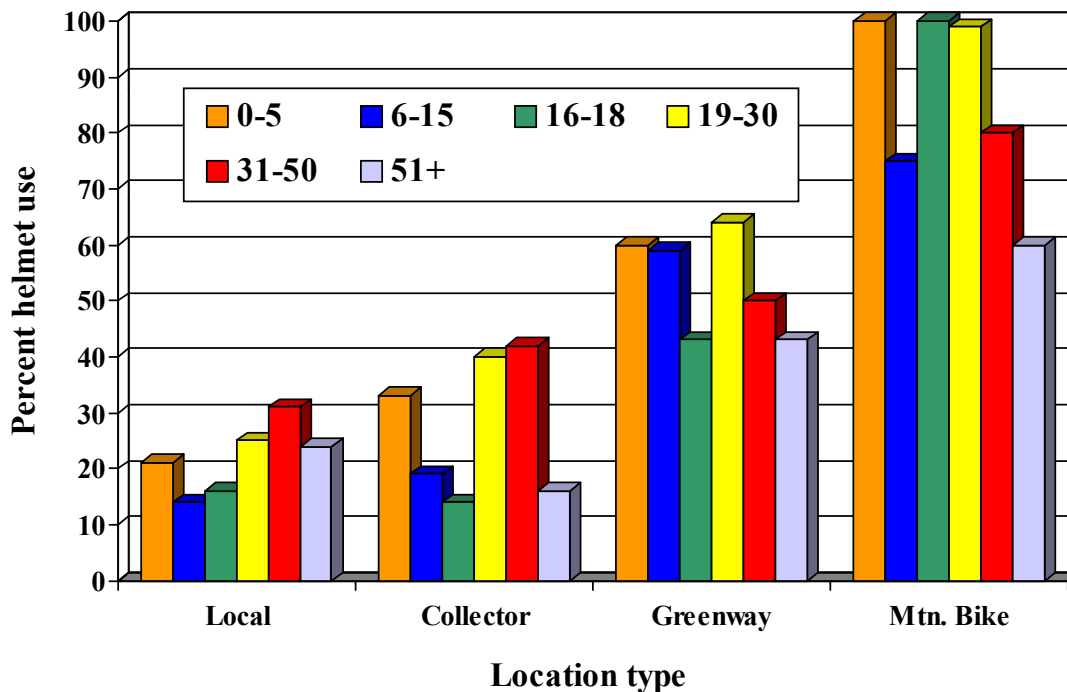


Figure 1. Observed helmet use by age and location type - 2002 North Carolina statewide survey.

Misuse of helmets

In the 2002 survey, we again recorded helmets as either *correctly used*, *misused*, or *not used*. Overall, slightly under 3% (or 58 cases) of bicyclists were observed to be misusing helmets at all locations (Table 3). Eight percent of the 717 helmets being *worn* were, therefore, misused.

The highest misuse was observed on *local streets* at 16% of helmets worn, followed by 12% on *collector streets*, 5% on *greenways*, and 2% on *mountain biking trails*. Helmets were also apparently misused at a higher rate on *weekdays* (11% of those worn) compared to *weekends* (7%). The youngest age group misused helmets 17% of the time they were worn; 21% of helmets were misused by *6 to 15 year olds*, and 16% by *16 to 18 year olds* (Table 3). Adults misused helmets less frequently than children (as a percentage of helmets worn), but misuse among the oldest age group was higher (11%) than among the other adult age groups (3% and 4%). As might be expected, misuse was also higher for those on *child bikes* (21%) compared to those on *mountain* (6%) and *road* (4%) *bicycles*. There were so few (only 3 observed) helmets worn by those on *other adult bikes* that misuse cannot be stated with precision (although one of the three observed was being misused). Figure 2 illustrates graphically the proportions of *misuse* and *correct helmet use* by age group.

