AN ANALYSIS OF BICYCLE ACCIDENT DATA FROM TEN NORTH CAROLINA HOSPITAL EMERGENCY ROOMS

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CHAPTER 1. INTRODUCTION AND LITERATURE REVIEW

Introduction

This report is an outgrowth of the concerns of two eastern North Carolina physicians for the number of injured bicyclists being treated in hospital emergency rooms. In a preliminary study at the Beaufort County Hospital in Washington, N.C., Dr. Frank Sheldon found that 43 bicycle accident victims received emergency room treatment during the five-month period from May through September, 1984. At least half of these involved serious injuries. In contrast, a check of the North Carolina accident files revealed only 29 police-reported bicycle accidents in the Washington area over a time span of six years.

Spurred by these findings, Dr. Sheldon and a colleague, Dr. Joseph Williamson at Pitt County Memorial Hospital in nearby Greenville, N.C., expanded their bicycle accident study during the following year (1985) to incorporate data from a total of 11 North Carolina hospital emergency rooms. Survey information was collected on the age and sex of the cyclist, date and time of accident, helmet usage, mechanical defects to bicycle, whether or not a motor vehicle was involved, whether or not the accident was reported to the police, and further information on the type of accident and nature of injury and treatment. The data collection period was from mid-May through mid-September, 1985. Although not randomly selected, the participating hospitals were located throughout the state and included both urban and rural settings.

The Highway Safety Research Center (HSRC) became involved in this effort in the fall of 1985, after data collection was completed. At this time HSRC, working through the N.C. Department of Transportation Bicycle Program, received a grant from the N.C. Governor's Highway Safety Program to:

1. Conduct a review of the literature pertinent to bicycle accidents.

2. Assist with the analysis of the resulting hospital emergency room data.

3. Use this available data to expand knowledge of the nature and scope of the bicycle accident problem in North Carolina.

4. Make recommendations for future research and program activities addressing bicycle accidents in North Carolina.

Unfortunately, the final number of cases available for analysis (N=244) was lower than anticipated. A decision was therefore made to redesign the survey instrument and contact additional hospitals to participate in expanded data collection activities during the current riding season (May - September, 1986). The scope of HSRC's project was extended to assist in these efforts.

This report presents an analysis of the 1985 survey data, which includes single variable and two- and three-way crosstabulations of the data, as well as comparisons with police-reported bicycle accidents found on 1985 N.C. accident files. Recommendations are made regarding research needs and actions that can be taken by the State and the local communities to reduce the incidence and severity of bicycle accidents.

Although the data base examined in this report is limited with respect to its size and representativeness, it strongly suggests that the scope of the bicycle accident problem in North Carolina (and elsewhere) is much greater than commonly thought. Police reports and state accident files clearly do not present a total picture of the risks associated with cycling. This is borne out by the literature review as well. It is hoped that this report is at least a beginning step toward greater recognition of the bicycle as a vehicle in need of increased attention by transportation and safety officials.

Literature Review

Background Data

The National Highway Traffic Safety Administration reports a total of 849 bicyclists killed in U.S. motor vehicle traffic accidents in 1984, based on data from the Fatal Accident Reporting System (FARS) (NHTSA, 1986). This figure is down 12 percent from 1980, when nearly 1,000 bicyclists were reported killed. Still, it represents 1.9 percent of all motor vehicle-related traffic deaths. For children aged 5-14, Baker, O'Neill and Karpf (1984) report that bicycle-motor vehicle deaths comprise about 15 percent of all traffic deaths for this age group.

In addition to those bicyclists killed in collisions with motor-vehicles, the National Safety Council (NSC, 1984) reports that 40,000 bicyclists were injured in motor vehicle traffic accidents during 1984. Like the fatal count cited above, this count is based primarily on police-reported accidents located in the state accident files. However, in the case of non-fatal bicycle accidents, there is a much greater likelihood of underreporting. In their landmark study of bicycle-motor vehicle accident types, Cross and Fisher (1977) 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. When applied to the NSC estimate of 40,000 bicycle injuries, this would translate into 120,000 actual bicycle-motor vehicle accidents with 80,000 resulting injuries.

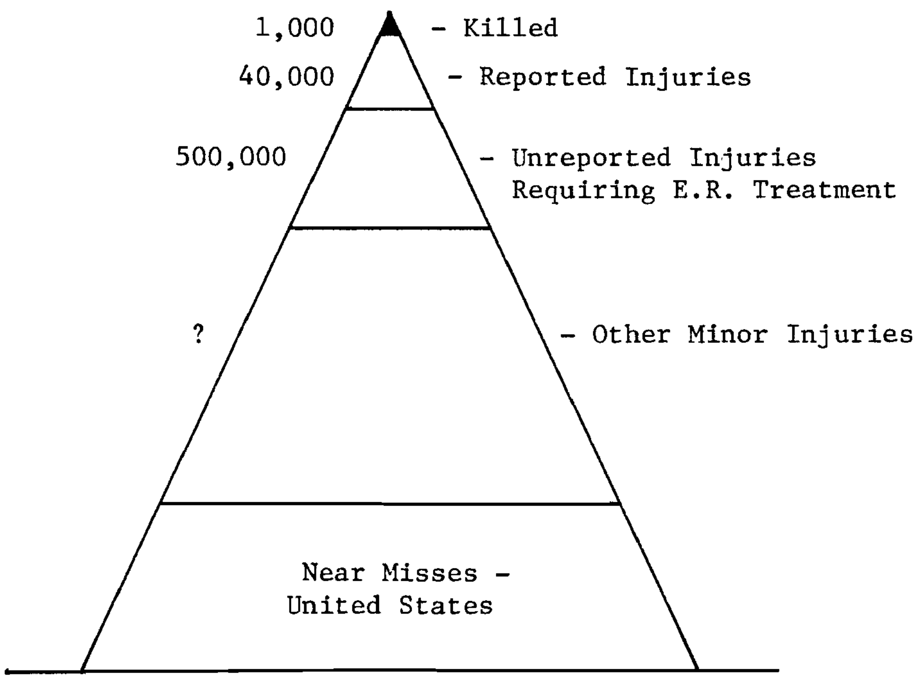
Bicycle accidents not involving a motor vehicle are not routinely reported by the police, so that estimates of the numbers of bicyclists killed or injured in non-motor vehicle related accidents must come from other sources. One source of information on fatal injuries is the National Center for Health Statistics (NCHS), whose data includes a full range of causes of death (including motor vehicle accidents). Kraus, Fife and Conroy (1986) noted that when NCHS and FARS data were compared, 90 percent of all U.S. bicycle-related deaths were found to be motor vehicle-related. This same figure of 90 percent is also cited by Baker, et al. (1984).

A source of information on bicyclists injured in non-motor vehicle accidents is the National Electronic Injury Surveillance System, or NEISS, data. This data is compiled by the Consumer Product Safety Commission and based upon a representative sample of 119 U.S. hospital emergency rooms. During 1984, there were an estimated 556,682 bicycle-related injuries in the U.S. requiring emergency room treatment (U.S. Consumer Product Safety Commission, 1985). Since this figure does not exclude bicycle-motor vehicle accidents or accidents reported by the police, an estimate of non-motor vehicle related bicycle injuries might be approximately 500,000.

Cross (1978) also examined the NEISS data (for the year 1975), and concluded that 18 percent of all bicycle-related fatalities and 94.5 percent of all bicycle-related injuries were the result of non-motor vehicle accidents. Cross further concluded that non-motor vehicle bicycle accidents (those not reported by the police) "account for no fewer than 100 fatalities and one half million serious injuries each year." These numbers are in line with the data cited above.

There are thus many levels of reporting of bicycle accidents in the United States. Bouvier (1984) found this same phenomenon in Australia, and described it by constructing a bicycle accident "iceberg." At the top of his "iceberg" were the well documented fatal cases (N = 30), followed by accidents reported to the police (N = 1100), then those not reported to the police but requiring emergency room treatment (N = 30,000), and finally those requiring only first-aid administered at home (N = 900,000) and the unknown numbers of near misses.

A similar sort of "iceberg" constructed for U.S. bicycle accidents might appear as follows:



While these numbers are approximate, they give a better idea of the full range of the bicycle accident problem.

Overview of Literature Search

Given this background, a literature review was carried out focusing on what is known about the population of bicycle accidents requiring medical attention and how this population compares with the population of police-reported bicycle accidents. Searches were carried out on both the Transportation Research Information System (TRIS) data files, which includes the Highway Safety Literature (HSL) file, and MEDLINE, incorporating the Index Medicus listings. Additional studies were identified through personal contacts with physicians, bicycle professionals, etc. (One very good source of information was the Fourth International Conference on Bicycle Programs and

Promotions sponsored by the Bicycle Federation of America and held in Seattle, Washington, September 1986).

The studies identified fall within the following categories:

- hospital/emergency room-based studies
    - prospective data analyses
    - retrospective data analyses
- population-based survey studies
- studies based on police-reported data (state accident files)

For purposes of this report, greatest emphasis has been placed on the hospital-based studies, since this is the focus of the current research. However, highlights of studies in each of these areas are included in the sections that follow.

Hospital/Emergency Room Studies

U.S. Studies. One of the earlier attempts to gain information about the causes and injury outcomes of bicycle accidents was a study conducted at the University of Vermont College of Medicine (Waller, 1971). Waller examined patterns of bicycle ownership, use, and injury among over 6,000 school children over a four-month period. His study incorporated survey data obtained from the children in their school classrooms, observational data collected in the neighborhoods, and analysis of records from the local medical center coupled with follow-up interviews with the mothers of the injured children. From this data Waller estimated that two percent of the bicycle owners in the 3-12 year age group can expect to have bicycle injuries requiring medical treatment each year. Injury rates (number of injuries per 1000 owners) were fairly stable for children ages 5-9, then dropped slightly for 10-12 year-olds. Boys had a significantly higher injury rate than girls (part of which may be explained by differences in exposure). Two-thirds of the injuries treated were abrasions, contusions, and lacerations; a fifth of the injuries involved fractures; and five percent concussions.

More recent hospital-based studies of bicyclists in accidents have been carried out in Boulder, CO; Eugene, OR; Minneapolis, MN; Oklahoma City, OK; and King County, WA. In the Boulder, CO study (Watts, Jones, et al., 1986), all patients seeking emergency treatment at the Boulder Community Hospital as a result of a bicycle accident during the study period April 1 - September 30, 1983 were asked to fill out a questionnaire. Follow-up interviews were utilized as needed for completing the forms. During the six-month study period 253 patients were treated for bicycle-related injuries -- 166 men and 87 women. The average age was 22, higher than normal and reflective perhaps of a higher percentage of serious cyclists and bicycle commuters. (Boulder is home to the University of Colorado and a training ground for many competitive cyclists.) In this population of somewhat older riders, 73 percent of the accidents occurred on streets, 16 percent on bike paths, and 11 percent on sidewalks. Nearly half of the accidents involved a motor vehicle. Concerning injuries, abrasions and contusions were most common (80 percent of cases), followed by lacerations (39 percent), fractures (14 percent), and closed head injuries (10 percent). Eight percent of the cyclists were admitted to the hospital, but there were no deaths. To reduce the frequency and severity of bicycle accidents, the authors recommend helmet usage, adequate lighting for nighttime riding, and regular removal of gravel and other debris from the roadway.

