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Bicycle Accidents: An Examination Of Hospital Emergency Room Reports and Comparison with Police Accident Data

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HSRC - PR157
January 1988

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Paper Presented at the

**67 Annual Meeting of the
Transportation Research Board
National Research Council
Washington, D.C.**

January 11-14, 1988

Acknowledgments

Funding for this project has been provided by the North Carolina Governor's Highway Safety Program and the Centers for Disease Control. Particular appreciation is expressed to Ms. Melissa Marion with the North Carolina Department of Transportation Bicycle Program for her role in initiating this joint effort between the medical and University communities.

Abstract

Bicycle accident data collected by ten North Carolina hospital emergency rooms during the summer of 1985 and 15 hospital emergency rooms during the summer of 1986 are analyzed and compared with State police-reported data. Two-thirds of those treated in the hospital emergency rooms were children under the age of 15 and 70 percent were male. Only a fifth of the emergency room bicycle accident cases involved collisions with a motor vehicle, and only ten percent appeared on State accident files. Results confirm that in addition to not providing any information on bicycle-non motor vehicle accidents, police accident files miss a substantial portion of the bicycle-motor vehicle accidents. Combining the emergency room data with information available statewide on hospital discharges, it was estimated that 800 children ages 0-19 are hospitalized annually in North Carolina for bicycle-related injuries, and 13,300 children receive emergency room treatment. Recommendations are given for continued research activities in the area and implementation of programs for reducing the frequency and severity of bicycle-related injuries.

Introduction

The traditional source of information on bicycle-related injuries and deaths is police accident data. North Carolina State accident files show 32 bicyclists killed and an additional 1245 injured in 1986 (1). Nationwide, the National Safety Council reported 1,000 bicycle fatalities and 40,000 injuries (2).

These numbers clearly do not reflect the full extent of the bicycle accident problem. In their landmark 1977 study of bicycle-motor vehicle accidents, Cross and Fisher estimated that only a third of all bicycle-motor vehicle accidents are reported to the police, and that half of the unreported accidents are injury producing (3). Cross further concluded that 95 percent of all bicycling injuries do not result from collisions with motor vehicles (4).

One estimate of the overall magnitude of the bicycle accident problem comes from the Consumer Product Safety Commission, which operates the National Electronic Injury Surveillance System (NEISS). The NEISS is based on a representative sample of U.S. hospital emergency rooms. Using this data, the Commission has estimated that 550,000 persons receive emergency room treatment each year for bicycle-related injuries (5).

The present study was carried out to examine the characteristics of emergency room-reported bicycle accidents, and to compare these with accidents reported on police accident files. The emergency room data were also used in conjunction with N.C. Hospital Discharge Data to estimate the number of children hospitalized and the number receiving emergency room treatment each year in North Carolina due to bicycle-related injuries.

Background

A sample of N.C. hospital emergency rooms has been involved in the collection of supplemental data for bicycle-related injuries since 1984. The effort was initiated by Dr. Frank Sheldon at the Beaufort County Hospital in Washington, N.C. and Dr. Joseph Williamson at Pitt County Memorial Hospital in Greenville, N.C. A pilot study carried out during the summer of 1984 at the Beaufort County Hospital showed 43 bicyclists treated over a five-month period. At

least half of the cases involved serious injury. However, a check of N.C. accident files revealed only 29 police reported accidents in the Washington area over a time span of six years!

Spurred by these findings, data collection activities were expanded to ten N.C. hospitals during the summer of 1985 and to 15 hospitals during the summer of 1986. A detailed report on the 1985 data is found in Stutts, 1986 (6). The present paper combines the 1985 and 1986 surveys and focuses on comparison of the emergency room and police data bases and evaluation of the magnitude of the bicycle accident problem in North Carolina. A parallel paper presenting an epidemiologic examination of the emergency room data is being prepared for publication in the medical literature (7).

Literature Review

An indepth review of the literature concerning bicycle accidents is contained in Stutts, 1986 (6). Studies in the following categories were identified and examined:

Hospital/emergency room based studies -

Survey studies;

Retrospective analyses of hospital data;

Population based survey studies;

Studies based on police reported accident data.

Emergency room surveys examining bicycle accidents have been carried out in Burlington, Vermont (8); Boulder, Colorado (9); Eugene, Oregon (10); Minneapolis, Minnesota (11); Oklahoma City, Oklahoma (12); King County, Washington (13); and Philadelphia, Pennsylvania (14), along with a number of hospitals in Australia (15,16,17), Great Britain (18,19,20) and Sweden (21). All of the studies clearly show the young disproportionately represented in bicycle accidents. While reported percentages vary according to the nature of the study and characteristics of the cycling environment, the 5-14 year age group generally accounts for 70 percent or more of the study population. Males also dominate by a ratio of at least 2:1.

The emergency room studies are a particularly valuable source of information on the nature of injuries encountered by bicyclists. By far the most frequently reported injuries are abrasions,

lacerations, and contusions. In 60-70 percent of cases these are the most serious injuries presenting. Fractures are cited in 15-25 percent of cases and head injuries in 10-25 percent. (The wide range to the latter is due in part to varying definitions of head injury.)

The majority of emergency room-reported bicycle accidents do not involve a motor vehicle. Reported percentages vary widely, however, again reflective of the particular characteristics of the bicycling environment. Numbers range from 13 percent reported in the Minneapolis study (11) to 50 percent reported in the Boulder study (9).

The best estimate of the percentage of emergency room bicycle accident cases requiring hospital admission comes from an analysis of bicycle accident cases reported to the Massachusetts Statewide Childhood Injury Prevention Project (22). Overall, six percent of 573 injured riders required hospitalization; for those riders involved in collisions with motor vehicles, this figure increased to 27 percent. Other percentages reported in the literature are eight percent for the Boulder, Colorado study (9) and 13 percent for the King County, Washington study (13). Both of the latter involved a higher than usual rate of bicycle-motor vehicle collisions.

While this discussion has focused primarily on emergency room-based surveys of bicycle accidents, other studies have involved retrospective examination of hospital records and/or self-reported accident involvement through population surveys. All have helped to expand our understanding of the nature and scope of the bicycle accident problem.

Methodology

Hospital Emergency Room Data

Hospital emergency room data were collected in two separate surveys -- the first conducted mid-May through mid-September, 1985, and the second June 1 through September 30, 1986. Ten hospitals participated in the first survey and 15 in the second. A listing of the hospitals and the number of cases submitted by each is given in Table 1.

