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Pedestrian Safety at Bus Stops Study

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Executive Summary

The purpose of this research—conducted in partnership with Michael Baker, Jr., Inc.—was to identify high pedestrian crash locations at or near bus stops in New Jersey; analyze motorist and pedestrian behavior proximate to identified bus stops; comprehend pedestrian safety perceptions; and, analyze built environment characteristics that may contribute to crashes. Assessing factors that contribute to pedestrian crashes can be very complex, so our research approach incorporated a number of methods to assess the problem from different vantage points. These methods included:

- Interviews with experts to gain a complete understanding of the regional policy context – the decision making process regarding location and design of bus stops and perceived opportunities and barriers to improving bus stop pedestrian safety.
- A geographic information systems analysis of crashes using crash reports, road characteristics, and other data to identify the sites and corridors with the highest crash incidence, to determine the factors associated with high crash incidence, and to select locations for site-level analysis.
- An intercept survey of bus passengers to determine what they believe are the most significant factors contributing to crashes.
- Direct observations of pedestrian and motor vehicle driver behavior at selected bus stops both to identify behavior that may contribute to crashes, and to identify the proportion of pedestrians in the vicinity of bus stops that are bus passengers.
- Field inventories at selected bus stops in order to better identify and understand design and operational issues that may contribute to pedestrian crashes near bus stops.

Two methods were employed to designate crash clusters in the study. First, crash scores were tallied from geocoded crash data. These scores were normalized using information on area employment and population. Significant clusters were then identified in each of the 21 New Jersey counties, and the resulting clusters were further stratified by high- and low-density categories. This yielded 45 total clusters for site-level analysis. The findings of the site-level analysis showed motorists primarily responsible for the majority of crashes, with "Left Turn Parallel Path" and "Motorist Failed to Yield" crashes the most common crash types. In the 45 selected clusters, nearly 4 percent of crashes involved pedestrians confirmed or suspected of being bus passengers, higher than those reported by other studies (2.2 percent). [1]

The second set of clusters was chosen for field observation. Thirty bus stop clusters were chosen based on geographic distribution, total number of crashes, documented involvement of bus passengers in crashes, and the possible involvement of passengers in crashes. Field observation revealed that 11.5 percent of bus stops met NJ Transit criteria for bus stop length, and that near-side stops were more closely associated with obstructed view crashes than far-side stops. Furthermore, pedestrians in low ridership and low density areas took more risks than pedestrians in high ridership and high density areas. These findings suggest that infrastructure improvements at bus stops in low ridership areas, such as lengthening the size of the bus stop area or relocating stops to the far side of intersections where feasible, may address some of the risky behavior of bus patrons near stops.

In the interviews, one of the biggest concerns was the need for better coordination between state agencies and municipalities on the location of bus stops. Proper coordination could work to address the haphazard placement of some stops and serve to improve connections to locations that may be inaccessible from the pedestrian network. As coordination improves, the eventual development of design guidelines as suggested by the experts would help to provide all users of the system suitable access to areas that may have been otherwise inaccessible. Many of those interviewed agreed that safety at bus stops could be significantly improved when combined with an effective educational campaign and proper enforcement.

The final component of the study was a survey of bus patrons. The survey instrument was developed by the research team and distributed at 17 sites. The sites were categorized as high- and low-density and high- and low-ridership. Questions involved patron perceptions of crime, traffic, transit infrastructure, and bus driver performance. The key findings were:

- Crime was viewed as much more of a concern than traffic safety.
- High ridership bus facilities had a significantly higher perception of traffic dangers than low ridership stations.
- Weak evidence was found of a relationship between reported risky pedestrian behavior and perceptions of crime.

The detailed analysis of factors contributing to bus stop safety presented above suggests a variety of potential improvement strategies. The research team focused their recommendations on practical improvements to common problems observed or reported throughout the different phases of the study. These strategies are summarized below and detailed in the full document.

For intersections:

- Evaluate alternative signal equipment to better accommodate pedestrians
- Install "Turning Vehicles Stop for Pedestrians" signs at intersections with a high number of left turn and right turn crashes.
- Evaluate the potential for prohibiting vehicular turning movements if they are associated with a high degree of pedestrian and vehicular conflicts, and if the movements can be accommodated through alternative means within the larger roadway network.
- Install visible pedestrian information plaques at signalized intersections, to better inform pedestrians on the need to actuate the button for the appropriate crossing.

For midblock locations:

- Evaluate opportunity for installing crosswalks at midblock locations where high volumes of pedestrians are crossing.
- Evaluate appropriate accompanying treatment to midblock crosswalks to increase motorist yielding rate.
- On multilane roadways, evaluate the possibility of a "road diet" treatment

At bus stops:

- Change stops to far-side of the intersection where feasible, as this was shown to present a lower risk for obstructed view crashes.
- Develop context-sensitive bus stop position siting guidelines.
- Improve pedestrian level lighting around bus stops.
- Conduct an educational advertising campaign to encourage pedestrians to cross at marked and preferably controlled locations on their trips to and from the bus stop.
- Provide adequate space for buses at stops, to accommodate the ability of buses to fully dock at the curb.
- Educate bus drivers on the importance of docking at the curb.
- Provide raised islands as pedestrian refuges, or, as in the case of Newark at Market Street and Broad Street, install a decorative fence on a median to discourage midblock crossings.

Introduction

All levels of government in New Jersey – regional, state, and municipal – recognize pedestrian safety as a significant concern. Pedestrians make up a significant proportion of traffic fatalities—roughly 10 percent in New Jersey—and are due special protection because they face greater risk. New Jersey experiences a disproportionate number of pedestrian injuries, crashes, and fatalities compared to the nation as a whole. Many crashes at and near bus stops occur on congested urban streets and along highway corridors. Crashes involving pedestrians are also a significant problem along state highway corridors where many park-and-ride lots and commercial centers are located.

Assessing the factors that contribute to pedestrian crashes can be very complex. There is significant interplay between human factors (i.e., individual and group behavior) and built environment characteristics (i.e. land use, roadway design and transit system operations). This complexity demands a holistic approach to examining the problem as well as determining which policies and other interventions may have the greatest potential to improve safety outcomes. In addition, short-term, quick-fix solutions must be weighed against longer-term, more impactful interventions. Factors that may influence pedestrian-vehicle crashes at bus stops include: risky pedestrian behavior; risky driver behavior; presence/absence of sidewalks; bus stop locations; location and design of crossings; roadway type and design factors; and lighting, time of day, and weather.

Purpose of the Report

The purpose of this research was to identify high pedestrian crash locations at or near bus stops; analyze motorist and pedestrian behavior proximate to identified bus stops; comprehend pedestrian safety perceptions; and, analyze built environment characteristics that may contribute to crashes. Through the collaboration of the Alan M. Voorhees Transportation Center (VTC), Michael Baker Jr., Inc. (Baker), and the Bloustein Center for Survey Research (BCSR), herein referred to as the “research team”, the following activities were performed under the research:

- A thorough review of both practice-oriented and academic literature to provide the research team with a broad understanding of the issues surrounding pedestrian safety at bus stops, methodological issues with utilizing crash data, and best practices in educational campaigns and design interventions.
- Interviews with experts to gain a complete understanding of the regional policy context – the decision making process regarding location and design of bus stops and perceived opportunities and barriers to improving bus stop pedestrian safety.
- A geographic information systems analysis of crashes using crash reports, road characteristics, and other data to identify the sites and corridors with the highest crash incidence, to determine the factors associated with high crash incidence, and to select locations for site-level analysis.
- An intercept survey of bus passengers to determine what they believe are the most significant factors contributing to crashes.

- Direct observations of pedestrian and motor vehicle driver behavior at selected bus stops both to identify behavior that may contribute to crashes, and to identify the proportion of pedestrians in the vicinity of bus stops that are bus passengers.
- Field inventories at selected bus stops in order to better identify and understand design and operational issues that may contribute to pedestrian crashes near bus stops.

Literature Review

Pedestrians make up a significant portion of traffic fatalities and are due special protection as they are threatened by greater risks of fatality and severe injury. Moreover, New Jersey experiences a disproportionate number of pedestrian crashes and fatalities compared to the nation as a whole. This difference can be associated with the state's population density (highest in the nation) and high pedestrian activity. The state has twice the national rate of workers commuting by transit and an above average percentage of households without vehicles. These demographic factors create more reliance on walking.[2]

Determinants of Pedestrian Crash Occurrence

Pedestrian safety has been the focus of many studies throughout the last two decades. A considerable number of these studies evaluated the relationship between pedestrian crashes and various socio-economic, built environment, and traffic variables. LaScala et al. showed that in the City and County of San Francisco, pedestrian crashes were most likely to occur in areas of the city with greater population density, greater proportions of males, lower proportions of children, greater unemployment rates, and lower proportions of well-educated residents (high school degree or better).[3] Clifton and Kreamer-Fults found commercial access, percentage of non-white, population density, and mixed use to be significantly associated with higher aggregate crash severity.[4] A study in Los Angeles also showed that high-collision neighborhoods contained a majority of low-income and minority populations, which might be a result of higher rates of walking and public transit use in such neighborhoods.[5]

In addition to the above mentioned socio-economic variables, environmental variables have also proven to be significant in pedestrian safety. Ewing and Dumbaugh concluded that development patterns impact safety primarily through traffic volume generation, and secondarily through the speeds they encourage.[6] Roadway design impacts safety primarily through the traffic speeds it allows, and secondarily through the traffic volumes it generates. Traffic volumes in turn are the primary determinants of crash frequency; whereas, traffic speeds are the primary determinants of crash severity. As a result, sprawling development patterns associate with higher accident rates. Ewing has shown that the incidence of fatal and non-fatal injuries as a result of traffic accidents is closely related to vehicle miles traveled (VMT), automobile speed, and traffic volumes.[7]

Moudon et al. found additional environmental variables in Seattle that correlate with the risk of crash occurrence.[8] These included presence of crosswalks, number of lanes, presence of nearby retail uses, number of traffic signals, street-block size near the location, and crashes located outside the city. Their earlier study in King County, Washington led to similar results.[9] Furthermore, Wier et al. concluded that traffic volume was a primary environmental cause of vehicle and pedestrian injuries and collisions. In addition to traffic volume, employee and resident populations, arterial streets without public transit, proportions of land area zoned for neighborhood commercial and residential use, proportion of people living in poverty, and proportion of people aged 65 and over were found to be statistically significant predictors of vehicle-pedestrian injury collisions in a multivariate model at the census-tract level in San Francisco, California.[10]

While pedestrian activity is a determinant of the number of crashes, the relationship is not linear. This concept ("safety in numbers") implies that although higher pedestrian flow increases the level of exposure, it does not result in more pedestrian crashes. When risks for pedestrians were calculated as the expected number of reported pedestrian accidents per pedestrian, risk decreased with increasing pedestrian flows, and increased with increasing vehicle flow.[11] Other studies also show that collision rate decreases as the number of pedestrians increases. [12]

Pedestrian activity is also one of the most important exposure measures. Exposure measures are generally used to normalize the number of crash incidents in order to evaluate safety and compare crash numbers in different geographic areas. While pedestrian volume is a crucial measure, the data is not available in most cases. To deal with this shortcoming, models have been developed to estimate or predict pedestrian activity.[13] [14]Among other variables, Moudon et al. found that road-level measures (e.g., average daily traffic and posted speed)and neighborhood level measures (e.g., number of residential units and bus ridership) were significantly associated with the risk of pedestrian crashes, whereas employment density and other pedestrian activity generators (e.g., educational facilities) appeared to be unreliable measures of exposure.[15]

Another variable that is commonly associated with pedestrian crashes is alcohol use. LaScala et al. evaluated injuries in which alcohol use by the pedestrian was implicated and concluded that the presence of a greater number of bars in a neighborhood was related to a greater rate of "had been drinking" pedestrian injuries, regardless of whether the police reported an extent of obvious impairment.[16] In their England and Wales study, Noland and Quddus also found increased per capita expenditure on alcohol to be associated with more serious pedestrian injuries. In a different context, Kim et al. showed that drunken male pedestrians in Hawaii were ten times more likely than other groups to be at fault in crashes. [17]

Research on determinants of pedestrian crashes in other countries show similar results. Noland and Quddus found that more serious pedestrian injuries in England and Wales were associated with lower-income areas, increases in percent of local roads, and total population.[18] The same authors in another study found that urbanized areas tend to have fewer traffic casualties, whereas areas with higher employment density have more traffic casualties.[19] However, Graham and Glaister's study in England shows that higher employment density will increase the pedestrian casualty rate, but in the most extremely dense economic environments there is a fall in incidence.[20]

Some authors have focused on identifying special groups (e.g. child pedestrians) in analyzing pedestrian safety.[21] [22] [23] According to Assailly, the two groups most "at risk" in every European country are children between the ages of 5 and 9 and the elderly.[24] The children are at risk in terms of high accident involvement, whereas the elderly are at risk in terms of mortality from injuries sustained.

Identifying and Ranking High Crash Locations

Research shows that built environment modifications can substantially reduce the risk of pedestrian crashes.[25] Therefore identifying and ranking high crash locations (HCLs) for further improvement has become a well-established approach to study pedestrian safety in the literature. This process usually consists of developing measures of pedestrian crashes and ranking zones or locations according to the assigned measures. The measures most commonly used include individual methods such as crash indices based on frequency, weighted severity factor, vehicular traffic volume, and pedestrian age group, as well as composite methods such as the sum-of-the-ranks method and the crash score method.[26] [27] Following is a brief definition of each index.

- The crash index based on frequency ranks the HCLs on the basis of the number of crashes in each HCL.
- The crash index based on weighted frequency accounts for the density of crashes in addition to the severity of pedestrian crashes. In computing the weighting factor, fatal and serious injury pedestrian crashes are given higher weights. For example, Pulugurtha et al. (2005) used values of 5 and 3 as weights for fatal and severe injury crashes, respectively.[28]
- The crash index based on vehicular traffic volume is defined on the basis of the number of pedestrian crashes and the average daily traffic (ADT).
- The crash index based on pedestrian age group separates crashes on the basis of the age of the pedestrians and assigns different risk factors to each group. Vasudevan et al. (2002) have calculated the average risk factor for people 55 years of age to be 2.42. They have also considered the number to be the same for people younger than 18 years old.
- The sum-of-the-ranks method combines the previous methods to calculate a composite index. A ranked list is prepared for each of the selected methods, and then the ranks for each HCL within these lists are summed to produce a composite rank.
- The crash score method is based on the normalization of the values to the same scale to obtain a score for each method. Such a normalization procedure is used to address the challenge of combining disparate components.

Vasudevan et al. have evaluated the relationship between these different ranking methods. Their results indicate that the rankings based on the individual methods are strongly correlated to the rankings from the composite methods, as are the rankings between the composite methods. They also indicate that the rankings based on individual methods are correlated among themselves, although this correlation is not as strong. Pulugurtha et al. also confirm that while the results from the individual methods show a significant variation, composite indices produce relatively consistent results with little to no variation.[29] In identifying and ranking high crash locations, geographic information system (GIS) has become one of the major tools due to its geographic and analytical capabilities. There have been specific methodologies developed to study the spatial patterns of pedestrian crashes and identify high pedestrian crash zones using GIS.[30] [31] [32]

Pedestrian Safety and Transit

There are a limited number of studies focusing on pedestrian safety in relation to transit stops or corridors. Troung and Somenahalli have identified and ranked unsafe bus stops in Adelaide metropolitan area, Australia, using 13 years of pedestrian-vehicle crash data.[33] Using GIS applications their methodology consists of two main steps: identifying pedestrian-vehicle crash hot spots using crash severity index and identifying bus stops in those selected hot spot areas and ranking them based on crash severity index for pedestrian crashes in their vicinities (within a 100-meter network distance to bus stops).

These two steps were previously taken by Pulugurtha and Vanapalli in their study of the Las Vegas metropolitan area. However, they have normalized pedestrian crash frequencies within a 100-foot buffer radius by traffic volumes and transit ridership rather than crash severity.[34]

Kim et al. have taken a different approach in studying pedestrian crashes around bus stops in Honolulu, Hawaii.[35] They have aggregated bus boarding and alighting volumes at bus stop locations (100-meter buffer zones) with pedestrian crashes. Then correlation analysis was used to examine the relationship between bus stop volume and pedestrian accidents, while spatial analysis was utilized to locate the key locations in which to focus pedestrian safety measures. In a similar study, Hess et al. have concluded that bus stop usage (riders loading and alighting from bus) is associated with pedestrian collisions along state facilities (highways and urban arterials).[36] While the unit of analysis in these studies is usually buffer zones around bus stops, Pulugurtha and Penkey assessed the relationship between transit ridership and pedestrian safety by analyzing road segments with and without transit service.[37] They concluded that pedestrian crashes are high on transit corridors, and that a significant number of pedestrian crashes on these corridors involve transit system riders.

It is also possible to identify unsafe bus stops on the basis of design criteria instead of crash rates. Hazaymeh, in studying a single bus route in Malaysia, has selected three categorical attributes. The attributes are location (if located before a traffic light or road intersection), characteristics (no lighting, curb, or shelter), and surface (located on a sloped surface).[38] These attributes are then used to identify risky bus stops as those exhibiting two or three categories of risk. [39] [40]

Resource with Recommendations for Pedestrian Safety at Bus Stops

As "A Review of Pedestrian Safety Research in the United States and Abroad"- the publication by the Federal Highway Administration - indicates, two percent of all pedestrian collisions in urban areas can be classified as pedestrian collisions at bus stops. Most of these collisions do not involve a pedestrian being struck by a bus. Instead, the role of the bus in the collision is that it creates a visual screen between approaching drivers and pedestrians who dart out in front of the bus and try to cross the street. The countermeasure proposed is relocating the bus stop to the far side of intersections to encourage pedestrians to cross behind the bus instead of in front of it.[41]

The FHWA Pedestrian Facilities Users Guide also provides a matrix of suggested countermeasures for twelve general categories of crashes.[42] According to this document there are three possible causes/ problems in bus-related crashes:

- Motorist fails to yield to pedestrian or pedestrian crossing during inadequate gap in traffic due to limited sight distance at intersection;
- Pedestrian has difficulty walking along roadway and crossing at midblock location with high vehicle speeds and/ or high volumes;
- Pedestrian has difficult time crossing, waiting or walking in the vicinity of school bus stop.

The Pedestrian Road Safety Audit Guidelines and Prompt Lists provide guidelines to conduct road safety audits (RSA) with special consideration for pedestrians.[43] The field manual section of this document includes detailed descriptions of pedestrian safety problems at transit and school bus stops. The Toolkit for Bus Stop Accessibility and Safety Assessment by Easter Seals Project ACTION is another resource that provides guidelines on conducting bus stops inventory.[44] The Easter Seals Project toolkit also makes design recommendations that include improvements to lighting, signage, street furniture, etc., to make stops safe and accessible.

New Jersey Department of Transportation also has over 100 recommendations for systematically strengthening pedestrian safety in New Jersey in various areas such as management, education, and engineering.[45] New Jersey's Safety Management Task Force has done a similar study and identified eight emphasis areas to reduce crash injuries and fatalities in New Jersey, based on a detailed analysis of New Jersey's crash records database and a survey of Task Force members.[46] Similarly the Pedestrian Safety Guide for Transit Agencies emphasizes education and enforcement while suggesting helpful engineering actions that consider sidewalk design, roadway crossings, pedestrian crossings of rail systems, transit vehicle design, and transit stop location and design.[47]

There are similar studies considering pedestrian safety in relation to other modes of public transportation. Cleghorn's work (2009), for example, documents best practices to improve pedestrian and motorist safety along light rail transit alignments and provides detailed designs, physical treatments, and control devices such as path delineation, signs, barriers, curbs and fencing.[48] Some authors have focused more on crime and personal safety at transit stops. [49] [50]

Shortcomings in Pedestrian Safety Research

There are several shortcomings common to studies involving pedestrian crashes. First, although most studies have considered the police crash reports as their main source of information, these reports "do not provide an accurate picture of pedestrian traffic crashes. Comparisons with hospital and emergency room data show that many non-fatal pedestrian injuries are not reported to the police. Some are overlooked; some are not eligible since they occur off the roadway or do not directly involve a motor vehicle. Even for those that are reported, the police record lacks vital information, such as pedestrian actions prior to the crash, sight lines for pedestrians and motorists, and special crash characteristics such as pedestrian disabilities." [51] Relying solely on state police-reported motor vehicle crash data may underestimate the magnitude and scope of the pedestrian and bicyclist injury.[52] Also, there is no way to determine if the population of unreported incidents is systematically different than reported incidents.

Furthermore, geographically based studies may have problems with spatial autocorrelation which introduces bias into statistical analysis due to the violation of the assumption of unit independence. Two spatial units that are adjacent can exert some effect on each other and therefore, if taken as separate observations, are not truly independent. To overcome this problem authors have taken different approaches. For instance, LaScala et al. in their San Francisco study used a Moran coefficient to test for the significance of spatial autocorrelated errors and found it to be significant in each case.[53] They proceeded further by using a model from Gruenewald et al. to correct for any spatial autocorrelation.[54]

Expert Interviews

In addition to research performed for the literature review, eight interviews with key stakeholders from local municipalities, state agencies, and non-profit organizations were conducted. The interviews served to provide expert commentary on built environment characteristics and policy issues associated with bus stop placement and design. Questions focused on five major topics: bus stop location/placement; bus stop design; intersection design; driver and pedestrian education; and policy and decision making processes. A complete copy of the interview questions can be found in Appendix A. The following segment summarizes the responses and highlights similarities among the different participants.