The Eugene study (Regional Consultants, Inc., 1979) was conducted as part of a comprehensive evaluation of that city's Master Bikeways Plan. Voluntary bicycle accident reporting forms were provided to all local hospitals and clinics. Questions on the form focused on the specific characteristics of the bicycle accident; no injury-related information was requested. Over the three-month survey period completed forms were obtained from 104 bicyclists injured in accidents. Comparing these results with records of police-reported bicycle accidents during the same three-month time period, the authors concluded that 25 percent of bicycle-motor vehicle accidents are not reported to the police, while almost all bicycle injury accidents not involving a motor vehicle go unreported. Injured bicyclists involved in non-motor vehicle crashes comprised 61 percent of the survey sample.

The Minnesota study (Davis, Litman, Crenshaw and Mueller, 1980), like the current effort in North Carolina, was instigated by physicians seeking information to reduce the frequency of bicycle injuries. Data were collected on 192 consecutive bicycle injury cases treated over a one-year period at a large Minneapolis hospital. Although the patients ranged in age from 4-63, the mean age was 15.4 and 77 percent were aged 6-16. Sixty percent were male. The most frequent injuries were to the face and head (N = 68); most of these were soft tissue injuries (abrasions, contusions and lacerations), but there were five concussions and one skull fracture. Next in frequency were knee injuries (N = 33), followed by hand and wrist injuries (N = 28). Skeletal injuries (fractures, dislocations, etc.) most frequently involved the wrist and hand (20 cases), shoulder (8 cases), or forearm (6 cases). Motor vehicles were involved in only 13 percent of the accidents, and in 42 percent of the accidents the bicyclist was "unequivocally at fault." Other study variables included the type of bicycle, bicycle maneuver (straight and level, turning downhill, etc.), bicycle mechanical defect, and other associated factors (gravel on road, pothole, etc.)

Data on bicycle injuries were also collected at two hospitals in the state of Oklahoma, one a large metropolitan pediatric hospital and the other a suburban community hospital (Ernster and Gross, 1982). The study was restricted to children under 19 years of age and included follow-up telephone interviews with parents to inquire about details of the accident and injury. Over the seven-month study period there were 85 injury cases plus one fatality. Five percent of the injury cases were under age five, 60 percent were aged 5-10, 22 percent aged 11-14, and 13 percent aged 15-19. The distribution of <u>most severe</u> injury was as follows:

Abrasions	19%
Lacerations (requiring sutures)	24%
Contusions/Sprains	19%
Fractures	17%
Head Injury	16%
Head Injury with Skull Fracture	5%

Overall 12 percent of the injuries were judged severe (hospitalization required), 9 percent moderate (fractures requiring casting), 35 percent mild (lacerations requiring sutures, sprains), and 44 percent very mild (observation only or rest at home).

The follow-up telephone interviews for the Oklahoma study produced information on a variety of factors related to the bicyclist and circumstances surrounding the accident. Some of these are highlighted below:

Road type: 8% major streets, 17% busy side streets, 46% residential streets, 16% fields or parking lots, 13% sidewalks or driveways.

Precipitating factors: 40% hitting object, 29% riding downhill, 27% speeding, 19% doing tricks.

Motor vehicle involvement: 26% of cases.

Familiarity with bicycle: 55% riding new or borrowed bike.

Unlike these emergency room-based studies, the King County study (LeValley and Mueller, 1985) in the Seattle, WA area is based on data reported by Emergency Medical Services (EMS) technicians and paramedics. The King County EMS responded to 307 incidents of bicycle injuries from May-September, 1984. Study data consisted of information from the Medical Incident Report Form supplemented by survey information obtained for 186 of the injured cyclists. Study variables included rider age and sex, helmet use, trip purpose, bicycle mechanical condition, accident location, precipitating factors, and injury type and location.

The sample of accidents generated by this approach was more severe than that produced by emergency room visits. The majority of the King County accidents (57 percent) occurred in the street, and 37 percent involved a motor vehicle. The victims were also generally older: 46 percent were aged 15 or more. Of the 307 reported cases, 44 percent involved injuries determined to be urgent or life threatening and 13 percent were eventually admitted to a hospital. The most serious injuries were head injuries, present in 25 percent of the cases.

Table 1 below summarizes information available from the six U.S. hospital emergency room studies of bicycle accidents. The average age of the riders was greatest in the Boulder, CO and King County, WA studies. Both of these studies also reported a fairly high percentage of cases involving a motor vehicle (50 percent and 37 percent, respectively). In all of the studies reporting rider sex, males consistently outnumbered females by a factor of about 2 to 1. Injury type distributions are not directly comparable, since in some cases the authors reported the percentage of all injuries of a given type while in other cases they reported the percentage of all riders with a given injury. The latter results in percentages totalling greater than 100 percent. Nevertheless, it is clear that abrasions, contusions and lacerations are the most commonly experienced bicycle injuries. Fractures were cited in 15-25 percent of cases, and head injuries in 10-25 percent. (Lower percentages generally referred to specific types of head injury, such as skull fracture.) Obviously, definitions of a codeable head injury could have varied greatly among the studies. Only two of the studies gave information on the percentage of cases requiring hospital admission -- eight percent in Boulder, CO and 13

Table 1. Summary of U.S. hospital survey bicycle accident studies.

Study Author (Year)	Location	No. Cases	Mean Age/ Age Distribution	Sex	Injury Type	% Admitted to Hospital	% Involving Motor Vehicle
Waller, et al. (1971)	Burlington, VT	69 (Injured)	8 (restricted to ages 3-12)	71% M 29% F	[1] 67% abrasions, concussions, lacerations 20% fractures 5% concussions	Not Reported	Not Reported
Watts, et al. (1986)	Boulder, CO	253	22	66% M 34% F	[2] 80% abrasions, concussions 39% lacerations 14% fractures 10% closed head injury	8%	50%
Regional Consultants, Inc. (1979)	Eugene, OR	104	Not Reported	Not Reported	Not Reported	Not Reported	39%
Davis, et al. (1980)	Minneapolis, MN	192	15.4 77% 6-16	60% M 40% F	abrasions, contusions, lacerations most common [2] 23% fractures, dislocations 3% concussions, skull fractures	Not Reported	13%
Ernster and Gross (1982)	Oklahoma City, OK	86	5% <5 60% 5-10 22% 11-14 13% 15-19 (restricted to <19)	Not Reported	[3] 62% abrasions, contusions, lacerations 17% fractures 21% head injury	Not Reported	26%
LeValley and Mueller (1985)	King Co., WA (Seattle area)	307 (187 with survey information)	18	71% M 29% F	[2] 81% abrasions 25% fractures 25% head	13%	37%

[1]Percent of injuries (Total = 100%) [2]Percent of cases with given injury type [3]Most severe injury distribution

percent in King Co., WA. Both of these studies appeared to involve a generally more severe sample of accidents.

Foreign Studies. In addition to these U.S. studies, the literature contains a number of similar hospital-based studies carried out in foreign countries, particularly Australia and Great Britain. These are briefly highlighted below, and some comparisons made with the U.S. studies.

In an Australian study, Gonski, Southcombe and Cohen (1979) reviewed 1978 data from nine Sydney hospitals. Of 4,589 reported accident cases, 312 (6.8%) involved bicycles. Half of the bicycle injuries were to children aged 5-9. Follow-up interviews with 139 of the cases revealed that only three (2 percent) involved a motor vehicle. The most frequently cited "causes" for the accidents were riding double, striking potholes, riding up or down hills, and playing games.

In another Australian study, McFarlane, Jones, and Lawson (1982) report on data collected during five separate one-week surveys at seven emergency departments in Sydney (2 in 1978, 2 in 1979, 1 in 1980). Bicycle accidents were the cause of 10 percent of all trauma visits for children aged 0-14. Of the 178 bicyclists treated, 31 percent were aged 5-9 and 34 percent aged 10-14. Three quarters were male. Motor vehicles were involved in 12 percent of the cases. Fifty-one percent of the principal injuries were lacerations, 20 percent bruises or other crushing injuries, and 18 percent fractures (including three skull fractures, one a fatality). Information on a variety of causative factors was also cited.

More recently a study was carried out by two physicians concerned about the number of children being treated for bicycle-related injuries at the Redcliffe Hospital on the Australian Redcliffe Peninsula (Armson and Pollard, 1986). Part of their investigation involved surveying children in the schools to determine the extent of bicycle use, the use of protective clothing, etc. This data was analyzed in conjunction with emergency room data for all children aged 16 or younger presenting for treatment at the Redcliffe Hospital over a nine-month period as the result of a bicycle accident (N=154). The authors found that the majority of the accidents (75 percent) occurred on a road with other traffic, and that children aged 5-6 were disproportionately represented when their exposure was taken into consideration.

Examples of British studies include two conducted by Illingworth and his colleagues at the Children's Hospital in Sheffield (Illingworth, Noble, Bell, Kemn, Roche and Pascoe, 1981; Illingworth, 1985). The earlier of the studies involved 150 children seen over a six-month period and compared their bicycle-related injuries to injuries due to other causes such as skateboards, play equipment, and other road traffic accidents. Forty-five percent of the cases involved minor wounds and injuries, 44 percent more serious injuries such as undisplaced fractures and minor head injuries, nine percent injuries serious enough to require admission (seriously displaced fractures, concussions), and just over one percent life threatening injuries. Particular effort was taken to try to determine the cause of the accident: cited most frequently were hitting an obstruction, loss of control, and skidding on loose gravel. Moving motor vehicles were implicated in only four cases.

The more recent (1985) study by Illingworth compared accidents on BMX bicycles ("dirt bikes") with ordinary (conventional) bicycles. The study sample included 300 cases of bicycle accidents treated over 60 consecutive days starting July, 1984. The injury distribution was similar to that reported for the earlier study, with riders of the BMX bicycles experiencing somewhat more severe injuries than riders of the ordinary style bicycles. For this sample there were ten reported collisions with moving cars (3.3 percent of the study sample).

In another recent British study (Ballham, Absoud, Kotecha, and Bodiwala, 1985), patients presenting for bicycle-related injuries at a Leicester hospital were asked to complete a form reporting on a variety of rider, bicycle, and accident factors. Injury information was added by the doctor in charge. During the six-month study period, completed forms were obtained from 314 patients. Information was not available for four fatalities, eight cases of severe injury, and an additional 56 cases where the survey form was not completed adequately. Sixty-six percent of the patients were between the ages of six and 15. Accidents where the bicycle collided with another vehicle or object comprised 48 percent of the sample, while the remaining 52 percent were classified as "falls." Motor vehicles were involved in 42 percent of the collision cases, or approximately 20 percent overall. Concerning injuries, 49 percent of the riders had injuries to the head or face and another 49 percent injuries to the upper limbs. The most frequent injury types were abrasions (47 percent) and closed soft tissue injury (46 percent). Twenty percent of the patients had fractures, and nine percent were admitted to the hospital.

As a final example of a hospital-based survey of bicycling injuries, Björnstig and Näslund (1984) analyzed 447 cases of bicycle-related injuries treated at a hospital in northern Sweden over a one-year period. Information is again available on such factors as rider age and sex, accident time and location, accident causation, and injury type and location. Severity of injury was coded using the Abbreviated Injury Scale (AIS). Two-thirds of the injuries were minor (Maximum AIS = 1) while 17 percent were serious enough to require hospital admission (mean duration 6 days). Accidents involving a motor vehicle (13 percent of the sample) were generally among the most severe and had a higher Maximum AIS. The authors note that whereas their study had documented 392 cases of road traffic accidents (i.e., accidents occurring in the road), the official police statistics for that year had only recorded 37 bicycle traffic accidents, with 29 of these involving a motor vehicle. From this they conclude that fewer than one in ten bicycle accidents resulting in injury are officially reported.

