Factors Contributing to Pedestrian and Bicycle Crashes on Rural Highways

Final Report

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Introduction

Approximately 25% of pedestrian and bicycle fatal and injury accidents occur on rural highways. Rural highways have different characteristics than urban highways, such as higher average vehicle speeds and a lack of sidewalk provisions that force pedestrians and bicyclists to use the shoulder or travel lane. There has been very little prior research on these rural issues. For instance, the extent to which the presence, quality, and width of shoulders affects pedestrian and bicyclist accidents has not been studied, but may be an important factor in justifying additional costs associated with building improved shoulders. Virtually no research has been conducted on rural roadways where crash types were defined with more detailed coding than exists on standard police forms and where the crash data could be linked with roadway characteristics and traffic counts. The goals of this study are first, to examine differences between pedestrian and bicycle crashes in urban and rural settings in North Carolina, and second, to identify specific crash types and crash locations on rural highways that are of high priority for treatment development. North Carolina data were used in this study because of the presence of supplemental information providing much more detailed crash typing than is available in other states.

Organization of this Report

The results of this study are organized into the following sections:

- *General Comparison of Rural to Urban Crashes* – this section compares and contrasts general descriptive statistics of rural and urban pedestrian-motor vehicle and bicycle-motor vehicle crashes.
- *Analysis of Rural Crashes by Road Class* – this section examines the rural crashes more specifically by breaking them down according to the functional class of the road on which they occurred. The intention of this section is to demonstrate which road class has the highest priority for safety improvements.
- *Analysis of Rural Crashes by Crash Type* – this section further breaks down the rural crashes according to the crash type (as defined by pre-crash actions of both parties). The intention of this section is to identify "problem areas", which are high priority combinations of crash type and road class.
- *Characteristics of Problem Areas* – this section examines the characteristics of the problem areas identified in the previous section to determine trends and areas for potential treatment. Characteristics of the pedestrian, bicyclist, driver, environment, and roadway are considered.
- *Discussion of Countermeasures for Rural Areas* – this section lists potential countermeasures for the identified problem areas and discusses the potential safety effectiveness and feasibility of each countermeasure for a rural environment.

Past Research

A 1996 study entitled "Pedestrian and Bicycle Crash Types of the Early 1990s" analyzed a sample of 5,000 pedestrian and 3,000 bicycle-motor vehicle crashes from five states *(1)*. While the crashes occurred in both urban and rural locations, urban crashes were the predominant type, comprising about two-thirds of the crashes. This study used a crash-typing method developed by NHTSA to refine and update crash type distributions. In addition to the crash type, the study also analyzed the distributions of other factors that may have contributed to collision trends, such as pedestrian age and driver sobriety. The most common crash types were midblock dart/dash, other midblock, intersection-related, and vehicle turn/merge. The majority of bicycle-motor vehicle collisions occurred when the parties were crossing paths and were usually due to a failure to yield. The most common crossing-path crash types were motorist failing to yield, bicyclist failing to yield at an intersection, and bicyclist failing to yield midblock.

A recent review by Campbell, Zegeer, Huang, and Cynecki incorporated over 200 studies pertaining to pedestrian safety *(2)*. They found that while pedestrian crashes predominantly occur in urban areas, rural crashes more often lead to pedestrian deaths, possibly due to higher vehicle speeds. Pedestrian groups that were over-represented were young children, pedestrians who had consumed alcohol, and older pedestrians. The most common crash types were dart-outs, intersection dash, and turning-vehicle collisions.

Ivan, Gårder, and Zajac examined factors influencing pedestrian injury severity in rural Connecticut *(3)*. They found that vehicle type, driver alcohol involvement, pedestrian alcohol involvement, and pedestrian age over 65 significantly increased pedestrian injury severity in these rural crashes.

Hall, Brogan, and Kondreddi identified the most prominent characteristics of rural pedestrian fatalities in states with above-average rural pedestrian fatalities *(4)*. They found that the prominent characteristics were clear weather, hours of darkness, weekends, non-intersection locations, and level, straight roads. They also recognized the influential role of alcohol consumption.

Ossenbruggen, Pendharkar, and Ivan modeled pedestrian-vehicle crashes on rural roads New Hampshire *(5)*. The factors they used describe a site by land use, roadside design, traffic control, and traffic exposure. They found that "village" sites, defined by multi-purpose land use zones with sidewalks, crosswalks, onstreet parking, and pedestrian-friendly amenities, were less hazardous than residential and shopping sites. The latter two types are defined by single-purpose land use zones, bordered by single-family dwelling units and roadside shopping units with ample offstreet parking, a lack of sidewalks, higher vehicle speeds, and greater vehicle exposure.

While the studies above examined pedestrian crashes and general characteristics of rural crashes, there is a need for examination of specific crash types and characteristics of rural pedestrian and bicycle crashes. This study explores these issues and addresses the role of countermeasures in rural environments.

Crash Data

Source Databases

North Carolina PBCAT

The Pedestrian and Bicycle Crash Analysis Tool (PBCAT) developed by the UNC Highway Safety Research Center has been used yearly since 1997 to build a database of pedestrian and bicycle crashes in North Carolina (*6)*. This PBCAT database contains crash data for urban and rural roads, as well as data on location and road classification. One of the most prominent features of the PBCAT database is the crash type data. Each crash is designated to be a particular crash type, based on police report information on the pre-crash actions of both parties. Examples of crash types are “motorist overtaking a bicyclist” and “pedestrian walking along roadway”. These detailed data can prove to be useful when identifying treatments for frequently occurring problems.

HSIS

The Highway Safety Information System (HSIS) database contains crash-related data and roadway inventory data for urban and higher-volume rural roads for North Carolina (i.e., all roads except those that would be “county” roads in other states). The crash-related data are obtained from police accident reports. The roadway inventory data are obtained from the state inventory database.

Study Datasets

The PBCAT crash data were linked to roadway data in HSIS to provide the dataset for use in this study. Since HSIS predominantly contains data only for urban and medium-to-high volume rural roads, only a subset of PBCAT rural crashes were contained in the HSIS database (1849 out of 6037 bicycle crashes; 3598 out of 13508 pedestrian crashes). This subset of rural crashes was the primary focus of this study. The urban crashes from the PBCAT database were also extracted and linked with the HSIS roadway data to form a dataset to use in general comparison. Note that these “urban” crashes would be those that occur on state routes through urban areas. These are most likely to be major arterial roadways, and would not include residential streets or other non-major urban roads.

Description of Crash Data

The final crash dataset used in this study spans the years 1997 to 2002. The data comprise 1849 total bicycle-vehicle crashes, of which 956 (52%) are rural and 893 (48%) are urban, and 3598 pedestrian-vehicle crashes, of which 1947 (54%) are rural and 1651 (46%) are urban. These rural-urban designations were given in the PBCAT database, which defines crashes occurring within municipal limits as urban and those outside municipal limits as rural. The data consist of crashes on state-maintained roads. In North Carolina, approximately 78,000 miles of roadway are owned by the state, but only 39,385 miles are included in the HSIS database – those road segments to which crashes can be “mileposted.” As discussed above, these are the urban and medium-to-high volume rural roads. Low volume rural roads are not included in this study, nor are residential streets in urban areas.

General Comparison of Rural to Urban Crashes

This section compares and contrasts general descriptive statistics of the two datasets from this project, rural and urban PBCAT crashes that were contained in HSIS, as well as comparing both to the distributions from the 1996 crash type study, which contained crashes on urban and rural roadways from five states (*1*). While the database from the 1996 study was not available, the distributions and descriptive statistics listed in the 1996 report are used in this comparison. Although the report does not give distributions of these factors separately for rural crashes, these data can be used for comparison to a combined group of urban and rural crashes. Tables showing highlights of the general comparison are found in Appendix A.

A general comparison of rural and urban crashes is useful for indicating which factors are common to both localities as well as which factors are overrepresented in a rural environment. Overrepresentation is defined as having substantially higher proportion of a particular variable in rural crashes than urban crashes. This was determined by using a cross-tabulation analysis and examining the adjusted standardized residuals. Variable levels with residuals over 1.96 were considered overrepresented.

Bicycle Crashes

Bicyclist Characteristics

The most common age range for bicyclists in both rural and urban crashes was 25-44 years old (32% and 37%, respectively) (Figure 1). Other common bicyclist ages were 10-14 years old for rural crashes (21%) and 15-19 years old for urban crashes (16%). The 0-9 and 10-14 groups were overrepresented in rural crashes. The 1996 study involved age ranges of 10-14 years (27%) and 25-44 years (23%). The majority of bicyclists were male in all three databases. White bicyclists were overrepresented in rural crashes, and black and Hispanic bicyclists were overrepresented in urban crashes.

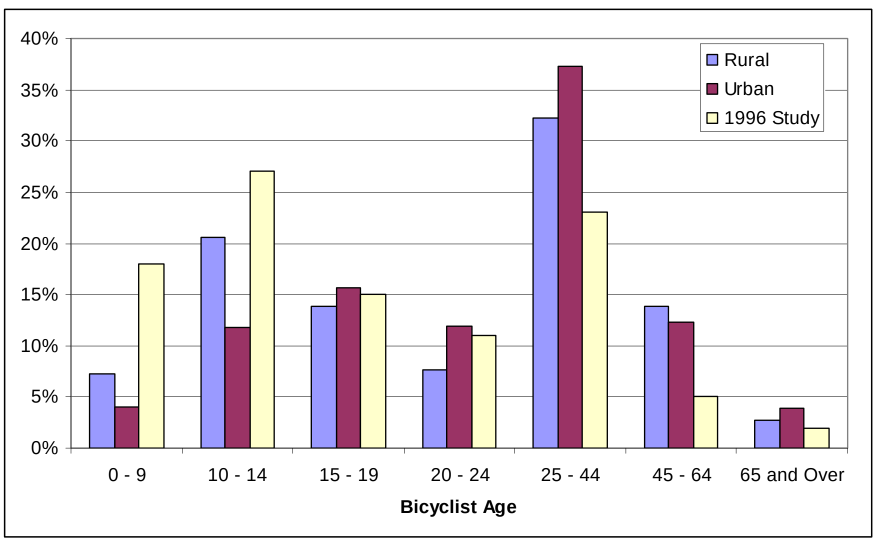


Figure 1. General Comparison - Bicyclist Age

Almost all bicyclists in rural crashes were on the street at the time of collision, either in the travel lane (74%), or in the bicycle lane/shoulder (10%) (Figure 2). A lesser proportion of urban bicyclists were in a travel lane (59%) and only 2% were in a bicycle lane or shoulder. Remaining urban bicyclists were on a sidewalk, crosswalk, or unknown location. A high percentage (93%) of the collisions that occurred on a sidewalk, crosswalk, or driveway crossing was urban. The majority of rural crashes occurred with the bicyclist traveling in the same direction as the vehicle traffic, while the urban crashes were more evenly split between bicyclists traveling with traffic (46%) and facing traffic (32%).

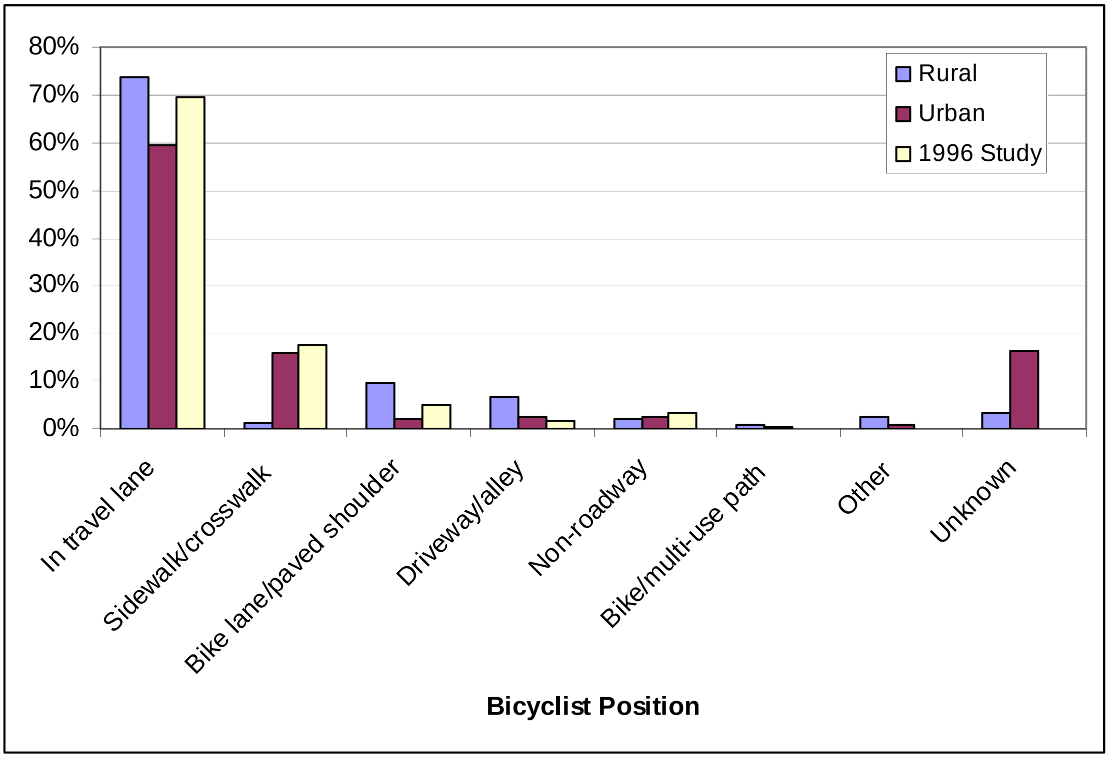


Figure 2. General Comparison - Bicyclist Position

Eight percent of bicyclists in rural crashes and 6% of bicyclists in urban crashes had consumed alcohol. However, bicyclist alcohol levels were unknown for 42% of crashes in both datasets. For comparison, 5% of bicyclists in the 1996 study had consumed alcohol, with an unknown percentage of only 4%. This comparison seems to indicate that the percentages of bicyclist who had consumed alcohol in the rural and urban datasets are reasonable, under the assumption that most of the 42% unknown are likely to be non-alcohol.

The most common bicyclist injuries in rural and urban crashes were B (evident) injuries (44% and 43%, respectively), followed by C (light or possible) injuries (30% and 39%, respectively) (Figure 3). Rural bicyclists had a higher percentage of A (disabling) injuries and fatalities than urban crashes. The 1996 study showed injury statistics similar to urban crashes.

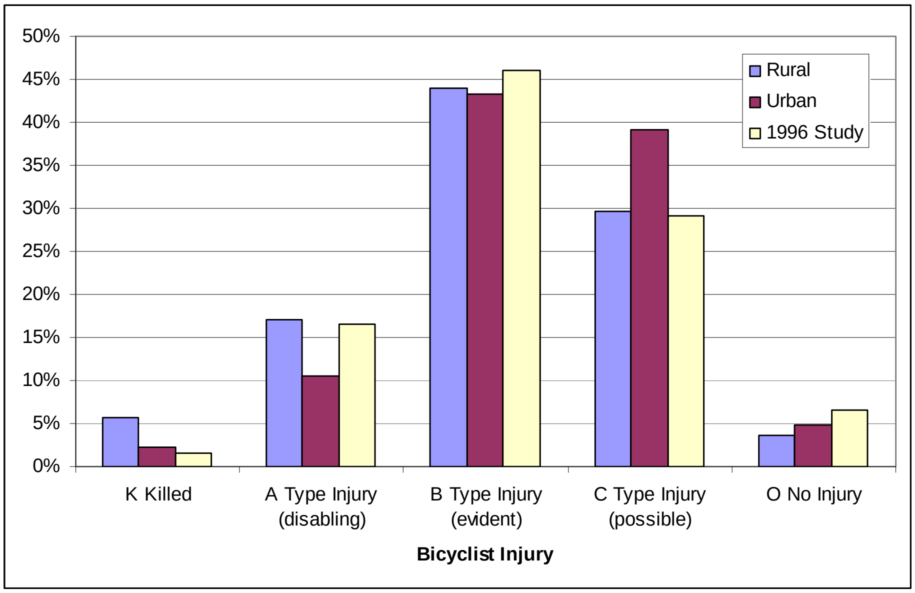


Figure 3. General Comparison - Bicyclist Injury

Driver Characteristics

The most common age range for drivers in rural and urban bicycle crashes was 25-44 years old (35% and 40%, respectively), followed by 45-64 years old (25% and 22%, respectively) (Figure 4). The difference in percentages between rural and urban was not statistically significant. The 1996 study also showed similar age range statistics. The majority of drivers were male. White drivers were overrepresented in rural crashes, and black drivers were overrepresented in urban crashes.

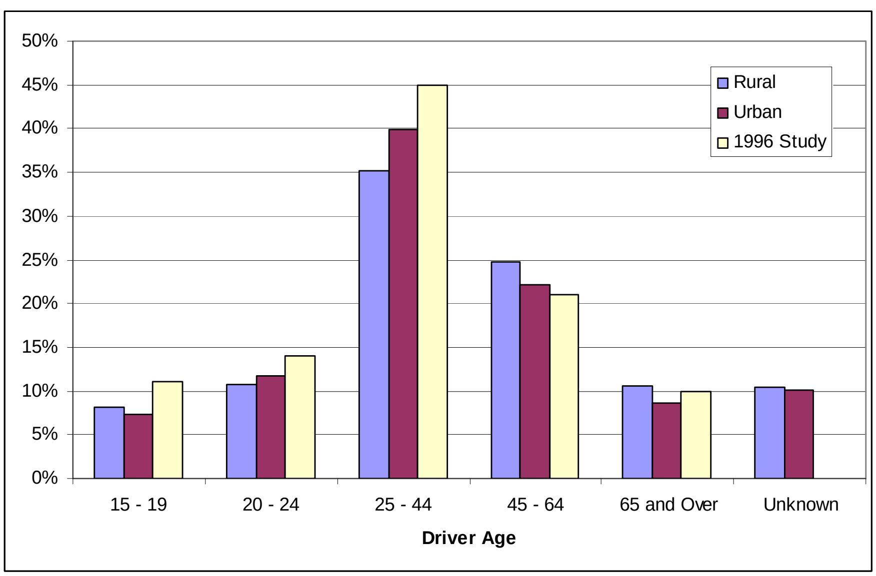


Figure 4. General Comparison - Driver Age in Bicycle Crashes

Four percent of drivers in rural crashes and 2% of drivers in urban crashes had consumed alcohol. For comparison, 2% of drivers in the 1996 study had consumed alcohol. The vast majority of drivers in all three datasets sustained no injuries from their crash.

Vehicle Characteristics

The majority of vehicles in all three datasets were passenger cars and pickups. No significant trends in vehicle type were noted. As expected, estimated speeds of vehicles in rural crashes were significantly higher than those in urban crashes (Figure 5). In rural crashes, the largest proportion of vehicles were estimated to have been traveling between 41 and 60 mph (47%), followed by 21-40 mph (29%) and 0-20 mph (22%). In urban crashes, the majority of vehicles were estimated to have been traveling between 0 and 20 mph (56%), followed by 21-40 mph (34%). This difference in speeds may result from both lower speed limits and the prevalence of intersections in urban areas, where motorists would be traveling slowly to make turns or to stop for traffic control.

