North Carolina
Pedestrian Crash Types
2012 - 2016

Prepared for

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

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

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December 2018

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Introduction and Purpose

A total of 14,993 collisions between pedestrians and motor vehicles were reported in North Carolina over the five-year period of 2012 to 2016. A total of 929 crashes led to a pedestrian fatality with another 990 resulting in disabling injury.[1] See the companion *North Carolina Pedestrian Crash Facts* report for a summary of pedestrian injuries and fatalities and related crash factors.

This report summarizes pedestrian-motor vehicle crash types that were developed for 2012-2016 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 tables and text in the following sections.

The report provides information on common crash groups across the state and suggests potential countermeasures that might be appropriate to help reduce these crashes. Local agencies can use this information 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 *North Carolina Pedestrian Crash Facts* summary report.

Background on Crash Typing

The information from the State crash report forms (DMV-349) and reported by public safety officials 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.).

However, the data contained in the crash database provides little information about the actual sequence of events leading to crashes between pedestrians and motor vehicles. The development of effective countermeasures to help prevent and reduce the severity of these crashes is limited by this lack of detail on events that led up to crashes. To address this type of 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 2006 in a project sponsored by the Federal Highway Administration (FHWA). For more information on PBCAT and crash typing, including detailed descriptions and images of typical crash scenarios, see the PBCAT webpage. PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System, also sponsored by FHWA, is a companion tool that helps to identify potentially appropriate countermeasures for the types of crashes and other problems identified by analyzing data from PBCAT and state crash files. Other

[1] These numbers reflect crashes that involved one or more fatalities or disabling injuries and does not capture if more than one pedestrian was struck and killed or injured.

FHWA tools that can assist with diagnosing problems are the North Carolina Pedestrian and Bicycle Road Safety Assessment Guide (Thomas et al. 2018) and FHWA's Pedestrian Road Safety Audit Guidelines and Prompt Lists (Nabors et al. 2007) . More resources are mentioned in the final section of this report, and in the crash facts summary report.

Crash Events and Description

This report examines crash groups instead of the more specific crash types (which are available for querying on this website). Some police reports are not detailed enough to arrive at a crash type (for example, being unclear as to a motorist's or pedestrian's actions in a walking along roadway crash) leaving a coder to select "other/unknown." In previous years, it was also discovered that some crash types have very few cases (are rare). In turn, this situation can make it more difficult to identify the most prevalent patterns and associated crash factors that provide substantial targets for treatment. Additionally, countermeasures can be developed based on these broader crash groups, which consolidate several specific types.

Crash Group

Table 1 shows a listing of 16 crash groups generated by the coding for each of the five years, with their totals and percentages organized by prevalence.

The names are reasonably self-explanatory, but more details as to the meaning of each crash group, and the more specific crash types associated with each group, are available on the software web page, in the manual that accompanies the software.

There is some year-to-year variability in the frequencies and proportions of each crash group, especially those with smaller numbers. Much of this variation is likely explained by chance, but some variation is potentially attributable to changes in behaviors including effects of roadway treatments or education and enforcement measures. Also, numbers in some categories may vary somewhat year to year due to different interpretations of crash reports or different levels of information available.

Table 1 Pedestrian crash groups by year

Crash group	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Unusual Circumstances	577	499	567	479	548	2,670
	19.3%[1]	18.1%	19.0%	15.7%	17.2%	17.8%[2]
Crossing Roadway – Vehicle Not Turning	536	442	392	456	465	2,291
	17.9%	16.0%	13.1%	14.9%	14.6%	15.3%
Off Roadway	353	339	366	379	407	1,844
	11.8%	12.3%	12.2%	12.4%	12.8%	12.3%
Walking Along Roadway	321	308	342	421	414	1,806
	10.7%	11.2%	11.4%	13.8%	13.0%	12.0%
Crossing Roadway – Vehicle Turning	253	258	340	397	383	1,631
	8.4%	9.3%	11.4%	13.8%	13.0%	10.9%
Backing Vehicle	302	309	311	321	360	1,603
	10.1%	11.2%	10.4%	10.5%	11.3%	10.7%
Dash / Dart-Out	177	187	277	256	254	1,151
	5.9%	6.8%	9.3%	8.4%	8.0%	7.7%
Pedestrian in Roadway – Circumstances Unknown	217	198	154	96	123	788
	7.2%	7.2%	5.2%	3.1%	3.9%	5.3%
Crossing Driveway or Alley	65	60	73	67	62	327
	2.2%	2.2%	2.4%	2.2%	1.9%	2.2%
Working or Playing in Roadway	47	47	49	40	61	244
	1.6%	1.7%	1.6%	1.3%	1.9%	1.6%
Other / Unknown – Insufficient Details	43	31	34	65	47	220
	1.4%	1.1%	1.1%	2.1%	1.5%	1.5%
Multiple Threat / Trapped	28	20	24	32	22	126
	0.9%	0.7%	0.8%	1.0%	0.7%	0.8%
Bus-Related	26	32	22	14	18	112
	0.9%	1.2%	0.7%	0.4%	0.6%	0.7%
Unique Midblock	21	9	22	17	16	85
	0.7%	0.3%	0.7%	0.6%	0.5%	0.6%
Crossing Expressway	28	20	13	13	10	84
	0.9%	0.7%	0.4%	0.4%	0.3%	0.6%
Waiting to Cross	3	2	3	1	2	11
	0.1%	0.1%	0.1%	0.0%	0.1%	0.1%
Total	2,997	2,761	2,989	3,054	3,192	14,993
	20.0%[3]	18.4%	19.9%	20.4%	21.3%	

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

The remaining analyses focuses on those crashes that occurred on the roadway system (and excludes those where the crash location was indicated to be 'non-roadway'). Although important to consider parking lot and driveway design with respect to non-roadway crashes, lighting and education, the remainder of this report focuses on roadways that are under the purview of state and local transportation system providers.

Crash Group and Severity

Table 2 presents statistics for reported injury status of the (first) pedestrian involved in roadway-related crashes. Over all roadway-related pedestrian crashes, 8 percent involved a fatally injured pedestrian, and nearly another 8 percent were indicated to receive disabling type injuries (Table 2, bottom row). (Note that the definition of A-type injury in the KABCO classification changed during 2016, but this change was phased in toward the end of the year.)

Crossing Roadway - Vehicle Not Turning types of crashes accounts for the largest percentage of roadway crashes over all (22%), and nearly one-third (31%) of all those where a pedestrian received fatal or disabling (A-type) injuries making it the most injurious type of crash in North Carolina.

Table 2 Crash group and pedestrian injury severity (reported status of injury) - roadway crashes

Crash Group	Fatal Injury	Disabling Injury	Fatal + Disabling Injury	Other/ Unknown Injury	Total
Crossing Roadway - Vehicle Not Turning	288	245	533	1758	2,291
	33.0%	29.8%	31.4%	19.7%	21.6%
Walking Along Roadway	128	116	244	1,562	1,806
	14.6%	14.1%	14.4%	17.5%	17.0%
Crossing Roadway - Vehicle Turning	15	33	48	1583	1,631
	1.7%	4.0%	2.8%	17.7%	15.4%
Unusual Circumstances	117	144	261	1269	1,530
	13.4%	17.5%	15.4%	14.2%	14.4%
Dash / Dart-Out	73	116	189	962	1,151
	8.4%	14.1%	11.1%	10.8%	10.8%
Pedestrian in Roadway - Circumstances Unknown	166	94	260	528	788
	19.0%	11.4%	15.3%	5.9%	7.4%
Crossing Driveway or Alley	0	3	3	324	327
	0.0%	0.4%	0.2%	3.6%	3.1%
Working or Playing in Roadway	9	11	20	224	244
	1.0%	1.3%	1.2%	2.5%	2.3%
Backing Vehicle	4	9	13	203	216
	0.5%	1.1%	0.8%	2.3%	2.0%
Multiple Threat / Trapped	3	8	11	115	126
	0.3%	1.0%	0.6%	1.3%	1.2%
Bus-Related	7	11	18	94	112
	0.8%	1.3%	1.1%	1.1%	1.1%
Unique Midblock	5	5	10	75	85
	0.6%	0.6%	0.6%	0.8%	0.8%
Crossing Expressway	32	10	42	42	84
	3.7%	1.2%	2.5%	0.5%	0.8%
Waiting to Cross	1	1	2	9	11
	0.1%	0.1%	0.1%	0.1%	0.1%
Other / Unknown - Insufficient Details	26	17	43	177	220
	3.0%	2.1%	2.5%	2.0%	2.1%
Total	874	823	1,697	8,925	10,622
	8.2%	7.7%	16.0%	84.0%	100.0%

