Bicycle–Motor Vehicle Crash Types: The Early 1990s

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The purpose of this research was to apply the basic NHTSA bicyclist typologies to a sample of recent crashes and to refine and update the crash type distributions with particular attention to roadway and locational factors. Three thousand bicycle-motor vehicle cases were coded in a population-based sample drawn from the states of California, Florida, Maryland, Minnesota, North Carolina, and Utah. The crash types were distributed as: (*a*) parallel paths—36 percent, (*b*) crossing paths—57 percent, and (*c*) specific circumstances—6 percent. Most frequent parallel path crashes were motorist turn/merge into bicyclist's path (34.4 percent of all parallel path crashes), motorist overtaking (24.2 percent), and bicyclist turn/merge into motorist's path (20.6 percent). Most frequent crossing path crashes occurred when the motorist failed to yield (37.7 percent of crossing path crashes), the bicyclist failed to yield at an intersection (29.1 percent), and when the bicyclist failed to yield midblock (20.5 percent). Future safety considerations should be systemwide and include an examination of intersections and other junctions, well-designed facilities, bicyclist riding practices, and increased awareness of bicyclists by motor vehicle drivers.

Approximately 900 bicyclists are killed each year as a result of collisions with motor vehicles (*1*). According to the 1991 General Estimates System data about 70,000 bicyclists were injured in this type of crash (*2*). Many injuries are not reported to record-keeping authorities. A study by Stutts et al. (1990) showed that less than two-thirds of bicycle-motor vehicle crashes serious enough to require emergency room treatment were reported on state motor vehicle crash files (*3*).

The development of effective countermeasures to help prevent pedestrian and bicyclist crashes is hindered by insufficient detail on computerized state motor vehicle crash files. Analysis of existing crash file data can provide information on where pedestrian and bicyclist crash events occur (city street, two-lane rural highway, intersection location, etc.), when they occur (time of day, day of week, etc.), and to whom they occur (age of victim, gender, level of impairment, etc.), but can provide very little information about the actual sequence of events leading to the crash.

To address this situation, NHTSA developed a system of "typing" both pedestrian and bicyclist crashes. Each identified crash type is defined by a specific sequence of events, and each has precipitating actions; predisposing factors; and characteristic populations, locations, or both that can be targeted for interventions. The original pedestrian accident typology was developed and applied during the early 1970s (*4–7*). Cross and Fisher later developed a similar typology for bicycle crashes (*8,9*). Example bicycle-motor vehicle crash types include:

- Motorist left turn facing the bicyclist;
- Cyclist left turn in front of traffic;
- Motorist drive out from a driveway or alley; and
- Cyclist ride out from a stop sign or flashing red signal.

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The purpose of this research was to apply the current NHTSA bicyclist typologies to a sample of recent crashes and to refine and update the crash type distributions with particular attention to roadway and locational factors. An important objective was to develop an updated data base for identifying engineering-based interventions and perhaps other strategies for reducing the frequency of bicyclist crashes and their resulting injuries.

METHOD

Highway Safety Research Center (HSRC) staff became familiar with the bicycle-motor vehicle crash typology scheme currently being used in NHTSA's General Estimates System (GES) data base (*10*). A Coding Variables List comprising the following main groups of variables was then developed and included:

- Crash descriptors—crash type, and motor vehicle and bicycle precrash maneuver.
- Locational characteristics—road feature, detailed bicyclist location, public/private property details, bikelane presence, sidewalk presence, number of lanes, lane width, etc.
- Bicyclist characteristics—helmet use, other safety equipment used, bicycle type, direction of travel at/near impact, etc.
- Intersection action details—bicyclist and motorist intended intersection maneuver, bicyclist entering condition, crossing approach, etc.
- Driver contributing factors—alcohol use, failed to yield, stop sign violation, improper backing, etc.
- Bicyclist contributing factors—alcohol use, failed to yield, stop sign violation, riding against traffic, swerved left while being overtaken, etc.
- Motor vehicle contributing factors—defective brakes, defective steering, etc.
- Bicycle contributing factors—no/defective/ineffective brakes, no relevant lights, etc.
- Roadway/environment contributing factors—glare, vision obstructions, loose material on surface, etc.
- Fault—driver, bicyclist, both, neither, or unknown.

The contributing factors were a growing compendium for driver, bicyclist, and the other listed categories. Based on their analysis of the crash diagram, narrative, and other information, project staff compiled lists of factors pertinent to the crash. Fault was assigned based on the contributing factors and the individual coder's interpretation of prudent motorist and bicyclist behavior. Fault was assigned whether or not the investigating police officer issued a citation.

The crash sample was selected from the states of California, Florida, Maryland, Minnesota, North Carolina, and Utah. Cases were selected from small, medium, and large communities in each state. Five hundred cases involving the collisions between bicycles and motor vehicles were coded from each state for a total of 3,000 cases. Besides coding the crash type and other variables previously discussed, the cases were also linked to the basic crash file for each state. This increased the number of variables in the analysis, such as age and gender of bicyclist and driver, other roadway descriptors, motor vehicle variables, and others. Upon completion of cleanup and file linkage, 2,990 cases were available for analysis.

OVERVIEW OF BICYCLE-MOTOR VEHICLE CRASHES

This section presents an overview of the 2,990 bicycle-motor vehicle crashes from the six states. The variables reported include those coded by the project team during its review of the crash report form and the variables recorded on the computerized crash files from each state. Selected variables from the previously mentioned coding list are reported in the sections that follow.

Single-variable frequencies are presented in summary tables, while relevant cross tabulations are merely discussed in the text. (More detail is available in the entire project report prepared for the FHWA (*11*)).