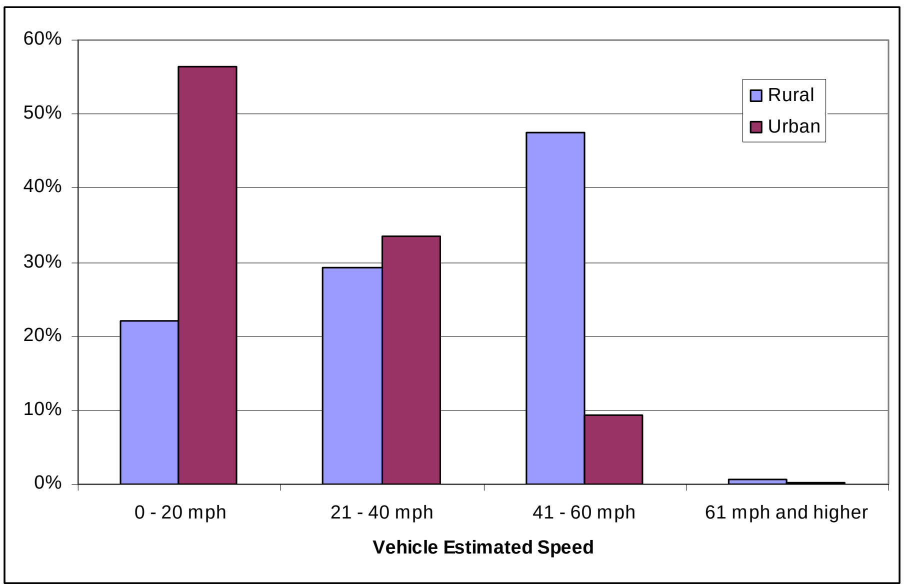


Figure 5. General Comparison - Estimated Vehicle Speeds in Bicycle Crashes

Crash Characteristics

Crashes in all datasets were spread fairly evenly throughout days of the week, with the exception of weekends, which had an overrepresentation of rural crashes. The largest portion of bicyclist crashes occurred between 2:00pm and 6:00pm for rural, urban, and the 1996 study datasets (35%, 36%, and 31%, respectively) (Figure 6). The next most common time periods were 10:00am-2:00pm and 6:00pm-10:00pm for all datasets. During evening and night hours, there were more rural crashes than urban crashes or 1996 study crashes. For crashes occurring during hours of darkness, rural crashes contributed to most of the crashes on non-lighted roadways, and urban crashes contributed to most of the crashes on lighted roadways. The 1996 study followed the trend of the urban crashes with respect to light condition.

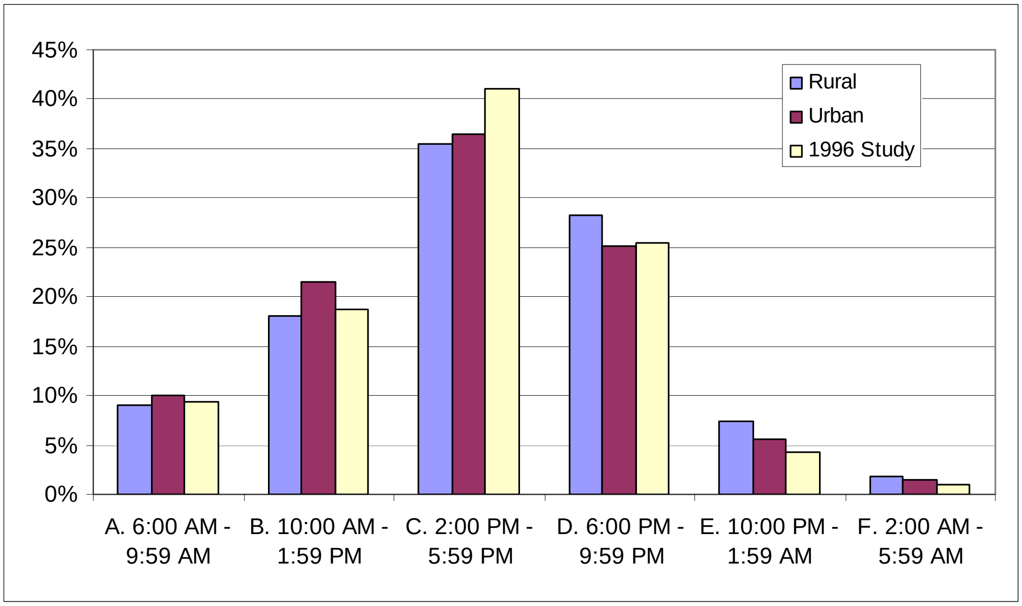


Figure 6. General Comparison - Time of Day in Bicycle Crashes

The most common crash types for rural crashes were “bicyclist turn/merge into path of motorist” (31%), “motorist overtaking” (25%), and “bicyclist failed to yield at midblock” (10%) (Table 1). The most common crash types for urban crashes were “motorist failed to yield” (26%), “bicyclist failed to yield at midblock” (13%), “motorist turn/merge into path of bicyclist” (12%), and “bicyclist failed to yield at intersection” (12%). The most common crash types of the 1996 study were the same as the urban dataset and had similar percentages. Most of the common crash types for the rural dataset occurred in circumstances where the bicyclist and the motorist were on parallel paths, whereas most of the common crash types for the urban dataset occurred where the bicyclist and the motorist were crossing paths. This is reasonable, since one would expect more crossing-path crashes where there are more intersections (i.e., urban areas).

Table 1. General Comparison - Types of Bicycle Crashes

	Rural	Urban	1996 Study
Bicyclist Turn/Merge Into Path of Motorist	31%	10%	7%
Motorist Overtaking	25%	8%	9%
Motorist Failed to Yield	7%	26%	22%
Bicyclist Failed to Yield, Midblock	10%	13%	12%
Motorist Turn/Merge Into Path of Bicyclist	7%	12%	12%
Bicyclist Failed to Yield, Intersection	7%	12%	17%
Intersection Crash	2%	8%	3%
Unknown/Insufficient	4%	4%	2%
Wrong Way Operator	3%	2%	3%
Specific Circumstances	2%	1%	7%
Operator Lost Control	1%	1%	2%
Bicyclist Did Not Clear Intersection	0%	2%	1%
Bicyclist Turning Error	0%	1%	1%
Motorist Turning Error	1%	0%	1%
Bicyclist Overtaking	0%	0%	3%

Location and Roadway Characteristics

The majority of rural crashes occurred on two-lane undivided roads, likely reflecting the predominance of these roads in rural North Carolina. Locations of urban crashes were split between two-lane (30%) and four-lane roads (28%), followed by five-lane roads (19%). Most roads with urban crashes were undivided (72%), and the second most common urban crash location was divided roads with an unprotected median (20%). The 1996 study had the majority of crashes on two-lane roads (which would have included two-lane residential streets not found in the HSIS urban database).

The majority of rural crashes occurred at non-intersection locations (77%), while urban crashes were split between intersection (48%) and non-intersection locations (48%). In like fashion, the majority of rural crashes occurred where there was no traffic control (71%), while urban crashes occurred at locations with no traffic control (50%), signal control (27%), and stop sign control (20%).

Land development in rural crash areas was mainly Farms/Woods/Pasture (47%) and residential (35%). Urban crash areas were mainly commercial (65%). Rural crashes were found to occur on roads with higher speed limits than urban crash locations (Figure 7). The majority of rural crashes occurred on roads with speed limits of 50 mph or higher (54%), followed by 40-45 mph (27%). Urban crashes mainly occurred on roads with speed limits of 30-35 mph (56%), followed by 40-45 mph (32%). The 1996 study crashes occurred mainly in 30-35 mph zones (50%), but had a sizable proportion in 25 mph or lower (27%).

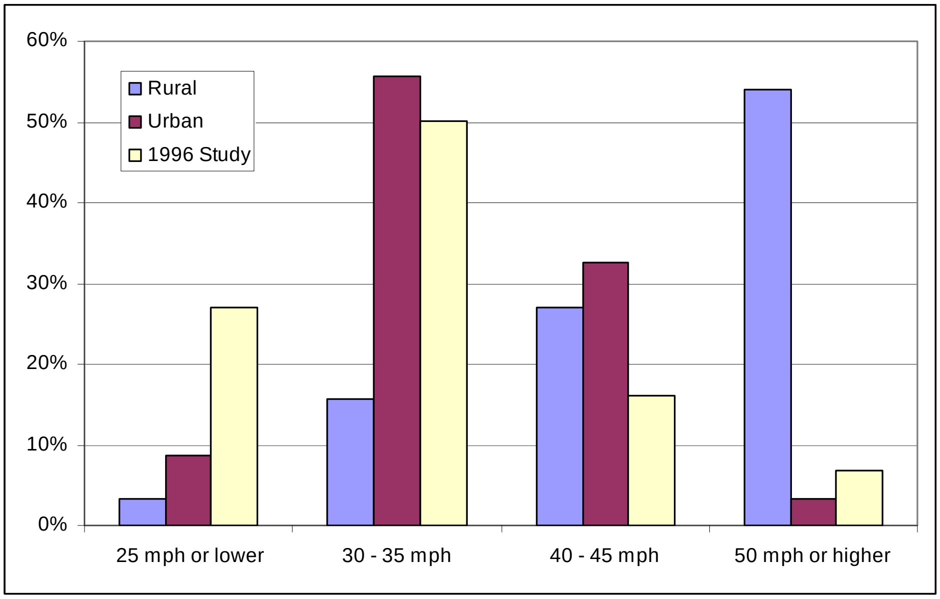


Figure 7. General Comparison - Posted Speed Limits in Bicycle Crashes

The majority of rural crashes occurred on roads with unpaved shoulders (80%) with a small proportion having paved shoulders (11%). Most of the unpaved shoulders had a width of 4-8 feet. Almost all of the paved shoulder crashes had shoulder widths between 8 and 16 feet. Urban crash shoulder types were mainly curb-and-gutter (72%), followed by unpaved shoulders (20%). The 1996 study did not provide good comparison data for shoulder characteristics, since 75% of that study's crashes had no shoulder type indicated.

Pedestrian Crashes

Pedestrian Characteristics

The most common age range for pedestrians in rural, urban, and the 1996 datasets was 25-44 years old (37%, 38%, and 30% respectively) (Figure 8). Other common pedestrian ages were 45-64 years old for rural and urban crashes (18% and 19%, respectively) and 0-9 years old for the 1996 study (19%). The 0-9 and 15-19 age groups were overrepresented in rural crashes. The majority of pedestrians were male in all three databases. White pedestrians were overrepresented in rural crashes, and black and Hispanic pedestrians were overrepresented in urban crashes.

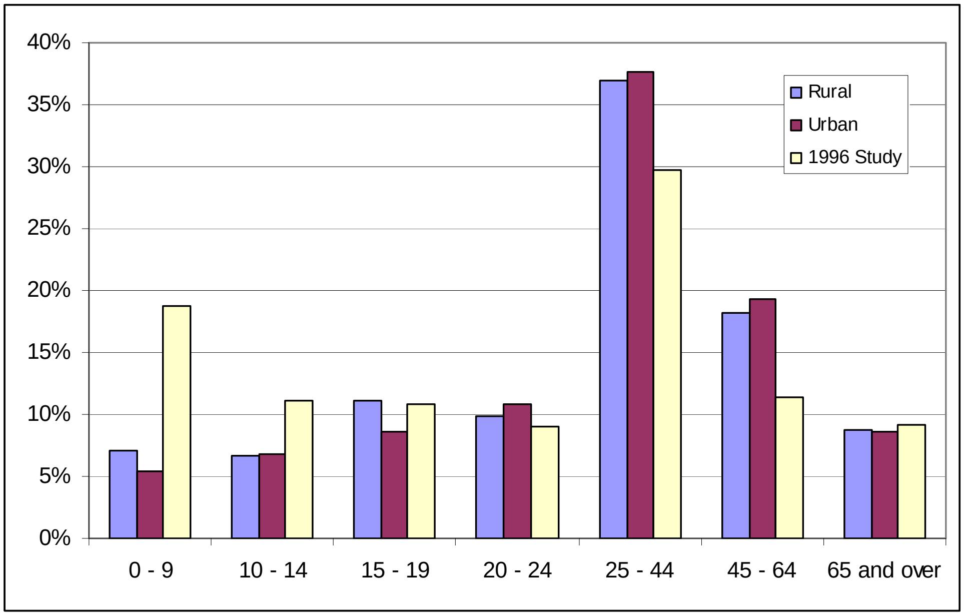


Figure 8. General Comparison - Pedestrian Age

Twenty-four percent of pedestrians in rural crashes and 19% of pedestrians in urban crashes had consumed alcohol. For comparison, 15% of pedestrians in the 1996 study had consumed alcohol. The difference between alcohol involvement in rural and urban areas was significant, with alcohol consumption being overrepresented in rural crashes.

The most common pedestrian injuries in rural and urban crashes were B (evident) injuries (33% and 37%, respectively), followed by C (light or possible) injuries (24% and 31%) and A (disabling) injuries (23% and 19%) (Figure 9). Fatalities made up 18% of rural crashes but only 10% of urban crashes, leading to an overrepresentation of fatalities in rural crashes. Overall, rural crashes incurred more severe injuries to pedestrians than urban crashes.

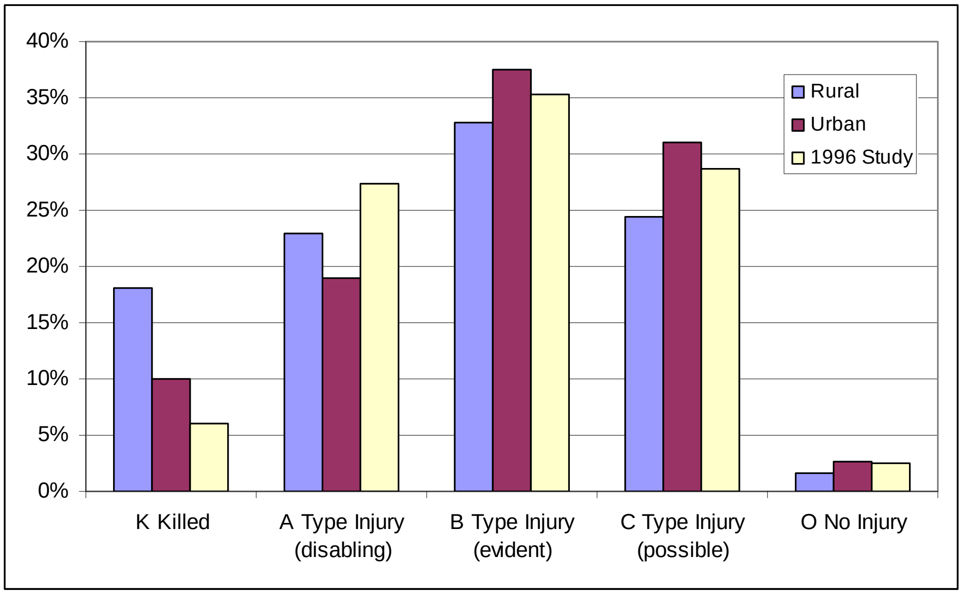


Figure 9. General Comparison - Pedestrian Injury

Driver Characteristics

The most common age range for drivers in rural and urban pedestrian crashes was 25-44 years old (33% and 36%, respectively), followed by 45-64 years old (22% and 21%, respectively) (Figure 10). The 1996 study also showed similar age range statistics. The majority of drivers were male. White and Native American drivers were overrepresented in rural crashes, and black and Hispanic drivers were overrepresented in urban crashes.

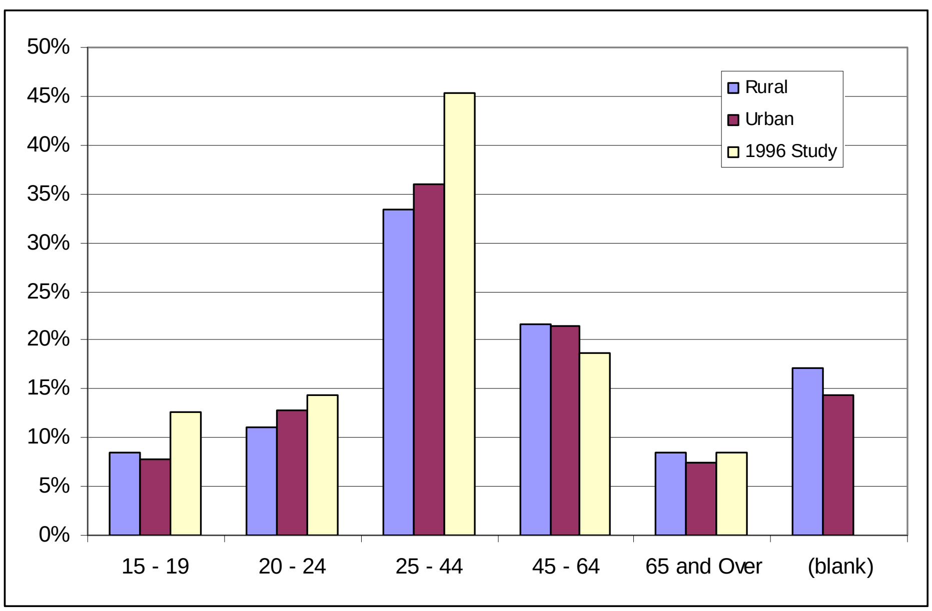


Figure 10. General Comparison - Driver Age in Pedestrian Crashes

Four percent of drivers in rural crashes and 3% of drivers in urban crashes had consumed alcohol. For comparison, 6% of drivers in the 1996 study had consumed alcohol. The vast majority of drivers in all three datasets sustained no injuries from their crash; however, injuries that did occur were more common to rural crashes than urban crashes.

Vehicle Characteristics

The majority of vehicles in all three datasets were passenger cars and pickups. No significant trends in vehicle type were noted. Estimated speeds of vehicles in rural crashes were higher than those in urban crashes (Figure 11). In rural crashes, the largest proportion of vehicles was estimated to have been traveling between 41 and 60 mph (46%), followed by 0-20 mph (27%) and 21-40 mph (22%). In urban crashes, the majority of vehicles were estimated to have been traveling between 0 and 20 mph (40%), followed by 21-40 mph (38%) and 41-60 mph (20%). Again, this difference in speeds may result from both lower speed limits and the prevalence of intersections in urban areas, where motorists would be traveling slowly to make turns or to stop for traffic control.