Bus Stop Location and Placement

Three major points were brought up by the experts regarding the placement of bus stops. These included: pedestrian accessibility, inter-agency/municipal coordination, and bus stop design. Concerns ranged from the "haphazard" nature of bus stop placement to the lack of sufficient design or placement standards used in the state. An often repeated comment was the apparent lack of interagency/municipal coordination. One expert stated that, "A structured process is needed to review and recommend the best locations", while another added that they "sensed a disconnection between the decision-making at NJDOT and the decision-making at NJ Transit." Responses also centered on the issue of accessibility, thus highlighting the need for "gaps in the network" to be filled to provide adequate access without "forcing pedestrians into travel lanes."

Bus Stop Design

One major theme was derived from questions that focused on bus stop design: accessibility. Other responses focused on coordination, placement, and integration of facilities within the surrounding network of pedestrian amenities. For example, several experts expressed dissatisfaction in the way bus stops do not consider all users. One expert stated that "universal and complete street design standards should be used." Another added, in reference to those with restricted mobility "If there happens to be a person with any kind of limitations in terms of mobility they will not have an easy time maneuvering from the stop itself to the system." One additional concern highlighted the need to integrate the facilities better with the surrounding areas, as this would encourage use. Others suggested installation of passenger amenities such as sidewalks, shelters, seating, pedestrian scale lighting, and flashing beacons used to notify drivers of waiting passengers.

Intersection Design

When asked about the design of intersections at bus stops, one expert stated that "a major challenge for the design is that every location is different." Aside from suggesting treatments such as countdown pedestrian signal heads, HAWK signals, ADA accessibility, and lead pedestrian intervals, the consideration of far-side vs. near-side stop placement was identified as an important aspect of intersection design by several of the experts. What highlighted this was the comment: "[I]n terms of pedestrian safety, the wisdom is that the pedestrian should exit and cross behind the bus, not in front of the bus." Similarly, another expert stated a preference for far-side stops within their community, as they "seem to make the most sense." No other expert made a distinct reference to preference on what side of the intersection a bus stop should be placed, but experts once again brought up the issue of coordination between the different agencies as a major solution to the problems that are associated with their design. One expert stated that "I think the concerns that the designers are addressing in terms of intersection design are not necessarily in line with the concerns that NJ Transit is addressing, because obviously, NJ Transit, I believe, is going to choose sites that are going to put riders as close as possible to the facilities they are headed to."

Driver and Pedestrian Education

Almost all of the experts agreed that both education and enforcement need to be increased in order to promote bus stop safety. One expert expressed the desire to provide educational resources regarding pedestrian safety at bus stops, but lacked the guidance on how to implement such a program. Another felt that "in general, people do not have the knowledge or understanding of how to interact with buses." They went on to say that successes have been made with similar efforts in their community regarding bicycle and pedestrian safety, so an effort to provide additional information to bus passengers could be beneficial. One expert suggested a campaign that would utilize social networking sites such as Facebook, or Twitter as means to reach out to transit users. Others had recognized seeing educational materials being utilized and suggested that these types of outreach be continued. Still, some experts did agree that enforcement of laws was a critical issue. One expert stated that cars that park at bus stops were a major issue and enforcement "requires vigilance, because it's tempting as a driver to want to park in a bus stop for a short period of time if busses are only appearing there six times an hour." Additional enforcement suggested by the experts went on to include issuing violations to motorists who fail to stop for pedestrians in the crosswalk and pedestrians who jaywalk.

Policy and Decision-Making Process

Several experts were not familiar with the policy and decision making processes that are in place for bus stops. One that was familiar stated "Our current system is broken, and in need of repair." This expert went on to say that "NJ Transit needs a more enhanced role in dealing with this issue, but that it will only occur if there are design standards that are realistic, safe and pedestrian friendly that municipalities are required to comply with." Others reinforced the need for standards and called for a "formalized process for bus stop placement", which seemed to resonate throughout the interviews from all experts.

In summary, one of the biggest concerns expressed by the interviewees was the need for better coordination between state agencies and municipalities where bus stops are being located. This issue came up in several conversations and was often repeated throughout the interviews. Proper coordination could work to address the haphazard placement of some stops and serve to improve connections to locations that may be inaccessible from the pedestrian network. The emerging thought from the experts is that better connections would result in increased ridership. As coordination improves, the eventual development of design guidelines as suggested by the experts would help to provide all users of the system suitable access to areas that may have been otherwise inaccessible. When combined with an effective educational campaign, supported by proper enforcement, many of those interviewed agreed that safety at bus stops could be significantly improved.

Identification and Analysis of High Crash Bus Stop Locations

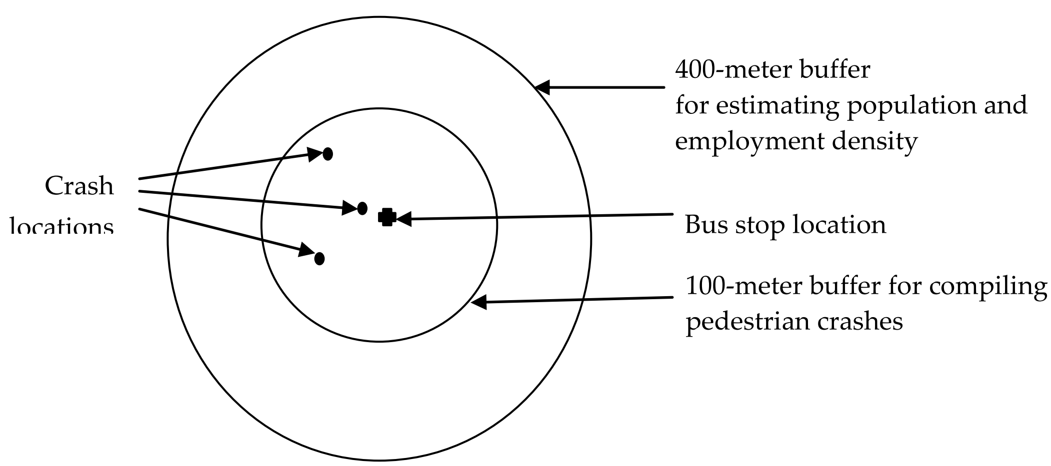
For the purpose of developing strategies to address pedestrian safety issues near bus stops, it was necessary to first identify an adequate number of high-crash bus-stop locations. These locations were identified by analyzing data from throughout the State of New Jersey. The three data components for the identification of high-crash bus-stop locations were (a) bus-stop locations from 2009 NJ TRANSIT GIS maps, (b) Plan4Safety pedestrian crash data for 2005-2009, and (c) Census data on employment and population for all Block Groups. Population statistics were extracted from American Community Survey 2005-2009 averages while the Longitudinal Employer-Household Dynamics (LEHD) database was used to obtain employment data for 2005-2008.

Calculation of Crash Index for Bus Stops

In the first step of analysis, all bus stops in the NJ TRANSIT bus network were identified. In the second step, by using GIS techniques, 400-meter buffers were created around each bus stop and the Census Block Groups that intersected with the buffers were identified (400 meters equals 0.25 miles). In the third step, Census data on employment and population for these Block Groups were compiled to compute average employment density and population density for the buffer area around each bus stop. The estimation of employment and population density was necessary to normalize the number of crashes around bus stops. Normalization of crashes was important because larger volumes of workers and population increase the potential number of persons exposed to crash sites.

In the fourth step of analysis, 100-meter buffers were created around all bus stops for the purpose of compiling pedestrian crashes around bus stops. It was decided that 100 meters would be an optimum distance for the buffers because (a) beyond this distance crashes may have little or nothing to do with transit service; and (b) it would be difficult to develop strategies to address pedestrian crashes for larger areas. The two types of buffers, one for the compilation of pedestrian crashes, and the other for the estimation of employment and population density, are shown in the figure below.

Figure 1: Pedestrian Crashes and Estimation of Employment and Population Density



Source: Voorhees Transportation Center

In the fifth step, a crash score is calculated for each bus stop. To calculate the crash score, in an intermediate step, crash indices based on crash frequency, population density and employment density were calculated for a bus stop. The crash score for a bus stop is then calculated by summing the score of all crash indices (normalized values of crash indices). Mathematically, the crash score is calculated as follows:

Step 1. Calculate for each bus stop the crash index based on crash frequency (CIF), crash index based on population density (CIP), and crash index based on employment density (CIE).

CI_F = Total number of pedestrian crashes within 400-meter buffer

$$CI_P = \frac{}{}$$

$$CI_E = \frac{}{}$$

Step 2. Calculate the score for each index for each bus stop:

$$\text{Score } CI_F = \frac{}{} \text{ X } 100$$

$$\text{Score } CI_P = \frac{}{} \text{ X } 100$$

$$\text{Score } CI_E = \frac{}{} \text{ X } 100$$

Step 3. Calculate crash score (CS) for each bus stop:

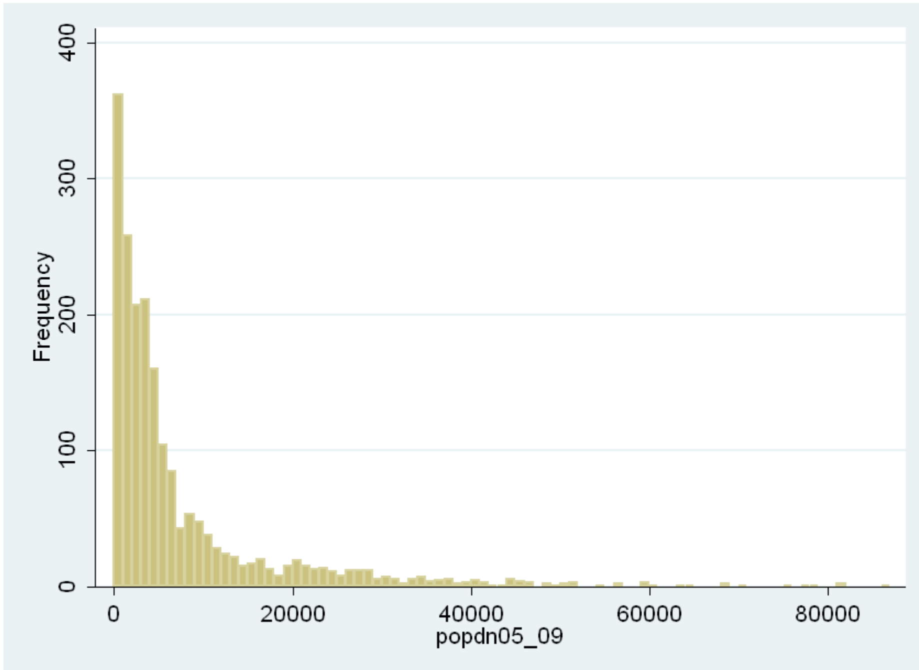
$$CS = \text{Score } CI_F + \text{Score } CI_P + \text{Score } CI_E$$

Selection of High-Crash Bus Stops

Once the crash scores for all bus stops were calculated, they were ranked according to their crash scores (CS). To ensure that the high-crash bus stops selected for further analysis were not similar in nature, and to ensure that the locations represented different parts of the state, a few additional steps were undertaken.

First, by considering the Census Tract population density, the bus stops were classified into high and low density locations. High density locations were defined as Census Tracts with densities of 7000 persons per square mile or more and low density locations as Census Tracts with densities less than 7000 persons per square mile. This classification was made based on natural breaks in population density, identified by the following histogram.

Figure 2: Natural Breaks in Population Density Histogram



Source: Voorhees Transportation Center

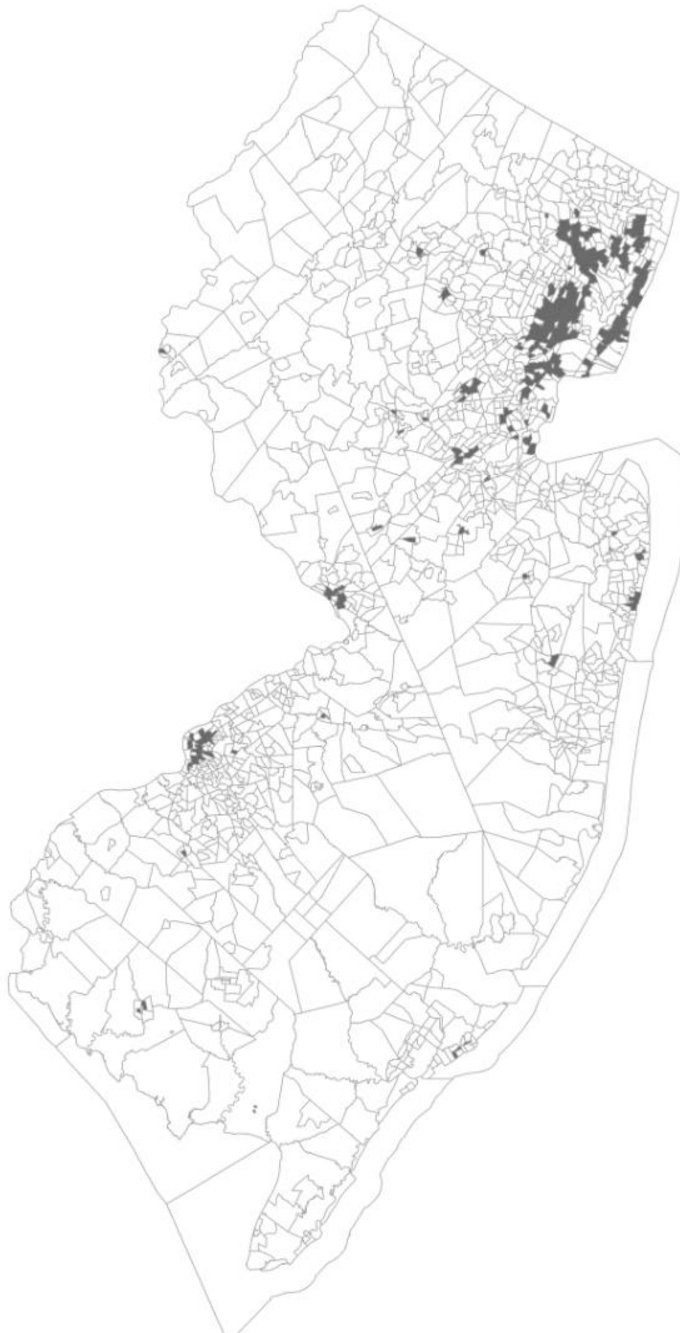
As a result, 1387 low density Census Tracts and 563 high density Census Tracts were identified in New Jersey whose distribution is shown in the following map.

The calculations of crash indices and scores were done for each group of high and low density locations separately. This step was crucial to ensure low density areas do not remain underrepresented through the normalization process based on highest values.

Another step taken to ensure the representativeness of the distribution was making sure at least one high-crash bus stop is selected in each county of New Jersey. To do so the stops with the highest crash score in high and low density areas of each county were selected and the one with more crashes within 100-meter distance was identified as the critical one. If there were no bus stops in a county, or no crash sites within the 100-meter buffer of a bus stop, no stop was selected in the county. Doing so resulted in selecting bus stops in 15 counties and leaving out 6 of the counties. All bus stops with less than 5 crashes during the 5-year period (2005-2009) were excluded from the analysis.

The remaining bus stops in high and low density areas were ranked separately and 15 High-Crash Locations (HCL) in high density Census Tracts and 15 HCLs in low density Census Tracts were selected. HCLs are the site of one bus stop or a cluster of bus stops with the highest crash scores. When the selected bus stops were within 200 meters of each other, high-crash clusters were created so that the issues relating to these bus stops could be studied together.

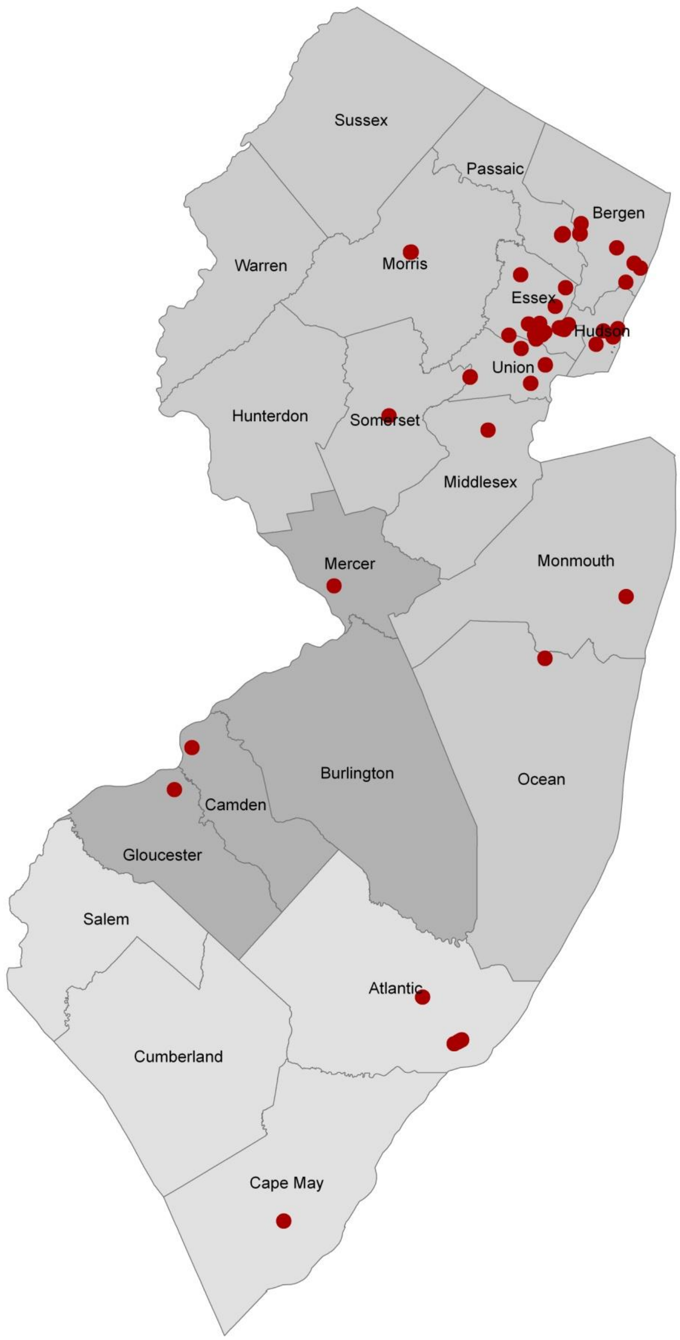
Figure 3: Census Tract Distribution Map



Source: Voorhees Transportation Center

This process resulted in a total of 45 high-crash clusters, where some clusters contained multiple bus stops and others contained a single bus stop. The following map shows the distribution of these clusters.

Figure 4: Cluster Distribution Map



Source: Voorhees Transportation Center

The total number of pedestrian crashes occurring within a 100-meter distance of these bus stops during 2005-2009 was 561. Essex County with 16 clusters has the highest number of clusters and cluster number 31 in Atlantic City with 12 bus stops has the highest number of bus stops in a cluster. The latter was evaluated as a special case regarding the unique characteristics of the cluster, area, and crash frequency. A summary of each cluster's information is included in the following table.

Table 1: Summary of Crash Clusters

Cluster	Cluster ID	County	Police Department	Crashes	Buses	Cluster Area
1	CR	Atlantic	Atlantic City	10	2	0.0144
2	CR	Bergen	Fort Lee	11	1	0.01211
3	CR	Camden	Camden	17	2	0.01371
4	CR	Cape May	Middle Township	5	2	0.01382
5	CR	Essex	Irvington	12	2	0.01425
6	CR	Gloucester	Woodbury City	8	1	0.01211
7	CR	Hudson	Jersey City	20	2	0.01426
8	CR	Mercer	Trenton	7	1	0.01211
9	CR	Middlesex	Metuchen	9	1	0.01211
10	CR	Monmouth	Asbury Park	7	1	0.01211
11	CR	Morris	Town Of Dover	22	5	0.028
12	CR	Ocean	Lakewood	5	2	0.01939
13	CR	Passaic	Paterson	18	4	0.0281
14	CR	Somerset	Somerville	6	1	0.01211
15	CR	Union	Twp Of Union	9	2	0.01732
16	HD	Essex	South Orange	13	1	0.01211
17	HD	Union	Plainfield/ Scotch	7	4	0.02327
18	HD	Essex	Irvington	19	3	0.01627
19	HD	Essex	Newark/ East	13	2	0.01361
20	HD	Bergen	Elmwood Park	10	5	0.02488
21	HD	Essex	Bloomfield	13	1	0.01211
22	HD	Essex	Nutley	12	4	0.01636
23	HD	Essex	Irvington	17	1	0.01211
24	HD	Essex	Newark	12	7	0.02673
25	HD	Essex	Newark	10	2	0.0156
26	HD	Union	Linden	12	3	0.01638
27	HD	Bergen	Ridgefield	8	1	0.01211
28	HD	Essex	Newark/ ECCPD	12	2	0.01526
29	HD	Essex	Irvington	10	2	0.01511
30	HD	Bergen	Teaneck	9	1	0.01211
31	LD	Atlantic	Atlantic City	83	12	0.08483
32	LD	Passaic	Paterson	12	4	0.02408
33	LD	Essex	Millburn	11	1	0.01211
34	LD	Hudson	Harrison/ Kearny	11	2	0.01352
35	LD	Essex	Caldwell	12	2	0.01464
36	LD	Bergen	Leonia	14	2	0.02102
37	LD	Union	Elizabeth	8	1	0.01211
38	LD	Hudson	Hoboken/	9	2	0.01424
39	LD	Bergen	Fair Lawn	8	4	0.01722
40	LD	Hudson	Jersey City	12	2	0.019
41	LD	Hudson	Jersey City	9	1	0.01211
42	LD	Atlantic	Galloway	8	2	0.01378
43	LD	Essex	Irvington	8	1	0.01211
44	LD	Essex	Irvington	8	1	0.01211
45	LD	Essex	Newark	5	2	0.01382

Source: Voorhees Transportation Center *Note: LD – Low Density; HD – High Density; CR – County Representative*

Summary of Conditions at Forty-Five Cluster Bus Stops

This section summarizes the crash history of the 551 crashes in the 45 statewide clusters. The involvement of bus passengers in crashes is reviewed, along with an analysis of crash type; demographics; month, day, and time; and, road and light conditions.

