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Bicycle-Motor Vehicle Accidents in the Boston Metropolitan Region

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ABSTRACT

The Metropolitan Area Planning Council, the regional planning agency for the Boston metropolitan area, studied bicycle-motor vehicle accidents occurring within Route 128, a major beltway encircling 35 communities. A sample of one of every four accidents reported to the Massachusetts Registry of Motor Vehicles in 1979 and 1980 was chosen for review. Data were collected by a paid intern and by six volunteers who reviewed bicycle accidents occurring within their individual communities. This sampling technique resulted in a distribution of accidents by month and location statistically almost identical with the distribution for all accidents in the study area. The accidents were classified by using a modified version of the classification system developed by Kenneth Cross. The accident class with the highest frequency involved a motorist turning right or left at an intersection and hitting a bicyclist coming from behind or from the opposite leg of the intersection. Virtually as frequent was the accident in which a motorist entered an intersection and struck a cyclist emerging from the orthogonal leg. These accidents occurred primarily among cyclists more than 18 years of age. Accidents in which the cyclist entered the road at a midblock location (bicycle ride-out) also occurred with some frequency, particularly among children younger than 11. Frequencies of key variables such as time of accident were also obtained. Recommendations include publicity of the study results, education of bicyclists and motorists, increased enforcement of traffic laws, and improved record keeping for ongoing classification of bicycle-motor vehicle accidents.

In 1982, in response to the request of the Environmental Protection Agency (EPA) for the development of reasonably available control measures (RACMs) to reduce air pollution in the Boston metropolitan area, the Metropolitan Area Planning Council (MAPC), which is the regional planning agency for the Boston metropolitan area, with 101 member communities, developed two projects to increase the use of bicycles for commuting in its area. One of these projects was a study of accidents between bicycles and motor vehicles in the Boston area patterned after the Cross-Fisher study completed in 1977 and the Missoula, Montana, study of 1981 (1,2). The purpose of the study was to identify the most common types of accidents occurring in the MAPC region and to develop a set of countermeasures to reduce the frequency of these accidents. The other project, which is ongoing, is an employer-based incentive program for bicycle commuting.

Several studies and articles had previously suggested the importance of fear for safety as a major deterrent against bicycle commuting (3, p.18). It was expected that the study would result in the implementation of recommendations for education and increased enforcement and directly reduce the number of accidents in the region. In addition, publicity about the study's findings could be used to increase motorists' and bicyclists' awareness about the most frequent accident classes and thereby motivate them to take actions to prevent their occurrence. Ultimately, it was hoped that these measures would result in the increased use of bicycles for commuting with a concomitant decrease in automobile-generated pollution.

In choosing to carry out this study, MAPC was aware of the limitations of the method used--review of police and operator accident reports. As has been pointed out in other studies of this type, only a fraction of the bicycle-motor vehicle accidents that occur are formally reported. Cross estimated that between 1972 and 1977, about 1,000 fatal and 40,000 nonfatal bicycle-motor vehicle accidents across the country were reported to police, whereas another 40,000 injury-producing accidents went unreported (1, p.1).

Still, without an extraordinary effort, accident reports provide the best consistent source of information about bicycle-motor vehicle accidents. Another suggested source of data is hospital records. The forms used would not be standardized and would include only the most serious accidents. They would also lose the advantage of involving the police in the study. It is beneficial for police to be involved, because any recommendations for improved enforcement will rely largely on the police for implementation. Another possible benefit is that use of these forms for research purposes will encourage police, motorists, and bicyclists to complete them with greater attention to the quality of description. Currently, the quality of data is mediocre.

METHODOLOGY

The study was carried out between November 1982 and June 1983. Data from police and operator reports of bicycle-motor vehicle accidents occurring in 1979 and 1980 were obtained by the following methods:

1. A paid intern reviewed microfilm of accident reports at the state's Registry of Motor Vehicles and
2. Volunteers reviewed actual reports of accidents at six local police departments.

The area within Route 128, a major beltway in the region encompassing 35 cities and towns, including Boston and Cambridge, was chosen for the study (Figure 1). Because almost 2,000 accidents had been reported for 1979 and 1980, it was decided to study a sample of the reported accidents.

FIGURE 1 Study area.

The selection of accidents was made by using a computer printout provided by the Massachusetts Department of Public Works of all bicycle-motor vehicle accidents occurring in the study area during 1979 and 1980. One in four accidents was selected for review. When accident reports were missing from the registry of Motor Vehicles or the local police department, alternate reports were selected from this printout. This procedure resulted in a sample of 516 reports. [The similarity of the accidents in the sample to all reported accidents in the study area was examined on the variables of month and city or town of accident. A high correlation was found (Pearson's chi-square: $p < 0.05$, 34 df, city or town; $p < 0.02$, 34 df, month).] Of these, 87 provided insufficient information for accident classification purposes and were included in the results only for purposes of examining other variables such as month of year, time of day, and weather conditions. In total, 429 accidents were classified by using a modification of the Cross scheme (6). (This sample size allows generalization of the distribution of accident classes to the study area as a whole at a confidence level of approximately 90 percent. Any other breakdown of the data, such as into accident types or age groups, will differ in the extent to which they can be generalized.)

CLASSIFICATION SCHEME AND MAPC REVISIONS

The Manual Accident Typing (MAT) scheme prepared by NHTSA in 1982 was used to classify the accidents (4,p.6). This scheme is based on the classification system created by Kenneth Cross in his 1977 study, which classifies accidents according to four variables:

1. Precollision direction of travel of each operator,
2. Relative precrash motion of the two vehicles,
3. Operator errors, and
4. Characteristics of accident location.

In his study, Cross created 36 types (types 1-36), which he grouped into seven classes (classes A-G). The MAT scheme added eight types to the Cross classification system and fitted these into classes A-G.

