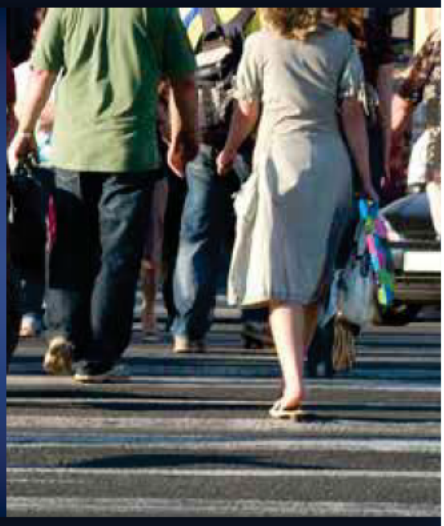
North Carolina
Pedestrian Crash Types
2011 - 2015



Prepared for

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

Prepared by

THE UNIVERSITY OF NORTH CAROLINA
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Introduction and Purpose

A total of 14,498 collisions between motor vehicles and pedestrians were reported in North Carolina over the five-year period of 2011 to 2015. On average, 176 crashes resulted in pedestrian fatalities, and another 188 resulted in disabling-type injuries each year.[1] See the companion *North Carolina Pedestrian Crash Facts* report for a summary of pedestrian injuries and fatalities.

This report summarizes pedestrian-motor vehicle crash types that were developed for 2011-2015 for the entire State. UNC Highway Safety Research Center staff reviewed diagrams and narratives and other details on copies of all crash report forms submitted to NCDOT, and used PBCAT software to code crash type, pedestrian position, and crash location variables for each crash. These data elements were combined with the crash data elements already available from the State's crash databases. The results are summarized in figures, tables, and text in the following sections.

The report provides information about common crash types across the state and suggests potential countermeasures that might be appropriate to help reduce these crashes. Local agencies can use the information herein as a guide to analyze and understand their own specific crash issues and potential treatments. The information is for summary purposes only. Appropriate diagnosis and other procedures are necessary before implementing treatments at any location. Additional information on person, environmental, and roadway factors is provided in the companion *North Carolina Pedestrian Crash Facts* summary report.

Background on Crash Typing

The information reported by public safety officials using standard crash reporting (source DMV-349) across the State is stored in electronic crash databases. Analysis of these data can provide information on *where* pedestrian-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.). Reported crash data were compiled and used to describe such pedestrian-motor vehicle crash characteristics in the companion, *North Carolina Pedestrian Crash Facts* summary report.

However, the data contained in the crash database provides little information about the actual sequence of events leading to crashes between motor vehicles and pedestrians. The development of effective countermeasures to help reduce the frequency and severity of these crashes is limited by insufficient detail on the events leading up to the crash, or the crash type.

[1] This number reflects crashes that involved one or more fatalities, and does not capture if more than one pedestrian was struck and killed or injured. See more on pedestrian fatalities and injuries in the Crash Facts summary report.

To help 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 locations that can be targeted for interventions. Certain demographic groups (for example children versus older adults) may also be more highly associated with different types and locations of crashes. 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), interactive software that enables both pedestrian and bicycle crashes to be easily and quickly typed by answering a series of on-screen questions. PBCAT version 2 (sponsored by the Federal Highway Administration, FHWA) was released in 2006 (Harkey, Tsai, Thomas, and Hunter, 2006). For more information on PBCAT and crash typing, including detailed descriptions and images of crash types, see the PBCAT webpage. A companion tool, PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System, also sponsored by FHWA and updated in 2013, is an internet-only interactive tool that helps users identify potentially appropriate countermeasures for the types of crashes and other problems identified by analyzing data from PBCAT and state crash files. Another FHWA tool that can assist with diagnosing problems is the Pedestrian Road Safety Audit Guidelines and Prompt Lists.

Crash Events and Description

Pedestrian Crash Location

On average, forty-three percent of all pedestrian crashes in NC from 2011-2015 involved Non-Intersection roadway locations - that is, at midblock locations or segments (Table 1). These segments may include features such as driveway connections, (and pedestrians crossing driveways who were struck by vehicles entering/exiting the roadway), bridges, or exit ramps, but do not include intersections or signalized commercial driveways. Location types of pedestrian crashes include the following:

- 43 percent (as mentioned above) occurred at non-intersection locations (midblock, or more than 50 feet from the corners of an intersection).
- 28 percent of all the pedestrian collisions occurred at an intersection or within 50 feet of an intersection (Intersection-Related), including here signalized, commercial driveways.
- 29 percent occurred at Non-Roadway locations, most often parking lots or public or private driveways, but not the junctions of these with the roadway or a sidewalk along the roadway, which are included in roadway crashes.

Considering only roadway crashes (excluding Non-Roadway and Unknown), 61 percent of roadway crashes occurred at midblock locations, with 39 percent at or related to an intersection.

Table 1 NC pedestrian crashes by location type[2]

Crash Location	2011	2012	2013	2014	2015	Total
Intersection	448	568	486	567	598	2,667
	16.6 [1]	19.0	17.6	19.0	19.6	18.4 [2]
Intersection-Related	227	306	250	287	293	1,363
	8.4	10.2	9.1	9.6	9.6	9.4
Non-Intersection	1,200	1,266	1,207	1,265	1,266	6,204
	44.5	42.2	43.7	42.3	41.5	42.8
Non-Roadway	816	849	816	868	894	4,243
	30.3	28.3	29.6	29.0	29.3	29.3
Unknown	6	8	2	2	3	21
	0.2	0.3	0.1	0.1	0.1	0.1
Total	2,697	2,997	2,761	2,989	3,054	14,498
	18.6[3]	20.7	19.0	20.6	21.1	100

Figure 1 shows how the proportions of location types as they vary from rural to urban crash locations in NC. Non-intersection crash locations make up 64 percent of the total pedestrian crashes in rural areas compared with 35 percent in urban areas, while non-roadway (parking lot crashes), intersection and intersection-related crashes are a lower percentage in rural areas. Proportions of crashes occurring at different location types may also vary across different towns and cities depending on how closely spaced intersections are, the type of infrastructure present, and other factors.

