North Carolina

Bicycle Crash Types

2006 - 2010



Prepared for

The North Carolina Department of Transportation
Division of Bicycle and Pedestrian Transportation

Prepared by

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Contents

Background and Methods

During the five year period of 2006-2010, an average of 968 bicycle-motor vehicle crashes were reported to the North Carolina Division of Motor Vehicles each year. On average, 20 bicyclists were killed and more than 800 were injured each year during this same period.[1]

The development of effective countermeasures to help prevent these crashes is hindered by insufficient detail on standard police crash report forms. The information from the crash report forms is stored on computerized files. Analysis of these data can provide information on *where* bicycle-motor vehicle crashes occur (city street, two-lane roadway, 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, the National Highway Traffic Safety Administration (NHTSA) developed a system of "typing" pedestrian and bicycle crashes. Each identified crash type is defined by a specific sequence of events, and each has precipitating actions, predisposing factors, and characteristic populations and/or locations that can be targeted for interventions. The original pedestrian crash typology was developed and applied during the early 1970's (Snyder and Knoblauch, 1971; Knoblauch, 1977; Knoblauch, Moore and Schmitz, 1978). Cross and Fisher (1977) later developed a similar typology for bicycle crashes. Harkey, Mekemson, Chen, and Krull (2000) created the Pedestrian and Bicycle Crash Analysis Tool (PBCAT) that enabled both pedestrian and bicycle crash typing to be done by software. Harkey, Tsai, Thomas, and Hunter updated this tool in 2005. (See **PBCAT** for a detailed explanation of crash typing and associated crash types as well as to download the free software.) BIKESAFE describes potentially suitable countermeasures for different crash type groups from PBCAT (Hunter, Thomas, and Stutts, 2006).

Example bicycle-motor vehicle crash types include:
Bicyclist ride through sign-controlled intersection,
Bicyclist left turn – same direction,
Motorist overtaking – undetected cyclist,
Motorist right-turn – same direction.

This report summarizes bicycle-motor vehicle crash types that were developed for 2006-2010 North Carolina data. UNC Highway Safety Research Center staff used PBCAT software to add crash types, position, direction and location factors to all bicycle-motor vehicle crashes for which a standard police report form was available. The results are summarized in the following tables and text. The crash type descriptions that follow are in part related to exposure, or when and where people ride, as well as to the types of errors made by bicyclists and drivers in maneuvers leading up to the crashes.

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[1] The number of bicyclists killed and injured reflects only the "first" bicyclist reported on in the crash. A few crashes each year involve multiple bicyclists and may involve multiple injuries as well. These circumstances are, however, relatively rare, and in order not to over-represent the number of crashes, the data discussed in this report account for only the first verified bicyclist in the crash.

Results

Crash Location

Table 1 shows the frequency and percentage of bicycle crashes by the general crash location as determined during the crash typing process. Nearly half (49%) of the collisions occurred in non-intersection (i.e., mid-block) sections along streets and roadways. These include crashes that occurred at or related to commercial and private driveways as long as they were not signalized junctions (which would be coded as intersection). Another 43% were at intersections (i.e., within the motor vehicle stop bars or pedestrian crosswalks), and 4% were intersection-related (i.e., close enough that an intersection maneuver such as slowing traffic may have led to the crash). About 4% occurred in non-roadway locations (typically parking lots).

Table 1. NC bicycle-motor vehicle crashes by location type.

Crash Location	2006	2007	2008	2009	2010	Total
Intersection	436	431	461	350	411	2089
	44.8[1]	41.8	44.2	42.2	42.5	43.2 [2]
Intersection-Related	20	35	28	32	55	170
	2.1	3.4	2.7	3.9	5.7	3.5
Non-Intersection	470	519	501	402	463	2355
	48.3	50.4	48.1	48.5	47.9	48.7
Non-Roadway	45	42	47	42	37	213
	4.6	4.1	4.5	5.1	3.8	4.4
Unknown Location	2	3	5	3	0	13
	0.2	0.3	0.5	0.4	0	0.3
Total	973	1030	1042	829	966	4840
	20.1 [3]	21.3	21.5	17.1	20	100

[1] Row percent of column total
[2] Row total percent of total
[3] Column percent of row total

Figure 1 shows how the proportion of location types vary from rural to urban crash locations in NC, and may also vary from city to city, depending on how closely-spaced intersections are, and other factors. Non-intersection crash locations make up an even higher percentage, 70%, of the total bicycle crashes in rural areas compared with 40% in urban areas, while non-roadway (parking lot crashes) are understandably a lower percentage (<3%) in rural areas than in urban (6%). Intersections and crashes near intersections account for 55% of urban area crashes.