MAPC revised the MAT scheme slightly. Accident type 27 (Cyclist Overtaking) was removed from class G, and types 35 (Drive-Out: On-Street Parking) and 41 (Cyclist Strikes Parked Vehicle) from the two MAT miscellaneous classes were used to create a new class, G [(Revised): Slowed or Parked Car]. It was believed that the accident types in this class represented a distinct set that may be addressed by specific countermeasures. "Other" or "weird" accident types, which were separate in the MAT system, were combined into class H [(Revised): Other]. In all other respects, the MPAC classification scheme is similar to the MAT system. [Readers are encouraged to contact Wendy Plotkin to request a detailed written description of the methodology. This will include a discussion of the problems involved in obtaining a record of bicycle-motor vehicle accidents, retrieving the data, using the data, and classifying the accidents. The MAT administrator's guide (4) contains a good discussion of potential problems as well.]

Below is a list of the eight classes used in the MAPC system:

1. Class A, Bicycle Ride-Out from Driveway, Alley, or Other Midblock Location: Involves a bicycle emerging from a driveway, alley, or other midblock location (such as over a shoulder or curb) and colliding with a motor vehicle.
2. Class B, Bicycle Ride-Out at Intersection: Involves a bicycle emerging at an intersection and proceeding straight across the intersection (accidents involving bicycles making right or left turns are included in class E).
3. Class C, Motorist Drive-Out: Involves a motor vehicle emerging from a midblock location (driveway, alley) or an intersection, thus paralleling classes A and B. Only motor vehicles proceeding straight across the intersection or turning right on red are included in this class (accidents involving motorists making right or left turns are included in class F).
4. Class D, Motorist Overtaking and Overtaking Threat: Involves a motor vehicle approaching from behind and colliding or almost colliding with a bicycle.
5. Class E, Bicyclist Unexpected Turn or Swerve: Involves a bicycle making a left or right turn at an intersection or swerving midblock into the path of an overtaking or approaching motor vehicle. Excluded are accidents where the bicyclist swings too sharply or too widely and collides with a motor vehicle on the perpendicular leg of the intersection, which are included in class H).
6. Class F, Motorist Turn: Involves a motorist turning right or left at an intersection and colliding with a motor vehicle approaching from behind or from the opposite leg of the intersection. Excluded are accidents where the motorist turns right on red (included in class C) or where the motorist makes a left-hand turn (included in class H).
7. Class G (Revised), Slowed or Parked Cars: Involves a bicyclist overtaking and colliding with a motor vehicle that is slowed in traffic, parked, or entering or exiting parking. As mentioned previously, this class was created by MAPC and was not included separately in the Cross or Missoula studies or NHTSA's MAT system.
8. Class H (Revised), Other: Involves unrelated accidents that do not fall under any of the foregoing classes. This class therefore cannot be analyzed as a class in terms of specific countermeasures; each of the types must be assessed individually. This class differs from the Cross or Missoula studies and from NHTSA's MAT system.

RESULTS OF STUDY

Description of Sample

Year of Accident (N = 516)

Of the 516 accidents, 45 percent occurred in 1979 and 55 percent in 1980. In calculating the percentages for the frequencies, only the cases in which information was available on the variable being studied were included. Significance tests for all comparisons are being computed and will be available in February 1984.

Month of Year (N = 513)

The majority of accidents occurred during the summer months, from June through August (54 percent). This is consistent with statistics provided by the Massachusetts Department of Public Works for the MAPC region as a whole (Figure 2). Although no information on comparative ridership exists for the study area, a report by Buckley covering primarily Boston and its immediate neighbors shows a less steeply peaked distribution (5,pp.11-12). The difference may be due to a higher proportion of children in the study area relative to the area in which the Buckley bicycle counts were undertaken. In this case, it is assumed that children are more likely to ride in summer and to have accidents. Additional work is necessary to determine the relationship between accident counts and ridership. The accidents in the MAPC study showed a greater tendency to cluster during the summer months than those in the Cross study (1,p.117), which included two cities with year-long moderate weather in the sample.

Day of Week (N = 512)

Accidents were more likely to occur on weekdays; Friday was the day with the highest frequency (17 percent) and Sunday had the lowest frequency (10 percent). Results, shown in Figure 3, are consistent with those of both the MAPC and the Cross studies (1,p.112). This variable was not studied in the Buckley report (5).

Time of Day (N = 479)

Accidents occurred during different time periods on weekdays and weekends. Weekday accidents were concentrated during the afternoon peak hours, between 3:00 and 7:00 p.m. (42 percent). Weekend accidents were more likely to occur during the midday period, 10:00 a.m. to 3:00 p.m. (46 percent). These and the percentages for the other periods are shown in Figure 4.

Light Conditions (N = 488)

More than 82 percent of accidents occurred during

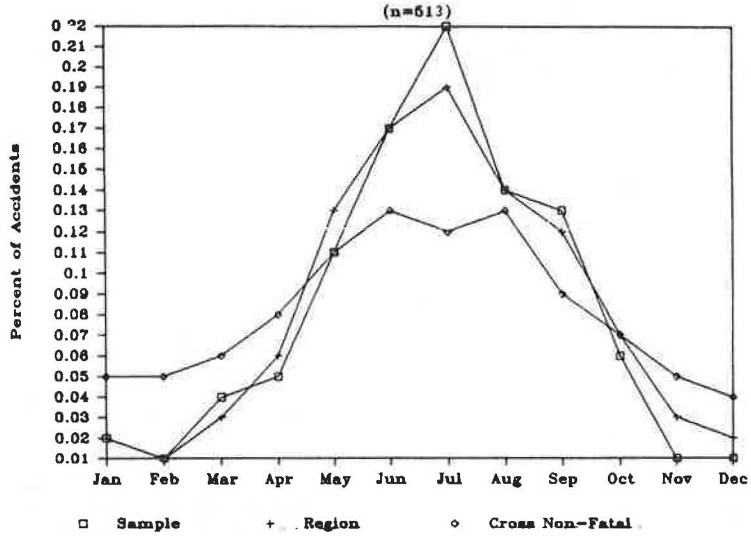

FIGURE 2 Accident frequency by month.