[2] In this and all subsequent tables, the percentages are as shown:
[1] Row percent of column total
[2] Row total percent of total
[3] Column percent of row total

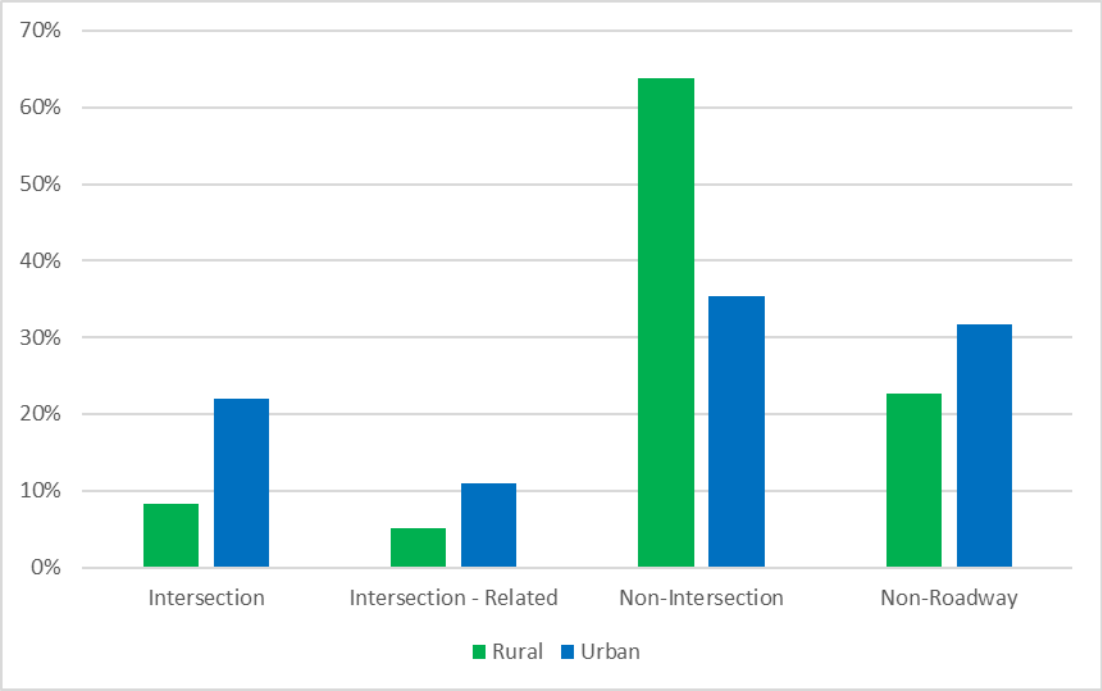


Figure 1 NC rural and urban crash percentages by location type, 2011- 2015 (n = 3,790 rural; 10,708 urban)

In addition to greater numbers of crashes, the fatality rate is much higher for pedestrians struck along road sections (non-intersection locations) compared with intersections. Motorists may be expecting interactions with other road users at intersections (especially those with traffic controls), or slowing for turns and other maneuvers, compared with mid-block/segment locations.

The 650 fatal crashes at non-intersection locations represented 74 percent of all NC pedestrian fatal crashes (Figure 2). In part, the higher severity of crashes at non-intersection locations may also reflect pedestrians being struck at a higher frequency at non-intersection locations in rural areas (as shown in Figure 1). In rural areas, speeds are typically higher, roadways are often not lighted, and other differences may contribute to the higher fatality rate. Pedestrian crashes at non-intersection locations resulted in fatal injuries 11 percent of the time, while those occurring at intersections were fatal about 4 percent of the time. Crashes that occurred close to but not at an intersection resulted in fatal injuries 6 percent of the time. Crashes at non-roadway locations resulted in fatalities about 1percent of the time. The percentages described were calculated from the numbers shown in Figure 2.

There may be many reasons pedestrians choose to cross at a non-intersection location, including, but not limited to the following: distance to the nearest controlled crossing, conflicts with turning vehicles at intersections, signals that do not detect pedestrians or provide adequate crossing time, and others. Thus, there is potential influence of intersection characteristics (and spacing of intersections) on the rate of pedestrians being struck (and killed) at non-intersection locations.

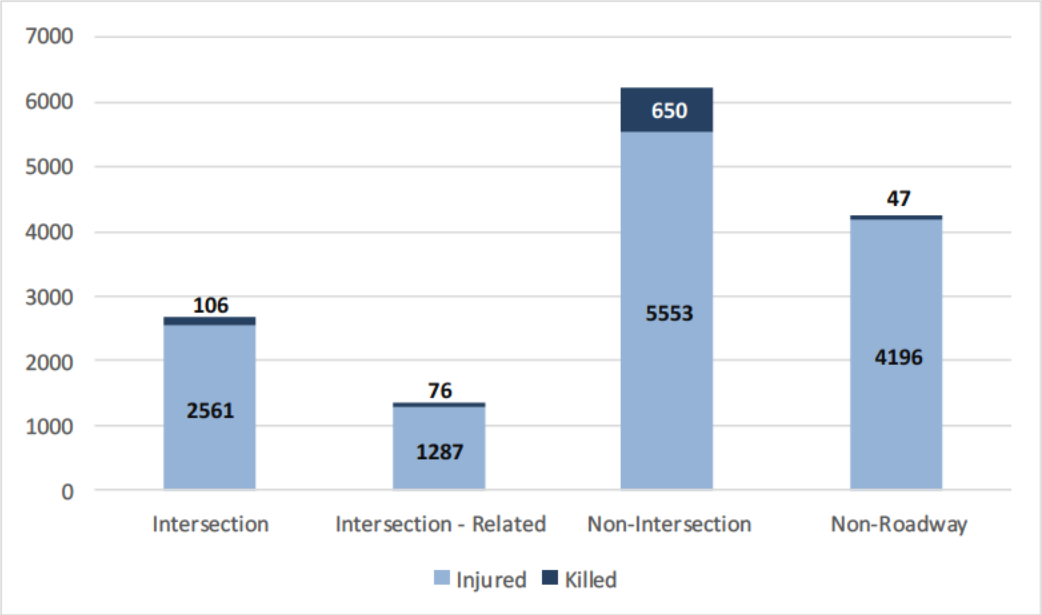


Figure 2 Pedestrian injury severity by location type, 2011-2015

Pedestrian Position

Table 2 describes the pedestrian's position at the time of the crash. Forty-five percent of pedestrians were walking/crossing/standing in a regular traffic lane, but not in a crosswalk or other specially designated area, at the time they were struck. Another 26 percent were in parking lots or other non-roadway areas that were not within the road right-of-way. Eleven percent were crossing the street in a crosswalk (marked or implied) as best determined from diagrams and other information on the crash report forms. (Note that the presence of an implied or marked crosswalk is not always discernible from crash reports.) Five percent of pedestrians were walking on paved shoulders, bike lanes, or parking lanes prior to being struck. Smaller percentages (3%) of pedestrians were struck when walking along sidewalks, shared use paths or driveway crossings (usually by motorists turning into or out of the main road). About 2 percent were within the intersection proper (within the corners of the intersection, not in the crosswalk areas) before they were struck. Finally, about 2 percent were on unpaved right-of-way areas such as grassy shoulders alongside roadways when struck.

