CRASHES *and* COMMUNITIES *of* CONCERN

in the Greater Philadelphia Region

DELAWARE VALLEY
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REGIONAL
PLANNING COMMISSION

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The Delaware Valley Regional Planning Commission is the federally designated Metropolitan Planning Organization for a diverse nine-county region in two states: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey.

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

DVRPC's vision for the Greater Philadelphia Region is a prosperous, innovative, equitable, resilient, and sustainable region that increases mobility choices by investing in a safe and modern transportation system; that protects and preserves our natural resources while creating healthy communities; and that fosters greater opportunities for all.

DVRPC's mission is to achieve this vision by convening the widest array of partners to inform and facilitate data-driven decision-making. We are engaged across the region, and strive to be leaders and innovators, exploring new ideas and creating best practices.

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INTRODUCTION

The intersection of North Front Street and Lehigh Avenue, in Fairhill, Philadelphia, where a pedestrian was killed in a crash in 2016.

As the metropolitan planning organization for the nine-county Greater Philadelphia region, the Delaware Valley Regional Planning Commission (DVRPC) works to increase mobility choices, protect and preserve natural resources, and create healthy communities that foster greater opportunities for all. Past projects that DVRPC has undertaken that specifically address equity and health include Equity Through Access, the Camden Health Element, and the Greater Philadelphia Food Systems Study.

DVRPC is also committed to creating a safer transportation system. The risk of death or serious injury resulting from a traffic crash is a critical public health issue. Nationally, car crashes are a leading cause of death, especially for younger age groups, and in recent years, more and more people have been affected by severe vehicle crashes after a period of decline. Nationwide, 37,461 people died in car crashes in 2016, which represents a 10 percent increase over 2012. Regionally, 1,889 people lost their lives in a vehicle crash between 2012 and 2016. Another 5,294 people were seriously injured in a crash during the same period. Of these 7,183 people that were either killed or seriously injured, 21 percent were pedestrians or bicyclists (referred to in this report as "vulnerable users"), despite accounting for only 11.6 percent of trips in the region (DVRPC, 2015).

While all road users are at risk of being involved in a severe crash, the overrepresentation of vulnerable users in severe crashes shows that these risks are not borne by all people equally. Indeed, mode choice is just one dimension along which one's likelihood of being killed or severely injured in a vehicle crash can differ. As this report will show, many severe vehicle crashes concentrate in areas of the region where roadway design enables high speeds and there are large concentrations of bicylists and pedestrians. These areas also tend to be where populations of potential disadvantage, such as racial minorities or low-income individuals, live. This puts these populations at higher risk of being killed or seriously injured in a crash.

A better understanding of how severe vehicle crashes are distributed throughout the region, and which communities with higher rates of potentially disadvantaged populations (sometimes referred to as "communities of concern") are most commonly impacted, can help DVRPC and its partners begin to address inequities in crash experience across the region. This report uses a data-driven approach in order to identify which potentially disadvantaged populations are most exposed to severe vehicle crashes. In addition, the report locates where this crisis is most severe in order to expand upon DVRPC's efforts to address issues in the built environment and promote public health and equity in the region.

This report is divided into five sections. The first section, "Literature Review," discusses the current state of research on this topic. The second, "Methodology," details the data sources used for this study in addition to the processes used to conduct the statistical and spatial analysis. The "Findings" section discusses the results of this analysis, while the "Case Studies" section analyzes trends in the crash experience in communities of concern identified for further study by the regional analysis. Lastly, the "Conclusions" section discusses DVRPC's recommendations for addressing inequities in crash experience across the region, based on the insights gleaned from the regional and case study analyses.

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LITERATURE REVIEW

Route 130 (Burlington Pike), which was the most dangerous road in New Jersey for pedestrians in 2016, according to a report by the Tri-State Transportation Campaign.

A significant body of evidence, stretching back decades, exists to support the idea that one's likelihood of being involved in a severe crash is linked to where one lives. A study in Montreal, which used data from the 1980s, found that children living in neighborhoods with income levels in the lowest quintile had traffic fatality rates four times greater than children living in neighborhoods with income levels in the highest quintile (Dougherty, Pless, and Wilkins, 1990). One of the first studies to make this connection domestically was conducted by researchers at the Prevention Research Center in Berkeley, California, which investigates the relationship between the environment and public health. Their research, published in 2000, found that pedestrian injury rates in San Francisco correlated with greater traffic flow, higher population density, older age composition, higher unemployment rates, higher proportion of males, and lower educational attainment (LaScala, Gerber, and Gruenewald, 2000).