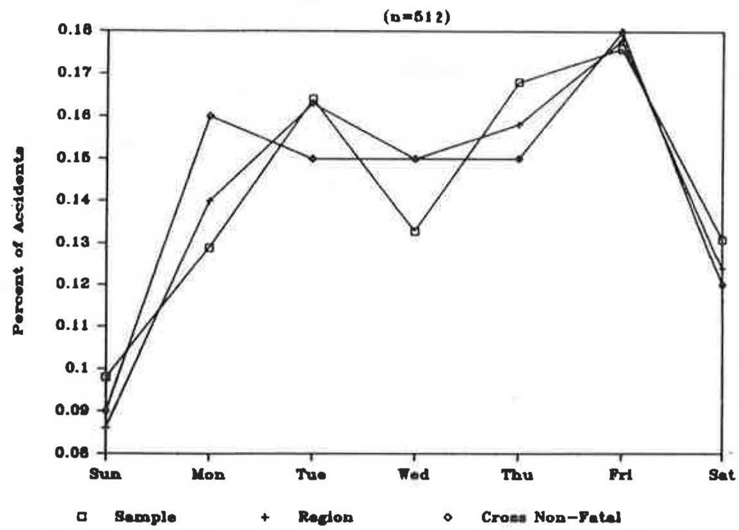

FIGURE 3 Accident frequency by day.

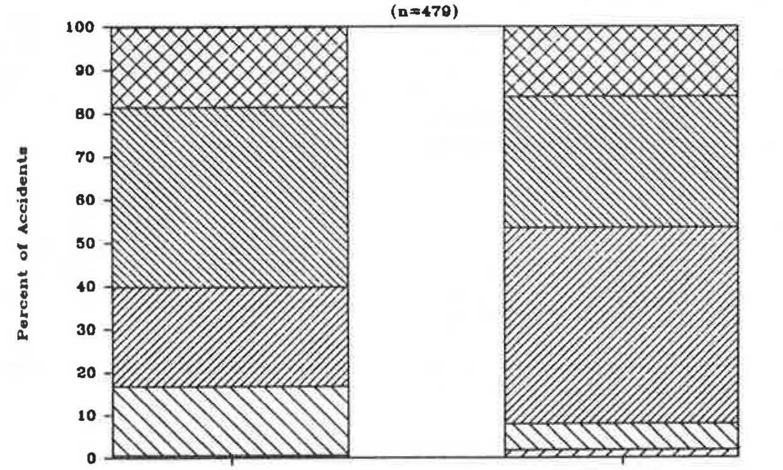

FIGURE 4 Time of day.

daylight (Figure 5). In the Cross study a similar percentage of daylight accidents (85 percent) was found and it was noted that this was consistent with several other studies of bicycle-motor vehicle accidents (1,p.116).

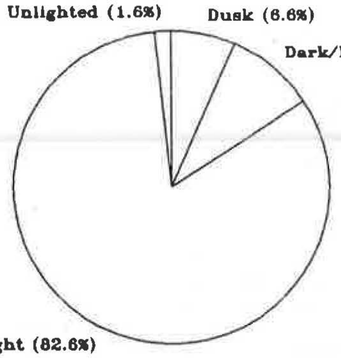

FIGURE 5 Light conditions.

Weather Conditions (N = 481)

Most accidents occurred on clear days (88 percent). Cloudy weather (5 percent) and rainy weather (5 percent) were the next most likely conditions under which accidents occurred. Snow was reported in less than 2 percent of the cases. These findings are consistent with those of the Cross study (1,p.118).

Road Surface (N = 472)

Not surprisingly, given the above weather conditions, most of the accidents occurred on dry surfaces (91 percent). Wet surfaces accounted for 8 percent of the accidents and snowy surfaces for less than 1 percent. Cross does not report on this variable separately from weather.

Road Condition (N = 454)

Almost all of the accidents (97 percent) occurred on roads with no defects. Another 3 percent occurred on roads with holes, ruts, foreign matter, or other nonideal conditions. For more than 12 percent of the accidents there was no report on this variable. These findings are different from those in the Cross study (1,p.135). They also reflect the judgment of primarily operators and police, who filed most of the reports studied. Because so few bicyclists completed reports, it is not possible to determine whether their greater sensitivity to the condition of the road would result in a more critical judgment.

Age of Cyclist (N = 382)

Table 1 shows the distribution of the ages of bicyclists involved in accidents using the same categories as those chosen for the Cross study. Unfortunately, on 26 percent of the accident reports the cyclist's age was not given. Percentages both including and excluding these unreported ages are shown.

As can be seen from Table 1, cyclists between the ages of 6 and 19 accounted for more than 65 percent of the accidents in the MPAC study. Although this is high, it is still less than that accounted for in the Cross study (1,p.83). More than 30 percent of the accidents for which age was given on the report occurred to cyclists more than 20 years old.

TABLE 1 Age of Bicyclist

		Percentage of Accidents		
Age (years)	No. of Accidents (N = 516)	Including Those Not Reported (N = 516)[a]	Excluding Those Not Reported (N = 382)	Cross Study (Nonfatal) (N = 753)[a]
<6	10	2	3	2
6-11	81	16	21	28
12-15	89	17	23	37
16-19	80	16	21	14
20-29	66	13	17	12
30-44	37	7	10	4
45-59	15	3	4	2
60	4	1	1	2
NA	134	26	–	–

Note: NA = data from reports on which age was not given.
[a]Actual total exceeds 100 percent because of rounding.

Age was not recorded in the Buckley report (5). However, the large number of universities in the area suggests a somewhat higher number of riders in the 17-25 age group (many of these colleges have graduate schools) than in other areas with fewer universities.

Cyclist Wearing Helmet (N = 516)

In more than 97 percent of the cases, the report did not indicate whether the bicyclist was wearing a helmet. In 3 percent of the cases, such compliance was indicated. However, the form of the question (a box with the instruction "Check if wearing helmet") and its obscure placement raise the possibility that many did not see the question.

Cyclist Injury (N = 516)

In almost three-quarters of the accidents, the cyclist was reported as being injured or killed (73 percent). There was one fatality in our sample. However, eight fatalities occurred in the study area during the study period, and all were included in our sample, resulting in an overrepresentation of fatalities.

Seriousness of Cyclist Injury (N = 382)

The injury categories of the accident report form and the proportions in each category are shown as follows; only accidents involving an injury or fatality are included in calculating percentages:

Category	Percentage
Killed	2
Visible signs of injury (bleeding wound, distorted member, or need to be carried from scene)	31
Other visible injury (bruises, abrasions, swelling, limping, etc.)	45
No visible injury but complaints of pain or momentary unconsciousness	22
No injury reported	27

Other Persons Injured (N = 12)

In only 12 cases (2 percent) was a person other than the cyclist injured. In 10 of these cases, it was another cyclist. In one case, it was a cyclist passenger and in another a driver passenger. In three other cases, the identity of the person injured was not shown. These results were similar to the findings in the Cross study.