Table 2 Pedestrian position prior to the crash, 2011-2015

Pedestrian Position	2011	2012	2013	2014	2015	Total
Intersection Proper	59	116	104	17	31	327
	2.2	3.9	3.8	0.6	1.0	2.3
Crosswalk Area	250	316	323	321	391	1,601
	9.3	10.5	11.7	10.7	12.8	11.0
Travel Lane	1,273	1,329	1,135	1,380	1,384	6,501
	47.2	44.3	41.1	46.2	45.3	44.8
Paved Shoulder / Bike Lane / Parking Lane	159	230	175	123	73	760
	5.9	7.7	6.3	4.1	2.4	5.2
Sidewalk / Shared Use Path / Driveway Crossing	99	105	78	107	84	473
	3.7	3.5	2.8	3.6	2.8	3.3
Unpaved Right-of-Way	18	16	87	140	93	354
	0.7	0.5	3.2	4.7	3.0	2.4
Driveway / Alley	91	98	86	82	84	441
	3.4	3.3	3.1	2.7	2.8	3.0
Non-Roadway - Parking Lot / Other	725	751	729	786	810	3,801
	26.9	25.1	26.4	26.3	26.5	26.2
Other / Unknown	23	36	44	33	104	240
	0.9	1.2	1.6	1.1	3.4	1.7
Total	2,697	2,997	2,761	2,989	3,054	14,498
	18.6	20.7	19.0	20.6	21.1	

Individual Crash Types

Table 3 shows the numbers of each of 56 different individual crash types for the years 2011 – 2015. The crash type, as well as the already described location and position information, was developed by using PBCAT software to code the five years of crashes from copies of crash report forms. Each of the 14,498 reported pedestrian-motor vehicle crashes were assigned crash types using the PBCAT software. Only 17 had no useful information about where the crash occurred or what happened (Other – Unknown Location).
Table 3 shows the many ways pedestrian-motor vehicle crashes can occur, including backing vehicles in parking lots, motorists turning across the paths of pedestrians, pedestrian dart-outs and dashes, pedestrians being struck while walking along the roadway, and many others.

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. In general, the most frequent crash types tend to occur in similar proportions across years.

Table 3 Individual NC pedestrian crash types by year

Crash Type	2011	2012	2013	2014	2015	Total
Assault with Vehicle	23	33	25	32	35	148
	0.9	1.1	0.9	1.1	1.1	1.0
Dispute-Related	64	101	73	79	82	399
	2.4	3.4	2.6	2.6	2.7	2.8
Pedestrian on Vehicle	36	23	29	38	34	160
	1.3	0.8	1.1	1.3	1.1	1.1
Vehicle-Vehicle / Object	70	97	82	105	120	474
	2.7	3.2	3.0	3.5	3.9	3.3
Motor Vehicle Loss of Control	119	126	98	120	54	517
	4.4	4.2	3.5	4.0	1.8	3.6
Pedestrian Loss of Control	26	28	23	33	18	128
	1.0	0.9	0.8	1.1	0.6	0.9
Other Unusual Circumstances	14	14	17	33	10	88
	0.5	0.5	0.6	1.1	0.3	0.6
Backing Vehicle - Driveway	35	35	28	21	26	145
	1.3	1.2	1.0	0.7	0.9	1.0
Backing Vehicle - Driveway / Sidewalk Intersection	10	4	9	13	8	44
	0.4	0.1	0.3	0.4	0.3	0.3
Backing Vehicle - Roadway	36	36	35	30	33	170
	1.3	1.2	1.3	1.0	1.1	1.2
Backing Vehicle - Parking Lot	218	221	237	247	251	1,174
	8.1	7.4	8.6	8.3	8.2	8.1
Backing Vehicle - Other / Unknown	7	6	0	0	3	16
	0.3	0.2	0.0	0.0	0.1	0.1
Driverless Vehicle	40	60	53	39	42	234
	1.5	2.0	1.9	1.3	1.4	1.6
Disabled Vehicle-Related	46	41	53	36	38	214
	1.7	1.4	1.9	1.2	1.2	1.5
Emergency Vehicle-Related	13	12	9	10	4	48
	0.5	0.4	0.3	0.3	0.1	0.3
Play Vehicle-Related	22	42	37	42	42	185
	0.8	1.4	1.3	1.4	1.4	1.3
Working in Roadway	35	44	41	40	38	198
	1.3	1.4	1.5	1.3	1.2	4
Playing in Roadway	13	3	6	9	2	33
	0.5	0.1	0.2	0.3	0.1	0.2
Lying in Roadway	18	13	21	16	18	86
	0.7	0.4	0.8	0.5	0.6	0.6
Entering / Exiting Parked Vehicle	4	10	2	12	9	37
	0.1	0.3	0.1	0.4	0.3	0.3

Crash Type	2011	2012	2013	2014	2015	Total
Mailbox-Related	7	10	6	6	6	35
	0.3	0.3	0.2	0.2	0.2	0.2
Commercial Bus-Related	7	8	4	4	1	24
	0.3	0.3	0.1	0.1	0.0	0.2
School Bus-Related	20	18	28	18	13	97
	0.7	0.6	1.0	0.6	0.4	0.7
Ice Cream / Vendor	5	1	1	4	2	13
Truck-Related	0.2	0.0	0.0	0.1	0.1	0.1
Walking Along Roadway	183	230	216	255	308	1,192
With Traffic - From Behind	6.5	7.6	7.7	8.5	10.1	8.2
Walking Along Roadway	2	0	6	5	5	18
With Traffic - From Front	0.1	0.0	0.2	0.2	0.2	0.1
Walking Along Roadway	10	12	8	7	17	54
Against Traffic - From Behind	0.4	0.4	0.3	0.2	0.6	0.4
Walking Along Roadway	49	76	74	69	88	356
Against Traffic - From Front	1.6	2.5	2.7	2.3	2.9	2.4
Walking Along Roadway	4	3	4	6	3	20
- Direction / Position Unknown	0.1	0.1	0.1	0.2	0.1	0.1
Motorist Entering	9	5	5	8	8	35
Driveway or Alley	0.3	0.2	0.2	0.3	0.3	0.2
Motorist Exiting	50	60	55	65	58	288
Driveway or Alley	1.9	2.0	2.0	2.2	1.9	2.0
Driveway Crossing -	0	0	0	0	1	1
Other / Unknown	0.0	0.0	0.0	0.0	0.0	0.0
Waiting to Cross -	2	1	0	1	0	4
Vehicle Turning	0.1	0.0	0.0	0.0	0.0	0.0
Waiting to Cross -	1	2	2	2	0	7
Vehicle Not Turning	0.0	0.1	0.1	0.1	0.0	0.0
Waiting to Cross -	1	0	0	0	1	2
Vehicle Action Unknown	0.0	0.0	0.0	0.0	0.0	0.0
Standing in Roadway	51	76	62	65	63	317
	1.9	2.5	2.2	2.2	2.1	2.2
Walking in Roadway	126	128	115	73	15	457
	4.5	4.1	4.2	2.4	0.5	3.1
Non-Intersection - Other	13	10	16	20	38	97
/ Unknown	0.5	0.3	0.6	0.7	1.2	0.7
Intersection - Other /	21	27	14	12	24	98
Unknown	0.8	0.9	0.5	0.4	0.8	0.7