Hospitals were selected by Dr.'s Sheldon and Williamson on the basis of their likelihood to participate and their geographic location in the State. Although there was a mix of urban and rural hospitals, no attempt was made to select a statistically representative sample. Figure 1 shows the distribution of the hospitals across the state for each of the surveys.

No follow-up was made to assess the level of participation by the hospitals; however, examination of the returns shows consistent reporting throughout the four-month data collection periods by about half the hospitals. About one-fourth submitted cases over a period of one month or less, and the remaining one-fourth appeared inconsistent in their reporting. In only one case was there an obvious bias to report only the most severe cases, and these data were excluded from the analysis. Hospitals also showed consistent reporting across the day of week and time of day variables, indicating participation by at least a good portion of the emergency room staff.

Copies of the survey forms are included as Figures 2 and 3. Following the 1985 survey, the form was revised and expanded to include more detailed information on the nature of the trip, the location and severity of injury (including an AIS score (23)), and involvement of alcohol and drugs.

N.C. State Accident Data

For comparison purposes, N.C. police reported bicycle accidents are examined for 1985 and 1986. In addition to comparing overall trends (age and sex of rider, motor vehicle involvement, rider injury, etc.), emergency room and police reported cases were matched on a case-by-case basis. This process required listing the police reported cases sequentially by date along with

Table 1. Number of cases reported by participating hospitals in 1985, 1986 surveys.

1985 Survey		1986 Survey	
Hospital	No. Cases	Hospital	No. Cases
Beaufort County	50	Beaufort County	29
Cannon Jr. Memorial	10	Cannon Jr. Memorial	9
Craven County Memorial	11	Charlotte Memorial	16
Edgecombe General	24	Edgecombe General	12
Memorial Mission	17	Haywood County	3
New Hanover Memorial	14	Lexington Memorial	9
North Carolina Memorial	10	Memorial Mission	24
Onslow Memorial	19	Moses Cone	3
Pitt County Memorial	55	Nash General	32
Wayne County Memorial	11	Northern Surry	76
		Onslow County	13
		Pardee Memorial	55
		Pitt County	66
		St. Josephs	13
		Wayne County Memorial	45

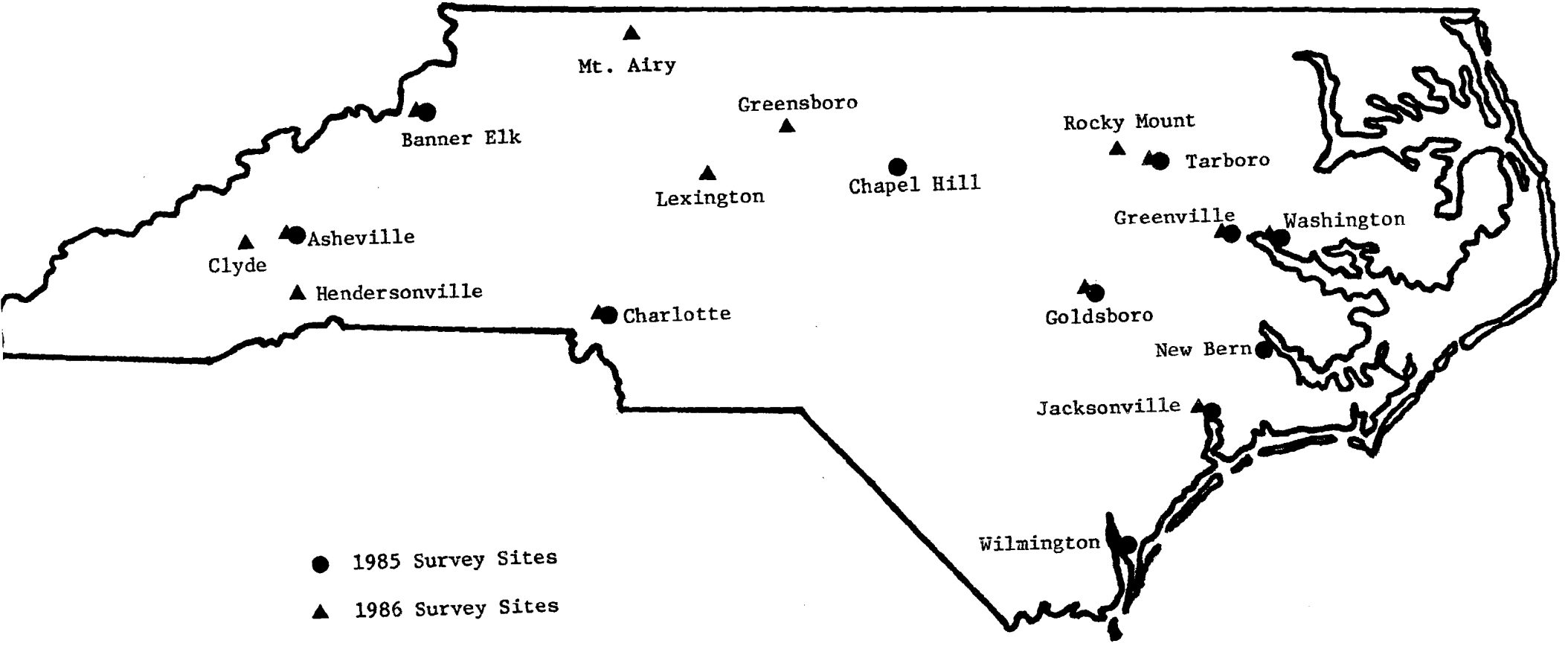

Figure 1. Location of hospitals participating in the 1985 and 1986 N.C. bicycle accident surveys.

CHECKLIST OF INFORMATION
REGARDING BICYCLE ACCIDENTS

PATIENT NAME:

SEX:

AGE:

DATE OF ACCIDENT:

TIME OF DAY:

LOCATION (Street name if possible):

	YES	NO	REMARKS
1. Did accident involve automobile?	____	____	
2. Did accident involve another bicycle?	____	____	
3. Was accident reported to police?	____	____	
4. Was cyclist riding against traffic?	____	____	
5. Any mechanical defects to bike which may have caused the accident?	____	____	
6. Bicycle helmet worn?	____	____	
7. More than one person on bike?	____	____	
8. Did accident require visit to emergency room (or physician's office)?	____	____	
a. X-Ray Required	____	____	
b. Lacerations	____	____	
c. Abrasions	____	____	
d. Fractures/Dislocation	____	____	
e. Dental Injury	____	____	
f. Head Injury	____	____	
g. Admission to hospital required	____	____	
h. Fatality	____	____	
9. Brief description of accident:			
a. At an intersection	____	____	
b. At a driveway	____	____	
c. Midblock	____	____	
d. Sidewalk	____	____	
e. Railroad Crossing	____	____	
f. Other (Please Explain)	____	____	

10. Brief description of circumstances surrounding accident. (If need additional space, please use back.)

Figure 2. Survey form for 1985 emergency room bicycle accident study.