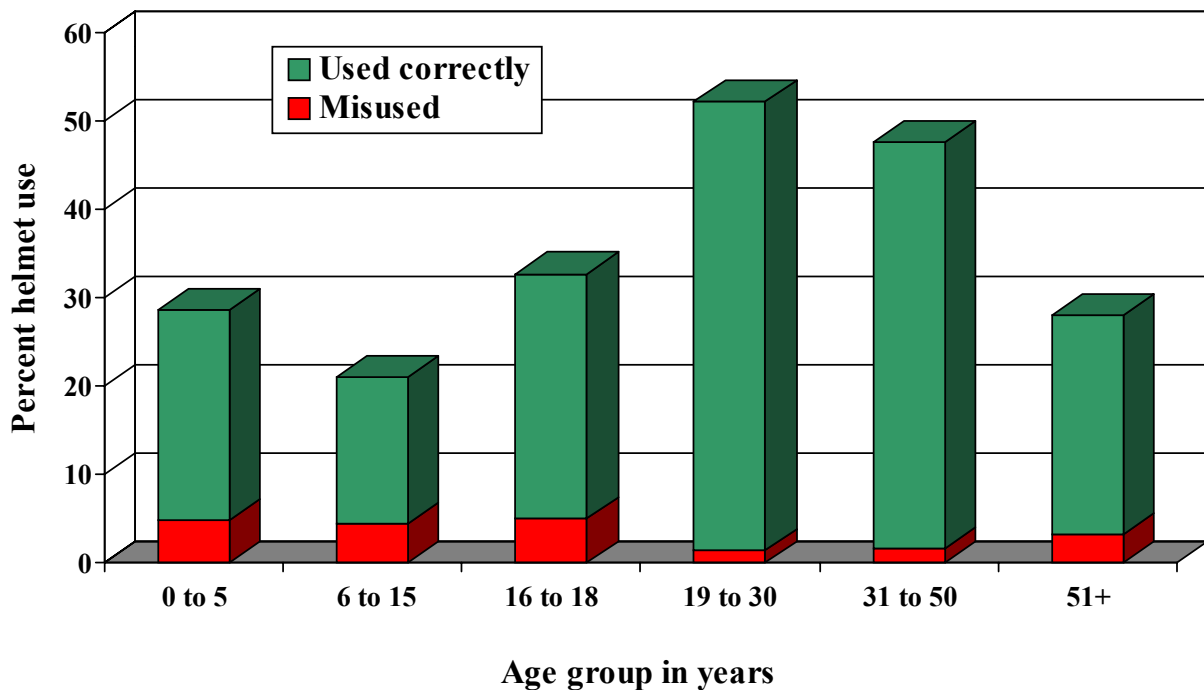


Figure 2. 2002 survey proportions of misused and correctly used helmets by age group - all locations.

Table 3. Misuse of helmets as a percentage of helmets used - total 2002 sample.

Variable	# Helmets used (incl. misused)	# Misused	Misuse % of Helmets Used
Region			
<i>Coast</i>	52	9	17
<i>Piedmont</i>	545	41	8
<i>Mountains</i>	120	8	7
Location Type			
<i>Local</i>	164	26	16
<i>Collectors</i>	154	18	12
<i>Greenways</i>	203	10	5
<i>Mtn. Biking</i>	6	4	2
Part of Week			
<i>Weekend</i>	481	33	7
<i>Weekday</i>	236	25	11
Age group			
<i>0 - 5 years</i>	12	2	17
<i>6 - 15</i>	136	29	21
<i>16 - 18</i>	51	8	16
<i>19 - 30</i>	263	7	3
<i>31 - 50</i>	220	8	4
<i>51+ years</i>	35	4	11
Gender			
<i>Male</i>	544	42	8
<i>Female</i>	173	16	9
Bicycle Type			
<i>Mountain</i>	474	30	6
<i>Road</i>	139	6	4
<i>Other adult</i>	3	1	33
<i>Child's</i>	100	21	21
Glove Use			
<i>Yes</i>	296	5	2
<i>No</i>	400	53	13

The type of misuse was recorded for 52 of the 58 cases (Table 4). The largest percentage, about 40% of misuse cases, was due to helmets being tipped back exposing the forehead (often related to a too-small helmet). Another 31% of misused helmets were obviously too large or with loose chin straps, while 17% of riders misusing helmets were wearing hats or scarves beneath the helmet. Another 8% had unhooked chin straps, and 2% were other types of misuse (such as wearing a helmet that obviously was not an approved safety helmet).

Table 4. Distribution of types of helmet misuse observed in 2002 survey.

Type of Misuse	% of Misuse
Tipped back	40
Too large, loose strap	31
Hat or scarf beneath	17
Unhooked chin strap	8
Other	2



Helmet tipped back exposing the forehead

Statewide and regional estimates of helmet use

The probability sample for this survey, as in 1999, included local and collector streets and did not include the greenway and mountain biking trail observations. Thus, the weighted estimates of statewide helmet use reported here are based only on the data from on-street locations. North Carolina helmet use (any use) estimated from on-street locations for 2002 is 24.3% +/- 4.4% (95% confidence intervals) compared to 17.8% +/- 2.8% for 1999 (Table 5). Correct helmet use is estimated at 20.3% +/- 4.2% for 2002 compared to 14.2% +/- 2% for 1999. (The earlier reported estimates for 1999 were slightly higher, but with larger confidence intervals based on equal weighting of data from local and collector streets. See Hunter, et al., 1999.)

By region, 2002 helmet use (correct and misuse) was estimated to be 9.2% +/- 2.8% for the coastal plain compared to 9.5% +/- 2.8% for 1999. Helmet use in the Piedmont was estimated at 25.5% +/- 5.7% compared to 18.8% +/- 3.6% in 1999. Helmet use in the mountain region was estimated at 46% +/- 10.1% compared to 40% +/- 8.9% in 1999. Correct helmet use in the coastal plain was estimated at 7.6% +/- 2.6% for 2002, virtually identical to 7.6 +/- 2.4% estimated for 1999. Correct helmet use in the Piedmont was estimated at 21% +/- 5.3% compared to 14.7% +/- 2.6% in 1999. Correct use for the mountain region was estimated at 42.9% +/- 9.9% compared to 34.3% +/- 8.5% in 1999. It is not appropriate to provide estimates of use for other variables due to the sampling design. (We do provide estimates by city in Appendix A, but these estimates should be interpreted with caution as this survey was designed to produce accurate statewide estimates, not accurate city by city estimates, and confidence intervals are generally quite large.)

Table 5. Weighted estimates of total and correct helmet use in North Carolina and by region from pre-law and post-law observational surveys.

Region	1999 Estimate with 95% Confidence Interval	2002 Estimate with 95% Confidence Interval
Statewide		
Any use*	17.8% +/- 2.8%	24.3% +/- 4.4%
Correct use	14.2% +/- 2.0%	20.3% +/- 4.2%
Coast		
Any use	9.5% +/- 2.8%	9.2% +/- 2.8%
Correct use	7.6% +/- 2.4%	7.6% +/- 2.6%
Piedmont		
Any use	18.8% +/- 3.6%	25.5% +/- 5.7%
Correct use	14.7% +/- 2.6%	21.0% +/- 5.3%
Mountains		
Any use	40.0% +/- 8.9%	46.0% +/- 10.1%
Correct use	34.3% +/- 8.5%	42.9% +/- 9.9%

*Any use includes both correct and incorrect use of helmets.