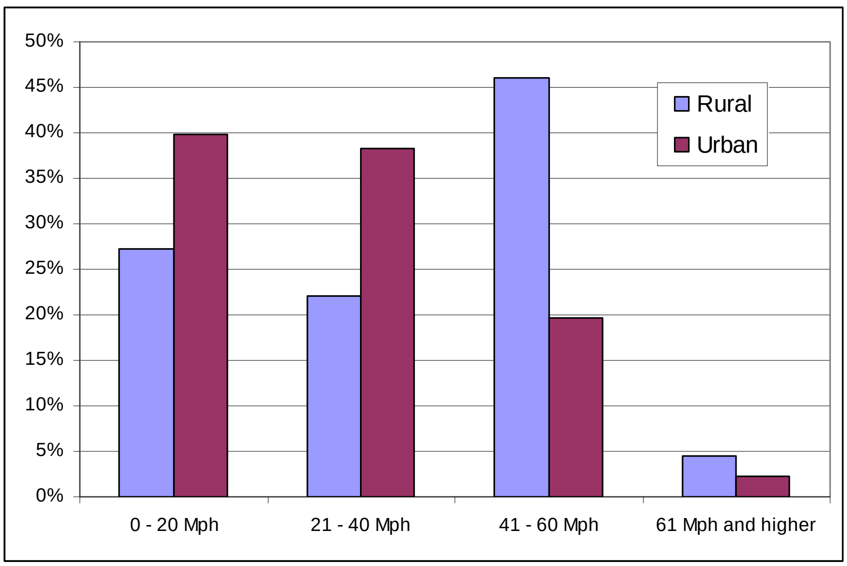


Figure 11. General Comparison - Estimated Vehicle Speeds in Pedestrian Crashes

Crash Characteristics

Crashes in all datasets were spread fairly evenly throughout days of the week, with the exception of weekends, which had an overrepresentation of rural crashes. The largest portion of pedestrian crashes occurred between 6:00pm and 10:00pm for the rural and urban datasets (32% and 30%, respectively) (Figure 12). The next most common time period was 2:00pm-6:00pm for both datasets. The majority of the 1996 study crashes occurred in the 2:00pm-6:00pm time period. During evening and night hours, there were more rural crashes than urban crashes or 1996 study crashes. For crashes occurring during hours of darkness, rural crashes contributed to most of the crashes on non-lighted roadways, and urban crashes contributed to most of the crashes on lighted roadways. The 1996 study followed the trend of the urban crashes with respect to light condition.

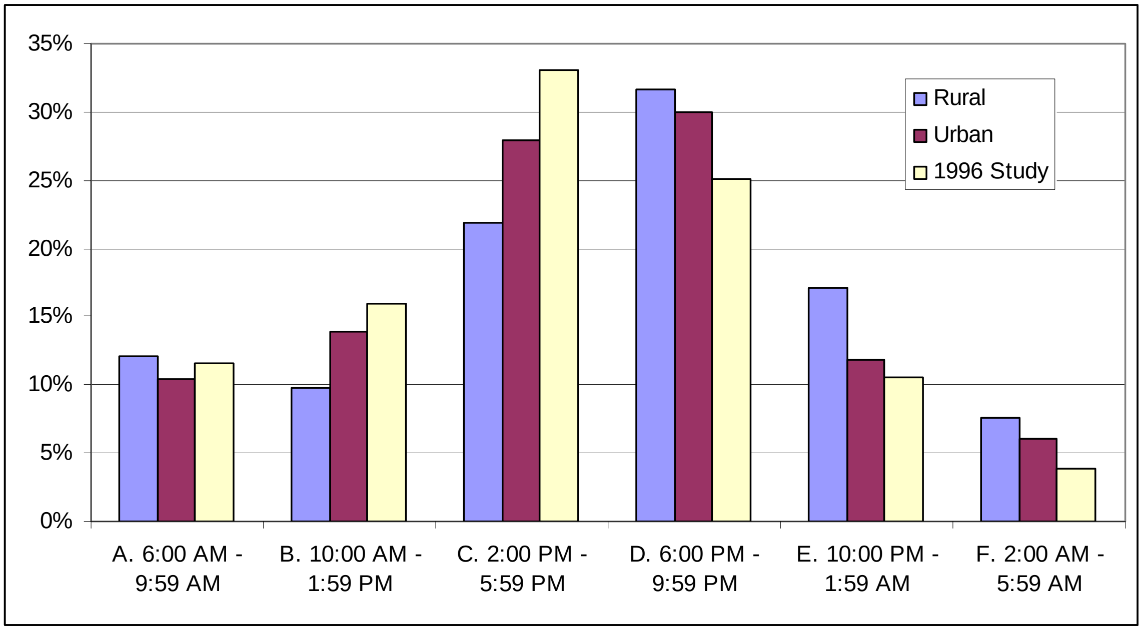


Figure 12. General Comparison - Time of Day of Pedestrian Crashes

The most common crash types for rural crashes were “walking along roadway” (26%), “miscellaneous” (26%), “pedestrian failed to yield” (21%), and “midblock dart/dash” (11%) (Table 2). The most common crash types for urban crashes were “pedestrian failed to yield” (27%), “midblock dart/dash” (19%), “miscellaneous” (17%), and “walking along roadway” (10%). Note that the same four crash types are the most common for both datasets, just in different order of percentages. In addition to this assessment of the overall frequency of each crash type, it is helpful to look at the statistical differences in the crash types of the two datasets. For rural crashes, the most overrepresented crash types (in order, starting with the most overrepresented) were “walking along roadway”, “miscellaneous”, “working/playing in road”. For urban crashes the most overrepresented types were “turning vehicle”, “multiple threat/trapped”, and “midblock dart/dash”. The rural crash types seem to indicate that a lack of shoulders and sidewalks may lead to large amounts of walking, working, and playing in the roadway. Direct comparison to the 1996 study is difficult because crash types were grouped differently, however, general characteristics show that most of the 1996 study crashes concerned midblock occurrences, and a smaller percentage of crashes involved intersections.

Table 2. General Comparison - Types of Pedestrian Crashes

	Rural	Urban	1996 Study
Pedestrian Failed to Yield	21%	27%	
Miscellaneous	26%	17%	15%
Walking Along Roadway	26%	10%	8%
Midblock Dart/Dash	11%	19%	13%
Working/Playing in Road	8%	4%	3%
Turning Vehicle	1%	7%	10%
Motorist Failed to Yield	1%	4%	5%
Crossing Expressway	2%	3%	
Multiple Threat/Trapped	0%	3%	
Backing Vehicle	1%	2%	7%
Unique Midblock	2%	1%	13%
Non-Roadway	1%	2%	9%
Intersection Related	1%	2%	10%

* Comparison according to crash type is difficult because the 1996 study used different crash type grouping, hence the blank cells for some crash types.

Location and Roadway Characteristics

The majority of rural crashes occurred on two-lane roads (76%), compared to urban crashes, which occurred on four-lane (28%) and two-lane roads (27%). Most crashes in both datasets occurred on undivided roads, followed by smaller proportions on roads divided by an unprotected median. The 1996 study had the majority of crashes on roads with one or two lanes.

The majority of rural crashes occurred at non-intersection locations (82%), while urban crashes occurred at non-intersection (55%) and intersection locations (39%). The majority of rural crashes occurred where there was no traffic control (76%), while urban crashes occurred at locations with no traffic control (68%) and locations with signal control (21%).

Land development in rural crash areas was mainly Farms/Woods/Pasture (51%) and residential (30%). Urban crash areas were mainly commercial (68%) and residential (27%). As expected, rural crashes were found to occur on roads with higher speed limits than urban crash locations (Figure 13). The majority of rural crashes occurred on roads with speed limits of 50 mph or higher (57%), followed by 40-45 mph (27%). Urban crashes mainly occurred on roads with speed limits of 30-35 mph (46%), followed by 40-45 mph (32%). The 1996 study crashes occurred mainly in 30-35 mph zones (48%), but had a sizable proportion in 25 mph or lower (25%).

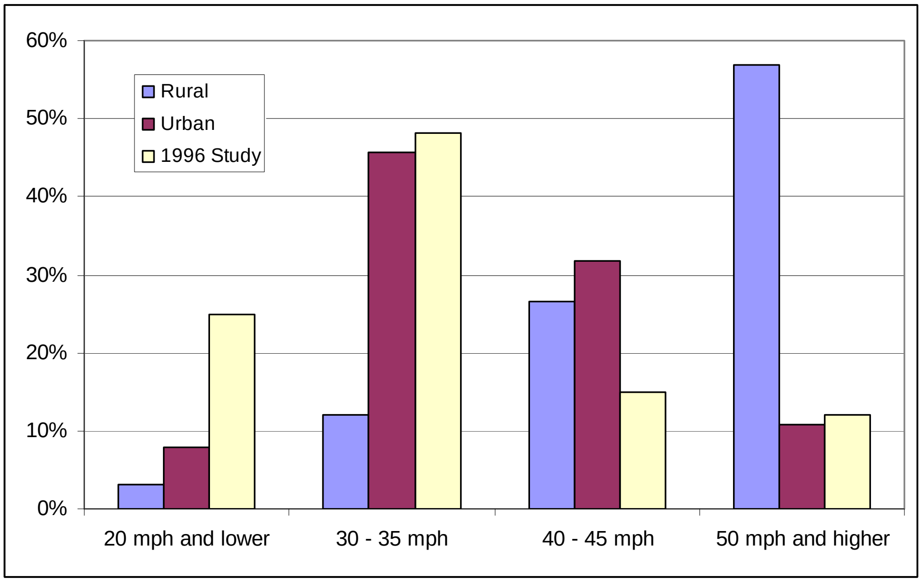


Figure 13. General Comparison - Posted Speed Limit at Pedestrian Crashes

The majority of rural crashes occurred on roads with unpaved shoulders (71%) with a small proportion having paved shoulders (19%). Most of the unpaved shoulders had a width of 4-8 feet. Almost all of the paved shoulder crashes had shoulder widths between 8 and 16 feet. Urban crash shoulder types were mainly curb-and-gutter (65%), followed by unpaved shoulders (18%) and paved shoulders (15%). The 1996 study did not provide good comparison data for shoulder characteristics, since 49% of that study's crashes had no shoulder type indicated.

Summary of General Comparison

The above general comparison of rural to urban crashes can be summarized as follows:

- Rural crashes had a higher percentage of fatalities than urban crashes.
- Rural crashes had higher percentages of bicyclist and pedestrian alcohol consumption than urban crashes.
- Rural crashes had higher estimated vehicle speeds and speed limits than urban crashes.
- For bicycle crashes, the most common crash types were different for rural and urban areas. "Bicyclist turn/merge into path of motorist" and "motorist overtaking" were some of the most common for rural bicycle crashes, and "motorist failed to yield", "bicyclist failed to yield at midblock", and "bicyclist failed to yield at intersection" were some of the most common for urban crashes. One prominent difference is that common rural crash types are ones that would occur at midblock segments while the urban crash types would occur at intersections.
- For pedestrian crashes, both rural and urban areas had the same top three most common crash types, but in different orders. For example, "Walking Along Roadway" was the most common for rural whereas "Pedestrian Failed to Yield" was the most common for urban. Similar to the comparison of bicycle crash types,

the most common rural type has more to do with midblock segments, whereas the most common urban type would mainly occur at intersections.

- The majority of bicycle crashes occurred during daylight for both rural and urban areas. This was different from pedestrian crashes, for which the majority occurred in dark hours for rural areas but daylight for urban areas. This could be due to the fact that bicyclists are less likely to ride at night than pedestrians are to walk at night. For bicycle or pedestrian crashes occurring during hours of darkness, rural crashes occurred mainly on unlighted roadways, whereas urban crashes occurred mainly on lighted roadways.
- By far, the majority of bicycle and pedestrian crashes in rural areas occurred at non-intersection locations. Urban bicycle and pedestrian crashes were more evenly split between intersection and non-intersection locations.
- The majority of rural crashes occurred on roads with unpaved shoulders, whereas the majority of urban crashes occurred on roads with curb-and-gutter shoulders.

Differences between PBCAT and HSIS Rural/Urban Designations

The previous section covering a general comparison of urban crashes to rural crashes was conducted by dividing the bicyclist and pedestrian crashes into two groups according to the PBCAT designation of rural or urban. However, for the comparisons in the sections below involving roadway class, the rural and urban roadway types are defined by the HSIS designation of rural or urban. As is shown in the tables **Error! Reference source not found.**, these two designations do not always match up. While this does not significantly affect the results of this study, it does warrant some discussion.

Table 3. Bike Crashes Comparison of Rural/Urban Designation

		PBCAT Designation	
		Rural	Urban
HSIS Designation	Rural	765	34
	Urban	190	855

Table 4. Pedestrian Crashes Comparison of Rural/Urban Designation

		PBCAT Designation	
		Rural	Urban
HSIS Designation	Rural	1572	62
	Urban	372	1583

The shaded cells in the tables **Error! Reference source not found.** show the number of instances where a crash was designated as urban by PBCAT but given a rural roadway class by HSIS or designated as rural by PBCAT but given an urban HSIS roadway class. This difference in classification happened most often with 2-lane roads that were designated as rural by PBCAT but urban by HSIS. These irregularities occur because there are differences in the way that the rural/urban designations are obtained in each database. The PBCAT designations depend on whether the crash occurred inside or outside municipal limits. The HSIS designations rely mainly on census tract data (population density) to define a crash as rural or urban.

This difference in definitions is not surprising. Definitions of rural and urban commonly vary from city to city and state to state. Even among research projects, the definition is not standardized. Ivan used a population density cutoff to determine if crashes occurred in a rural area, and Oxley more loosely defined rural crashes as occurring outside of "urbanized or built-up" areas (*3*, *10*). Given that this study explores general trends and characteristics of rural and urban crashes, and that the majority of both bicycle and pedestrian crashes fall into the same urban/rural category for both PBCAT and HSIS coding (i.e., the unshaded cells), this difference in definitions does not greatly affect the discussion.

Analysis of Rural Crashes by Road Class

Previous sections of this paper compared rural and urban pedestrian and bicycle crashes by examining their general characteristics and trends. It is the objective of this study, however, to examine rural crashes specifically. Given the availability of roadway inventory data in HSIS, it was possible to examine rural pedestrian and bicycle crashes with respect to characteristics of the roads where they occur. Roads in rural areas can be divided into classes according to number of lanes, level of access control, and other such characteristics. The HSIS classification scheme used in this study divides rural roads into the following categories:

- RUR 2-LANE ROADS – Rural 2-lane roads have partial or no access control, are located outside urbanized areas, and have two lanes.
- RUR MUL DIV NON-FREE – Rural multilane divided non-freeway roads have partial or no access control, are located outside urbanized areas, have three or more lanes, and are divided by some type of median.
- RUR MUL UNDV NON-FREE - Rural multilane undivided non-freeway roads have partial or no access control, are located outside urbanized areas, have three or more lanes, and are not divided by any type of median.
- RUR FREEWAYS – Rural freeways have full access control, are located outside urbanized areas, and have four or more lanes. Roads of this class are typically divided by a median.

North Carolina has a large amount of rural roadway mileage. Table 5 shows the amount of mileage contained in the HSIS database for each road class.

Table 5. Road Class Information for North Carolina

Roadway Class	Mileage		Million Vehicle Miles per Year	
RUR 2-LANE ROADS	30298	94%	23735	61%
RUR MUL DIV NON-FREE	824	3%	4099	10%
RUR MUL UNDV NON-FREE	364	1%	1643	4%
RUR FREEWAYS	900	3%	9619	25%
Grand Total	*32386*	*100%*	*39095*	*100%*

Knowing where crashes occur can assist state officials and engineers in prioritizing locations for countermeasures. The road class analysis shown in Table 6 and Table 7 gives the following values for each road class:

- *Crash frequency* – this value shows the number of bicycle or pedestrian crashes that occurred on the road class. A relatively high frequency of crashes on a particular road class may indicate that the road class is of high priority for safety improvements. This value basically addresses the magnitude of the problem. The number shown is the total crashes over the six years of data collected.

- *Crashes per mile* – this value shows the rate of crashes per road mile in the state. If one is considering treating either the full system or sections of a given system without further targeting (e.g., without further identification of "high-crash locations"), this rate may indicate how expensive it would be to treat a problem. If there is a low rate of crashes per mile, it would indicate that there are a low number of crashes occurring on a commonly used road class. It may be expensive to treat all the mileage of that road class. However, if there is a high rate of crashes per mile, it is probable that there are a relatively high number of crashes occurring on a less common road class. The relatively fewer miles of that road class may make the problem less expensive to treat.
- *Crashes per 100,000 vehicle miles* – this value shows the rate of crashes per 100,000 vehicle miles traveled per year. It uses the amount of vehicle traffic on the road class statewide to show the influence of vehicle traffic on pedestrian and bicycle crashes. This calculation is made possible by the availability of ADT data in HSIS. Although this value does not account for the pedestrian and bicycle exposure, it does account for vehicle exposure. Although vehicle exposure is only part of the story, it is indicative of some level of risk, and actually turns out to correspond fairly closely to the trend in crash frequency.

Table 6. Rural Bicycle Crashes by Road Class

Roadway Class	6-Year Crash Freq	Crashes per 1000 Roadway Miles	Crashes per **100** Million Vehicle Miles per Year
RUR 2-LANE ROADS	725	23.9	0.51
RUR MUL DIV NON-FREE	43	52.2	0.17
RUR MUL UNDV NON-FREE	28	76.9	0.28
RUR FREEWAYS	3	3.3	0.01

Table 7. Rural Pedestrian Crashes by Road Class

Roadway Class	6-Year Crash Freq	Crashes per 1000 Roadway Miles	Crashes per **100** Million Vehicle Miles per Year
RUR 2-LANE ROADS	1331	43.9	0.93
RUR MUL DIV NON-FREE	110	133.5	0.45
RUR MUL UNDV NON-FREE	71	195.1	0.72
RUR FREEWAYS	118	131.1	0.20

These tables give the general picture of the distribution of rural crashes by road class. This allows for the identification of road classes that seem to have an over-represented number or rate of crashes. For bicycle crashes, the crash frequency and crashes per vehicle mile indicate that rural 2-lane roads are the biggest problem, even after vehicle exposure is accounted for. The crashes per roadway miles indicate that rural multilane undivided non-freeway would be the most cost effective to treat.

For pedestrian crashes, crash frequency indicates that rural 2-lane roads are the biggest problem areas. Crashes per road mile indicate that rural multilane undivided non-freeways would be the most cost-effective to treat. Crashes per vehicle mile indicate that rural 2-lane roads and rural multilane undivided non-freeways are the biggest concerns.

Overall, it seems that rural 2-lane roads call attention as the road class with the most priority for safety improvements due to the large number of crashes that occur on these roads. However, this is due in part to the fact that the majority of vehicle miles driven in rural North Carolina are on rural 2-lane roads. Other states may see a different prioritization of road classes.

Analysis of Rural Crashes by Crash Type

One of the most prominent features of the North Carolina pedestrian and bicycle crash database is the crash type data. Based on the crash sketch and narrative, each crash is designated to be a particular crash type, such as "Motorist overtaking a bicyclist" or "Pedestrian walking along roadway". These detailed data on pre-crash actions of the parties involved can prove useful when identifying treatments for problem areas. The following section explores the crashes according to type and road class. Specific combinations of type and road class are identified as problem areas. These problem areas are then explored to determine recurring characteristics of the crashes.