Compared with the U.S. studies, these foreign studies of bicyclists treated in hospital settings show a generally lower percentage of accidents involving a motor vehicle: the range for the foreign studies was 2-20 percent, compared with 13-50 percent for the U.S. studies. Injury outcomes appear fairly comparable. Sex distributions, when reported, were at the same 2 to 1 ratio or perhaps slightly higher. Like their U.S. counterparts, the authors of these foreign studies are concerned with the large numbers of children experiencing bicycle-related injuries.

Retrospective Analyses of Medical Data

Studies based on retrospective analyses of medical records obviously can not produce the same degree of detail as prospective studies on the rider, the bicycle, and the circumstances surrounding the accident. However, they can be particularly useful for viewing bicycle accidents in relation to other accidents and types of injury. For example, for young children one might be interested in comparing the frequency of bicycle accidents with pedestrian accidents, skateboard accidents, or falls.

A paper by Gallagher, Finison, Guyer and Goodenough (1984) examines the incidence of injuries among 87,000 Massachusetts children and adolescents utilizing data from a statewide childhood injury surveillance system. The system captures information from 23 hospitals in 14 communities and includes emergency room visits, hospital admissions, and deaths. Pedal cycle - non motor vehicle and pedal cycle - motor vehicle are included as two of 19 external causes of childhood injuries. For children aged 6-12, one in 80 required hospital treatment for a pedal cycle - non motor vehicle injury. This compares with one in every 270 children aged 6-12 injured as motor vehicle occupants. The most common cause of injury requiring hospital treatment was a fall, affecting one out of every 18 children under 20 years of age.

The Massachusetts data was subsequently employed to examine in greater depth the epidemiology of bicycling injuries (Friede, Azzara, Gallagher, and Guyer, 1985). The specific data base consisted of a 25 percent sample of all reported bicycle injuries and a 100 percent sample of all deaths occurring over a three-year time period. This produced a study sample of 604 bicycle-related deaths (8.3 per million children aged 0-19) and 573 injuries (87.8 per 10,000 person years). The most common injuries were contusions and abrasions (36 percent of all injuries), followed by open and crushing wounds (27 percent) and fractures (20 percent). Overall six percent of the injuries required hospitalization; however, 27 percent of injuries resulting from bicycle collisions with motor vehicles required hospitalization.

In a similar effort, Runyan, et al. examined North Carolina hospital discharge data for 1980 to determine relative frequencies of various childhood injuries (Runyan, Kotch, Margolis, and Buescher, 1985). For children aged 5-9, 6.6 percent of all hospitalizations were due to bicycle accidents; for those aged 10-14, 4.8 percent; and for those aged 15-19, 1.1 percent. For comparison purposes the corresponding percentages for motor vehicle injuries were 6.9 percent (aged 5-9), 9.9 percent (aged 10-14), and 39.2 percent (aged 15-19). Thus, the contribution of bicycle accidents toward hospitalization decreased with age while that of motor vehicle accidents increased.

As another example of a retrospective analysis of medical records, Kraus, et al. (1985) assimilated data from a variety of medical sources in and around San Diego County to study bicycle-related brain injuries. Results of these analyses revealed that males were three times more likely to suffer bicycling-related brain injuries than females, and that 22 percent of the brain injuries were to children under 15 years of age. While only a third of the bicycle accidents resulting in brain injuries involved a motor vehicle, those that <u>did</u> involve a motor vehicle were more severe and required longer hospital stays.

The bicycle literature also contains a large number of foreign studies involving retrospective analyses of hospital data. Included are the following:

A comparison of head injuries among pedal cyclists and motorcyclists treated at four hospitals in Melbourne, Australia (McDermott and Klug, 1985).
Motorcyclists were found to suffer more severe injuries overall, but bicyclists were found to suffer more frequent and severe head injuries, due to their non-use of safety helmets.

An analysis of hospital records for 880 children with head injuries admitted to an Ottawa children's hospital (Ivan, Choo, and Ventureyra, 1983).
Bicycles were the single most common cause of treated head injuries.

A general analysis of bicycling injuries in Calgary, Alberta using admissions records from three hospitals (Guichon and Myles, 1975).
Two-thirds of bicyclists admitted to hospital sustained head injuries.

A comparison of bicycle and motorcycle injuries treated over a 16 month period at a large British hospital (Pedder, Hagues, Mackay and Roberts, 1981).
Eighty-eight percent of pedal cyclists were injured in accidents <u>not</u> reported to the police.

A series of studies based on records from several Swedish hospitals and institutions, focusing on the prevention of bicycle injuries due to falls (Thorson, 1974).
Falls from bicycles were found to be associated with different injury patterns than bicycle collisions with motor vehicles.

An analysis of injuries resulting from childhood accidents of all sorts with special reference to bicycle injuries (Sibert, Maddocks, and Brown, 1981).
Bicycle-related injuries were found to account for 48 percent of all injuries to children 15 or under.

Finally, the literature review revealed several studies, both U.S. and foreign, where hospital records were used to examine specific injuries resulting from bicycle accidents. Examples here include femoral shaft fractures (Hedlund and Lindgren, 1986), maxillofacial fractures (Lindqvist, Sorsa, Hyrkas, and Santavirta, 1986), scaphoid fractures (Christodoulou and Colton, 1986), and bicycle spoke injuries to the foot and ankle (Izant, Rothman, and Frankel, 1969). A study of fatal bicycle injuries based upon autopsy reports (Fife, Davis, Tate, Wells, Mohan, and Williams, 1983) might also be included among these "specialized" hospital studies.

Population Surveys

Population surveys represent a third source of information on bicycle injuries that can potentially yield information on a much broader range of injuries than that captured in the medical records. As an example, Kruse and McBeath (1980) sent questionnaires to a random sample of 1200 college students registered at the University of Wisconsin. Sixty-three percent of the 852 students responding indicated that they rode bicycles, and nearly a third of these had been involved in an accident over the past three years. Of those in accidents, 62 percent reported that they had been injured, and 32 percent had sought medical attention for their injuries. Only eight percent of the injuries had been reported to the police.

A similar survey approach was used by Sgaglione, et al. to learn about bicycle-related accidents and injuries among a small sample of Manhattan cyclists (Sgaglione, Saljaga-Petchel, and Frankel, 1982). Information was requested on riding experience, mileage, use of a safety helmet, accident involvement, injury outcome, etc. Of the 93 cyclists included in the final study sample, 51 (55 percent) reported that they had at some time been involved in an accident. Six percent of the resulting injuries were severe enough to require hospitalization, 31 percent required treatment at an emergency room or by a private physician, and the remaining required no professional treatment. The types of injuries reported were 64 percent abrasions and lacerations, 15 percent sprains and strains, 12 percent fractures, and nine percent concussions. Accident involvement was significantly correlated with both weekly mileage and total length of time cycling.

A 1971 study by HSRC (Pascarella, 1971) obtained monthly mileage and accident involvement information from a sample of 523 elementary and junior high age riders in Raleigh, NC. Over the six-month study period, 93 survey participants reported involvement in an accident. The overall bicycle accident rate was 1.4 accidents per 1,000 miles, with no significant differences between male and female riders or between riders of highrise, lightweight, and standard style bicycles. During the same six-month study period, 14 bicycle accidents were reported by the local police and 131 by Raleigh hospital emergency rooms. The authors concluded that for every accident reported by the police, ten others occurred that were serious enough to require professional treatment.

Survey studies can also be used to complement other research efforts. For example, in their evaluation of bicycle helmet efficacy, Weiss, et al. examined emergency room data from three hospitals over a period of four years, eventually identifying 58 cases of bicycle-related serious head injuries (Weiss, Belongia, Bowman, and Rattanassiri, 1985). Supplementing this medical data was data derived from an on-road survey of 847 riders. The survey was used to gather information on variables that might impact on helmet use, such as rider age and sex, length of trip, previous falls, frequency of riding, and type of bicycle.

As a final example, Perreault, Matthias, and Anderson (1977) combined survey data with police-reported data to develop bicycle accident rates in the state of Arizona. The rates were calculated on the basis of accidents per million bicycle trips and were reported for the state as a whole, for urban versus rural locations, and for selected urban areas. The overall trend was one of increased accidents over time.

Studies Based on Police Accident Reports

A final category of bicycle accident and injury studies that will be cited here are those based on police accident reports. Obviously the major drawback to these studies is that they reflect but a small portion of the total bicycle accident picture. Nevertheless, police-reported data exists in vast quantities which can yield considerable information on that subset of bicycle accidents (namely, bicycle-motor vehicle accidents) most likely to result in serious injury to the cyclist.

The most recent statewide analysis of bicycle accidents occurring in North Carolina was conducted by HSRC and utilized police-reported data for the three-year period 1974-1976 (Hunter, Cole, and Leggett, 1978). Bicycle accidents were also compared with motorcycle and moped accidents in a 1979 HSRC report based on 1976-1978 N.C. accident data (Hunter and Stutts, 1979). The following summary tallies are pulled from the latter report and reflect a total of 3500 police-reported bicycle accidents over the three-year period:

Variable		Percent
Rider Age:	< 16	69.7
	16-21	15.2
	22-55	12.5
	> 55	2.6
Rider Sex:	Male	80.5
	Female	19.5
Injury Severity:	Killed (K)	2.5
	Serious (A)	17.7
	Moderate (B)	51.2
	Minor (C)	24.6
	None (O)	4.0
Road Feature:	Intersection of two roads	41.2
	Driveway or alley	16.1
	Other	42.7
Road Type:	Interstate, U.S. or N.C. route	26.0
	Rural paved or rural unpaved	30.3
	City street	38.8
	Private property	4.8

Other descriptive analyses of police-reported bicycle accidents found in the literature focus on the cities of Milwaukee, WI, (Abou-Loghd, Chatterjee, and Sinha, 1976), Tucson, AZ (Halek, Webster, and Hughes, 1980), and Lexington, KY (Agent and Zegeer, 1980). A recent analysis of police-reported accidents in Palo Alto, California (Carey, Lewiston, and Likens, 1985) contains an added dimension. Here, the authors have supplemented three years of police accident data with exposure data to determine the relative risks of certain riding behaviors. For example, riders under age 18 were involved in 45 percent of the reported accidents but constituted only a third of the observed population. Thus, younger riders were deemed at higher risk of accident involvement. Similarly, wrong-way riding was implicated in 38 percent of the accidents but observed among only 20 percent of the riders, making this another high risk factor. Sex by itself was not found to be associated with accident risk.

Undoubtedly other communities and states have examined their police-reported bicycle accidents, although such studies do not routinely appear in the literature. Police-reported data also form the basis for most all bicycle accident statistics reported at the national level, e.g., the figures cited earlier by the National Safety Council and the National Highway Traffic Safety Administration. (The NEISS data, based on a nationwide sample of hospital emergency rooms, is an exception.) Again, it must be noted that this data is, in effect, a subset of all bicycle accidents, emphasizing the more severe accidents and those involving a motor vehicle.

Summary

This literature review has encompassed a wide range of studies, each contributing to our understanding of the nature and scope of the bicycle accident problem. A common theme throughout has been that bicycle accidents are a significant source of injury -- particularly among children -- deserving increased attention by health and safety officials. The results presented in this report will hopefully further extend our knowledge in this important area.