Severity of Other Person's Injuries (N = 12)

The severity of the other person's injuries was reported as follows:

Category	Percentage
Killed	0
Visible signs of injury (bleeding wound, distorted member, or need to be carried from scene)	33
Other visible injury (bruises, abrasions, swelling, limping, etc.)	42
No visible injury but complaints of pain or momentary unconsciousness	25

Accident's Roadway Location (N = 491)

The majority of the accidents occurred at intersections (52 percent). After intersections, midblock locations accounted for the largest portion (30 percent), followed by driveways (16 percent). Alleys, rotaries, off ramps, parking lots, and other locations accounted for only a negligible proportion of accidents (2 percent).

The Cross study (1,p.128) reported a lower proportion of accidents at intersections (44 percent) and a slightly higher proportion of accidents at midblock locations (34 percent). This is probably due to the greater number of rural roads included in the study.

Traffic Controls Present (N = 241)

For the most part, presence of traffic controls was only indicated on reports for accidents that occurred at intersections. Traffic control information on the operators' reports proved to be unreliable when checked against the reviewer's knowledge of the intersection. This was generally true where the operator reported that there were no traffic controls present. For this reason, for all reports that indicated no controls the intersections were verified with the local police department. The following figures are based on the verified information:

Type of Control	Percentage	Percentage from Cross
Stop sign	27	59
Signal light	35	30
None	36	11
Other	2	-

Traffic control information was not available for 6 percent of the intersections.

The Cross study thus showed a much higher percentage of intersections with stop signs and a much lower percentage with no controls. The proportion with signal lights was approximately the same. It is likely that the differences are due in part to a higher proportion of uncontrolled intersections in the MAPC region. However, in the absence of additional information on this subject, the extent to which other factors account for the difference (e.g., failure of cyclists or motorists to yield at these intersections) is unknown.

Situation for Motorist (Before Accident) (N = 476)

Motorists proceeding straight ahead accounted for the highest proportion of accidents (48 percent). Right turns (16 percent) and left turns (15 percent) were the next most likely maneuvers before the accident. Parked cars (6 percent) accounted for a significant number of accidents. These results are shown in Figure 6.

Situation for Cyclist (Before Accident) (N = 205)

Cyclists proceeding straight ahead accounted for 63 percent of the accidents for which this information was available; making left turns accounted for 13

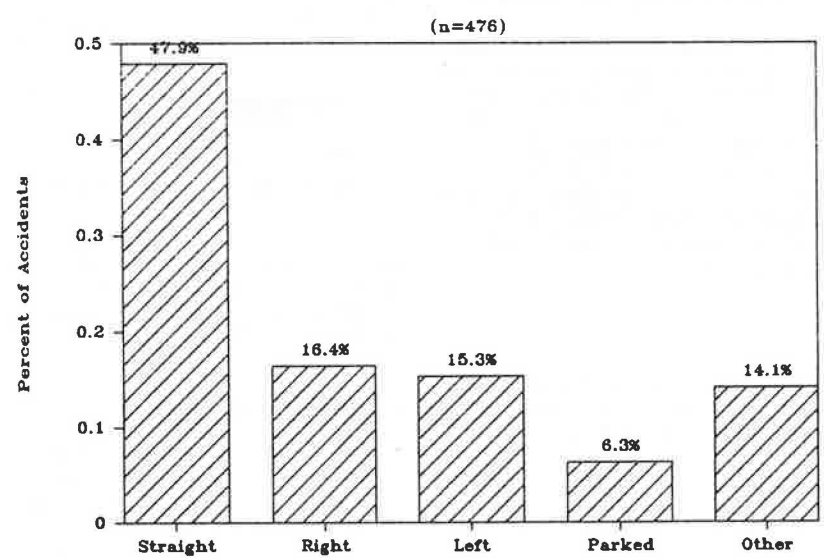

FIGURE 6 Situation for motorist.

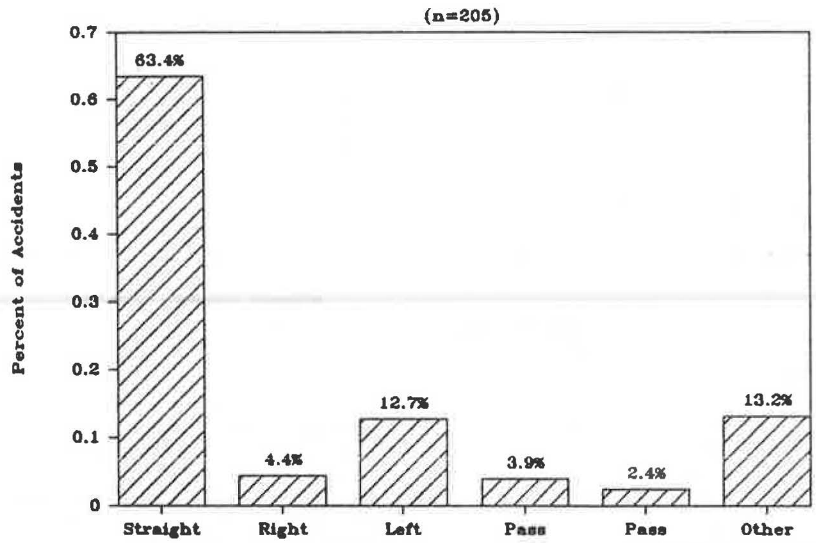

FIGURE 7 Situation for cyclist.

percent. Right turns, passing, and other movements accounted for the remainder (24 percent). Unfortunately, the situation for the cyclist was only reported on 40 percent of the accident reports, making it difficult to assess the accuracy of these statistics for the overall sample. Figure 7 shows these results.

Cyclist Violations

Three types of cyclist violations were reported: wrong-way riding, riding through a red light, and running a stop sign.