Helmet use by children and adults

We were primarily interested in what happened to helmet use among children covered by the new law. Table 6 shows unweighted helmet use data (on-street locations) for all observed age groups by survey year. Observed helmet use rates for *6 to 15 year olds* (covered by the helmet law) were the same as for *16 to 18 year olds* (not covered by the law) in 2002 at 15%, the lowest rates by age group. Observed use among *0 to 5 year olds* was slightly higher at 22% (although an apparent decrease from 1999).

As in the 1999 survey, adults generally showed higher helmet use rates than children in 2002 at 33% observed for *19 to 30 years*, 36% for *31 to 50 years*, and 20% for *51+ years* (on-street locations). Since some of the child age groups were different between the two surveys due to the ages affected by the law being different than anticipated in 1999, age groups were combined for further analyses and between years comparisons (see the lower portion of Table 6). In 2002, helmet use observed among ages *0 to 15* and covered by the helmet law, was approximately 16% while that for ages 16 and up was nearly 30%. Figure 3 illustrates graphically the observed helmet use rates by year for the three combined age groups used in the logistic analyses. Observed helmet use for children, *0 to 18 years* of age (includes those 0 to 15 covered by the law), increased from approximately 12% to 16%, a gain of 33% over 1999 observed rates. Observed helmet use for adults aged *19 to 30* went from 25% to 33% in 2002, a gain of 32%, while increases for adults 31 and up were slightly more modest, from 29% to 32%, a gain of 10%. (The observed increase for all adults 19 and up was from 27% to 32%, a 19% increase.)

Table 6. Observed NC helmet use by age group at on-street locations.

Age group	% Helmet Use 1999	% Helmet Use 2002	% Change
0 - 5	28 (n=92)	22 (n=36)	-21%
6 - 13 (1999)	12 (n=497)	n/a	n/a
6 - 15 (2002)	n/a	15 (n=569)	n/a
14 - 18 (1999)	7 (n=344)	n/a	n/a
16 - 18 (2002)	n/a	15 (n=110)	n/a
19 - 30*	25 (n=349)	33 (n=297)	+32
31 - 50	32 (n=297)	36 (n=253)	+12
51+	15 (n=68)	20 (n=85)	+33
0 - 15 (2002 combined)	n/a	16 (n=605)	n/a
16 + (2002 combined)	n/a	30 (n=745)	n/a
0 - 18 (combined)*	12 (n=933)	16 (n=715)	+29
19+ (all adults combined)	27 (n=714)	32 (n=635)	+19
31+ (combined)*	29 (n=365)	32 (n=338)	+10

*The three groups shown in figure 3 and used in logistic analyses.

Effects of the law and other factors

Results of logistic regression analyses indicate those variables with significant correlations with helmet use (Table 7). There was a significant increase in helmet use between survey years (1999 and 2002) with other factors in the model (Year effect, $p = .0251$), but there was no differential increase for those 15 and under and covered by the law compared with those not covered (Law effect, $p = .6527$). Region, Bicycle Type, Glove Use, Backpack Use, Gender, and Part of Week all had statistically significant differences with respect to overall helmet use. Riding Location Type was nearly significant ($p = .1268$). As noted previously, riders on *collector streets* were observed to wear helmets about 30% of the time compared with 19% observed on *local streets*; these differences did not, however, result in significant differences in the odds of being helmeted with other factors included in the logistic model. Covariation among factors complicates the ability to separate effects on helmet use. For example, cyclists using gloves and road bikes were more commonly observed on collector streets than on neighborhood streets, whereas child bicyclists are observed in greater proportions on neighborhood streets. Age Group also appeared non-significant in predicting helmet use, although differences were likely obscured by combining age groups into only three levels.

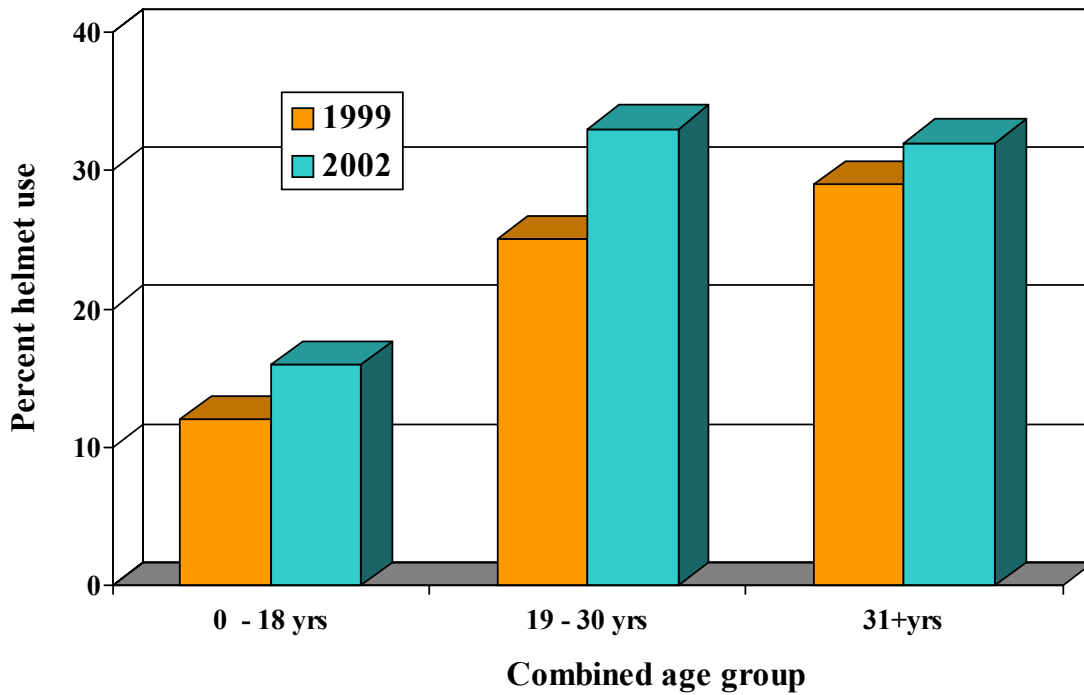


Figure 3. Observed helmet use by age group at on-street locations during pre- and post-law surveys.