Bicyclist Characteristics

Variables describing the crash-involved bicyclist are summarized in Table 1. Nearly half (45.1 percent) of the bicyclists in collisions with motor vehicles were children less than 15 years old, with an additional 15 percent ages 15 to 19 years old. About one-fourth of the bicyclists were ages 25 to 44, compared to about 10 percent in the Cross and Fisher study (*8*) and perhaps reflecting increased ridership for this age groups in the last decade or so.

Almost 80 percent of the bicyclists were male. This pattern tends to be constant across age groups except for bicyclists over age 44, where the male percentage increases to about 88 percent. This tendency seems to have changed little over time and almost surely remains related to exposure.

Less than 2 percent of the crashes resulted in a bicyclist fatality and an additional 17 percent resulted in serious (A-level) injury. This A + K percentage total is considerably less than for pedestrians (typically over 30 percent A + K). Bicyclists older than age 44 were overrepresented for fatal and serious injuries, where "overrepresented" means this group had a considerably greater proportion of fatal and serious injuries than the proportion of fatal and serious injuries for all age groups combined. The terms "more than expected" and "more than their share" are also used to reflect this kind of comparison. The 15 to 19-year-old bicyclists seemed to suffer less serious injuries than the other age groups.

About 5 percent of the bicyclists were judged by the investigating police officer to have been impaired by alcohol or drugs at the time of the crash, and an additional 4 percent impaired otherwise. Alcohol or drug/use was also coded for about 4 percent of the cases as a bicyclist contributing factor. It should be emphasized that most of these outcomes are based on the officer's opinion at the scene of the crash, and not on the results of any chemical tests administered. Alcohol use was highest in the 25 to 44 and over 65 age groups and for males. Bicyclists using alcohol or drugs were more likely to suffer serious and fatal injuries.

Temporal/Environmental Factors

Temporal and environmental factors characterizing bicycle crashes are summarized in Table 2. Bicycle crashes have always been more frequent in summer, and the months of June, July, and August each contained about 13 percent of the crashes. Exposure would certainly be a factor. Crash experience was appreciably less during cold

TABLE 1 Bicyclist Characteristics

Age	N	%	Injury Severity	N	%
0-9	504	18.2	Fatal (K)	46	1.6
10-14	745	26.9	Serious (A)	473	16.6
15-19	406	14.6	Moderate (B)	1315	46.1
20-24	292	10.5	Minor (C)	830	29.1
25-44	641	23.1	None (O)	188	6.6
45-64	134	4.8	Unknown	91	--
65+	52	1.9			
Unknown	169	--			
Gender	**N**	**%**	**Alcohol/Drug Use**	**N**	**%**
Male	2246	78.9	Alcohol	131	5.3
Female	602	21.1	Other	93	3.8
Unknown	95	--	None	2252	90.9
			Unknown	467	--

TABLE 2 Temporal/Environmental Factors

	N	%
Month		
January	105	3.6
February	130	4.4
March	180	6.1
April	244	8.3
May	342	11.6
June	385	13.1
July	390	13.3
August	366	12.5
September	296	10.1
October	267	9.1
November	144	4.9
December	91	3.1
Unknown	3	--
Day of Week		
Monday	440	15.0
Tuesday	386	13.1
Wednesday	450	15.3
Thursday	476	16.2
Friday	452	15.4
Saturday	374	12.7
Sunday	362	12.3
Unknown	3	--

	N	%
Weekday/Weekend		
Weekday	2065	70.2
Weekend	878	29.8
Time of Day		
6:00 a.m. - 9:59 a.m.	274	9.4
10:00 a.m. - 1:59 p.m.	547	18.8
	1192	41.0
2:00 p.m. - 5:59 p.m.	739	25.4
6:00 p.m. - 9:59 p.m.	124	4.3
10:00 p.m. - 1:59 a.m.	30	1.0
2:00 a.m. - 5:59 a.m.	37	--
Unknown		
Light Condition	2318	79.2
	169	5.8
	329	11.2
Daylight	111	3.8
Dawn/dusk	16	--
Dark, street lights		
Dark, no lights		
Unknown		

weather months. These trends showed some variability by age group, with children less than 10 years old more heavily represented in crashes in April, May, and September, but not in summer. On the other hand, the 10- to 14-year-olds were somewhat overrepresented in summer. The 20 to 24 and 25 to 44 age groups were overrepresented in cold weather months (October through February). The pattern for those over age 64 had lower frequency and was quite varied. For bicyclist injury severity, fatal injuries were overrepresented in cold weather months (November through March). Male bicyclists were overrepresented in cold weather months and female bicyclists underrepresented.

Unlike pedestrian crashes, bicyclist crashes were not overrepresented on weekends. Patterns within age groups were not distinctive. The 45 to 64-year-old age group was somewhat overrepresented on weekends, while those over age 64 were somewhat overrepresented on weekdays. Gender of the bicyclist seemed to have no effect. Serious and fatal injuries were more prevalent on weekends. As expected, the alcohol-related crashes were heavily overrepresented, with half of these crashes occurring on weekends.

About two-thirds of the bicyclist crashes occurred during late afternoon and early evening hours (41 percent from 2 p.m. to 6 p.m. and 25 percent from 6 p.m. to 10 p.m.). Exposure is likely quite high during these hours, and visibility can be a problem. The pattern again varied by age group. Children less than 10 years old were overrepresented during late afternoon and early evening, while bicyclists 20 to 24 and 25 to 44 years old were overrepresented late at night. The 45 to 64-year-old and the over 65 age groups were overinvolved from 6 a.m. to 10 a.m. and 10 a.m. to 2 p.m. These tendencies are again likely related to exposure.