1. Wrong-way cyclists were reported in 24 percent of the accidents (N = 442). Cross reported that 19 percent of the nonfatal sample were traveling against the flow of traffic. These proportions must be considered in light of the fact that most cyclists observe directional rules.
2. Cyclists entering an intersection on a red light were involved in 6 percent of the accidents (N = 465). The Cross study noted no accidents in this situation. However, the Cross standards were somewhat higher in assigning an accident to this class (i.e., that the cyclist entered after the light had turned red).
3. Cyclists entering an intersection without observing a stop sign accounted for only 2 percent of the accidents (N = 477). On the other hand, 8 percent of the accidents in the Cross nonfatal sample were considered to have violated a stop sign. The difference here may be due to the much higher percentage of signed intersections included in the Cross study and the greater difficulty that our coder, in the absence of an interview, had in determining whether the stop sign was obeyed.

Motorist Violations

In fewer than 2 percent of the cases did the motorist run a red light (N = 482) or a stop sign (N = 470). This is consistent with the findings of the Cross study (1, p.160).

Accident Distribution by City or Town (N = 514)

Figure 8 shows the distribution of accidents. Statistical tests show this distribution to be similar to that of all bicycle-motor vehicle accidents reported during the study years (Pearson's chi-square: 34 df, $p < 0.05$).

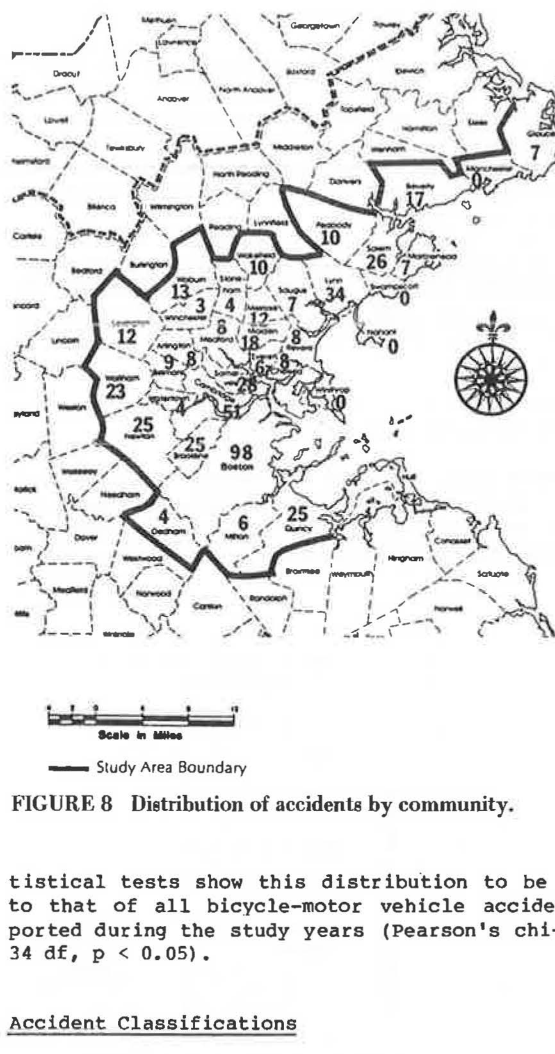

FIGURE 8 Distribution of accidents by community.

Accident Classifications

In Tables 2 and 3, the distribution of accidents by classes and types is shown. Table 2 presents the distribution using the original Cross classification scheme, allowing comparison of the data from this study with data from both the Cross and the Missoula, Montana, studies. Table 3 presents the dis-

TABLE 2 Comparison of MAPC Data with Data from Missoula and Cross-Fisher Studies

Accident Class	No. of Accidents[a] (N = 432)	Percentage of Accidents MAPC Data	Missoula Data	Cross-Fisher Data Injuries	Fatalities
A: Bicycle Ride-Out from Driveway, Alley, and Other Midblock Locations	71	16.4	8.9[b]	13.9	15.1
B: Bicycle Ride-Out at Controlled Intersection	41	9.5	10.0	17.0	12.0[c]
C: Motorist Turn or Merge or Drive Through or Drive-Out	68	15.7	23.3[b]	18.7	2.4
D: Motorist Overtaking and Overtaking Threat	36	8.3	13.3	10.5	37.8[c]
E: Bicyclist Unexpected Turn or Swerve	38	8.8	8.9	14.2	16.2[d]
Class F: Motorist Unexpected Turn	76	17.6	20.0	14.5	2.4[d]
Class G: Other	102	23.6	15.6[b]	11.2	13.8[c]

Note: Accident classes are from the original Cross scheme.
[a]MAPC data.
[b]$p < 0.10$.
[c]$p < 0.01$.
[d]$p < 0.05$.

tribution using the modified Cross scheme, based on NHTSA's MAT system, which added seven new types to the Cross scheme.

In using the MAT system for this study, one prominent accident type, that involving opening doors of parked cars, was removed from the original Cross type 17 and included with two other types in a new class G, Slowed or Parked Cars. "Other" types were grouped together in class H. It is believed that these revisions improve the classification system. This revised classification is used in the cross-tabulations with other variables in the study.

In the following, the classes are reviewed in the order of their frequency of occurrence in this study. After the name of each class there are four percentages: the MAPC revised MAT classification frequency (MAPC Rev), the MAPC original Cross system frequency (MAPC), the Cross nonfatal sample frequency (Cross NF), and the Missoula, Montana, frequency. In addition to the frequency of occurrence, the relationship of each class to four other variables in the study is observed: wrong-way riding, age of cyclist, time of occurrence, and the severity of injury. Finally, those accident types with high frequencies within the class are noted.

Class F: Motorist Turn (MAPC Rev, 17.2 percent; MAPC, 17.6 percent; Cross NF, 14.5 percent; Missoula, 20.0 percent)

Class F involved accidents in which a motorist who is turning right or left at an intersection (excluding right turns on red) collides with a bicyclist approaching from the motorist's front or rear. Only 14 percent of these accidents involved a wrong-way cyclist compared with the 24 percent of all accidents involving wrong-way cyclists (however, five of the six accidents included in type 22, Motorist Left Turn; Parallel Paths; Same Direction, involved wrong-way cyclists).