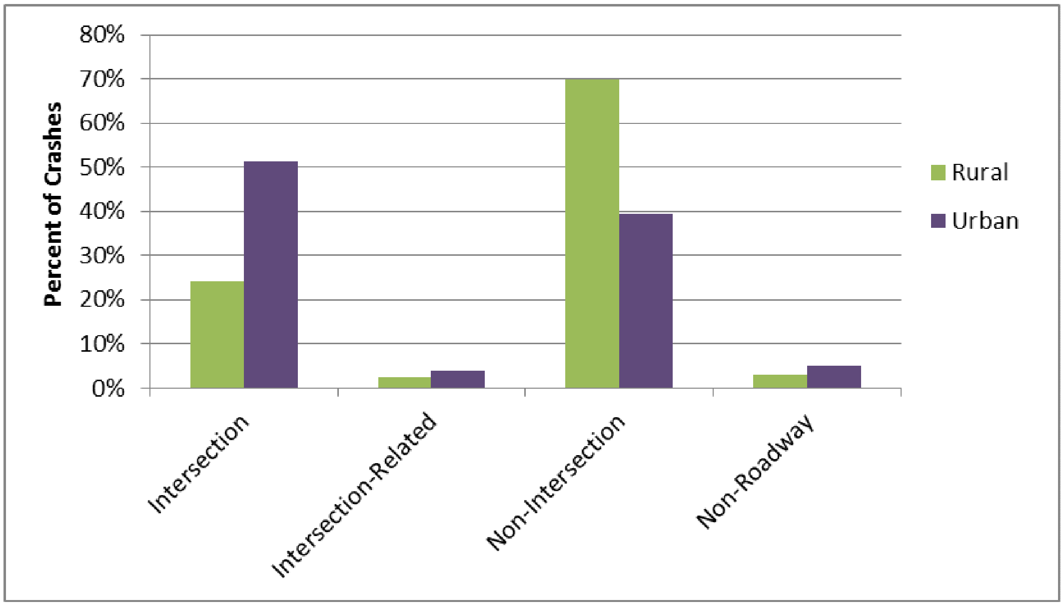


Figure 1. Percentages of NC rural and urban bicycle crashes by location type, 2006-2010.

In addition to greater numbers of crashes, the fatality rate for bicyclists struck along road sections (non-intersection or midblock locations) is considerably higher than that at intersection locations. Among crashes that occurred at midblock locations, 3.4% were fatal compared with 1% of collisions that occurred at intersection locations resulting in fatalities (data not shown). The 79 fatal crashes at midblock locations also represent 79% of all fatal bicycle-motor vehicle crashes, with 21% of fatal crashes occurring at intersection and intersection-related locations. During this five year period, no fatal bicycle crashes were *reported* from non-roadway locations. In part, the higher fatalities resulting from non-intersection crashes reflect that bicyclists are struck more often at non-intersection locations in rural areas, where speeds are typically higher, travel lanes are typically shared, and roadways often have no supplemental lighting.

Bicyclist Position

Table 4 shows the initial position of the (primary) bicyclist involved the crash and indicates that 64% of the bicyclists were on a street in a lane shared with motor vehicle traffic just prior to the crash. On average, another 15% were on a sidewalk, crosswalk, or driveway crossing just prior to the collision. About 3% were on a driveway or alley before any maneuvers such as the bicyclist riding out into a street, or a motor vehicle turning in, and another 6% were in other non-roadway areas such as parking lots. According to data available in crash reports, bicyclists were riding on paved shoulders or bicycle lanes 5% of the time prior to their collisions on average. Bicyclist initial position was unknown/unable to be determined in an average of 7% of the crashes.

Table 2. Bicyclist position prior to the crash, NC bicycle-motor vehicle crashes.

Bicyclist Position	2006	2007	2008	2009	2010	Total
Travel Lane	599	640	635	547	674	3095
	61.6 [1]	62.1	60.9	66	69.8	63.9 [2]
Bike Lane / Paved Shoulder	33	43	71	37	58	242
	3.4	4.2	6.8	4.5	6	5
Sidewalk / Crosswalk / Driveway Crossing	137	127	179	124	148	715
	14.1	12.3	17.2	15	15.3	14.8
Multi-use Path	5	8	7	3	6	29
	0.5	0.8	0.7	0.4	0.6	0.6
Driveway / Alley	42	53	18	16	25	154
	4.3	5.1	1.7	1.9	2.6	3.2
Non-Roadway	56	58	63	50	37	264
	5.8	5.6	6	6	3.8	5.5
Other	3	6	8	5	5	27
	0.3	0.6	0.8	0.6	0.5	0.6
Unknown	98	95	61	47	13	314
	10.1	9.2	5.9	5.7	1.3	6.5
Total	973	1030	1042	829	966	4840
	20.1 [3]	21.3	21.5	17.1	20	100

[1] Row percent of the column (yearly) total
[2] Row total percent of total
[3] Column percent of the total

Bicyclist Direction of Travel

Table 3 shows that 57% of the bicyclists were riding with traffic (i.e., in the same direction as traffic) and 23% were riding opposed or facing traffic. The percentage riding opposed to traffic was 29% when including only crashes on the roadway network for which direction was known. Direction was considered not applicable for parking lot, driveway, and other off-road locations. Bicyclist travel direction was unknown/not determinable for about 10% of the crashes.

Riding facing traffic is against the rules of the road and may contribute to crash occurrence since bicyclists are approaching from an unexpected direction.

Table 3. Bicyclist travel direction in NC bicycle-motor vehicle crashes.

Bicyclist Direction	2006	2007	2008	2009	2010	Total
With Traffic	470	556	628	503	612	2769
	48.3 [1]	54	60.3	60.7	63.4	57.2 [2]
Facing Traffic	257	232	252	175	212	1128
	26.4	22.5	24.2	21.1	21.9	23.3
Not Applicable	92	109	118	123	111	553
	9.5	10.6	11.3	14.8	11.5	11.4
Unknown	154	133	44	28	31	390
	15.8	12.9	4.2	3.4	3.2	8.1
Total	973	1030	1042	829	966	4840
	20.1 [3]	21.3	21.5	17.1	20	100

[1] Row percent of column total
[2] Row total percent to total
[3] Column total percent of row total

Individual Crash Types

Table 1 shows a complete listing of all the individual crash types generated by the coding for each of the five years, and totals for all five years. (Two crashes during this period could not be typed.)

The table shows the many ways bicycle-motor vehicle collisions can occur, including various turning and merging maneuvers in traffic, overtaking events, ride outs and drive outs, bicyclists and motorists losing control of their vehicle, motorists intentionally striking bicyclists, unusual circumstances, and parking lot/non-roadway events, etc. The names are reasonably self-explanatory, but more details as to the meaning of each crash type are available in the software.