Roadway Location and Rural or Urban Setting

The injury severity trends of different types of crashes are affected by a combination of factors including where these crashes typically occur. For example, as can best be determined from reviews of individual crash reports, pedestrians overall are most often (62%) in a regular travel lane, not in a crosswalk area (17%), intersection (3%), or other type of location (driveway crossing, paved shoulder) when struck (Table 3). When the pedestrian was killed or received disabling type injuries in the crash, 80 percent were in a regular travel lane, not in a crosswalk area, or other facility type.

Table 3 Position of pedestrian when struck and pedestrian injury status - roadway crashes

Pedestrian Position when Struck	Pedestrian Killed or Disabling Injury	Evident, Possible, No, or Unknown Injury	Total
Travel Lane	1,350	5,242	6,592
	79.6%	58.8%	62.2%
Crosswalk Area	100	1,651	1,751
	5.9%	18.5%	16.5%
Intersection Proper	58	244	302
	3.4%	2.7%	2.8%
Paved Shoulder / Bike Lane / Parking Lane	83	638	721
	4.9%	7.2%	6.8%
Sidewalk / Shared Use Path / Driveway Crossing	23	452	475
	1.4%	5.1%	4.5%
Unpaved Right-of-Way	47	407	454
	2.8%	4.6%	4.3%
Other / Unknown	36	274	310
	2.1%	3.1%	2.9%
Total	1,697	8,908	10,605
	16.0%	84.0%	

Highlights indicate pedestrian positions with a greater proportion of fatal and disabling injuries compared to overall representation in total crashes.

Whether a crash occurs at an intersection or non-intersection location is also associated with pedestrian injury severity. Overall, nearly 60 percent of crashes involved pedestrians struck at non-intersection (and not intersection-related) locations, but among those where pedestrians were killed or received disabling injuries, the proportion was 74 percent (Table 4). Intersection-related indicates a crash that occurred within 50 feet of an intersection. A non-intersection crash could involve a pedestrian crossing or in the roadway at a midblock location, or a pedestrian struck at a driveway not controlled by a signal. Pedestrians may be less anticipated by motorists when crossing at a location not associated with an intersection, there may be no crosswalk markings or other facilities or lighting enhancements, and motorists may not be slowing in anticipation of turns or stopping for traffic controls. Nighttime, as shown in the crash facts report, can multiply these issues.

Table 4 Crash location and pedestrian injury status - roadway crashes

Crash Location	Pedestrian Killed or Disabling Injury	Evident, Possible, No, or Unknown Injury	Total
Intersection	249	2,570	2,819
	14.7% [1]	28.9%	26.6%
Intersection-Related	186	1,295	1,481
	11.0%	14.5%	14.0%
Non-Intersection	1,262	5,043	6,305
	74.4%	56.6%	59.5%
Total	1,697	8,908	10,605
	16.0%	84.0%	100.0%

Rural areas account for 28 percent and urban areas 72 percent of roadway-related crashes across the State (Table 5). However, rural areas account for a relatively larger percentage — 45 percent — of fatal and disabling injury crashes, and urban areas 55 percent. (Urban is defined here, as being within municipal boundaries and does not always reflect differences in development intensity but is a useful approximation.)

Table 5 Rural/Urban setting and pedestrian injury status - roadway crashes

Rural/Urban Setting	Pedestrian Killed or Disabling Injury	Evident, Possible, No, or Unknown Injury	Total
Rural	764	2175	2,939
	45.0% [1]	24.4%	27.7%
Urban	933	6733	7,666
	55.0%	75.6%	72.3%
Total	1,697	8,908	10,605
	16.0% [2]	84.0%	

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

Table 6 shows the frequency of the different groups of pedestrian-motor vehicle crashes by the crash location type within urban or rural settings and highlights the top most frequent combinations that may offer the largest treatment targets. Other types may be locally important. (Percentages are not shown in this table to limit the size of the table.) As mentioned above, certain patterns emerge, and some of these factors may be associated with likelihood of severe injuries when pedestrians are struck. While almost any type of crash may find exceptions, certain types, such as pedestrians who were struck while ***Crossing a Driveway or Alley*** or ***Waiting to Cross*** are rare in rural areas. On the other hand, ***Walking Along Roadway*** occurs more frequently in rural areas (outside of municipalities), despite there being more pedestrians in urban areas. This is likely because of a lack of sidewalks or other space to walk along most rural roads, a lack of lighting and other reasons.

Along with being the most common crash type over all, and the most common type involving serious injuries to the pedestrian as presented previously, ***Crossing Roadway - Vehicle Not Turning*** is the most common group of crashes in urban areas of North Carolina (24% of all urban area roadway crashes) (Table 6). These crashes involve pedestrians crossing a roadway being struck by a through (not turning) motor vehicle and may involve failure to yield by either the motorist or the pedestrian (Figure 1). Although they occur at all types of locations, the largest number (nearly 40% of all) of these occur, in urban areas at non-intersection locations. ***Dash / Dart-Out*** types of crashes also occur most often in urban areas at non-intersection locations and could be investigated along with other ***Crossing Roadway - Vehicle Not Turning*** types.

The second most frequent type (nearly 20%) in urban areas is ***Crossing Roadway – Vehicle Turning***. The largest proportion of these types of crashes, which involve motorists turning right or left across the path of a pedestrian, occur at urban intersections. Others may occur at driveways or other non-intersection access points. Information on intersection strategies, such as providing Leading Pedestrian Intervals at signalized locations, and others, may help to address crashes involving motorists turning across the path of pedestrians at intersections. See the Additional Resources section for more information.

In rural areas, the most frequent type of crash (31% of those in rural areas) involves pedestrians ***Walking Along the Roadway*** (with or against traffic) being struck by a motorist approaching from the rear or the front. (See Figure 2 for an example of how this crash type may occur). These crashes most often happen at non-intersection locations, but can occur anywhere along a roadway.

Table 6 Pedestrian crash counts by crash group, urban/rural setting, and location type

	Rural				Urban			
Crash Group	**Inter-section**	**Intersection-Related**	**Non-Intersection**	**Rural Total**	**Inter-section**	**Intersection-Related**	**Non-Intersection**	**Urban Total**
Crossing Roadway - Vehicle Not Turning	77	52	302	431	581	364	915	1860
Walking Along Roadway	21	56	846	923	45	165	673	883
Crossing Roadway - Vehicle Turning	75	14	11	100	1273	158	100	1531
Unusual Circumstances	48	33	440	521	174	170	662	1006
Dash / Dart-Out	29	23	191	243	177	201	530	908
Pedestrian in Roadway - Circumstances Unknown	21	22	355	398	41	62	287	390
Crossing Driveway or Alley	3	0	11	14	18	8	287	313
Working or Playing in Roadway	12	4	76	92	31	40	81	152
Backing Vehicle	2	2	47	51	15	28	122	165
Other / Unknown - Insufficient Details	11	3	38	52	70	16	68	154
Multiple Threat / Trapped	5	0	5	10	47	19	50	116
Bus-Related	10	3	25	38	23	21	30	74
Unique Midblock	0	0	34	34	5	11	35	51
Crossing Expressway	0	0	31	31	0	0	53	53
Waiting to Cross	0	1	0	1	5	5	0	10
Total	314	213	2412	2939	2505	1268	3893	7666

Highlights indicate the most frequent combinations of rural/urban location and crash type (> 500 crashes).