Cyclists 15 years of age and more accounted for more than 87 percent of these accidents. Those more than 18 years of age accounted for more than 55 percent of the cases. As with the other classes of accidents, approximately three-quarters of class F accidents occurred on weekdays. Most often, these occurred during the afternoon peak between 3:00 and 7:00 p.m. (40 percent). On weekends, these accidents were more likely to occur between 10:00 a.m. and 3:00 p.m. (50 percent).

Class F accidents showed a similar distribution in the incidence and type of injury as did the sample as a whole.

The most frequent type of accident within this class is that in which the motorist turns left in front of a cyclist coming from the opposite direction (type 23). This was the most frequent accident type in the study. The next most frequent type within class F is the one in which the motorist turns right in front of a cyclist coming from the same or the opposite direction (type 24, 6 percent). Least frequent in this class was the accident type involving a motorist turning left in front of a cyclist coming from the same direction (type 22, 1 percent). As pointed out previously, however, wrong-way riders accounted for 83 percent of type 22 accidents.

Class C: Motorist Drive-Out (MAPC Rev, 16.8 percent; MAPC, 15.7 percent; Cross NF, 18.7 percent; Missoula, 23.3 percent)

Class C involves a motorist emerging from an intersection, driveway, or alley onto a roadway and colliding with a bicyclist on that roadway. Right turns on red are included as type 10. Although Cross limited intersection accidents in this class to those in which the motorist's approach was controlled by a sign or signal, MAT added type 48, which are accidents that involve a collision at an uncontrolled intersection where it is established that the motorist failed to yield to the cyclist.

Wrong-way cyclists were overrepresented in this class relative to the sample as a whole; they were involved in 49 percent of class C accidents compared with 24 percent of all accidents. Class C accidents occurred among a slightly older population than the other classes. More than 76 percent occurred among cyclists over 15 years old, and 31 percent involved cyclists older than 25.

Class C accidents occurred on weekdays in the same proportion as did all accidents. Midday weekday accidents are overrepresented in this class; 36 percent occurred during the hours of 10:00 a.m. to 3:00 p.m. compared with 24 percent of all accidents. The afternoon peak period was the next most likely time period to experience these accidents (38 percent compared with 41 percent of all accidents). Weekend class C accidents were most likely to occur during the period 10:00 a.m. to 3:00 p.m. (58 percent for class C versus 47 percent of all weekend accidents).

Class C accidents were somewhat less likely than other classes to result in fatalities or the most serious injuries and somewhat more likely to result in no injury at all. The most common type of accident within class C was type 9, motorist failure to yield at stop or yield sign, which accounted for 9 percent of all accidents. This was the second most common type of accident in the study. Wrong-way cyclists were involved in 53 percent of type 9 accidents.

Class A: Bicycle Ride-Out at Driveway, Alley, or Midblock (MAPC Rev, 16.6 percent; MAPC, 16.4 percent; Cross NF, 13.9 percent; Missoula, 8.9 percent)

Class A involves a cyclist emerging from a residen-

TABLE 3 Revised MAPC Accident Classifications with Selected Cross-Tabulations

			Cross-Tabulation by Variable (% of class)										
									Severity of Injury				
Accident Class	No. of Accidents (N = 429)	Percentage of Sample	Wrong Way (N = 99)	Over 18 (N = 100)	Weekday[a] A.M. Peak[b] (N = 46)	Midday[c] (N = 75)	P.M. Peak[d] (N = 127)	Evening[e] (N = 59)	Death (N = 8)	Visible Signs of Injury (N = 100)	Other Visible Injury (N = 141)	Pain or Momentary Unconsciousness (N = 70)	None Reported (N = 110)
A: Bicycle Ride-Out at Driveway, Alley, or Midblock	71	16.6	9.9	6.4	8.3	25.0	56.2	10.4	1.4	25.4	30.0	15.5	28.2
B: Bicycle Ride-Out at Intersection	51	11.9	17.6	21.6	24.3	8.1	51.4	16.2	3.9	25.5	39.2	9.8	21.6
C: Motorist Drive-Out	72	16.8	47.2	41.2	7.1	35.7	37.5	19.6	1.4	13.9	37.5	12.5	34.7
D: Motorist Overtaking or Overtaking Threat	15	3.5	6.7	41.7	9.1	27.3	36.4	27.3	6.7	20.0	26.7	40.0	6.7
E: Bicyclist Unexpected Turn or Swerve	38	8.8	21.0	7.7	7.1	25.0	39.3	28.6	0.0	23.7	36.8	23.7	15.8
F: Motorist Turn	74	17.2	13.5	55.2	17.3	23.1	40.4	19.2	1.4	20.3	37.8	17.6	23.0
G Revised: Slowed or Parked Cars	49	11.4	10.2	64.5	29.4	26.5	29.4	14.7	2.0	22.4	16.3	32.6	26.5
H Revised: Other	59	13.8	42.4	28.6	17.1	22.0	39.2	26.8	1.7	35.6	18.6	15.2	28.8
Total			24.0	31.2	15.0	24.4	41.4	19.2	1.9	23.3	32.9	16.3	25.6

[a]No weekday accidents were reported between 1:00 and 6:00 a.m.
[b]6:00 to 10:00 a.m.
[c]10:00 a.m. to 3:00 p.m.
[d]3:00 to 7:00 p.m.
[e]7:00 p.m. to 1:00 a.m.

tial or commercial driveway, alley, or sidewalk and colliding with a motor vehicle approaching on the roadway. Only 10 percent of these accidents involved a wrong-way cyclist (compared with the 24 percent of wrong-way cyclists in the sample). More than 90 percent of class A accidents involved cyclists 14 years and less. This class was by far the most likely to include accidents with younger cyclists.

Class A accidents most frequently occurred on weekdays (75 percent). Fifty-six percent of class A weekday accidents took place between 3:00 p.m. and 7:00 p.m., the highest proportion of any class to occur within the afternoon peak. On the weekends these accidents were more likely to occur between 10:00 a.m. and 3:00 p.m. (44 percent, similar to the 47 percent share of all weekend accidents occurring during this period).

Class A accidents were among the most likely to result in the most serious category of nonfatal injury (visible signs of injury).