Identification of Problem Areas

Table 8 and Table 9 show the breakdown of pedestrian and bicycle crashes by road class and crash type. Shaded cells indicate a group of crashes that were prioritized by the authors for further examination. These were generally selected according to the number of crashes represented in the cell, but the criteria also considered the potential for treatment. For example, "miscellaneous" is the second most occurring pedestrian crash type; however, the crashes included in that group are so diverse that it would be futile to further examine the crash characteristics.

Table 8. Rural Pedestrian Crashes by Road Class and Crash Type

	Crash Frequency				
Crash Type Group	**RUR 2-LANE ROADS**	**RUR MUL DIV NON-FREE**	**RUR MUL UNDV NON-FREE**	**RUR FREEWAYS**	***Total***
Walking Along Roadway	369	23	13	10	*415*
Miscellaneous	214	22	15	24	*275*
Pedestrian Failed to Yield, Midblock	228	20	18	3	*269*
Midblock Dart/Dash	164	11	7	2	*184*
Vehicle-Vehicle/Object	66	4		20	*90*
Disabled Vehicle-Related	52	4	1	24	*81*
Pedestrian Failed to Yield, Intersection	51	8	7		*66*
Lying in Roadway	39	3		2	*44*
Working in Roadway	34	3		2	*39*
Crossing Expressway		2		28	*30*
Unique Midblock	25	1		2	*28*
Turning Vehicle	18	5	2		*25*
School Bus-Related	21		1	1	*23*
Backing Vehicle	15	2			*17*
Motorist Failed to Yield	11		4		*15*
Non-Roadway	11				*11*
Intersection Related	6	2	2		*10*
Playing in Roadway	6				*6*
Multiple Threat/Trapped	1		1		*2*
Total	*1331*	*110*	*71*	*118*	***1630***

Table 9. Rural Bicycle Crashes by Road Class and Crash Type

	Crash Frequency				
Crash Type Group	**RUR 2-LANE ROADS**	**RUR MUL DIV NON-FREE**	**RUR MUL UNDV NON-FREE**	**RUR FREEWAYS**	***Total***
Bicyclist Turn/Merge Into Path of Motorist, Midblock	225	7	4	1	*237*
Motorist Overtaking, Midblock	175	9	3	1	*188*
Bicyclist Failed to Yield, Midblock	83	3	3	1	*90*
Bicyclist Failed to Yield, Intersection	45	10	2		*57*
Motorist Failed to Yield, Intersection	26	4	2		*32*
Unknown/Insufficient	29		3		*32*
Motorist Turn/Merge Into Path of Bicyclist, Intersection	23	3	3		*29*
Wrong Way Operator	25	1	1		*27*
Motorist Turn/Merge Into Path of Bicyclist, Midblock	22	3	1		*26*
Intersection Crash	16	2			*18*
Bicyclist Turn/Merge Into Path of Motorist, Intersection	14				*14*
Motorist Failed to Yield, Midblock	10	1	2		*13*
Specific Circumstances	12				*12*
Operator Lost Control	8		2		*10*
Motorist Overtaking, Intersection	5				*5*
Motorist Turning Error	4				*4*
Bicyclist Turning Error	1		2		*3*
Bicyclist Overtaking	1				*1*
Bicyclist Did Not Clear Intersection	1				*1*
Total	*725*	*43*	*28*	*3*	***799***

Characteristics of Problem Areas

This section examines the problem areas identified in Table 8 and Table 9. Characteristics of the pedestrian, bicyclist, driver, environment, and roadway are considered for each combination. These characteristics are compared to the characteristics of all crash types on that road class. This comparison allows the analyst to determine which characteristics are over-represented in the problem area. Any overrepresentation may indicate potential treatment areas. For reference, Table 10 and Table 11 display the characteristics across all crash types for each road class. The pages that follow these tables will focus on each problem area individually and refer back to the statistics from each road class as shown in the tables below. For example, the top of Table 10 indicates the distribution of pedestrian age for each road class, disregarding crash type. For each critical crash-type/location combination, the distribution of pedestrian ages will be compared to these general distributions. If, for example, a type/location combination indicates that younger pedestrians are more involved than indicated by the general distribution, treatments more specific to younger pedestrians will be more appropriate.

NOTE: In the tables below, injury severity ranges from type A (most serious injury) to type C (least serious injury) and includes separate codes for fatalities and non-injuries.

Table 10. Pedestrian Crash Characteristics by Road Class for All Crash Types

Characteristic	Value	RUR 2-LANE ROADS		RUR MUL DIV NON-FREE		RUR MUL UNDV NON-FREE		RUR FREEWAYS	
Pedestrian Age	0 - 9	115	**8%**	7	**6%**	7	**9%**	2	**2%**
	10 - 14	109	**8%**	4	**3%**	3	**4%**	2	**2%**
	15 - 19	173	**13%**	6	**5%**	10	**13%**	11	**8%**
	20 - 24	116	**8%**	14	**12%**	6	**8%**	17	**13%**
	25 - 44	467	**34%**	53	**45%**	26	**35%**	63	**47%**
	45 - 64	248	**18%**	24	**21%**	16	**21%**	33	**25%**
	Over 65	139	**10%**	9	**8%**	7	**9%**	5	**4%**
Pedestrian Alcohol	Yes	331	**24%**	39	**33%**	23	**31%**	15	**11%**
	No	1063	**76%**	79	**67%**	52	**69%**	119	**89%**
Pedestrian Injury	K Killed	227	**16%**	32	**27%**	15	**21%**	39	**30%**
	A Type Injury (disabling)	307	**22%**	25	**21%**	27	**37%**	39	**30%**
	B Type Injury (evident)	482	**35%**	34	**29%**	20	**27%**	28	**21%**
	C Type Injury (possible)	347	**25%**	27	**23%**	9	**12%**	24	**18%**
	O No Injury	22	**2%**	0	**0%**	2	**3%**	2	**2%**
Driver Age	15 - 19	143	**9%**	11	**9%**	7	**9%**	7	**4%**
	20 - 24	156	**10%**	21	**17%**	11	**14%**	24	**13%**
	25 - 44	503	**33%**	33	**26%**	23	**29%**	65	**34%**
	45 - 64	320	**21%**	28	**22%**	17	**22%**	38	**20%**
	Over 65	137	**9%**	11	**9%**	8	**10%**	13	**7%**
	(blank)	248	**16%**	22	**17%**	12	**15%**	42	**22%**

Characteristic	Value	RUR 2-LANE ROADS		RUR MUL DIV NON-FREE		RUR MUL UNDV NON-FREE		RUR FREEWAYS	
Driver Alcohol	Yes	56	**4%**	3	**2%**	3	**4%**	10	**5%**
	No	1336	**88%**	111	**87%**	70	**90%**	145	**77%**
	Unknown	119	**8%**	13	**10%**	5	**6%**	34	**18%**
Vehicle Type	Passenger Car	849	**56%**	80	**63%**	46	**59%**	89	**48%**
	Pickup	309	**20%**	16	**13%**	15	**19%**	28	**15%**
	Van	70	**5%**	4	**3%**	6	**8%**	15	**8%**
	Other Vehicle Types	107	**7%**	14	**11%**	7	**9%**	35	**19%**
	Sport Utility	57	**4%**	2	**2%**	0	**0%**	14	**8%**
	Unknown	119	**8%**	11	**9%**	4	**5%**	4	**2%**
Estimated Speed	25 and lower	431	**29%**	35	**28%**	25	**32%**	74	**39%**
	25 - 35 Mph	204	**14%**	10	**8%**	12	**15%**	6	**3%**
	35 - 45 Mph	355	**24%**	22	**17%**	18	**23%**	11	**6%**
	45 - 55 Mph	473	**31%**	54	**43%**	22	**28%**	18	**10%**
	55 and higher	46	**3%**	6	**5%**	1	**1%**	79	**42%**
Speeding Indicated as Factor?	No	1302	**98%**	108	**98%**	70	**99%**	115	**97%**
	Yes	29	**2%**	2	**2%**	1	**1%**	3	**3%**
Light Condition	Daylight	552	**42%**	41	**38%**	25	**35%**	60	**51%**
	Dark - Roadway Not Lighted	663	**50%**	64	**59%**	20	**28%**	48	**41%**
	Dark - Lighted Roadway	61	**5%**	2	**2%**	20	**28%**	5	**4%**
	Dusk	30	**2%**	1	**1%**	3	**4%**	1	**1%**
	Dawn	20	**2%**	1	**1%**	3	**4%**	4	**3%**
Day of Week	Weekend	414	**31%**	36	**33%**	25	**35%**	37	**31%**
	Weekday	917	**69%**	74	**67%**	46	**65%**	81	**69%**
Time of Day	A. 6:00 AM - 9:59 AM	159	**12%**	4	**4%**	5	**7%**	19	**16%**
	B. 10:00 AM - 1:59 PM	127	**10%**	16	**15%**	4	**6%**	15	**13%**
	C. 2:00 PM - 5:59 PM	309	**23%**	20	**18%**	15	**21%**	26	**22%**
	D. 6:00 PM - 9:59 PM	424	**32%**	36	**33%**	32	**45%**	24	**20%**
	E. 10:00 PM - 1:59 AM	213	**16%**	21	**19%**	11	**15%**	22	**19%**
	F. 2:00 AM - 5:59 AM	99	**7%**	13	**12%**	4	**6%**	12	**10%**
Weather	Clear	978	**76%**	85	**79%**	49	**71%**	86	**78%**
	Cloudy	208	**16%**	17	**16%**	15	**22%**	17	**15%**
	Rain	96	**7%**	5	**5%**	5	**7%**	7	**6%**
Road Grade and Curvature	Curve - Grade	57	**4%**	4	**4%**	0	**0%**	7	**6%**
	Curve - Hillcrest	9	**1%**	0	**0%**	0	**0%**	2	**2%**
	Curve - Level	92	**7%**	6	**5%**	2	**3%**	6	**5%**
	Straight - Bottom	23	**2%**	2	**2%**	0	**0%**	0	**0%**
	Straight - Grade	202	**15%**	20	**18%**	14	**20%**	20	**17%**
	Straight - Hillcrest	35	**3%**	2	**2%**	1	**1%**	2	**2%**
	Straight - Level	909	**69%**	75	**68%**	54	**76%**	81	**69%**
	Unknown	0	**0%**	1	**1%**	0	**0%**	0	**0%**
Speed Limit	25 and lower	53	**4%**	3	**3%**	6	**8%**	0	**0%**
	30 - 35 Mph	163	**12%**	7	**6%**	19	**27%**	1	**1%**
	40 - 45 Mph	308	**23%**	20	**18%**	24	**34%**	5	**4%**

Characteristic	Value	RUR 2-LANE ROADS		RUR MUL DIV NON-FREE		RUR MUL UNDV NON-FREE		RUR FREEWAYS	
	50 and higher	790	**59%**	77	**70%**	21	**30%**	111	**94%**
	Unknown	17	**1%**	3	**3%**	1	**1%**	1	**1%**
Intersection	Intersection	195	**15%**	22	**21%**	21	**31%**	3	**3%**
	Non-Intersection Location	1096	**85%**	85	**79%**	47	**69%**	113	**97%**
Traffic Control	No Control Present	986	**75%**	89	**82%**	54	**76%**	108	**93%**
	Double Yellow Line	198	**15%**	3	**3%**	5	**7%**	0	**0%**
	Stop Sign	65	**5%**	4	**4%**	1	**1%**	0	**0%**
	Stop And Go Signal	28	**2%**	8	**7%**	10	**14%**	1	**1%**
	Human Control	30	**2%**	3	**3%**	0	**0%**	0	**0%**
	Other	11	**1%**	1	**1%**	1	**1%**	7	**6%**
Land Use	Farms - Woods - Pastures	717	**54%**	54	**50%**	13	**19%**	106	**90%**
	Residential	410	**31%**	15	**14%**	15	**21%**	3	**3%**
	Commercial	173	**13%**	39	**36%**	41	**59%**	9	**8%**
	Institutional	25	**2%**	1	**1%**	1	**1%**	0	**0%**
Shoulder Type	Unpaved	1149	**86%**	16	**15%**	12	**17%**	0	**0%**
	Paved	106	**8%**	69	**63%**	12	**17%**	113	**100%**
	Curb and gutter	74	**6%**	25	**23%**	47	**66%**	0	**0%**
Shoulder Width	1 - 4	99	**7%**	0	**0%**	1	**1%**	0	**0%**
	4 - 8	783	**59%**	9	**8%**	3	**4%**	0	**0%**
	8 - 12	292	**22%**	29	**27%**	15	**21%**	41	**39%**
	12 - 16	43	**3%**	44	**41%**	4	**6%**	65	**61%**
	Over 16	0	**0%**	0	**0%**	0	**0%**	0	**0%**
	(blank)	113	**8%**	26	**24%**	47	**67%**	0	**0%**

Table 11. Bicycle Crash Characteristics by Road Class for All Crash Types

Characteristic	Value	RUR 2-LANE ROADS		RUR MUL DIV NON-FREE	
Bicyclist Age	0 – 9	54	**8%**	1	**2%**
	10 – 14	171	**24%**	2	**5%**
	15 – 19	95	**13%**	7	**16%**
	20 – 24	47	**7%**	8	**19%**
	25 – 44	226	**31%**	16	**37%**
	45 – 64	100	**14%**	9	**21%**
	65 and Over	25	**3%**	0	**0%**
Bicyclist Alcohol	Yes	50	**7%**	4	**9%**
	No	363	**50%**	19	**43%**
	Unknown	317	**43%**	21	**48%**
Bicyclist Injury	K Killed	40	**5%**	4	**9%**
	A Type Injury (disabling)	128	**18%**	7	**16%**
	B Type Injury (evident)	321	**44%**	19	**43%**
	C Type Injury (possible)	209	**29%**	11	**25%**
	O No Injury	30	**4%**	3	**7%**
Driver Age	15 - 19	65	**9%**	3	**7%**
	20 - 24	84	**11%**	7	**16%**
	25 - 44	259	**35%**	10	**23%**
	45 - 64	176	**24%**	16	**37%**
	65 and Over	82	**11%**	4	**9%**
	(blank)	78	**10%**	3	**7%**
Driver Alcohol	Yes	16	**2%**	3	**7%**
	No	699	**94%**	40	**93%**
	Unknown	30	**4%**	0	**0%**
Vehicle Type	Passenger Car	445	**60%**	29	**67%**
	Pickup	140	**19%**	4	**9%**
	Van	39	**5%**	4	**9%**
	Other Vehicle Types	37	**5%**	3	**6%**
	Sport Utility	24	**3%**	2	**5%**
	Unknown	59	**8%**	1	**2%**
Estimated Speed of Vehicle	25 and lower	166	**22%**	11	**26%**
	25 - 35 Mph	124	**17%**	0	**0%**
	35 - 45 Mph	222	**30%**	9	**21%**
	45 - 55 Mph	216	**29%**	22	**51%**
	55 and higher	12	**2%**	1	**2%**
Bicyclist Position	On a street- in a shared travel lane	532	**76%**	31	**74%**
	On a street- bicycle lane or paved shoulder	66	**9%**	5	**12%**
	On a separate bicycle/multi-use path	8	**1%**	0	**0%**
	On a sidewalk- crosswalk/driveway crossing	7	**1%**	1	**2%**
	On a driveway or alley	54	**8%**	2	**5%**

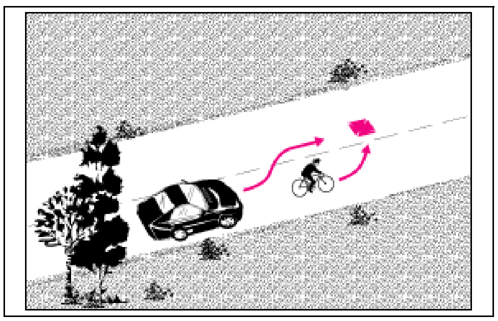
Characteristic	Value	RUR 2-LANE ROADS		RUR MUL DIV NON-FREE	
	Other non-roadway areas	14	**2%**	1	**2%**
	Other	20	**3%**	2	**5%**
Bicyclist Direction	With traffic	510	**75%**	29	**76%**
	Facing traffic	95	**14%**	6	**16%**
	Not applicable	79	**12%**	3	**8%**
Speeding Indicated as Factor?	No	714	**98%**	42	**98%**
	Yes	11	**2%**	1	**2%**
Light Condition	Daylight	496	**69%**	23	**53%**
	Dark - Roadway Not Lighted	173	**24%**	14	**33%**
	Dark - Lighted Roadway	13	**2%**	1	**2%**
	Dusk	34	**5%**	2	**5%**
	Dawn	7	**1%**	3	**7%**
Day of Week	Weekend	251	**35%**	9	**21%**
	Weekday	474	**65%**	34	**79%**
Time of Day	A. 6:00 AM - 9:59 AM	62	**9%**	6	**14%**
	B. 10:00 AM - 1:59 PM	134	**18%**	8	**19%**
	C. 2:00 PM - 5:59 PM	265	**37%**	13	**30%**
	D. 6:00 PM - 9:59 PM	205	**28%**	9	**21%**
	E. 10:00 PM - 1:59 AM	46	**6%**	5	**12%**
	F. 2:00 AM - 5:59 AM	13	**2%**	2	**5%**
Weather	Clear	599	**83%**	32	**74%**
	Cloudy	95	**13%**	10	**23%**
	Rain	28	**4%**	1	**2%**
Road Grade and Curvature	Curve - Bottom	5	**1%**	1	**2%**
	Curve - Grade	37	**5%**	0	**0%**
	Curve - Hillcrest	5	**1%**	0	**0%**
	Curve - Level	58	**8%**	1	**2%**
	Straight - Bottom	11	**2%**	1	**2%**
	Straight - Grade	98	**14%**	3	**7%**
	Straight - Hillcrest	20	**3%**	0	**0%**
	Straight - Level	488	**68%**	37	**86%**
Speed Limit	25 and lower	29	**4%**	0	**0%**
	30 - 35	100	**14%**	4	**9%**
	40 - 45	155	**22%**	4	**9%**
	55 and higher	428	**60%**	35	**81%**
Intersection	Intersection	133	**18%**	19	**44%**
	Intersection-Related	9	**1%**	0	**0%**
	Non-Intersection Location	577	**80%**	24	**56%**
Traffic Control	No Control Present	521	**72%**	24	**56%**
	Double Yellow Line	100	**14%**	1	**2%**
	Stop Sign	81	**11%**	8	**19%**
	Stop And Go Signal	15	**2%**	9	**21%**
	Flashing Signal With Stop Sign	4	**1%**	1	**2%**

Characteristic	Value	RUR 2-LANE ROADS		RUR MUL DIV NON-FREE	
	Other	2	**0%**	0	**0%**
Development	Farms - Woods - Pastures	397	**55%**	21	**49%**
	Residential	236	**33%**	1	**2%**
	Commercial	82	**11%**	21	**49%**
	Institutional	7	**1%**	0	**0%**
Shoulder Type	Unpaved	632	**87%**	9	**21%**
	Paved	53	**7%**	27	**63%**
	Curb and gutter	40	**6%**	7	**16%**
Shoulder Width	1 - 4	55	**8%**	0	**0%**
	4 - 8	424	**59%**	0	**0%**
	8 - 12	168	**23%**	16	**37%**
	12 - 16	22	**3%**	19	**44%**
	Over 16	0	**0%**	1	**2%**
	(blank)	55	**8%**	7	**16%**

Characteristics of Bicycle Problem Area Crashes

The characteristics of each combination are compared to the characteristics of all crash types on that road class (Table 11) to determine if they are out of the ordinary.