Table 7. Logistic regression results: observed bicyclist characteristics association with helmet use.

Contrast	Degrees of freedom	P-value
Overall model	15	0.0000
Region	2	0.0000
Location Type	1	0.1268
Age group (three combined)	2	0.6290
Bicycle Type	3	0.0000
Glove Use	1	0.0000
Backpack use	1	0.0221
Gender	1	0.0004
Part of week	1	0.0009
Year	1	0.0251
Law	1	0.6527

Table 8 shows the odds ratios (OR) for the variable effects on helmet use. Glove Use had the strongest association with helmet use across the two surveys. The odds of wearing a helmet for those using bicycling gloves was 57 times the odds for those not wearing gloves. The odds for *road bike* riders wearing a helmet was nearly three times that for *mountain bike* riders while *child bike* and *other adult bike* riders had lower odds (0.6 and 0.2, respectively) of wearing a helmet than *mountain bike* riders (OR = 1). The odds of *females* being helmeted were nearly three times the odds of *males* being helmeted. Figures 4, 5, and 6 illustrate the relationships between the variables Glove Use, Bicycle Type, and Gender, and helmet use.

Another characteristic strongly associated with helmet use was cyclist's Region of the state. Riders observed in the *mountains* had nearly three times the odds of wearing a helmet as *Piedmont* riders, and nearly seven times the odds of *coastal plain* riders (Table 8, Fig. 7).

Among other significant factors, Backpack users had nearly two times the odds of using a helmet as those not wearing backpacks (Table 8, Fig. 8). *Weekend* riders had twice the odds of being helmeted as *weekday* riders (Table 8, Fig. 9). The odds of riders being helmeted during the 2002 survey were nearly 90% higher than the odds of riders being helmeted in 1999.

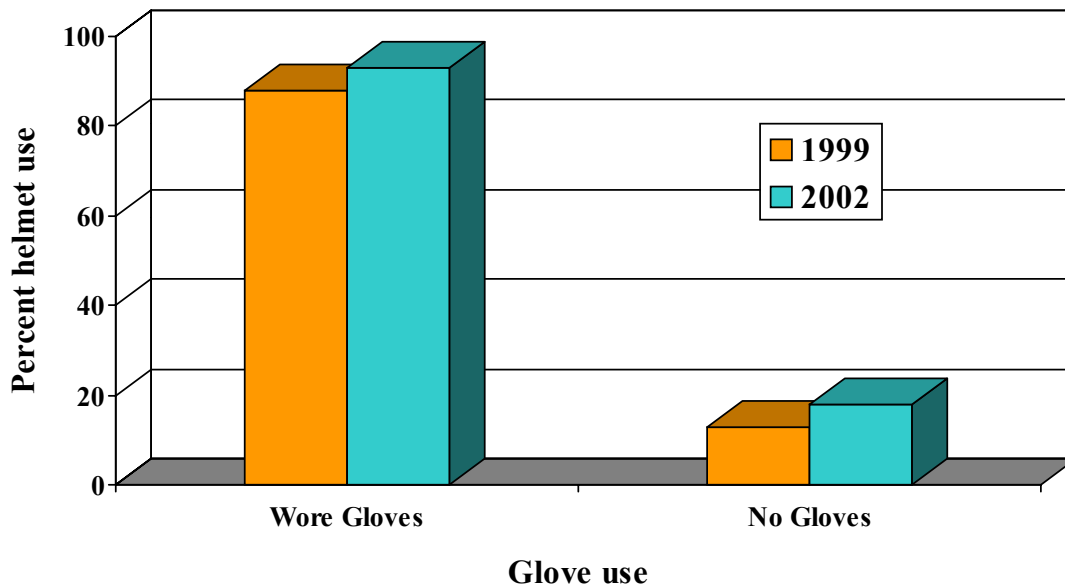


Figure 4. Observed helmet use by glove use at on-street locations during 1999 and 2002 surveys.

Table 8. Odds ratios for helmet use by observed bicyclist characteristics.*

Bicyclist characteristics	Odds Ratio	Lower 95% limit OR	Upper 95% limit OR
Region			
<i>Coastal</i>	0.40	0.27	0.59
<i>Piedmont</i>	1.00	1.00	1.00
<i>Mountains</i>	2.72	1.68	4.41
Riding location			
<i>Collector streets</i>	1.42	0.90	2.23
<i>Neighborhoods</i>	1.00	1.00	1.00
Age group			
<i>0 - 18 years</i>	0.91	0.45	1.82
<i>19 - 30 years</i>	0.78	0.44	1.35
<i>31+ years</i>	1.00	1.00	1.00
Bicycle Type			
<i>Mountain</i>	1.00	1.00	1.00
<i>Road</i>	2.83	1.59	5.05
<i>Other adult</i>	0.25	0.12	0.51
<i>Child</i>	0.61	0.37	0.98
Glove Use			
<i>Yes</i>	57.07	26.73	121.81
<i>No</i>	1.00	1.00	1.00
Backpack use			
<i>Yes</i>	1.85	1.10	3.09
<i>No</i>	1.00	1.00	1.00
Gender			
<i>Male</i>	0.36	0.22	0.59
<i>Female</i>	1.00	1.00	1.00
Part of Week			
<i>Weekend (S,S)</i>	1.00	1.00	1.00
<i>Weekday (M-F)</i>	0.50	0.34	0.72
Year of survey			
<i>1999</i>	1.00	1.00	1.00
<i>2002</i>	1.86	1.09	3.16
Law			
<i>Covered by law</i>	1.00	1.00	1.00
<i>Not covered</i>	1.17	0.58	2.35

*All independent variables are shown, even if non-significant in overall model.