Although comprising a large group overall, the ***Unusual Circumstances*** types are a blend of various specific circumstances such as vehicle loss of control or pedestrians being struck in secondary crashes (following vehicle into vehicle crashes) and other individually rather infrequent circumstances that may require very targeted types of approaches to address. Other crash groups tend to occur at much lower frequencies. More information on these lower frequency groups can be obtained by querying on crash types on the website query tool for the state, region, county, or city.

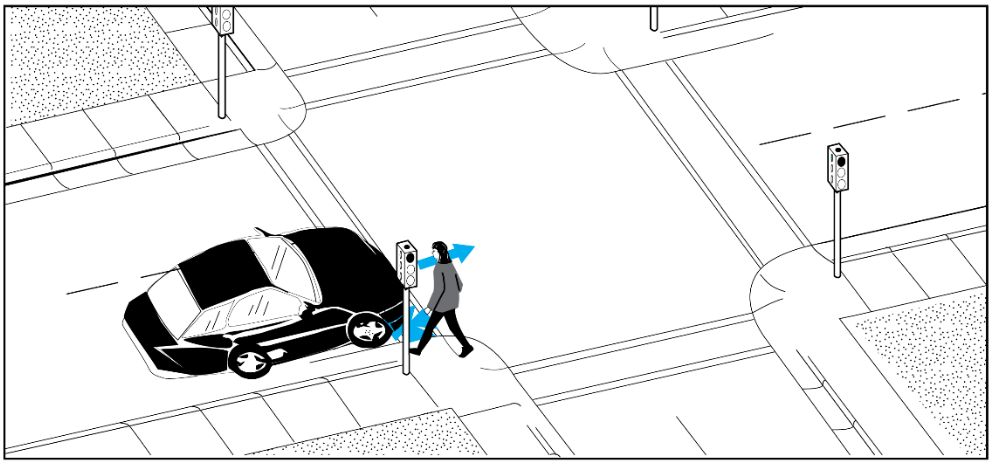


Figure 1 An example of a *Crossing Roadway – Vehicle Not Turning* crash

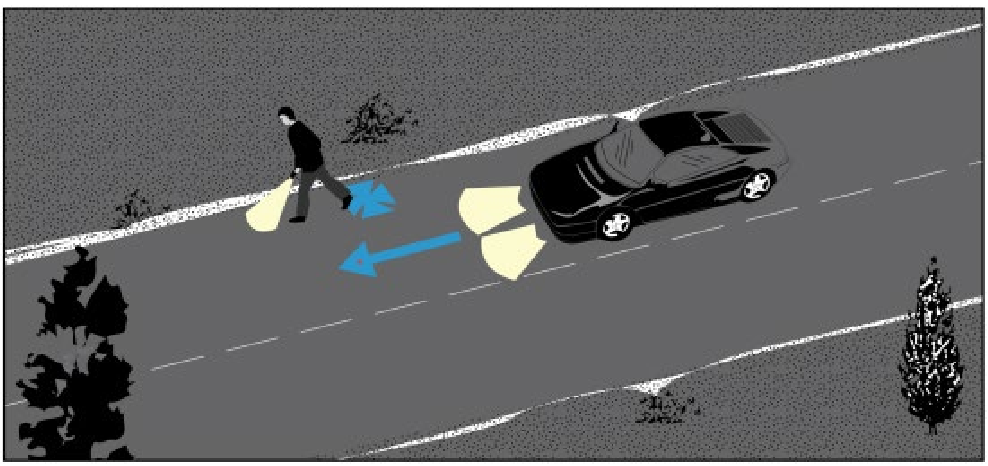


Figure 2 An example of a *Walking Along Roadway* crash

Walking Along Roadway is the most frequent rural crash group. A primary countermeasure for these crashes is to provide space for pedestrians to walk separated from the vehicle trafficway. These facilities could include 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 near path 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, to walk facing traffic, and move off the roadway when vehicles approach. (This may not be possible for pedestrians using wheelchairs.) 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 even these measures may be insufficient to attract attention of motorists in competition with on-coming headlights. There are also limitations in detection distance of pedestrian lighting if speeds are high and sight distances are short (such as near curves).

As mentioned, ***Crossing Roadway - Vehicle Not Turning*** is both the most frequent crash type overall and the most frequent type associated with fatal and disabling-type injuries, especially in urban areas. The next section focuses more attention on the factors associated with this type of crashes.

Pedestrian Crossing Roadway - Vehicle Not Turning Crash Group

This section focuses additional attention on the most frequent crash type, ***Pedestrian Crossing Roadway - Vehicle Not Turning*** (which accounts for 2,291 crashes from 2012-2016), and also results in the most fatalities and disabling type injuries (533 from 2012-2016) across North Carolina.

Figure 3 illustrates where the pedestrian was walking at the time struck. The chart on the left indicates that more than three-fourths (77%) of pedestrians were struck while in a regular traffic lane, but not at an intersection or in a crosswalk. The figure on the right shows that an even higher percentage of fatal and disabling injury pedestrian crashes occurred when the pedestrian was walking in a travel lane, outside of any distinct crossing area (84%). This situation, which places pedestrians where they are less apt to be expected by motorists, likely results from a mix of a lack of crossing facilities and poor choices of crossing location by some pedestrians.

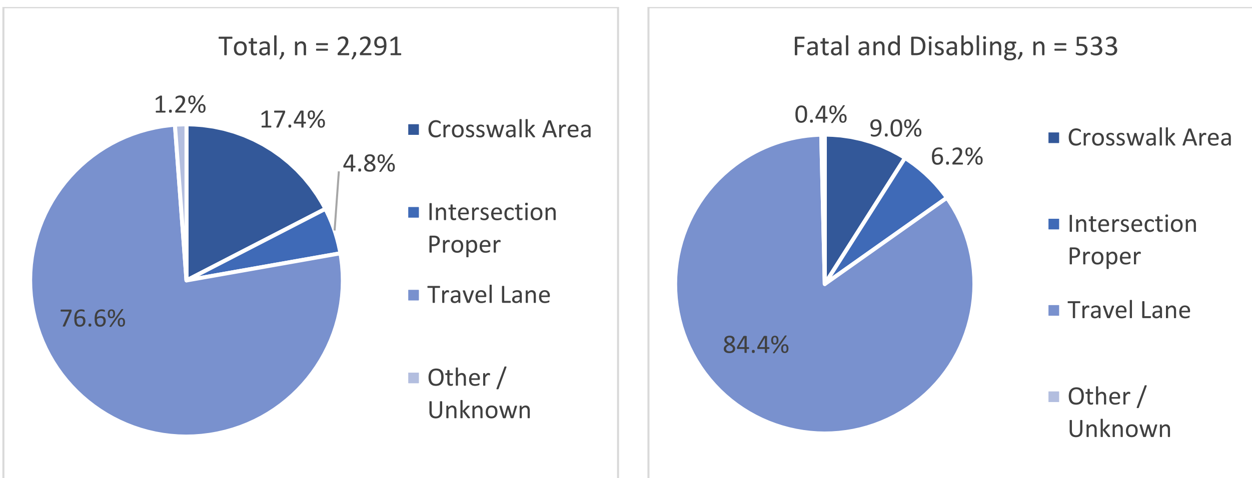


Figure 3 *Pedestrian Crossing Roadway - Vehicle Not Turning* by pedestrian position at time of crash

Figure 4 shows the traffic control that was present, if any, for this crash type. Over 64 percent of these crashes occurred where no traffic control was present. Where there was a traffic control, a stop and go signal is the most common control device.