There is some year-to-year variability in the frequencies and proportions of each crash type, especially those with smaller numbers. Much of this variation is likely explained by chance, but some variation may represent changes in behaviors including effects of treatments. Beginning with 2006 data, a new version of PBCAT has been used to type the crashes, resulting in a few changes in definitions of crash types for years since 2006 compared to 2005 and earlier years. For example, Head-On collisions were more explicitly defined to indicate which vehicle was in the wrong-lane.

Table 4. NC bicycle crash types by year.

Crash Type	2006	2007	2008	2009	2010	Total
Motorist Turning Error - Left Turn	6	2	7	4	3	22
	0.6 [1]	0.2	0.7	0.5	0.3	0.5 [2]
Motorist Turning Error - Right Turn	2	3	1	1	2	9
	0.2	0.3	0.1	0.1	0.2	0.2
Motorist Turning Error - Other	1	0	0	1	1	3
	0.1	0	0	0.1	0.1	0.1
Bicyclist Turning Error - Left Turn	7	8	2	0	1	18
	0.7	0.8	0.2	0	0.1	0.4
Bicyclist Turning Error - Right Turn	5	2	3	0	5	15
	0.5	0.2	0.3	0	0.5	0.3
Bicyclist Turning Error - Other	0	1	0	1	1	3
	0	0.1	0	0.1	0.1	0.1
Bicyclist Lost Control - Mechanical Problems	9	9	15	7	9	49
	0.9	0.9	1.4	0.8	0.9	1
Bicyclist Lost Control – Oversteering, Improper Braking, Speed	4	1	3	0	0	8
	0.4	0.1	0.3	0	0	0.2
Bicyclist Lost Control - Alcohol / Drug Impairment	5	3	1	0	1	10
	0.5	0.3	0.1	0	0.1	0.2
Bicyclist Lost Control - Surface Conditions	2	0	0	3	1	6
	0.2	0	0	0.4	0.1	0.1
Bicyclist Lost Control - Other / Unknown	6	6	9	11	8	40
	0.6	0.6	0.9	1.3	0.8	0.8
Motorist Lost Control - Mechanical Problems	0	1	1	0	1	3
	0	0.1	0.1	0	0.1	0.1
Motorist Lost Control – Oversteering, Improper Braking, Speed	0	0	1	1	1	3
	0	0	0.1	0.1	0.1	0.1
Motorist Lost Control - Alcohol / Drug Impairment	1	1	0	0	0	2
	0.1	0.1	0	0	0	0
Motorist Lost Control - Surface Conditions	0	0	0	0	2	2
	0	0	0	0	0.2	0
Motorist Lost Control - Other / Unknown	3	2	4	6	9	24
	0.3	0.2	0.4	0.7	0.9	0.5
Motorist Drive Out - Sign-Controlled Intersection	91	79	116	81	82	449
	9.4	7.7	11.1	9.8	8.5	9.3

Crash Type	2006	2007	2008	2009	2010	Total
Bicyclist Ride Out - Sign-Controlled Intersection	22	21	22	9	22	96
	2.3	2	2.1	1.1	2.3	2
Motorist Drive Through - Sign-Controlled Intersection	6	2	10	5	10	33
	0.6	0.2	1	0.6	1	0.7
Bicyclist Ride Through - Sign-Controlled Intersection	49	75	53	36	41	254
	5	7.3	5.1	4.3	4.2	5.2
Multiple Threat - Sign-Controlled Intersection	0	0	1	0	0	1
	0	0	0.1	0	0	0
Sign-Controlled Intersection - Other / Unknown	7	4	17	10	7	45
	0.7	0.4	1.6	1.2	0.7	0.9
Motorist Drive Out - Right Turn on Red	21	21	18	7	9	76
	2.2	2	1.7	0.8	0.9	1.6
Motorist Drive Out - Signalized Intersection	4	3	2	9	17	35
	0.4	0.3	0.2	1.1	1.8	0.7
Bicyclist Ride Out - Signalized Intersection	19	19	3	6	13	60
	2	1.8	0.3	0.7	1.3	1.2
Motorist Drive Through - Signalized Intersection	0	3	5	7	2	17
	0	0.3	0.5	0.8	0.2	0.4
Bicyclist Ride Through - Signalized Intersection	28	29	22	12	19	110
	2.9	2.8	2.1	1.4	2	2.3
Bicyclist Failed to Clear - Trapped	5	5	8	2	1	21
	0.5	0.5	0.8	0.2	0.1	0.4
Bicyclist Failed to Clear - Multiple Threat	1	1	2	2	0	6
	0.1	0.1	0.2	0.2	0	0.1
Signalized Intersection - Other / Unknown	11	11	33	19	16	90
	1.1	1.1	3.2	2.3	1.7	1.9
Bicyclist Failed to Clear - Unknown	2	0	0	2	1	5
	0.2	0	0	0.2	0.1	0.1
Crossing Paths - Uncontrolled Intersection	7	0	7	8	9	31
	0.7	0	0.7	1	0.9	0.6
Crossing Paths - Intersection - Other / Unknown	18	25	2	23	25	93
	1.8	2.4	0.2	2.8	2.6	1.9
Motorist Left Turn - Same Direction	9	12	7	13	11	52
	0.9	1.2	0.7	1.6	1.1	1.1
Motorist Left Turn - Opposite Direction	54	58	56	53	84	305
	5.5	5.6	5.4	6.4	8.7	6.3
Motorist Right Turn - Same Direction	30	45	48	34	41	198
	3.1	4.4	4.6	4.1	4.2	4.1
Motorist Right Turn - Opposite Direction	3	8	5	7	5	28
	0.3	0.8	0.5	0.8	0.5	0.6