Crash Type	2011	2012	2013	2014	2015	Total
Multiple Threat	14	25	12	13	27	91
	0.5	0.8	0.4	0.4	0.9	0.6
Trapped	8	3	8	11	5	35
	0.3	0.1	0.3	0.4	0.2	0.2
Dash	161	147	153	220	197	878
	6.0	4.9	5.5	7.4	6.5	6.1
Dart-Out	22	30	34	57	59	202
	0.8	1.0	1.2	1.9	1.9	1.4
Pedestrian Failed to Yield	396	434	374	343	409	1,956
	14.7	14.5	13.5	11.5	13.4	13.5
Motorist Failed to Yield	76	102	68	49	47	342
	2.8	3.4	2.5	1.6	1.5	2.4
Motorist Left Turn - Parallel Paths	134	160	161	183	222	860
	5.0	5.3	5.8	6.1	7.3	5.9
Motorist Left Turn - Perpendicular Paths	4	6	9	6	17	42
	0.1	0.2	0.3	0.2	0.6	0.3
Motorist Right Turn - Parallel Paths	24	33	37	43	52	189
	0.9	1.1	1.3	1.4	1.7	1.3
Motorist Right Turn on Red - Parallel Paths	1	4	3	5	2	15
	0.0	0.1	0.1	0.2	0.1	0.1
Motorist Right Turn on Red - Perpendicular Paths	17	17	19	33	39	125
	0.6	0.6	0.7	1.1	1.3	0.9
Motorist Right Turn - Perpendicular Paths	23	29	28	60	52	192
	0.9	1.0	1.0	2.0	1.7	1.3
Motorist Turn / Merge - Other / Unknown	4	4	1	10	13	32
	0.1	0.1	0.0	0.3	0.4	0.2
Off Roadway - Parking Lot	299	271	298	365	369	1,602
	11.1	9.0	10.8	12.2	12.1	11.0
Off Roadway - Other / Unknown	68	82	41	1	10	202
	2.5	2.7	1.5	0.0	0.3	1.4
Other - Unknown Location	5	6	1	2	3	17
	0.2	0.2	0.0	0.1	0.1	0.1
Crossing an Expressway	31	28	20	13	13	105
	1.2	0.9	0.7	0.4	0.4	0.7
Total	2,697	2,997	2,761	2,989	3,054	14,498
	18.6	20.7	19.0	20.6	21.1	

Most Frequent Cash Types and Potential Countermeasures

Table 4 shows the top 12 most frequent individual crash types for all five years combined. This set of 12 crash types accounted for 70 percent of reported pedestrian – motor vehicle collisions statewide. These types could therefore be among the priorities for targeting safety treatments. Other crash types, some closely related to the top 12, also account for sizable numbers and may be targets for similar measures or others. The resources mentioned in the Background and at the end of this report, provide further guidance for selecting appropriate treatments.

Table 4 Top 12 most frequent NC pedestrian crash types, 2011-2015

Rank	Crash Type	Total	% of NC Total
1	Pedestrian Failed to Yield	1,956	13.5%
2	Off Roadway - Parking Lot	1,602	11.0%
3	Walking Along Roadway With Traffic – From Behind	1,192	8.2%
4	Backing Vehicle – Parking Lot	1,174	8.1%
5	Dash	878	6.1%
6	Motorist Left Turn - Parallel Paths	860	5.9%
7	Motor Vehicle Loss of Control	517	3.6%
8	Vehicle-Vehicle / Object	474	3.3%
9	Walking in Roadway	457	3.2%
10	Dispute-Related	399	2.8%
11	Walking Along Roadway Against Traffic – From Front	356	2.5%
12	Motorist Failed to Yield	342	2.4%
	Total Top 12 types for frequency	10,207	70.4%

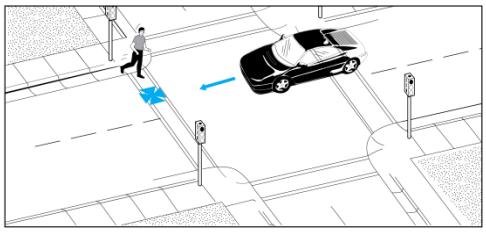
The most frequent crash types encompass a mix of typical roadway crashes involving pedestrians crossing the roadway (Pedestrian Failed to Yield and Dashes, Motorist Failed to Yield), Walking Along and *In* the roadway crashes, Motorists striking pedestrians while making Left Turns, etc., *and* Off-Roadway and parking lot crashes as well as some 'unusual' types.

The most frequent type, **Pedestrian Failed to Yield**, accounted for about 14 percent of the total across North Carolina. This type describes all instances where a pedestrian was attempting to cross the roadway and apparently failed to yield the right-of-way to a through (not turning) motorist but did not clearly run into the street or dart-out from an obscured location. This crash type includes crashes where the pedestrian is trying to cross at an uncontrolled midblock location and attempts to cross with an insufficient gap in traffic or fails to detect an approaching motorist

(who could be speeding). Sixty percent of these crashes occurred at mid-block locations. Other instances occur when a pedestrian crosses against a traffic signal at a signalized intersection or other signalized location and does not appear to have right-of-way (see illustration). Forty percent of Pedestrian Failed to Yield types occurred at intersections or related to an intersection. The crash type should not necessarily be construed to imply fault. Additionally, there are many locations on roadways across the State, in rural areas, but also in many urban and suburban areas, with there are few controlled crossings for long intervals, so pedestrians may need to cross at uncontrolled locations between junctions.