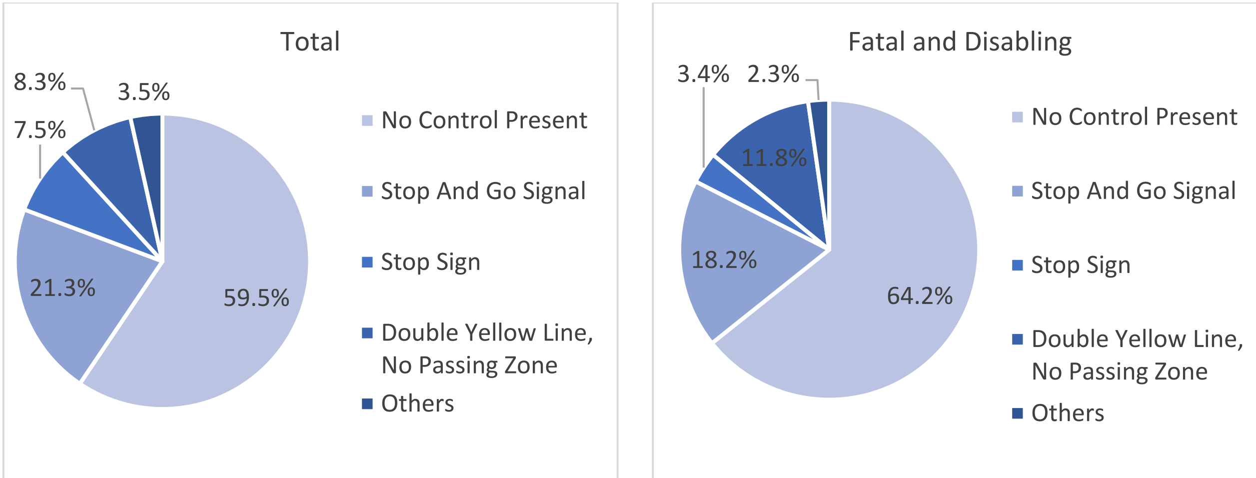


Figure 4 *Pedestrian Crossing Roadway - Vehicle Not Turning* by type of traffic control present at crash location

Figure 5 comparison shows that the speed limits of roads where this crash group most commonly occurs are from 30 - 35 mph (46%), followed by 40 - 45 mph (30%). However, among fatal and disabling injury crashes, higher speed limit roads were more prevalent. Roads of 40 - 45 mph account for 45 percent and roads of 50 to 55 mph, for another 17 percent for fatal and disabling types.

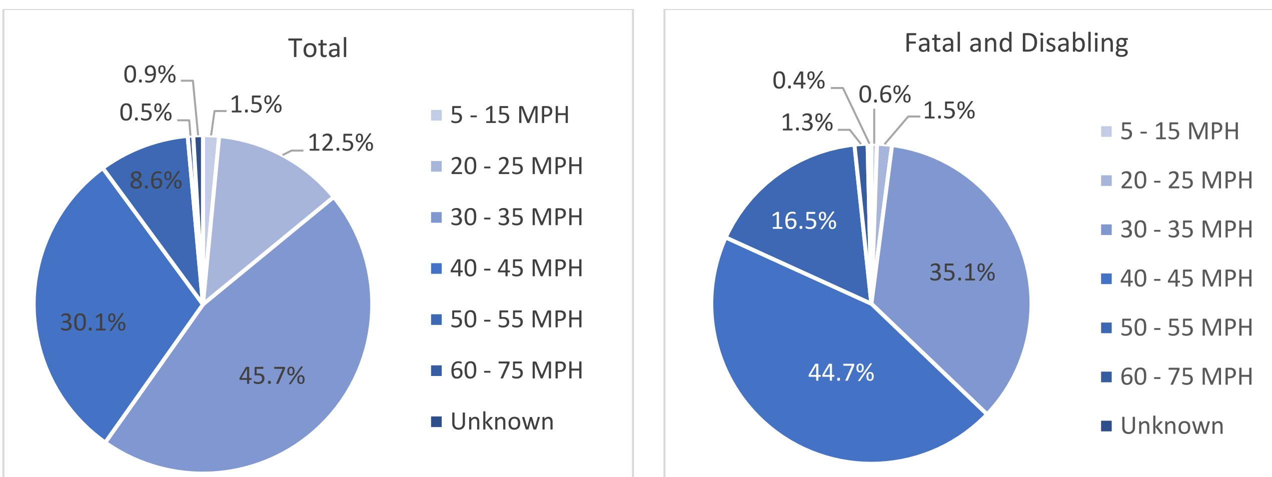
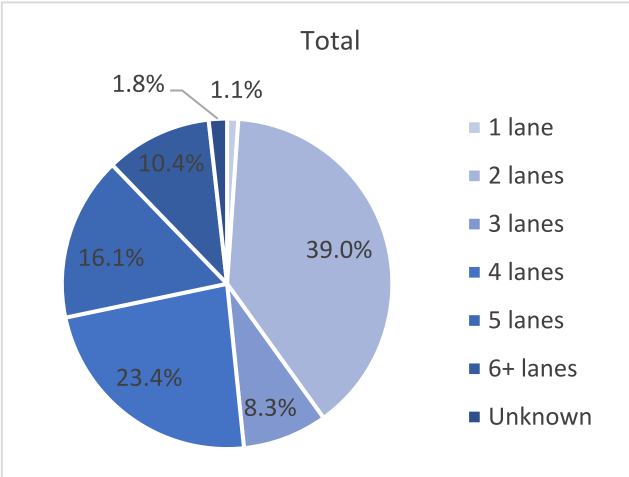


Figure 5 *Pedestrian Crossing Roadway - Vehicle Not Turning* by speed limit of roadway

Roads with two travel lanes are apparently the most common for all crashes of this group (39%), and for crashes involving fatal and disabling injuries (Figure 6). The chart on the right shows that larger percentages of fatal and disabling types occurred on roads with four or more through lanes, compared with those for all severity. Especially notable, is the sizable percentage of those involving more severe injuries on roadways of 5 through lanes (22%) compared with 16 percent for all severity crashes. Five-lane roads are typically roads with a two-way, continuous center left turn lane. (Note that numbers of lanes from reported crash data are subject to error.) Information on countermeasures and links to other resources are provided in the sections below.



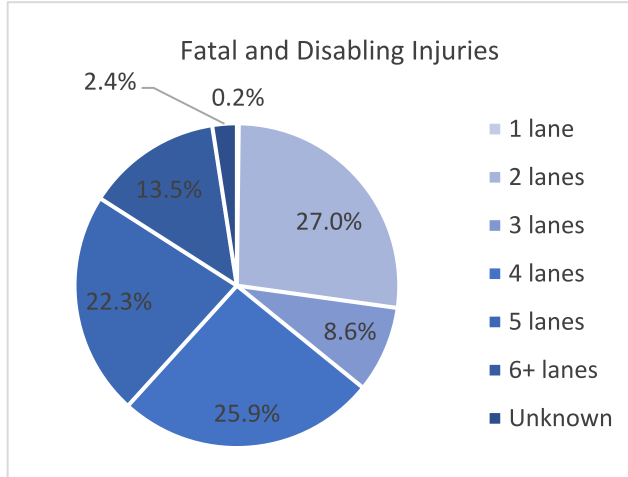
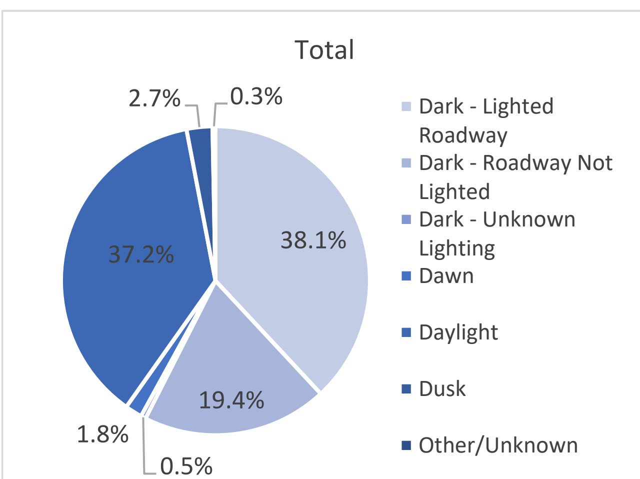