Crash Type: Bicyclist Turn/Merge into Path of Motorist, Midblock
Road Class: RUR 2-LANE ROADS
Number of Crashes: **225** (31% of all Rural 2-Lane Road crashes)
Crash Type Definition: The bicyclist turns or merges into the path of an overtaking or oncoming motorist at a midblock location. These crashes can also involve a bicyclist riding out from a sidewalk or path beside the road. The bicycle and the motor vehicle are initially on parallel paths.



Graphics and crash type definition taken from http://www.bicyclinginfo.org/bikesafe/crash_analysis-types.cfm

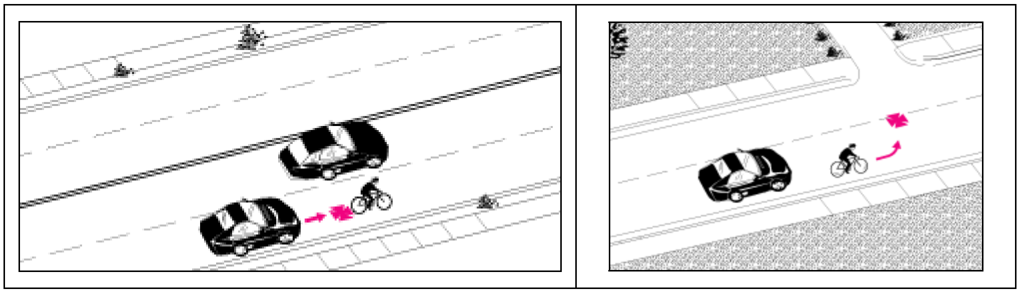
Prominent characteristics (compared to all crash types on rural 2-lane roads):

- More **10-14 year old bicyclists** (39% vs. 24% avg)
- **Higher estimated vehicle speeds** (41% were "45-55 Mph" vs. 29% avg)
- Majority of bicyclists were traveling in **same direction with traffic** (83%)
- Mostly occurred in **daylight** (75%)
- Occurs more frequently in zones with **high speed limits** (71% in "55 mph or higher" vs. 60% avg)
- Occurs more frequently in areas with **Farms/Woods/Pastures** development (65% vs. 55% avg)
- No difference from the average characteristics with respect to shoulder width and shoulder type.

Summary Statement:

This crash type and road class combination occurred in very rural areas with high speed roads and involved a disproportionately high proportion of young bicyclists.

Crash Type: Motorist Overtaking, Midblock
Road Class: RUR 2-LANE ROADS
Number of Crashes: **175** (24% of all Rural 2-Lane Road crashes)
Crash Type Definition: The motorist is overtaking a bicyclist and strikes the bicyclist from behind at a midblock location. These crashes tend to occur because the motorist fails to detect the bicyclist, the bicyclist swerves to the left to avoid an object or surface irregularity, or the motorist misjudges the space necessary to pass the bicyclist.



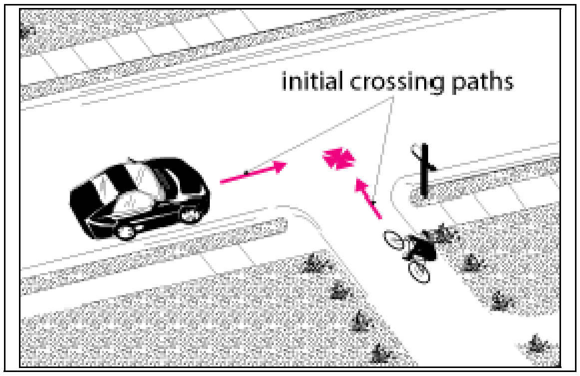
Graphics and crash type definition taken from
http://www.bicyclinginfo.org/bikesafe/crash_analysis-types.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- Young bicyclists not prominent; higher than average proportion of **adult bicyclists** (44% were 25-44 years old vs. 31% avg)
- More **fatalities** (9% vs. 5% avg)
- 23% are **hit and run**, therefore many drivers' ages, alcohol involvement, and vehicle type are unknown.
- Most bicyclists were **in a travel lane** (90%) and the rest were in a bicycle lane or on a paved shoulder (10%)
- More crashes occurred **in the dark on unlighted roadways** (43% vs. 24% avg); fewer occurred in daylight (51% vs. 69% avg)
- More crashes occurred at **morning and night hours** (15% from "6-10 am" vs. 9% avg; 12% from "10pm-2am" vs. 6% avg)
- More frequently occurred in zones with **high speed limits** (over 40 mph) (91% vs. 82% avg)
- Occurs more frequently in areas with **Farms/Woods/Pastures** development (61% vs. 55% avg)
- Occurs more frequently on roads with **unpaved shoulders** (95% vs. 87% avg)

Summary Statement:
This crash type and road class combination occurred in very rural areas with a disproportionately high proportion of high speed limits, and unlighted roadways. There was also a moderate over-representation of unpaved shoulders. Additionally, these crashes were more severe than other crashes on this road class.

Crash Type: Bicyclist Failed to Yield, Midblock
Road Class: RUR 2-LANE ROADS
Number of Crashes: **83** (11% of all Rural 2-Lane Road crashes)
Crash Type Definition: The bicyclist rides out from a residential driveway, commercial driveway, sidewalk, or other mid-block location into the road without stopping and is struck by or collides with a motorist.



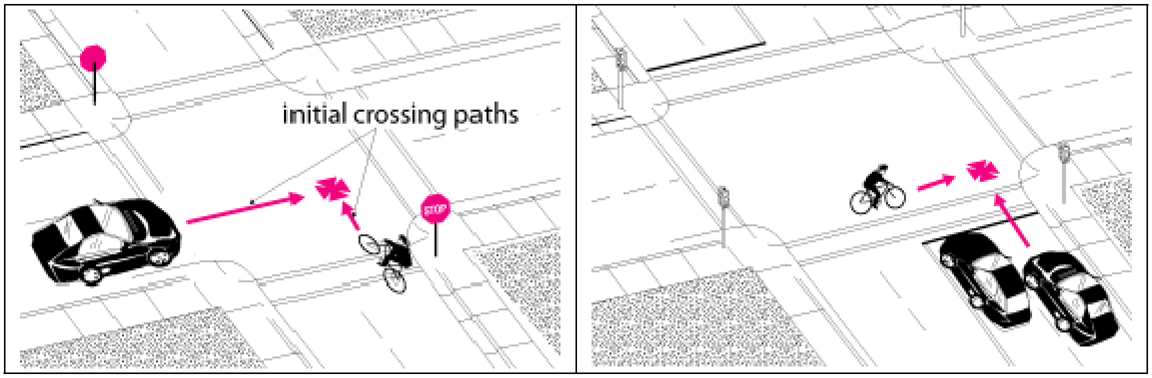
Graphics and crash type definition taken from http://www.bicyclinginfo.org/bikesafe/crash_analysis-types.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- Many more **young bicyclists** (35% were "0-9 years old" vs. 8% avg; 33% were "10-14 years old" vs. 24% avg)
- Higher occurrence of **A-class injuries** (24% vs. 18% avg); fewer C-class injuries
- More estimated **speeds in mid-ranges** (63% from 25-45 mph vs. 47% avg); much fewer estimated speeds in low range (7% at "25mph and lower" vs. 22% avg)
- More crashes occurred in **daylight** (86% vs. 69% avg)
- Occurred more frequently in zones with **speed limits of 55 and higher** (66% vs. 60% avg)
- Occurred more frequently in **residential areas** (47% vs. 33% avg)
- Occurred more frequently on roads with **unpaved shoulders** (95% vs. 87% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of young bicyclists, residential areas, higher estimated speeds and speed limits. There was also a moderate over-representation of unpaved shoulders.

Crash Type: Bicyclist Failed to Yield, Intersection
Road Class: RUR 2-LANE ROADS
Number of Crashes: **45** (6% of all Rural 2-Lane Road crashes)
Crash Type Definition: The bicyclist enters an intersection and fails to stop or yield at a non-signalized intersection (typically controlled by a stop sign), colliding with a motorist who is traveling through the intersection; OR the bicyclist enters an intersection on a red signal or is caught in the intersection by a signal change, colliding with a motorist who is traveling through the intersection on green.



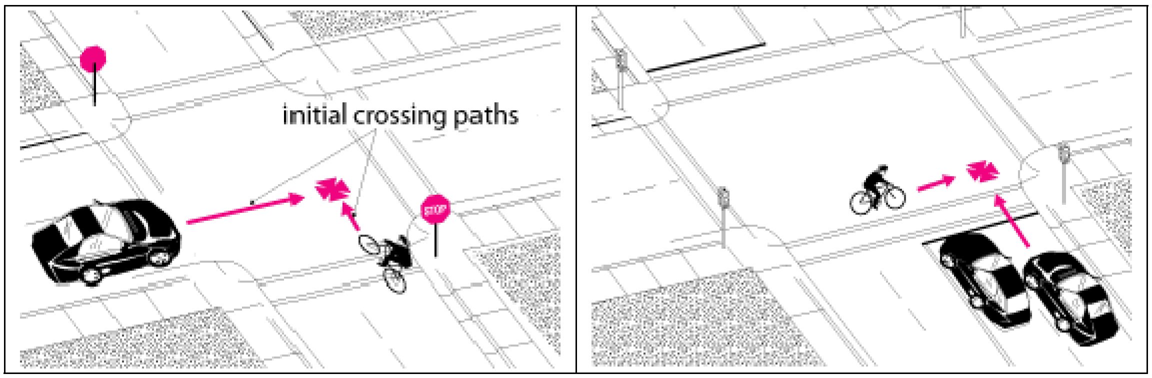
Graphics and crash type definition taken from http://www.bicyclinginfo.org/bikesafe/crash_analysis-types.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- More **child and teenage bicyclists** (14% were "0-9 years old" vs. 8% avg; 21% were "15-19 years old" vs. 13% avg)
- More occurrences of A-type injuries (25% vs. 18% avg), but also more non-injury crashes (9% vs. 4% avg)
- More estimated **speeds in mid-ranges** (26% at "25-35 mph" vs. 17% avg)
- More crashes occurred in **daylight** (80% vs. 69% avg)
- Occurred more frequently on **weekdays** (84% vs. 65% avg)
- Occurred more frequently in zones with **speed limits of 30-35 mph** (31% vs. 14% avg)
- Occurred more frequently in **residential areas** (47% vs. 33% avg)
- Occurred more frequently on roads with **curb and gutter shoulders** (13% vs. 6% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of younger bicyclists, residential areas, and mid-range speed limits.

Crash Type: Bicyclist Failed to Yield, Intersection
Road Class: RURAL MULTILANE DIVIDED NON-FREEWAY
Number of Crashes: **10** (23% of all Rural Multilane Divided Non-Freeway crashes)
Crash Type Definition: The bicyclist enters an intersection and fails to stop or yield at a non-signalized intersection (typically controlled by a stop sign), colliding with a motorist who is traveling through the intersection; OR the bicyclist enters an intersection on a red signal or is caught in the intersection by a signal change, colliding with a motorist who is traveling through the intersection on green.



Graphics and crash type definition taken from http://www.bicyclinginfo.org/bikesafe/crash_analysis-types.cfm

Prominent characteristics (compared to all crash types on rural multilane divided non-freeways):

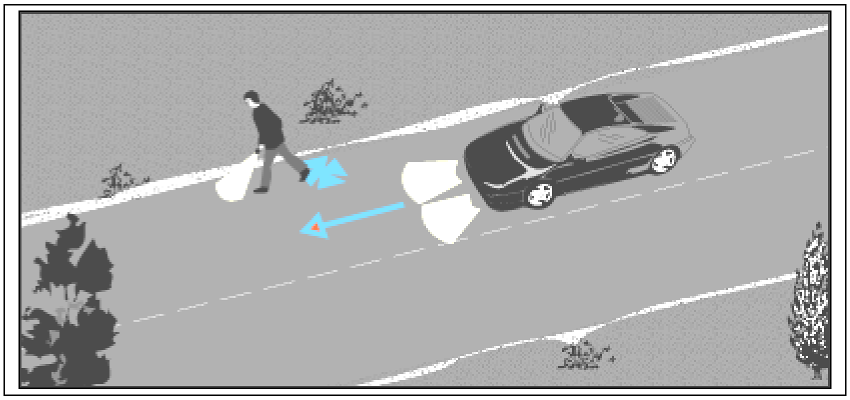
- More **teenage and young adult bicyclists** (40% were "15-19 years old" vs. 16% avg; 40% were "20-24 years old" vs. 19% avg)
- **High estimated vehicle speeds** (60% were "45-55 mph")
- More crashes occurred in the **dark on unlighted roadways** (40% vs. 33% avg)
- Occurred more frequently on **weekdays** (100% vs. 79% avg)
- Occurred more frequently in zones with **speed limits of 55 mph and higher** (90% vs. 81% avg)
- Occurred more frequently on roads with **paved shoulders** (80% vs. 63% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of teenage and young adult bicyclists, high speed limits, dark roadways, and paved shoulders.

Characteristics of Pedestrian Problem Area Crashes

The characteristics of each combination are compared to the characteristics of all crash types on that road class (Table 10) to determine if they are out of the ordinary.

Crash Type: Walking Along Roadway
Road Class: RUR 2-LANE ROADS
Number of Crashes: **369** (27% of all Rural 2-Lane Road crashes)
Crash Type Definition: The pedestrian was walking or running along the roadway and was struck from the front or from behind by a vehicle.



Graphics and crash type definition taken from
http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- More pedestrians **25-44 years old** (45% vs. 34% avg); few young and elderly pedestrians
- More **pedestrian alcohol** consumption (35% vs. 24% avg)
- **Higher estimated vehicle speeds** (28% were "35-45mph" vs. 24% avg; 39% were "45-55mph" vs. 31% avg)
- Occurred much more frequently **in the dark on unlighted roadways** (76% vs. 50% avg)
- Occurred more frequently in zone with **speed limits of 50mph or higher** (68% vs. 60% avg)
- Occurred more frequently in areas with **Farms/Woods/Pastures** development (64% vs. 54% avg)
- Occurred more frequently on roads with **unpaved shoulders** (92% vs. 86% avg)
- Driver age, driver alcohol involvement, and vehicle type had many unknown values, most likely due to the fact that 21% of crashes were "hit and run".

Special Analysis
Additional data in the database on the pedestrian's direction with respect to the direction of traffic made it possible to take a further look at this problem area. Table 12 shows that 47% of "walking along roadway" crashes on rural 2-lane roads occurred with the motor vehicle striking the pedestrian from behind while they were walking *with* traffic. In North Carolina, where these crashes occurred, it is the rule (and assumed general practice) that

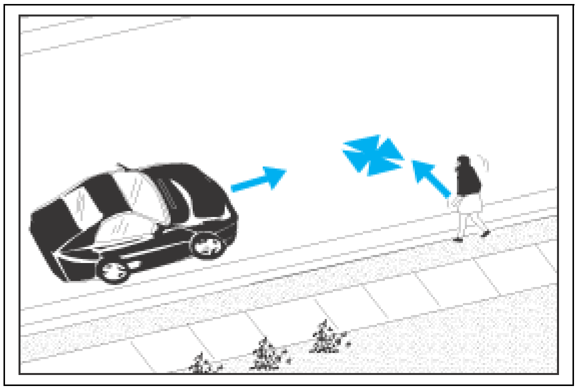
pedestrians should walk on the left side of the road facing traffic. If we assume that most pedestrians follow this rule, then pedestrians being hit from behind while walking with traffic are greatly overrepresented (47%).

Table 12. Pedestrian Walking Direction with Respect to Traffic Flow

Crash Type	N	%
Walking along roadway, with traffic, hit from behind	174	47%
Walking along roadway, against traffic, hit from front	63	17%
Walking along roadway, against traffic, hit from behind	25	7%
Walking along roadway, with traffic, hit from front	7	2%
Walking along roadway, other or direction unknown	100	27%
Total	*369*	*100%*

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of pedestrian alcohol consumption, high vehicle speeds, and dark roadways. There was a moderate over-representation of unpaved shoulders. There was also an over-representation of pedestrians hit from behind while walking with traffic.

Crash Type: Pedestrian Failed to Yield, Midblock
Road Class: RUR 2-LANE ROADS
Number of Crashes: **228** (17% of all Rural 2-Lane Road Crashes)
Crash Type Definition: The pedestrian failed to yield to the motorist at a midblock location, but further detail is unavailable.



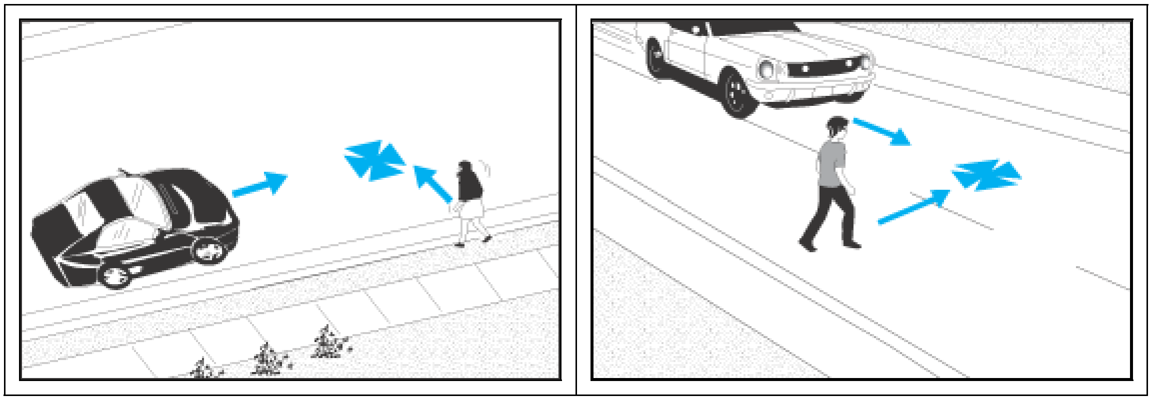
Graphic taken from http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- More **older pedestrians** (19% were "over 65 years old" vs. 10% avg)
- 24% of crashes involved pedestrians that had consumed alcohol, which is the average for this road class.
- Much **higher fatalities** (27% vs. 16% avg) and **A-class injuries** (31% vs. 22% avg)
- **Higher estimated vehicle speeds** (39% were "45-55mph" vs. 31% avg); much fewer occurrences at low speeds (13% were "25 mph and lower" vs. 29% avg)
- Occurred slightly more frequently in **residential** (35% vs. 31% avg) and **commercial** areas (18% vs. 13% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of older pedestrians and high vehicle speeds. These crashes were also much more severe than other crash types that occurred on this road class.