BICYCLE ACCIDENTS
Supplemental Data Form

Return to:
Dr. Joe Williamson
Dept. of Emergency Medicine
ECU School of Medicine
Pitt County Memorial Hospital
Greenville, NC 27834

Hospital: _____

Patient Number: _____

Sex: _____

Age: _____

Date of Accident: _____

Time of Accident: _____ ☐ a.m. ☐ p.m.

Location of Accident (city and/or county): _____

Purpose of Trip:

__1 recreation
__2 commuting
__3 errand
__4 other (specify) _____

Accident Type (Check one):

__1 intersection
__2 driveway
__3 city street (non-intersection)
__4 sidewalk
__5 rural road (non-intersection)
__6 RR crossing
__7 other (specify) _____

Location of Injury: (If more than one, number in order of severity, 1=most severe)

__1 head
__2 face
__3 neck
__4 thorax
__5 abdomen, lower back
__6 shoulder, upper arm
__7 elbow, lower arm, hand
__8 hip, upper leg
__9 knee, lower leg, foot
__10 other (specify) _____

AIS Injury Severity (Most severe injury):

__ 0 No injury
__ 1 Minor injury (e.g., soft-tissue wound, broken tooth, finger fracture)
__ 2 Moderate injury (e.g., non-dislocated fracture of mandible or ankle)
__ 3 Serious injury (e.g., open and/or dislocated fracture, pneumothorax, or hemothorax)
__ 4 Severe, life threatening injury (e.g., splenic rupture)
__ 5 Critical injury (e.g.., intracranial hemorrhage, liver rupture)
__ 6 Maximum injury (unsurvivable)

Description of Injury(ies): _____

_____

Treatment:

__1 treated and released
__2 admitted to hospital
__3 fatality

	Yes	No
Did accident involve automobile or other motor vehicle?	___	___
Did accident involve another bicycle?	___	___
Was accident reported to police?	___	___
Was bicyclist riding against traffic?	___	___
Was bicyclist riding on bicycle path or in marked bicycle lane?	___	___
Was bicyclist at fault?	___	___
Any mechanical defects to bike which may have caused accident?	___	___
Bicycle helmet worn?	___	___
More than one person on bicycle?	___	___
Alcohol/drugs involved?	___	___

Brief description of circumstances of accident. (If need additional space, please use back.)

Figure 3. Survey form for 1986 emergency room bicycle accident study.

pertinent identifying information such as age and sex of rider, location (county) and time of accident, and injury severity. The emergency room cases were then individually examined to determine whether or not they were duplicated on the State files. In a few cases it was necessary to examine the actual hard copies of the police accident reports, since this allowed for comparisons of the emergency room accident description with the police officer's narrative description and diagram of the accident. Following this procedure it was possible to determine the percentage of emergency room bicycle accident cases found on the State accident files and the characteristics of these cases.

N.C. Hospital Discharge Data

A final data set examined was 1980 Hospital Discharge Data provided by the State Center for Health Statistics (1980 being the last year for which a complete sample is available). For purposes of the current study, information was obtained on the total number of pediatric hospital discharges statewide by age group and by cause of injury. The latter is reported using the "E" code classification, which includes categories of bicycle-motor vehicle and bicycle - non-motor vehicle accidents. Hospital discharge data was available for an estimated 89 percent of all pediatric hospitalizations and E code information available for 67 percent of these cases (24). The data were adjusted to reflect statewide totals, assuming even distributions of the missing cases.

Data Analysis

Analysis of the hospital emergency room data is primarily descriptive and includes one-way frequency distributions and two- and three-way crosstabulations of the variables. Results for the two years (1985 and 1986) are tabulated separately, but presented in parallel in the tables. Chi-square statistics are reported where appropriate, although small sample (i.e., cell) sizes limited the extent to which the data could be statistically examined. Also, the reader is reminded that the emergency room bicycle accident cases were not a randomly selected sample, and the reported descriptive results must be viewed with this limitation in mind. At the same time, the projected statewide bicyle-related hospitalizations and injuries are estimated using additional data sources and are not necessarily affected by this limitation.

Results

Descriptive Analysis of Emergency Room Survey Data

A total of 244 bicycle accident cases was reported by the 10 hospitals participating in the 1985 survey, and 405 cases by the 15 hospitals participating in the 1986 survey. Since there were variations in the survey form and in the particular hospitals participating, results for the two years are kept separate in the analyses that follow.

Table 2 gives the distribution of emergency room cases by rider age and sex. For both surveys, males comprised 70 percent of the reported cases. For the 1985 survey, 63 percent of the riders were under the age of 15, and for the 1986 survey 69 percent were under age 15. The largest single age category by far was 10-14 year-olds, representing over a third of the total number of cases reported.

Day of week and time of day information is depicted graphically in Figures 4 and 5. There are no clear day of week trends. For the 1985 survey, the number of accidents reported peaked on Wednesday, while for the 1986 survey accidents peaked on Tuesday. Weekend accidents comprised 28 percent of the 1985 sample and 31 percent of the 1986 sample. Concerning time of day, the greatest numbers of accidents occured in the afternoon and early evening hours, with the 1986 sample skewed more toward the later hours.

Table 3 presents information on where the emergency room-reported accidents occurred. The lower percentage of intersection accidents for the 1986 survey may be due in part to changes introduced to the survey form. It may also indicate that the hospitals participating in that particular survey served more rural locales. Nevertheless it should be noted that the largest portion of accidents occurred on non-intersection road segments. There was also a high percentage of accidents occurring at or in driveways (17 percent for each of the samples) and accidents occurring at "other" locations (including off-road accidents in yards, parking lots, etc.).

Additional accident information is summarized in Table 4. For the 1985 survey, 22 percent of the reported cases involved a motor vehicle and 20 percent were recorded as reported to police. Corresponding figures for 1986 were 15 percent and 13 percent, respectively. These differences

Table 2. Frequency of emergency room reported bicycle accidents by rider age and sex.