Figure 6 *Pedestrian Crossing Roadway - Vehicle Not Turning* by total number of lanes

Figure 7 shows light conditions present when these crashes occurred. Dark conditions are over-represented for all severity crashes of this type —58 percent for all types of dark conditions, combined, compared to 40 percent for all types (data for all types are included in the Crash Facts companion report). Fatal and disabling injury outcomes were even more apt to occur at night, with 45 percent at night on lighted roads, and 32 percent at night on unlighted roadways—a total of 77 percent of all these serious injury crashes. It can be very challenging for pedestrians to recognize safe crossing gaps (speed and closing distance are difficult to estimate) at night, while motorists also have difficulty seeing pedestrians at night. Locations with no crossings or pedestrian refuges, inadequate lighting, and no traffic controls to separate pedestrian crossings from through motor vehicle traffic or increase conspicuity are especially challenging for safe interactions.



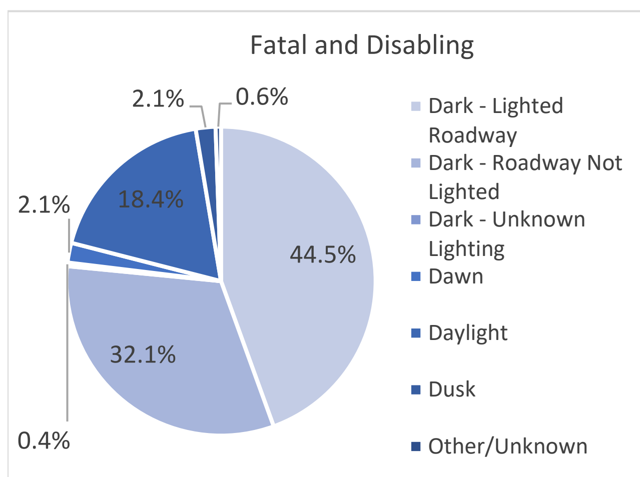


Figure 7 *Pedestrian Crossing Roadway - Vehicle Not Turning* by light conditions at time of crash

Finally, these risky situations may be exacerbated further if one or both parties are under the influence of alcohol. Suspected or detected alcohol use by either the driver or the pedestrian is also associated with greater injury severity outcomes in these types of crashes compared to the group as a whole (Figure 8).

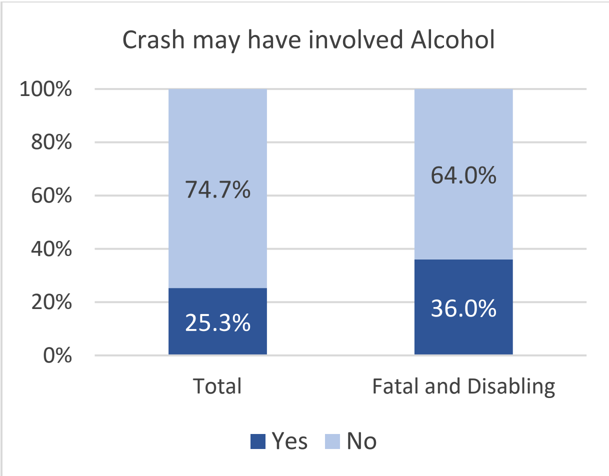


Figure 8 *Pedestrian Crossing Roadway - Vehicle Not Turning* by crash alcohol indicator (any use suspected/detected by the driver, pedestrian or both)

Pedestrian Crossing - Vehicle Not Turning Crash Factors Tree Diagram

To take a closer look at some of the combinations of factors most associated with a pedestrian who was crossing the roadway being struck by a straight through motorist, we developed a crash tree that looks at hierarchical combinations of several of the most prevalent factors and the most severe injuries (Figure 9). Because speed limits, roadway designs, lighting and a number of other factors vary for rural and urban locations, we first subdivided by rural/urban location. Although a higher percentage of rural crashes led to fatal and disabling type injuries (37%) compared to urban areas (20%), the frequency is much higher in urban areas, and thus, a plurality of more severe crashes also occurred in urban areas.

As shown in Figure 3 above, the pedestrian was most often not in a crosswalk or within an intersection, but rather crossing the roadway in a regular travel lane when struck. In addition, there was most often no specific traffic control associated with these crashes. (The presence of a double-yellow line, a form of traffic control that restricts passing but does not provide any indication of control of crossing-related potential conflicts with pedestrians was included with the 'No Traffic Control' group.) The 'No Control' group accounted for 58 percent (1084/1860) of all severity crashes (1084/2291) and 64 percent of all fatal and disabling injury crashes of this type in urban areas (242/378). Beyond that, roads with higher speed limits (40 or more mph) was associated with a much higher rate of severe injuries. The combination of pedestrian being struck in an urban setting, while crossing in a travel lane with no specific traffic controls on higher speed limit roads captured 21 percent of all of these crashes (399/1860), but 36 percent (137/378) of fatal and disabling injury crashes in urban locations. (A majority of these were 40 - 45 mph roads.) Finally, among this set of crashes, roads with 5 through lanes (typically two-way, center turn lane designs) accounted for a significant percentage: while only 7% of all severity crashes, these road types in conjunction with the other factors, were associated with 13 percent of fatal and disabling types in urban settings.