The serious and fatal bicyclist injuries were more prevalent late night (10 p.m. to 2 a.m.) and early morning (2 a.m. to 6 a.m.). Males were heavily overrepresented during these time periods, as was the presence of alcohol and other drugs.

Almost 80 percent of the bicycle-motor vehicle crashes occurred under daylight conditions. The pattern here by age group was predictable—younger children overrepresented during daylight and those ages 15 to 64 overrepresented during conditions of darkness. Children under 10 had more than their share of crashes during dawn or dusk. Serious and fatal injuries to the bicyclist were heavily overrepresented during conditions of darkness with no streetlights. And as noted earlier, male bicyclists were much more likely than females to be riding under conditions of darkness.

Weather and roadway surface conditions were also examined in this category. The vast majority occurred under either clear or cloudy weather conditions. Four percent occurred under rainy conditions, and less than 1 percent in snow and other situations. Similar results were noted in the road condition variable, where over 92 percent of the crashes occurred on dry roads.

Roadway Factors

A wide range of data pertaining to the roadway is summarized in Table 3. As expected, the largest portion of bicycle crashes (34 per-

TABLE 3 Roadway Factors

Road Class[1]	N	%
Interstate	3	0.2
U.S. route	138	8.0
State route	313	18.1
County route	475	27.5
Local street	582	33.7
Other	217	12.6
Unknown	1215	

[1]Data missing from CA, UT

Speed Limit	N	%
40 km/h or less	666	27.0
48-56 km/h	1234	50.1
65-73 km/h	396	16.1
81+ km/h	168	6.8
Unknown	526	--

(1 km = 0.62 miles)

Road Feature	N	%
No special feature	793	26.5
Bridge	8	0.3
Public driveway	344	11.5
Private driveway	229	7.6
	70	2.3
Alley intersection	1402	46.8
Intersection of roadways	108	3.6
Intersection of roadways related	6	0.2
Non-intersection median crossing	2	0.1
End/beginning of divided highway	8	0.3
Interchange ramp	1	0.0
Interchange service road	3	0.1
Railroad crossing	7	0.2
Bike/multi-use path intersects with road	5	0.2
Parking lot abuts road	3	0.1
Other	8	--
Unknown		

Traffic Control Device	N	%
No control		
Stop sign	1712	57.7
Yield sign	739	24.9
Traffic signal	9	0.3
Flashing signal with stop	473	16.0
sign	3	0.1
Flashing signal without stop sign	5	0.2
Railroad gate and flasher		
Human control	1	0.0
Other	4	0.1
Unknown	20	0.7
	31	--

(*continued on next page*)

cent) occurred on local streets, with county routes (28 percent) close behind. United States and state routes combined accounted for about one-quarter of the total. Young children experienced more crashes on the local and county routes, while bicyclists ages 45 to 64 and 65 and over were overrepresented on higher speed routes. Interestingly, no gender or alcohol presence differences were reflected by the road class variable. There was a slight tendency for the more serious (A + K) crashes to occur on U.S. and state routes.

The typical roadway configuration was a two-lane undivided roadway with a speed limit of 56 km per hour (35 mph) or less. Roads with higher speed limits had more than their share of serious and fatal injuries. Children less than 10 years old had almost 90 percent of their crashes on two-lane roads, while older bicyclists (ages 20 and up) were overrepresented on the 4, 5, and 6 + lane roads. Class A injuries to bicyclists were overrepresented on three-lane roads and fatal injuries were overrepresented on roads with more than four lanes.

Where data were available in regard to lane width, the crashes were spread fairly evenly. Interestingly, about one-fourth of the crashes occurred on roads with lanes over 4.9 m (16 ft) wide. The older bicyclists (45 to 64 and over 65 years of age) were overrepresented in the widest lane category, as well as 3.1 to 3.4-m (10- to 11-ft) and 3.7-m (12-ft) lanes. (Some of these wide lanes may have contained parallel parking spaces that could not be discerned from the police diagram. Parking presence is discussed later in this section.) Class A and fatal injuries were overrepresented on the 2.7-meter (9-ft) or less and 3.1- to 3.4-m (10- to 11-ft) lanes, and, to a lesser extent, on 3.7-m (12-ft) lanes. Serious and fatal injuries were thus underrepresented as lane widths became wider.

In regard to road feature, almost half of the bicycle-motor vehicle crashes took place at roadway intersections, and another 3.6 percent were intersection-related. Almost 20 percent of the crashes occurred at driveways, with another 2 percent at alley intersections. Thus, close to three-fourths of all crashes occurred at junctions of some kind. About one-fourth of the crashes occurred at nonintersection locations with no distinguishing roadway features. At intersections, bicyclists ages 25 to 44 were slightly overrepresented and those less than 10 years old slightly underrepresented. Almost half of the crashes involving children less than age 10 occurred at private driveways. Young children were also overrepresented at alley

TABLE 3 (*continued*)

	N	%
Shoulder Type		
None indicated	2176	74.5
Unpaved	89	3.1
Paved	131	4.5
Curb and gutter	384	13.2
Shoulder indicated, type unknown	142	4.5
Unknown	75	--
Bicyclist Side On-Street Parking		
None	2528	87.9
Parallel parking	341	11.9
Diagonal parking	7	0.2
Unknown	121	--

	N	%
Number of Lanes		
1 lane	46	1.8
2 lanes	1656	64.9
3 lanes	69	2.7
4 lanes	614	24.1
5 lanes	56	2.2
6 or more lanes	109	4.3
Unknown	446	--
Lane Width		
2.7 meters or less	47	9.5
3.1 - 3.4 meters	117	23.7
3.7 meters	116	23.5
4.0 - 4.9 meters	88	17.8
5.2+ meters	126	25.5
Unknown	2338	--
Non-road	164	--
(1 meter = 3.3 feet)		

intersections. Locations with no special feature (e.g., midblock locations) were the sites of serious and fatal injuries more than expected. Bicyclists in private driveway locations had more than their share of Class A injuries.