Crash Type	2006	2007	2008	2009	2010	Total
Motorist Drive In / Out - Parking	0	0	2	0	0	2
	0	0	0.2	0	0	0
Motorist Right Turn on Red - Same Direction	0	2	0	0	2	4
	0	0.2	0	0	0.2	0.1
Motorist Right Turn on Red - Opposite Direction	0	0	0	1	0	1
	0	0	0	0.1	0	0
Motorist Turn / Merge - Other / Unknown	1	2	2	1	0	6
	0.1	0.2	0.2	0.1	0	0.1
Bicyclist Left Turn - Same Direction	36	39	59	29	60	223
	3.7	3.8	5.7	3.5	6.2	4.6
Bicyclist Left Turn - Opposite Direction	18	14	8	3	6	49
	1.8	1.4	0.8	0.4	0.6	1
Bicyclist Right Turn - Same Direction	16	16	12	8	15	67
	1.6	1.6	1.2	1	1.6	1.4
Bicyclist Right Turn - Opposite Direction	0	6	3	1	1	11
	0	0.6	0.3	0.1	0.1	0.2
Bicyclist Ride Out - Parallel Path	7	6	14	5	8	40
	0.7	0.6	1.3	0.6	0.8	0.8
Motorist Overtaking - Undetected Bicyclist	33	41	38	26	30	168
	3.4	4	3.6	3.1	3.1	3.5
Motorist Overtaking - Misjudged Space	24	32	44	42	55	197
	2.5	3.1	4.2	5.1	5.7	4.1
Motorist Overtaking - Bicyclist Swerved	34	32	19	28	22	135
	3.5	3.1	1.8	3.4	2.3	2.8
Motorist Overtaking - Other / Unknown	68	67	75	88	74	372
	7	6.5	7.2	10.6	7.7	7.7
Bicyclist Overtaking - Passing on Right	3	2	2	4	1	12
	0.3	0.2	0.2	0.5	0.1	0.2
Bicyclist Overtaking - Passing on Left	1	2	1	0	3	7
	0.1	0.2	0.1	0	0.3	0.1
Bicyclist Overtaking - Parked Vehicle	1	3	2	2	8	16
	0.1	0.3	0.2	0.2	0.8	0.3
Bicyclist Overtaking - Extended Door	2	1	1	1	2	7
	0.2	0.1	0.1	0.1	0.2	0.1
Bicyclist Overtaking - Other / Unknown	4	7	6	8	7	32
	0.4	0.7	0.6	1	0.7	0.7
Head-On - Bicyclist	22	31	28	11	21	113
	2.3	3	2.7	1.3	2.2	2.3
Head-On - Motorist	5	9	3	2	4	23
	0.5	0.9	0.3	0.2	0.4	0.5

Crash Type	2006	2007	2008	2009	2010	Total
Head-On - Unknown	1	1	4	0	1	7
	0.1	0.1	0.4	0	0.1	0.1
Parallel Paths - Other / Unknown	10	10	11	11	8	50
	1	1	1.1	1.3	0.8	1
Bicyclist Ride Out - Residential Driveway	19	25	14	11	16	85
	2	2.4	1.3	1.3	1.7	1.8
Bicyclist Ride Out - Commercial Driveway / Alley	18	31	8	6	10	73
	1.8	3	0.8	0.7	1	1.5
Bicyclist Ride Out - Other Midblock	9	13	21	20	16	79
	0.9	1.3	2	2.4	1.7	1.6
Bicyclist Ride Out - Midblock - Unknown	43	32	18	26	5	124
	4.4	3.1	1.7	3.1	0.5	2.6
Motorist Drive Out - Residential Driveway	6	4	8	5	3	26
	0.6	0.4	0.8	0.6	0.3	0.5
Motorist Drive Out - Commercial Driveway / Alley	55	56	59	25	39	234
	5.7	5.4	5.7	3	4	4.8
Motorist Drive Out - Other Midblock	1	0	7	7	12	27
	0.1	0	0.7	0.8	1.2	0.6
Motorist Drive Out - Midblock - Unknown	1	1	3	4	4	13
	0.1	0.1	0.3	0.5	0.4	0.3
Multiple Threat - Midblock	6	3	5	4	3	21
	0.6	0.3	0.5	0.5	0.3	0.4
Crossing Paths - Midblock - Other / Unknown	5	1	4	2	8	20
	0.5	0.1	0.4	0.2	0.8	0.4
Bicycle Only	1	1	0	1	1	4
	0.1	0.1	0	0.1	0.1	0.1
Motorist Intentionally Caused	6	4	3	4	3	20
	0.6	0.4	0.3	0.5	0.3	0.4
Bicyclist Intentionally Caused	0	0	0	1	0	1
	0	0	0	0.1	0	0
Backing Vehicle	4	12	5	4	9	34
	0.4	1.2	0.5	0.5	0.9	0.7
Play Vehicle-Related	2	0	0	0	0	2
	0.2	0	0	0	0	0
Unusual Circumstances	2	5	3	0	1	11
	0.2	0.5	0.3	0	0.1	0.2
Non-Roadway	45	42	47	42	37	213
	4.6	4.1	4.5	5.1	3.8	4.4
Unknown Approach Paths	24	14	14	13	11	76
	2.5	1.4	1.3	1.6	1.1	1.6

Crash Type	2006	2007	2008	2009	2010	Total
Unknown Location	2	3	5	3	0	13
	0.2	0.3	0.5	0.4	0	0.3
Total	973	1030	1042	829	966	4840
	20.1 [3]	21.3	21.5	17.1	20	100

[1] Row percent of the column (yearly) total
[2] Row total percent of the total
[3] Column total percent of the total

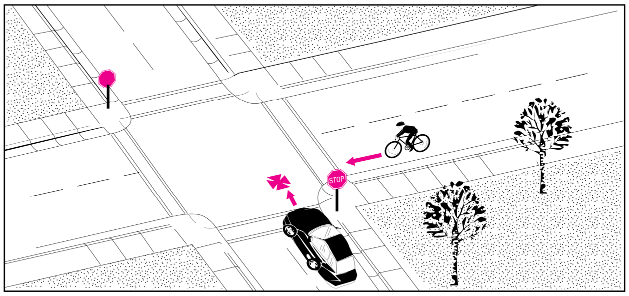
Table 2 shows the top ten most frequent individual crash types for all five years combined, which together accounted for 54% of all of NC's bicycle collisions.