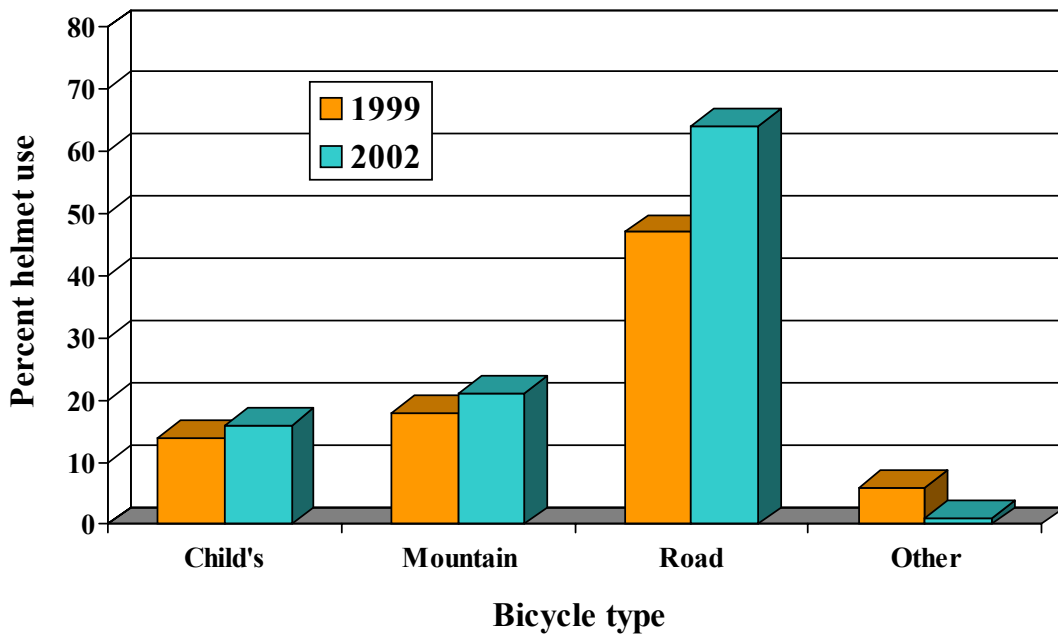


Figure 5. Observed helmet use by bicycle type at on-street locations during 1999 and 2002 surveys.

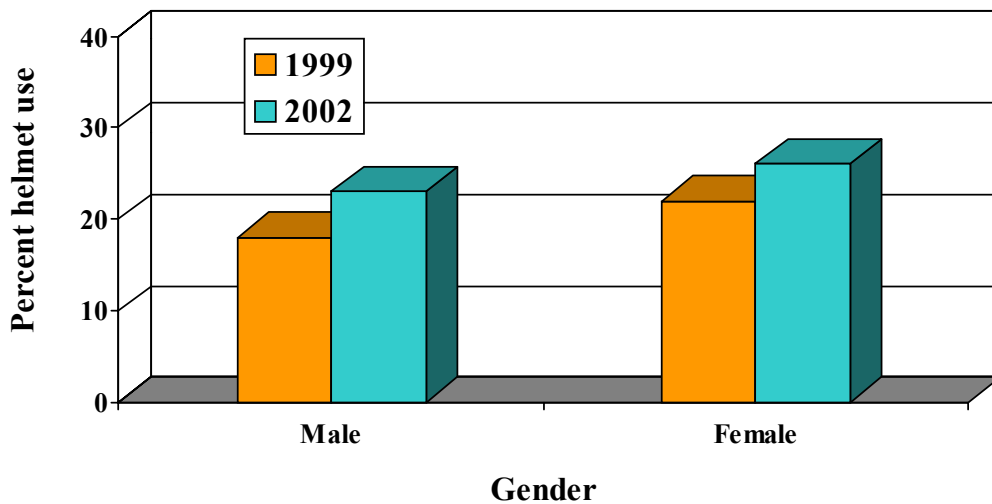


Figure 6. Observed helmet use by gender at on-street locations during 1999 and 2002 surveys.

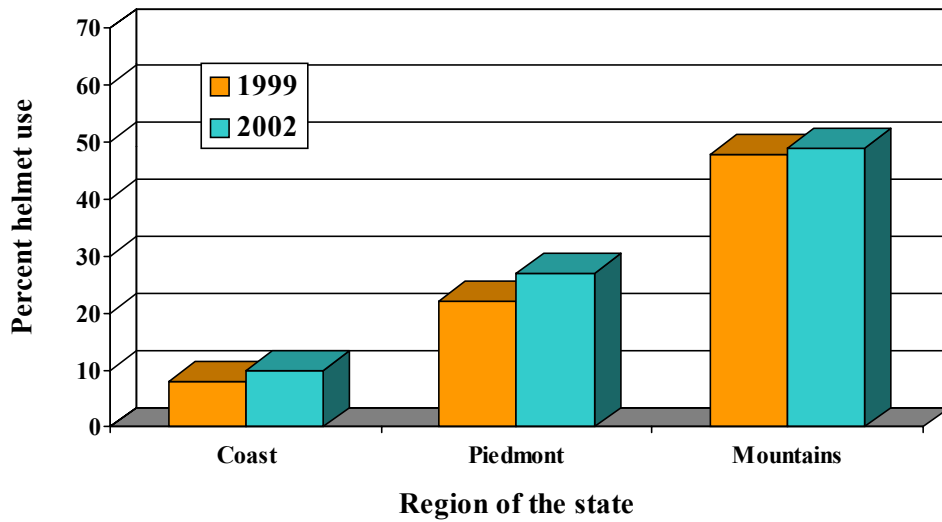


Figure 7. Observed helmet use by NC geographic region at on-street locations during 1999 and 2002 surveys.