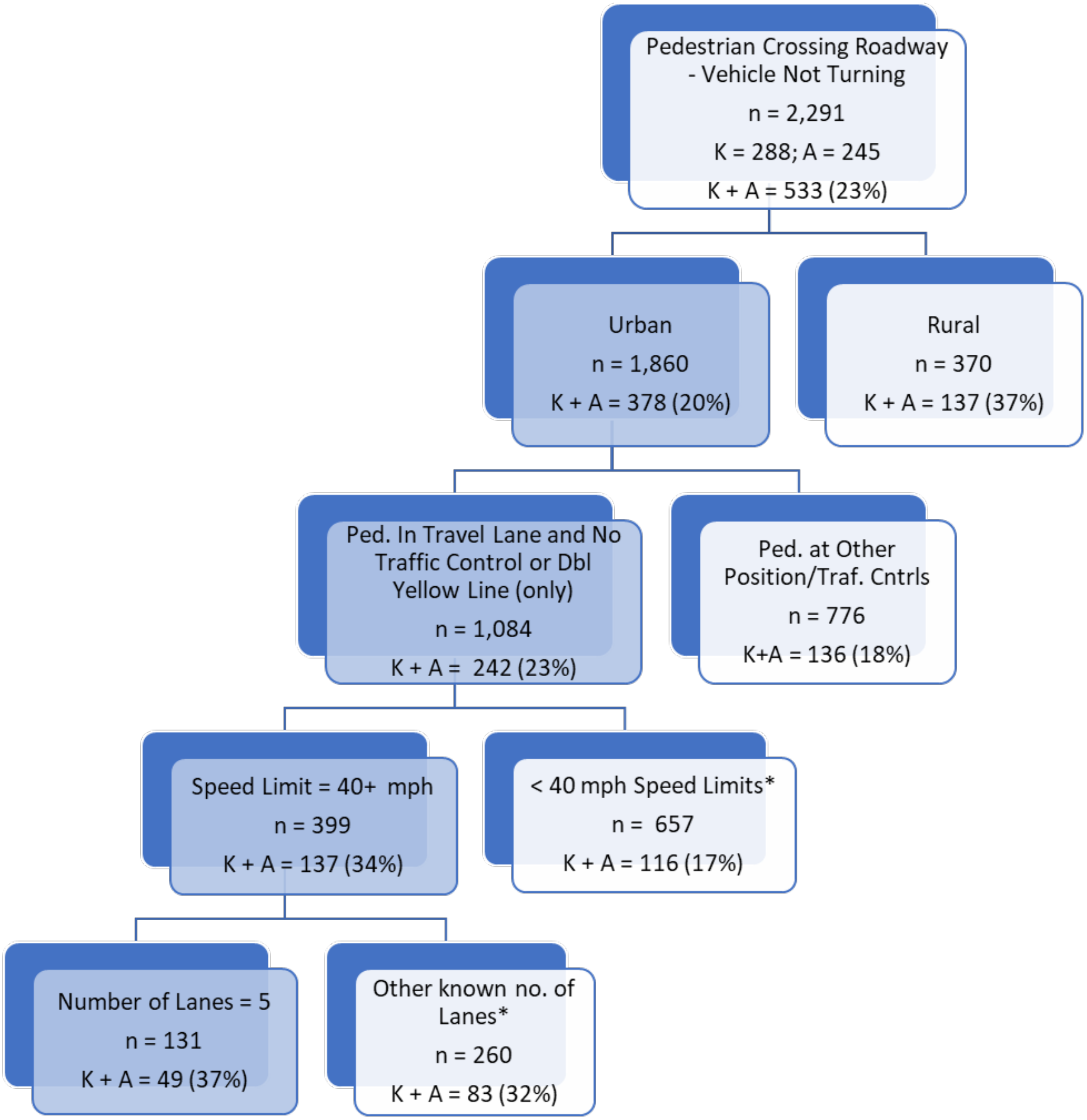


Figure 9 Tree Diagram of Prevalent Factors Associated with Pedestrian Crossing Roadway - Vehicle Not Turning types of Crashes.

Finally, we examined the representation of Pedestrian Crossing - Vehicle Not Turning crashes in counties across the state by frequencies and by population-based rates. These maps are presented and discussed in Appendix A and show that while the most populous counties tend to have the highest counts of both total pedestrian crashes and Crossing Roadway - Vehicle Not Turning crashes, a few have higher proportions of this type. Additionally, when examined by population-based rates, several rural counties appear in the lists as having relatively high rates of total pedestrian crashes or this focus type of crash. The jurisdictions in these counties may consider further investigation of the conditions and locations of these crashes and potential treatments.

While there may be some errors in reporting of these factors in crash data, similar associations have been reported for pedestrian crashes and injury severities in many other studies (Thomas et al. 2018). These factors could potentially be used to proactively identify locations for further assessment, especially in conjunction with land uses/destinations, transit, and other measures that are associated with pedestrian activity.

Countermeasures for these crashes should aim to provide safe locations and times for pedestrians to cross roadways, separated from conflicts with motor vehicles (such as through traffic control signals or pedestrian hybrid beacons), especially on higher speed, higher volume, and multilane roads (Thomas et al. 2018; Blackburn et al. 2017). Medians or median islands and crossings can provide refuge areas for pedestrians crossing multi-lane roads and roads with a center, two-way, left turn lane. Lighting enhancements, especially at designated crossing locations used by pedestrians at night, are important for enhancing pedestrian conspicuity. Where designated crosswalks are appropriate, advance stop-yield bars and high visibility crosswalks can add aid conspicuity and visibility between pedestrians and drivers, especially important on multi-lane roads (Thomas et al. and Blackburn et al. 2017). Measures should minimize the chance of harm by providing sufficient crossing opportunities, encourage safer speeds, and provide appropriate levels of separation for the road type, speed and volume of users present, especially since motorists do not always yield even if they observe pedestrians.

Additional Resources

For complete crash group and type definitions, see the PBCAT Manual, Images and Tech Support Information. 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 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, and in NCHRP reports. These include The Systemic Pedestrian Safety Analysis guidebook, NCHRP Report 893, which provides information about pedestrian risk identification and potentially appropriate and effective countermeasures in a more proactive approach to safety (Thomas, Sandt et al. 2018).

In order to develop countermeasures for particular locations, crash and other data specific to those locations should be examined. Identification of the specific problems and treatments should include site visits and problem diagnoses, such as through interdisciplinary roadway safety audits, before any treatments are selected or implemented. See *North Carolina Pedestrian and Bicycle Road Safety Assessment Guide* (Thomas, Gelinne et al. 2018) for guidance on analyzing, diagnosing, and prioritizing safety problems, and *North Carolina Pedestrian Crossing Guidance* (Schroeder, O'Brien & Findley, 2015) and the associated flow chart for help determining appropriate treatments. Another resource is the Crash Modification Factors Clearinghouse, which provides estimates of expected crash reductions for various treatments.

To improve interactions of road users, see Watch for Me - NC webpage and NHTSA's *Countermeasures That Work* (Richard et al. 2018), which is updated frequently with information on effective behavior change programs. 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 designing facilities, see the North Carolina Department of Transportation's Complete Streets webpage, the *Guide for the Development of Bicycle Facilities* available from AASHTO, and the NACTO Urban Street Design Guide, among others.

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Appendix A – Maps of Pedestrian-Motor Vehicle Crashes

The following North Carolina maps and tables illustrate the total number of pedestrian-motor vehicle crashes by county and the standard deviation of the average annual rate per 10,000 residents for all crashes. The total number of ***Crossing Roadway – Vehicle Not Turning*** crashes and their average annual rate per 10,000 residents are also illustrated in maps and tables following.

More populous, urbanized counties have the highest total number of all crashes (Table 7). The same counties appear in the top 10 for ***Crossing Roadway – Vehicle Not Turning*** crashes as well (Table 8), although not in exactly the same rank order (Table 8). Additionally, among the top 10 counties for frequency of ***Crossing Roadway - Vehicle Not Turning*** types of crashes, several have a high proportion of all pedestrian crashes that are these types. These include Cumberland and New Hanover counties, followed by Durham county. See Figure 10 and Figure 12 to illustrate these relationships for all counties. Figure 14 provide a map of all counties with county name labels for reference.

Table 7 Top 10 NC Counties for pedestrian crashes

County	Total Pedestrian Crashes
Mecklenburg	2,620
Wake	1,627
Guilford	1,201
Durham	784
Cumberland	603
Buncombe	490
Forsyth	452
New Hanover	452
Gaston	346
Pitt	308

Table 8 Top 10 counties for Crossing Roadway - Vehicle Not Turning crashes

County	Total Pedestrian Crossing - Motorist Not Turning Crashes	Proportion of Total Crashes in County
Mecklenburg	415	15.8%
Wake	262	16.1%
Guilford	185	15.4%
Durham	147	18.8%
Cumberland	136	22.6%
New Hanover	99	21.9%
Buncombe	77	15.7%
Forsyth	59	13.1%
Gaston	52	15.0%
Pitt	48	15.6%

When adjusted for population, the top 10 highest-ranking counties are more varied (Table 9 and Table 10). Durham County has the highest average annual rate per 10,000 residents for any county in the State with 5.4 per 10,000 for all crashes as well as having the highest rate ***for Crossing Roadway – Vehicle Not Turning*** crashes with 1.0 per 10,000. More rural counties have a high adjusted rate as well, with Halifax County appearing in both the overall top counties as well as the top counties for ***Crossing Roadway – Vehicle Not Turning*** crashes. Other more rural counties also appear in one or the other list. See Figure 11 and Figure 13 to illustrate where each county stands in terms of relative crash risk per population.