Methodology

The research team reviewed data on 561 pedestrian crashes that occurred at 45 clusters in New Jersey between January 1, 2005, and December 31, 2009. These clusters consisted of an area 100 meters (320 feet) in radius around bus stops identified as located in high pedestrian crash areas. Baker obtained copies of reports for the 561 crashes from NJDOT, and reduced the number to 551, since the original request included a number of duplicates or crashes that, upon review, did not involve pedestrians. The primary purpose of the report review was to summarize the Crash Description that appears in box 135 of NJTR-1, the official New Jersey crash report form. The Crash Description provided the only means by which the research team could determine whether the pedestrian cited in the report was preparing to board a bus or had alighted from a bus before the crash. Baker tabulated and analyzed the crash history.

Crash Clusters

Table 2 indicates the 45 clusters and the number of crashes associated with each from 2005 through 2009. Essex County had the highest number of clusters, at 16. Within Essex County, Irvington Township had 6 clusters, and Newark had 5. Bergen County was second in number of clusters, with 6, and Hudson County had 5.

Table 2: Crashes by Cluster

Cluster	County	Municipality	Crashes
1	Atlantic	Atlantic City	9
31	Atlantic	Atlantic City	83
42	Atlantic	Galloway Twp	5
20	Bergen	Elmwood Park	10
39	Bergen	Fair Lawn	8
2	Bergen	Fort Lee	11
36	Bergen	Leonia	8
27	Bergen	Ridgefield	8
30	Bergen	Teaneck	9
3	Camden	Camden	17
4	Cape May	Middle Township	5
21	Essex	Bloomfield	13
35	Essex	Caldwell	9
5	Essex	Irvington	12
18	Essex	Irvington	19
23	Essex	Irvington	16
29	Essex	Irvington	10
43	Essex	Irvington	12
44	Essex	Irvington	14
33	Essex	Millburn	11
19	Essex	Newark	12
24	Essex	Newark	12
25	Essex	Newark	10
28	Essex	Newark	12
45	Essex	Newark	8
22	Essex	Nutley	12
16	Essex	South Orange	13
6	Gloucester	Woodbury City	7
34	Hudson	Harrison/Kearny	11
38	Hudson	Hoboken	8
7	Hudson	Jersey City	19
40	Hudson	Jersey City	8
41	Hudson	Jersey City	8
8	Mercer	Trenton	6
9	Middlesex	Metuchen	8
10	Monmouth	Asbury Park	7
11	Morris	Dover	22
12	Ocean	Lakewood	5
13	Passaic	Paterson	17
32	Passaic	Paterson	12
14	Somerset	Somerville	6
37	Union	Elizabeth	12
26	Union	Linden	12
17	Union	Scotch Plains	6
15	Union	Union Twp	9

Source: Michael Baker Corporation

Crashes Involving Bus Passengers or Buses

Based upon the Crash Description, the research team identified 12 crashes in which the pedestrian was reported to be a bus passenger, and these are listed in Table 3, indicating cluster, case number (number assigned by the local police department), municipality, and intersection. Three crashes occurred in three different clusters in Irvington, and three occurred in three different clusters in Newark. No other municipality had more than one crash in which the pedestrian was also reported as a bus passenger.

Three of the identified crashes involved collisions between buses and bus passengers. They are however of less interest than the other nine in this category because of their unusual circumstances:

- A pedestrian became involved in a crash when he was placing his bicycle in the luggage compartment of the bus, and the bus began pulling away (2006-20279).
- A pedestrian was banging on the bus door, and was struck when the bus began pulling away (08-46263).
- A bus struck a passenger when the driver pulled up too close to the curb (CC#08-20980).

In each of these crashes, the built environment appeared to be a minor contributing factor, with the interaction between the bus driver and passenger being of greater importance. Further, unlike the other nine crashes, none of these crashes involved a pedestrian who was in the process of crossing the roadway.

Table 3: Crashes Involving Bus Passengers

Cluster	Case No.	Municipality	Intersection
4	2006-20279	Middle Township	Rt 47 & 5th Street
18	0511781	Irvington	CR 603 & Maple Avenue
22	07-021142	Nutley	CR 645 & CR 648
23	2007/8520	Irvington	CR 603 & Myrtle Avenue
24	06-58504	Newark	Park St & Raymond Boulevard
25	CC#08-20980	Newark	Route 510 & Broad Street
28	08-46263	Newark	Main St & MLK Boulevard
30	07041548	Teaneck	CR 60 & CR 41
37	08-14892	Elizabeth	CR 623 & E. Grand Street
40	85193-05	Jersey City	CR 609 & Stegman Avenue
42	2007-32561	Galloway	US 30 & CR 654
43	06-18537	Irvington	Clinton Ave & CR 509

Source: Michael Baker Corporation

In addition to the crashes listed above, the research team also identified crashes in which pedestrians were not described by the police as bus passengers, but in which the recorded events suggested bus passenger activity. The team did so since reliance upon the identification of a pedestrian as a bus passenger likely underestimates the number of crashes involving bus passengers. The NJTR-1 Form Field Manual (Rutgers University Police Technical Assistance Program, 2008) states that the Crash Description should describe the "physical facts involved in the crash," and should also provide accounts from involved parties and witnesses along with the investigator's conclusion. Reporting police officers frequently do not record the activity that occurred just before the precipitating action, or the pedestrian's motivation for crossing the street. In the 551 crashes, the officer rarely indicated the immediate origin or destination of the pedestrian. If a pedestrian suddenly enters the street to conduct a midblock crossing, the reporting officer may find that fact of interest, without noting that the pedestrian was just dropped off by a bus at a midblock stop. The interest of the responding officer in recording a pedestrian as a bus passenger would likely lessen as distance between the bus stop and the location of the crash increases. Finally, the pedestrian was incapacitated or otherwise unavailable to be interviewed by the police in the majority of cases suggestive of bus activity. In some of these cases, witnesses told police that they had seen the pedestrian walking toward a bus stop, but the pedestrian was not interviewed to confirm that destination.

Information provided about these "suspected bus passenger" cases was often highly subjective. For example, a pedestrian was recorded as walking into the street from between two buses at a bus stop; the bus stop has a high level of passenger activity, and the land uses next to the bus stop are boarded up, so there is no other pedestrian generator in the vicinity. In another case, a pedestrian was recorded as crossing the street and running toward a bus stop early in the morning; the bus stop was in front of a retail complex, but all stores would have been closed at the time of the crash. There are nine crashes in which the pedestrians are suspected to be bus passengers, and these are summarized in Table 4.

Table 4: Crashes Involving Suspected Bus Passengers

Cluster	Case No.	Municipality	Intersection
4	2006-25016	Middle Township	Rt 47 & 5th Street
5	2005-37547	Irvington	CR 601 & Union Avenue
15	09-32766	Union Twp	NJ 82 & Caldwell Avenue
18	07-32452	Irvington	CR 603 & Maple Avenue
20	2007-000583	Elmwood Park	Rt 4 & Rosedale Avenue
27	06-010802	Ridgefield Boro	Rt 1 & Shaler Boulevard
31	05-0729	Atlantic City	Atlantic Ave & Ohio Avenue
36	07-07246-183	Leonia	Broad Ave & CR 56 III
44	07-2779	Irvington	CR 603 & Avon Avenue

Source: Michael Baker Corporation

Finally, the research team also noted those crashes in which a bus was directly involved in a crash with a pedestrian who was not walking toward or away from the bus, and who was likely not a bus passenger. These crashes are summarized in Table 5. Since they did not involve identified or suspected bus passengers, they are of less interest than crashes listed in Tables 2 and 3.

Table 5: Crashes Involving Buses and No Bus Passengers

Cluster	Case No.	Municipality	Intersection
37	08-22336	Elizabeth	E. Jersey Street & CR 623
23	07-3834	Irvington	CR 603 & CR 665
24	07-20586	Newark	Raymond Boulevard & Broad Street
45	08-15942	Newark	Market Street & Alling Street
22	05-0020984	Nutley	CR 648 & Franklin Avenue
16	2005-7769	South Orange	CR 510 & Scotland Road

Source: Michael Baker Corporation

In summary:

- 12 crashes, or 2.2% of the 551 crashes, involved identified bus passengers;
- 9 crashes, or 1.6%, involved pedestrians suspected of being bus passengers; and,
- 6 crashes, or 1.1%, involved buses but not bus passengers.

In all, 3.8% of crashes involved pedestrians confirmed or suspected of being bus passengers. Other studies have indicated that bus passengers comprise 2% of pedestrian crashes in urban areas, which closely corresponds to the 2.2% confirmed passenger finding noted above. [55]

However, as discussed above, the police likely understated the percentage of pedestrians that were bus passengers. Our field observations suggest that the percentage of pedestrians comprised of bus passengers is higher than 2%. We determined that a median of 15.1% of pedestrians at the 30 sites would eventually board or alight from buses. This percentage can be assumed to be the upper range of the percentage of pedestrians in the study area that were bus passengers. Therefore, bus passengers likely comprise anywhere from 2% to 15% of pedestrian crashes in the study area, with 3.8% being a more reasonable floor than 2%.

Crash Type

The reporting police officer categorized the crash type for most of the crashes as "Pedestrian" or "Other." This crash typology is of little use in analyzing the crashes to help determine contributing patterns. The research team therefore categorized each crash based upon the typology developed for PBCAT (Pedestrian and Bicycle Crash Analysis Tool, Version 2.0) by the University of North Carolina, and disseminated by the FHWA. The PBCAT pedestrian crash typology is described at the following website:

http://www.walkinginfo.org/facts/pbcat/index.cfm?/pc/pbcat.htm

The research team modified the PBCAT pedestrian crash typology by indicating whether "Dash" crashes and "Pedestrian Failed to Yield" crashes occurred at intersections or non-intersections, since this characteristic was determined to be of interest. Typing pedestrian crashes is often a subjective exercise, since many pedestrian crashes can be classified as more than one type. The research team sought to classify each crash by the action seen as most significant in the evolution of the crash.

As shown in Table 6, the most common crash type was "Left Turn Parallel Path," in which a motorist turned left into a pedestrian crossing the receiving roadway. This accounted for 195 crashes, or 35.4% of the total. The second most common crash type, "Pedestrian Failed to Yield – At Intersection," accounted for 62 crashes, or 11.3%, slightly higher than "Pedestrian Failed to Yield – Not Intersection," which accounted for 61 crashes, or 11.1%. The fourth most common crash type was "Motorist Failed to Yield," with 38 crashes, or 6.9%. Other crash types are shown in descending order.

Table 6: Crashes by Type

	Crashes	
Crash Type	**Number**	**Percent**
Left Turn Parallel Path	195	35.4%
Pedestrian Failed to Yield - At Intersection	62	11.3%
Pedestrian Failed to Yield - Not at Intersection	61	11.1%
Motorist Failed to Yield	38	6.9%
Right Turn Parallel Path	36	6.5%
Dash - Not at Intersection	33	6.0%
Backing Vehicle	16	2.9%
Miscellaneous/Unknown	15	2.7%
Dart Out	12	2.2%
Entering/Exiting Parked Vehicle	11	2.0%
Right Turn Perpendicular Path	11	2.0%
Dash - At Intersection	9	1.6%
Walking along Roadway with Traffic	8	1.5%
Exiting Driveway/Alley	7	1.3%
Commercial Bus Related	6	1.1%
Left Turn Perpendicular Path	6	1.1%
Multiple Threat	5	0.9%
Trapped	5	0.9%
Waiting to Cross	4	0.7%
Other	11	2.0%
TOTAL	551	100.0%

Source: Michael Baker Corporation

To identify effective counter-measures, it is useful to determine whether the motorist or pedestrian has primary responsibility for the crashes. For this study, responsibility was assigned based upon the crash type. It was assumed that motorists are primarily responsible for the following crash types:

- Left Turn Parallel Path
- Motorist Failed to Yield
- Right Turn Parallel Path
- Backing Vehicle
- Waiting to Cross
- Exiting Driveway/ Alley

It was assumed that pedestrians are primarily responsible for the following crash types:

- Pedestrian Failed to Yield
- Dash
- Dart-out
- Right Turn Perpendicular Path
- Left Turn Perpendicular Path
- Commercial Bus Related
- Multiple Threat

Primary responsibility was not assigned to the other crash types. Given these assumptions, the motorist appears to be primarily responsible for the majority of crashes. Of the 551 crashes evaluated, the motorist was primarily responsible for 53.7% of crashes, and the pedestrian responsible for 37.2%. Responsibility was undetermined for the remaining 9%.

It should be emphasized, however, that assigning responsibility based upon crash type is not a clear-cut exercise. There are likely many exceptions within the main categories. For example, for "Left Turn Parallel Path," police may have recorded that a vehicle turned left into a pedestrian crossing at an intersection, without necessarily indicating that the pedestrian was crossing during a "Don't Walk" signal phase.

It is noted that the crash type, "Commercial Bus Related," does not cover all of the crashes identified as involving buses. In this crash type, a pedestrian walks out from behind a commercial bus docked at the curb and is struck by a vehicle. The inhibition of sight distance by the parked bus contributes to the crash. Six crashes fell into this category.

Crashes were also classified by whether they occurred at an intersection, or not at an intersection. As indicated in Table 7, slightly less than two-thirds (65.5%) of the crashes occurred at intersections, and one-third occurred at non-intersection locations.

Table 7: Crashes by Location

	Crashes	
Location	**Number**	**Percent**
At Intersections	361	65.5%
Not at Intersections	190	34.5%
TOTAL	551	100.0%

Source: Michael Baker Corporation

Demographics

There were 569 pedestrians involved in the 551 crashes, since a number of crashes involved two or three pedestrians. Of the 569 pedestrians, 297, or 52.2% were female, and 271, or 47.6%, were male (Table 7). The gender of one pedestrian was not identified.

The ages of pedestrians are summarized in Table 9. The age groups of 25-44 and 45-64 are equally well represented, at 30.8% and 30.1% of pedestrians respectively, and collectively represent the majority of involved pedestrians. The age group of 20-24 accounts for 9.7% of the total, and the age group of 15-19 accounts for 9.5%.

Table 8: Involved Pedestrians by Gender

	Pedestrians	
Gender	**Number**	**Percent**
Male	271	47.6%
Female	297	52.2%
Unknown	1	0.2%
TOTAL	569	100.0%

Source: Michael Baker Corporation

Table 9: Involved Pedestrians by Age Range

	Pedestrians	
Age Range	**Number**	**Percent**
0-4	7	1.2%
5-9	18	3.2%
10-14	28	4.9%
15-19	54	9.5%
20-24	55	9.7%
25-44	175	30.8%
45-64	171	30.1%
65+	51	9.0%
Unknown	10	1.8%
TOTAL	569	100.0%

Source: Michael Baker Corporation

Month, Day and Time

The month in which the crashes occurred is summarized in Table 10. October had the highest number of crashes, with 59, or 10.7% of the total, and August was second, with 51 crashes, or 9.3%. The months of February and March each had 50 crashes, or 9.1%.

Table 11 categorizes crashes by day of the week. The highest number of crashes occurred on Friday, with 106, or 19.2%. Tuesday was second with 92 crashes, or 16.7%, and Thursday was third with 86 crashes, or 15.6% of the total.

Table 12 categorizes crashes by time, subdividing the day into 4-hour periods. The highest number of crashes took place from 2:00 PM to 5:59 PM, coinciding with the afternoon peak period. In this period there were 166 crashes, or 30.1% of the total. The time period of 6:00 PM to 9:59 PM had the second highest number of crashes, with 132, or 24%. The period of 10:00 AM to 1:59 PM was third, at 19.6% of the total. The morning peak period, 6:00 AM to 9:59 AM, accounted for 85 crashes, or 15.4% of the total.

Table 10: Crashes by Month

	Crashes	
Month	**Number**	**Percent**
January	49	8.9%
February	50	9.1%
March	50	9.1%
April	39	7.1%
May	49	8.9%
June	45	8.2%
July	36	6.5%
August	51	9.3%
September	41	7.4%
October	59	10.7%
November	40	7.3%
December	42	7.6%
TOTAL	551	100.0%

Source: Michael Baker Corporation

Table 11: Crashes by Day

	Crashes	
Day of Week	**Number**	**Percent**
Sunday	48	8.7%
Monday	76	13.8%
Tuesday	92	16.7%
Wednesday	79	14.3%
Thursday	86	15.6%
Friday	106	19.2%
Saturday	64	11.6%
TOTAL	551	100.0%

Source: Michael Baker Corporation

Table 12: Crashes by Time

Time of Day	Crashes Number	Crashes Percent
6:00 AM to 9:59 AM	85	15.4%
10:00 AM to 1:59 PM	108	19.6%
2:00 PM to 5:59 PM	166	30.1%
6:00 PM to 9:59 PM	132	24.0%
10:00 PM to 1:59 PM	35	6.4%
2:00 PM to 5:59 PM	20	3.6%
Unknown	5	0.9%
TOTAL	551	100.0%

Source: Michael Baker Corporation

Road and Light Conditions

As indicated in Table 13, the large majority of crashes occurred during good weather conditions. The road surface was dry in 422 crashes, or 76.6% of the total. The roadway was wet in 21.8% of the crashes, and icy in only 0.9%.

Table 14 indicates the light conditions at the time of the crash. The majority of crashes occurred during daylight, with 352 crashes, or 63.9%. The sky was dark for 178 crashes, or 32.3%, and it was dawn or dusk for 3.3% of the crashes.

Table 13: Road Condition

Road Surface Condition	Crashes Number	Crashes Percent
Dry	422	76.6%
Icy	5	0.9%
N/a or Unknown	1	0.2%
Snowy	3	0.5%
Wet	120	21.8%
TOTAL	551	100.0%

Source: Michael Baker Corporation

Table 14: Light Condition

Light Condition	Crashes Number	Crashes Percent
Dark	178	32.3%
Dawn / Dusk	18	3.3%
Daylight	352	63.9%
N/a or Unknown	3	0.5%
TOTAL	551	100.0%

Source: Michael Baker Corporation

Selection of Cluster Sites for Field Views and Observations

Upon completion of the analysis of crash reports, the research team met with NJDOT to review the findings and recommendations. This section highlights the methodology used in selecting the clusters sites and the list of 30 clusters chosen for field views and observations.

Methodology

Table 15 highlights the 30 clusters chosen for field views and observations. The predominant reasons for the selection of the clusters were geographic distribution, total number of crashes, documented involvement of bus passengers in crashes, and the possible involvement of passengers in crashes. A secondary reason was to capture a cross-section of stops within a variety of both high and low ridership corridors and high and low density areas. As described earlier, High density locations were defined as Census Tracts with densities of 7000 persons per square mile or more and low density locations as Census Tracts with densities less than 7000 persons per square mile. High ridership areas are defined as study sites with 250 or more observed transit passengers within a two-hour period at each study site, and low ridership areas are defined as study sites with less than 250 observed transit passengers.

Since many of the recommended clusters contained more than one bus stop, the research team identified a study area within each cluster for field inventory (See Figure 5). The study area ranged from 220 to 660 feet in length, aligned with the major roadway in the cluster. The study area included the intersection associated with the highest number of crashes within the cluster, and the bus stops (typically two) proximate to that intersection.

Figure 5: Sample Cluster Area – Dover C11 with 5 Bus Stops

Source: Voorhees Transportation Center

Table 15: 30 Study Sites Chosen for Field Views and Observations

Cluster	Municipality	Reason(s)
3	Camden	Geographic distribution, number of crashes
4	Middle Township	Identified passenger involvement
5	Irvington	Possible passenger involvement
6	Woodbury City	Geographic distribution
8	Trenton	Geographic distribution, % of pedestrians responsible
9	Metuchen	Geographic distribution
10	Asbury Park	Geographic distribution
11	Dover	Geographic distribution, number of crashes
12	Lakewood	Geographic distribution, % of pedestrians responsible
13	Paterson	Number of crashes
14	Somerville	Geographic distribution, % of pedestrians responsible
15	Union Township	Possible passenger involvement
16	South Orange	% of pedestrian responsible
18	Irvington	Identified passenger involvement
20	Elmwood Park	Possible passenger involvement
22	Nutley	Identified passenger involvement
23	Irvington	Identified passenger involvement
24	Newark	Identified passenger involvement
25	Newark	Identified passenger involvement
27	Ridgefield Borough	Possible passenger involvement
30	Teaneck	Identified passenger involvement
31	Atlantic City	Possible passenger involvement
32	Paterson	Possible passenger involvement
34	Harrison/Kearny	Number of crashes, % of motorist involvement
36	Leonia	Possible passenger involvement
37	Elizabeth	Identified passenger involvement
40	Jersey City	Identified passenger involvement
42	Galloway	Identified passenger involvement
43	Irvington	Identified passenger involvement
44	Irvington	Possible passenger involvement

Source: Voorhees Transportation Center

Observational Data Collection

Pedestrian behavioral data has not been collected in a comprehensive way by any transit or transportation agency in New Jersey, yet it is critical to understand pedestrian-involved crashes and interventions to reduce or eliminate these unnecessary tragedies. In order to understand how pedestrian and motorist behavior contributes to crashes around bus stops, observational data were collected on pedestrian and motorist behavior at and around 30 study sites. The methodology used to collect these data and the findings are described within the following sections.