CHAPTER 2. METHODOLOGY

As stated in the Introduction, this project was an outgrowth of efforts by two North Carolina physicians seeking information on the frequency and characteristics of bicycle-related injuries. During the spring of 1985, these physicians (Dr. Frank Sheldon and Dr. Joseph Williamson) solicited the assistance of their colleagues serving other hospital emergency rooms in collecting specialized data on patients presenting for bicycle-related injuries. The following hospitals agreed to participate in the study:

Pitt County Memorial Hospital	Greenville, NC
Beaufort County Hospital	Washington, NC
New Hanover Memorial Hospital	Wilmington, NC
N.C. Memorial Hospital	Chapel Hill, NC
Cannon Jr. Memorial Hospital	Banner Elk, NC
Craven County Hospital	New Bern, NC
Charlotte Memorial Hospital	Charlotte, NC
Memorial Mission Hospital	Asheville, NC
Edgecombe General Hospital	Tarboro, NC
Wayne County Memorial Hospital	Goldsboro, NC
Onslow Memorial Hospital	Jacksonville, NC

Figure 1 shows the locations of these hospitals on a map of North Carolina. Selection was based primarily on Dr. Sheldon's and Dr. Williamson's personal acquaintances with other emergency room physicians, so that the largest share of participating hospitals was from the eastern portion of the state. Nevertheless, an attempt was made to obtain participation from hospitals located in all regions of the state. (No analysis has been conducted of the representativeness of these hospitals with respect to all N.C. hospitals.)

Actual data collection was carried out at the hospitals from mid-May through mid-September, 1985.[1] Emergency room personnel were instructed to complete a special supplementary data form on all persons treated for bicycle-related injuries during this four-month time period (see Figure 2). All completed forms were mailed back to either Dr. Sheldon or Dr. Williamson. Midway through the survey period a letter was mailed to the primary contact

[1]A few of the hospitals appear to have varied slightly from this schedule, either beginning their data collection later or ending earlier.

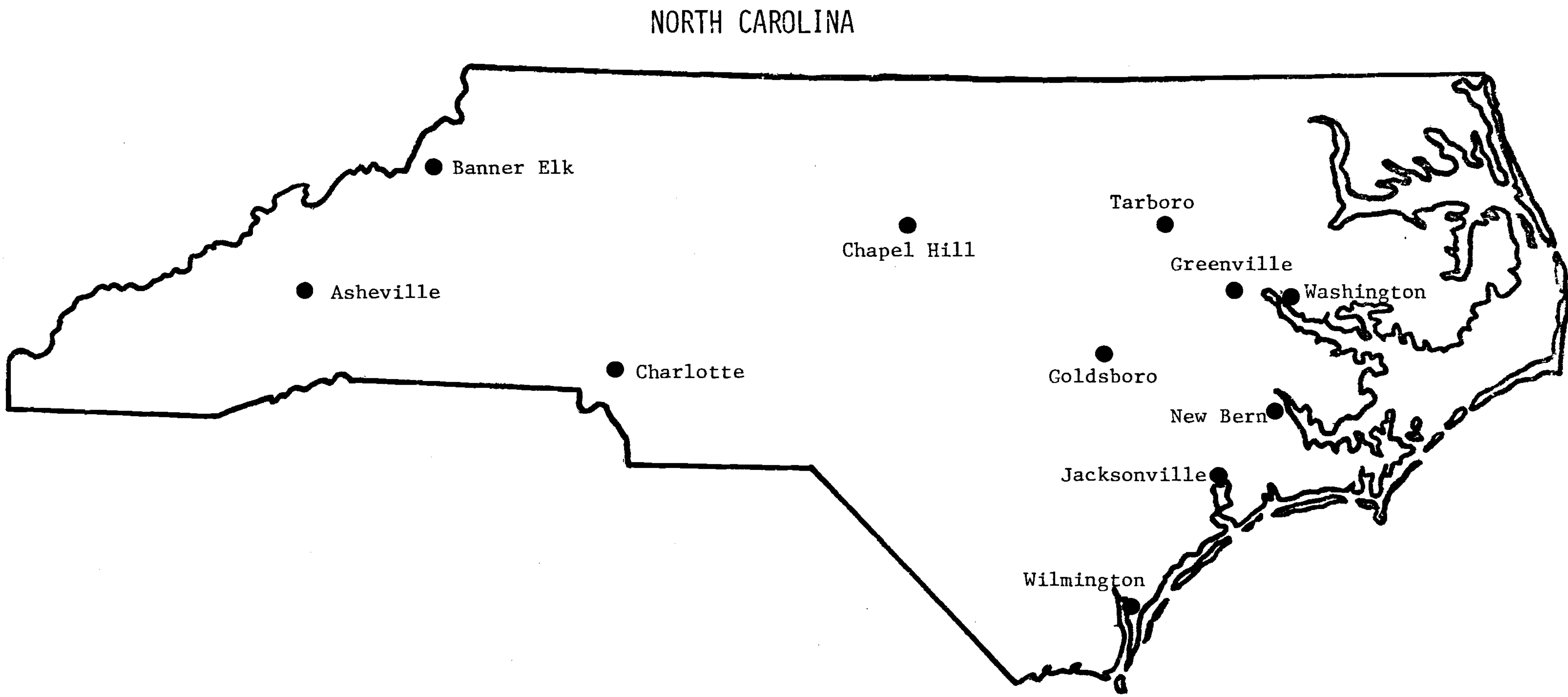


Figure 1. Location of hospitals participating in 1985 bicycle accident survey.

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 hospital emergency room reported bicycle accidents.

person at each hospital to address problem areas and encourage continued participation in the project.

Although some follow-up contacts were made at the conclusion of the data collection, these were done primarily to check on information recorded for specific cases. There was no structured attempt at this time to assess either the accuracy of the data or the level of participation by the hospitals. One large urban hospital (Charlotte Memorial) submitted only two cases, both fatalities, and so was excluded from the analyses. Generally, it was felt that participation by the hospitals was adequate, and that the data obtained was representative of bicycle accidents occurring in those areas served by the hospitals. (Some tables supporting this conclusion are presented in the Results section.)

Data from the returned forms was entered onto a computer file at East Carolina University (ECU) under the direction of Dr. Williamson and Dr. Ted Whitley, statistician for the project. Due to compatibility differences between the computer systems at ECU and HSRC, the data was then entered a second time onto a microfile at HSRC and uploaded onto the Center's IBM main frame computer. However, the two data bases are essentially identical, since a printout of the ECU data (rather than the raw data forms) was used as the basis for data entry at HSRC.

Current plans call for Drs. Williamson, Sheldon, and Whitley to analyze the data independently and publish their findings in the medical literature. The analysis contained in the present report should augment their work by incorporating data from the North Carolina accident file. The goal of both analyses is to further our understanding of the nature and magnitude of the bicycle accident problem in North Carolina and to begin to form some basis for effectively addressing this problem.

CHAPTER 3. RESULTS

In preparing the original data analysis plan for this project, it was assumed that the hospital surveys would yield information on approximately 500 injured bicyclists; however, only 244 cases were reported by the hospitals. Although this limited data base does not support sophisticated statistical analyses, it does provide at least a beginning picture of bicycle accidents requiring emergency room treatment that can, in turn, be contrasted with accidents reported on the North Carolina accident files.

The initial section of this chapter presents some tables used to examine the representativeness of the data from the participating hospitals. This is followed by descriptive analyses showing various single variable and selected cross-tabulations of interest. Interactions between variables are tested using chi-square and Fisher's exact test statistics. A final section presents basic descriptive tables for 1985 bicycle accidents reported on the State file and draws some comparisons with the emergency room data.

Individual Hospital Results

The results presented in this chapter are based on data reported by ten N.C. hospital emergency rooms. An eleventh hospital was included in the original sample, but submitted only two cases (both fatals) and so was excluded from the analyses. The following tables examine the representativeness of the data from the ten participating hospitals with respect to certain key variables.

Table 2 shows the total number of cases reported for each participating hospital. Also included for comparison purposes is information on hospital size as indicated by number of beds for inpatient care. Pitt County and Beaufort County hospitals are the "home bases" for Dr.'s Williamson and Sheldon and together account for 43 percent of the survey sample. This percentage is high and undoubtedly reflects the commitment of these physicians and their staffs to the project. It also likely reflects the generally high level of bicycling in these two eastern North Carolina communities. Other hospitals reporting fairly large numbers of cases are N.C. Memorial in Chapel Hill (home of the University of North Carolina and also an active bicycling community) and Edgecombe General in Tarboro.

Table 2. Total number of cases reported for each participating hospital.

Hospital	Number Reported Cases	Percent	Number Beds[1]	Percent
Pitt County Memorial	55	22.5	538	17.2
Beaufort County	50	20.5	151	4.8
New Hanover Memorial	14	5.7	454	14.5
N.C. Memorial	33	13.5	597	19.1
Canon Jr. Memorial	10	4.1	79	2.5
Craven County Memorial	11	4.5	254	8.1
Memorial Mission	17	7.0	435	13.9
Edgecombe General	24	9.8	127	4.1
Wayne County Memorial	11	4.5	341	10.9
Onslow Memorial	19	7.8	150	4.8
TOTAL	244	99.9	3,126	99.9

[1]As reported in the American Hospital Association's Guide to the Health Care Field, 1985 Edition.

The hospitals reporting the smallest numbers of cases were Cannon Jr. Memorial, Wayne County Memorial, Craven County Memorial, and New Hanover Memorial. Cannon Jr. in Banner Elk is a small hospital in a rural mountain community, so that one would not anticipate a large number of cases reported here. Wayne County (in Goldsboro) may have lost cases to a second larger hospital in Goldsboro as well as to a military hospital for the Seymour Johnson Air Force Base. Craven County Memorial (in New Bern) and New Hanover Memorial (in Wilmington), however, are both settings where one might have anticipated a greater number of reported bicycle cases. Clearly there are many influencing factors for which we do not have complete information -- the level of bicycling in the community, the effect of other hospitals in the area, the availability of alternative medical care facilities, etc. Also, there was no follow-up with the hospitals to obtain feedback regarding their appraised level of participation over the course of the study.

Table 3 examines the distribution of cases by day of week. (In this and all subsequent tables, overall totals less than 244 reflect missing variable information.) The fact that each hospital reported a mix of weekday and weekend cases supports the representativeness of their samples. Similarly, the distribution of cases by time of day (Table 4) is encouraging in that there are no obvious "gaps" in coverage. If all of a hospital's cases had occurred during one period of the day (say, 7 a.m. - 4 p.m.), one might question the representativeness of the data from that hospital.

Information related to the severity of the cases reported is shown in Table 5. Overall, nearly six percent of the cases in our sample required admission to the hospital for further treatment and/or observation. However, there was some variation here among the hospitals. As noted earlier, one hospital was excluded from the analysis, because it only submitted two cases and both of these involved fatalities. Craven County and Wayne County also reported a disproportionately high percentage of "admission" cases, but sample sizes in both cases were small.

While these tables certainly do not "prove" the representativeness of our data, neither do they point out any glaring deficiencies. The most likely area of weakness is an overall underreporting of cases, particularly those not involving serious injuries. None of the hospitals attains the volume of cases reported by either Beaufort County (Dr. Sheldon in charge) or Pitt Memorial (Dr. Williamson in charge). For the analyses that follow, we have combined the

Table 3. Number and percent of cases by reporting hospital and day of week.