No traffic control devices were present in about 60 percent of the cases. Stop signs were the controlling device in about one-fourth of the cases and traffic signals 16 percent of the time. This relates to the previous paragraph, where almost half the crashes occurred at roadway intersections. Young children were overrepresented at locations with no control and underrepresented at locations with traffic signals. Cyclists 10 to 14 and 15 to 19 years old were overrepresented at stop sign locations, while bicyclists 20 to 24 and 25 to 44 years old were overrepresented at traffic signal locations. Serious and fatal injuries were slightly overrepresented at locations with no traffic control device.

No shoulders were indicated about three-fourths of the time. Curbs and gutters were noted in 13 percent and paved shoulders were indicated in less than 5 percent of the crashes. Actual shoulder width on the bicyclist's side of the road was rarely available. Where available, just over 40 percent was coded as 1.5 to 2.7 m (5 to 9 ft) wide. Unpaved shoulders and shoulders where the type was unknown were overrepresented for serious and fatal injuries. Although sample sizes were small, shoulders at least 3.1 m (10 ft) wide reflected serious and fatal injuries more than expected.

Just under 90 percent of the crashes occurred at sites with no on-street parking on the bicyclist's side of the road. Where noted, the vast majority of parking was the parallel type. Young children were overrepresented at sites with parallel or diagonal parking.

Contributing Factors

Numerous factors contributing to the occurrence of the bicycle-motor vehicle crash were identified from the information provided on the crash report form. These contributing factors were coded into the categories of bicyclist, bicycle, motor vehicle driver, motor vehicle, and roadway/environment. An initial listing of factors was identified for each category, and other codes were added as identified during the course of the coding. Up to three factors were listed in each category for each crash coded. The results reported in Table 4 reflect the total number of times any given factor was coded and the percentage of cases involving each factor. (Note: Table 4 reflects a combined list of contributing factors that appeared with some frequency.) For example, 114 bicyclists had alcohol or drug use noted as one of their three possible contributing factors, so that the percentage of bicyclists coded with alcohol/drug use was 114/2,990 or 3.8 percent. Since more than one factor could be coded for each bicyclist, the percentages in Table 4 total more than 100 percent.

The most frequently coded bicyclist factors were:

- Failed to yield 20.7 percent
- Riding against traffic 14.9 percent
- Stop sign violation 7.8 percent
- Safe movement violation 6.1 percent

These all involve riding practices. Bicyclists riding against traffic are particularly vulnerable at intersections, especially for right-turning vehicles from a perpendicular street.

Lack of conspicuity was coded in 5.1 percent of the cases, but probably could have been coded a much higher percentage of the time had more detail been available on the crash report form. (Overall, about 20 percent of the crashes occurred during nondaylight conditions.) Bicyclists riding into an intersection from the sidewalk were cited in slightly more than 5 percent of the cases (and another 4 percent for coming off of a sidewalk at a driveway/alley location). Bicyclists riding in this location are not easily seen by drivers because the natural driver scanning pattern is in the roadway. Improper turn/no hand signal (4.8 percent) and traffic signal violations (4.7 percent) were also cited with some regularity.

TABLE 4 Contributing Factors to Bicycle-Motor Vehicle Crashes

Bicyclist Factors	N	%	Driver Factors	N	%
None	701	23.4	None	1294	43.1
Alcohol/drug use	114	3.8	Alcohol/drug use	46	1.5
Failed to yield	621	20.7	Yield violation	719	24.0
Stop sign violation	235	7.8	Stop sign/traffic signal violation	56	1.9
Traffic signal violation	140	4.7	Exceeding speed limit/safe speed	65	2.2
Exceeding speed limit/safe speed	36	1.2	Improper passing	65	2.2
Improper lane change/use of imp. lane	53	1.8	Improper turn	91	3.0
Improper turn/no hand signal	145	4.8	Safe movement violation	62	2.1
Lack of conspicuity	153	5.1	Improper backing	48	1.6
Safe movement violation	182	6.1	Right on red	60	2.0
Riding against traffic	446	14.9	Hit and run	428	14.3
Inattention	80	2.7	Inattention	60	2.0
Reckless riding/no hands/stunt ride/race	41	1.4	Reckless driving	41	1.4
Pass veh on rt/ride between stopped veh	42	1.4	No license	43	1.4
Improper road or lane position	30	1.0	Assault/possible assault with veh	40	1.3
Swerved left	75	2.5	Failed to look both ways	106	3.5
Came off sidewalk at intersection	153	5.1	Didn't see cyclist	366	12.2
Came off sidewalk at driveway	123	4.1	Couldn't avoid crash (driv. claim)	86	2.9
Improper passengers	52	1.7	All other	322	10.7
Misjudged intent of other party	40	1.3			
Didn't see vehicle (bicyclist claim)	137	4.6			
Couldn't avoid crash (bicyclist claim)	73	2.4	**Roadway/Environment Factors**		
Lost control	82	2.7			
All other	327	10.9	None	2471	82.4
			Sun/other glare	41	1.4
Bicycle Factors			Parked veh. vision obstruction	79	2.6
			Moving or stopped veh. vision obstruction	91	3.0
No defects/none	2734	91.1	Other vision obstruction	122	4.1
No/defective/ineffective brakes	92	3.1	All other	280	9.4
No relevant lights	131	4.4			
No/defective reflectors	28	0.9			
All other	50	1.7			

Alcohol or drug use by bicyclists was noted in 3.8 percent of the cases, and the vast majority of these citations pertained to alcohol use. Almost 5 percent of the bicyclists claimed that they did not see the motor vehicle. About one-fourth of the bicyclists had no contributing factors.