Crash Type: Midblock Dart/Dash
Road Class: RUR 2-LANE ROADS
Number of Crashes: **164** (12% of all Rural 2-Lane Road crashes)
Crash Type Definition: The pedestrian walked or ran into the roadway at an intersection or midblock location and was struck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before the impact.



Graphics and crash type definition taken from
http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- Many more **young pedestrians** (37% were "0-9 years old" vs. 8% avg; 21% were "10-14 years old" vs. 8% avg)
- **Low pedestrian alcohol**: fewer pedestrians consumed alcohol (7% vs. 24% avg)
- More **A-class injuries** (33% vs. 22% avg)
- Occurred more frequently in **daylight** (66% vs. 42% avg); much fewer in dark (27% vs. 55% avg)
- Many more occurred from **2pm-6pm** (42% vs. 23% avg)
- Occurred more frequently in zones of **30-35 mph speed limit** (20% vs. 12% avg)
- Occurred more frequently in **commercial areas** (24% vs. 13% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of young child pedestrians, occurrences in the daylight (particularly 2pm – 6pm), mid-range speed limits, and commercial areas.

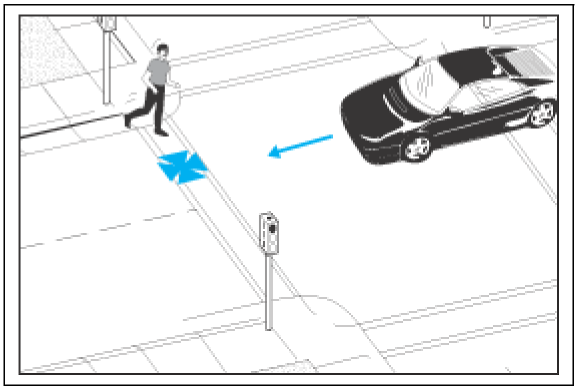
Crash Type: Disabled Vehicle Related
Road Class: RUR 2-LANE ROADS
Number of Crashes: **52** (4% of all Rural 2-Lane Road crashes)
Crash Type Definition: A vehicle struck a pedestrian who was standing or walking near a disabled vehicle.

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- **Relatively low pedestrian alcohol**: fewer pedestrians consumed alcohol (14% vs. 24% avg)
- Driver age and driver alcohol involvement had many unknown values, most likely due to the fact that 13% of crashes were “hit and run”.
- Many more occurred at **estimated speeds of 25 mph or lower** (52% vs. 29% avg)
- Occurred more frequently in the **dark on unlighted roadways** (65% vs. 50% avg)
- Occurred much more frequently in the **rain** (23% vs. 7% avg)
- Occurred more frequently on **level horizontal curves** (13% vs. 7% avg) and **straight roads on a grade** (27% vs. 15% avg)
- Occurred more frequently in zones of **speed limit 50 mph and higher** (73% vs. 59%)
- Occurred more frequently in areas with **Farms/Woods/Pastures** development (73% vs. 54% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of occurrences on curves and grades, high speed limits, dark roadways and rainy weather. Most of these characteristics indicate a lack of visibility. It also should be noted that estimated vehicle speeds were disproportionately low although the crashes occurred mostly in high speed limit zones. This could be due to the fact that the vehicle in motion was slowing down to assist or attempting to stop at the last minute.

Crash Type: Pedestrian Failed to Yield, Intersection
Road Class: RUR 2-LANE ROADS
Number of Crashes: **51** (4% of all Rural 2-Lane Road Crashes)
Crash Type Definition: The pedestrian failed to yield to the motorist at an intersection, but further detail is unavailable.



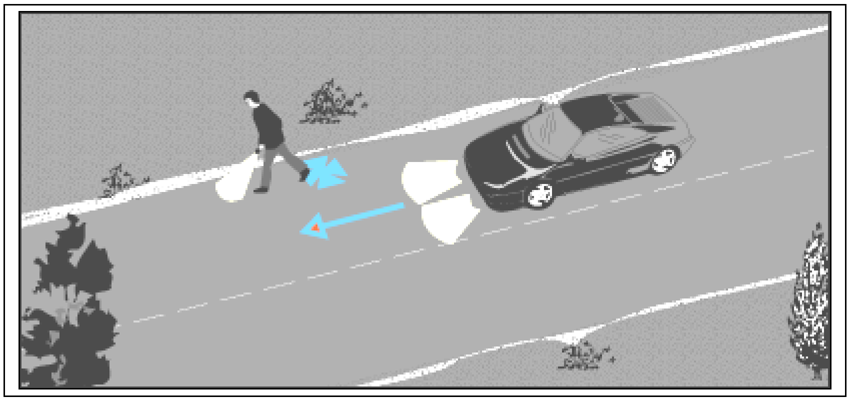
Graphic taken from http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural 2-lane roads):

- More **older pedestrians** (29% were "over 65 years old" vs. 10% avg)
- Slightly more **pedestrian alcohol** consumption (29% vs. 24% avg)
- More **older drivers** (18% vs. 9% avg)
- **Mid-range estimated vehicle speeds** (27% were "25-35 mph" vs. 14% avg)
- Occurred more frequently in the **dark on unlighted roadways** (14% vs. 5% avg)
- Occurred more frequently in zones with **speed limits of 30-35 mph** (31% vs. 12% avg)
- Occurred more frequently in **commercial** areas (37% vs. 13% avg)
- Occurred more frequently on roads with **curb-and-gutter shoulders** (14% vs. 6% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of older pedestrians, older drivers, dark roadways, and commercial areas. Many of these outstanding characteristics indicate a lack of visibility and slow response speed, either due to age or low light.

Crash Type: Walking Along Roadway
Road Class: RURAL MULTILANE DIVIDED NON-FREEWAY
Number of Crashes: **23** (21% of all Rural Multilane Divided Non-Freeway crashes)
Crash Type Definition: The pedestrian was walking or running along the roadway and was struck from the front or from behind by a vehicle.



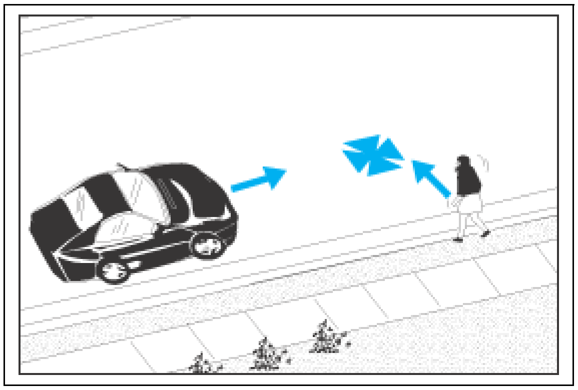
Graphics and crash type definition taken from
http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural multilane divided non-freeways):

- More **pedestrian alcohol** consumption (48% vs. 33% avg)
- Fewer fatalities (20% vs. 27% avg), but more A-class and B-class injuries
- Driver age, driver alcohol involvement, and vehicle type had many unknown values, most likely due to the fact that 21% of crashes were "hit and run".
- **Higher estimated vehicle speeds** (70% were "45-55mph" vs. 43% avg)
- Occurred much more frequently **in the dark on unlighted roadways** (83% vs. 59% avg)
- Occurred more frequently on **level horizontal curves** (13% vs. 5% avg)
- Occurred more frequently in zone with **speed limits of 50mph or higher** (83% vs. 70% avg)
- Occurred more frequently in areas of **Farms/Woods/Pastures** development (61% vs. 50% avg)
- Occurred more frequently on roads with **paved shoulders** (78% vs. 63% avg)
- Occurred more frequently on roads with **12-16 foot shoulders** (52% vs. 41% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of pedestrian alcohol consumption, high vehicle speeds and speed limits, dark roadways, and road curves. It is also interesting to note that there were disproportionately more occurrences on roads with paved and wide shoulders – characteristics that may increase the likelihood of pedestrians walking along the roadway.

Crash Type: Pedestrian Failed to Yield, Midblock
Road Class: RURAL MULTILANE DIVIDED NON-FREEWAY
Number of Crashes: **20** (18% of all Rural Multilane Divided Non-Freeway crashes)
Crash Type Definition: The pedestrian failed to yield to the motorist at a midblock location, but further detail is unavailable.



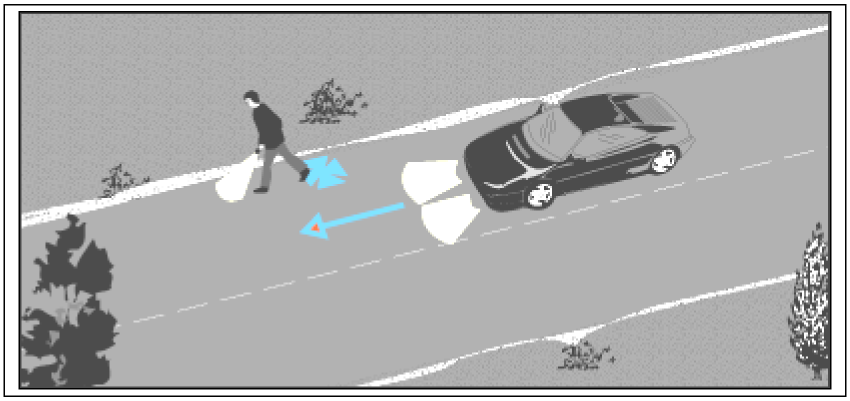
Graphic taken from http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural multilane divided non-freeways):

- More **pedestrians ages 45-64** (35% vs. 21% avg)
- More **pedestrian alcohol** consumption (45% vs. 33% avg)
- Much **higher fatalities** (45% vs. 27% avg)
- More **older drivers** (25% were "over 65 years old" vs. 9% avg)
- **Higher estimated vehicle speeds** (52% were "45-55mph" vs. 43% avg); much fewer occurrences at low speeds (14% were "25 mph and lower" vs. 28% avg)
- Occurred more frequently on roads with **unpaved shoulders** (30% vs. 15% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of pedestrian alcohol consumption, older pedestrians and drivers, high estimated vehicle speeds, and unpaved shoulders. Additionally, the proportion of fatalities was much higher than other crash types on this road class.

Crash Type: Walking Along Roadway
Road Class: RURAL MULTILANE UNDIVIDED NON-FREEWAY
Number of Crashes: **13** (18% of all Rural Multilane Undivided Non-Freeway crashes)
Crash Type Definition: The pedestrian was walking or running along the roadway and was struck from the front or from behind by a vehicle.



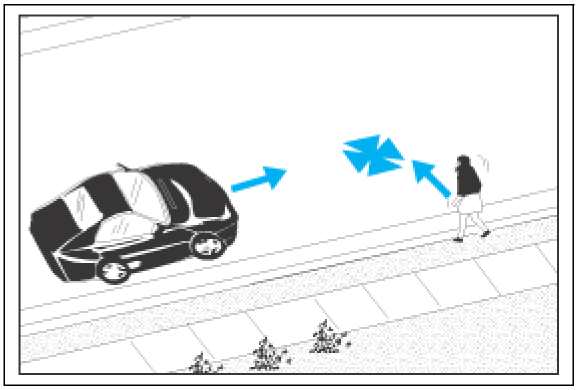
Graphics and crash type definition taken from
http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural multilane undivided non-freeways):

- More **pedestrian alcohol** consumption (69% vs. 31% avg)
- More **older drivers** (23% vs. 10% avg)
- More **mid-range estimated vehicle speeds** (25-35 and 35-45 mph)
- Occurred much more frequently **in the dark on lighted roadways** (38% vs. 28% avg)
- Occurred more frequently on **weekends** (54% vs. 35% avg)
- Occurred more frequently in zones with **mid-range speed limits** (30-35 and 40-45 mph)
- Occurred more frequently on roads with **curb-and-gutter shoulders** (85% vs. 66% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of pedestrian alcohol consumption, older drivers, and dark roadways. The mid-range speeds and curb-and-gutter shoulders plus consideration of the road class indicate that this crash type may have occurred in the more developed rural areas.

Crash Type: Pedestrian Failed to Yield, Midblock
Road Class: RURAL MULTILANE UNDIVIDED NON-FREEWAY
Number of Crashes: **18** (25% of all Rural Multilane Undivided Non-Freeway crashes)
Crash Type Definition: The pedestrian failed to yield to the motorist at a midblock location, but further detail is unavailable.



Graphic taken from http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural multilane undivided non-freeways):

- Fewer fatalities but more **A-class injuries** (61% vs. 37% avg)
- More **mid-range estimated vehicle speeds** (44% were "35-45 mph" vs. 23% avg)
- Occurred much more frequently **in the dark on unlighted roadways** (39% vs. 28% avg)
- Occurred more frequently in zone with **mid-range speed limits** (44% were "40-45 mph" vs. 34% avg)
- Occurred more frequently on roads with **paved shoulders** (28% vs. 17% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of mid-range estimated vehicle speeds and speed limits, dark roadways, and paved shoulders. These characteristics plus consideration of the road class indicate that these crashes may have occurred in the more developed rural areas.

Crash Type: Disabled Vehicle Related
Road Class: RUR FREEWAYS
Number of Crashes: **24** (20% of all Rural Freeway crashes)
Crash Type Definition: A vehicle struck a pedestrian who was standing or walking near a disabled vehicle.

Prominent characteristics (compared to all crash types on rural freeways):

- Fewer fatalities (17% vs. 30% avg), but more **A-class injuries** (43% vs 30% avg)
- Greater occurrence of low estimated vehicle speeds (52% were "25 mph and lower" vs. 39% avg), but a large portion of the estimated vehicle speeds for the remaining crashes were 55 mph and higher (31%).
- Occurred more frequently in **daylight** (67% vs. 51% avg)
- Occurred more frequently on **level horizontal curves** (13% vs. 5% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of occurrences in daylight and on roadway curves. The estimated speed data indicates that this type of crash involved vehicles traveling either very slow or very fast at the time of impact, perhaps suggesting that the drivers traveling slowly had seen the pedestrian and taken action while those traveling fast had not seen the pedestrian. In contrast to the disabled-vehicle-related crashes on two-lane rural roads which had an overrepresentation of dark and rainy conditions, most of these occurred in daylight.

Crash Type: Crossing Expressway
Road Class: RUR FREEWAYS
Number of Crashes: **28** (24% of all Rural Freeway crashes)
Crash Type Definition: The pedestrian was struck while crossing a limited-access expressway or expressway ramp.

Graphics and crash type definition taken from
http://www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm

Prominent characteristics (compared to all crash types on rural freeways):

- **Higher pedestrian alcohol involvement** (25% vs. 11% avg)
- **Higher fatality rate** (64% vs 30% avg)
- **Higher estimated vehicle speeds** (79% were "55 mph and higher" vs. 42% avg)
- Occurred more frequently **in the dark on unlighted roadways** (57% vs. 41% avg)
- Occurred more frequently during the hours of **6:00-10:00pm** (32% vs. 20% avg) and **6:00-10:00am** (25% vs. 16% avg)
- Occurred more frequently in **commercial** areas (14% vs. 8% avg)

Summary Statement:
This crash type and road class combination involved a disproportionately high proportion of pedestrian alcohol involvement, high estimated vehicle speeds, dark roadways, and commercial areas (perhaps indicating rural freeways in more urbanized areas). These crashes also had a much higher fatality rate than other crash types on this road class.

Table 13 summarizes the highlighted characteristics of each pedestrian crash type and road class problem area from the previous section. The columns have been grouped by crash type. For the crash types that have multiple road classes, there are some noticeable trends:

- Walking Along Roadway – pedestrians using alcohol, crashes occurring at night, very little surrounding development
- Pedestrian Failed to Yield, Midblock – older pedestrians
- Disabled Vehicle-Related – horizontal curves on a level grade

Table 13. Summary of Pedestrian Problem Area Crash Characteristics

Pedestrian Crashes	Walking Along Roadway			Pedestrian Failed to Yield, Midblock			Disabled Vehicle-Related		Pedestrian Failed to Yield, Intersection	Midblock Dart/Dash	Crossing Expressway
	RUR 2-LANE ROADS	RUR MUL DIV NON-FREE	RUR MUL UNDV NON-FREE	RUR 2-LANE ROADS	RUR MUL DIV NON-FREE	RUR MUL UNDV NON-FREE	RUR 2-LANE ROADS	RUR FREEWAYS	RUR 2-LANE ROADS	RUR 2-LANE ROADS	RUR FREEWAYS
Number of Crashes in Dataset	**369**	**23**	**13**	**228**	**20**	**18**	**52**	**24**	**51**	**164**	**28**
Pedestrian Age	Adults peds			Older peds	Older peds				Older peds	Young peds	
Pedestrian Alcohol	High	High	High		High		Low		Slightly high	Low	High
Pedestrian Injury		Lower fatalities, higher A and B injuries		Fatalities and type A injuries	Fatalities	Lower fatalities, higher A injuries		Lower fatalities, higher A injuries		Type A injuries	Fatalities
Driver Age			Older drivers		Older drivers				Older drivers		
Estimated Speed of Vehicle	Mid to High speeds	High speeds	Mid-range speeds	High speeds	High speeds	Mid-range speeds	Low speeds	Very low and very high speeds	Mid-range speeds		High speeds
Light Condition	Dark, unlighted	Dark, unlighted	Dark, lighted			Dark, unlighted	Dark, unlighted	Daylight		Daylight	Dark, unlighted
Day of Week			Weekends								
Time of Day										2 - 6 pm	Morning, evening
Weather							Rain				
Road Grade and Curvature		Level curves					Level curves and straight grades	Level curves			
Speed Limit	High speed limits	High speed limits	Mid-range speed limits			Mid-range speed limits	High speed limits			Mid-range speed limits	
Development	Farms/woods/ pastures	Farms/woods/ pastures		Residential and commercial			Farms/woods/ pastures		Commercial	Commercial	Commercial
Shoulder Type	Unpaved	Paved	Curb-and-gutter		Unpaved	Paved			Curb-and-gutter		
Shoulder Width		12 -16 feet									

Table 14 summarizes the highlighted characteristics of each bicycle crash type and road class problem area from the previous section. Just as in Table 13, the columns have been grouped by crash type. However, unlike the pedestrian crashes in Table 13, there is only one crash type that spans multiple road classes, "Bicyclist Failed to Yield, Intersection". The trends in that crash type indicate that young bicyclists are a trend in that type of crash, both from the overrepresented young ages and the weekday trends.