Hospital	Number of Cases	Percent of Cases						
		Sun.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.
Pitt County Memorial	54	9.3	7.4	9.3	25.9	14.8	11.1	22.2
Beaufort County	50	6.0	14.0	18.0	20.0	14.0	14.0	14.0
New Hanover Memorial	14	21.4	7.1	21.4	0.0	14.3	28.6	7.1
N.C. Memorial	33	12.1	9.1	21.2	30.3	15.2	6.1	6.1
Canon Jr. Memorial	10	20.0	30.0	20.0	0.0	10.0	20.0	0.0
Craven County Memorial	11	27.3	0.0	9.1	18.2	9.1	0.0	36.4
Memorial Mission	17	29.4	17.6	17.6	0.0	11.8	17.7	59.9
Edgecombe General	24	25.0	0.0	25.0	8.3	12.5	20.8	8.3
Wayne County Memorial	11	0.0	9.1	0.0	45.5	9.1	18.2	18.2
Onslow Memorial	19	15.8	0.0	15.8	26.3	5.3	15.8	21.1
TOTAL	243	14.0	9.1	16.0	19.8	12.8	14.0	14.4

Table 4. Number and percent of cases by reporting hospital and time of day.

Hospital	Number of Cases	Percent of Cases Mid- 7 am	7 am- Noon	Noon 4 pm	4 pm- 7 pm	7 pm- 9 pm	9 pm- Mid
Pitt County Memorial	54	5.5	12.7	27.3	14.5	25.5	14.5
Beaufort County	50	0.0	10.0	28.0	34.0	16.0	12.0
New Hanover Memorial	14	7.1	7.1	14.3	21.4	35.7	14.3
N.C. Memorial	33	3.0	30.3	15.2	33.3	9.1	9.1
Canon Jr. Memorial	10	0.0	20.0	40.0	40.0	0.0	0.0
Craven County Memorial	11	0.0	9.1	9.1	18.2	36.4	27.3
Memorial Mission	17	0.0	11.8	52.9	29.4	5.9	0.0
Edgecombe General	24	4.2	0.0	41.7	37.5	12.5	4.2
Wayne County Memorial	11	9.1	18.2	27.3	36.4	9.1	0.0
Onslow Memorial	19	5.3	0.0	26.3	15.8	42.1	10.5
TOTAL	244	3.3	12.3	27.9	27.0	19.3	10.2

Table 5. Number and percent of cases by reporting hospital and admission status.

Hospital	Admission Status: Not Admitted	Admission Status: Admitted	Total
Pitt County Memorial	52 (96.3)[1]	2 (3.7)	54
Beaufort County	49 (98.0)	1 (2.0)	50
New Hanover Memorial	14 (100.0)	0 (0.0)	14
N.C. Memorial	32 (97.0	1 (3.0)	33
Canon Jr. Memorial	10 (100.0)	0 (0.0)	10
Craven County Memorial	9 (81.8)	2 (18.2)	11
Memorial Mission	16 (94.1)	1 (5.9)	17
Edgecombe General	22 (91.7)	2 (8.3)	24
Wayne County Memorial	8 (72.7)	3 (27.3)	11
Onslow Memorial	17 (89.5)	2 (10.5)	19
TOTAL	229 (94.2)[1]	14 (5.8)	243

[1] Row percent

data from all of the hospitals. This requires at least a tacit assumption that the data adequately reflects the total population of bicycle accident cases presenting to these hospitals.

Clearly, this study makes no assumptions regarding the representativeness of our ten hospitals to all hospitals in the State. While a worthy goal for future study, this is beyond the scope of the current project.

Survey Data Analysis

Rider Variables

Table 6 shows the frequency of emergency room reported bicycle accidents by rider age and sex. Seventy percent of the emergency room cases were male, and nearly two-thirds involved riders under the age of 15. Males are overrepresented in the 0-4 and 25-29 age categories, females among older riders and those between the ages of 15 and 25. This information is depicted graphically in Figure 3.

Since individual cell counts in Table 6 were not adequate to permit a valid chi-square test, riders less than 15 versus those greater than or equal to 15 were grouped to produce a 2x2 table of age by sex. The resulting chi-square for this table was not significant (p=.32).

Information on helmet use is presented in Table 7 (by age) and Table 8 (by sex). Overall only six percent of the bicyclists treated indicated that they were wearing a helmet at the time of their accident. Older riders were much more likely to have been wearing a helmet than younger riders: 12 percent of riders aged 15 or older versus less than three percent of riders under age 15. Helmet use was particularly high for riders in the 20-24 year age group. Here, one-third of the riders reported wearing a helmet. When the older and younger riders were grouped (<15, ≥ 15) to overcome the small cell counts in Table 7, the resulting chi-square was significant at $P<.01$.

Concerning the effects of rider sex on helmet usage, Table 8 shows that males wore helmets with slightly greater frequency than females. However, these results are not significant (p=.76, based on the Fisher's exact test.)

Accident Variables

Day of week and time of day information is shown in Table 9 and Figures 4 and 5. The greatest number of bicycle accidents was reported on Wednesday, the least on Monday. The remaining days of the week were fairly evenly

Table 6. Frequency of emergency room reported bicycle accidents by rider age and sex.

Age	Sex		Total
	Male	Female	
0-4 years	4 (80.0)[1]	1 (20.0)	5 (2.1)[2]
5-9 years	39 (68.4)	18 (31.6)	57 (23.5)
10-14 years	69 (75.0)	23 (25.0)	92 (37.9)
15-19 years	18 (64.3)	10 (35.7)	28 (11.5)
20-24 years	13 (61.9)	8 (38.1)	21 (8.6)
25-29 years	11 (91.7)	1 (8.3)	12 (4.9)
30-39 years	11 (68.8)	5 (31.3)	16 (6.6)
$\geq$ 40 years	6 (50.0)	6 (50.0)	12 (4.9)
TOTAL	171 (70.4)[1]	72 (29.6)	243

[1]Row percent
[2]Column percent

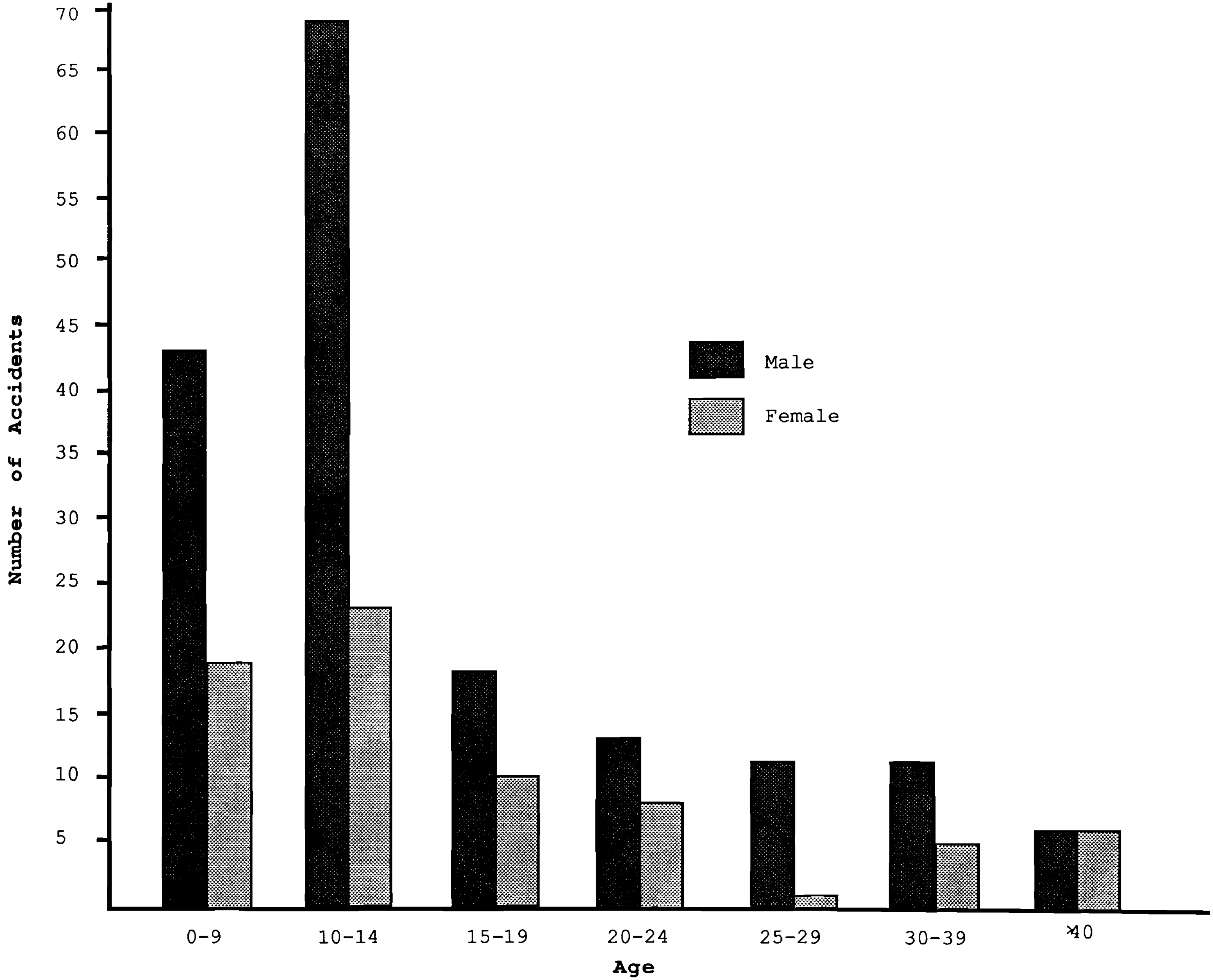


Figure 3. Frequency of accidents by rider age and sex.

Table 7. Bicycle helmet usage by age of rider.

Riders Age	Helmet Worn Yes	No	Total
0-4 years	0 (0.0)[1]	5 (100.0)	5 (2.1)[2]
5-9 years	1 (1.8)	56 (98.2)	57 (23.5)
10-14 years	3 (3.2)	90 (96.8)	93 (38.3)
15-19 years	1 (3.6)	27 (96.4)	28 (11.5)
20-24 years	7 (35.0)	13 (65.0)	20 (8.2)
25-29 years	1 (8.3)	11 (91.7)	12 (4.9)
30-39 years	1 (6.3)	15 (93.8)	16 (6.6)
$\geq$ 40 years	1 (8.3)	11 (91.7)	12 (4.9)
TOTAL	15 (6.2)	228 (93.8)	243

[1]Row percent
[2]Column percent

Table 8. Bicycle helmet usage by sex of rider.

Rider Sex	Helmet Worn Yes	No	Total
Male	11 (6.5)[1]	159 (93.5)	170 (70.2)[2]
Female	3 (4.2)	69 (95.8)	72 (29.8)
TOTAL	14 (5.8)	228 (94.2)	242

[1]Row percent
[2]Column percent

Table 9. Frequency of emergency room reported bicycle accidents by day of week and time of day.