Patterns of bicyclist contributing factor overrepresentation by age group included the following:

- 0 to 9 years old—yield violation, stop sign violation, improper turn, safe movement violation, inattention, didn't see vehicle, couldn't avoid crash, lost control;
- 10 to 14 years old—yield violation, stop sign violation, traffic signal violation, exceeding safe speed, improper lane change/use, improper turn, safe movement violation, inattention, reckless or stunt riding, swerved left, came off sidewalk at intersection, improper passengers, or didn't see vehicle;
- 15 to 19 years old—traffic signal violation, improper lane change/use, not conspicuous, riding against traffic, reckless or stunt riding, pass vehicle on the right/ride between stopped vehicles, improper road or lane position, came off sidewalk at intersection and at driveway, improper passengers, or misjudged intent;
- 20 to 24 years old—alcohol/drug use, traffic signal violation, exceeding safe speed, not conspicuous, reckless or stunt riding, pass vehicle on the right/ride between stopped vehicles, came off sidewalk at driveway, couldn't avoid crash;
- 25 to 44 years old—alcohol/drug use, not conspicuous, pass vehicle on the right/ride between stopped vehicles, improper road or lane position;
- 45 to 64 years old—alcohol/drug use, improper lane change/use, not conspicuous, improper road or lane position, misjudged intent of other party; and
- 65+ years old—alcohol/drug use, improper lane change/use, improper turn, swerved left, came off sidewalk at intersection, misjudged intent of other party.

Bicyclist contributing factors that produced more than their share of A + K injuries included alcohol/drug use, stop sign violation, improper lane change/use, improper turn, not conspicuous, safe movement violation, improper road or lane position, and swerved left.

It was rare that any bicycle contributing factors were coded (less than one-tenth of the cases). When coded, the most frequent factors were:

- No relevant lights (4.4 percent)
- No/defective/ineffective brakes (3.1 percent)

No or defective reflectors were cited in just less than 1 percent of the cases.

Cyclists ages 15 years and older were overrepresented in failing to have relevant lights, while children ages 10 to 14 were overrepresented in failing to have adequate brakes. Cyclists without relevant lights had more than their share of A + K injuries.

The most frequently coded driver contributing factors were:

- Failed to yield (24.0 percent)
- Hit and run (14.3 percent)
- Did not see bicyclist (driver claim or police conclusion) (12.2 percent)
- Failed to look both ways (3.5 percent)
- Improper turn (3.0 percent)

Hit and run would typically not be a contributing factor in the sense of crash causation but nonetheless was identified in 14 percent of the cases. Not all cases were blatant hit-and-run events. At times the driver would stop immediately and ask about the condition of the bicyclist. If told the bicyclist was "ok," the driver might leave the scene. Sometimes a parent would then report the crash a few hours later. In cases like this the investigating police officer would usually mark the case as hit and run, and coders would do likewise.

"Failed to yield" was coded as a driver contributing factor in about one-fourth of the cases but was not always a clear-cut label when, for example, the bicyclist emerged from a sidewalk or was inconspicuous. Failure to see the bicyclist could have resulted from a visual obstruction, bicyclist lack of conspicuity, etc. This was not coded unless claimed by a driver or concluded by the investigating officer.

Alcohol or drug use by drivers was coded in less than 2 percent of the cases. Nearly 43 percent of the cases had no driver contributing factors.

An examination of driver contributing factors by age of bicyclist tended to portray patterns of exposure. For example, when a driver was backing improperly, a young child was most likely the crash-involved bicyclist. Drivers who claimed they could not avoid the crash tended to strike children 0 to 9 and 10 to 14 years of age. Drivers improperly passing were more likely to strike middle-aged and older bicyclists. Driver contributing factors that produced more than their share of A + K bicyclist injuries included alcohol/drug use, exceeding the speed limit, improper passing, safe movement violations, reckless driving, and being unable to avoid the crash.

In regard to motor vehicle contributing factors, 91 percent of the cases had none and another 8 percent were coded as "unknown." Thus, there were only scattered instances of defective tires, wheels, brakes, etc.

Roadway/environment factors were also seldom identified, coded as "none" in 82 percent of the cases. Vision obstructions were the most frequently coded items. It was very difficult to determine if weather-related variables were actually contributing factors to the crash. Thus, these kinds of variables were treated more like inventory items and are reported earlier in the temporal/environmental factors section. The road condition was wet in about 7 percent of the cases.

Two points about these contributing factors should be emphasized. The percentages are likely conservative, because of a lack of detail on the crash report form, although California reports were a noteworthy exception. In addition, these should be viewed as possible contributing factors, based only on the information provided on the report form. A much more thorough crash reconstruction process would be necessary for a definitive identification of contributing factors.

SPECIFIC CRASH-TYPE INFORMATION

A total of 45 distinct bicycle-motor vehicle crash types are identified in the NHTSA Manual Accident Typing (MAT) for Bicyclist Accidents Coder's Handbook. Each type is characterized by a specific sequence of causal events or bicyclist/driver actions preceding the crash occurrence. For example, in a motorist drive-out from a driveway or alley, the motorist usually enters the street from a right angle and fails to perceive the bicyclist in the traffic stream.