Table 9 Counties with standard deviation > 1.5 for all crashes

County	Average Annual Rate per 10,000 Residents	Standard Deviation
Durham	5.4	> 2.5
Mecklenburg	5.2	> 2.5
Guilford	4.7	> 2.5
Halifax	4.4	> 1.5
New Hanover	4.2	> 1.5
Scotland	4.0	> 1.5
Buncombe	3.9	> 1.5
Vance	3.7	> 1.5
Watauga	3.7	> 1.5

Table 10 Counties with standard deviation > 1.5 for *Crossing Roadway - Vehicle Not Turning* crashes

County	Average Annual Rate per 10,000 Residents	Standard Deviation
Durham	1.0	> 2.5
New Hanover	0.9	> 2.5
Cumberland	0.8	> 2.5
Mecklenburg	0.8	> 1.5
Guilford	0.7	> 1.5
Richmond	0.7	> 1.5
Graham	0.7	> 1.5
Halifax	0.6	> 1.5

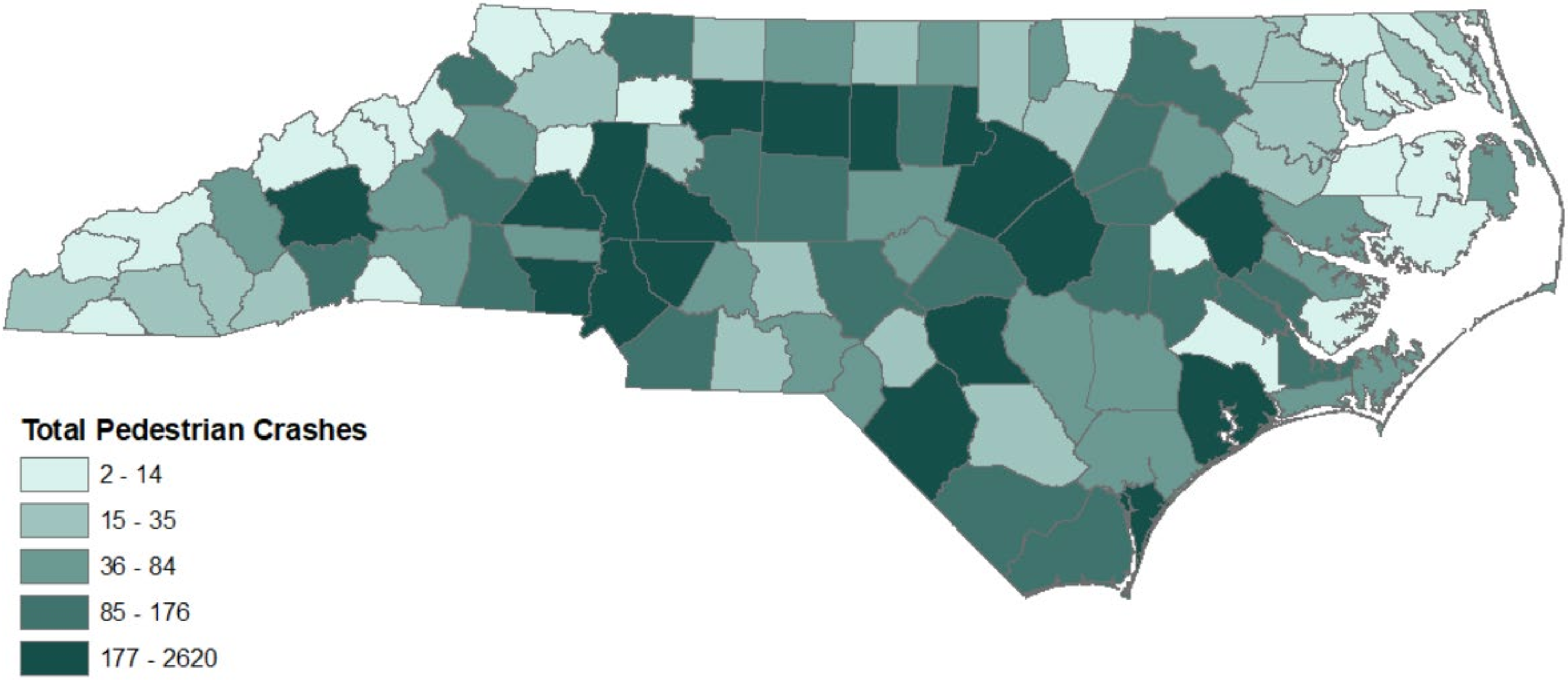

Figure 10 Total pedestrian crash frequencies by NC County

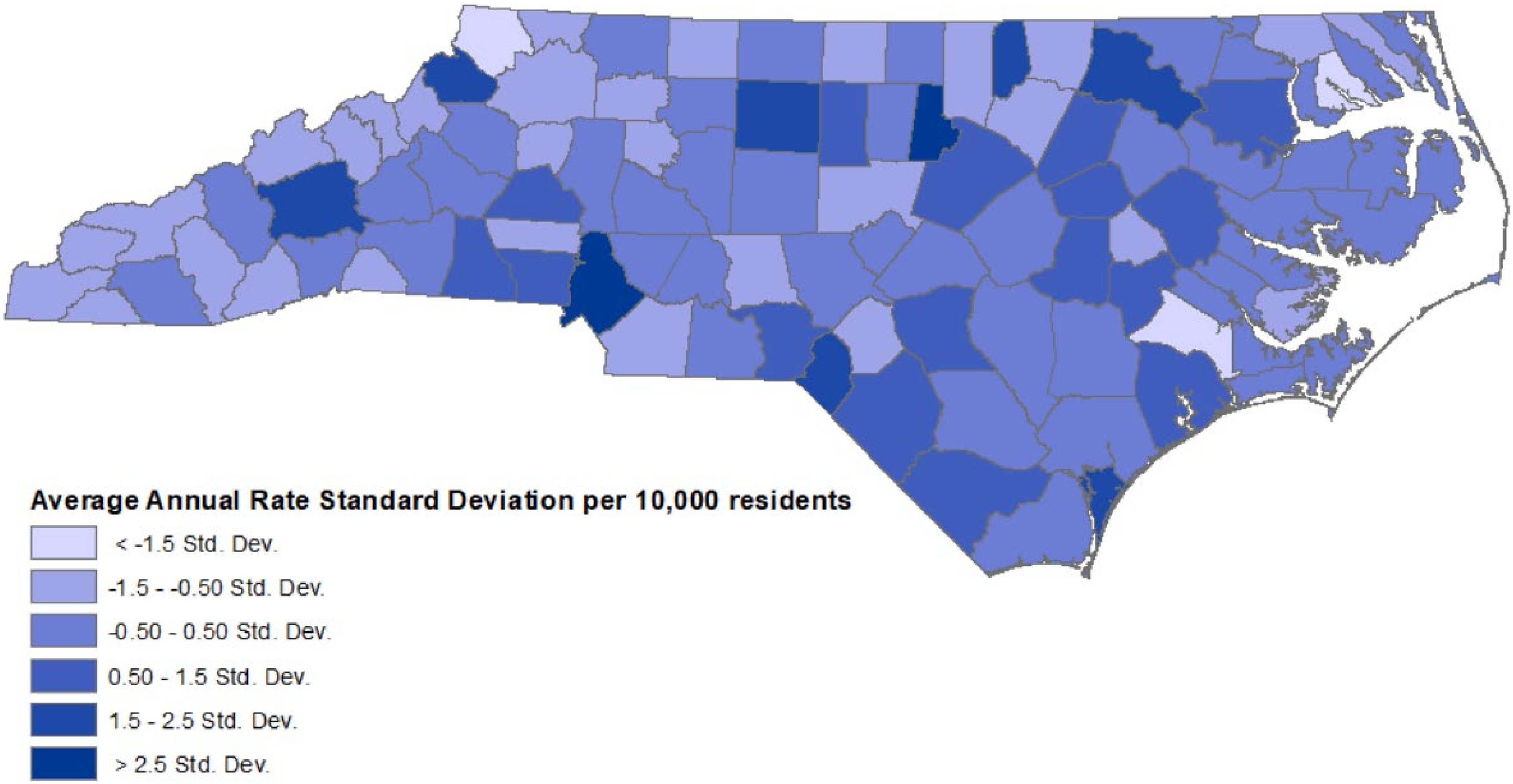

Figure 11 Standard deviation of average annual rate of total pedestrian crashes per 10,000 residents