Table 14. Summary of Bicycle Problem Area Crash Characteristics

Bicyclist Crashes	Bicyclist Turn/Merge Into Path of Motorist, Midblock	Motorist Overtaking, Midblock	Bicyclist Failed to Yield, Midblock	Bicyclist Failed to Yield, Intersection	
	RUR 2-LANE ROADS	RUR 2-LANE ROADS	RUR 2-LANE ROADS	RUR 2-LANE ROADS	RUR MUL DIV NON-FREE
Number of Crashes in Dataset	**225**	**175**	**83**	**45**	**10**
Bicyclist Age	Young bicyclists	Adult bicyclists	Young bicyclists	Young bicyclists	Young bicyclists
Bicyclist Injury		Fatalities	Type A injuries		
Estimated Speed of Vehicle	High speeds		Mid-range speeds	Mid-range speeds	High speeds
Bicyclist Position		In a travel lane			
Bicyclist Direction	Same direction as traffic				
Light Condition	Daylight	Dark, unlighted roads	Daylight	Daylight	Dark, unlighted roads
Day of Week				Weekdays	Weekdays
Time of Day		Morning and night			
Speed Limit	High speed limits	High speed limits	High speed limits	Mid-range speed limits	High speed limits
Development	Farms/woods/pastures	Farms/woods/pastures	Residential	Residential	
Shoulder Type		Unpaved shoulder	Unpaved shoulder	Curb and gutter	Paved shoulders

Discussion of Countermeasures for Rural Areas

The previous sections detailed the trends in rural pedestrian and bicyclist crashes as well as identification and characteristics of the most commonly occurring crash types. It is fitting to discuss potential countermeasures for these crash types. In recent years, the Federal Highway Administration has sponsored two projects, PEDSAFE and BIKESAFE, to provide comprehensive information on pedestrian and bicyclist safety, specifically focusing on crash types and countermeasures (*8*, *9*). For each crash type, the documents suggest a number of countermeasures that may prove effective.

The following sections will walk through each pedestrian and bicyclist crash type that was common in rural areas, examine the countermeasures that PEDSAFE and BIKESAFE suggest for it, and discuss the suitability of the treatment with respect to the rural setting. The suitability for rural settings will be rated according to two measures, the “Potential Safety Effectiveness” of the countermeasure and the “Feasibility in Rural Areas” of its implementation. Feasibility pertains to the fact that some countermeasures that can be implemented easily and effectively in an urban area may not be suitable or feasible in a rural setting. In some cases, the nature of rural areas makes a particular countermeasure inapplicable, such as removing street furniture, since street furniture is not commonly found in rural areas. In other cases, the countermeasure may be infeasible or ineffective based on the crash pattern, such as improving lighting for a particular crash type when most crashes of that type were found to occur in daylight.

Pedestrian Crash Countermeasures

The pedestrian crash types that were identified as problem areas in Table 8 were as follows:

- Walking Along Roadway (rural two-lane, rural multilane undivided, rural multilane divided)
- Pedestrian Failed to Yield, Midblock (rural two-lane, rural multilane undivided, rural multilane divided)
- Midblock Dart/Dash (rural two-lane)
- Disabled Vehicle-Related (rural two-lane, rural freeway)
- Pedestrian Failed to Yield, Intersection (rural two-lane)
- Crossing Expressway (rural freeway)

The following tables discuss each of these pedestrian crash types and the countermeasures recommended by PEDSAFE. Targeting refers to the application of the countermeasure to specific problem areas rather than all mileage of the road class.

Table 15. Countermeasures for "Walking Along Roadway" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Add Paved Shoulder	High	High	These crashes were overrepresented on road with unpaved shoulders. Paving shoulders may encourage pedestrians to walk farther away from the roadway.
Add Sidewalks	High	Medium (needs targeting)	This could be a good candidate treatment for rural areas, since a rural road is very likely to have little sidewalk provisions. The addition of sidewalks would separate pedestrian from vehicle paths. However, the large number of rural miles that could be treated would require targeting this treatment to areas of high-expected pedestrian exposure.
Improve Roadway Lighting	High	Medium (needs targeting)	Rural crashes are greatly overrepresented in dark hours with unlighted roadways, especially walking-along-roadway crashes. Improvements in roadway lighting are very likely to reduce this type of crash. Again, targeting would be needed to make this treatment feasible.
Improve Warning Signing	Low/Medium	Medium (needs targeting)	Installing signs to identify areas with high pedestrian traffic could inform drivers of the greater chance of pedestrians on or near the roadway. However, signs have not been found to have a large safety benefit. Moreover, the scattered nature of pedestrian activity on rural roads makes targeting difficult.
Use Speed Monitoring Trailers	Low/Medium	Medium (needs targeting)	This treatment alerts drivers to their speed in an effort to reduce vehicle speeds. Since this crash type predominantly involves vehicles traveling at high speeds, a reduction in speed may decrease occurrences of this crash type. Again, since there are significant numbers of miles of rural two-lane and multilane roads, targeting would be necessary.
Educate Pedestrians and Drivers	Low/Medium	Medium	Educating drivers and pedestrians is generally most effective for children. Since adults were overrepresented in this crash type, the effectiveness of education is questionable. Education would involve instructing pedestrians that walking on the left side of the road (facing traffic) is a safer walking practice.

Increase Police Enforcement	Medium/High	Medium (needs targeting)	Pedestrian alcohol consumption was a greatly overrepresented factor in this crash type. Police enforcement of "drunk walking along the roadway" or of closer monitoring of roads near alcohol outlets (e.g., bars, convenience stores) that could produce more drinking pedestrians would likely reduce these crashes.
Add Curb Ramps	Medium	High	This countermeasure is intended to ensure that disabled pedestrians have access to the sidewalk. Engineers should ensure that all sidewalks have curb ramps where needed, although sidewalks and disabled pedestrian traffic will both be few in number in rural areas.
Narrow the Roadway by Restriping	Medium (if produces 3-4 feet of paved shoulder)	Medium/ High (at locations with suitable pavement width)	This treatment is intended to slow vehicle speeds by reducing lane widths. The remaining space can be used to add bicycle lanes or give more buffer space for walking. Although the effects of this treatment may be beneficial, some rural roads are fairly narrow and may not be appropriate locations for road narrowing. This treatment should be evaluated on a case-by-case basis.
Relocate Street Furniture	Low	Medium	This treatment provides room for pedestrian travel by removing street furniture. This is less appropriate for rural areas, where street furniture is rarely an issue.
Improve School Zone Pedestrian Accommodations	Low	High	This crash type mostly involves adult pedestrians, so school zone improvements are unlikely to have a large effect on it. However, for the small number of miles that contain school zones, this treatment may reduce vehicle speeds.

Table 16. Countermeasures for "Pedestrian Failed to Yield, Midblock" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Educate Pedestrians	High	Medium	Pedestrians should be well-informed of the rules of the road in their state and the potential hazard in crossing the street. Additionally, many crashes of this type involved pedestrians who had consumed alcohol. An education campaign to reduce "drunk walking" may serve to reduce this crash type.
Improve Roadway Lighting	Medium	Medium (needs targeting)	Crashes of this type occurred frequently on dark roadways. Adding or improving lighting will improve visibility of both motorists and pedestrians and is likely to reduce this type of crash. However, the large number of miles indicated the need for treatment targeting at locations such as crosswalks.
Improve Signing	Medium	Medium	Installing signs to alert drivers of potential pedestrian activity might serve to decrease occurrences of this crash type. However, by definition, these crashes are due to the pedestrian failing to yield.
Utilize Traffic Calming Measures	Low	Medium (needs targeting)	Many motorists involved in this crash type were traveling at high speeds; however, these were generally in undeveloped areas where traffic calming measures would be more costly to install and less well-accepted by drivers. If implemented in residential areas, this treatment might have some effect on decreasing this crash type.
Add or Enhance Crosswalks	Low	Low	In areas with at least moderate levels of pedestrian activity, marked crosswalks may enhance safety for pedestrians crossing the road. However, there are few clusters of midblock pedestrian activity in rural areas.
Install Pedestrian Signal	Low	Low	Pedestrian activity in rural areas is generally not localized enough to warrant a pedestrian signal, although there may be specific situations where this treatment would be warranted.

Table 17. Countermeasures for "Midblock Dart/Dash" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Educate Pedestrians	High	High	Educating young children about the danger of darting out into the road through forums such as school programs may prove very effective in decreasing this type of crash.
Improve Signing	High	Medium/High (needs targeting)	This type of crash would likely be decreased with signing that indicated to motorists when they are entering a neighborhood or zone with high pedestrian activity. Most pedestrians involved are children who dart out unexpectedly, therefore greater attention by motorists may have a significantly positive effect.
Utilize Traffic Calming Measures	High	Medium (needs targeting)	Reducing vehicle speeds through traffic calming might decrease this crash type. Most of these crashes occurred in residential or commercial areas where it would be feasible to apply traffic calming measures.
Provide School Crossing Guard	Medium	High	If the dart/dash crashes are occurring in school zones, the provision of a crossing guard would serve to alert motorists and control the crossing action of the children.
Install Pedestrian Signal	Medium	Low	Pedestrian activity in rural areas is generally not localized enough to warrant a pedestrian signal, however, some neighborhoods or school locations may draw enough pedestrian activity to warrant a signal.
Improve Roadway Lighting	Low	N/A	Most crashes of this type occurred in the daylight. Improved lighting would most likely have little effect on these crashes.
Restrict On-Street Parking	Low	N/A	Restricting or removing on-street parking provides the motorist with more visibility of the street sides, but there is generally little on-street parking in rural areas.

Table 18. Countermeasures for "Disabled Vehicle Related" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Educate Drivers	Medium/High	High	Educating drivers about what to do if a vehicle becomes disabled might decrease occurrences of this crash type.
Add Paved Shoulders (to non-freeway roads)	High	Low	Full-width paved shoulders would allow the driver to position the disabled vehicle out of the roadway. Most crashes of this type occurred on roads with unpaved shoulders, so this treatment may have a significant effect on this crash type. However, targeting would be difficult due to the random locations of vehicle malfunctions.
Improve Roadway Lighting	High	Low	Most crashes of this type on rural 2-lane roads occurred on dark roadways where improved lighting may significantly decrease these crashes. However, most crashes of this type on rural freeways occurred during daylight, so improved lighting will have less of an effect on freeways. The difficulty with this treatment for disabled vehicles is that the rural mileage to be treated is high, and targeting would be virtually impossible.
Provide Motorist Assistance	Medium	Medium	A motorist assistance program would aid in getting disabled vehicles fixed or towed more quickly. However, the widespread and low volume nature of many rural roads would make such a program financially infeasible on all but the most major rural roads.
Add Sidewalks (to non-freeway roads)	Medium	Low	Sidewalks would give a person somewhere to stand away from traffic as they wait for assistance. However, a sidewalk could force the vehicle to be disabled in the travel lane rather than on the shoulder. Engineers should consider the characteristics of the roadway when considering this treatment.

Table 19. Countermeasures for "Pedestrian Failed to Yield, Intersection" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Educate Pedestrians	High	High	Educating pedestrians, especially children and older pedestrians, in the area of pedestrian safety may serve to decrease crashes of this type.
Improve Roadway Lighting	High	Medium	Most crashes of this type occurred during periods of darkness. Additionally, both older pedestrians and older drivers are overrepresented in these crashes. Improved roadway lighting will improve visibility for both parties and is likely to decrease crashes of this type.
Install Pedestrian Signal	High	Medium (needs targeting)	Installing traffic signals or retrofitting existing signals with pedestrian signals may cause greater compliance with signal operation (at previously signalized intersections) or clear priority for pedestrian (at previously unsignalized intersections). Older pedestrians are overrepresented in this crash type, so installing accessible (audible) pedestrian signals might assist them in crossing the street at the appropriate time.
Improve School Zone Pedestrian Accommodations	Medium	High	A portion of crashes of this type involved children, so improvements in school zones such as pavement markings, signs, and crossing guards may decrease some of these crashes.

Table 20. Countermeasures for "Crossing Expressway" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Improve Roadway Lighting	High	Medium (needs targeting)	Crashes of this type occurred frequently on dark roadways. Adding or improving lighting will improve visibility of both motorists and pedestrians and is likely to reduce this type of crash. This treatment would be most feasible if targeted to more urbanized rural areas and/or freeways adjacent to development.
Install Fence or Barrier	High	Medium (needs targeting)	A fence or barrier would prevent pedestrians from accessing the freeway from adjacent land. However, most rural freeways are adjacent to undeveloped land, so this treatment may not be as effective as it would be in urban areas. It could be targeted to “rural” freeways in the more urbanized areas where higher pedestrian volume is expected.
Install Pedestrian Overpass/ Underpass	High	Low (needs targeting)	This treatment should be targeted to locations where there are “generators” (e.g., housing units) on one side of the freeway and “attractors” (e.g., businesses) on the other.
Increase Police Enforcement	Medium	Medium	Pedestrian alcohol consumption was a greatly overrepresented factor in this crash type. Police restriction of "drunk walking" (before the pedestrian accesses the freeway) and enforcement of pedestrian restrictions (once the pedestrian is on the freeway) would likely reduce these crashes.
Provide Motorist Assistance	Medium	Medium (needs targeting)	If the pedestrian is crossing the freeway due to a disabled vehicle, a motorist assistance program would decrease crashes by getting disabled vehicles fixed or towed more quickly. However, the widespread and low volume nature of many rural roads would make such a program financially infeasible on all but the most major rural roads.

Bicycle Crash Countermeasures

The bicyclist crash types that were identified as problem areas in Table 9 were as follows:

- Bicyclist Turn/Merge into Path of Motorist, Midblock (rural two-lane)
- Motorist Overtaking, Midblock (rural two-lane)
- Bicyclist Failed to Yield, Midblock (called Bicycle Ride Out Midblock in BIKESAFE) (rural two-lane)
- Bicyclist Failed to Yield, Intersection (rural two-lane, rural multilane divided)

The following tables will discuss each of these bicycle crash types and the countermeasures recommended by BIKESAFE for each crash type.

NOTE: Although education is discussed as a potential countermeasure, there have been few comprehensive studies to evaluate the effectiveness of education as a countermeasure to bicycle-vehicle crashes. However, experts believe that education plays an important role in safe bicyclist travel; therefore it is included in the countermeasure discussion below.

Table 21. Countermeasures for "Bicyclist Turn/Merge into Path of Motorist, Midblock" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Gain Marked Pavement Space for Bicyclists	High	High (at locations with suitable pavement width)	Good pavement marking can delineate a bicyclist's space on the road in areas such as a bicycle lane or paved shoulder. A more well-defined bike space may serve to decrease this type of crash. Narrowed lane widths may reduce vehicle speeds and may provide room for exclusive bicycle lanes.
Add Paved Shoulder	High	Medium	Adding a paved shoulder provides more room on the road for bicyclists to travel and can serve to decrease hazardous interactions between bicyclists and motorists.
Educate Bicyclist	Medium/High	Medium	Since this crash type is due in part to the bicyclist's decision to turn or merge into the path of a vehicle, bicyclist education may prove effective in decreasing crashes of this type.
Increase Road Maintenance	Medium	Medium	Most of these crashes occurred on roads with no bicycle facility and unpaved shoulders, which forces bicyclists to ride on the roadway. Increased attention to road maintenance, including sweeping, landscape trimming, pavement maintenance, and pavement edge-drop reductions makes a clearer path for bicyclists along the side of the road and may decrease these crashes.
Utilize Traffic Calming Measures	Medium	Low	Traffic calming measures, such as speed humps and chicanes, can reduce vehicle speeds but are intended for medium to low speed roadways. Most rural crashes of this type occurred on high speed roadways where this treatment would not be appropriate.

Table 22. Countermeasures for "Motorist Overtaking, Midblock" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Gain Marked Pavement Space for Bicyclists	High	High (at locations with suitable pavement width)	Most crashes of this type occurred on roads with no bicycle lane or paved shoulder. The addition of dedicated bicycle space would separate the paths of motorists and bicyclists and likely reduce this type of crash. Pavement markings that narrow the vehicle lane can delineate a bicyclist's space on the road in areas such as a bicycle lane or paved shoulder.
Improve Roadway Lighting	High	Medium (needs targeting)	Many crashes of this type occurred on dark roadways. Improved roadway lighting would likely give the motorist greater visibility of bicyclists in the road and decrease crashes of this type. The high number of rural miles would mean that targeting of lighting to areas of higher bike use would likely be required.
Add Separate Shared-Use Path	High	Low	A separate path for bicyclists would take the bicyclist out of the roadway and decrease crashes of this type. While this would be an effective solution, most crashes of this type occurred in undeveloped rural areas where it is questionable whether the relatively low amounts of bicycle activity would warrant the installation of a separate path.
Increase Road Maintenance	Medium	Medium	Most of these crashes occurred on roads with no bicycle facility and unpaved shoulders, which causes bicyclists and motorists to share the travel lane. Increased attention to road maintenance, including sweeping, landscape trimming, and pavement maintenance, makes a clearer path for bicyclists along the side of the road and may decrease these crashes. One of the most effective impacts that road maintenance can have is to improve sight distance.
Educate Bicyclist	Medium	Medium	Many crashes of this type occurred on dark roadways. Educating bicyclists on safe riding practices, such as riding with properly visible clothes and gear, may decrease crashes of this type. The potential for educational benefit is greater for younger bicyclists.

Utilize Traffic Calming Measures	Medium	Low	Traffic calming measures, such as speed humps and chicanes, can reduce vehicle speeds but are intended for medium to low speed roadways. Most rural crashes of this type occurred on high speed roadways where this treatment would not be appropriate.
Educate Motorist	Low/Medium	High	Educating motorists about interacting safely with bicyclists on the road may decrease crashes of this type.

Table 23. Countermeasures for "Bicyclist Failed to Yield, Midblock" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Reduce Lane Width	High	Medium (needs targeting)	Narrowed lanes can slow down vehicles and may provide room for exclusive bicycle lanes that may be helpful in reducing bicycle-vehicle interactions. Since many crashes of this type occurred in residential and mid-to-low speed areas, this may be an effective treatment for these types of rural areas.
Add Intersection/Trail/ Driveway Warnings	Medium/High	Medium (needs targeting)	Signs that notify motorists of possible bicyclist entry on the roadway may prove effective in decreasing crashes of this type. This treatment would be targeted to locations with trails of high bicyclist volume or areas of high driveway density.
Utilize Traffic Calming Measures	Medium/High	Medium (needs targeting)	Traffic calming measures, such as speed humps and chicanes, can reduce vehicle speeds and are intended for medium to low speed roadways. Since many crashes of this type occurred in these areas, this may be an effective treatment for rural areas.
Educate Bicyclist (and Parents of Child Bicyclists)	Medium/High	Medium	Many crashes of this type involved child bicyclists. Educating these children and their parents on the dangers of riding out in the road could prove effective in decreasing crashes of this type.
Improve School Zones	Medium	High	School zone improvements such as warning signs, visible crosswalks, crossing guards, and reduced vehicle speeds would likely decrease crashes of this type in school zones.