Instead of dealing with all 45 crash types, this study concentrates on the three major categories from which the 45 crash types derive, namely, specific circumstances, parallel paths, and crossing paths. Specific circumstances include "weird" or unusual events (e.g., bicyclist struck by falling cargo), bicyclist riding a play vehicle (e.g., a tricycle), a motor vehicle that was backing, and nonroadway situations such as parking lots. For parallel path crashes, the bicycle and motor vehicle are approaching on parallel paths, either heading in the same or opposing direction. For crossing path crashes, the bicycle and motor vehicle are on intersecting paths. The bicycle-motor vehicle crashes are distributed into the three main categories as follows:

Category	*n*	*%*
Specific circumstances	209	7.0
Parallel paths	1,061	35.5
Crossing paths	1,720	57.5
Total	2,990	100.0

Within the NHTSA coding scheme, the three major categories further subdivide into 15 groups. Table 5 shows the distribution of the 15 groups by state. For the parallel path cases, the most frequent crash types were:

Crash-Type Groups	*n*	*% of Parallel Path Crashes*	*% of All Crashes*
Motorist turned or merged into the cyclists path	365	34.4	12.2
Motorist overtaking the cyclist	257	24.2	8.6
Cyclist turned or merged into the motorist's path	219	20.6	7.3

For the crossing path cases, the most frequent crash types were:

Crash-Type Groups	*n*	*% of Crossing Path Crashes*	*% of All Crashes*
Motorist failed to yield to cyclist	648	37.7	21.7
Cyclist failed to yield to motorist at an intersection	501	29.1	16.8
Cyclist failed to yield to motorist, midblock	353	20.5	11.8

There was considerable variability in crash type by state.

TABLE 5 Major Crash Type Groups by State

Group	State						
	CA	FL	MD	MN	NC	UT	Total
Specific Circumstances	8 (1.6)	50 (10.0)	47 (9.4)	19 (3.8)	42 (8.5)	43 (8.6)	209 (7.0)
Parallel Paths							
Motorist turn/merge into path of cyclist	81 (16.2)	58 (11.6)	36 (7.2)	73 (14.6)	50 (10.1)	67 (13.4)	365 (12.2)
Cyclist turn/merge into path of motorist	35 (7.0)	36 (7.2)	31 (6.2)	37 (7.4)	48 (9.7)	32 (6.4)	219 (7.3)
Operator on wrong side of street	7 (1.4)	15 (3.0)	23 (4.6)	7 (1.4)	23 (4.6)	9 (1.8)	84 (2.8)
Motorist overtaking the cyclist	33 (6.6)	53 (10.6)	53 (10.6)	27 (5.4)	64 (12.9)	27 (5.4)	257 (8.6)
Cyclist overtaking motor vehicle	32 (6.4)	12 (2.4)	14 (2.8)	8 (1.6)	12 (2.4)	4 (0.8)	82 (2.7)
Operator lost control	13 (2.6)	7 (1.4)	8 (1.6)	3 (0.6)	15 (3.0)	8 (1.6)	54 (1.8)
Crossing Paths							
Cyclist did not clear intersection	9 (1.8)	3 (0.6)	2 (0.4)	8 (1.6)	2 (0.4)	18 (3.6)	42 (1.4)
Motorist failed to yield	137 (27.5)	125 (25.1)	73 (14.7)	119 (23.9)	62 (12.5)	132 (26.5)	648 (21.7)
Cyclist failed to yield, midblock	40 (8.0)	50 (10.0)	86 (17.3)	72 (14.4)	64 (12.9)	41 (8.2)	353 (11.8)
Cyclist failed to yield, intersection	65 (13.0)	67 (13.4)	101 (20.3)	96 (19.2)	92 (18.5)	80 (16.1)	501 (16.8)
Motorist turning error	4 (0.80)	5 (1.0)	3 (0.6)	2 (0.4)	1 (0.2)	4 (0.8)	19 (0.6)
Cyclist turning error	6 (1.2)	1 (0.2)	2 (0.4)	3 (0.6)	3 (0.6)	6 (1.2)	21 (0.7)
Crash occurred at an intersection	25 (5.0)	9 (1.8)	12 (2.4)	17 (3.4)	8 (1.6)	15 (3.0)	86 (2.9)
Unknown/insufficient information	4 (0.8)	8 (1.6)	7 (1.4)	8 (1.6)	11 (2.2)	12 (2.4)	50 (1.7)

Figures 1–6 describe the parallel and crossing path crash types listed previously and provide detailed information about the pattern of the crash. The patterns of overrepresentation indicate more involvement than expected for any particular variable when compared to all crashes. For example, Figure 1 shows that bicyclists ages 20 to 24 were overrepresented in crashes where the motorist turned or merged into the path of the bicyclist. Bicyclists ages 20 to 24 were involved in 21.3 percent of these motorist turn/merge crashes as opposed to making up 10.5 percent of the overall sample of crash-involved bicyclists.

DISCUSSION OF RESULTS

This paper includes findings from a study of bicycle-motor vehicle crash types occurring in 1991 and 1992. The following points are offered as a summary:

1. The basic crash patterns are similar to those seen in the late 1970s. Intersections, driveways, and other junctions continue to be locations where many crashes occur. Emerging facilities should be designed with this fact in mind.