Methodology

The research team developed four observational data forms to assist in data collection at each study site. To the greatest extent possible, the limits of the study area were demarcated by placing orange traffic cones 75 ft. away from each bus stop in each direction. The four forms consisted of a motorist behavioral form, pedestrian behavioral form, pedestrian tally form, and transit-passenger tally form. Motorist behavioral forms were used to record the number of motorists observed exhibiting risky behaviors, such as the failure to yield to pedestrians in crosswalks, not stopping at stop signs, running red lights, and stopping in crosswalks. It is important to note that the number of motorists in the study area was not tallied; only those motorists observed exhibiting risky behaviors were counted.

Pedestrian behavioral forms were used to record the number of pedestrians observed exhibiting risky behaviors, such as not crossing within crosswalk, darting out between parked cars into traffic, running to catch a bus, and disobeying traffic signals. Pedestrian tally forms were used to record, in thirty minute increments, the total number of pedestrians (including transit passengers) within the defined study area. Lastly, transit-passenger tally forms were used to record (also in thirty minute increments) the number of transit passengers entering and exiting buses, and the number of buses arriving within the study area. The observation data collection forms are provided in Appendix B.

Figure 6: Rutgers Observation Team in Middle Township, NJ

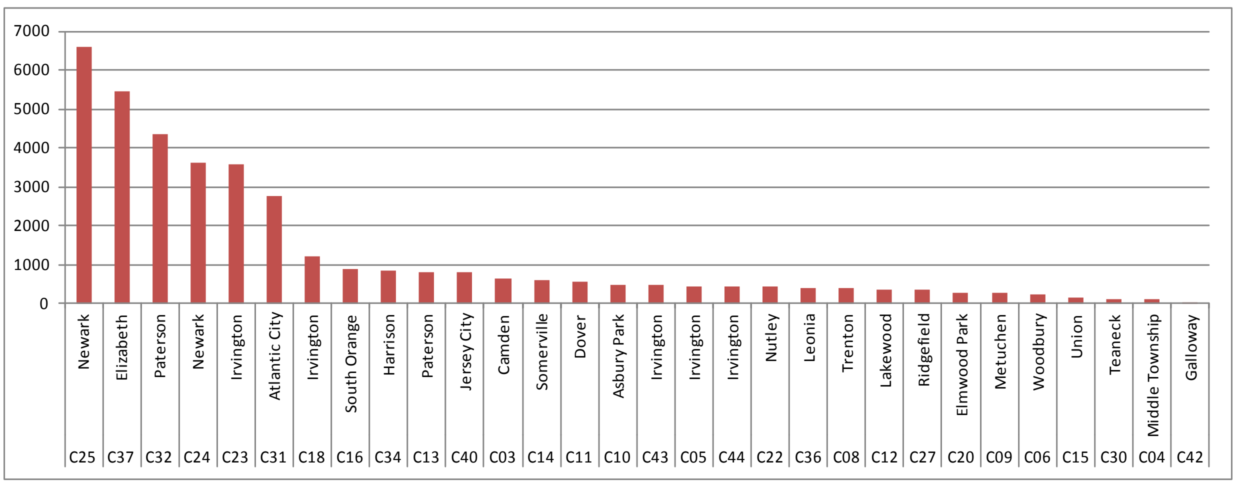
Source: Voorhees Transportation Center

In most cases, the data collection team consisted of five graduate students and two supervisors from VTC. The team wore red "Rutgers" t-shirts and used handheld tally clickers to count pedestrians, buses, and transit passengers. Data were collected at each site between the hours of 4:00 p.m. and 6:00 p.m., with no exceptions. Data collection commenced on June 7, 2011 in Metuchen (C09) and concluded on August 12, 2011 in Middle Township (C04).

Pedestrian Totals

Figure 7 shows the number of pedestrians (includes transit passengers) tallied within the defined study area at each study site. In total there were 37,512 pedestrians counted. The locations with the most pedestrians tallied included Newark (C25), Elizabeth (C37), and Paterson (C32). The locations with the least amount of pedestrians tallied included Teaneck (C30), Middle Township (C04) and Galloway (C42). Although there were on average 1,250 pedestrians tallied at each study site, most sites had far less than 1,000 pedestrians.

Figure 7: Number of Pedestrians at Each Study Site



Source: Voorhees Transportation Center

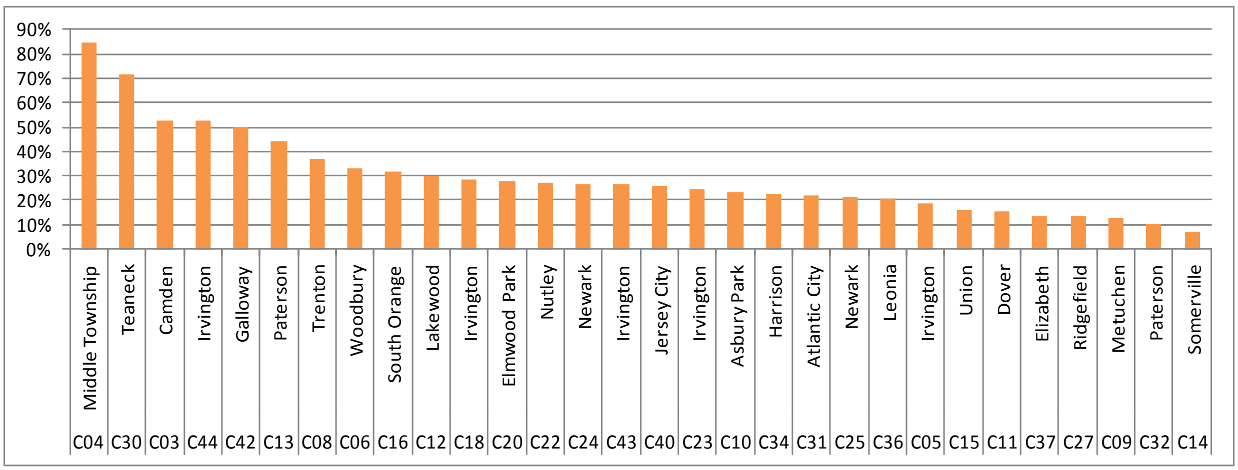
Pedestrian Behavior

To monitor pedestrian behavior at each study site, a list of risky pedestrian behaviors were identified. The list of risky behaviors includes:

- Not crossing within the crosswalk;
- Not waiting for traffic to stop before crossing;
- Pausing between traffic while crossing;
- Darting out between parked cars into traffic;
- Dashing out into the street;
- Running to catch a bus;
- Disobeying traffic signals; and,
- Walking/running along roadway.

Figure 8 shows the percentage of pedestrians observed exhibiting risky behaviors at each study site. Of the 37,512 pedestrians tallied, 8,288 (22 percent) were counted exhibiting risky behaviors. Middle Township (C04) had the highest percentage (85 percent) of pedestrians exhibiting risk behaviors, while Somerville (C14) had the lowest (7 percent). One possible reason for the differences in pedestrian behaviors between the two study sites is geographical location and pedestrian-related infrastructure. The study site in Somerville (C14) is located on Main Street with high volumes of pedestrian traffic, adequate sidewalks, crosswalks and pedestrian signals, and low traffic volumes. The site also has less speeding by vehicles and heightened police presence. In contrast, the site in Middle Township (C04) is located along a major arterial with high traffic volumes, speeding vehicles, inadequate sidewalks, crosswalks and pedestrians signals, and minimal police presence. Therefore, it is believed that these differences influenced pedestrian behavior at each study site.

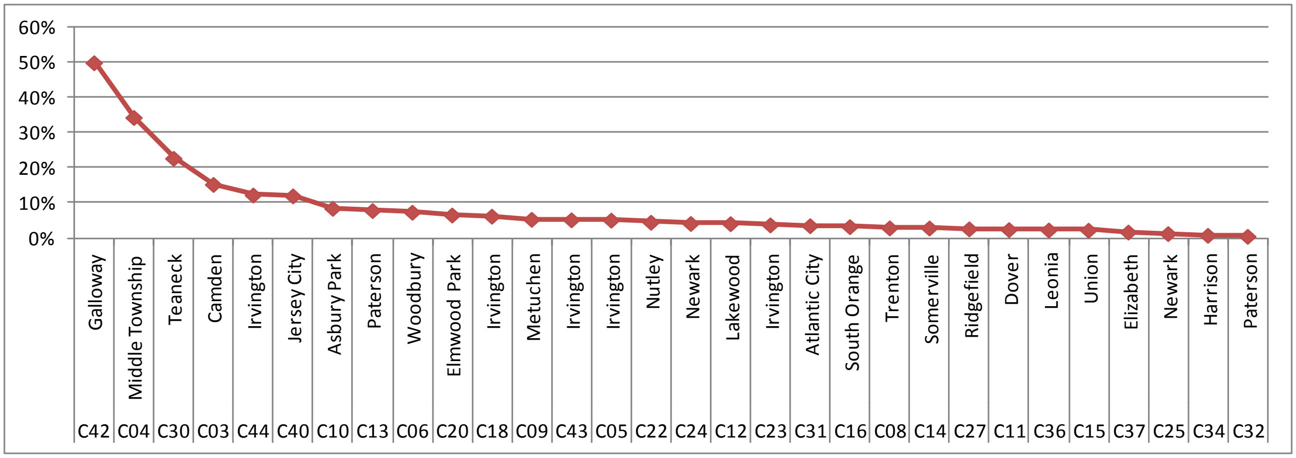
Figure 8: Percent of Pedestrians Observed Exhibiting Risky Pedestrian Behaviors at Each Study Site



Source: Voorhees Transportation Center

Figure 9 shows the percentage of pedestrians observed exhibiting multiple risky pedestrian behaviors at each study site. Multiple refers to pedestrians observed committing more than one risky behavior at a time within the define study area, such as running to catch a bus and disobeying traffic signals. There were 1,320 pedestrians counted exhibiting multiple risky behaviors at the final study sites. Galloway (C42) had the highest percentage (50 percent) of pedestrians exhibiting multiple risky behaviors and Newark (C25), Harrison (C34), and Paterson (C32) had the lowest (1 percent). One explanation for the multiple infractions in Galloway (C42) was the overall absence of sidewalks within the study area; the lack of sidewalks in the study area forced pedestrians to take multiple risks.

Figure 9: Percent of Pedestrians Observed Exhibiting Multiple Risky Pedestrian Behaviors at Each Study Site



Source: Voorhees Transportation Center

Pedestrian Behavior – High and Low Ridership Areas

Table 16 categorizes risky behavior in high and low ridership areas. High ridership areas included study sites such as Newark (C24 and C25), Elizabeth (C37), Paterson (C32), Atlantic City (C31), and Irvington (C23 and C18). Low ridership areas included study sites such as Woodbury (C06), Nutley (C22), and Union (C15).

There were 8,288 pedestrians, or 22 percent, counted exhibiting risky behaviors in high and low ridership areas. Of these, 5,389 were in high ridership areas and 2,899 were in low ridership areas. Collectively, not crossing within crosswalks was the most common risky behavior (15.1 percent), while darting out between parked cars into traffic was the least common (1 percent). As a percentage of the total number of pedestrians observed at the final study sites, there were a higher percentage of pedestrians exhibiting risky behaviors in low ridership areas than high ridership areas, 29.1 percent vs. 19.6 percent respectively. Pedestrians in low ridership areas (6.5 percent) exhibited multiple risky behaviors slightly more often than in high ridership areas (2.4 percent), and were more likely to not cross within a crosswalk (20 percent vs. 13.3 percent) and disobey traffic signals (11.9 percent vs. 7.7 percent).

One potential explanation for the risky behavior of pedestrians in low ridership areas versus high ridership areas is low vehicular traffic volumes. When vehicular traffic volumes are low, pedestrians in low ridership areas tend to disobey traffic signals and not cross within crosswalks. This is due, in part, to the habitual nature of pedestrians witnessing cars pass infrequently and crosswalks being located farther apart in low ridership areas.

Table 16: Risky Pedestrian Behaviors in High and Low Ridership Areas

	High Ridership		Low Ridership		Grand Total	
Risky Pedestrian Behaviors	**Number**	**Pct. of Pedestrians Observed**	**Number**	**Pct. of Pedestrians Observed**	**Grand Total**	**Pct. of Pedestrians Observed**
Not crossing within crosswalk	3,672	13.3%	1,985	20.0%	5,657	15.1%
Not waiting for traffic to stop before crossing	139	0.5%	135	1.4%	274	0.7%
Pausing between traffic while crossing	139	0.5%	126	1.3%	265	0.7%
Darting out between parked cars into traffic	29	0.1%	26	0.3%	55	0.1%
Dashing out into the street	98	0.4%	74	0.7%	172	0.5%
Running to catch a bus	112	0.4%	28	0.3%	140	0.4%
Disobeying traffic signals	2,126	7.7%	1,185	11.9%	3,311	8.8%
Walking/running along roadway	180	0.7%	139	1.4%	319	0.9%
Total number of pedestrians exhibiting risky behaviors	**5,389**	**19.6%**	**2,899**	**29.1%**	**8,288**	**22.1%**
Total number of pedestrians exhibiting multiple risky behaviors	**671**	**2.4%**	**649**	**6.5%**	**1,320**	**3.5%**
Total number of pedestrians observed at 30 sites	**27,565**	**100.0%**	**9,947**	**100.0%**	**37,512**	**100.0%**

Source: Voorhees Transportation Center

Pedestrian Behavior – High and Low Density Areas

Table 17 categorizes risky behavior in high and low density areas. There were 8,288 pedestrians, or 22.1 percent, counted exhibiting risky behaviors in high and low density areas. Of these, 5,044 were in high density areas and 32.6 percent were in low density areas. As a percentage of the total number of pedestrians observed at the final study sites, there was a higher percentage of risky behavior observed in low density areas than high density areas, 32.6 percent vs. 18.3 percent. Similar to the behavior of pedestrians in high and low ridership area, not crossing within crosswalks was the most common risky behavior (15.1 percent), while darting out between parked cars into traffic was the least common (1 percent). Pedestrians in low density areas (5.7 percent) were observed exhibiting multiple risky behaviors more often than in high density areas (2.7 percent), and were also more likely to not cross within a crosswalk (24.5 percent vs. 11.7 percent) and disobey traffic signals (9.2 percent vs. 8.7 percent).

Table 17: Risky Pedestrian Behaviors in High and Low Density Areas

Risky Pedestrian Behaviors	High Density		Low Density		Grand Total	
	Number	Pct. of Pedestrians Observed	Number	Pct. of Pedestrians Observed	Grand Total	Pct. of Pedestrians Observed
Not crossing within crosswalk	3,218	11.7%	2,439	24.5%	5,657	15.1%
Not waiting for traffic to stop before crossing	145	0.5%	129	1.3%	274	0.7%
Pausing between traffic while crossing	165	0.6%	100	1.0%	265	0.7%
Darting out between parked cars into traffic	30	0.1%	25	0.3%	55	0.1%
Dashing out into the street	110	0.4%	62	0.6%	172	0.5%
Running to catch a bus	90	0.3%	50	0.5%	140	0.4%
Disobeying traffic signals	2,398	8.7%	913	9.2%	3,311	8.8%
Walking/running along roadway	192	0.7%	127	1.3%	319	0.9%
Total number of pedestrians exhibiting risky behaviors	**5,044**	**18.3%**	**3,244**	**32.6%**	**8,288**	**22.1%**
Total number of pedestrians exhibiting multiple risky behaviors	**755**	**2.7%**	**565**	**5.7%**	**1,320**	**3.5%**
Total number of pedestrians observed at 30 sites	**27,565**	**100.0%**	**9,947**	**100.0%**	**37,512**	**100.0%**

Source: Voorhees Transportation Center

Overall, pedestrians in low ridership and low density areas took more risks than pedestrians in high ridership and high density areas. Pedestrians in low ridership areas were slightly more likely to not wait for traffic to stop before crossing the street, dash out into street, disobey traffic signals, walk/run along the roadway, and exhibit multiple risky behaviors than pedestrians in other areas. Similarly, pedestrians in low density areas were slightly more likely to exhibit risky pedestrian behavior and not cross within a crosswalk. Based upon these findings, it is believed that pedestrians in low ridership and low density areas take more risks for the following reason: low traffic volumes; location of crosswalks; minimum mid-block crossings; minimal police presence; and inadequate pedestrian-relative infrastructure (e.g., pedestrian signals and sidewalks).

Motorist Behavior - Pedestrians

To monitor motorist behavior at each study site, a list of risky motorist behaviors were identified. The list of risky behaviors includes:

- exiting and entering driveways or alleys without yielding to pedestrians;
- failing to stop for pedestrians in crosswalks;
- not stopping at STOP signs;
- running red light signals;
- stopping in crosswalks;
- talking on cell phones;
- eating food; and,
- illegally passing stopped cars.

As previously discussed, not all motorists were counted within the defined study; only the number of motorists "observed" exhibiting risky behaviors were counted. To estimate the impact of risky motorist behavior on pedestrians at each study site, a Motorist Behavior Index (MBI) was developed. The motorist behavior index analyzes the level of unsafe motorist behavior per 1,000 pedestrians at each study site in a two-hour period. Table 18 categorizes the results of the MBI. It should be noted that unless reported otherwise, a rate of zero (0) for a location means that the risky behavior was not applicable at that site. For example, Woodbury (C06) has a rate of zero under the behavioral column "not stopping at STOP signs" because no STOP sign was present within the defined study area. Woodbury (C06) did however have a red light, which is why a rate of 202 in listed under the behavioral column "running red lights".

According to the Table 18, Woodbury (C06), Lakewood (C12), and Metuchen (C09) have the highest rates of risky motorist behavior, while Irvington (C23), Paterson (C32), and Elizabeth (C37) have the lowest. Comparatively, motorists in Metuchen (C09) rate highest in four categories: failure to yield to pedestrians in crosswalks; failure to stop at STOP signs; stopping in crosswalks; and, illegally passing stopped cars, whereas Elizabeth (C37) rates lowest in four categories: stopping in crosswalks; talking on the cell phone; eating food; and, illegally passing stopped cars.

In terms of individual risky motorist behaviors, Woodbury (C06) rates highest in motorists who fail to yield to pedestrians while entering and existing driveways, while Harrison (C34) rates lowest. Nutley (C22) rates highest in terms of motorists running red lights, while Camden (C03) and Atlantic City (C31) rate lowest. When it comes to motorists talking on the phone while driving, Lakewood (C12) rates highest, whereas Elizabeth (C37) and Atlantic City (C31) rate lowest. Lakewood also rates highest in motorists eating while driving, with Elizabeth (C37), Paterson (C32), Newark (C24) and Irvington (C05) all tied for the lowest.

Table 18: Motorist Behavior Index per 1,000 Pedestrians

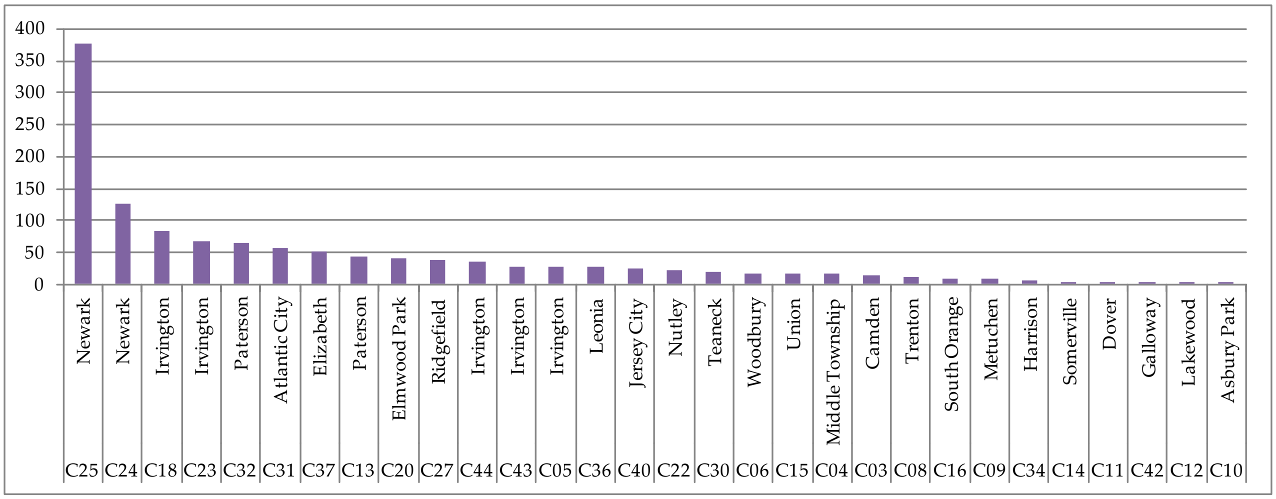
Cluster ID	Location	Exiting or entering driveways or alleys without yielding to pedestrians	Failure to stop for pedestrians in crosswalks	Not stopping at STOP signs	Running red lights	Stopping in crosswalks	Talking on cell phone	Eating food	Illegally passing stopped cars
C06	Woodbury	21	132	0	202	198	576	99	4
C12	Lakewood	19	91	3	0	17	740	166	0
C15	Union	8	69	0	191	31	435	46	0
C44	Irvington	2	24	0	9	19	154	26	0
C34	Harrison	1	4	0	8	43	74	10	4
C03	Camden	0	25	0	0	72	58	23	0
C04	Middle Township*	0	97	0	398	161	2,172	538	22
C05	Irvington	0	43	0	45	56	90	2	0
C08	Trenton	0	11	0	91	24	336	75	13
C09	Metuchen	0	162	234	0	385	129	4	126
C10	Asbury Park	0	19	0	13	85	190	51	0
C11	Dover	0	69	0	9	113	46	28	7
C13	Paterson	0	46	0	6	78	142	22	0
C14	Somerville	0	100	0	7	7	34	15	2
C16	South Orange	0	102	0	7	98	84	19	5
C18	Irvington	0	45	0	17	12	67	18	0
C20	Elmwood Park	0	28	0	38	17	460	136	0
C22	Nutley	0	0	0	204	17	302	94	29
C23	Irvington	0	6	0	11	2	36	3	1
C24	Newark	0	17	0	3	35	43	2	0
C25	Newark	0	2	0	7	74	13	4	2
C27	Ridgefield	0	51	0	68	146	304	63	3
C30	Teaneck*	0	129	0	50	228	1,366	327	0
C31	Atlantic City	0	5	0	1	20	29	10	1
C32	Paterson	0	33	0	0	8	17	2	0
C36	Leonia	0	34	0	31	99	152	31	5
C37	Elizabeth	0	5	0	4	5	10	2	1
C40	Jersey City	0	16	0	4	73	78	21	1
C42	Galloway*	0	444	0	889	4,333	12,500	2,778	0
C43	Irvington	0	48	22	4	81	359	46	0
Total		**51**	**1,854**	**258**	**2,317**	**6,537**	**20,996**	**4,662**	**225**

** Sites with less than 200 pedestrians.* *Source: Voorhees Transportation Center*

Bus Totals

There were 1,257 buses tallied at the 30 final study sites, of which 833 buses were in high density and high ridership areas and 424 were in low density and low ridership areas. Figure 10 shows the number of buses at each study site within a two-hour period. Newark (C24) had the most buses[1] to arrive within a two-hour period, and Lakewood (C12) and Asbury Park (C10) had the least (126 versus 2 and 1, respectively).