Potential Countermeasures. Countermeasures for pedestrian failed to yield crash types include providing marked crosswalks at suitable locations (may use high visibility) and other enhancements (such as pedestrian signals, Pedestrian Hybrid Beacons, median crossing islands, and advance yield bars and yield signs) at appropriate locations. Appropriate measures may also include lighting (if nighttime crashes are a problem), roadway narrowing through bulb-outs or curb extensions, reductions in lane number or width (with and without provision of bike lanes), and potentially other traffic calming measures to slow traffic speeds. In some instances, such as where crossings of high-speed, high volume roads are needed, pedestrian overpasses may be the most appropriate solution. At intersections, addition of signals, or changes in signal timing and phasing (such as leading pedestrian intervals or turn restrictions), bus stop relocation, and other measures may be appropriate. In all cases, engineering studies or multi-stakeholder review (such as through roadway safety audits), speed studies, and in-depth diagnosis are needed to fully assess the problems and identify the most appropriate solutions. Another valuable resource to help with problem diagnosis is Pedestrian Road Safety Audit Guidelines and Prompt Lists. PEDSAFE provides information on countermeasures for different crash types and general safety problems.

The **Dash**, #5 in the list, also describes a crossing situation, but one where the pedestrian runs into the roadway and is struck by a vehicle; the driver's view of the pedestrian was not obviously obstructed just prior to the crash. Dashes may also occur at both midblock and intersection locations.



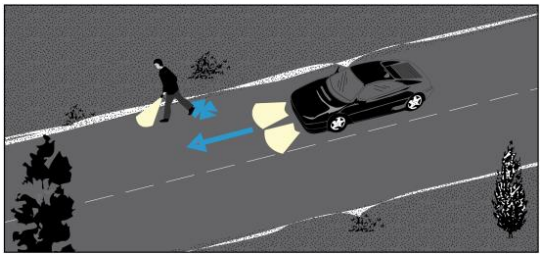
Potential Countermeasures. Most of the countermeasures are similar to those for Pedestrian Failure to Yield. Additional educational measures targeting child pedestrians may be warranted since children are frequently over-represented in this type of crash (39% of pedestrians involved in dash crashes are under age 16). Access management treatments to restrict motorist through movements or reduce volumes on neighborhood streets, and street furniture (plantings, barriers) may also be used to limit pedestrians from crossing or dashing out unexpectedly. Parking should also be assessed with respect to this crash type since parking can obscure pedestrians.

Motorist Failed to Yield was 12th on the list, and as with Pedestrian Failed to Yield and Dashes involves motorists traveling straight through at either intersections or mid-block locations and

striking a pedestrian is crossing the road. However, in these cases, the pedestrian appeared to have right-of-way. Most of these types (75%) occurred at intersections, whereas a majority of Pedestrian Failed to Yield occurred at midblock locations.

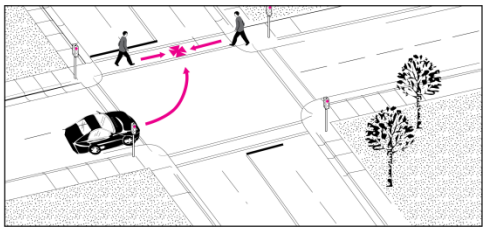
Potential countermeasures. Many of the ***countermeasures*** for Motorist Failed to Yield are similar to those for the foregoing crash types, regardless of whether the motorist or pedestrian had legal right-of-way. Measures should aim to provide safe locations and times for pedestrians to cross separated from conflicts (such as through traffic control signals or pedestrian hybrid beacons) with motor vehicles, and to encourage pedestrians to use these locations, and for both types of users to follow rules of the road. Treatments to ensure adequate sight distance and visibility between pedestrians and motorists and shorten crossing distance such as through bulb-outs or curb extensions, median islands, or lane reductions, and raised crosswalks, along with enhanced lighting could be considered. Measures should minimize the chance of harm by providing sufficient crossing opportunities, encouraging safe speeds, and appropriate level of separation for the road type, speed and volume of users present.

Walking Along Roadway With Traffic - From Behind (#3 in list), involves, not surprisingly, pedestrians walking along an edge or shoulder of a roadway with their backs to traffic - which typically occurs in locations lacking sidewalks. These types of collisions also often occur at night. Accidents involving pedestrians **Walking Along Roadway Against Traffic – From Front** occur less frequently but are still the 11th most frequent crash type.



Potential Countermeasures. Primary countermeasures for walking along or in the roadway crashes (either direction) are to provide space for pedestrians to walk separated from the vehicle trafficway, either sidewalks, separated paths, or wide shoulders, depending on the area type, speed of traffic, and other conditions present. Consider the need for lighting such as paths junctions with roadways, recreational areas, or other areas with frequent nighttime pedestrian activity. Pedestrians who must walk in areas with no separated facilities should also be reminded about the importance of being conspicuous at night, and to walk facing traffic and move off the roadway when vehicles approach. Active lighting and reflective gear and clothing are much more effective than white or light-colored clothing for helping pedestrians to be seen by motorists, but these measures may be insufficient in attracting attention of motorists, and suffer limitations if speeds are high and sight distances are short (at curves, etc.).

Another frequently occurring crash type involves **Motorists** making **Left Turns** and striking **Parallel Path** pedestrians (#6 in list). Crashes involving turning motorists occur at both intersections and at driveways or other junctions where pedestrians may be struck while crossing an intersecting road or



driveway. Over the entire State, 78 percent of these crashes occurred at intersections, however. Pedestrians typically have the right-of-way at both driveways and intersections unless they are crossing against a signal.

Potential Countermeasures. *Countermeasures* for crashes involving turning vehicles include providing leading pedestrian intervals (LPI) or providing a fully protected left turn phase separate from the pedestrian walk phase at signalized locations. Other potential remedies include roundabout intersection design, narrowing curb radii and realigning skewed intersections or driveways to slow turning vehicles, enhanced crosswalk markings, sidewalk level driveway crossings at driveways, and sign improvements (Yield to Pedestrians when Turning; time-based turning restrictions). Median refuge islands may also help to slow turns and provide refuge space for pedestrians during their crossing. Median barriers on the main road to restrict turning movements could be considered for some situations. Law enforcement and motorist education, as with many crash types, may also be needed.

Motorist Loss of Control (#7 in list) involves motorists losing control of their vehicle due to drugs/ alcohol, surface irregularities, too high speed, or other factors. This crash type often results in the vehicle departing the regular trafficway lanes and may include a road departure that results in a pedestrian walking next to the roadway (on a sidewalk or shoulder) being struck. Turning errors resulting in the motorist turning into the wrong lane is its own crash type and would not be included here, unless there were clear indications that the motorist lost control of the vehicle.