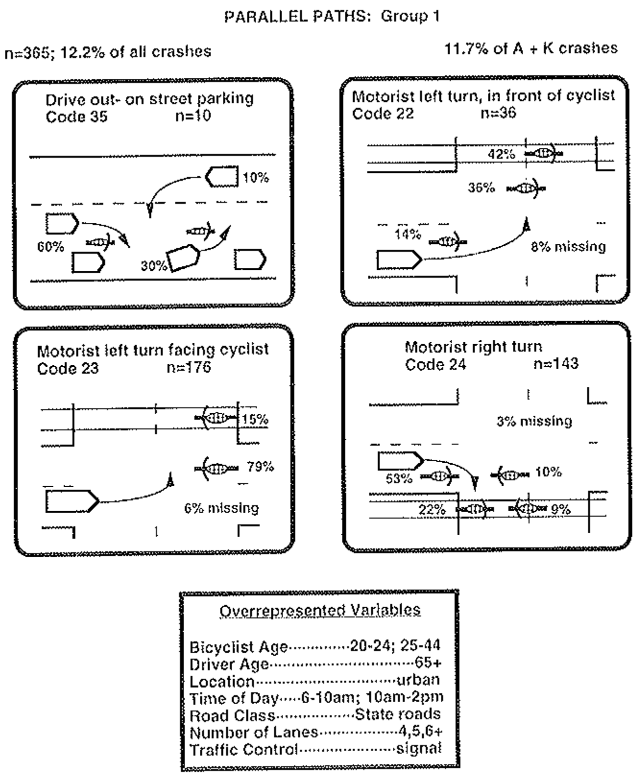

FIGURE 1 The motorist turned or merged into the path of the bicyclist.

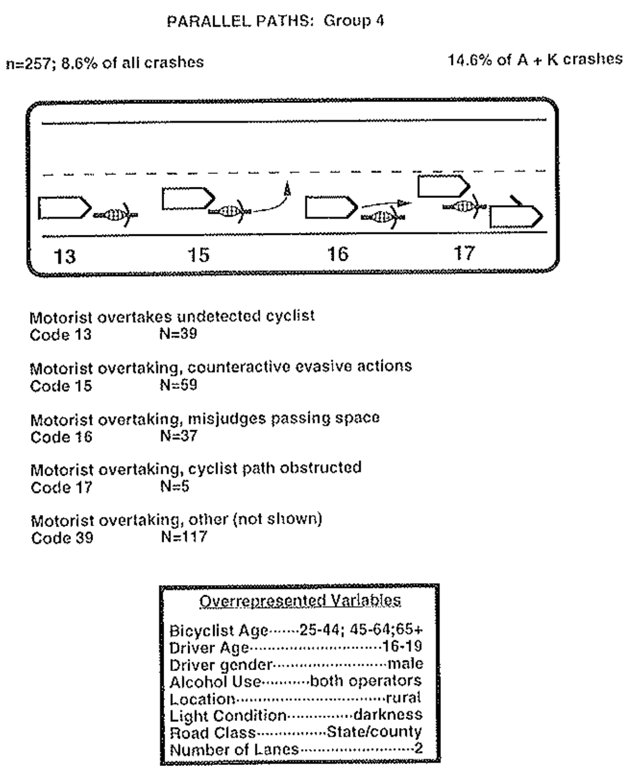

FIGURE 2 The motorist was overtaking the bicyclist.

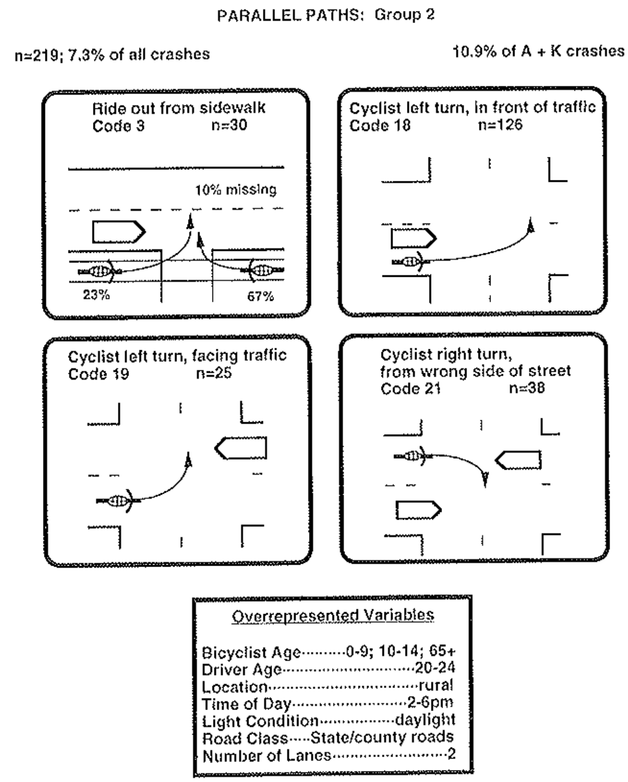

FIGURE 3 The bicyclist turned or merged into the path of the motorist.