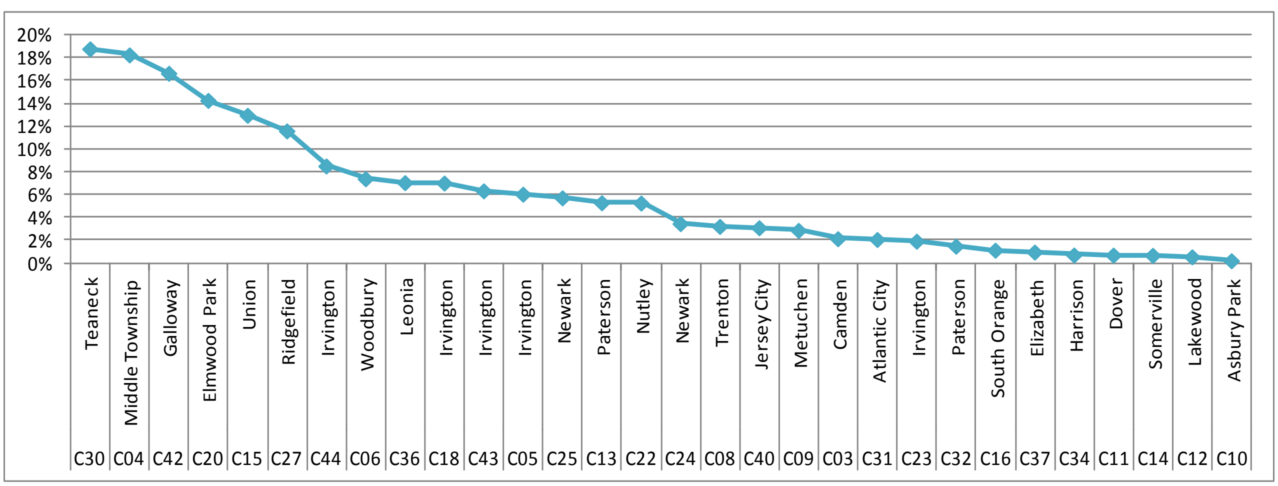
Figure 10: Number of Buses at Each Study Site



Source: Voorhees Transportation Center

Figure 11 shows the ratio of buses to pedestrians at each study site. Teaneck (C30), Middle Township (C04), and Galloway (C42) had the highest ratio of buses to pedestrians, whereas Somerville (C14), Lakewood (C12), and Asbury Park (C10) had the lowest.

Figure 11: Ratio of Buses to Pedestrians at Each Study Site



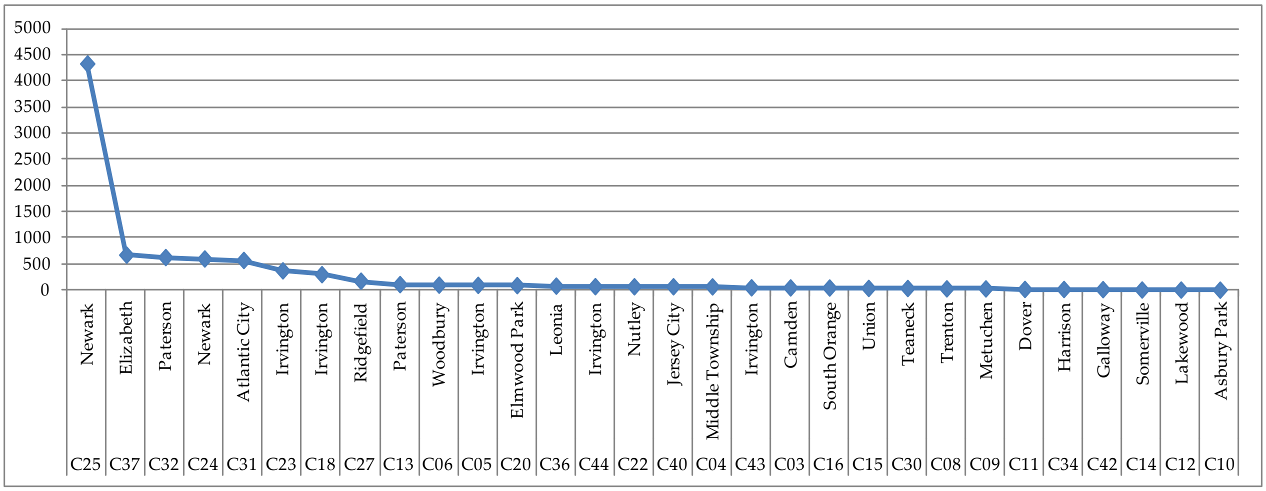
Source: Voorhees Transportation Center

[1] We excepted Newark (C25) from this portion of the analysis because it was so far outlying from other observed sites.

Transit Passenger Totals

Figure 12 shows the number of transit passengers at each study site. There were a total of 8,649 transit passengers tallied at the final study sites, for an average of 288 transit passengers per site. Of the transit passengers tallied, 1,491 were recorded in areas classified as high ridership and high density areas and 832 in areas classified as low ridership and low density areas. Newark (C25) had the most transit passengers (4,324) and Asbury Park (C10) had the least (1).

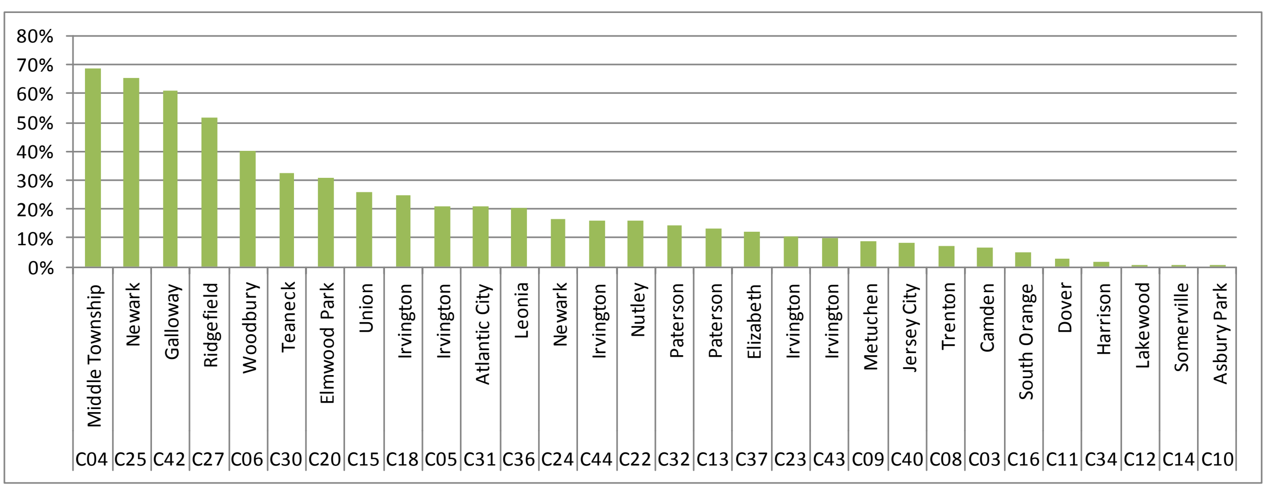
Figure 12: Number of Transit Passengers at Each Study Site



Source: Voorhees Transportation Center

Figure 13 shows the percentage of transit passengers observed out of total number of pedestrians tallied at each study site. Middle Township (C04) had the highest percentage of transit passengers observed at 69 percent, while Asbury Park (C10) had the least at less than 1 percent.

Figure 13: Percent of Transit Passengers Observed Out of Total Number of Pedestrians



Source: Voorhees Transportation Center

Field Inventory and Analysis

Crash Activity in Focus Areas

There were 208 crashes reported in these cluster focus areas, or 37.7% of the 551 crashes identified within the initial screening area. The crash types for the 208 crashes are indicated in Table 16, and are similar in proportion to the 551 crashes in the larger study area. "Motorist fault" crashes accounted for 54.1% of crashes in the larger study area, and 53.8% of crashes in the cluster focus areas; "pedestrian fault" crashes accounted for 36.8% of crashes in the larger study area, and 38.5% of crashes in the cluster focus area.

Table 16: Crash Types within Cluster Focus Areas

	Crashes	
Crash Type	**Number**	**Percent**
Left Turn Parallel Path	74	35.6%
Pedestrian Failed to Yield - At Intersection	33	15.9%
Pedestrian Failed to Yield - Not at Intersection	22	10.6%
Motorist Failed to Yield	10	4.8%
Right Turn Parallel Path	21	10.1%
Dash - Not at Intersection	8	3.8%
Backing Vehicle	4	1.9%
Miscellaneous/Unknown	7	3.4%
Dart Out	1	0.5%
Right Turn Perpendicular Path	5	2.4%
Dash - At Intersection	4	1.9%
Walking along Roadway with Traffic	5	2.4%
Exiting Driveway/Alley	1	0.5%
Commercial Bus Related	5	2.4%
Left Turn Perpendicular Path	1	0.5%
Multiple Threat	1	0.5%
Waiting to Cross	2	1.0%
Other	4	1.9%
TOTAL	208	100.0%

Source: Michael Baker Jr., Inc.

Land Use Characteristics

As indicated in Table 17, with one exception, cluster focus areas are predominantly commercial in character. Mixed uses are found at 20 of the 30 clusters. Of those, 12 clusters host commercial and residential mixed uses. The residential uses at all sites are comprised of apartments, attached housing, or single-family uses at a high or medium density. Institutional uses, such as government buildings or schools, are mixed with commercial uses at seven clusters. This finding is consistent with other studies, which have indicated pedestrian crash activity to be more significant proximate to commercial uses than other land uses. Virtually all of the clusters are in urban areas. The two exceptions are Cluster 4 in Middle Township, and Cluster 42 in Galloway Township, which are suburban in character.

Table 17: Land Use Type of Focus Areas

	Clusters	
Land Use Type	**Number**	**Percent**
Commercial	10	33.3%
Commercial & Residential	12	40.0%
Commercial & Institutional	7	23.3%
Residential & Institutional	1	3.3%
TOTAL	30	100.0%

Source: Michael Baker Jr., Inc.

Roadway Characteristics

Table 18 summarizes the classification of the primary roadway within the 30 focus areas. Because the research team identified two intersecting roadways at one focus area as being of interest, the roadway classification is shown for 31 roadways, not 30. As indicated, over 90% of the roadways were arterials, with over half being principal arterials. Average daily traffic volumes were collected from the NJDOT Data Collection website for study area roadways where available. Average daily traffic volumes ranged from 8,000 to 45,000, with the median being 19,600. Given the higher traffic volumes found on arterials, and the numbers of pedestrians generated by the major commercial areas located on these arterials, it is not unexpected that they would be the roadway of interest for the large majority of focus areas.

Table 18: Classification of Primary Roadway in Focus Areas

	Roadways	
Roadway Classification	**Number**	**Percent**
Urban Principal Arterial	16	51.6%
Urban Minor Arterial	12	38.7%
Urban Collector	3	9.7%
TOTAL	31	100.0%

Source: Michael Baker Jr., Inc.

Vehicular speed and the number of travel lanes on roadways have been identified in previous studies as important factors in pedestrian safety.[56] Table 19 indicates the number of travel lanes on the roadways. As seen, 16 of the 31 roadways had four lanes or more, versus 15 roadways of three lanes or less. There were no one-way streets. Table 20 indicates the speed limit for the roadways. Slightly more than two-thirds of the roadways were posted at 30 mph or less, and over half of the roadways had a speed limit of 25 mph. The predominance of lower speed roadways in the focus areas reflects typical speed limits of urban areas with higher pedestrian volumes.

Table 19: Number of Travel Lanes in Focus Areas

Travel Lanes	Roadways	
	Number	Percent
2	11	35.5%
3	4	12.9%
4	10	32.3%
5	5	16.1%
6	1	3.2%
TOTAL	31	100.0%

Source: Michael Baker Jr., Inc.

Table 20: Speed Limits in Focus Areas

Speed Limit	Roadways	
	Number	Percent
25 mph	17	54.8%
30 mph	7	22.6%
35 mph	2	6.5%
40 mph	4	12.9%
45 mph	1	3.2%
TOTAL	31	100.0%

Source: Michael Baker Jr., Inc.

Table 21 categorizes crashes on focus area roadways by number of travel lanes and primary fault (pedestrian or motorist). Roadways were categorized as three lanes or less, or four lanes or more, since many studies have identified four lanes as the cross-section where pedestrian crossings become more hazardous. Table 22 categorizes crashes by posted speed and primary fault. Roadways were characterized as 25 mph or 30 mph or more, since 25 mph is the most desirable speeds for roadways serving as main streets of New Jersey municipalities. The classification of crashes as being motorist fault or pedestrian fault was described in Tables 5 and 14.

As shown in Table 21, pedestrian fault crashes account for a much larger percentage of crashes on roadways with four lanes or more (44.2%) than on roadways of three lanes or less (28.4%). It will be recalled that pedestrian fault crashes comprise "Pedestrian Failed to Yield", "Dash", and other crash types in which the pedestrian proceeds in front of a vehicle at midblock locations, or at signalized intersections where the pedestrian proceeds despite having a red light. Table 21 suggests that pedestrians are more likely to make poor roadway crossing decisions on multilane roadways than on two- to three-lane roadways.

Figure 6: Four Lane Roadway in Irvington – Particularly Hazardous for Pedestrians to Cross

Source: Michael Baker Jr., Inc.

Surprisingly, Table 22 indicates a relatively even split between pedestrian fault crashes on roadways posted at 25 mph or less, or roadways 30 mph or greater. It was assumed by the research team that the percentage of pedestrian fault crashes would be larger on higher-speed roadways, as pedestrians would have less time to react if they make a poor crossing decision. To a certain extent, the data may reflect inconsistent speed policies for focus area roadways, or may indicate that the speed limits do not indicate the speed at which motorists actually travel. For example, CR 603 (Springfield Avenue) in Irvington is not posted; according to New Jersey law (39:4-98) the statutory speed limit is 25 mph since it runs through a central business district. Since the roadway has four lanes and the speed limit is unposted, it would not be unexpected if motorists regularly exceed the speed limit. CR 60 in Bergen County is a four-lane roadway in a low-density area, yet is posted at 25 mph. Conversely, Atlantic Avenue in Atlantic County is posted at 30 mph, even though it runs through a busy business district with heavy pedestrian volumes. Finally, given the predominance of urban commercial areas in this study, the number of higher speed roadways is relatively small, making a robust comparison between low-speed and high-speed roads difficult.

Table 21: Crash Category by Number of Travel Lanes

	Motorist Fault		Pedestrian Fault		Other		Total	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Roadways of three	56	63.6%	25	28.4%	7	8.0%	88	100.0%
Roadways of four	58	48.3%	53	44.2%	9	7.5%	120	100.0%

Source: Michael Baker Jr., Inc.

Table 22: Crash Category by Posted Speed

	Motorist Fault		Pedestrian Fault		Other		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Roadways of 25	63	54.3%	43	37.1%	10	8.6%	116	100.0%
Roadways of 30	51	55.4%	35	38.0%	6	6.5%	92	100.0%

Source: Michael Baker Jr., Inc.

Appropriate to the predominantly urban and commercial character of most of the clusters, parking lanes are present on 20 of the 31 roadways, as noted in Table 23. The large majority of roadways have no median, as indicated in Table 24.

Table 23: Parking Lanes in Focus Areas

	Roadways	
Parking Lanes	**Number**	**Percent**
0	11	35.5%
1	3	9.7%
2	17	54.8%
TOTAL	31	100.0%

Source: Michael Baker Jr., Inc.

Table 24: Medians in Focus Areas

	Roadways	
Medians	**Number**	**Percent**
None	26	83.9%
Concrete	3	9.7%
Jersey Barrier	1	3.2%
Island	1	3.2%
TOTAL	31	100.0%

Source: Michael Baker Jr., Inc.

Intersection Conditions

As shown in Table 25, about three-quarters (76.4%) of crashes in the cluster focus areas occurred at intersections, with 23.6% occurring outside the intersection.

Table 25: Crashes by Location in Focus Areas

	Crashes	
Location	**Number**	**Percent**
At Intersection	159	76.4%
Not At Intersection	49	23.6%
Total	208	100.0%

Source: Michael Baker Jr., Inc.

At the study sites, the large percentage of crashes occurring at intersections was likely facilitated by the short block network found in many of the urban areas, and the higher volumes of pedestrians congregating at intersecting roadways. Although "not at intersection" crashes account for only 23.6% of crashes within the cluster focus areas, this percentage should be compared to the percentage of pedestrians in these areas conducting midblock crossings, to determine the relative hazard. The research team documented that a median of 15.1% of pedestrians in focus areas crossed outside the intersection. This is significantly less than the percentage of crashes that took place outside the intersection, and may thus indicate a greater hazard of crossings outside of intersections.

The research team also evaluated intersection conditions within cluster focus areas. There are 40 intersections within the clusters; as noted in Table 26, the large majority of intersections (85.0%) are signalized. As indicated in Table 27, the large majority of signalized intersections (91.2%) have pedestrian signals.

Table 26: Intersection Controls

	Intersections	
Intersection Controls	**Number**	**Percent**
Signalized	34	85.0%
Stop Controlled	6	15.0%
TOTAL	40	100.0%

Source: Michael Baker Jr., Inc.

Table 27: Pedestrian Signals

	Signalized Intersections	
Pedestrian Signals	**Number**	**Percent**
Yes	31	91.2%
No	3	8.8%
TOTAL	34	100.0%

Source: Michael Baker Jr., Inc.

Signalized intersections were also inventoried to determine whether pedestrian actuation is required to cross the major roadway. As noted in Table 28, actuation is required to call the pedestrian signal at 14 of signalized intersections, or 41.2%.

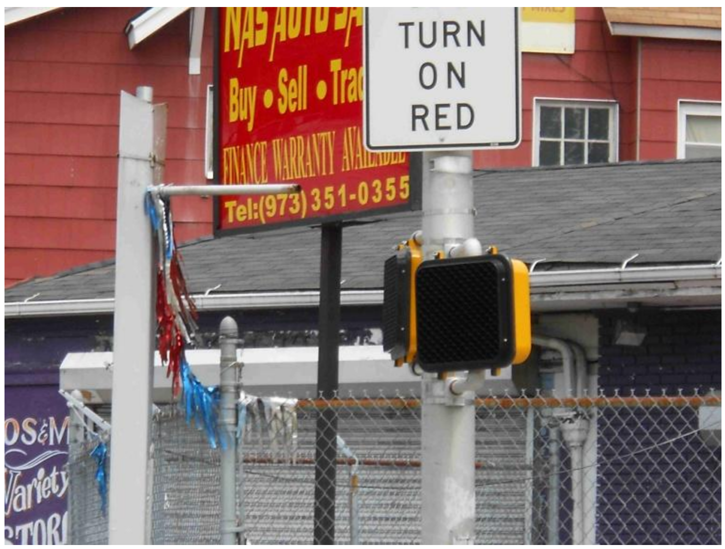
Table 28: Pedestrian Actuation

	Signalized Intersections	
Pedestrian Actuation	**Number**	**Percent**
Yes	14	41.2%
No	20	58.8%
TOTAL	34	100.0%

Source: Michael Baker Jr., Inc.

On field views, the research team noted many pedestrians crossing the major roadway at signalized intersections without waiting for the "Walk" indication to appear. Specifically, at signalized intersections in focus areas, we documented a median of 11.3% of pedestrians crossing the roadway against the traffic signal. A point of concern is whether that percentage increases at sites with pedestrian actuation, since transportation professionals have often noted the failure of pedestrians to actuate the signal when required, including along transit routes in New Jersey. [57] It was determined that at signalized intersections in which pedestrian actuation is required to call the "Walk" signal to cross major roadways, 18.1% of pedestrians crossing within the intersection proceeded during the "Don't Walk" phase. At signalized intersections without pedestrian actuation, 8.2% of pedestrians crossed during the "Don't Walk" phase. The presence of pedestrian actuation at traffic signals is thus associated with a higher percentage of illegal crossings.