More recent research has also focused primarily on vulnerable users, such as bicyclists and pedestrians, who are less likely than vehicle occupants to survive a crash. Using data from 2003 to 2004, researchers at the University at Buffalo and the University of North Carolina at Charlotte found that pedestrian and bicycle crashes were associated with socioeconomic and demographic variables and not with roadway characteristics or the percentage of bicyclist and pedestrian commuters (Delmelle, Thill, and Ha, 2012). Bicycle crashes occurred more often in neighborhoods with higher population density, lower educational attainment, and a higher percentage of residents who identify as ethnic minorities, while pedestrian crashes occurred more often in neighborhoods with a higher density of retail establishments and a higher percentage of residents who identify as racial minorities (Delmelle, Thill, and Ha, 2012). Their research was conclusive in identifying a racial and ethnic component to crash risk for vulnerable users. The authors wrote: "Caucasian dominated neighborhoods are safer to pedestrians and bicyclists alike" (Delmelle, Thill, and Ha, 2012). Other research has also looked specifically at race, especially in the context of environmental justice (EJ). Researchers at the University of Illinois in Chicago analyzed pedestrian crashes in the Chicago region, using data from 2005, and found that pedestrian crashes were more prevalent in census tracts with high low-income and minority populations (Cottrill and Thakuriah, 2010).

What these studies overlooked, however, was the role that built environment factors play in causing these disparities in crash experience. Recent thought in public health research acknowledges that health outcomes have more to do with the physical attributes of a community than its racial composition or median income. Dr. Thomas A. LaVeist, a professor at George Washington University's Milken Institute School of Public Health, co-wrote a 2011 report titled "Segregated Spaces, Risky Places: The Effects of Racial Segregation on Health Inequalities," which makes the connection between race, place, and health explicitly: "race helps to determine place, and in turn, place influences health" (LaVeist, Gaskin, and Trujillo, 2011). A study in Montreal, using crash data from 1999 to 2003, drew the missing link between disadvantaged populations and increased crash incidence, finding that four-way intersections, intersections with arterial roads, and higher average daily traffic are more common in poorer areas of the city, which partially accounts for the higher pedestrian injury rates experienced in these areas (Morency et al., 2012). The relationship between some of these built environment factors and crashes in the Greater Philadelphia region is examined in Chapter 5: "Case Studies" of this report.

Dangerous by Design, a report produced by Smart Growth America, uses the Pedestrian Danger Index (PDI) to rank metropolitan areas based on the pedestrian fatality rate, which is normalized using the share of commuters who walk to work. It also examines which pedestrians are most at risk based on race and income. In 2011, *Dangerous by Design* reported that black pedestrians had a fatality rate 1.7 times that of a white non-Hispanic pedestrian; Hispanic pedestrians had a fatality rate 1.6 times higher. As a result, even though non-whites made up only 32 percent of the population as a whole, they made up 43 percent of pedestrian deaths. It also reported that in counties where more than 20 percent of families were in poverty, the pedestrian fatality rate was 1.8 times higher than the national rate (Ernst, 2011). The most recent edition of *Dangerous by Design*, published in 2016, found that while the pedestrian fatality rate had decreased since 2011, black and Hispanic pedestrians still had a higher fatality rate than white non-Hispanic pedestrians (1.9 and 1.5 times, respectively; Atherton et al., 2016).

Charles Brown, a senior researcher at the Alan M. Voorhees Transportation Center at Rutgers University, looked specifically at "communities of concern" and whether they are more at risk of being involved in a severe crash. Communities of concern expands the definition of environmental justice communities to include not only minority and low-income populations, but also a variety of other demographic or socioeconomic indicators of disadvantage. These communities were identified in the Regional Fair Housing and Equity Assessment (FHEA) for 13 counties in northern New Jersey conducted by the North Jersey Transportation Planning Authority (NJTPA) under the auspices of the Together North Jersey planning initiative for sustainability in the region (Brown, 2015). These communities may have minority or low-income concentrations equal to or exceeding the regional threshold, or they may have two or more other disadvantaged populations, such as single female-headed households, carless households, older adults, or persons with limited English proficiency, equal to or exceeding the regional threshold instead (Brown, 2015). Brown also investigated racially and ethnically concentrated areas of poverty (RCAP/ECAP), which have a majority non-white population and a family poverty rate more than three times that of the regional average (Brown, 2015).

Brown's research sought to determine whether pedestrian crashes occurred more often, and whether these crashes were more severe, in communities of concern or RCAPs/ECAPs than in other communities. Brown used data from 2008 to 2013 and normalized crashes by population and area (Brown, 2015). Both normalization methods found elevated crash rates in communities of concern compared to non-communities of concern (Brown, 2015). Furthermore, despite making up just 8.6 percent of the population, 20.7 percent of crashes occurred in RCAPs (Brown, 2015). Brown's approach of determining whether census tracts with a higher proportion of communities of concern also experience higher crash rates served as a model for this study's goal of determining whether a similar relationship exists in the Greater Philadelphia region.

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METHODOLOGY

The intersection of Market Street and 60th Street in Cobbs Creek, Philadelphia, where a pedestrian was seriously injured in 2013.

DVRPC uses an analysis called the "indicators of potential disadvantage" (IPDs) to address federal requirements related to equity in transportation funding. The project team used a correlation analysis to determine which, if any, IPDs are related to crash rates at the census tract level. There were five basic steps to this process:

1. Prepare New Jersey Department of Transportation (NJDOT) and Pennsylvania Department of Transportation (PennDOT) crash data.