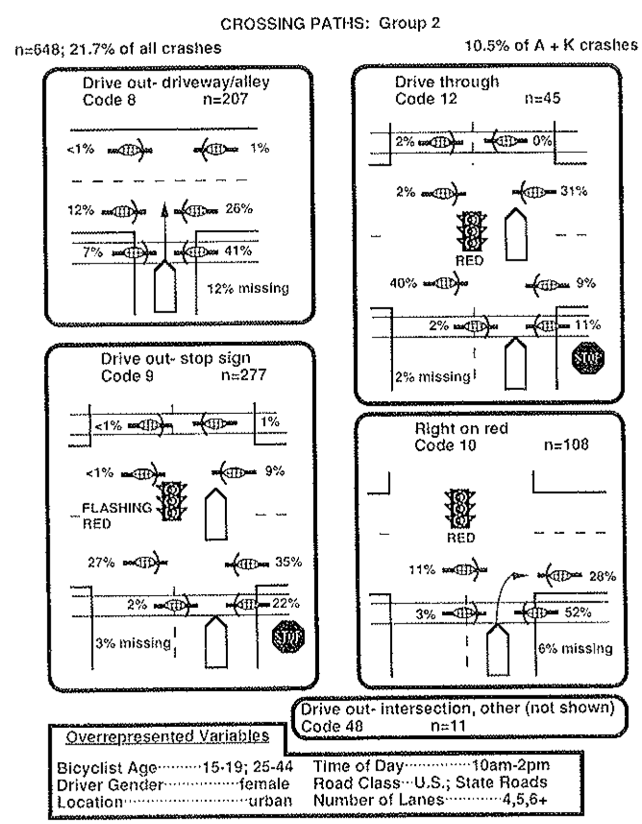

FIGURE 4 The motorist failed to yield to the bicyclist.

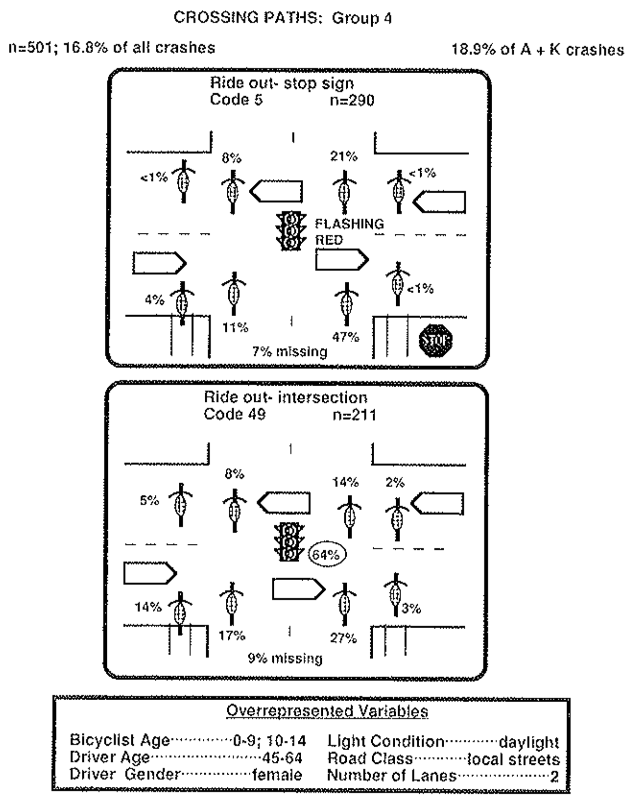

FIGURE 5 The bicyclist failed to yield to the motorist at an intersection.

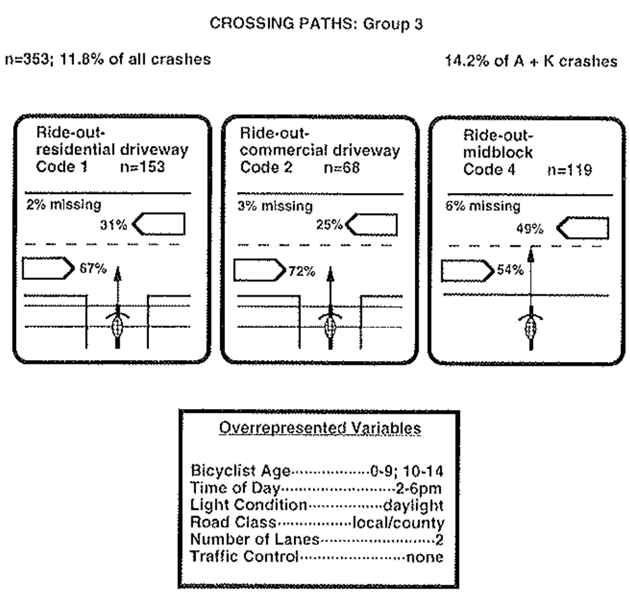

FIGURE 6 The bicyclist failed to yield to the motorist, midblock.

2. Roads with narrower lanes and roads with higher speed limits were associated with more than their share of serious and fatal injuries to bicyclists.

3. Alcohol use was noted in about 5 percent of all crashes, but was 15 percent for the 25 to 44-year-old age group. This would appear to be an emerging problem.

4. Much of what is reported in this study seems strongly connected to basic riding and driving patterns—in other words, related to exposure. Future studies of bicyclists or bicycle facilities should be planned with this need in mind.

5. Bicyclist riding practices, such as riding against traffic and failing to obey traffic signals, are factors in these crashes. Cyclists need training about how to ride in traffic.

6. As a measure of accountability, it is recommended that local and state pedestrian-bicycle coordinators continually track crashes in their jurisdictions. A simplified crash typing procedure that coordinators can easily use should be prepared and disseminated.

7. With the current increased interest in both bicycling and walking, crash investigators at the state and local levels should be urged to report completely on any bicyclist and pedestrian crashes.

8. A systemwide approach will be necessary to make safety gains as well as reach the goals of the National Bicycling and Walking Study (*11*), namely: (*a*) to double the number of trips made by bicycling and walking, and (*b*) to reduce by 10 percent the number of bicyclists and pedestrians injured and killed in traffic collisions. Engineering, education, and enforcement approaches are vital to improved safety. There is a continuing need to establish the mindset that bicyclists (and pedestrians) are worthy and viable users of our transportation system.

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