Age	1985 Survey			1986 Survey		
	Male	Female	Total	Male	Female	Total
0-4 years	4 (80.0)[1]	1 (20.0)	5 (2.1)[2]	11 (52.4)	10 (47.6)	21 (5.2)
5-9 years	39 (68.4)	18 (31.6)	57 (23.5)	71 (62.3)	43 (37.7)	114 (28.2)
10-14 years	69 (75.0)	23 (25.0)	92 (37.9)	106 (74.1)	37 (25.9)	143 (35.3)
15-19 years	18 (64.3)	10 (35.7)	28 (11.5)	47 (83.9)	9 (16.1)	56 (13.8)
20-24 years	13 (61.9)	8 (38.1)	21 (8.6)	16 (76.2)	5 (23.8)	21 (5.2)
25-29 years	11 (91.7)	1 (8.3)	12 (4.9)	12 (66.7)	6 (33.3)	18 (4.4)
30-39 years	11 (68.8)	5 (31.3)	16 (6.6)	9 (56.3)	7 (43.8)	16 (4.0)
≥ 40 years	6 (50.0)	6 (50.0)	12 (4.9)	13 (81.3)	3 (18.8)	16 (4.0)
TOTAL	171 (70.4)[1]	72 (29.6)	**243**	285 (70.4)	120 (29.6)	**405**

[1]Row percent.
[2]Column percent.

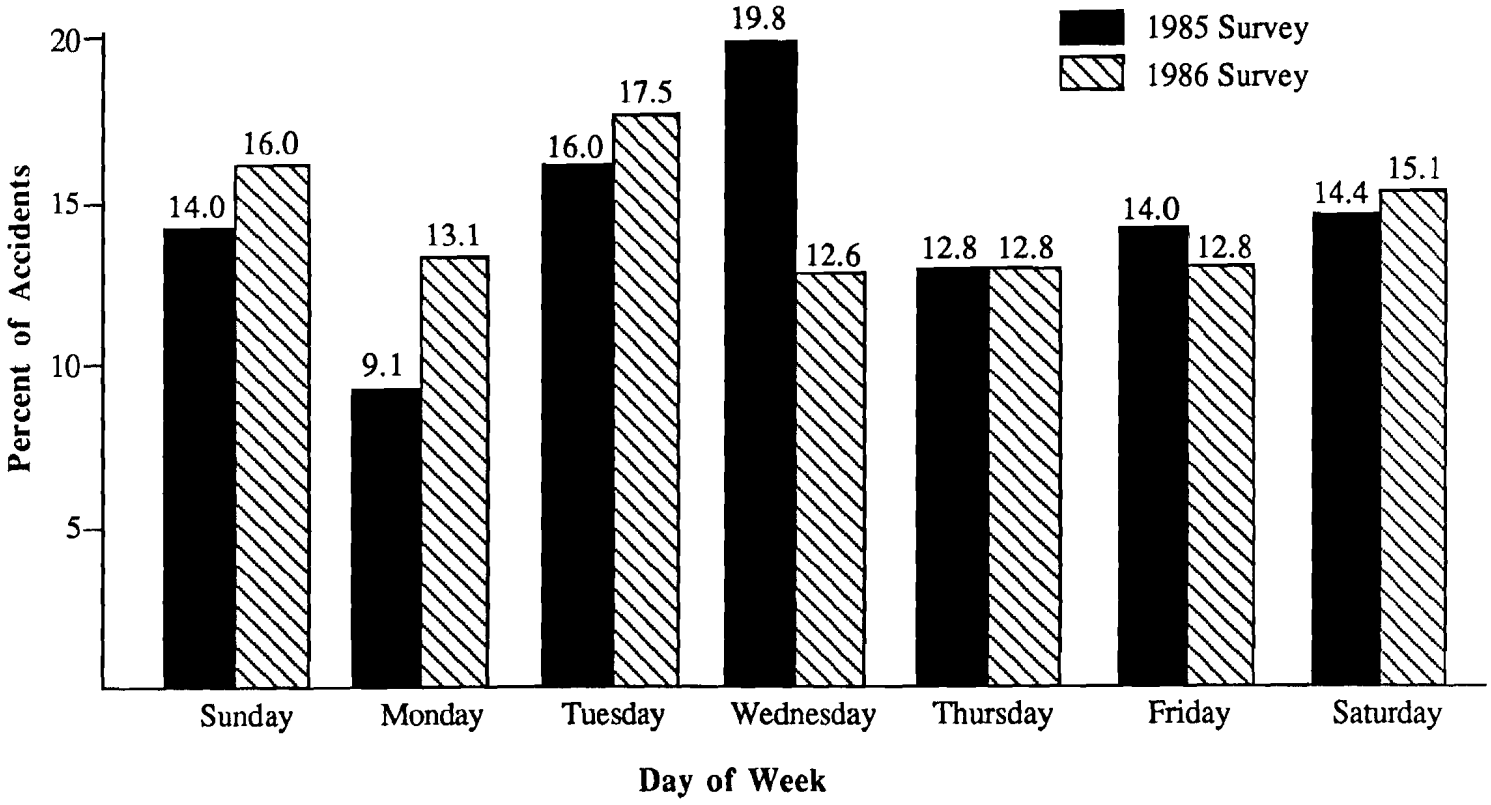

Figure 4. Distribution of emergency room-reported bicycle accident cases by day of week.