Day of Week	Time of Day: Mid-7 am	7 am-Noon	Noon-4 pm	4 pm-7 pm	7 pm-9 pm	9 pm-Mid	Total
Sunday	1 (2.9)[1]	4 (11.8)	12 (35.3)	7 (20.6)	6 (17.7)	4 (11.8)	34 (14.0)[2]
Monday	0 (0.0)	3 (13.6)	7 (31.8)	9 (40.9)	1 (4.6)	2 (9.1)	22 (9.1)
Tuesday	1 (2.6)	4 (10.3)	7 (18.0)	16 (41.0)	9 (23.1)	2 (5.1)	39 (16.0)
Wednesday	2 (4.2)	8 (16.7)	7 (14.6)	15 (31.3)	8 (16.7)	8 (16.7)	48 (19.8)
Thursday	0 (0.0)	2 (6.5)	11 (35.4)	5 (16.1)	9 (29.0)	4 (12.9)	31 (12.8)
Friday	4 (11.8)	4 (11.8)	9 (26.5)	6 (17.7)	10 (29.4)	1 (2.9)	34 (14.0)
Saturday	0 (0.0)	5 (14.3)	15 (42.9)	8 (22.9)	4 (11.4)	3 (8.6)	35 (14.4)
TOTAL	8 (3.3)	30 (12.3)	68 (27.9)	66 (27.1)	47 (19.7)	24 (9.8)	243

[1]Row percent
[2]Column percent

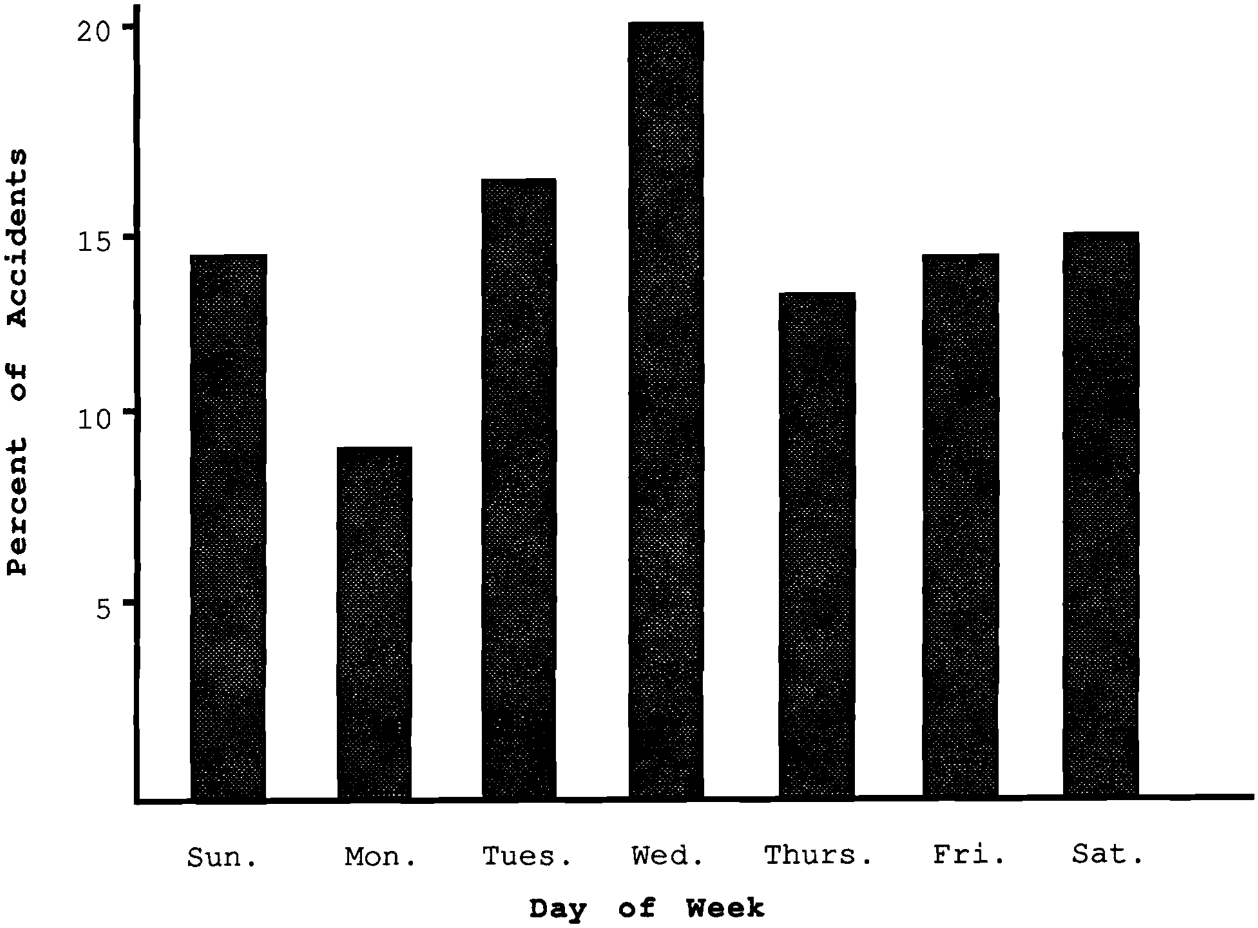


Figure 4. Percentage of emergency room reported bicycle accidents by day of week.

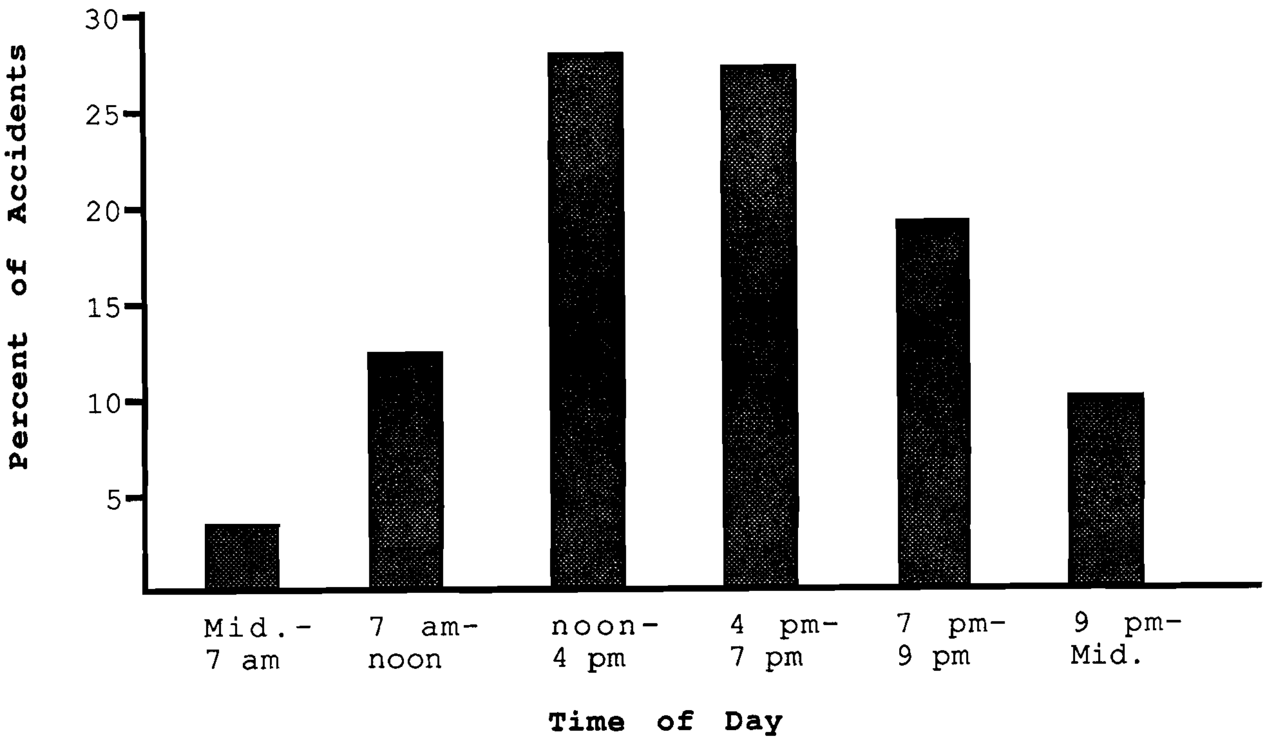


Figure 5. Percentage of emergency room reported bicycle accidents by time of day.

represented. Over half of the accidents occurred during the afternoon (noon - 4 p.m.) and evening commuting hours (4 - 7 p.m.). Looking within the cross-classified categories of day of week by time of day one finds that

- Mid-day (noon - 4 p.m.) accidents occurred with greatest frequency on Saturday.
- Accidents during the evening commuting hours (4 - 7 p.m.) peaked on Monday and Tuesday.
- Accidents during the early evening hours (7-9 p.m.) occurred most frequently later in the week, on Thursday and Friday.
- The day of week with the greatest number of accidents occurring from midnight to 7 a.m. was Friday (half of the eight cases reported).

As cell counts in Table 9 were too sparse to permit a valid chi-square test of the association between day of week and time of day, a crosstab was obtained for day of week (weekday, weekend) versus time of day (same six levels). Results here showed an insignificant chi-square ($p = 0.17$).

The following tables were also examined for significant variable interactions:

Day of week (7 levels) x age (2 levels)

Day of week (7 levels) x sex (12 levels)

Time of day (6 levels) x age (2 levels)

Time of day (6 levels) x sex (2 levels)

The only table producing a significant chi-square was time of day x age ($p < .01$): older riders were more likely to be involved in accidents occurring from 9 p.m. - 7 a.m. (22 percent for riders ≥ 15, eight percent for riders < 15), whereas younger riders were overrepresented in accidents occurring from 7-9 p.m. (24 percent of their accidents, versus 12 percent for the older riders). Although there were no significant differences associated with rider sex, males were somewhat more likely than females to be involved in weekend accidents (31 percent for males versus 21 percent for females, $p = .12$).

Two sections on the survey form intended to provide information on the location and/or type of accident. One of these was at the top of the form, where the provider was asked to write in the accident location, giving street names where possible. From this information the following location categories were developed: city street, highway, and other (parking lot, yard, etc.). Unfortunately, with the exception of Beaufort County and Pitt Memorial, hospital personnel were not adept at completing this section of the form, resulting in large quantities of missing information. The breakdown of the variable was:

	N	%
City street	75	30.7
Highway	15	6.2
Other	31	12.7
Missing	123	50.4
	244	100.0

A later section of the survey form asked for accident location and type information through a series of yes/no check boxes. This information is summarized in Table 10. Overall, 12 percent of the accidents occurred at intersections, 17 percent at driveways, and 38 percent along non-intersection road segments (including both city streets and rural roads or highways). Fourteen accidents occurred on sidewalks, half as many as at intersections. The large "other" category includes approximately 20 unknown cases in addition to a sizeable number of accidents occurring off-road ($N = 9$), in yards ($N = 8$), on private or dirt roads ($N = 9$), etc.

Since each of the accident type categories listed in Table 10 was originally entered as a separate variable, it was possible to conduct a series of two-way tables examining each by rider age and by rider sex (e.g., intersection (yes? no?) by age (< 15, ≥ 15); intersection (yes? no?) by sex (male, female); etc.). When expected cell counts were too sparse for valid chi-square testing, Fisher's exact test was applied. No significant differences were found with respect to rider sex. Concerning age, riders aged 15 or older were significantly more likely to be involved in intersection accidents than those under age 15 -- 18.0 percent vs. 9.1 percent, respectively ($p = 0.04$). The other accident type variables were not significantly associated with rider age.

Two key variables concern whether or not the accident was reported to the police and whether or not a motor vehicle was involved. Table 11 presents these results. Overall, 20 percent of the cyclists indicated that their accident had been reported to the police. Of these, 78 percent involved a motor vehicle ($p < .01$). Also of interest here is the sizeable number of accidents involving a motor vehicle but <u>not</u> reported to the police ($N = 16$, or

Table 10. Frequency of emergency room reported bicycle accidents by accident type.

Accident Type	Number	Percent
Intersection	30	12.3
Driveway	42	17.2
Road Segment (non-intersection)	94	38.5
Sidewalk	14	5.7
Railroad Crossing	2	0.8
Other or Unknown[1]	62	25.4
TOTAL	244	99.9

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

Table 11. Frequency of emergency room reported bicycle accidents by whether reported to police and motor vehicle involvement.