Class H (Revised): Other (MAPC Rev, 13.8 percent; MAPC class G, 23.6 percent; Cross NF, 11.2 percent; Missoula, 15.6 percent)

Class H involves accident types that do not fit into the other classes. It thus differs from classes A through G by a lack of commonality among the types. As noted in the introduction to this section, class H has been revised from the original class G by removing two types, which have been placed in the new class G, Slowed or Parked Cars (type 27, Bicyclist Overtaking, and type 35, Motorist Drive-Out from On-Street Parking).

Within class H, the most frequent types of accidents are type 25, Accident at Uncontrolled Intersection, and type 26, Vehicles Collide Head On, Wrong-Way Cyclist.

Type 25 accidents include those that occur at uncontrolled intersections and where failure to yield is not apparent from the accident report. In the Cross study, all accidents occurring at uncontrolled intersections were included in this type (even where fault was assignable), and the MAPC share (7 percent) of accidents of this type using this definition was much greater than that in the Cross or Missoula studies. Undoubtedly this resulted from the larger proportion of accidents at uncontrolled intersections in the MAPC study (36 percent of all intersection accidents versus 10 percent in the Cross study).

Class B: Bicycle Ride-Out at Intersection (MAPC Rev, 11.9 percent; MAPC, 9.4 percent; Cross NF, 17. percent; Missoula, 10 percent)

Class B accidents involve bicyclists emerging from one leg of an intersection and colliding with a motorist emerging from the orthogonal leg of the intersection. Wrong-way cyclists were involved in 18 percent of class B accidents compared with their 24 percent share of all accidents.

Unlike class A accidents, which involve bicycle ride-out from midblock locations, class B accidents occur among a slightly older population. Over 21 percent of these accidents occurred among bicyclists more than 25 years of age (approximately the same proportion in which this age group is represented in the study sample). None of these accidents occurred to cyclists between 19 and 25, whereas more than 40 percent occurred among those between 15 and 18. In fact, those 19 to 25 years old seemed remarkably exempt from accidents. Twenty-one percent of class B accidents occurred among cyclists between 12 and 14 and 16 percent among those less than 11.

Class B weekday accidents occurred with a greater frequency during both the morning peak hours (24 versus 15 percent) and the afternoon peak hours (51 versus 41 percent) than did other accident classes. This was also true on weekends (20 percent, morning peak; 50 percent, afternoon peak). They were less likely than other accident classes to occur during midday, particularly on weekdays (8 versus 29 percent). Class B accidents were slightly overrepresented among the accidents involving serious injuries.

The most frequent type among class B accidents was an unnumbered type, Bicyclist Entering Intersection on a Red Light. The 6.5 percent of this type of accident was higher than that in both the Cross and Missoula studies, which showed 1.2 percent and 0 percent, respectively, of this type of accident. This discrepancy may in part be due to coding; Cross indicates in his narrative that he was only likely to include an accident in this type if the cyclist entered the intersection well after the light turned red. The MAPC coder generally placed an accident in this type whenever the cyclist entered on the red.

Class G: Slowed or Parked Cars (MAPC Rev, 11.3 percent; MAPC, not applicable; Cross NF, 2.07 percent; Missoula, 3.3 percent)

Class G, which was created for the MAPC study, includes accidents in which a bicycle collides with a motor vehicle that is slowed or stopped in traffic, entering or exiting on-street parking, or has a door opening to let the driver out. Comparison with the percentages for the Cross and Missoula studies of the aggregates of these three types of accidents shows that the MAPC region is much higher in the relative frequency with which these accidents occur. This may be due to the greater congestion and narrower widths of the major urban thoroughfares in the MAPC study area. Only 10 percent of class G accidents involved wrong-way cyclists compared with 24 percent of all accidents in the study.

Class G accidents are more common among older bicyclists; 87 percent occurred among bicyclists 15 and older. More than 64 percent of these accidents occur among bicyclists more than 18 years old. Class G accidents are unusual in that, unlike all other classes except class B, they occur with a greater relative frequency during the morning peak hours (between 6:00 and 10:00 a.m.), both on weekdays and weekends.

Class G accidents are somewhat less likely to occur during the afternoon peak hours (29 versus 41 percent of all accidents occurring during the afternoon peak). Although these accidents involve a slowed or stopped motor vehicle, they are as likely to result in serious injury as the other accidents studied.

The most frequent type represented in this class is type 41, Cyclist Strikes Open Door on Driver's Side of Parked Car, which includes 5.3 percent of all accidents. This type accounted for only 0.8 percent of all accidents in the Cross study, and they were negligible enough in the Missoula study to be classified as type 36, Weird. Again, further investigation is needed to explain this higher relative frequency, but it is reasonable to guess that the Boston area's narrow streets and traffic congestion are significant factors.

Class E: Bicyclist Unexpected Turn or Swerve (MAPC Rev, 8.9 percent; MAPC, 8.8 percent; Cross NF, 14.2 percent; Missoula, 8.9 percent)

Class E accidents involve a bicyclist turning into the path of a motorist approaching from behind or ahead. Wrong-way cyclists were involved in 21 percent of these accidents, which is close to the 24 percent of all accidents involving wrong-way cyclists.

Like class A accidents, class E accidents occurred among a younger population: 42 percent among bicyclists age 11 and less. Cyclists between 15 and 18 years were also overrepresented in this age group; they represented 35 percent of the class E accidents.

Class E accidents occurred more frequently during the weekday evening hours (7:00 p.m. to 1:00 a.m.) than did the sample as a whole (29 versus 19 percent). They were most likely to occur during the afternoon peak (39 percent). On weekends they were twice as likely as the average accident to occur during the afternoon peak (14 compared with 7 percent).

Class E accidents were distributed among the various injury levels in approximately the same proportion as were the overall sample. Type 18 accidents, Bicyclist Unexpected Left Turn with Auto Approaching from Same Direction, accounted for the greatest proportion of class E accidents.

Class D: Motorist Overtaking or Overtaking Threat (MAPC Rev, 3.4 percent; MAPC, 8.3 percent; Cross NF, 10.5 percent; Missoula, 13.3 percent)

Class D accidents involved a motorist striking a bicycle from behind or beside the bicyclist. As with the Cross study, this was the class with the lowest frequency in the study. The difference between the revised MAPC percentage and the MAPC Cross classification scheme percentage is the removal of accidents with parked car doors from this class and their placement in class G. Wrong-way riding contributed to only 7 percent of these accidents.