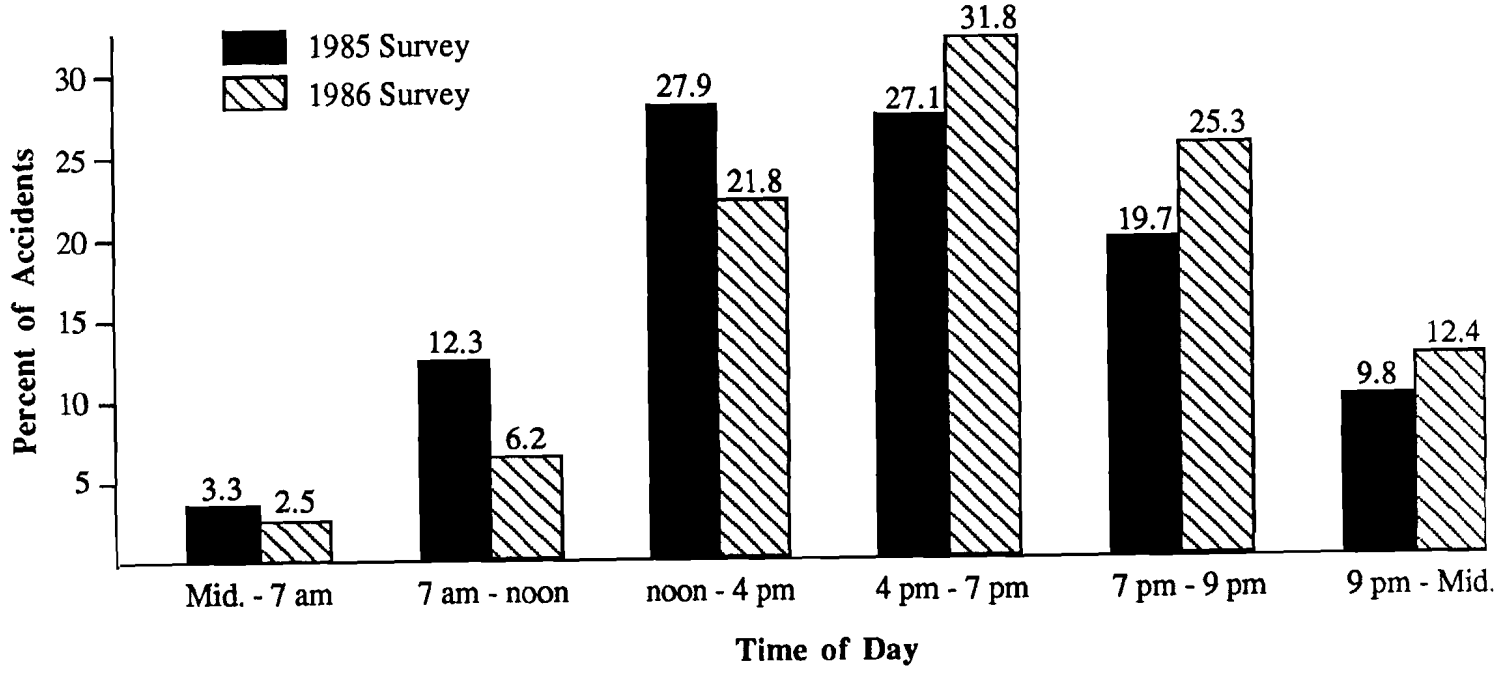

Figure 5. Distribution of emergency room-reported bicycle accident cases by time of day.

Table 3. Frequency of emergency room reported bicycle accidents by accident location.

Location of Accident	1985 Survey	1986 Survey
Intersection	30 (12.3)[1]	22 (5.6)
Driveway	42 (17.0)	69 (17.4)
Road Segment (non-intersection)	94 (38.5)	--
City Street	--	112 (28.3)
Rural Road	--	85 (21.5)
Sidewalk	14 (5.7)	25 (6.2)
Railroad Crossing	2 (0.8)	2 (0.5)
Other or Unknown[2]	62 (25.4)	81 (20.5)
TOTAL	244	396

[1]Percent of total.

[2]Includes accidents occurring off-road, in yards, on dirt or private roads, in parking lots, etc.

Table 4. Additional characteristics of emergency room reported bicycle accidents.

Accident Variable	1985 Survey[1] Yes	1985 Survey[1] No	1986 Survey[2] Yes	1986 Survey[2] No
Motor vehicle involved?	54 (22.1)[3]	190 (77.9)	62 (15.5)	339 (84.5)
Another bicycle involved?	19 (7.8)	225 (92.2)	25 (6.2)	376 (93.8)
Accident reported to police?	49 (20.1)	195 (79.9)	52 (13.1)	344 (86.9)
Bicyclist at fault?	--[4]	--	242 (62.9)	143 (37.1)
Bicyclist riding against traffic?	26 (10.7)	216 (89.3)	28 (7.4)	350 (92.6)
Bicyclist riding on bike path/lane?	--	--	7 (1.8)	380 (98.2)
More than one on bike?	27 (11.1)	217 (88.9)	34 (8.5)	364 (91.5)
Bicycle mechanical defect?	38 (15.6)	205 (84.4)	49 (12.5)	344 (87.5)
Helmet worn?	14 (5.8)	228 (94.2)	3 (0.8)	392 (99.2)
Alcohol or drugs involved?	--	--	21 (5.3)	375 (94.7)

[1]Totals less than 244 represent missing information.
[2]Totals less than 405 represent missing informtion.
[3]Row percent.
[4]Information not available for 1985 survey.

may again be reflective of the urban/rural characteristics of the two survey samples. (For example, in the 1986 survey none of the 77 cases reported by Northern Surry hospital in predominantly rural Surry County, N.C. involved a motor vehicle.) In any case, it its clear that the vast majority of bicycle accidents serious enough to require emergency room treatment do not involve a motor vehicle and are not reported to the police.

For the 1986 survey, reporting physicians were asked to determine from the patient's description of the accident who was at fault. Overall, the bicyclist was judged to be at fault in 63 percent of the accidents. For accidents involving a motor vehicle, the bicyclist was at fault in 55 percent of cases. Interestingly, there were no statistically significant differences by either age or sex of rider, although percentage at fault was slightly higher for the youngest and oldest age groupings.

Along with "at fault" data, information was obtained (in both the 1985 and 1986 surveys) on the percentages of cases involving wrong way riding (i.e., riding facing traffic) and riding two or more on a bicycle. For the former, percentages ranged from seven to 11 percent, and for the latter eight to 11 percent. Younger riders (those 15 and under) were no more likely than older riders to be cited for wrong way riding. Another causative factor, a mechanical defect of the bicycle (chain coming off, brakes not working, etc.), was reported in 12 to 16 percent of the cases. Again, there were no significant age differences.

One very important issue concerns helmet use. For the 1985 survey, six percent of the injured bicyclists were reported wearing a helmet. About half of these were in the 20-24 year age category, while the rest were spread evenly among the age groups. In 1986, only three bicyclists (all over age 15) were reported to have been wearing a helmet. This represents less than one percent of the total emergency room sample.

Finally, information on alcohol/drug involvement was included in the 1986 survey. While the overall percentage reported was five percent, the percentage is considerably higher for older bicyclists, as shown in Table 5. For the 122 riders 15 years of age and older, 21 (17.2 percent) were in accidents where alcohol was judged to have been involved. For riders age 20 and older, this percentage climbed to 23 percent. There was no significant diference in alcohol involvement

Table 5. Frequency of alcohol involvement in emergency room reported bicycle accidents - 1986 data.