Figure 7: Nonfunctional Pedestrian Signal in Study Area



Source: Michael Baker Jr., Inc.

Given the predominance of left turn parallel path crashes in the study area, the presence of left turn signal phases was also viewed as an important factor. Although left turn signal phases can in general be designed in several different ways, within the cluster focus areas, they adhered to the same pattern; opposing intersection approaches are given a protected left turn signal phase, during which time, pedestrians are controlled by "Don't Walk" indication. At the end of the phase, the left turn signal is dropped, and all movements at the opposing intersection approaches are permitted. Simultaneously, pedestrians are shown the "Walk" indication. As noted in Table 29, a left turn signal phase is present at about one-third (32.4%) of signalized intersections.

Table 29: Left Turn Signal Phases

Left Turn Signal Phase	Signalized Intersections	
	Number	Percent
Yes	11	32.4%
No	23	67.6%
TOTAL	34	100.0%

Source: Michael Baker Jr., Inc.

The large majority of intersections in study area clusters are striped with crosswalks, as indicated in Table 30. Two of the intersections missing crosswalks were minor, and crosswalks were badly faded at the third intersection.

Table 30: Presence of Crosswalks

Crosswalks Present	Intersections	
	Number	Percent
Yes	37	92.5%
No	3	7.5%
TOTAL	40	100.0%

Source: Michael Baker Jr., Inc.

Bus Stop Conditions

There are 61 bus stops within the cluster focus areas, and their design is of major interest to the study. Their position, location, and length have significant ramifications for how pedestrians interact with buses and surrounding traffic.

An important design aspect of bus stops is their position on a block: whether they are far side (just past the intersection), near side (just before the intersection) or midblock. As indicated in Table 31, near side bus stops predominate in the study area, representing 33 of the 61 bus stops, or 54.1%. Far side bus stops accounted for 36.1%, and midblock bus stops accounted for 9.8%. A bus stop was characterized as "midblock" if it was placed approximately half a block from the intersection of interest.

Table 31: Bus Stop Position

Bus Stop Position	Bus Stops	
	Number	Percent
Far Side	22	36.1%
Near Side	33	54.1%
Midblock	6	9.8%
TOTAL	61	100.0%

Source: Michael Baker Jr., Inc.

The research team also documented the location of bus stops, i.e., the distance between bus stop signs and the curb line of the closest intersecting street. The results, indicated in Table 32, are categorized by the three bus stop positions. As expected, near side bus stops were closest to the intersecting street, at a median distance of 30 feet. Far side bus stops were, on average, 83 feet from the intersecting street, and midblock bus stops were 147 feet from the intersection of interest.

Table 32: Bus Stop Location

Bus Stop Position	Median Distance
Far Side	83
Near Side	30
Midblock	147

Source: Michael Baker Jr., Inc.

The length of bus stops was also documented. Table 33 indicates the length recommended for bus stops by NJ Transit, and the actual length of bus stops in the cluster focus areas. As indicated, just 7 of the 61 bus stops, or 11.5%, meet NJ Transit criteria. The recommended length of far side bus stops is shortest, since buses can use the preceding intersection to navigate into position to dock at the curb. At near side intersections in urban areas, buses may be able to pull in to the curb only after passing parked vehicles, and the recommended length is thus slightly longer than far side bus stops. Midblock bus stops are of the greatest length, since buses may need to maneuver toward the curb in between two parked cars.

Table 33: Bus Stop Length

Position	Recommended Length	Length < Minimum	Minimum or Above
Far Side	100 ft	19	3
Near Side	105 ft	29	4
Midblock	135 ft	6	0
TOTAL		54	7

Source: Michael Baker Jr., Inc.

At locations where there is insufficient space for buses to fully dock at the curb, buses will often nose to the curb as close as practicable, and then discharge their passengers in the street. This practice was often witnessed at study area bus stops. It was also noted that buses occasionally failed to pull over to the curb even at those stops where space permitted that practice. The disadvantage to this approach is that passengers, discharged in the street, may be tempted to cross the street at the point of alighting rather than return to the sidewalk and cross at the intersection. The research team did not document if the practice of discharging passengers away from the bus stop resulted in an increased number of passengers crossing midblock, but this should be investigated in future studies.

Figure 8: Inadequate Bus Stop Length:

Source: Michael Baker Jr., Inc.

It should further be noted that the above bus stop length criteria apply to conditions in which only one bus at a time is anticipated. Given the high transit demand in many of the study area clusters, it is common for multiple transit routes to stop at the same bus stop, and with such frequency that more than one bus at a time must be accommodated. When this happens, the practice of discharging passengers in the street occurs with even greater frequency, and the temptation for pedestrians to cross the street at the point of alighting may be further increased.

Lighting Conditions

The research team estimated the approximate height of the street light closest to each bus stop, and the distance of the closest street light to each bus stop. As indicated in Table 34, approximately one-third of the lights are pedestrian scale (height of 15 feet or less), with two-thirds being highway scale (height of 20 feet or greater). The median distance of pedestrian-scaled street lights from bus stops is 0 feet (i.e., the bus stop sign was typically affixed to the lighting standard, or immediately next to it), while the median distance of highway-scaled street lights from bus stops is 50 feet.

Many factors must be taken into consideration to determine the adequacy of street lighting at bus stop areas – the bulb height and lumens, spacing and distance – and a comprehensive evaluation of lighting could not be undertaken as part of this study. However, as a rough gauge of the effectiveness of street lights in illuminating the cluster focus areas, the study compared the percentage of crashes that occurred under different lighting conditions on roadways with pedestrian-scale street lights and roadways with highway-scale lights. A significant difference in the frequency of crashes occurring in the dark could correspond to different levels of effectiveness in illuminating pedestrian paths. As indicated in Table 35, there is little difference in the incidence of crashes in the dark at sites with the two lighting types. In focus areas with pedestrian scale lights, 32.5% of crashes occur in the dark, slightly lower than the percentage occurring at sites with highway scale lights (35.2%).

Table 34: Bus Stop Lighting Conditions

Light	Number and Distance from Bus Stop		
	Number	Percent	Median Distance (ft)
Pedestrian Scale	20	32.8%	0
Highway Scale	41	67.2%	49.5
TOTAL	61	100.0%	25

Source: Michael Baker Jr., Inc.

Table 35: Crash Lighting Conditions by Lighting Type

Lighting Type	Daylight Crashes		Dawn/Dusk		Dark Crashes		Total Crashes	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Pedestrian Scale	53	63.9%	3	3.6%	27	32.5%	83	100.0%
Highway Scale	79	63.2%	2	1.6%	44	35.2%	125	100.0%

Source: Michael Baker Jr., Inc.

Analysis of Crashes Involving Bus Passengers

The final level of analysis was conducted of conditions at the bus stops associated with the 18 crashes involving bus passengers.

Summary of Crash Activity

As noted earlier, there were 21 crashes involving confirmed or suspected bus passengers, with 18 of these being of the most interest. The other three crashes involved unusual circumstances, in which the contributing factors were not roadway design, but the particular interaction between driver and passenger. Table 36 provides a brief summary of these 18 crashes. Following is an analysis of the conditions found in the areas of the 18 crashes. Given the relatively small sample size, it is difficult to draw sweeping conclusions, but some patterns emerge.

The first point of interest is the direction in which the pedestrian was moving when the crash occurred: Was the pedestrian heading toward the bus to board it or walking away from the stop after alighting from the bus? This question touches upon an important difference between crashes associated with bus stops and crashes associated with other land uses. If passengers are on their way to the bus stop while they see their bus approaching, they have a strong incentive to engage in a number of unsafe behaviors, such as darting across the street or crossing the street during the "Don't Walk" signal, to avoid having to waiting a longer period than desirable. This would be especially true for passengers on their way to a scheduled event, whether a doctor's appointment or the beginning of a work shift. When passengers alight from a bus, on the other hand, the compulsion for running may not be as urgent (with the exception of those passengers seeking to transfer to another bus or a train). Assuming this to be true, there would be a higher number of crashes associated with pedestrians moving toward the bus stop than moving away.

However, as indicated by a review of Table 36, there was an even split in passenger direction; nine pedestrians were heading toward the bus stop, and nine pedestrians were walking away from the bus stop. It is noted, however, that the motorist was the responsible party in three of the "walking away" crashes – crashes 2005-37547, 2007-32561, and 07-2779 –and that pedestrians in general exhibited more risky behavior in the "heading toward" bus stop crashes. The small sample size indicates that pedestrians behaved in a more risky manner heading toward buses than leaving bus stops, but that the difference is not nearly as significant as anticipated by the research team. On field observations, we documented a median of 3.2% of bus passengers running to catch the bus. This relatively small percentage supports the point that there is a small difference in relative risk exhibited by pedestrians moving towards and from bus stops.

Table 36: Summary of Crashes Involving Confirmed or Suspected Bus Passengers

Case Number	Cluster	Municipality	Intersection	Summary	Crash Location	Bus Stop Position and Location	Travel Lanes	Posted Speed	Median	Light Condition
2006-20279	4	Middle Township	NJ 47 at 5th Street	Pedestrian ran across NJ 47 toward bus stop	Not at intersection (25 ft east)	Far side (84 ft east)	5	40	Concrete	Daylight
2005-37547	5	Irvington Township	CR 601 at Union Avenue	Pedestrian walking in southern crosswalk after bus passed by	At intersection	Near side (33 ft west)	2	25	None	Daylight
09-32766	15	Union Township	NJ 82 at Caldwell Avenue	Pedestrian ran across NJ 82 toward waiting bus	Not at intersection (75 ft east)	Far side (100 ft east)	4	30	None	Dark
0511781	18	Irvington Township	CR 603 at Maple Street	Pedestrian walked between two buses to cross CR 603	Not at intersection (west)	Near side (16 ft west)	4	25	None	Daylight
07-32452	18	Irvington Township	CR 603 at Maple Street	Pedestrian ran across CR 603 to catch bus	Not at intersection (10 ft east)	Near side (29 ft east)	4	25	None	Daylight
2007-000583	20	Elmwood Park Borough	NJ 4 at Rosedale Avenue	Pedestrian crossed NJ 4 toward bus stop	At intersection	Near side (20 ft east; 270 ft east	5	40	Concrete	Dark
07-021142	22	Nutley Township	CR 645 at CR 648	Pedestrian ran along CR 645 to catch bus	Not at intersection (100 ft	Near side (25 ft south)	2	35	None	Dark
2007/8520	23	Irvington Township	CR 603 at Myrtle Avenue	Pedestrian exited bus and crossed CR 603	Not at intersection (60 ft east)	Near side (32 ft east)	4	25	None	Daylight
06-58504	24	Newark	Proximate to Park Place and Raymond Blvd	Pedestrian crossed roadway in order to board bus and was struck by bus	Not at intersection (unknown)	Unknown	4 or 2	25	None	Daylight
06-010802	27	Ridgefield Borough	US 1 at Shaler Blvd	Pedestrian suddenly crossed US 1 toward bus stop	At intersection	Far side (75 ft south)	4	40	None	Dark

07041548	30	Teaneck Township	CR 60 at River Road	Pedestrian ran across CR 60 in front of bus after exiting	Not at intersection (200 ft west)	Midblock (162 ft west)	4	25	None	Daylight
05-0729	31	Atlantic City	Atlantic Avenue at Ohio Avenue	Pedestrian crossed Atlantic Avenue toward bus station	Not at intersection (40 ft west)	Far side (144 ft west)	4	30	None	Dark
07-07246-183	36	Leonia	Broad Avenue at CR 56	Pedestrian crossed Broad Avenue toward bus stop	Not at intersection (30 ft south)	Far side (55 ft south)	2	25	None	Daylight
08-14892	37	Elizabeth	CR 623 at Grand Street	Pedestrian crossed CR 623 after exiting bus	Not at intersection (south)	Near side (35 ft south)	2	25	None	Daylight
85193-05	40	Jersey City	CR 609 at Stegman Street	Pedestrian crossed CR 609 in front of bus after exiting	Not at intersection (50 ft south)	Far side (52 ft south)	2	25	None	Daylight
2007-32561	42	Galloway Township	US 30 at CR 654	Pedestrian crossed US 30 after exiting bus	At intersection	Near side (20 ft east)	4	45	Jersey barrier	Dark
06-18537	43	Irvington Township	Clinton Avenue at CR 509	Pedestrian crossed Clinton Avenue in front of bus after exiting	At intersection	Near side (28 ft east)	2	25	None	Daylight
07-2779	44	Irvington Township	CR 603 at Avon Avenue	Pedestrian crossed Avon Avenue after exiting bus	At intersection	Near side (15 ft west)	4	25	Principal arterial	Dark

Source: Michael Baker Jr., Inc.

Location of Bus Passenger Crashes

As shown in Table 37, there is a significant difference between the location of crashes associated with bus passengers, and the location of all crashes in the cluster focus areas. Twelve of the 18 bus passenger crashes (66.6%) occurred outside the intersection, while only 23.6% of crashes in the cluster focus areas took place outside the intersection. This wide disparity suggests several theories:

a. Bus passengers are more likely to conduct hazardous midblock crossings than pedestrians heading to or from other types of land uses;
b. On crash reports, pedestrians are typically recorded by the police as bus passengers only when the pedestrian conducts a midblock crossing to access or leave the bus stop; or,
c. Combination of both.

The study did not assess the risk of bus passenger crossing activity relative to crossing activity by other pedestrians. However, there are certainly grounds for considering theory B as valid. As discussed elsewhere, the documentation of pedestrians as bus passengers likely diminishes in proportion to the distance between the bus stop and the crash location. If a pedestrian had exited a bus and then proceeded to cross the street within the crosswalk at the intersection, before becoming involved in a crash, the responding police may have found that pre-crash history to be less significant than if the pedestrian had decided to conduct a midblock crossing where s/he alighted from the bus.

Table 37: Location of Focus Area Crashes vs. Passenger Crashes

	Focus Area Crashes		Passenger Crashes	
Location	**Number**	**Percent**	**Number**	**Percent**
At Intersection	159	76.4%	6	33.3%
Not At Intersection	49	23.6%	12	66.7%
Total	208	100.0%	18	100.0%

Source: Michael Baker Jr., Inc.

Past studies have identified the position of bus stops to be of significant interest. It has been posited that the placement of near side bus stops likely contributes to crashes to a greater degree than far side bus stops. The expressed concern is that when pedestrians alight from a bus at a near side bus stop, they will proceed to cross at the intersection in front of the stopped bus. Motorists approaching the intersection from the same direction as the stopped bus will have their view of the crossing pedestrian obstructed by the bus.

Table 38 summarizes the incidence of crashes at bus stops at the three different bus stop positions. The proportion of crashes at bus stop positions largely corresponds to the proportion of bus stop type in the cluster focus areas. The percentage of crashes at near side bus stops, at 55.6%, is slightly higher than the percentage of bus stops at the cluster focus areas (54.1%). Of even greater interest, however, is the nature of crashes to which the bus stop position contributes. There were five crashes involving passengers in the study area for which the responding officer indicated that the blockage of views by buses was instrumental. Three crashes were at near side bus stops; one was at a far side bus stop; and one was at a midblock bus stop. Two of the near side bus crashes fit the pattern described above. The third near side crash with a blocked view was somewhat unusual; the pedestrian was walking from the bus along the roadway and crossing the adjacent intersection, when a motorist driving in the same direction as the bus turned around the bus into the side street.

However, the problem of obstructed views is not unique to near side bus stops. Obstructed views were also cited as a central factor in one midblock bus stop crash and one far side bus stop crash. If passengers alighting the bus at a far side stop determine that they would like to travel to a land use downstream of the bus, they may end up crossing in front of the bus, rather than behind it at the intersection.

Table 38: Position of Bus Stops vs. Bus Stops Associated with Bus Passenger Crashes

	Bus Stops		Bus Stops Associated With	
Bus Stop Position	**Number**	**Percent**	**Number**	**Percent**
Far Side	22	36.1%	6	33.3%
Near Side	33	54.1%	10	55.6%
Midblock	6	9.8%	1	5.6%
Unknown	NA	NA	1	5.6%
TOTAL	61	100.0%	18	100.0%

Source: Michael Baker Jr., Inc.

Figure 9: Near-side Bus Stop

Source: Michael Baker Jr., Inc.

Figure 10: Far-side Bus Stop in Jersey City

Source: Michael Baker Jr., Inc.

In reference to Figure 10 and Figure 11, near–side bus stops are associated with obstructed view crashes to a greater degree than bus stops in other positions. However, obstructed view crashes can happen with far side bus stops, as a far side stop in Jersey City was the site of an obstructed view crash.

The distance of the bus stop from the intersection is another important factor of bus stop design. The research team presumed that bus passenger crashes stemming from "not at intersection" crossings would correspond to bus stops located the farthest distance from signalized intersections, since pedestrians may choose to conduct a hazardous midblock crossing rather than travel out of their way to a safer crossing point.

There was little difference, however, between the location of bus stops at which midblock crashes occurred, and all other bus stops. Twelve of the 18 passenger crashes involved a passenger crossing the main roadway at an unsignalized location. The median distance from the bus stop to the closest signalized intersection at these 12 sites was 70 feet. This was only slightly longer than the median distance between all bus stops and the closest signalized intersection, at 64 feet. The range in distance from bus stop to signalized intersections is between 16 feet and 300 feet.

The relatively small difference may not necessarily indicate that bus stops located at a greater distance from signalized intersections are less dangerous, as much as it may indicate the willingness of bus passengers to conduct midblock crossings even when the stop is at close distance to intersections. The fact that eight pedestrians conducting midblock crossings were struck at a distance of from 10 feet to 75 feet from a signalized intersection indicates that it is not possible to eliminate the possibility of midblock crashes merely by situating a bus stop in immediate proximity to a signalized intersection.

Figure 11: Pedestrian Crash Location

Source: Michael Baker Jr., Inc.

Roadway Characteristics at Bus Stops

As noted in Table 39, roadways associated with passenger crashes had a higher number of travel lanes than roadways at the 30 focus areas; two-thirds (66.7%) of the sites associated with passenger crashes have four lanes or more, versus half (51.6%) of the roadways in the focus areas.

Table 39: Travel Lanes at Focus Area Roadways vs. Bus Passenger Crash Sites

	Focus Area		Bus Passenger Crash Sites	
Travel Lanes	**Number**	**Percent**	**Number**	**Percent**
2	11	35.5%	6	33.3%
3	4	12.9%	0	0.0%
4	10	32.3%	9	50.0%
5	5	16.1%	2	11.1%
6	1	3.2%	1	5.6%
TOTAL	31	100.0%	18	100.0%

Source: Michael Baker Jr., Inc.

Table 40 indicates that there is a higher percentage of crash sites along roadways posted 25 mph versus focus area roadways (61.1% to 54.8%). However, crash sites also had a higher percentage of roadways posted at 40 or 45 mph (22.3% to 16.1%). As discussed in Section 4.3, because of the relatively small sample of higher speed roadways, it is difficult to draw conclusions as to the relationship of posted speed to crashes.

Table 40: Speed Limits at Focus Area Roadways vs. Bus Passenger Crash Sites

	Focus Area		Bus Passenger Crash Sites	
Speed Limit	**Number**	**Percent**	**Number**	**Percent**
25 mph	17	54.8%	11	61.1%
30 mph	7	22.6%	2	11.1%
35 mph	2	6.5%	1	5.6%
40 mph	4	12.9%	3	16.7%
45 mph	1	3.2%	1	5.6%
TOTAL	31	100.0%	18	100.0%

Source: Michael Baker Jr., Inc.

Medians at Bus Stops

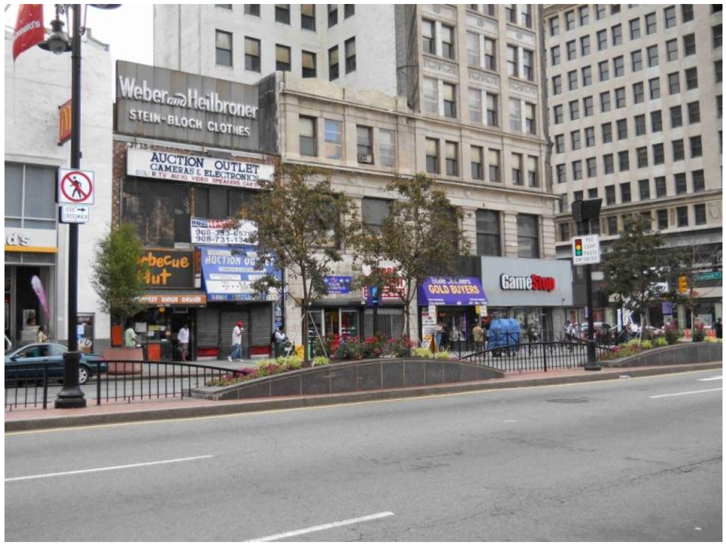
Five of the cluster focus areas have raised medians, and crashes associated with bus passengers occurred at three of these five sites. In two of the crashes, pedestrians were conducting a midblock crossing. Studies have consistently shown raised medians to be effective in reducing the number of crashes resulting from midblock pedestrian crossings, but the sample size is too small to draw conclusions about their role in pedestrian safety for this study.[58] It is worth scrutinizing one of the two sites with a median that did not experience any pedestrian crashes associated with bus passengers. Cluster 25 at Broad Street and Market Street in Newark has a much higher number of bus passengers than any other site; 4,324 bus passengers were counted in the weekday 4:00 to 6:00 PM period by the research team, or two-thirds of the pedestrians counted at this site. In comparison, the cluster with the second-highest number of bus passengers, Elizabeth, had 670 passengers from 4:00 to 6:00 PM. Both of the intersecting roadways are heavily trafficked four-lane roadways. Despite this, the cluster had a moderate number of total pedestrian crashes (10 over the 5-year study period) and no crashes associated with bus passengers.