Class D accidents were most likely to occur among cyclists 15 years and more (67 percent). These accidents were overrepresented among evening and midday accidents (both 27 percent compared with 19 and 24 percent for the sample). They occurred with greatest frequency during the afternoon peak (36 percent). All of the weekend class D accidents occurred between 7:00 p.m. and 6:00 a.m.

Class D accidents were the least likely among all accident classes to result in no reported injuries, but unlike the Cross study, they were more likely to cause minor injuries rather than the severe or fatal injuries. Given the smaller number of cases in this class, the one fatality that occurred involved a higher proportion of class D accidents (6.7 percent) than were involved in any other accident class.

RECOMMENDATIONS

The following recommendations are general in nature and are based on an initial review of the data. Their purpose is to help reduce the number of accidents and to prevent the most frequent occurrences.

Publicity

These findings should be made available to the Registry of Motor Vehicles, local traffic safety officers, bicycle advocacy groups, and local schools for inclusion in their own programs. The results of the study should also be developed into a series of public service announcements to be aired on radio and television. These announcements will emphasize the highest-frequency accident classes (e.g., motor vehicles turning into a bicyclist's path, motor vehicles colliding with a bicyclist at an intersection) and types (e.g., opening of door of a parked car). The purpose of the publicity is to encourage further analysis of the findings and identification of countermeasures and to increase awareness of the most frequent accidents.

Additional Exposure Information

The foregoing discussion lacks an essential element--the measurement of risk as well as frequency. Other than the Buckley report (5), little information exists on bicycle ridership and ridership habits in the greater Boston area. Additional information should be obtained to allow an assessment of the likelihood that a specific accident type will happen to an individual as well as the overall frequency.

Education

The study's findings indicate that high-frequency accidents can be reduced or prevented in part by education. Education has the dual goal of increasing awareness of an undesirable situation and providing the necessary skills to avoid the situation. The presence of a high proportion of accidents involving intersection collisions indicates the opportunity that additional training may offer, particularly among adults, who had the greatest incidence of these accidents. Although this type of accident may be no riskier, or even less risky, than other accidents, the volume of bicyclists entering intersections on busy downtown streets could itself be responsible for the high ranking. Eliminating or reducing this type of accident would affect a large portion of accidents in the study area.

Bicyclists in the Boston area agree with Kenneth Cross' assessment that wrong-way riding occurs among bicyclists in a lower proportion than it shows up in accidents. Awareness of the role of wrong-way riding in contributing to accidents may also result in a decrease in that riding behavior and a reduction in accidents.

The Registry of Motor Vehicles can also provide motorists with information on improving their search skills in spotting bicyclists at intersections and emphasize this in its driver education materials.

Enforcement

Education and awareness are likely to improve the skills and behavior of only some bicyclists and motorists, whereas others may not be exposed to the education and publicity or may choose to ignore it. Law enforcement officials must impress on bicyclists in particular that wrong-way riding is illegal as well as dangerous. Currently, bicyclists are rarely cited or stopped for wrong-way riding in the Boston area.

Improved Record Keeping

Local police departments for the most part have no separate file of bicycle-motor vehicle accidents and thus are not able to carry on an elementary classification of bicycle accidents in their own communities. Police departments should create such files and review them periodically. Similarly, the Registry of Motor Vehicles should establish a separate file of bicycle-motor vehicle accidents to allow easy reference and analysis and develop a campaign to obtain the cooperation of local police departments in doing the same.

Improved Reporting

The quality of data on cyclists was markedly poorer than that on motor vehicle operators. Age of the cyclist was not reported on 26 percent of the sample accident reports (compared with less than 1 percent for motor vehicle operators); the situation for the cyclist was not reported on 60 percent of the sample reports (compared with 8 percent for the situation of the motorist). In many cases, information on the bicyclist was only reported in the section of the accident report that deals with persons injured rather than in the section on vehicles, indicating that police and operators do not consistently identify the bicycle as a vehicle. In addition, information on traffic controls at the bicyclist's approach to an intersection was inaccurate in many reports (for both police and operator). Anecdotal evidence also has suggested that road surface and road condition may not be reported accurately in many reports. Finally, the question on helmet use is phrased in such a way as not to allow a distinction between no use and no response.

In the narrative and diagram sections of the report, little information was provided on whether the bicyclist observed a stop sign. Because this has been identified in the Cross report as a key variable in accident causation, it would be useful to increase reporting of this information in these sections.

Reporting could be improved in three ways. The Registry should actively encourage police and operators to solicit from and record complete information on both the motor vehicle operator and bicyclist and to treat the bicycle as a vehicle. The Registry, MAPC, and the Boston Area Bicycle Coalition should encourage bicyclists to complete reports on all motor vehicle collisions in which they are involved (less than 1 percent of the sample reports were filed by bicyclists). Finally, the Registry should consider revising the accident report form to address the problems identified earlier (e.g., rephrasing the helmet question and adding the phrase "including bicycles, motorcycles, mopeds" after the word "vehicle").

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Promotion and Planning for Bicycle Transportation: An International Overview

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ABSTRACT

International bicycle use, promotion, and planning were studied within the framework of a model project, a "bicycle-friendly town," sponsored by the German Federal Environmental Agency. The results of these international reports were presented and discussed during an international planning seminar in the associated model city of Graz. The results of the reports and the seminar are summarized and an overview of bicycle promotion and planning in western and eastern Europe as well as that in Japan and Australia are given. It has been found that cycling is becoming increasingly popular in many countries, and a large number of measures to encourage cycling are described. The international comparison shows that the types of measures to promote cycling are not limited to simply improving the bicycle infrastructure. Finally, an attempt is made to summarize those solutions and facilities that have been characteristic of bicycle-friendly cities to determine the ideal conditions for such an environment.

In 1981 a model project (a "bicycle-friendly town") commissioned by the Federal Environmental Agency was begun in the Federal Republic of Germany. The goal of this project was (1) "to create a model infrastructure for cyclists and a climate of opinion which is generally favourable toward cyclists, during a five year developmental period."

This model project centered in two main model cities, Detmold and Rosenheim. Eight subsidiary cities were directly involved in exchanging information and experiences. Foreign cities were also associated with the project.