Age Category	Alcohol Involvement? No	Yes	Total
0-14	274 (100.0)[1]	0 (0.0)	274
15-19	48 (90.6)	5 (9.4)	53
20-24	16 (80.0)	4 (20.0)	20
25-29	12 (70.6)	5 (29.4)	17
30-39	13 (81.3)	3 (18.3)	16
40+	12 (75.0)	4 (25.0)	16
Total	375 (94.7)	21 (5.3)	396

[1]Row percent

for male versus female riders.

Concerning injuries, there were a total of seven fatalities reported -- four in 1985 and three in 1986. All involved collisions with a motor vehicle. Ages of the fatally injured riders ranged from six to 20, and all but one was male. Two of the accidents occurred at intersections, one at midblock, and four on State highway/rural road segments. All of the fatally injured cyclists suffered a head injury, and none was wearing a helmet.

The percentage of cases requiring hospital admission was fairly consistent for the two samples -- 5.8 percent in 1985 and 6.4 percent in 1986. AIS information , available for the 1986 sample, indicated that 81 percent of the injuries were minor (AIS 1), 12 percent moderate (AIS 2), four percent serious (AIS 3), and three percent severe, critical, or life threatening (AIS 4 or greater). Male riders were nearly twice as likely as female riders to experience an injury of AIS 2 or greater -- 22 percent for males versus 12 percent for females ($p<.01$). The percentage of cases experiencing serious injury was also significantly greater for the oldest age groups, for accidents involving a motor vehicle, accidents reported to the police, and accidents involving alcohol or drugs (see Table 6).

Concerning location and type of injury, results of the 1985 survey indicated that 14 percent of the riders suffered a head injury and 25 percent some form of fracture or dislocation. The most common injuries were abrasions and lacerations, affecting 71 percent and 45 percent, respectively.

Injury information for the 1986 survey was coded differently, with separate codes for location of injury and injury severity. Twenty-four percent of the 1986 sample had some sort of head injury and 17 percent an injury to the face (see Table 7). Note, however, that injuries to the head can include lacerations, abrasions, etc., and do not necessarily infer a "head" injury in the same sense as reported by the 1985 survey. Most frequent were injuries to the knee and lower leg (42 percent) and to the elbow and lower arm (37 percent).

Examining AIS information available for the 1986 data, the presence of a head injury was not found to be significantly associated with overall AIS injury severity, although trends were according to expectations (head injury present in 22 percent of cases involving only minor injury and 33 percent of cases involving moderate or greater injury). Injuries to the shoulder and arm

Table 6. Percentage of cases with moderate or worse injury (AIS $\geq$ 2) by selected rider/accident variables -- 1986 data.

Variable Levels	Percent Moderate or Worse Injury (AIS $\geq$ 2)
Sex	
Male	22.2
Female	11.7
Age	
0-4	0.0
5-9	15.7
10-14	20.3
15-19	17.9
20-24	19.1
25-29	22.2
30-39	31.3
40+	43.8
Admitted to hospital?	
Yes	92.0
No	13.7
Motor vehicle involved?	
Yes	32.3
No	16.9
Reported to police?	
Yes	42.3
No	15.7
Alcohol/drugs involved?	
Yes	33.3
No	18.5

Table 7. Location and severity of injuries - 1986 emergency room data.

Injury Location	Injury Severity		Total Cases Reported (N=692)
	Minor (AIS=1)	Moderate or Worse (AIS ≥ 2)	
Head	73 (74.5)[1]	25 (25.5)	98 (24.3)[2]
Face	58 (85.3)	10 (14.7)	68 (16.8)
Neck	12 (80.0)	3 (20.0)	15 (3.7)
Thorax	23 (76.7)	7 (23.3)	30 (7.4)
Abdomen, lower back	23 (85.2)	4 (14.8)	27 (6.7)
Shoulder, upper arm	53 (74.7)	18 (25.4)	71 (17.6)
Elbow, lower arm, hand	112 (76.2)	35 (23.8)	147 (36.4)
Hip, upper leg	23 (88.5)	3 (11.5)	26 (6.4)
Knee, lower leg, foot	147 (86.5)	23 (13.5)	170 (42.1)
Other	33 (82.5)	7 (17.5)	40 (9.5)

[1]Row percent.
[2]Percent of riders (N=404) with injury at a given location.

were also associated with higher AIS scores. Examination of survey hard copies showed that the latter frequently involved fractures or dislocations.

In addition to the coded information summarized above, considerable insight to the nature of bicycle accidents could be gained from the accident descriptions included at the bottom of the survey forms. These yielded information, for example, on the frequency of accidents caused by dogs, by "phantom" motor vehicles which leave the accident scene, and by feet, clothing, etc. becoming entangled in the bicycle spokes. All such information is of value in the planning of countermeasures to reduce the frequency and severity of bicycle accidents.

Comparison of Emergency Room and Police Data

The North Carolina Division of Motor Vehicles reports that, in 1986, 1245 bicyclists were injured in police reported traffic accidents and an additional 32 bicyclists were killed (1). These figures are up considerably from the previous year, when 1125 bicyclists were reported injured and 22 killed.

An examination of the 1985 police-reported data is contained in Stutts, 1986 (6). The 1986 data was similarly examined for the present study. The combined results show that

> Less than half of the police reported accidents involve riders under the age of 15, compared with two-thirds of the emergency room-reported cases;
>
> Almost 85 percent of the riders in the police reported data are male, compared with 70 percent in the emergency room data;
>
> Police reported accidents involve more serious injuries to the rider, with two percent of the riders killed, 26-27 percent seriously injured, and 41-42 percent moderately injured.

Whereas motor vehicles are only a factor in about one-fifth of the emergency room cases, virtually all of the police reported cases involve collisions between bicycles and motor vehicles. Also, over 95 percent of the police reported cases occur either on local (city) streets or rural highways (including US and NC routes and secondary roads); only two or three percent are reported occurring at "off-road" locations such as parking lots, driveways, etc.

A more direct approach used to compare the emergency room and police reported bicycle accidents involved a case-by-case matching of the two samples. As noted in the Methodolgy

section, cases were considered a "match" if they occurred on the same date, at approximately the same time, in the same city and/or county, and involved a rider of the same age and sex. Where questions arose, actual hard copies of the accident reports, including the accident narrative and diagram, were viewed and compared with information on the emergency room reports.