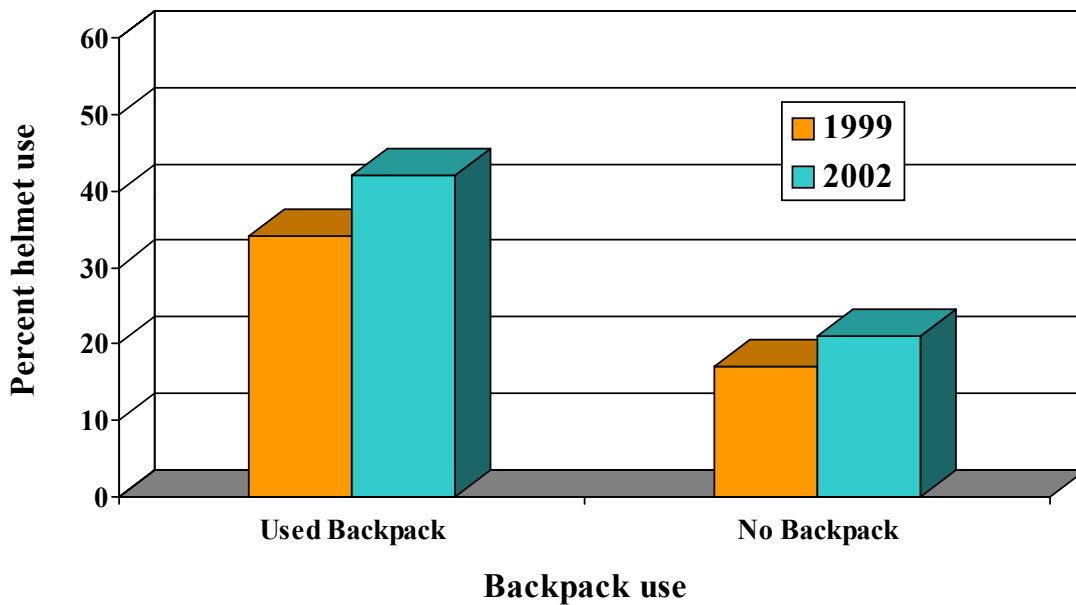


Figure 8. Observed helmet use by backpack use at on-street locations during 1999 and 2002 surveys.

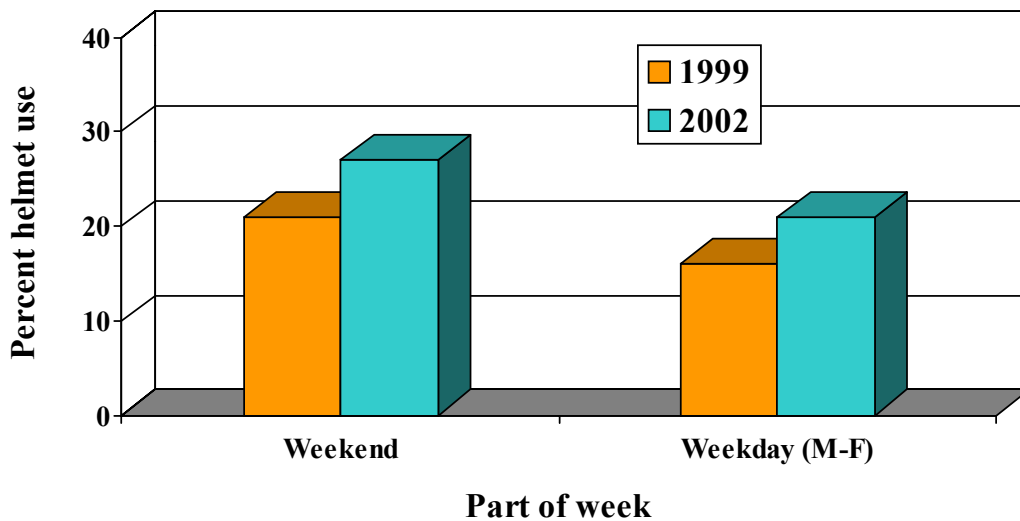


Figure 9. Observed helmet use by part of week at on-street locations during 1999 and 2002 surveys.

Discussion

Following the 2001 enactment of a statewide law mandating use of bicycle safety helmets by riders under 16 years of age, we repeated a statewide observational survey of bicycle helmet use. This survey, conducted in late spring and summer of 2002, replicated as closely as possible a pre-law survey performed in 1999, in order to allow between surveys comparisons.

The variable distributions indicate that we observed a very similar population of riders during the 1999 and 2002 surveys. There was some shift in bicycle type with proportionally more child bicycles, particularly, and proportionally fewer mountain bicycles and other adult bicycles. These changes may be indicative of continued growth in popularity of the BMX type bicycles since 1999, which were categorized as child bikes due to their small wheels.