Potential Countermeasures. Enforcement of speed, alcohol and reckless or distracted driving laws, are important countermeasures in addition to roadway designs that help to control operating speeds. In urban areas, wider buffers, street trees, and other design elements (such as constructed bollards) between the travel lanes and pedestrian walkways may help to buffer pedestrians from this type of crash.

Another unusual crash type includes **Vehicle-Vehicle or Vehicle-Object** (8th in list). This describes situations in which the pedestrian is struck as the result of a vehicle first striking another vehicle or an object (and includes some crashes involving motorists crashing into buildings. It is debatable whether such incidents should be counted as pedestrian crashes.). Pedestrians standing near the scene of a prior crash may also be struck by a secondary impact, or by an impact to one of the disabled vehicles at the scene of a prior crash; however this type is coded as **Disabled Vehicle-Related.**

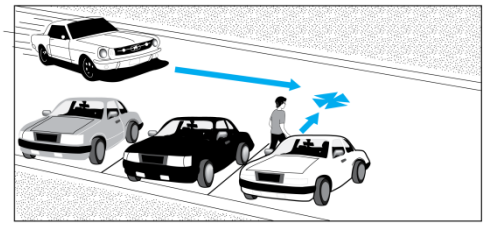
Potential Countermeasures. Apart from educating drivers to slow and pull over to give space and educating responders who work or stand near crash scenes, there may be few measures to address these types of crashes. Walkways that are buffered from traffic, pull-off areas and shoulders could help. In general, buffers between the travel way and pedestrian areas, and good roadside / facility design for the type and speed of roadway may help to minimize both the primary impacts and secondary impacts resulting from prior collisions and/or objects.

Temporary cones or markers and emergency traffic controls may help to protect emergency responders working near crash scenes.

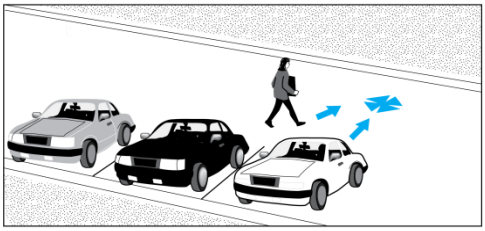
Walking in Roadway (#9 in the list) is a crash type that encompasses cases for which it was not evident whether the pedestrian was walking along the road, intending to cross the road, or otherwise just walking in the roadway. Providing facilities similar to those for Walking Along Roadway may be of assistance, as can providing enhanced crossing facilities, depending on the circumstances present.

Additionally, there are a significant number of **Dispute-Related** crashes (10th on list). This crash type occurs when a pedestrian is hit by a vehicle during a domestic alteration or other dispute (often in parking lots or streets at night) and contact with the pedestrian was apparently unintentional. The pedestrian does not need to be a party to the dispute.

Potential Countermeasures. Countermeasures for dispute-related or outright assaults with vehicles are somewhat outside the typical traffic and roadway safety domain, and may involve victims not typically thought of as pedestrians. Countermeasures may involve law enforcement, parking lot security measures and enhanced lighting. Education in anger management may be the only way to prevent a domestic dispute from escalating. Additionally, a prompt call to police if a dispute has escalated can lower the chances of such a crash occurring.



A significant proportion of crashes occurred off the street and highway network. The second and fourth most frequent crash types involving pedestrians occurred in **Off-Roadway** locations including **Parking Lots** (#2) or involved **Backing Vehicles** in **Parking Lots** (#4).
These two crash types combined accounted for 19 percent of reported pedestrian crashes statewide. There are likely to be far more of these types of collisions that were unreported.



Potential Countermeasures. Although many treatments are again, not typically within the purview of roadway authorities, they may be under more control of local planning boards and design commissions. Parking lot design and design of pedestrian access to buildings from parking areas and from the street may improve conditions for pedestrians in off-road areas. Especially consider providing walkways that can help reduce the incidence of pedestrians walking behind parked vehicles, and consider driveway designs that minimize conflicts between pedestrians accessing the building and cars traveling through. Lighting, driver and pedestrian education, and other measures may also be appropriate. Event planners should also provide guidance in how to set up safe temporary parking facilities.

Many other crash types accounted for relatively small numbers of the overall crash problem. However, some of the other types may be amenable to treatment and each jurisdiction should

consider the specific types of crashes and conflicts prevalent within the jurisdiction. In addition, a number of the individual crash types may benefit from the same or similar types of treatments as those described here. There may be a need for enhanced enforcement and education as well as design and other roadway improvements.

More discussion on potential countermeasures is provided in the next section.

Pedestrian Age Group and Crash Group Involvement

As might be expected, adults of different ages and children tend to be more involved in different types of crashes, often at different types of locations. A summary of key trends for all five years is shown in
Table 5 in the Appendix. The summary information provided below draws on findings shown in Table 5, which uses data for related crash types combined into crash type groups (a variable also provided through PBCAT crash typing), and the interaction with pedestrian age groups. Among the more predominant crash types, age-related trends are as follows:

- **Backing vehicle** –Young children (those 5 and under), and older adults (61 and over) are most involved in this type of crash, compared to all other ages. Backing vehicle crashes accounted for 19 percent of age five and under reported crashes, 20 percent of older adults' crashes, but 11 percent over all ages. Both very young and older pedestrians can be vulnerable to serious injury in this crash type.
- **Off Roadway** – Young children and older adults are also the most over-represented in Off Roadway crashes in general, including crashes in driveways and parking lots (when the vehicle is not backing). This group accounts for 28 percent of age 5 and under crashes and 18 percent of aged 61 and older crashes, compared with about 13 percent of crashes overall.
- **Pedestrian Dart-out or Dash** – Children under age 16 are highly over-represented in this crash type, which accounts for 28 percent the crashes among those 5 and under, 35 percent for those 6 to 10, and 22 percent for those 11 to 15. Even those 16 to 20 (10 percent of their crashes) are more highly involved in this type compared to all ages (8 percent for all ages).
- **Crossing Roadway – Vehicle Turning** – Older adults are somewhat over-represented in this crash type, possibly because older adults more often cross in crosswalks at intersections than other ages.
- **Walking along Roadway** – Youth and young adults tend to be more involved in these types which account for 16 percent of crashes among those 16 to 20 and 14 percent of those 21 to 30 compared to 11 percent for all ages.
- **Unusual circumstances** – Adults of all ages, but particularly those from about 21 to 30 years are most involved in this group of crashes (about 21 percent of their crashes are these types). These include such circumstances as assault with vehicle, dispute-related crashes, pedestrians on or clinging to a vehicle that began moving, the result of vehicle striking vehicle or vehicle striking object crashes, and vehicles leaving the road and striking pedestrians on a sidewalk or off-road area, as well as collisions involving emergency vehicles, vehicles without drivers and others. This age group is also most involved in crashes where they were in the roadway, but other circumstances are unknown.