Following this procedure for the 1985 data, only 26 of the 244 reported emergency room cases (**10.7** percent) were found documented on State accident files. All but one of these 26 cases involved a motor vehicle. Out of the total of 244 emergency room-reported cases, 54 involved a motor vehicle, so that the rate of reporting of bicycle-motor vehicle accidents was 25/54 or **46.3** percent. Similarly, the rate of reporting for bicycle accidents not involving a motor vehicle was 1/190 or 0.5 percent.

For the 1986 data, a total of 42 cases, all involving a motor vehicle, was matched to the State accident files, producing a similar overall reporting rate of 42/405 or **10.4** percent. There were 16 additional cases of bicycle-motor vehicle accidents not found on police files, so that the rate of reporting of bicycle-motor vehicle accidents for this sample was higher at 42/58 or **72.4** percent. (It should be noted that one of the emergency room-reported bicycle-motor vehicle accidents that was not found on the State files involved a fatally injured six-year-old girl.)

The above information is summarized in Table 8. These results clearly indicate that a substantial percentage of bicycle-motor vehicle accidents are not appearing on police accident files. Virtually no non-motor vehicle bicycle accidents appear on the files, even though many of these do occur on public roadways and result in serious injuries.

Statewide Projections for Childhood Bicycle Injuries

It was noted earlier that 5.8 percent of the 1985 emergency room-reported cases and 6.4 percent of the 1986 emergency room-reported cases required hospital admission. This information was combined with 1980 Hospital Discharge Data from the State Center for Health Statistics to produce estimates of the numbers of children receiving emergency room treatment statewide for bicycle-related injuries, along with comparisons for other types of traffic injuries.

Table 8. Comparison of emergency room reported and police reported bicycle accidents.

Emergency Room Cases	Located on State Accident File? Yes	No	Total
1985 Data			
Motor vehicle involved	25 (46.3)1	29 (53.7)	54 (22.1)2
Non-motor vehicle involved	1 (0.5)	189 (99.5)	190 (72.9)
Overall	26 (10.7)	218 (89.3)	244
1986 Data			
Motor vehicle involved	42 (72.4)[1]	16 (27.6)	58 (14.3)[2]
Non-motor vehicle involved	0 (0.0)	347 (100.0)	347 (85.7)
Overall	42 (10.4)	363 (89.6)	405

[1]Row percent.
[2]Column percent.

Table 9 shows the reported number of N.C. hospital discharges for bicycle-related injuries by age group. The unadjusted numbers at the top of the table are low, since they do not take into account the fact that discharge data was only available for 89 percent of all N.C. pediatric hospitalizations, and E code information only available for an estimated 67 percent of these cases (24). Incorporating these adjustments to the data produces the estimate of just over **800** children under the age of 20 hospitalized annually for bicycle-related injuries. Approximately 350 of these children are in the 5-9 year age category and an additional 300 in the 10-14 year age category. Only 18 percent of the hospitalizations are shown as resulting from a motor vehicle collision.

Our survey data indicate that these hospitalized cases represent approximately six percent of emergency room cases occurring in the State. (This is identical to the percentage reported by Fried, et al. (22), based on a larger representative sample of bicycle accidents reported to the Massachusetts based Childhood Injury Surveillance Project.) Based on this percentage, the following estimates of yearly numbers of emergency room treated bicycle accident cases for children less than age 20 in North Carolina were calculated:

Age Group	Estimated Number Emergency Room Cases
0 - 4	800
5 - 9	5,800
10 - 14	5,000
15 - 19	1,700
Total	13,300

Thus it is estimated that over 13,000 children under the age of 20 are treated each year in North Carolina hospital emergency rooms for bicycle-related injuries.

Table 9. North Carolina pediatric hospital discharges for bicycle-related injuries - 1980 State Center for Health Statistics Data.

Cause of Injury	Age 0-4	5-9	10-14	15-19	Total
Unadjusted Data[1]					
Bicycle-motor vehicle	3 (10.0)[3]	30 (14.3)	35 (19.6)	19 (30.6)	87 (18.1)
Bicycle-non motor vehicle	27 (90.0)	180 (85.7)	144 (80.4)	43 (69.4)	394 (81.9)
Total	30 (6.2)	210 (43.7)	179 (37.2)	62 (12.9)	481
Adjusted Data[2]					
Bicycle - motor vehicle	5.0	50.3	58.7	31.9	145.9
Bicycle - non-motor vehicle	45.3	301.9	241.5	72.1	660.7
Total	50.3	352.2	300.2	104.0	**806.6**

[1]Discharge data available for 89 percent of all pediatric hospitalizations. Cause (E-code) information available for 67 percent of reported cases.

[2]Assumes an even distribution for missing cases.

[3]Column percents.

Discussion

Significance of Research

This study is part of a continued effort towards a more accurate assessment of bicycle accidents occurring in North Carolina. In the past the primary source of information on bicycle accidents and their resulting injuries has been State motor vehicle accident files. Such data do not present an accurate account of the full range of accidents and injuries occurring to bicyclists. This is true even for the relatively small percentage of accidents involving a motor vehicle.

Hospital records represent an alternative source of information on bicycle-related accidents and injuries. Retrospective analyses of hospital data have yielded considerable information regarding the numbers of bicyclists being injured and the significance of bicycle injuries compared with other types of injuries. However, examinations of bicycle-related accidents and injuries based solely upon hospital emergency room or admissions records clearly cannot provide detailed information on the circumstances surrounding the accident, and it is this information which is critical to the development of effective countermeasures for reducing the frequency and severity of bicycle accidents.

To provide this information, additional data collection activities are needed, either at the time of treatment or later, through follow-up contacts. The emergency room survey studies cited earlier are examples of this type of approach. The present investigation goes beyond these studies by also examining police-based data and drawing comparisons between the emergency room and police results. Thus, it is more able to address the question, "What do police reports fail to tell us about the nature and magnitude of the bicycle accident problem?"

Major Findings

Two key variables that we were interested in examining were the percentage of emergency room accidents involving a motor vehicle and the percentage reported to the police. Overall, 22 percent of the 1985 emergency room cases and 14 percent of the 1986 emergency room cases involved a motor vehicle. Only 10 percent of the emergency room cases were duplicated on State

accident files; not surprisingly, almost all of these involved a motor vehicle. The percentage of emergency room-reported bicycle-motor vehicle accidents located on State accident files was 46 percent for the 1985 survey data and 72 percent for the 1986 survey data.