Table 5. Top 10 most frequent NC bicycle crash types, 2006-2010.

Rank	Crash Type	Total	Percent of NC Total
1	Motorist Drive Out - Sign-Controlled Intersection	449	9.3%
2	Motorist Overtaking - Other / Unknown	372	7.7%
3	Motorist Left Turn - Opposite Direction	305	6.3%
4	Bicyclist Ride Through - Sign-Controlled Intersection	254	5.2%
5	Motorist Drive Out - Commercial Driveway / Alley	234	4.8%
6	Bicyclist Left Turn - Same Direction	223	4.6%
7	Non-Roadway	213	4.4%
8	Motorist Right Turn - Same Direction	198	4.1%
9	Motorist Overtaking - Misjudged Space	197	4.1%
10	Motorist Overtaking - Undetected Bicyclist	168	3.5%
	Subtotal for top 10	2613	54.0%

The top 10 crash types accounted for 54% of the State total bicycle-motor vehicle crashes. Parallel path types of crashes (rank #s 2, 3, 6, 8, 9, 10) – that is, ones in which the motorist and bicyclist were initially on parallel paths before any turns or other maneuvers that led to the crash – accounted for 30%. Crossing path crashes (rank #s 1, 4, and 5) – that is ones in which the motorist and bicyclist were initially on crossing or perpendicular paths – accounted for 19%. Non-roadway types of crashes such as in parking lots or on public or private driveways accounted for another 4%.

Countermeasures. Educational messages, training and enforcement could focus on the most common types of errors and situations that lead to the most common types of collisions. For further targeting countermeasures, adults and children also tend to be involved in different types of collisions at different locations. Often both driver and cyclist contributed to the crash. Education and enforcement efforts should target safe driving around bicyclists and reinforce both motorists and bicyclists following traffic laws. Motorists need to understand safe passing maneuvers, to watch out for bicyclists before turning at driveways and junctions and to obey all traffic controls. Both children and adults should be encouraged to properly use safety helmets when riding to help prevent injuries in crashes. Helmet use is required by law Statewide for children 15 and younger when riding on public thoroughfares. Children should also be closely supervised, provided safe places to ride and to learn safe cycling, and taught about hazards when riding on sidewalks and neighborhood streets as they mature enough to ride in these locations. Young riders should also be taught to observe all traffic rules and regulations as they progress to riding on other types of streets as well as to watch out for common types of conflicts. More information on behavioral countermeasures is available in Countermeasures That Work (NHTSA, 2011). Engineering types of countermeasures are described in BIKESAFE. Some potential countermeasures are identified in the following descriptions of the most frequent crash types.

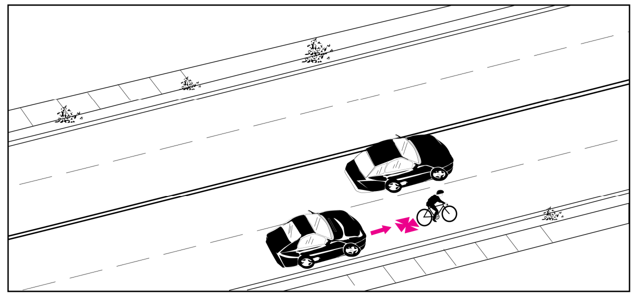


The most frequent event coded over this time period, **Motorist Drive Out – Sign-Controlled Intersection** refers to a motorist who apparently obeyed a stop sign but then drove out into the path of the bicyclist. In 58% of the crashes of this type, bicyclists were riding wrong-way (facing traffic, whether on the sidewalk or the roadway) and therefore may have contributed to the crash by coming from an unexpected direction where the driver was less likely to notice them before pulling out.

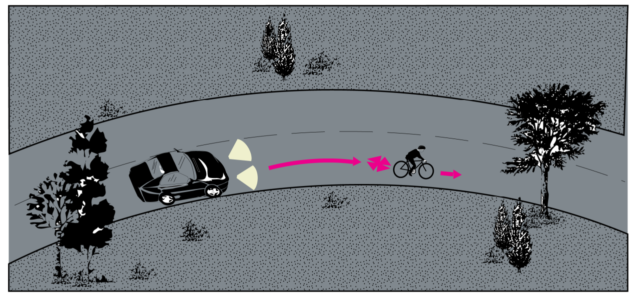
Potential Countermeasures. Intersection improvements including mini-traffic circles or roundabouts, narrowing curb radii to reduce turning speeds, improved lighting, improved sight distance and visibility, and motorist and bicyclist education are among the countermeasures for this crash type.

Motorist Overtaking – Other/Unknown, the second most frequent crash type, describes events where the motorist and bicycle were on parallel paths in the same direction and there was no information to indicate whether the motorist misjudged the space needed to pass, failed to detect the bicyclist, or the bicyclist swerved into the path of the motorist. There were very few cases (3%) where the bicyclist was traveling in the wrong direction.

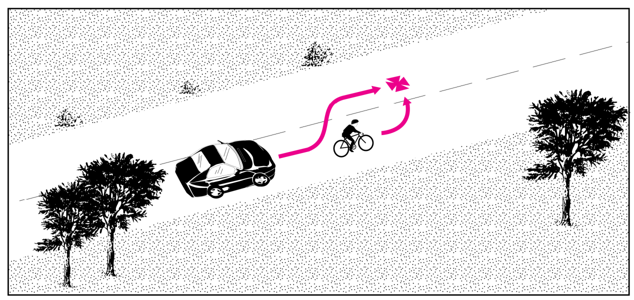
There are three other types of **Motorist Overtaking** crashes; two others are also in the top 10 list: **Misjudged Space** (no. 9) implies that the motorist misjudged the space or distance needed to safely pass the bicyclist.