Potential Countermeasures. Educating youngsters about how to walk safely should start at an early age and continue throughout the school years, with caregivers providing frequent opportunities to practice together and talk about choices. Education and enforcement of speed laws and motorist yielding at crosswalks are other potentially useful countermeasures to address identified problems. Some of these countermeasure types have already been described under the specific crash types discussion.

However, the most important measure for the youngest ages of pedestrians is supervision. Young children should be closely supervised by parents and other caregivers, and taught about hazards of being or playing around, on or in any motor vehicle, even those that seem parked. New technologies such as vehicle backup cameras and others may also help to reduce the incidence of these types of crashes.

In order to develop countermeasures for particular locations, crash and other data specific to those locations needs to be examined. A comprehensive diagnosis that includes field investigations is also needed to fully assess the problems before any treatments are selected or implemented (Nabors et al., 2007).

See the NC Pedestrian Crash Facts summary report for more information on pedestrian crash characteristics and associated environmental and roadway crash factors.

High Frequency Crash Scenarios

Increasingly, states and local jurisdictions are seeking ways to be more proactive in addressing bicycle and pedestrian safety issues. It may help to identify common crash scenarios that might be addressed by implementing treatments or designs at many locations that can help prevent these types of crashes in the future. A systemic safety process seeks to identify common or focus crash types, and to treat locations that have characteristics that have been associated with common types across the network. This approach can complement a 'hotspot' approach that seeks to treat locations where crashes have already occurred. See Appendix B for a summary and a tree diagram that illustrates this approach to begin identification of focus crash types in combination with crash location characteristics. The tree analysis identified most common crash location and crash type scenarios for North Carolina as a whole. Note, however, that these scenarios do not account for exposure – that is the extent of these conditions, and the amounts of walking that occur under these different conditions.

Further analysis at local or regional levels of these or other high crash scenarios could be used to help identify specific roadway, built environment, and population characteristics associated with these common scenarios in order to identify potential treatment targets and countermeasures.

Additional Resources

For complete crash type definitions, see the PBCAT Manual, Images and Tech Support Information. More information on crash types and engineering countermeasures is available from PEDSAFE, and *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* (Blackburn, Zegeer & Brookshire 2017) developed for the U.S Department of Transportation, Federal Highway Administration. In addition, see *North Carolina Pedestrian Crossing Guidance* (Schroeder, O'Brien & Findley (2015) and the associated decision flow chart.
For designing facilities, see the North Carolina Department of Transportation's *Complete Streets Planning and Design Guidelines*, and the *Guide for the Development of Bicycle Facilities* available from AASHTO, and the NACTO Urban Bikeway Design Guide. Another resource is the Crash Modification Factors Clearinghouse, which provides estimates of expected crash reductions for various treatments. For assistance with safety planning and assessment see *How to Develop a Pedestrian and Bicycle Safety Action Plan* (Gelinne et al. 2017).

More information on behavioral countermeasures is available in *Countermeasures That Work* (Goodwin et al. 2013). *Advancing pedestrian and bicyclist safety: A primer for highway safety professionals* describes common pedestrian and bicycle safety challenges and comprehensive approaches to addressing pedestrian safety (Brookshire et al. 2016). For

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Appendix A – Crash Type Group by Pedestrian Age Group

Table 5 Crash type (group) involvement by age group of pedestrians, 2011-2015

Crash Type by Pedestrian Age Group	0-5	6 to 10	11 to 15	16-20	21 - 30	31 to 60	61 +	Total
Backing Vehicle	19.0%	4.9%	3.3%	6.8%	8.9%	11.1%	19.6%	10.7%
Bus-Related	1.3%	8.1%	4.8%	1.0%	0.3%	0.2%	0.2%	0.8%
Crossing Driveway or Alley	0.8%	0.0%	1.1%	2.1%	2.4%	2.4%	2.9%	2.2%
Crossing Expressway	0.0%	0.0%	0.5%	0.3%	0.9%	0.9%	0.6%	0.7%
Crossing Roadway - Vehicle Not Turning	7.7%	11.0%	19.6%	18.1%	13.5%	16.8%	15.7%	15.8%
Crossing Roadway - Vehicle Turning	2.4%	2.9%	5.9%	9.0%	10.2%	10.8%	13.9%	10.0%
Dash / Dart-Out	28.2%	34.5%	21.8%	10.3%	5.6%	4.1%	1.8%	7.5%
Multiple Threat / Trapped	0.0%	1.6%	1.6%	1.9%	0.8%	0.6%	0.6%	0.9%
Off Roadway	27.7%	14.1%	8.0%	7.9%	10.5%	12.8%	17.6%	12.5%
Other / Unknown - Insufficient Details	1.1%	0.7%	1.1%	1.6%	1.9%	1.4%	1.3%	1.5%
Pedestrian in Roadway - Circumstances Unknown	1.1%	2.9%	5.5%	5.4%	7.7%	6.3%	4.0%	5.9%
Unique Midblock	0.8%	1.8%	0.5%	0.4%	0.4%	0.6%	0.9%	0.6%
Unusual Circumstances	7.7%	13.0%	13.2%	19.1%	21.0%	18.0%	15.5%	17.8%
Waiting to Cross	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%
Walking Along Roadway	0.8%	2.0%	11.6%	15.7%	14.3%	11.9%	4.5%	11.4%
Working or Playing in Roadway	1.6%	2.5%	1.4%	0.6%	1.5%	2.1%	0.8%	1.6%
Note that Unknown ages were omitted for presentation.								

Appendix B – Tree Diagram of High Frequency North Carolina Pedestrian-Motor Vehicle Crash Scenarios

Figure 14 is a tree diagram of pedestrian crashes divided by Rural and Urban locations. The purpose of this diagram is to highlight the most common combinations of pedestrian crash factors to aid targeting of potential further efforts to reduce these crashes. Rural locations are defined here as areas which are outside of Municipal limits and some crashes in this group may be in areas of mixed development (i.e. between 30 percent and 70 percent developed) or even urban development (for example, a subdivision outside of Municipal limits). Similarly, some areas designated as urban by virtue of being within municipal boundaries, may not be very developed. The data used reflect crashes which could be geolocated and mapped on the NCDOT Bicyclist and Pedestrian Crash Map. Relatively few crashes lacked adequate information to be located to at least the appropriate section of roadway or nearest intersection. Crash types were derived through coding using PBCAT software, as described in the main text.