Improve Driveways / Sight Distance	Medium	Medium	Clear sight distances, proper curb radius, and right angle of entry are characteristics of driveways that improve conditions for bicyclists and may decrease crashes of this type.
Add Median/Crossing Island	Medium	Low	Medians may help slow traffic speeds, and median cut-throughs can assist bicyclists in making two-stage crossings. Oftentimes this can be implemented by the elimination of a two-way left-turn lane, however, most of these crashes occurred on rural two-lane roads that do not have these turn lanes. This may be more cost-effective in certain high activity locations rather than systemwide.
Remove On-Street Parking	Low	N/A	Removing on-street parking would allow the motorist to see the bicyclist approaching from the roadside. However, this treatment is more suited to urban areas where parking is more common.

Table 24. Countermeasures for "Bicyclist Failed to Yield, Intersection" Crashes

Countermeasure	Potential Safety Effectiveness	Feasibility for Rural Areas	Discussion
Improve School Zones	High	High	Many young bicyclists were involved in this crash type. School zone improvements such as warning signs, visible crosswalks, crossing guards, and reduced vehicle speeds would likely decrease crashes of this type in school zones.
Improve Sight Distance	High	Medium	Parked cars, vegetation, or improperly placed signs may obstruct the bicyclist's view. Ensuring a clear sight distance may reduce crashes of this type.
Add Intersection/Trail/ Driveway Warnings	Medium/High	Medium (needs targeting)	Signs that notify motorists of possible bicyclist entry on the roadway may prove effective in decreasing crashes of this type. This treatment would be targeted to locations with trails of high bicyclist volume or areas of high driveway density.

Utilize Traffic Calming Measures	Medium/High	Medium (needs targeting)	Traffic calming measures, such as mini circles, roundabouts, and raised intersections, can reduce vehicle speeds and are intended for medium to low speed roadways. Some crashes of this type occurred in these areas, so this may be a moderately effective treatment for this crash type.
Install Bike-Activated Signal	Medium/High	Low	Signals that are activated by bicyclists may reduce the number of instances when a bicyclist proceeds against the signal. This may be an effective treatment for signalized intersections; however, most crashes of this type occurred at stop-controlled intersections.
Educate Bicyclist	Medium/High	Medium	This treatment would be most effectively targeted at child bicyclists. Emphasis could be placed on the importance of riding on the correct side of the street.
Decrease Curb Radii	Medium	Low	Decreasing a corner radius can serve to slow motorists as they make a turn. This would lead to increased reaction time if a bicyclist has failed to yield. However, there are few curbs at rural intersections, making this less effective than in an urban setting.
Check Signal Timing	Low/Medium	Medium	At some signalized intersections, the yellow and/or green time may be improperly timed to account for bicycle traffic. Longer times may be necessary to ensure that the bicyclist clears the intersection.
Improve Roadway Lighting	Low	N/A	Most crashes of this type occurred in daylight. Improving roadway lighting would not be expected to have a significant effect on this crash type.

Summary of Countermeasures

Most crash types identified as problem areas had several countermeasures recommended by PEDSAFE and BIKESAFE that were judged by the authors to be highly appropriate for rural areas, based on the suitability of the countermeasure for the characteristics of the particular crash type. Due to the fact that pedestrian and bicyclist activity is generally low for the numerous miles of rural roads, many of these countermeasures were recommended to be "targeted" to areas more appropriate for the countermeasure (e.g., adding sidewalks only in areas with higher levels of pedestrian activity). The list below summarizes the countermeasure discussion found in Table 15 through Table 24.

NOTE: The addition of paved shoulders was recommended as a low-cost option for areas where adding sidewalks may be infeasible. This was primarily intended to address crashes that occur when the pedestrian is walking along the roadway. Most of these crashes occurred on roads with unpaved shoulders. Sidewalks are recommended as the primary option for removing pedestrians from the travel lane, but it is clear that installing sidewalks along both sides of all rural roads is infeasible. The addition of sidewalks would have to be targeted to areas with moderately high pedestrian activity. However, the addition of a paved shoulder can be implemented on a wider scale and may still encourage the pedestrian to walk further from the travel path of vehicles and decrease occurrences of this crash type.

Common rural pedestrian crash types and corresponding countermeasures with high potential safety effectiveness <u>and</u> medium or high feasibility in rural areas

- *Walking Along Roadway* (found to be common on rural two-lane, rural multilane undivided, and rural multilane divided roadways)
    - Add sidewalks (targeted)
    - Add paved shoulders
    - Add roadway lighting (targeted)
- *Pedestrian Failed to Yield, Midblock* (found to be common on rural two-lane, rural multilane undivided, and rural multilane divided roadways)
    - Educate pedestrians
- *Midblock Dart/Dash* (found to be common on rural two-lane roadways)
    - Improve signing (targeted)
    - Educate pedestrians
    - Utilize traffic calming measures (targeted)
- *Disabled Vehicle-Related* (found to be common on rural two-lane roadways and rural freeways)
    - Educate drivers
- *Pedestrian Failed to Yield, Intersection* (found to be common on rural two-lane roadways)
    - Educate pedestrians
    - Install pedestrian signal (targeted)
    - Improve roadway lighting (targeted)
- *Crossing Expressway* (found to be common on rural freeways)
    - Improve roadway lighting (targeted)

  - Install fence or barrier (targeted)

Common rural bicycle crash types and corresponding countermeasures with high potential safety effectiveness <u>and</u> medium or high feasibility in rural areas

- *Bicyclist Turn/Merge into Path of Motorist, Midblock* (found to be common on rural two-lane roadways)
  - Gain marked pavement space for bicyclists (locations with suitable pavement width)
  - Add paved shoulder
- *Motorist Overtaking, Midblock* (found to be common on rural two-lane roadways)
  - Gain marked pavement space for bicyclists (locations with suitable pavement width)
  - Improve roadway lighting (targeted)
- *Bicyclist Failed to Yield, Midblock* (found to be common on rural two-lane roadways)
  - Reduce lane width (targeted)
- *Bicyclist Failed to Yield, Intersection* (found to be common on rural two-lane and rural multilane divided roadways)
  - Improve sight distance
  - Improve school zones

Conclusions

The goal of this exploratory study was to develop additional knowledge related to rural pedestrian and bicycle crashes. As expected, a general comparison of rural and urban crashes found that these crashes in these two environments have many differences. Rural crashes were typified by higher fatality rates, higher vehicle speeds, less roadway lighting, unpaved shoulders, and more non-intersection locations than urban crashes.

The analysis further examined rural crashes according to road class and crash type. For bicycle crashes, the crash frequency and crashes per vehicle mile indicate that rural 2-lane roads are the biggest problem, even after vehicle exposure is accounted for. The crashes per roadway miles indicate that rural multilane undivided non-freeway roads would be the most cost effective to treat. For pedestrian crashes, crash frequency indicates that rural 2-lane roads are the biggest problem areas. Crashes per road mile indicate that rural multilane undivided non-freeway roads would be the most cost-effective to treat. Crashes per vehicle mile indicate that rural 2-lane roads and rural multilane undivided non-freeway roads are the biggest concerns. Overall, it seems that rural 2-lane roads call attention as the road class with the most priority due to the large number of crashes that occur on these roads. However, this could be due in part to the fact that the majority of vehicle miles driven in rural North Carolina are on 2-lane roads. States with a different cross-section of rural road classes may see a different prioritization.

Specific problem areas (combinations of road class and crash type) were identified and described in terms of characteristics of the crash participants and crash location. Eleven pedestrian problem combinations were identified, of which the most prevalent were "walking along roadway" on rural 2-lane roads, "pedestrian failed to yield, midblock" on rural 2-lane roads, and "midblock dart/dash" on rural 2-lane roads. Five bicycle problem areas were identified, of which the most common were "bicyclist turn/merge into path of motorist, midblock" on rural 2-lane roads and "motorist overtaking, midblock" on rural 2-lane roads. Characteristics of each problem area were examined in detail.

Potential countermeasures for these problem areas were discussed in view of their potential safety effectiveness and feasibility for rural areas. Pedestrian crash countermeasures that were rated as having high potential for safety effectiveness and medium or high feasibility in rural areas included improving roadway lighting, educating pedestrians and motorists, and adding sidewalks and paved shoulders. Bicycle crash countermeasures that were rated as having high potential for safety effectiveness and medium or high feasibility in rural areas included gaining marked pavement space for bicyclists, adding paved shoulders, and improving roadway lighting.

Future Research

Based on the results of this study, the authors recommend the following topics for further research:

- *Safety Treatment Development* – as observed in the countermeasure discussion, there are several rural crash types which state-of-the-practice countermeasures do not effectively address. Future research could concentrate on developing new and innovative safety treatments for the following areas:
    - pedestrian failed to yield, midblock
    - disabled vehicle related
    - bicyclist failed to yield, midblock
- *Evaluation of the Effect of Shoulder Type* – results from this study indicate that unpaved shoulders may be correlated with "walking along roadway" crashes. Future research would examine the effect of shoulder type (paved vs. unpaved) on the frequency of these crashes. An effective evaluation should consider pedestrian volume or some correlate thereof.
- *Evaluation of Pedestrian Education* – results indicate that pedestrian "walking along roadway" crashes are more common when the pedestrian is walking with traffic (not facing traffic, as is recommended). Future research could examine the effect of various types of pedestrian education, including public advertisements and new types of signs with messages such as "Walk Facing Traffic".

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Appendix A: General Comparison of Rural and Urban Pedestrian and Bicyclist Crashes

Bicycle – by person

Variable	PBCAT/HSIS Rural	PBCAT/HSIS Urban	1996 Study
Bicyclist Age	Most common were 25-44 (32%), followed by 10-14 (21%)	Most common were 25-44 (37%), followed by 15-19 (16%)	Most common were 10-14 (27%), followed by 25-44 (23%)
Bicyclist Gender	Majority were male (87%)	Majority were male (86%)	Majority were male (79%)
Bicyclist Alcohol	Alcohol was involved with 8% of bicyclists, with 42% of bicyclists having unknown alcohol levels	Alcohol was involved with 6% of bicyclists, with 41% of bicyclists having unknown alcohol levels	Alcohol was involved with 5% of bicyclists, with only 4% of bicyclists having unknown alcohol levels
Bicyclist Ethnicity	Majority were white (62%), followed by black (31%)	Majority split between black (48%) and white (44%)	No data.
Bicyclist Injury	Most common were B injuries (44%), followed by C injuries (30%). 6% were fatalities.	Majority split between B injuries (43%) and C injuries (39%). 2% were fatalities.	Majority split between B injuries (46%) and C injuries (29%). 2% were fatalities.
Driver Age	Most common was 25-44 (35%), followed by 45-64 (25%)	Most common was 25-44 (40%), followed by 45-64 (22%)	Most common was 25-44 (45%), followed by 45-64 (21%)
Driver Gender	Male (54%), female (36%), unknown (11%)	Male (50%), female (40%), unknown (10%)	Male (58%), female (42%)
Driver Alcohol	Alcohol was involved with 4% of drivers, with 4% of drivers having unknown alcohol levels	Alcohol was involved with 2% of drivers, with 5% of drivers having unknown alcohol levels	Alcohol was involved with 2% of drivers, with 9% of drivers having unknown alcohol levels
Driver Ethnicity	Majority were white (65%), followed by black (20%)	Majority were white (56%), followed by black (30%)	No data.
Driver Injury	Majority had no injuries (94%)	Majority had no injuries (96%)	Majority had no injuries (98%)
Vehicle Est Speed	Largest portion were 41-60 mph (47%), followed by 21-40 mph (29%) and 0-20 mph (22%)	Largest portion were 0-20 mph (56%), followed by 21-40 mph (34%)	No data.

Bicycle – by crash

Variable	PBCAT/HSIS Rural	PBCAT/HSIS Urban	1996 Study
Bicyclist Position	Almost all were on the street, either in travel lane (74%) or in bike lane/shoulder (10%)	Mostly on the street in travel lane (59%) but also some on sidewalk/driveway crossing (16%)	Same trend as urban
Bicyclist Direction	Majority were with traffic (71%)	More evenly split between going with traffic (46%) and facing traffic (32%)	Same trend as urban but with an add'l category of crossing traffic (12%)
Crash Type	Bicyclist turn/merge into path of motorist (31%), motorist overtaking (25%), and bicyclist failed to yield at midblock (10%)	Motorist failed to yield (26%), bicyclist failed to yield at midblock (13%), motorist turn/merge into path of bicyclist (12%), and bicyclist failed to yield at intersection (12%)	Top four types were same as urban. All percentages very similar to urban.
Light Condition	Majority were daylight (66%). Second most common were dark with roadway not lighted (26%)	Majority were daylight (73%). Second most common were dark with lighted roadway (18%)	Same trend as urban.
Weekday	No major trend.	Decreased crashes on Sunday.	No major trend.
Time of Day	Majority between 2:00pm – 6:00pm (35%)	Majority between 2:00pm – 6:00pm (36%)	Majority between 2:00pm – 6:00pm (31%)
Speed Limit	Majority in 50 mph or higher (54%), followed by 40-45 mph (27%)	Majority in 30-35 mph (56%), followed by 40-45 mph (32%)	Majority in 30-35 mph (50%), followed by 25 mph or lower (27%)
Number of Lanes	Majority on 2-lane roads (84%)	Majority split between 2-lane (30%) and 4-lane (28%), followed by 5-lane (19%)	Majority on 2-lane (60%)
Intersection/Non-intersection	Majority at non-intersection location (77%)	Majority split between intersection (48%) and non-intersection (48%)	Majority at intersection (47%), followed by non-intersection (28%) and non-roadway (21%)
Traffic Control	Majority at no control (71%)	Majority at no control (50%), followed by signal (27%) and stop sign (20%)	Same trend as urban.
Road Configuration	Majority at two-way not divided (92%)	Majority at two-way not divided (72%), followed by two-way divided with unprotected median (21%)	No data.
Development	Majority in Farms-Woods-Pasture (47%) and residential (35%)	Majority in commercial (65%)	No data.
Shoulder Type	Majority is unpaved (80%), followed by paved (11%)	Majority is curb-and-gutter (72%), followed by unpaved (20%)	Majority was none indicated or N/A (75%)
Shoulder Width	Majority were 4-8 ft (53%), followed by 8-12 ft (24%). 11% were blank with no width recorded.	Majority were blank with no width recorded (74%)	Majority split between 4-8 ft (42%) and 1-4 ft (39%)

Pedestrian – by person

Variable	PBCAT/HSIS Rural	PBCAT/HSIS Urban	1996 Study
Pedestrian Age	Most common were 25-44 (37%), followed by 45-64 (18%)	Most common were 25-44 (38%), followed by 45-64 (19%)	Most common were 25-44 (30%), followed by 0-9 (19%)
Pedestrian Gender	Majority were male (70%)	Majority were male (65%)	Majority were male (61%)
Pedestrian Alcohol	Alcohol was involved with 24% of pedestrians	Alcohol was involved with 19% of pedestrians	Alcohol was involved with 15% of pedestrians
Pedestrian Ethnicity	Majority were white (61%), followed by black (30%)	Majority split between black (48%) and white (42%)	No data.
Pedestrian Injury	Most common were B injuries (33%), followed by C injuries (24%) and A injuries (23%). 18% were fatalities.	Most common were B injuries (37%), followed by C injuries (31%) and A injuries (19%). 10% were fatalities.	Most common were B injuries (35%), followed by C injuries (29%) and A injuries (27%). 6% were fatalities.
Driver Age	Most common was 25-44 (33%), followed by 45-64 (22%)	Most common was 25-44 (36%), followed by 45-64 (21%)	Most common was 25-44 (45%), followed by 45-64 (19%)
Driver Gender	Male (50%), female (29%), unknown (21%)	Male (50%), female (34%), unknown (16%)	Male (63%), female (37%)
Driver Alcohol	Alcohol was involved with 4% of drivers, with 9% of drivers having unknown alcohol levels	Alcohol was involved with 3% of drivers, with 10% of drivers having unknown alcohol levels	Alcohol was involved with 6% of drivers, with 13% of drivers having unknown alcohol levels
Driver Ethnicity	Majority were white (56%), followed by black (19%)	Majority were white (52%), followed by black (28%)	No data.
Driver Injury	Majority had no injuries (87%)	Majority had no injuries (91%)	Majority had no injuries (96%)
Vehicle Est Speed	Largest portion were 41-60 mph (46%), followed by 0-20 mph (27%) and 21-40 mph (22%)	Largest portion were 0-20 mph (40%), followed by 21-40 mph (38%) and 41-60 mph (20%)	No data.

Pedestrian – by crash

Variable	PBCAT/HSIS Rural	PBCAT/HSIS Urban	1996 Study
Crash Type	Walking along roadway (26%), miscellaneous (26%), pedestrian failed to yield (21%), midblock dart/dash (11%)	Pedestrian failed to yield (27%), midblock dart/dash (19%), miscellaneous (17%), walking along roadway (10%)	Miscellaneous (15%), midblock dart/dash (13%), unique midblock (13%)
Light Condition	Majority were dark with roadway not lighted (50%). Second most common were daylight (41%)	Majority were daylight (54%). Second most common were dark with lighted roadway (31%)	Same trend as urban.
Weekday	No major trend.	Decreased crashes on Sunday.	No major trend.
Time of Day	Majority between 6:00pm – 10:00pm.	Majority between 6:00pm – 10:00pm.	Majority between 2:00pm – 6:00pm.
Speed Limit	Majority in 50 mph or higher (57%), followed by 40-45 mph (27%)	Largest portion in 30-35 mph (46%), followed by 40-45 mph (32%)	Majority in 30-35 mph (48%), followed by 25 mph or lower (25%)
Number of Lanes	Majority on 2-lane roads (76%), followed by 4-lane roads (13%)	Majority split between 4-lane (28%) and 2-lane (27%), followed by 5-lane (18%)	Majority on 1 or 2-lane roads (60%)
Intersection/Non-intersection	Majority at non-intersection location (82%)	Majority at non-intersection (55%), followed by intersection (39%)	Majority at non-intersection (59%), followed by intersection (41%)
Traffic Control	Majority at no control (76%)	Majority at no control (68%), followed by signal (21%)	Same trend as urban.
Road Configuration	Majority at two-way not divided (84%), followed by two-way divided with unprotected median (12%)	Majority at two-way not divided (64%), followed by two-way divided with unprotected median (24%)	No data.
Development	Majority in Farms-Woods-Pasture (51%) and residential (30%)	Majority in commercial (68%), followed by residential (27%)	No data.
Shoulder Type	Majority is unpaved (71%), followed by paved (19%)	Majority is curb-and-gutter (65%), followed by unpaved (18%) and paved (15%)	Majority was none indicated or N/A (49%), followed by unpaved (17%)
Shoulder Width	Majority were 4-8 ft (48%), followed by 8-12 ft (23%). 12% were blank with no width recorded.	Majority were blank with no width recorded (68%), followed by 4-8 ft (11%)	Majority were 4-8 ft (50%), followed by 8-12 ft (28%)