Helmet use on local and collector streets is still distressingly low, with an *overall statewide estimate of 24%, compared with approximately 18% estimated from the 1999 data.* The mountain region of the state seems to be doing better than the other two geographic regions, with on-street use estimated at approximately 46% compared with 40% in 1999. At least one of the mountain communities (Boone) has had a helmet ordinance in place since 1995. (See Appendix B

for a listing of NC communities with helmet ordinances.) We also suspect, however, that the mountainous topography in the western part of the state may affect rates of helmet use by reducing bicycle riding among less devoted cyclists who are less likely to wear a helmet. By the same token, continued low use rates of less than 10% in the eastern region may also reflect topography. The flat nature of the coastal plain may encourage a greater proportion of riding by less dedicated bicyclists. Helmet use in the Piedmont region falls in between that in the two outer regions of the state, as does the topography, and is close to the statewide estimate at about 26%, compared with approximately 19% in 1999.

As in 1999, helmet use observed at off-road trails and greenways during the 2002 survey was considerably higher than at on-street locations. While public greenways are covered by the helmet law, mountain biking trails may not be if they are not considered ‘public thoroughfares.’ Some mountain biking trails may, however, post site-specific rules requiring helmet use, and with the conditions inherent to mountain biking, most of these riders - approximately 90% - have adopted helmet use for its obvious protective benefits. Helmet use was also higher among all age groups at greenways than at on-street locations. Observed helmet use for all ages was approximately 55% at greenways, compared with observed use of 19% and 30% on local and collector streets, respectively. These results are not intuitive, since there would seem to be greater risk of serious injury at on-street locations, and may suggest that the types of riders frequenting greenways are different from those riding on streets. Alternatively, the type of ride could be perceived as different. For example, on greenways, there may be more families riding together with parents supervising helmet use, whereas riding in the neighborhood may be more spontaneous or casual. Bicyclists observed at greenways may also be more safety conscious.

Helmet use was also more likely among weekend riders than weekday riders, even after controlling for other factors associated with helmet use. It is difficult to explain why weekend riders differ from weekday riders with respect to helmet use. The weekend does differ, however, from the weekday by providing greater leisure time for many individuals. Taken together, the above results suggest that recreational riders, both those who make an effort to go to an off-road bicycling location, as well as those riding during leisure time on weekends, including enthusiasts riding for extended periods, may have greater awareness of the importance of helmet use and/or means to acquire and use helmets than non-recreational riders. Additional data would be required to ascertain why recreational riders might be more prone to using helmets and whether this is indeed the case.

Despite being covered by the statewide helmet law, children riding at on-street locations wear helmets at an unacceptably low rate. *Observed helmet use for children up to 15 years of age is only about 16% at on-street locations statewide.* Additionally, about one-fifth of helmets used by children are misused, with the largest percentage of misuse being due to helmets tipped back exposing the forehead. Wearing a helmet tipped back involves 50% greater risk of head injury when compared with a properly centered (level) helmet (Rivara, et al. 1999).

Not only are children covered by the law lagging behind adults in helmet use, but larger gains in helmet use were shown by adults than by children from 1999 to 2002. It is clear from these results, as well as from our statistical analyses, that the helmet requirement has had little effect on increasing helmet use by children thus far. Increases in helmet use among both children and adults may simply be due to an upward trend over time unrelated to the law. It is, however,

possible that the law has had a small effect on increasing helmet use among children, but that parents and other adults (perhaps to model good behavior) are also wearing helmets at a higher rate in response to the law. An increase in adult use attributable to the law would be a positive benefit. But the relatively modest increases among both children and adults indicate that much greater effort in promoting proper helmet use and enforcement of the helmet law is needed to obtain the bicycling safety improvement among children that was desired from this law.

The relationships of other bicyclist characteristics with helmet use offer insight into other populations, in addition to children, that should be targeted by helmet promotion campaigns. Efforts should be focused particularly in the coastal plain and to a lesser extent, the Piedmont. An effort should be made to reach more casual adult riders, which may be reflected by those lacking specialized gear such as riding gloves, road bikes, and backpacks. Children and adults riding casually in neighborhoods, where we saw the lowest helmet use among all the location types in both survey years, should also be a primary focus of helmet use campaigns. Teen bicyclists, including those 16 to 18 years who are outside the mandate of the helmet law, exhibited the lowest helmet wearing rates during both surveys. Additionally, male bicyclists appear to use helmets significantly less frequently than do females. Males also comprise nearly 80% of cyclists observed during both surveys, as well as more than 80% of bicyclists involved in reported crashes with motor vehicles in North Carolina from 1997 - 1999. These data suggest that an additional focus on persuading males to use bicycle safety helmets is warranted.

Acknowledgments

This study was supported by the North Carolina Governor's Highway Safety Program (GHSP) under Project Number TR_02-09-10. The opinions, findings, and recommendations contained herein are those of the authors and do not necessarily represent those of GHSP.

We particularly wish to acknowledge University of North Carolina Highway Safety Research Center staff members Charles Hamlett and Thomas Meadows, as well as Adam Cann, Erin Little, Jacob McGahey, and Bevin Kletter-Fell, for assistance with data collection. We also wish to thank representatives of local government agencies and businesses, including Steve Hancock of the City of Charlotte, who provided information regarding off-road facilities in their communities, as well as assistance in recruiting data collectors.

References

Hunter, W. W, R. D. Foss, J. C. Stutts, P. D. Periello and W. G. Tolbert. Statewide Survey of Bicycle Helmet Use in North Carolina. Chapel Hill, N.C.: University of North Carolina Highway Safety Research Center, 1999.