The site has two design features present at only a handful of other study area sites:

- A median that discourages pedestrian crossings through the use of decorative fence and planter treatments. The only other site with a median intended to discourage pedestrian crossing was Cluster 42 in Galloway, with a Jersey barrier.
- Prohibition of left turn movements. Of the 34 signalized intersections in the cluster focus areas, only 6 (including cluster 25) prohibit left turns. Further, Cluster 25 is the only signalized intersection to prohibit left turns from all approaches. The other five intersections prohibit left turns only from the major roadway.

These two design features – medians to discourage midblock crossings, and prohibition on left turn movements – were likely instrumental in minimizing the incidence of crashes involving bus passengers at this busy intersection.

Figure 12: Median Discouraging Unsafe Pedestrian Crossings in Newark, NJ



Source: Michael Baker Jr., Inc.

Lighting Conditions for Bus Passenger Crashes

As indicated in Table 41, crashes associated with bus passengers were more likely to take place when it was dark; 38.9% of the bus passenger crashes occurred during dark lighting conditions, versus 34.1% of all crashes in the focus area.

Table 41: Light Condition for Focus Area vs. Bus Passenger Crashes

	Focus Area Crashes		Bus Passenger Crashes	
Light Condition	**Number**	**Percent**	**Number**	**Percent**
Dark	71	34.1%	7	38.9%
Dawn / Dusk	5	2.4%	0	0.0%
Daylight	132	63.5%	11	61.1%
TOTAL	208	100.0%	18	100.0%

Source: Michael Baker Jr., Inc.

As a final note, caution is recommended in extrapolating the crash experience at bus stops analyzed in this report to all of New Jersey since most of the clusters are in busy urban areas. The clusters were selected based on the number and density of pedestrian crashes within 320 feet of bus stops. Because of the high level of activity associated with other land uses surrounding bus stops in urban areas, they may be associated with a high number of pedestrian crashes, but not necessarily a large number of crashes associated with bus passengers in particular. For example, Cluster 31 in Atlantic City had 83 pedestrian crashes from 2005 to 2009, but only one bus passenger crash. In comparison, Cluster 4 in Middle Township and Cluster 42 in Galloway Township were tied with the smallest number of crashes for the study period (five each from 2005 through 2009), and both of these sites had one bus passenger crash.

Other studies have evaluated pedestrian safety at bus stops on major suburban corridors, and these areas present somewhat different issues than most of the clusters analyzed in this study.[59] On these corridors, there can often be a quarter-mile or more between signalized intersections. At bus stops not located at these intersections, bus passengers may have a difficult choice whether to risk a midblock crossing of a multilane, high speed facility or to take the long walk around via a signalized intersection. For bus passengers in this study, by contrast, the walk from a bus stop to a signalized intersection was quite reasonable, while roadways were typically lower speed.

Transit Passenger Intersect Survey Administration

Another major data collection effort of this project was a stratified intercept survey of bus stops in the New Jersey transportation system. Surveys were fielded from September, 2011 to December, 2011. The surveys were handed out during morning or evening rush hour on a single day, with the exception of Newark (C25), which was surveyed on two separate days. A total of 4022 surveys were distributed and 719 were completed and returned (18 percent response rate). Response rates varied among the bus stops from a low of 7 percent (Ridgefield) to a high of 44 percent (Middle Township). Sample sizes also varied by site. Newark (C25) had the highest sample size (296 completed surveys); Ridgefield had the smallest (5 completed surveys). In general, older urban centers (e.g. Newark, Atlantic City, Elizabeth, and Paterson) had large sample sizes, while suburban areas (e.g. Elmwood Park, Middle Township, Ridgefield, and Nutley) had small samples.

Table 42: Intercept Survey Results

Bus Stop	Date	Time	# of Surveys Distributed	Completes	Response Rate
Metuchen (C09)	9/13/2011	AM and PM Rush	116	32	27.6%
Elmwood Park (C20)	10/20/2011	3PM to 7PM	72	6	8.3%
Teaneck (C30)	10/26/2011	3PM to 7PM	58	15	25.9%
Paterson (C32)	11/1/2011	3PM to 7PM	295	56	19.0%
Paterson (C13)	11/2/2011	3PM to 7PM	95	15	15.8%
Atlantic City (C31)	11/3/2011	3PM to 7PM	400	72	18.0%
Newark (C25)	11/8/2011	3PM to 6:45PM	943	160	17.0%
Newark (C24)	11/9/2011	3PM to 7PM	421	77	18.3%
Irvington (C18)	11/14/2011	3PM to 5:15PM	175	22	12.6%
Middle Township (C04)	11/15/2011	3PM to 7PM	16	7	43.8%
Newark (C25)	12/1/2011	6:30AM to 9:30AM	743	136	18.3%
Ridgefield (C27)	12/5/2011	6:30AM to 9:30AM	72	5	6.9%
Elizabeth (C37)	12/8/2011	6:30AM to 9:30AM	345	58	16.8%
Woodbury (C06)	12/12/2011	6:30AM to 9:30AM	48	13	27.1%
Leonia (C36)	12/13/2011	6:30AM to 9:30AM	112	25	22.3%
Nutley (C36)	12/13/2011	6:30AM to 9:30AM	39	8	20.5%
Jersey City (C40)	12/13/2011	6:30AM to 9:30AM	72	12	16.7%
	Total		**4022**	**719**	**17.9%**

Source: Bloustein Center for Survey Research

Site Selection

Table 42 shows the locations of where the intercept surveys were distributed and the number of completes for each group. A site selection rubric was used to maximize administration according to group types, high and low density areas and high and low ridership areas. There were 259 completes from high density/high ridership areas, 34 completes from high density/low ridership areas, 186 completes from low density/high ridership areas, and 104 completes from low density/low ridership areas.

Table 43: Study Sites Grouped According to High and Low Density and Ridership Area

	High Density	Low Density
High Ridership	Irvington C18 (22 completes) Newark C24 (77 completes) Newark C25 (160 completes) **Total: 259 completes**	Elizabeth C37 (58 completes) Paterson C32 (56 completes) Atlantic City C31 (72 completes) **Total: 186 completes**
Low Ridership	Elmwood Park C20 (6 completes) Nutley C22 (8 completes) Ridgefield C27 (5 completes) Teaneck C30 (15 completes) **Total: 34 completes**	Jersey City C40 (12 completes) Leonia C36 (25 completes) Metuchen C09 (32 completes) Middle Township C04 (7 completes) Paterson C13 (15 completes) Woodbury C06 (13 completes) **Total: 104 completes**

Source: Voorhees Transportation Center

Questionnaire Design

The questionnaire, designed by the research team, was pretested in Metuchen on 9/13/2011. At the conclusion of the pretest the surveys and the associated data were examined for survey content, response effects, and question comprehensibility. The final questionnaire was printed on cardstock legal paper in color. The survey was also translated into Latin American Spanish by a professional translation service, and was verified by bi-lingual staff at BCSR and VTC. Please see Appendix D for copy of the survey.

Protocol

The administration protocol for the intercept survey was designed by BCSR. At each administration, two to four full-time staff members were on site to supervise the survey administrators. All staff and survey administrators wore “Rutgers Red” aprons with the university logo to clearly identify themselves as being a part of Rutgers. Survey administrator placement was tailored for each site to guarantee maximum exposure of the survey to riders at that stop. The survey was administered at either AM or PM Peak ridership times. All respondents who filled out an entry card were entered into a lottery to win one of five $100 Visa gift cards. Survey administration dates for all the sites were coordinated by BCSR with input from VTC.

Data Entry and Cleaning

Data were entered by part-time staff, trained and supervised by BCSR, via a customized secure data entry application. The data were redundantly entered, and then compared to resolve any discrepancies in order to minimize data entry error to the maximum degree possible. The data were further reviewed and given final labels by the Project Director.

Bus Stop Survey Analysis

The survey instrument consisted of 22 questions focusing on assessing respondents' perceptions of crime, station condition, and traffic near the bus stops. Also included were a series of questions about the participants' behavior near the stop, such as whether they obey traffic rules or take risks near the stops. The following sections review these categories of questions, including pedestrian behavior, pedestrian perception of motorist behavior, perception of traffic safety near bus stops, and perception of crime near bus stops. Following those analyses is a categorical analysis by density and ridership. Each of the locations was categorized as either high or low density and high or low ridership. The responses were then grouped together based on those categories to look for trends in the data based on ridership and density.

1. Pedestrian Behavior

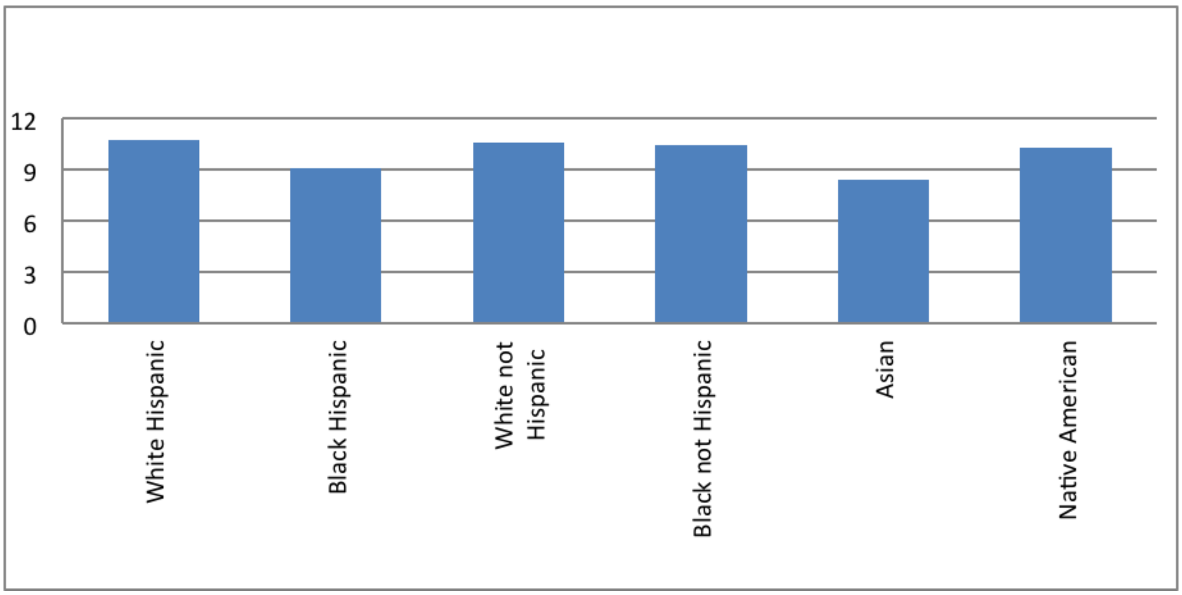
Much like the field observation, the bus stop survey also attempted to capture participants' self-reported risky behaviors. Risky behaviors surveyed in the instrument include:

- Not crossing within the crosswalk
- Not waiting for traffic to stop before crossing
- Walking out between parked cars into traffic
- Standing in the street while waiting for the bus to arrive
- Talking on the phone or texting while crossing the street
- Listening to music on headphones/earphones while crossing the street
- Disregarding traffic signals; and,
- Walking along the roadway (not on the sidewalk)

The research team developed a composite index of these self-reported pedestrian behavior responses. Each survey question provided a statement (e.g. "I use crosswalks to cross the street."), and the respondent was able to check one of four responses: Always, Often, Sometimes, or Never. For the composite index, these responses were each coded with a weight. "Always" was coded with a '2' weight (or '-2' for a negative question, such as "I walk out between parked cars into traffic."). "Often" was coded '1' or '-1'; "Sometimes", '-1' or '1'; and, "Never", '-2' or '2', respectively. The weights were then multiplied by the percentage of respondents for each response and question, and summed together to create a composite index. Lower scores mean more risky behavior reported. Higher scores mean less risky behavior reported. The range of results is 6.4 (Paterson – C13) to 11.8 (Nutley). The top four scores were suburban sites with low numbers of completed surveys. Both Newark sites scored highest among urban sites. Paterson (both sites), Atlantic City, and Leonia scored lowest. These results differ from the observed data. In the observed data, suburban sites had higher rates of risky behavior. Charts detailing the results of the pedestrian behavior questions are included in Appendix E.

Examination of these same self-reported behavior results by income show a slightly higher composite score (less reported risky behavior) among those with incomes of $100,000 or more than those with incomes of under $15,000. By reported racial identification, the results show less risky behaviors reported among Asian and black-Hispanic respondents than whites or non-Hispanic blacks.

Figure 13: Q13a-h Composite Score of Pedestrian Behavior by Race



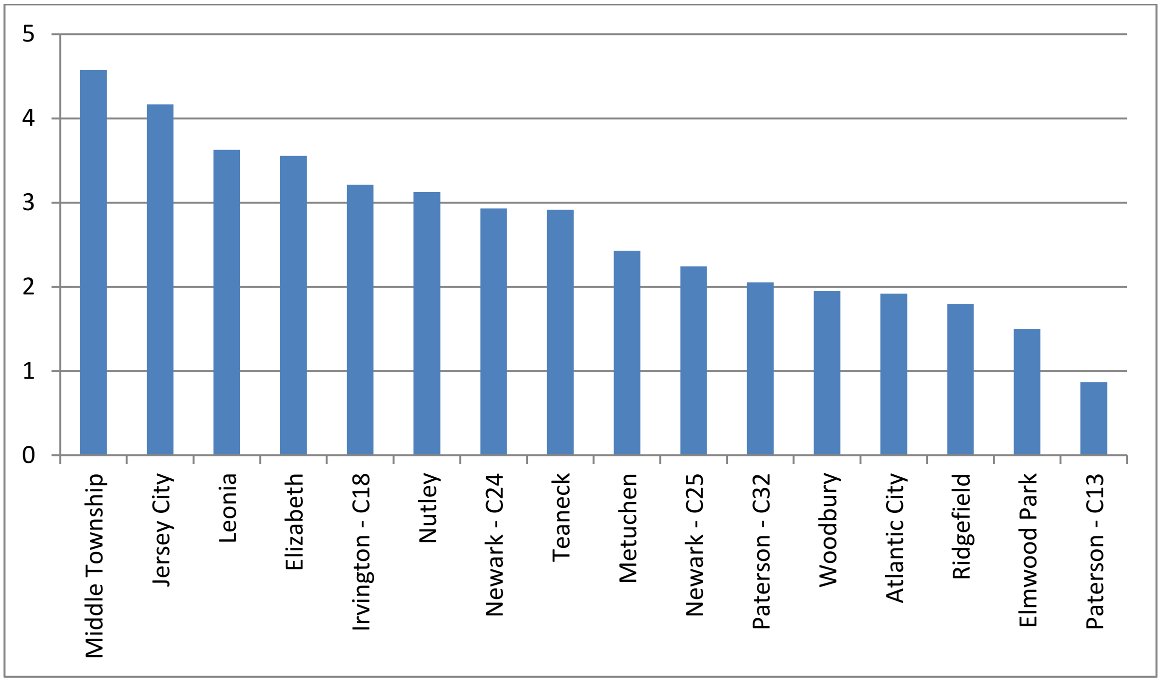
2. Motorist behavior

To assess motorist behavior, our survey asked participants to respond to a series of statements about driver behavior they had observed near the bus stop. The statements were:

- Drivers speed near this stop.
- Drivers do not stop when people are in crosswalks near this stop.
- Drivers ignore red lights or stop signs near this stop.
- Drivers use cell-phones while driving near this stop.
- Drivers eat or drink while driving near this stop.

Once again, a composite score was created to combine the results of all these questions into a single measure of observed driver behavior by survey respondents. For the composite index, these responses were each coded with a weight. “Always” was coded with a ‘2’ weight (or ‘-2’ for a negative question, such as “I walk out between parked cars into traffic.”). “Often” was coded ‘1’ or ‘-1’; “Sometimes”, ‘-1’ or ‘1’; and, “Never”, ‘-2’ or ‘2’, respectively. The weights were then multiplied by the percentage of respondents for each response and summed together to create a composite index. Lower scores mean more risky behavior reported. Higher scores mean less risky behavior reported. The range of results is 4.6 (Middle Township) to 0.9 (Paterson – C13). The top four scores (best reported driver behavior) were Middle Township, Jersey City, Leonia, and Elizabeth. The lowest four scores were Paterson (C13), Elmwood Park, Ridgefield, and Atlantic City.

Figure 14: Q11a-f Composite Score of Reported Driver Behavior



3. Safety at Bus Stops

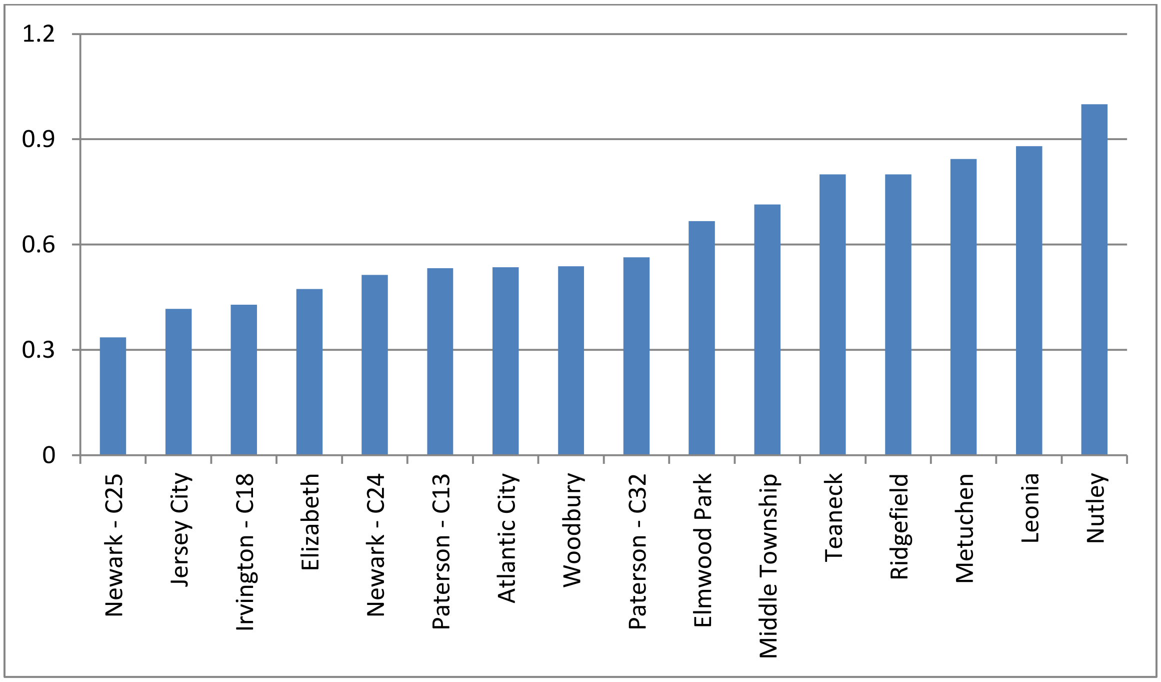
The survey of bus patrons was able to go beyond the observational data collection to ask participants about their perceptions of traffic safety and crime near the bus stops. The survey instrument attempted to confront these issues with a series of questions. First, we asked direct yes-or-no questions about participants' feeling of safety near bus stops. Then, we asked participants to respond to statements about safety, including the driver behavior questions summarized above. And last, we asked pedestrians about their own behavior and the risks they take.

Respondents indicated crime as a more important issue than traffic safety in general. Overall, 73 percent of respondents said they feel safe from traffic at their respective bus stop. The lowest reported traffic safety result was in Middle Township (57 percent); the highest reported result was in Woodbury (92 percent). Question 1 regarding safe places to cross the street yielded even higher results; an average of 83 percent of respondents felt there are safe places to cross the street at their stop.

Crime near bus stops, on the other hand, seems to be a more significant issue for most people. In aggregate, only 48 percent of respondents felt safe from crime at their respective bus stop (Q5). Nearly 14 percent of respondents reported being a victim of a crime (or having a family member who was a victim). Newark (C25) is a particularly unsafe location in the views of the respondents. It scored the lowest in the "crime" (34 percent) and "victim of a crime "(21 percent) questions, respectively. Nutley scored highest

(100 percent). Other bus stops with below average crime responses were: Jersey City (42 percent), Irvington (C18) (43 percent), and Elizabeth (47 percent).