While the latter two percentages cover a wide range, they nevertheless stand as firm evidence that police accident data do not provide accurate accountings of the numbers of bicyclists injured in traffic accidents. In addition to missing a significant portion of the bicycle-motor vehicle accidents, the police files provide almost no information on bicycle-non motor vehicle accidents. This was essentially the same conclusion reached by Cross and Fisher in their landmark 1977 study (3,4). Consequently, what police files are able to tell us about the nature of bicycle accidents and the characteristics of injured riders is not necessarily reflective of the total accident picture.

Using the emergency room survey data in conjunction with hospital discharge data, it was estimated that 800 children under the age of 20 are hospitalized each year in North Carolina for bicycle-related injuries, and that 13,300 children receive emergency room treatment. Going one step further, one could project that 17,000-18,000 North Carolinians of all ages receive emergency room treatment each year for bicycle-related injuries (this on the basis that one-fourth of our hospital emergency room sample involved riders age 20 or older). Interestingly, the latter estimate agrees well with the U.S. Consumer Product Safety Commission's projection of 550,000 bicycle-related emergency room cases (all ages) occurring annually in the U.S. (5). On a purely population basis, North Carolina could expect to entertain 2.6 percent or 14,300 of these cases. Given the particular popularity of bicycling in North Carolina, it is not unreasonable to assume a figure considerably higher than this.

In addition to providing an alternative description of who is involved in bicycle accidents and when, where and how these accidents occur, the emergency room survey data gives a more detailed picture of the injuries resulting. In particular, the 1985 survey revealed that 14 percent of the emergency room cases suffered a head injury; for those hospitalized, this percentage increased to nearly a third. Reported helmet use was less than six percent for the 1985 survey, and less than one percent for the 1986 survey.

Finally, the survey data provides additional detail on causative factors in bicycle accidents. Of interest here is that seven to 11 percent of the reported cases involved wrong-way riding, eight to 11 percent riding more than one on a bike, and 12 to 16 percent some mechanical defect of the bicycle. Perhaps contrary to expectations, older riders were found just as likely as younger riders to be cited for wrong way riding, and were just as likely to be judged at fault in the accident. Alcohol played a particularly prominant role in the accidents of the older riders -- cited in 23 percent of the cases for riders over the age of 19.

Conclusions and Recommendations

Further research is needed to better define the nature and magnitude of the bicycle accident problem. Police reported statistics, though frequently cited, represent only a small portion of the bicycle accident "iceberg." Unfortunately, the amount of highway safety dollars allocated to bicycle-related research has reflected a similar under-appreciation of the bicycle accident problem.

Yet bicycles are a major source of injury, particularly to young people. The Consumer Product Safety Commisssion has identified bicycles as the leading cause of sports or recreational injuries seen in hospital emergency rooms. In children, bicycle crashes are one of the leading if not the leading cause of hospitalized head injuries (25).

Interest in cycling continues to grow. The Metropolitan Statistical Bulletin reports that in 1981 there were 62-65 million bicycles in the U.S., or one for every two registered passenger cars (26). In recent years, the increasing emphasis on physical fitness, the growth of bicycle commuting, and the growing popularity of bicycle riding have all contributed to a bicycling "boom." One outcome of this growth is that the population of riders injured and killed in accidents has aged. What used to be primarily a "kid's" problem is today affecting more and more adults.

What can be done to alleviate this situation? We have already cited the need for more research to examine the characteristics of bicycle accidents -- both those involving a motor vehicle and those not involving a motor vehicle. Hospital-based studies and survey studies are two recommended approaches. Certainly the current study could and should be replicated on a larger

and more representative sampling of cases.

Efforts might also be directed at improving police-based reporting of bicycle accidents. In North Carolina, only bicycle accidents involving a motor vehicle appear routinely reported to the Department of Motor Vehicles to become part of the State's traffic records system. However, police officers frequently do investigate and file reports on non-motor vehicle bicycle accidents that occur on the roadway, particularly if they involve injury. While not forwarded to the DMV, these reports may be kept on file at the local level, and may even be retrievable by computer. A project aimed at collecting and examining data on all police investigated bicycle accidents would appear of value. Ultimately, it may be recommended that local law enforcement agencies file and submit reports to DMV on bicycle only as well as bicycle-motor vehicle accidents.

Concerning hospital-based sources of information on bicycle accidents and injuries, in response to the growing recognition of injuries as a major public health problem, there is a trend across the country towards implementing trauma registries and other large scale injury surveillance systems. In North Carolina, a grant was recently awarded to develop a statewide trauma registry to monitor the care of severely injured patients treated at the State's six major trauma centers. Parallel efforts are underway to develop a statewide plan for emergency room based injury surveillance, under a grant from the Centers for Disease Control. Such systems, when operational, have the potential for yielding information on large numbers of bicycle-related injuries, as well as how these injuries compare with other forms of trauma.

In addition to these research efforts, there are actions that can be taken now to reduce the frequency and severity of bicycle accidents. Most important is to encourage helmet usage by all cyclists, young and old, riding on the road or off. Head trauma is the leading cause of death in fatal bicycle accidents. Weiss (27) notes that "pediatricians and family physicians have a unique opportunity to provide education to families and communities about the importance of using helmets." In Madison, WI, a multi-pronged mass media campaign was carried out to increase helmet use by that city's large population of older cyclists (28); and the Harborview Injury Prevention Center in Seattle, WA, has prepared a guide for local communities interested in developing a children's bicycle helmet safety program (29).

Secondly, schools should adopt as part of their physical education curriculum instruction in bicycle safety, if possible including "on road" training. Considering the popularity of bicycling as a lifetime sport, the lack of attention devoted to its instruction in the schools appears unjustified. Effective bicycle education programs have already been developed, so that at this stage the greatest need is for some mechanism for placing such a program in the schools and funding to make it possible. Ideally, this should be accomplished at the state level, although individual communities and/or school systems could also take the initiative.

There are other steps that communities can take to lower their bicycle accident count. Enforcement of traffic laws, even for the very youngest riders on the street, has been shown to significantly reduce the frequency of bicycle-motor vehicle accidents (30). Attention should be directed at educating older cyclists not to mix drinking and riding. Communities might also adopt a pin-map approach to examining their own patterns of bicycle accidents to determine if any specific problem locations need attention.

Obviously there is much that can and should be done. As in other areas of injury prevention, many different people from many different areas of interest need to become involved -- educators, physicians, law enforcement officers, transportation engineers, researchers, and state and local government officials. The present investigation, which has pooled the resources of so many, is a step in this direction.

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