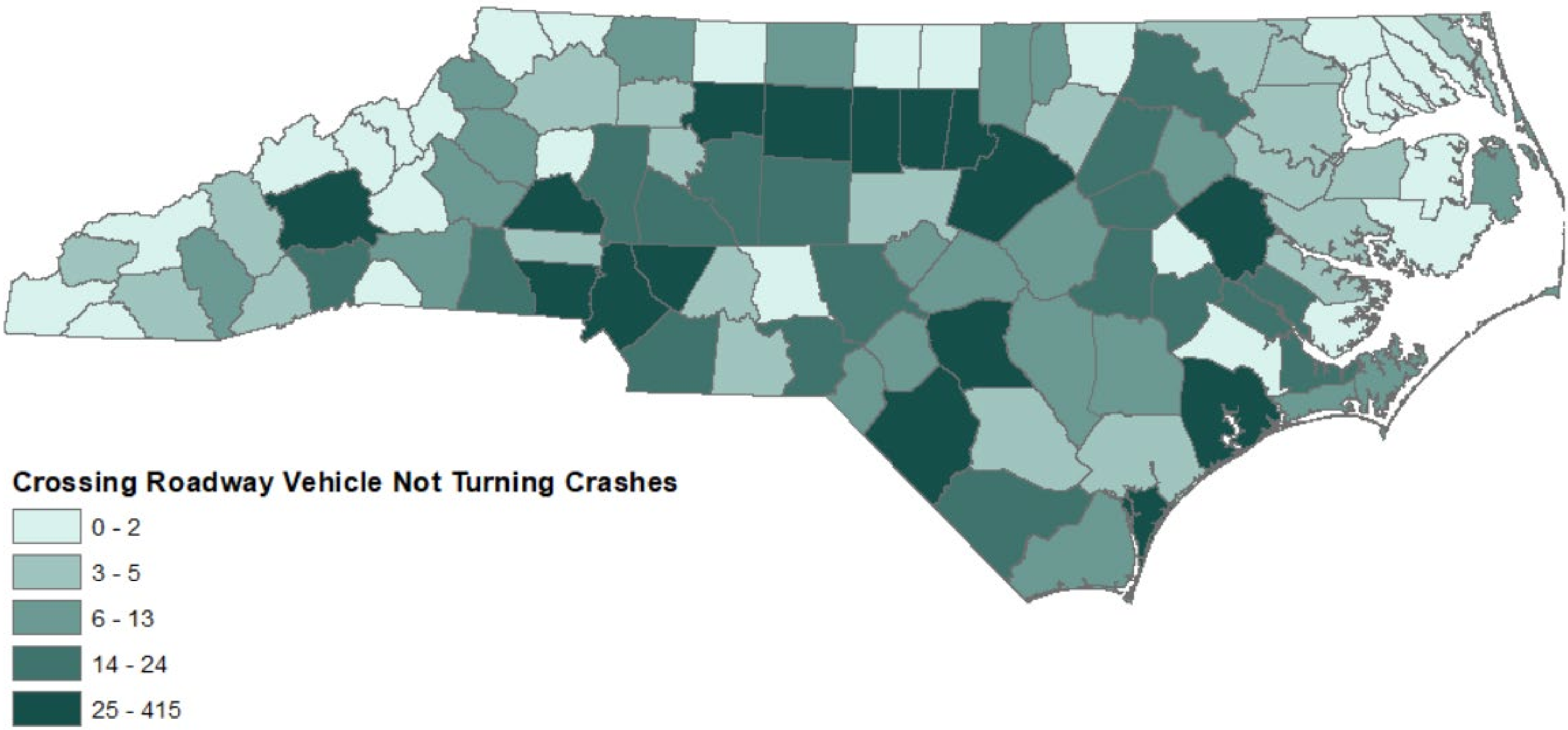

Figure 12 ***Crossing Roadway - Vehicle Not Turning*** **crash frequencies by County**

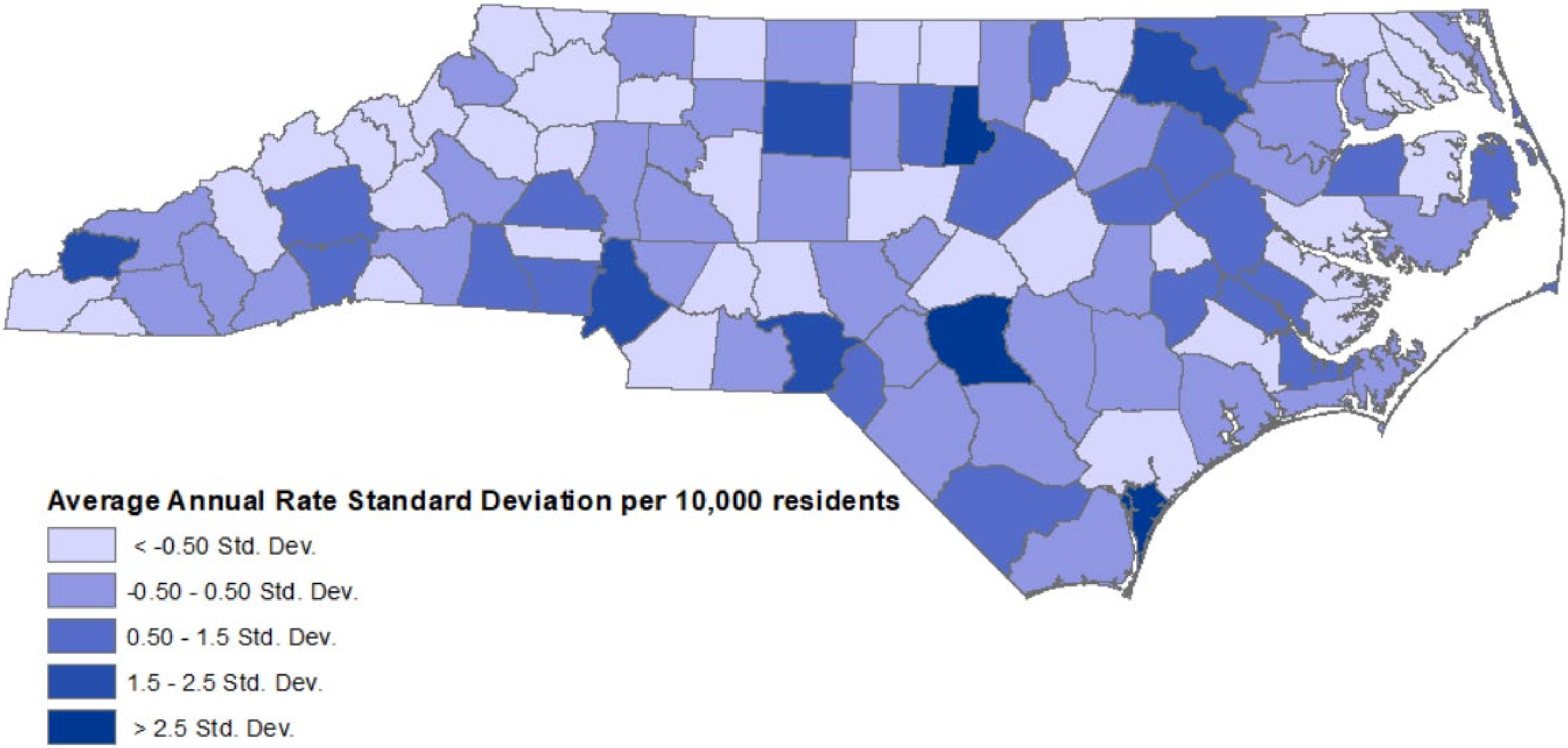

Figure 13 Standard deviation for *Crossing Roadway - Vehicle Not Turning* crashes per 10,000 residents

Figure 14 Map of NC Counties with County names