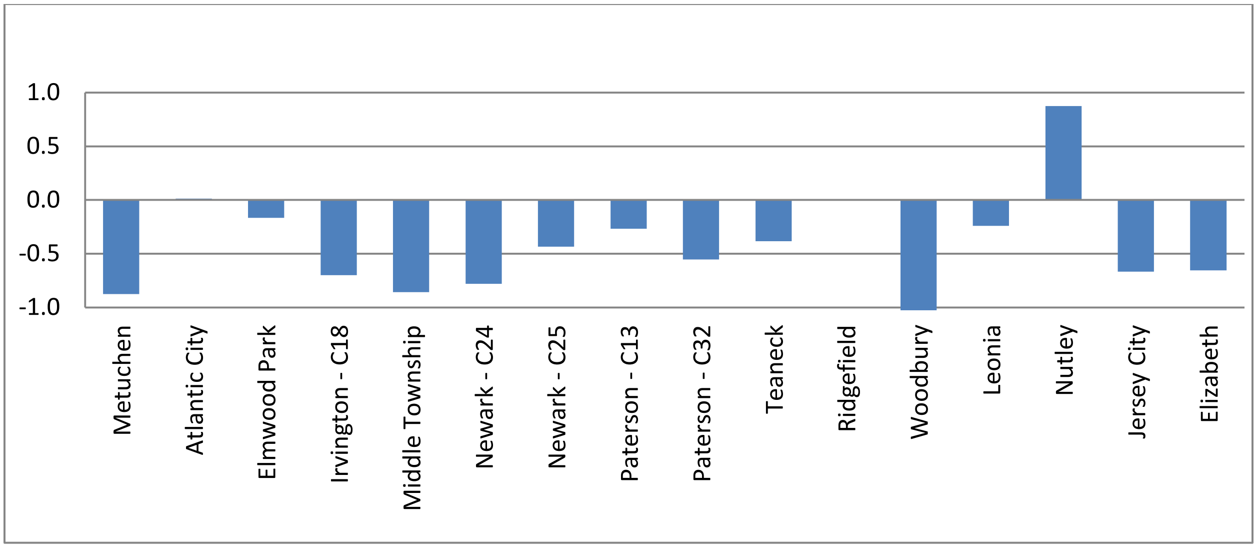
Figure 15: Q5 Safe From Crime



Composite scores were used to assess the relative response of participants to statements about safety around the stop (Q10). For each statement, the participants responded "Always", "Often", "Sometimes", or "Never". Each of these answers was given a score: Always (2), Often (1), Sometimes (-1), and Never (-2).

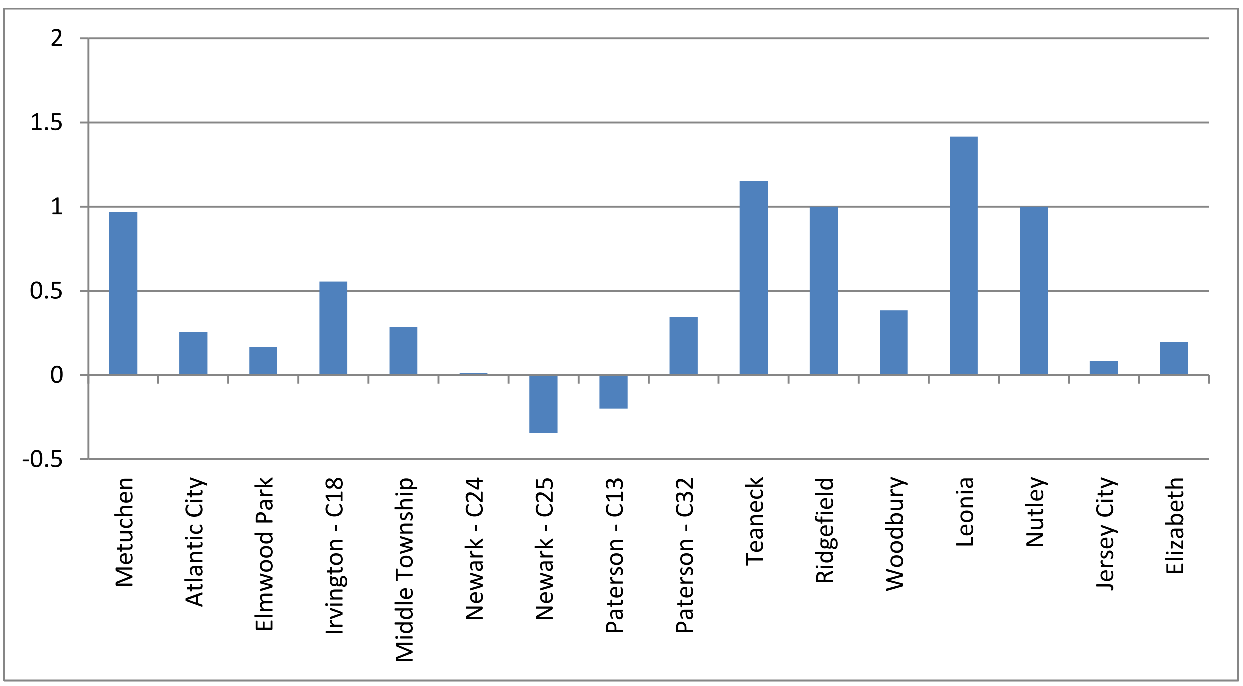
The first statement, "Police officers adequately patrol this stop", was negative across the board. This means that more people responded "Sometimes" or "Never". The only exceptions were Nutley (only 8 respondents) and Atlantic City (nearly even number of affirmative and negative responses).

Figure 16: Q10a "Police officers adequately patrol this stop."



The second safety-themed statement, "I would feel safe waiting at this stop with a small child", was mostly positive in response. This somewhat contradicts the previous responses to Q5. The only two bus stops with negative responses were Newark (C25) and Paterson (C13). Newark (C25) reported the lowest safety percentage in Q5, while Paterson (C13) was middle of the group.

Figure 17: Q10c "I would feel safe waiting at this stop with a small child."



4. Density and Ridership Traffic Safety Analysis

One way in which density and ridership classifications differ significantly is in the importance of traffic safety improvements to bus stops. Where density differences matter less for these issues, ridership matters much more. For example, when asked how important lower driving speeds are near their bus stop, those at high density stops responded only 3 percentage points higher than those at low density stops in the "Important" and "Most Important" categories. High *ridership* respondents, on the other hand, responded with "Important" or "Most Important" 21 percentage points more often than low ridership respondents. This is consistent across all traffic safety related questions in this section of the survey. General questions on traffic safety, such as Q1: Are there safe ways to cross the street, or Q4: Do you feel safe from traffic at this stop, yielded much smaller differences between "density" and "ridership" categories. The conclusion reached with these data is that high ridership locations may not be provided with adequate facilities to protect bus patrons from traffic when accessing the bus stop.

5. Density and Ridership Crime Analysis

The density and ridership analysis framework reveals a strong relationship between both density and ridership with respect to participants' perceptions of crime at bus stops. As with the traffic safety analysis, we examined the aggregate percentage point differences in questions related to crime based on the location's density and ridership characteristics. In both high density and high ridership locations, stops were perceived to be much more threatening than in lower density or ridership locations. Five of the six questions related to crime conformed to this pattern. One question—on the frequency of police patrols near bus stops—did not show any difference in high-low density locations or high-low ridership locations.

The potential consequences of these findings, given their relative magnitude compared to the other findings of this report, are important for NJ Transit. Though these questions address only the *perceptions* of the bus stops surveyed[2], these perceptions can be a strong deterrent toward transit ridership and possibly even alter pedestrian behavior near stops. A next step in this research will be to explore in more detail the potential link between perceptions of crime and differing pedestrian behavior near bus stops.

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[2] Except for Q6—Have you been a victim of a crime at or near this bus stop?—which revealed a strong association toward higher self-reported crimes in high density and high ridership locations)

Figure 18: Perception of Crime by Neighborhood Density

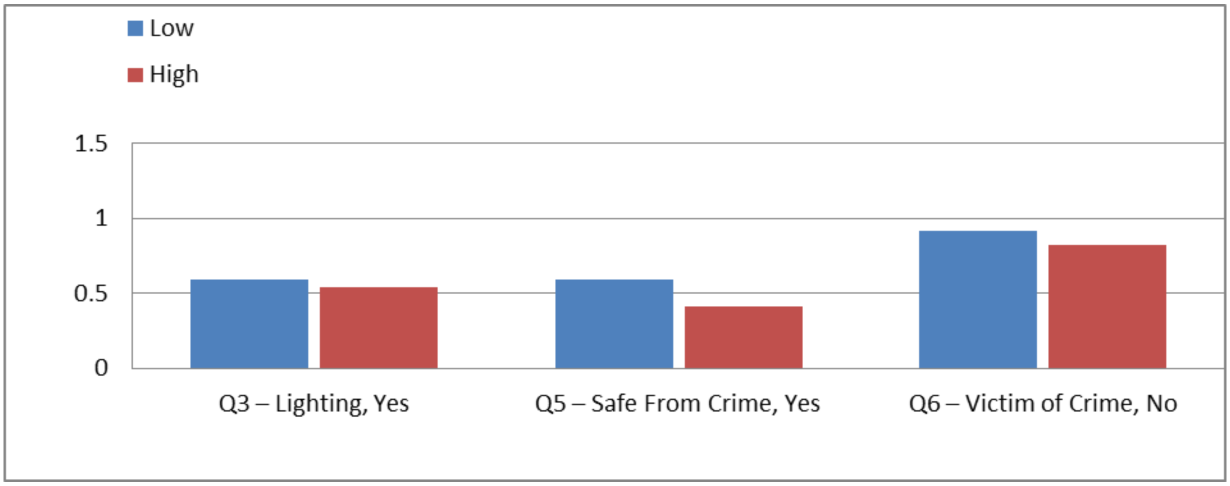
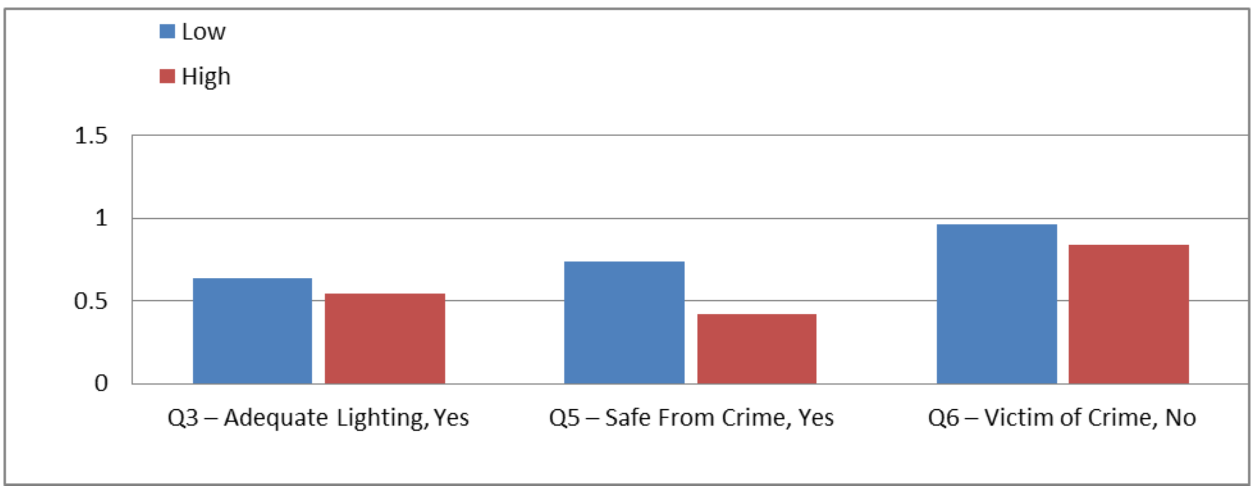


Figure 19: Perception of Crime by Ridership



Examining self-reported behaviors of respondents reveals a weak relationship between reported safety from crime (Q5) and stated risky pedestrian behavior. Those that felt they were not safe from crime at bus stops were 16 percentage points more likely to have ever walked in the road near their stop; 7 percentage points more likely to have ever crossed at locations other than crosswalks; and, 5 percentage points more likely to sometime ignore traffic signals. The pattern holds for both high/low density and ridership stations when analyzed separately. There is no distinguishable difference in stated behaviors versus safety from crime in dense or high ridership areas.

Figure 20: Crime safety cross-tabulations

Q7 – Walk in Road	Q5 – Safe from Crime? Yes	No	Difference
No	80%	64%	
Yes	20%	36%	16%

Q8 – Crosswalks	Q5 – Safe from Crime? Yes	No	Difference
No	65%	59%	
Yes	35%	41%	6%

Q9 – Traffic Signals	Q5 – Safe from Crime? Yes	No	Difference
No	76%	71%	
Yes	24%	29%	5%

In conclusion, though these data do show some evidence of safety from crime concerns at both high density and high ridership locations, this pattern does not seem to extend to reported pedestrian behavior around those stops.

6. Conclusions

The following are conclusions drawn from the survey analysis:

- The perception of crime is more important and concerning to those at high-risk bus stops than traffic safety. Though one might expect police presence (or the perception of police presence) to be lacking, there was no evidence of this lack based on the survey responses. Crime and safety perception issues, therefore, may not be lessened by increased police presence. Instead, improved service information may help decrease the amount of wait time passengers have at bus stops, therefore lessening their exposure to potential dangerous persons. This finding is also consistent with the survey respondents' desires for more real-time transit information as reported in this survey.
- High ridership bus facilities had a significantly higher perception of traffic dangers than low ridership stations. This finding is somewhat at odds with conventional planning wisdom, where low ridership stations are located next to buzzing highways or multi-lane arterials with high exposure to traffic. Instead, those surveyed at high ridership stations thought traffic safety was an issue. It should be noted that density played a much less important role in this relationship. One conclusion could be that the buses themselves are intimidating the riders, but there was little evidence of this in the questions we asked related to bus driver performance. Without more information, it is recommended that improvements be made to crossings or other infrastructure at high ridership locations to

calm traffic and make pedestrian more visible to drivers when crossing streets to access bus facilities.

- Weak evidence was found of a relationship between reported risky pedestrian behavior and perceptions of crime. Those feeling unsafe from crime tended to report riskier pedestrian behaviors, such as walking in the road, crossing outside of crosswalks, and disobeying traffic signals. It is recommended that pedestrian-centric improvements be made in high crime areas near bus stops to make movements across roads easier. This would allow uncomfortable pedestrians more and safer opportunities to avoid suspicious persons while accessing the bus stop.

Strategies

A broad range of strategies should be considered to enhance pedestrian safety at the crash clusters evaluated in this study. The large majority of crashes within the crash clusters are not associated with bus stop activity. Therefore, strategies to enhance the safety of pedestrians heading toward and leaving bus stops could be encompassed by an effort to promote safety in the larger area. Strategies should include:

For intersections:

- *Evaluate alternative signal equipment to better accommodate pedestrians.* Pedestrian actuation is necessary to cross the major roadway at over 40% of study area intersections, even in urban areas with regular pedestrian traffic. Since many pedestrians do not actuate the button, numerous crossings occur on the Don't Walk phase. Traffic studies should determine the need for pedestrian actuation at these intersections, and whether methods such as automated pedestrian detection would reduce conflicts.
- *Install "Turning Vehicles Stop for Pedestrians" signs at intersections with a high number of left turn and right turn crashes.* Left turns are the most common crash type in the study area, and studies have shown that such signs increase the awareness and yielding rate by motorists.
- *Evaluate the potential for prohibiting vehicular turning movements if they are associated with a high degree of pedestrian and vehicular conflicts, and if the movements can be accommodated through alternative means within the larger roadway network.*
- *Install visible pedestrian information plaques at signalized intersections, to better inform pedestrians on the need to actuate the button for the appropriate crossing.*

For midblock locations:

- *Evaluate opportunity for installing crosswalks at midblock locations where high volumes of pedestrians are crossing.*
- *Evaluate appropriate accompanying treatment to midblock crosswalks to increase motorist yielding rate.* On two-lane roadways, pedestrian warning signing may be sufficient. On multilane roadways, evaluate treatments such as an overhead flashing beacon, rectangular rapid flashing beacon, or the pedestrian hybrid beacon. Use advance stop markings to accompany crosswalk, and/or raised median islands to serve as pedestrian refuges.
- *On multilane roadways, evaluate the possibility of a "road diet" treatment.* As documented in this study, multilane roadways are associated with both a higher number of pedestrian fault crashes and crashes involving bus passengers. They are also associated with a lower yielding rate by motorists at pedestrian crossings.[60]

At bus stops:

- *Investigate moving bus stops to the far side of the intersection.* An important aspect of bus stop design is its position: near side, far side, or midblock. Based upon the review of crashes associated with bus passengers in this report, the far side stop is typically preferred, since it appears to present a lower risk for obstructed view crashes when compared to near side bus stops.

- *Consider the relationship with pedestrian generators and attractions for all bus stop sitings; use far-side siting whenever possible.* Given the tendency of pedestrians to find the most direct route between bus stops and their immediate destinations, the bus stop location should be selected to minimize midblock crossings. A study of pedestrian movements in the area should be conducted before finalizing bus stop selection. For example, a popular pedestrian attraction immediately downstream of a far side bus stop could encourage alighting bus passengers to cross the roadway in front of the bus, which would increase the risk of obstructed view crashes. A comprehensive review of the advantages and disadvantages of different bus stop positions is found in Transit Cooperative Research Program, *Report 19: Guidelines for the Location and Design of Bus Stops*, Transportation Research Board, 1996.
- *Provide good lighting at bus stops, and the area around bus stops.* Lighting should take into account both vehicle and pedestrian scales.
- *Conduct an educational advertising campaign to encourage pedestrians to cross at marked and preferably controlled locations on their trips to and from the bus stop.*
- *Provide adequate space for buses at stops, to accommodate the ability of buses to fully dock at the curb.* Further, bus drivers should be educated on the importance of docking at the curb.
- *Provide a raised island median or decorative fence at midblock locations.* As discussed above, various strategies exist to provide safer movements for those pedestrians that conduct midblock crossings, including formalizing locations. To encourage safer travel by bus passengers on multilane roadways in the absence of formalized midblock crossings, two contrasting approaches can be selected: provide a raised island as a pedestrian refuge, or, as in the case of Newark at Market Street and Broad Street, install a decorative fence on a median to discourage midblock crossings altogether.

Conclusions

Following are key conclusions:

- A small percentage of the 551 pedestrian crashes identified within the study area are associated with bus passenger crashes in the immediate vicinity of bus stops, in the range of 2.2% to 3.8% of crashes. Although bus passengers likely account for up to 15% of crashes in the study area, most of these crashes occur away from bus stops, and the pedestrians are not recorded as bus passengers. Strategies to enhance the safety of bus passengers should therefore not be confined to the immediate vicinity of bus stops, but should apply to the larger area.
- Motorists were found to be primarily responsible for the majority of crashes, with "Left Turn Parallel Path" and "Motorist Failed to Yield" crashes the most common crash types in this group. New Jersey should continue its efforts to educate motorists on the importance of yielding to pedestrians when conducting turns, and to pedestrians crossing at unsignalized intersections.
- Most of the clusters are in urban areas, with adequate infrastructure such as sidewalks and crosswalks.
- High crash clusters are associated with commercial areas along arterial roadways, and these should be a focus of crash remediation efforts.
- A larger percentage of pedestrian fault crashes occur along roadways of four lanes or more than roadways of three lanes or less. Further, two-thirds of bus passenger crashes occur along roadways of four lanes or more.
- At signalized intersections, the presence of pedestrian actuation is associated with a higher percentage of pedestrians crossing during the "Don't Walk" phase.
- Only 11.5% of bus stops were found to meet NJ Transit criteria for bus stop length. It was noted on field views that many buses were not able to fully dock at the curb, and thus discharged passengers into the street. Insufficient space at bus stops could contribute to the frequency of this activity.
- The presence of highway scale lights or pedestrian scale lights is associated with little difference in the percentage of pedestrian crashes occurring at night.
- Although the research team anticipated a higher percentage of bus passenger crashes to involve pedestrians headed toward the bus stop, the 18 crashes associated with bus passengers are evenly split between passengers headed toward or leaving the bus stop.
- Two-thirds of bus passenger crashes occur outside the intersection, with hazardous midblock crossings being the precipitating cause. Many of these midblock crashes occur in close proximity to the intersection. This suggests both that bus stop placements should carefully evaluate key pedestrian generators in the vicinity to identify major pedestrian travel paths, and that it will be difficult to significantly reduce midblock crashes by placing stops in close proximity to intersections.
- The perception of crime is more important and concerning to those at high-risk bus stops than traffic safety. Though one might expect police presence (or the perception of police

presence) to be lacking, there was no evidence of this lack based on the survey responses. Crime and safety perception issues, therefore, may not be lessened by increased police presence. Instead, improved service information may help decrease the amount of wait time passengers take at bus stops, therefore lessening their exposure to potentially dangerous persons. This finding is also consistent with the survey respondents' desires for more real-time transit information as reported in this survey.

- High ridership bus facilities had a significantly higher perception of traffic dangers than low ridership stations. This finding is somewhat at odds with conventional planning wisdom, where low ridership stations are located next to buzzing highways or multi-lane arterials with high exposure to traffic. Instead, those surveyed at high ridership stations thought traffic safety was an issue. It should be noted that density played a much less important role in this relationship. One conclusion could be that the buses themselves are intimidating the riders, but there was little evidence of this in the questions we asked related to bus driver performance. Without more information, it is recommended that improvements be made to crossings or other infrastructure at high ridership locations to calm traffic and protect pedestrians when crossing streets to access bus facilities.
- Weak evidence was found of a relationship between reported risky pedestrian behavior and perceptions of crime. Those feeling unsafe from crime tended to report riskier pedestrian behaviors, such as walking in the road, crossing outside of crosswalks, and disobeying traffic signals. It is recommended that pedestrian-centric improvements be made in high crime areas near bus stops to make movements across roads easier. This would allow uncomfortable pedestrians more and safer opportunities to avoid suspicious persons while accessing the bus stop.
- The percentages of crashes associated with bus stop position – near side, far side, and midblock – largely correspond to the frequency of each bus stop type. However, near side bus stops are associated with a larger number of obstructed view crashes. Based on the analysis, far side bus stops are typically preferred to near side stops, but all bus stop decisions must take into account the relationship to surrounding pedestrian generators and attractions.

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