Motorist Overtaking - Undetected Bicyclist (no. 10) signifies crashes in which the motorist apparently did not see the bicyclist ahead until it was too late to avoid a crash.



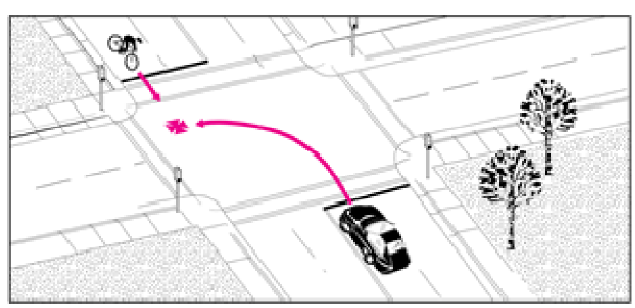
In addition, although not in the top 10, **Motorist Overtaking - Bicyclist Swerved** describes cases where the bicyclist suddenly swerved (apparently not an intentional merge or turn) into the path of the overtaking motorist. This type accounted for another 3% of crashes statewide.



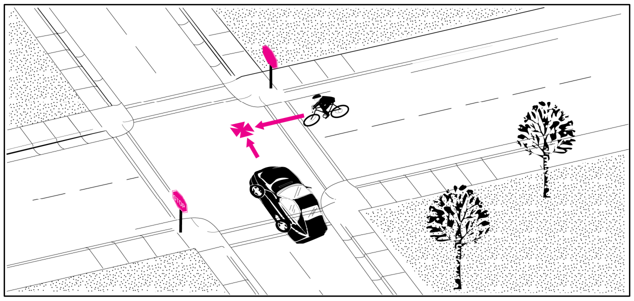
Thus, these four motorist overtaking crash types combined accounted for 18% of all of NC's bicycle-motor vehicle collisions.

Potential Countermeasures. Providing for sufficient sight distance for the speed of traffic, separated space to ride such as wide shoulders or bike lanes (or even separated facilities), and keeping shoulders or lanes clear of debris and well-maintained are countermeasures that can help to address these crash types. These crash types can be severe, particularly when motorized speeds are high. If separate space (paved shoulders, lanes, or path) or adequate sight distance cannot be provided, then it is important to consider whether speed limits should be lower, and to control traffic speeds so that overtaking motorists have sufficient time to react to any slower vehicles ahead, including bikes. Intermittent passing lanes could also be considered in some situations.

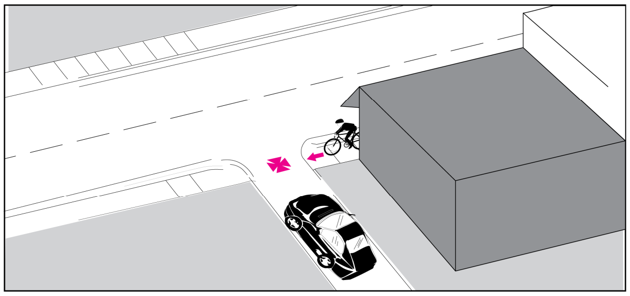
Motorist Left Turn – Opposite Direction (#3 in the list) involves events where the motorist turns left at an intersection or driveway in front of an oncoming bicyclist. These types of crashes may occur on multi-lane roads when the motorist's view of the bicyclist is block by other traffic lanes, or the driver may fail to look for or notice an



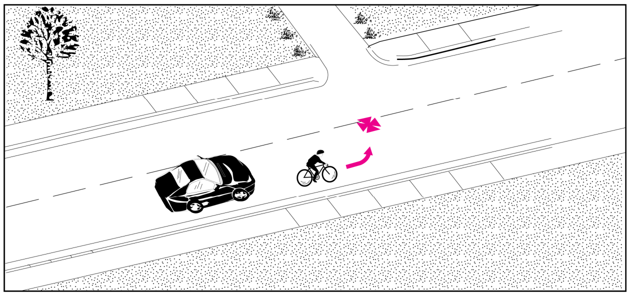
oncoming bicyclist.
Potential Countermeasures. Providing protected-only left-turn phasing at signalized locations, restricting left turns at midblock locations, reducing conflicting movements by providing roundabouts or traffic circles at intersections are among potential treatments for these types of collisions.



The fourth most frequent collision type over this time period, **Bicyclist Ride Through – Sign-Controlled Intersection**, is typically an event where the bicyclist ignored the sign controlling the bicyclist's direction. A lack of on-road bicycling experience, failure to notice the sign or look for conflicting traffic, a misjudgment of the available gap, or a reluctance to lose momentum are factors that could be present in such a crash type. Wrong-way riding (present in about 15% of the cases) could increase the chances that a bicyclist would not notice the traffic control.
Potential Countermeasures. In addition to educational/training measures, intersection treatments such as improved sight distance, roundabouts or traffic circles, installing a signal with bike detection, or providing alternate routes for bicyclists are improvements that may be warranted to safely accommodate bicyclist traffic, depending on the road and area type.