Accident Reported to Police	Motor Vehicle Involved? Yes	No	Total
Yes	38 (77.6)[1] (70.4)[2]	11 (22.4) (5.8)	49 (20.1)[2]
No	16 (8.2) (29.6)	179 (91.8) (94.2)	195 (79.9)
TOTAL	54 (22.1)[1]	190 (77.9)	244

[1]Row percent
[2]Column percent

percent of the 54 bicycle-motor vehicle accidents). As expected, bicycle accidents not involving a motor vehicle are seldom reported to the police -- less than six percent of the cases for this sample. (See later section on comparisons with N.C. accident data.)

Male bicyclists were more likely to encounter motor vehicles than were females (25.0 versus 16.7 percent), though this difference is not statistically significant ($p = .16$). Males were also more likely to be in accidents that were reported to the police (23.3 vs 13.9 percent), though again the difference is not statistically significant ($p = .10$).

Police reporting status and motor vehicle involvement were both significantly associated with rider age when the age variable was grouped (< 15, ≥ 15) to overcome small cell counts. Overall, 35.6 percent of the accidents involving riders aged 15 or older were reported to the police, compared with 11.6 percent of the accidents involving riders under age 15 ($p < .01$). Similarly, 34.4 percent of the older riders' accidents involved motor vehicles, versus 15.5 percent of the younger riders ($p < .01$). Table 12 shows results for the ungrouped age data. Obviously, a key factor here would be accident location, i.e., accidents occurring in yards, on dirt roads, in trailer parks, etc. are less likely to involve a motor vehicle and hence less likely to be reported to the police. They are also most likely to characterize the younger rider.

Some final accident-related variables are grouped in Table 13. Overall, eight percent of the reported bicycle accidents involved another bicycle, 11 percent involved wrong-way riding, another 11 percent more than one person on the bicycle, and 16 percent a mechanical defect with the bicycle that contributed to the accident. The only one of these variables found to be associated with either age or sex was that concerning more than one rider on the bicycle ($p < .01$). As might be expected, this occurred with greatest frequency for the younger-aged riders, particularly those aged 5-9 (16 percent of their accidents). The very youngest riders were also involved in a high percentage of "more than one on bike" accidents, presumably since they were being carried or otherwise transported by an adult.

Injury Variables

Results pertaining to injury are summarized in Table 14. There were four fatal cases reported by the hospitals -- one each from Craven County,

Table 12. Emergency room reported bicycle accidents by rider age, police reporting status, and auto involvement.

Rider Age	N	Percent Reported To Police	Percent Motor Vehicle Involved
0-4	5	20.0	20.0
5-9	57	7.0	8.8
10-14	93	14.0	19.4
15-19	28	21.4	25.0
20-24	21	47.6	42.9
25-29	12	33.3	33.3
30-39	16	37.5	31.3
$\geq$ 40	12	41.7	41.7
TOTAL	244	20.4	22.5

Table 13. Other accident-related variables.

Accident Variable	Yes	No	Total
Another bicycle involved?	19 (7.8)[1]	225 (92.2)	244
Cyclist riding against traffic?	26 (10.7)	216 (89.3)	242
More than one on bike?	27 (11.1)	217 (88.9)	244
Bicycle mechanical defect?	38 (15.6)	205 (84.4)	243

[1]Row percent

Table 14. Injury characteristics of emergency room reported bicycle accidents.

Injury Characteristic	Yes	No	Total
Fatality?	4 (1.6)[1]	240 (98.4)	244
Admitted to Hospital?	14 (5.8)	229 (94.2)	243
Head Injury?	33 (13.6)	209 (86.4)	242
Dental Injury?	19 (7.8)	225 (92.2)	244
Fracture/Dislocation?	60 (25.0)	180 (75.0)	240
Lacerations?	110 (45.1)	134 (54.9)	244
Abrasions?	172 (70.5)	72 (29.5)	244
X-Ray Required?	144 (59.0)	100 (41.0)	244

[1] Row percent

Edgecombe General, Wayne County, and Onslow Memorial hospitals. These four cases represent 1.6 percent of the bicyclists in the study sample. The age and sex of the bicyclists were as follows:

Hospital	Age and Sex
Craven County	7 year-old male
Edgecomb General	12 year-old male
Wayne County	18 year-old male
Onslow County	20 year-old male

All of the fatal accidents involved an auto, and all were reported to the police. One occurred at an intersection and three on a highway or other state road segment. All four of the fatally injured cyclists suffered a head injury and none was wearing a helmet. The accidents all occurred between 11 a.m. and 9 p.m.

Overall, 14 percent of the injured bicyclists presenting for emergency room treatment suffered head injuries (18 percent of riders 15 years and older, 12 percent of riders under 15 years, $p = .19$). Presence of head injury was significantly correlated with hospital admission: whereas only four of the 208 cases not involving head injury required hospital admission, 11 of the 34 head injury cases required hospital admission ($p < .01$, based on Fisher's exact test). Of the 34 bicyclists experiencing head injury, only two were not wearing a helmet at the time of their accident. The total number of helmet users was small, however ($N = 15$), and no significant relationship was found between helmet usage and head injury.

Concerning the other injury-related variables, eight percent of the reported cases involved dental injuries, 25 percent fractures and dislocations, 45 percent lacerations, and 71 percent abrasions. Older riders ($\geq$ 15) were more likely than younger riders to suffer fractures and dislocations (32 percent for the older riders versus 21 percent for the younger, $p = .07$). For the remaining generally less severe injury variables, the outcomes for older and younger riders were equivalent and chi-square values were not significant. Injury outcomes for males and females also did not differ significantly.

Comparisons with State Accident Data

During 1985 there was a total of 1343 bicycles involved in accidents recorded on the North Carolina accident files. This section presents some basic descriptive tables for this data and for the subset of data defined by the ten counties where hospital survey data was gathered. Where appropriate comparisons are made with the survey data results. A final section presents the results of matching the survey and State accident file data on a case-by-case basis.

Several caveats are in order when comparing outcomes between the ten county and emergency room data bases. First, the time periods do not coincide precisely. The survey dates were roughly mid-May through mid-September, with some apparent variations by individual hospitals (e.g., four of the hospitals did not report any cases for September, which could indicate that they ended their data collection early). The police data for the five-month period May-September thus encompasses a broader time span than does the survey data. Secondly, the police data draws from a wider geographic area. The hospital survey includes only one hospital reporting within each county, whereas for several of the counties (including Wayne, Onslow, and Buncombe) there are additional hospitals available for treating victims of bicycle accidents. Any comparisons between the two samples must bear in mind these differences. Finally, sample sizes in both cases are relatively small, contributing to variations in the data.

Data Base Comparisons

Table 15 compares the three data bases -- statewide police-reported data for 1985, police-reported data restricted to the ten survey counties and five-month survey period, and the emergency room survey data -- with respect to rider age and sex. The statewide data indicates that approximately 45 percent of bicyclists involved in police-reported accidents are under the age of 15. For the survey data this percentage is considerably higher - 63 percent of the bicyclists treated.

A factor which likely contributes to this difference is the location where the accidents occurred. This information is shown in Table 16. Compared with police-reported bicycle accidents, emergency room-reported accidents are less likely to have occurred on highway type roads and much more likely to have

Table 15. Comparison of police-reported and emergency room reported bicycle accidents by rider age and sex.

Rider Age and Sex	N.C. Police Reported Accidents 1985		10 County Sample Pol. Rep. Accidents May-Sept. 1985		E.R. Reported Bicycle Accident May-Sept. 1985	
	N	%	N	%	N	%
<u>Age</u>						
0-4 years	3	0.2	0	0.0	5	2.1
5-9 years	182	13.9	20	13.4	57	23.5
10-14 years	411	31.4	31	20.8	92	37.9
15-19 years	254	19.4	28	18.8	28	11.5
20-24 years	175	13.4	28	18.8	21	8.6
25-29 years	99	7.6	14	9.4	12	4.9
30-39 years	113	8.6	17	11.4	16	6.6
≥40 years	70	5.4	11	7.4	12	4.9
Not Stated	36	--	4	--	1	--
<u>Sex</u>						
Male	1,012	85.7	104	78.8	171	70.4
Female	169	14.3	28	21.2	72	29.6
Not Stated	162	--	21	--	1	--
TOTAL	1343		153		244	

Table 16. Comparison of police reported and emergency room reported bicycle accidents by accident location.

Accident Location	N.C. Police Reported Accidents 1985		10 County Sample Pol. Rep. Accidents May-Sept. 1985		E.R. Reported Bicycle Accidents May-Sept. 1985	
	N	%	N	%	N	%
Local (city) street	700	57.4	71	48.6	75	62.5
Highway (including U.S. and NC route, secondary route)	498	40.9	64	43.8	14	11.7
Other (including private road, private property, driveway	21	1.8	1	0.7	31	25.8
Not Stated	124	--	17	--	125	--
TOTAL	1343		153		245	

occurred at such "other" locations as a private road, driveway, yard, or other off-road site. As indicated earlier, this "other" category was also more frequently associated with the younger emergency room patients -- 52 percent of the riders less than age 15 versus 17 percent for those 15 or older.

Returning to the age/sex comparisons in Table 15, differences are also seen between variable distributions for statewide accidents and the ten county sample of accidents. The ten county sample has a higher percentage of older riders than the statewide sample and a higher percentage of female riders (21 percent versus 14 percent on the State file). Several factors could be at play here, for example, the generally flat terrain of eastern North Carolina could encourage greater use of bicycles for commuting purposes. In any case, both of the police-based files report a lower percentage of female bicyclists than does the emergency room file, which approaches 30 percent female.

Table 17 uses a similar format to provide information on day of week and time of day. With regard to day of week, the N.C. accident file demonstrates considerably less day-to-day variation than the other two files. This may be attributed in part to its larger sample size. No two of the files yield very similar distributions. Whereas Wednesday was one of the least often reported accident days on the N.C. file, it was one of the most frequently reported days on both the ten county and emergency room files. Weekend accidents comprise about 27-28 percent of the accidents on all three files.

Regarding the time of day distributions, one would anticipate a higher percentage of 7-9 pm accidents for the ten county and emergency room files, given the extended hours of daylight during the summer months. This was certainly the case for the emergency room data but not for the county data. With this exception the time of day distributions for the emergency room and N.C. accident files are fairly comparable.

Injury information for the statewide and ten county police-reported data is given in Table 18. Statewide in North Carolina there were 21 bicycle fatalities in 1985. Five of these occurred in our ten county May-September sample, and four were reported by our participating hospital emergency rooms. The 21 fatalities represent just under two percent of bicyclists involved in police reported accidents. In addition, there were 323 reported serious injuries or 27 percent of the bicycle accidents reported statewide.

Fewer serious level injuries were reported on the ten county file. With the exception of fatalities, corresponding injury information for the emergency

Table 17. Comparison of police reported and emergency room reported bicycle accidents by day of week and time of day.

Day of Week/ Time of Day	N.C. Police Reported Accidents 1985		10 County Sample Pol. Rep. Accidents May-Sept. 1985		E.R. Reported Bicycle Accidents May-Sept. 1985	
	N	%	N	%	N	%
Day of Week						
Sunday	167	12.4	24	15.7	34	14.0
Monday	188	14.0	22	14.4	22	9.1
Tuesday	197	14.7	14	9.2	39	16.0
Wednesday	187	13.9	25	16.3	48	19.8
Thursday	188	14.0	26	17.0	31	12.8
Friday	205	15.3	25	16.3	34	14.0
Saturday	211	15.7	17	11.1	35	14.4
Not stated	0	--	0	--	1	--
Time of Day						
Midnight - 7 am	38	2.8	5	3.3	8	3.3
7 am - Noon	187	14.0	28	18.3	30	12.3
Noon - 4 pm	369	27.6	44	28.8	68	28.0
4 pm - 7 pm	474	35.5	51	33.3	66	27.2
7 pm - 9 pm	161	12.0	13	8.5	47	19.3
9 pm - Midnight	108	8.1	12	7.8	24	9.9
Not stated	6	--	0	--	1	--
TOTAL	1343		153		245	

Table 18. Comparison of police reported and emergency room reported bicycle accidents by injury severity.