Predominant rural pedestrian-motor vehicle crash scenarios. A little more than one-fifth (20.1%) of crashes took place outside of Municipal limits over the five years. Among these rural crashes, 70 percent occurred at **non-intersection locations**, which are defined here as areas greater than 50 feet from an intersection. Roadway configuration is an important design consideration for mid-block crashes, especially in rural areas where speed limits are higher and roadways are less likely to have lighting. A large majority (85%) of these rural non-intersection crashes occurred along two-lane, undivided roadways with 25 percent of these crashes resulting in fatal or disabling injury for a pedestrian.

The most common crash type on these two-lane rural roads was *pedestrian was walking along the roadway*, typically along an edge or shoulder of a roadway. These crashes accounted for 37 percent of collisions on rural, two-lane roads at non-intersection locations. Another 11 percent involved pedestrians *walking in the roadway*. Potential countermeasures for these crashes include providing space for pedestrians to walk separated from the vehicle traffic way (such as a paved shoulder, path, or sidewalk), and to provide lighting in areas with frequent nighttime pedestrian activity.

Intersection and Intersection-Related crashes accounted for only 11percent of rural pedestrian-motor vehicle collisions with the most common intersection traffic control being a double yellow line indicating a no passing zone (39% of such crashes). These crashes are often in areas where the main road has no traffic control with a side street having traffic control. Non-roadway crashes were 18 percent of the rural total with 71 percent occurring in parking lots and 29 percent along a driveway or alley; a backing vehicle was involved 31percent of the time.

Predominant urban pedestrian-motor vehicle crash scenarios. Close to four-fifths (80%) of crashes occurred within Municipal limits. Intersection and intersection-related crashes accounted for 32 percent of Municipal collisions. The most common intersection traffic control was a stop and go signal (44% of these intersection crashes; 32% of these involved a motorist

making a left turn and striking a pedestrian travelling in a parallel path). Potential countermeasures for this situation include providing leading pedestrian intervals or a fully protected left turn phase separate from the pedestrian walk phase (requires left turn lanes), enhanced crosswalk markings, sign improvements, and redesigning an intersection into a roundabout.

When considering non-intersection crashes, the most prevalent road configuration again was two-way, not divided (69% of municipal, non-intersection collisions with two-lane roadways being 65% of this configuration). As found in rural scenarios, walking along the roadway was the most prevalent crash type accounting for 25 percent of two-lane, two-way, not divided roadway collisions. Thirty-two percent of municipal crashes occurred off the roadway network, with a clear majority (92%) of non-roadway crashes taking place in parking lots. Backing vehicle crashes accounted for 32 percent of these non-roadway collisions.

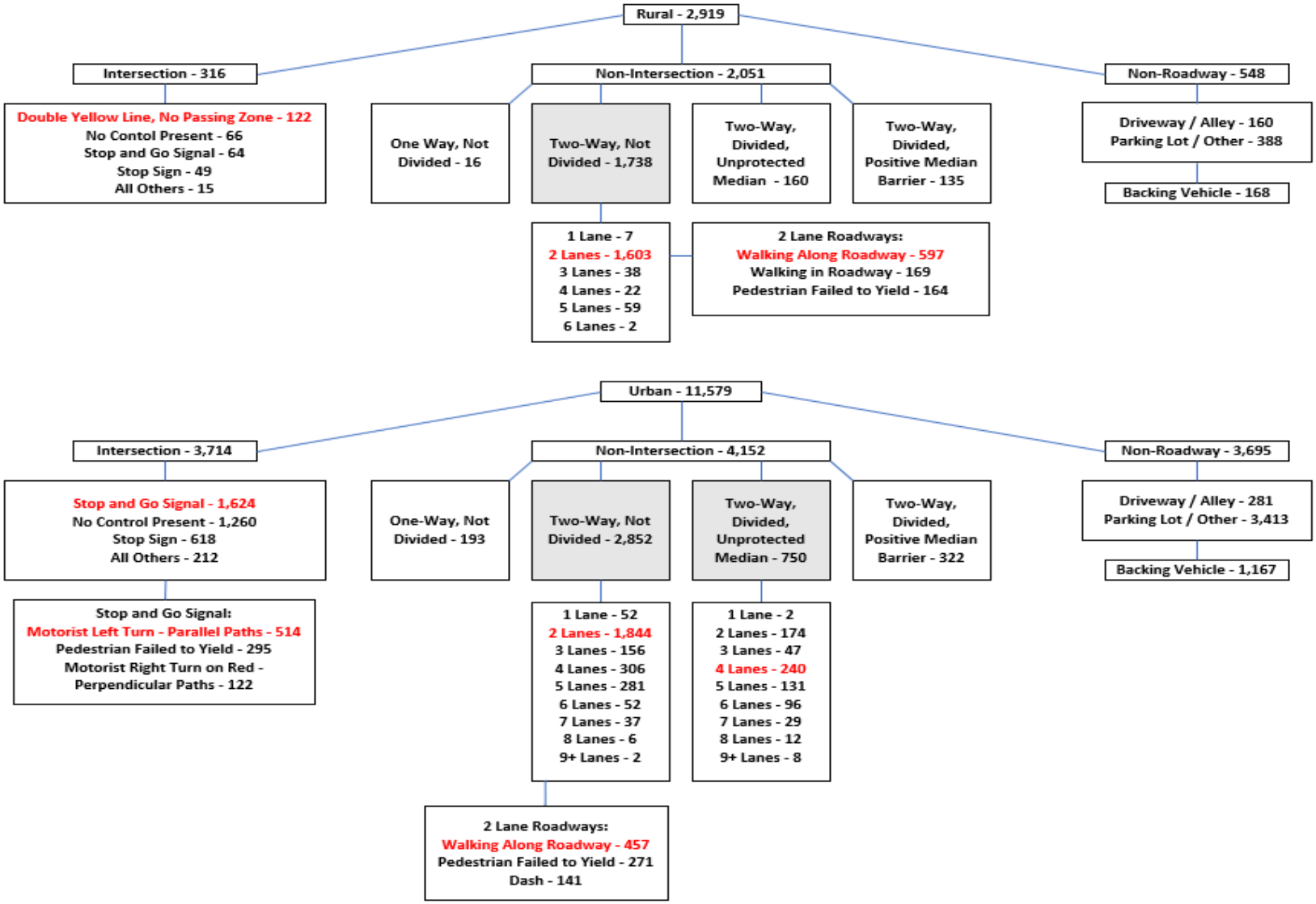

Figure 3 Tree diagram of rural and municipal crashes
Red font indicates common scenarios that might be a focus for a systemic approach to pedestrian safety.