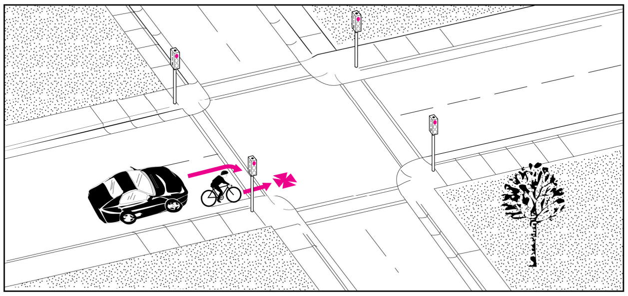
Motorist Drive Out - Commercial Driveways (#5) involves motorists driving out at these locations and failing to yield right-of-way to approaching bicyclists. As is also the case with motorist drive outs at sign-controlled junctions, this type has an over-representation (72% of the cases) of bicyclists traveling from the motorist's right against traffic (wrong side of street).
Potential Countermeasures. Sight distance issues may be contributing factors at driveways and should be addressed. In addition, driveway design and narrow turning radii can help to ensure that drivers stop and yield before pulling out.



Bicyclist left turn – Same Direction (#6) involves a bicyclist traveling along the right side of the roadway (usually) in the same direction as a motor vehicle and turning or merging left in front of, or into the side of, the motor vehicle traveling in the same direction. The rider fails to see or yield to a motorist coming from behind or could involve

a bicyclist riding out from a sidewalk or path beside the road. Speed of overtaking vehicles may be a factor in this group of crashes. The motorist also may not see the bicyclist, or may not suspect that the bicyclist will turn in front in time to react.
Potential Countermeasures. A variety of countermeasures may help reduce the occurrence of this crash type, specific to the situation. Bicyclists should be educated to use proper hand signals and check behind before changing position, and use lights at night, and motorists should be encouraged to allow ample space and be alert for when bicyclists may need to merge or turn. Speed enforcement and other efforts to control traffic speeds may also be needed.

The 7th most frequent crash type is a catch-all category for all **Non-Roadway** collisions that were reported (image not shown). This type means the crash occurred off the roadway network and typically refers to parking lot crashes, but may also include crashes on public and private driveways and other off-roadway areas.



Eighth on the list, **Motorist Right Turn – Same Direction** involves motorists passing and turning right (sometimes known as the "right-hook") in front of bicyclists who were traveling along the same roadway (or an adjacent path or walkway) in the same direction.
Potential Countermeasures. Conspicuous bike lanes combined with bike boxes or advance stop bars at intersections may be appropriate in some situations to allow bicyclists to proceed to the front of the queue at signalized locations. Turn and through lane design, intersection markings, narrower curb radii, and other treatments may be suitable, depending on the context.

More information on crash types and potential countermeasures is available from BIKESAFE, including a matrix linking countermeasures to crash type groups, and a countermeasure selection tool to assist with narrowing down potential countermeasures.

For complete crash type definitions, see PBCAT Manual and Tech Support**,** Appendix C. Example crash type images are also available on the PBCAT web pages.

Grouped Crash Types

For ease in understanding, the individual crash types from Table 1 have been consolidated into fewer (21) related crash type groups for additional examination and analyses. For example, the four separate **Motorist Overtaking** crash types in Table 1 are combined as one crash type group. These combined crash groups also show some variability by year but less than the individual crash types. Examining the totals across all five years, crash type groups are shown in rank order of frequency (Table 6).

Table 6. NC bicycle-motor vehicle crash type groups, 2005-2009.

Rank	Grouped Bicyclist Crash Type	Total	Percent of NC Total
#1	Motorist Overtaking Bicyclist	872	18.0
#2	Motorist Failed to Yield - Sign-Controlled Intersection	482	10.0
#3	Bicyclist Failed to Yield - Midblock	382	7.9
#4	Motorist Left Turn / Merge	357	7.4
#5	Bicyclist Failed to Yield - Sign-Controlled Intersection	351	7.2
#6	Motorist Failed to Yield - Midblock	300	6.2
#7	Crossing Paths - Other Circumstances	279	5.8
#8	Bicyclist Left Turn / Merge	272	5.6
#9	Motorist Right Turn / Merge	231	4.8
#10	Loss of Control / Turning Error	217	4.5
#11	Non-Roadway	213	4.4
#12	Bicyclist Failed to Yield - Signalized Intersection	202	4.2
#13	Head-On	143	3.0
#14	Motorist Failed to Yield - Signalized Intersection	128	2.6
#15	Parallel Paths - Other Circumstances	96	2.0
#16	Other / Unknown - Insufficient Details	89	1.8
#17	Bicyclist Right Turn / Merge	78	1.6
#18	Bicyclist Overtaking Motorist	74	1.5
#19	Other / Unusual Circumstances	38	0.8
#20	Backing Vehicle	34	0.7
#21	Parking / Bus-Related	2	0.0

The top 12 crash groups combined accounted for 86% of all of North Carolina's bicycle-motor vehicle crashes and will be the focus of this discussion. As mentioned in the discussion on individual crash types, the most frequent group, **Motorist Overtaking Bicyclist,** accounted for 18% of the collisions Statewide and describes all situations in which the motorist was approaching a bicyclist from behind and a collision occurred when the motorist was overtaking or attempting to pass the bicyclist. As mentioned, these crashes are often severe as they tend to occur on rural, higher speed roads. Forty-three of the 100 fatal crashes over the five years were these types. These collisions may be reduced by measures to provide separate space for bicyclists to ride, keeping roads and shoulders swept and well-maintained, by educating bicyclists to always use lights at night, and enforcing traffic laws relating to safe overtaking.

Motorist Failed to Yield - Sign-Controlled Intersection (#2) indicates that the motorist either failed to stop or stopped and then drove out into the path of a bicyclist crossing the intersection. This type accounted for 10% of all the collisions statewide. As mentioned before, bicyclist wrong-way riding may contribute to these types of crashes. Bicyclists may ride on sidewalks, where they more often ride wrong-way, when they don't feel comfortable with space or facilities available for the speed and volume of traffic on the roadway. Thus, conditions should be assessed to ensure that facilities are appropriate for all users for the speed and volume of traffic, number of travel lanes, and other roadway factors present.
Potential Countermeasures. Enforcement of yielding laws, bicycle lighting laws, ensuring intersections have adequate sight distance, narrowing curb radii, appropriately designed right-turn slip lanes, and other measures may also help ensure that motorists yield before driving out or turning right without yielding to bikes.