Injury Severity	N.C. Police Reported Accidents 1985		10 County Sample Pol. Rep. Accidents May-Sept. 1985		E.R. Reported Bicycle Accidents May-Sept. 1985	
	N	%	N	%	N	%
Fatal	21	1.8	5	3.8	4	1.7
A Injury (Serious)	323	27.1	23	17.3		
B Injury (Moderate)	501	42.0	62	46.6	(See Table 14 for other available injury info.)	
C Injury (Minor)	285	23.9	34	25.6		
O Injury (None apparent)	62	5.2	9	6.8		
Not Stated	151	--	20	--		
TOTAL	1343		153		244	

room file is not available. However, only six percent of the cases were serious enough to require admittance to hospital.

To summarize, the tables in this section show clear differences between bicycle accidents recorded on State files and those reported by our sample of hospital emergency rooms. The emergency room cases involved higher percentages of young riders, female riders, and riders injured in off-road and other non-highway type accidents. Variations by day of week and time of day are less consistent, and more information is needed in order to evaluate differences in injury level distributions.

The following final section makes some case-by-case comparisons between police-reported and emergency room-reported accidents.

Case-by-Case Comparisons

Table 19 presents information for each county regarding the number of emergency room-reported bicycle accidents and the corresponding number of police-reported accidents. Overall there were 244 emergency room cases and 153 police-reported cases, for an emergency room/police ratio of 8:5. It seems likely, however, that the true ratio of emergency room to police-reported bicycle accidents is considerably higher. This is because the presence of other hospitals in a county (as is the case in Onslow County) and any "missed" cases by the hospitals would deflate this total, while the police-reported total is at least slightly inflated by the longer five-month sampling period (May 1 - September 30 vs. mid May - mid September). In any case, the three situations in Table 19 where the number of police-reported cases actually exceeded the number of emergency room cases (New Hanover, Onslow, and Wayne counties) was not anticipated.

To more clearly examine the relationship between the samples, we compared the subset of police-reported emergency room cases with the N.C. accident file data on a case-by-case basis. Of the 244 emergency room cases, 49 were marked to indicate that the accident producing the emergency room visit had been reported to the police (see Table 11). By obtaining a listing by county and date of all of the bicycle accidents on the N.C. file (N=1343), along with information on rider age and sex and time of accident, it was possible to match the two samples and determine how many of the emergency room accidents actually appeared on the N.C. file.

Table 19. Frequency of state accident reported and hospital emergency room reported bicycle accidents by county and hospital.

County (Hospital)	Police-Reported State Accident Data (May - Sept., 1985)	Hospital Emergency Room Data
Avery County (Cannon Jr. Memorial Hospital)	1	10
Beaufort County (Beaufort County Hospital)	10	50
Buncombe County (Memorial Mission Hospital)	7	17
Craven County (Craven County Hospital)	10	11
Edgecombe County (Edgecombe General Hospital)	10	24
New Hanover County (New Hanover Memorial Hospital)	24	14
Onslow County (Onslow Memorial Hospital)	32	19
Orange County (N.C. Memorial Hospital)	23	33
Pitt County (Pitt County Memorial Hospital)	19	55
Wayne County (Wayne County Memorial Hospital)	17	11
TOTAL	153	244

Of the 49 emergency room cases where the bicyclist had indicated that his accident had been reported to the police, only 26 (53 percent) were located on the N.C. file. Two of the remaining cases did not contain a date and so could not be matched, but the others simply could not be located on the file anywhere near the time of their recorded occurrence. One possible explanation for this discrepancy is that the local police departments may not forward all of their accident reports to the State Division of Motor Vehicles, particularly if no motor vehicle was involved. All but one of the "matched" cases involved a motor vehicle, whereas 10 of the 21 unmatched cases did not involve a motor vehicle. Also, patients could have responded that their accident was reported to the police when in fact it was reported to some other authority, e.g., there was one case where the accident was coded "reported to police" when a note on the survey form indicated that it had only been reported to the "campus police".

The 26 cases matched to the police files included the four fatal bicycle accidents. There were also six A-level injuries, ten B-level injuries, five C-level injuries, and one case where injury information was not recorded. With the exception of the four fatal cases, the injury level distribution for this small sample of police-reported accidents was thus not unlike the distribution for all police-reported accidents shown in Table 18.

Table 20 compares the types of injuries cited for the subset of 26 police-reported emergency room cases with all emergency room cases. The percentages of cases involving abrasions and lacerations are about the same, but the police reported cases are more likely to include fractures/dislocations (35 percent versus 25 percent) and head injuries (27 percent versus 14 percent). The police-reported accidents are also more likely to require hospital admission (15 percent versus six percent). These all point toward a more severe sample of accidents appearing in the police files.

Table 20. Comparison of police-reported emergency room cases and all emergency room cases with respect to injury type.

Injury Type	% of Cases All Emergency Room Reported Bicycle Accidents (N=244)	Matched Sample of Police Reported ER Accidents (N=26)
Abrasion	70.5	69.2
Laceration	45.1	53.8
Fracture/Dislocation	25.0	34.6
Head Injury	13.6	26.9
Dental Injury	7.8	11.5
Serious Injury Requiring Admission to Hospital	5.8*	15.4*

*Excludes fatal cases

CHAPTER 4. DISCUSSION

Significance of Research

This study represents an initial effort toward 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. The literature suggests that 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, examination 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 hospital/emergency room study section in Chapter 1 offered several examples of this approach. The present investigation goes beyond these studies by also analyzing 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?"

The present study also laid the groundwork for expanded data collection activities that took place this past riding season (May-September 1986), involving additional hospitals and a revised data collection form. A copy of the form is included as Figure 6. The results of this effort will be presented in a later report. Following is a discussion of findings from the current report.

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 6. Survey form for 1986 hospital emergency room bicycle accident study.

Major Findings

Two key variables that we were interested in examining were the percentage of accidents reported to the police and the percentage involving a motor vehicle (results are summarized in Table 11). When asked whether their accident had been reported to the police, 49 (20 percent) of the bicyclists indicated that it had. However, only 26 of these cases were located on the N.C. accident file. Thus, the actual percentage of police-reported accidents for our emergency room file was 26/244 or 10.7 percent. (Reasons for non-reporting of bicycle accidents were suggested in Chapter 3.) Even more significant is that only one of the 26 police-reported accidents did not involve a motor vehicle.

Examined differently, of the 54 total bicycle-motor vehicle accidents on our survey file, 25 were reported on the N.C. motor vehicle accident file for a rate of <u>46 percent</u>. Of the 190 bicycle-non motor vehicle accidents, only one was reported for a rate of <u>0.5 percent</u>. These percentages can be compared with those reported by Cross (1978) and Regional Consultants, Inc. (1979). From his large national sample of bicycle accidents, Cross concluded that two-thirds of bicycle-motor vehicle accidents are not reported to the police; and that one-half of these, or one-third overall, are injury producing. The Regional Consultants, Inc. study, using data from Eugene, OR, concluded that 75 percent of bicycle-motor vehicle accidents are reported to the police, but "almost none" of the accidents not involving a motor vehicle. While differences in these studies discourage any direct comparisons, they all strongly indicate that in addition to not providing any information on bicycle-non motor vehicle accidents, state accident files also miss a significant portion of the bicycle-motor vehicle accidents.

By concentrating on motor vehicle accidents, state files also produce a different description of the population of accident-involved bicyclists. On the N.C. accident file, 86 percent of the riders were male and 45 percent were aged 5-14. For the N.C. hospital emergency room file, 70 percent were male and 61 percent aged 5-14 (see Table 15). The percentages of male riders for the six other U.S. emergency room studies also ranged from 60 to approximately 70 percent, and age levels again favored the younger riders (see Table 1). One obvious explanation for these differences in the police and hospital-based files is the different accident samples captured: by emphasizing bicycle-motor vehicle accidents the police files also emphasize older and male riders.

One of the obvious advantages of a hospital-based study of bicycle accidents is the added information available concerning injury outcome. Whereas police reports are usually limited to a general assessment of injury severity (fatal, serious, moderate, minor, or none), hospital/emergency room studies are able to include more detailed information on injury type/location.

For the North Carolina study, the most common injuries treated were abrasions (70 percent of those attending) and lacerations (45 percent of those attending). One-fourth of the sample suffered a fracture or dislocation, and 14 percent a head injury. These results correspond quite closely with those reported in the literature. Typical ranges here are 60-70 percent abrasions, contusions, and lacerations, 10-25 percent head injury, and 15-25 percent fracture. (Direct comparisons are again difficult, due to differences in defining and categorizing the injuries.) Six percent of the N.C. sample was injured seriously enough to require admission to hospital, whereas percentages from the literature were six percent in a statewide Massachusetts sample (Friede, et al., 1985), eight percent in Boulder, CO (Watts, et al., 1986), and 13 percent in King County, WA (LeValley and Mueller, 1985).

Finally, hospital/emergency room based studies, particularly those involving some interviewing of the rider, can provide a great deal of information on causative factors in bicycle accidents. While the North Carolina survey was fairly limited in this respect, it did reveal the following:

8 percent of the accidents involved another bicycle;
11 percent involved wrong-way riding;
11 percent involved more than one person on bicycle; and
16 percent involved some mechanical defect of the bicycle.

Several of the other studies cited in the Literature Review contained quite detailed information about the bicycle accident, examining variables such as condition of riding surface (presence of loose sand or gravel, potholes, etc.), bicycle maneuver (turning, going downhill, etc.), riding experience, and familiarity with bicycle. All of this information can be extremely useful in planning and selecting countermeasures to reduce the frequency and severity of bicycle accidents. For example, in Boulder, CO, where a third of the bicycle accidents were found to have resulted from poor roadway conditions (loose gravel, etc.), the city has hired one person full-time to regularly travel its

17 miles of bicycle paths and 14 miles of marked bicycle lanes and see that all maintenance problems are taken care of (Clarke, 1986).

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 Commission 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 <u>the</u> leading cause of hospitalized head injuries (Weiss, 1985).

Interest in cycling continues to grow. The Metropolitan Statistical Bulletin reported that in 1981 there were 62-65 million bicycles in the U.S., or one for every two registered passenger cars (Metropolitan Statistical Bulletin, 1981). In recent years, the increasing emphasis on physical fitness, the growth of bicycle commuting, and the growing popularity of bicycle racing have all contributed to a bicycle "boom." One of the results of this "growth" is that in recent years the population of riders injured and killed in accidents has "aged" slightly. 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 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.

There are also actions that can be taken <u>now</u> 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. 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,[1] so that at this stage the greatest need is for a mechanism for placing the programs in the schools and funding to make it all 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 bicycle-motor vehicle accidents (Hunter and Stutts, 1981). Communities can also examine their own patterns of bicycle accidents to determine if any specific problem areas need addressing. The actions taken by Boulder, CO, to reduce the hazard posed by loose gravel and sand is a good example.

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 government officials. In this regard, HSRC feels fortunate in having had the opportunity to work with Dr. Sheldon and Dr. Williamson, and also with the N.C. Department of Transportation Bicycle Program, in carrying out this project. We hope that the relationship can be continued as more hospitals become involved in this effort.

[1]For further information, contact the N.C. Department of Transportation Bicycle Program.

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