North Carolina Department of Transportation, Division of Bicycle and Pedestrian Transportation website. Retrieved 12/13/02 from http://www.pedbikeinfo.org/pbcat/facts_bike.cfm.

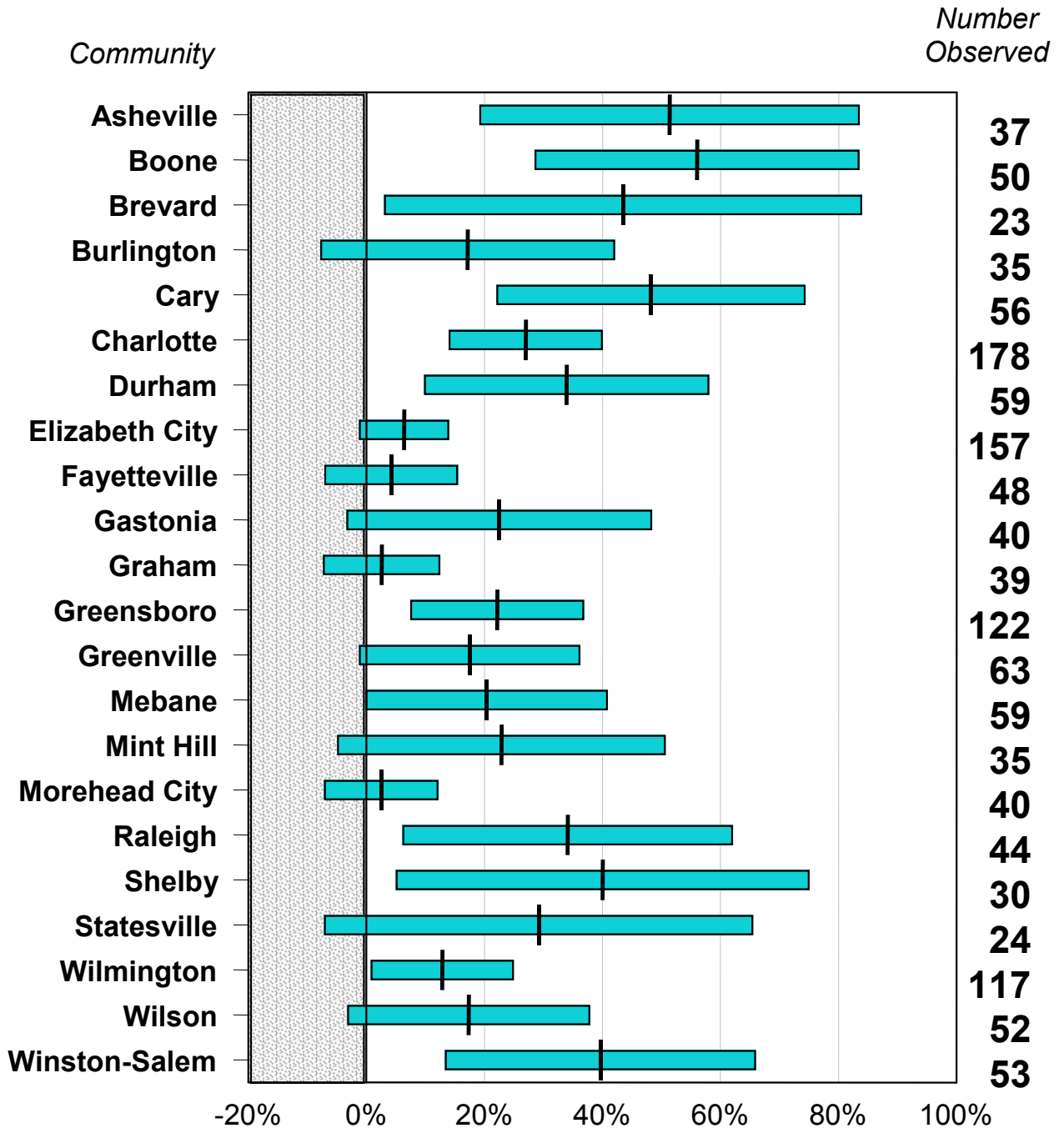
Rivara, F.P., Astley, S.J., Clarren, S.K., Thompson, D.C., and Thompson, R.S. (1999). Fit of bicycle safety helmets and risk of head injuries in children. *Injury Prevention* 5, 194-197.

Helmet use in NC following a statewide bicycle helmet law

APPENDIX A

Estimates of 2002 Helmet Use for Cities Included in Survey

95% Confidence Intervals for Helmet Use in Cities Where Observations Were Conducted - 2002



Note. Vertical line indicates observed use. Horizontal bar indicates range within which true use rate is likely to fall. Although helmet use less than 0% is not possible, confidence intervals are symmetric. Since many are wide, and use rates are low, several of these extend to negative values.

Helmet use in NC following a statewide bicycle helmet law

APPENDIX B

North Carolina Communities known to have bicycle helmet ordinances

APPENDIX B

North Carolina Communities known to have bicycle helmet ordinances

Community	Affected ages	Year implemented
Black Mountain	All ages	2001
Boone	All ages	1996
Carolina Beach	Under 16	1994
Carrboro	Under 16	1997
Cary	Under 16	2001
Chapel Hill	Under 16	1992
Charlotte*	Under 16	2002
Cornelius*	Under 16	2001
Greenville	Under 16	1998
Matthews*	Under 16	2001

*Helmet use required for other wheeled modes as well as bicycles.

Sources:

Bicycle Helmet Safety Institute. (n.d.). Helmet laws for bicycle riders. Retrieved November 26, 2002 from <http://www.helmets.org/mandator.htm>

The (NC) Charlotte Observer archives.