Bicyclist Failed to Yield - Midblock (#3) describes all the situations in which a bicyclist rode out from a non-intersection location such as a commercial or private driveway or yard and into the path of a motorist on the roadway. This group accounted for nearly 8% of crashes.
Potential Countermeasures include ensuring that sight distance/visibility is clear around driveways (including parked cars); educating bicyclists, especially child bicyclists, on looking behaviors and not riding out from between parked vehicles or other obstacles; and ensuring that speeds are appropriate to the roadway and uses. Bicyclists have difficulty detecting a safe gap if travel speeds are too high. Detecting suitable gaps at night may also be more challenging. Signal timing may be coordinated to provide midblock gaps suitable for bicyclist access.

Motorist Left Turn/Merge (#4) describes situations in which a motorist turned or merged into the path of a bicyclist who was either traveling from the opposite or same direction parallel to the motorists' path. This type may also include driving in or out of parking spaces or bus or delivery vehicle pullovers, and as a group, accounted for about 7% of crashes.
Potential Countermeasures. Protected left turns at signalized locations, roundabouts and traffic circles, reducing the number of lanes, enforcement, ensuring bicyclists use lights at night, and educational measures may help to reduce these types.

Bicyclist Failed to Yield - Sign-Controlled Intersection (#5) is similar to #3, except in this case, the bicyclist either rode through a stop sign without stopping or stopped and then rode into the path of a motorist. This group comprised about 7% of all the crashes.
Potential Countermeasures. Bicycle boulevards might be created in areas with a large number of cyclists to create a route that favors bicycle travel and to reduce the number of stops cyclists have to make. Educational measures may also be taken, and again, traffic speeds and gaps in traffic are important factors, especially where stop-controlled side streets intersect major roads with no traffic control.

Motorist Failed to Yield – Midblock (#6) describes situations where the motorist drove out from commercial or residential driveways or other midblock locations and into the path of a bicyclist traveling along the roadway (including adjacent sidewalks or paths). This type accounted for about 6% of the crashes.
Potential Countermeasures. Bicyclist education about wrong-way riding and motorist education and enforcement of traffic yielding laws are remedies to consider along with potential engineering remedies such as ensuring adequate sight distance and driveway design changes.

Crossing Paths - Other Circumstances (#7) describes situations in which bicyclists and motorists were on perpendicular paths at intersections or midblock locations prior to the crash, but traffic control or right-of-way or other details are unknown or do not fit any of the other situations described. Since details are lacking, countermeasures are difficult to identify.

Bicyclist Left Turn/Merge (#8 on the list) includes bicyclists turning or merging left into the path of motor vehicles traveling in the same or opposite direction and accounted for about 6% of crashes. This type also includes bicyclists riding along a parallel walkway or sidepath who rode out into the roadway in a parallel direction to (not across) traffic.
Potential Countermeasures. Engineering measures such as special bicycle turning pockets at intersections where cyclists can wait until it is safe to turn could also be appropriate for some situations. Potential remedies include bicyclist training and slowing vehicle speeds (so that bicyclists have time to merge across lanes), reducing the number of lanes, or designing shared lanes for low speeds.

Motorist Right Turn / Merge (#9, also about 5% of crashes) describes all situations in which the motorist turned right across the path of a through bicyclist – typically in the same direction, but sometimes with bicyclists traveling from the opposite directions (and perhaps wrong-way).
Potential Countermeasures. Bicycle boxes or advance stop bars that allow bicyclists to proceed to the front of a queue on a red signal when bike lanes or other space is available, may help reduce this type of crash when it involves vehicles turning right from a stopped position. Other remedies include enforcement of appropriate traffic laws and motorist and bicyclist education.

Loss of Control / Turning Error types of crashes (#10, about 5%) describes situations in which either the motorist or the bicyclist turned into the wrong lane or cut the corner, or otherwise lost control during the turn. These crashes typically result from too-high turning speed.
Potential Countermeasures. Reducing curb radii, adding median dividers at intersections, and providing protected left turn phasing at signalized locations are potential remedies.

Non-roadway (#11) means the crash occurred off the roadway such as in a parking lot or private driveway. All non-roadway crashes accounted for about 4%. Parking lot design could play a role in reducing these crash types.

Bicyclist Failed to Yield - Signalized Intersection (#12 on the list with 4%) includes crashes when the bicyclist either rode through a red light or stopped for a signal and then rode into the intersection and into the path of a motor vehicle against a signal indication. In addition to bicyclist errors or intentional violations, this group includes instances in which the bicyclist may not have been detected for a signal change, may have been trapped by a signal change, or otherwise failed to clear the intersection on a changing signal in the time allowed or before vehicles began moving.

Potential *Countermeasures* include ensuring bicyclists are detected at signalized locations, that signal timing allows for sufficient bicyclist clearance intervals, other possible intersection safety improvements, as well as educational/training measures.

The remaining crash type groups together accounted for less than 15% of the total, but crash countermeasures may still be available for some. More information on potential countermeasures for all of the above types of crashes may be reviewed in the interactive Web site and document, BIKESAFE: Bicycle Countermeasure Selection System (BIKESAFE). Additional resources are contained on Bicyclinginfo.org developed for the U.S Department of Transportation, Federal Highway Administration. In order to develop countermeasures for particular locations, crash data specific to those locations would need to be examined. A comprehensive evaluation through on-site safety audits, including behavioral and engineering assessments would also be needed.

For more information on bicycle crashes including characteristics of bicyclists and drivers involved, and descriptions of environmental, roadway, and other factors present, see the NC **Bicycle Crash Facts** summary report.

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