2. Join the crash data to the census tract using a geospatial analysis tool.

3. Normalize the crash data.

4. Run a correlation analysis between the normalized crash rates and each IPD.

5. Identify correlated IPDs for additional analysis.

The first three steps are described in the "Data Preparation" section of this chapter. The last two steps are described in the "Correlation Analysis" section. The first section of this chapter describes DVRPC's IPD methodology.

INDICATORS OF POTENTIAL DISADVANTAGE

Under Title VI of the Civil Rights Act and the Executive Order on Environmental Justice (#12898), metropolitan planning organizations (MPOs) are directed to create a method for ensuring that equity issues are investigated and evaluated in transportation decision making. There is additional guidance from the Federal Highway Administration's (FHWA) EJ recommendations (2017), FHWA's Title VI and Additional Nondiscrimination Requirements (2017), Federal Transit Administration's (FTA) EJ policy guidance (2012), and FTA's Title VI requirements and guidelines (2012). The IPD analysis is used throughout DVRPC to demonstrate compliance with Title VI of the Civil Rights Act and support the fair treatment of population groups identified through EJ.

Population Groups

The IPD analysis identifies populations of interest under Title VI and EJ using U.S. Census American Community Survey (ACS) 2012–2016 five-year estimates and maps these populations in each of the census tracts in the region via ArcGIS geospatial mapping software. Each population group is an "indicator" in the analysis and includes the following:

- **Youth**

  The youth indicator addresses FHWA's EJ recommendation to include children as a "traditionally underserved" population group when conducting equity analyses and FHWA's Additional Nondiscrimination Requirements under the Age Discrimination Act of 1975 to not discriminate based on age. This indicator uses age data from the ACS and includes all persons in the region under 18 years old.

- **Older Adults**

  The older adults indicator addresses the populations included in FHWA's Additional Nondiscrimination Requirement under the Age Discrimination Act of 1975 and FHWA EJ recommendations to not discriminate based on age. This indicator uses age data from the ACS and includes all persons in the region 65 years and older.

- **Female**

  The female indicator addresses FHWA's Additional Nondiscrimination Requirement under Section 162 (a) of the Federal-Aid Highway Act of 1973 (23 USC 324) that no person shall be subject to discrimination on the basis of sex under any program or activity receiving federal assistance. This Additional Nondiscrimination Requirement is connected to Title IX of the Civil Rights Act, which designates women as a protected class. This indicator uses sex data from the ACS and captures the U.S. Census Bureau's estimate of all persons identifying as female when given the choice of male or female on the survey form.

- **Racial Minority**

  The racial minority indicator addresses the populations included in Title VI of the Civil Rights Act, FHWA's Title VI of The Civil Rights Act of 1964 and Additional Nondiscrimination Requirements, and FTA's Title VI requirements and guidelines, all of which prohibit discrimination of persons in the United States based on race. This indicator uses race data from the ACS and includes all persons in the region who identified themselves as one or more of the following races in their census form: Black or African American, American Indian, Alaskan Native, Asian Indian, Japanese, Native Hawaiian, Chinese, Korean, Guamanian or Chamorro, Filipino, Vietnamese, Samoan, Other Asian, and/or Other Pacific Islander.

- **Ethnic Minority**

  The ethnic minority indicator addresses the populations included in Title VI of the Civil Rights Act, FHWA's Title VI of The Civil Rights Act and Additional Nondiscrimination Requirements, and FTA's Title VI requirements and guidelines, and the recommendation to consider minority under the Executive Order on Environmental Justice. This indicator uses ethnicity data from the ACS and includes all persons in the region who identified themselves as being of Hispanic, Latino, Spanish, Mexican, Chicano, Cuban, Puerto Rican, or Other Hispanic origin.

- **Foreign-Born**

  The foreign-born indicator addresses the populations included in Title VI of the Civil Rights Act, FHWA's Title VI of The Civil Rights Act of 1964 and Additional Nondiscrimination Requirements, and FTA's Title VI requirements and guidelines, all of which prohibit discrimination of persons in the United States based on national origin. This indicator uses national origin data from the ACS and includes all persons in the region who indicated they were born outside of the United States in their ACS form.

- **Limited English Proficiency**

  The limited English proficiency indicator addresses the populations included in Title VI of the Civil Rights Act, Executive Order 13166, "Improving Access to Services for Persons with Limited English Proficiency," FHWA's Title VI of the Civil Rights Act of 1964 and Additional Nondiscrimination Requirements, and FTA's Title VI requirements and guidelines, all of which prohibit discrimination of persons in the United States based on race and national origin. This indicator uses language data from the ACS and includes all persons in the region who indicated they speak English less than "very well."

- **Disabled**

  The disabled indicator addresses the populations included in FHWA's Title VI and Additional Nondiscrimination Requirements under Section 504 of the Rehabilitation Act of 1973 and Americans with Disabilities Act of 1990, which protect persons with a disability against discrimination. This indicator uses disability data from the ACS and includes all persons in the region who indicated they experience one or more physical and/or mental disabilities.

- **Low-Income**

  The low-income indicator addresses the populations included in the Executive Order on Environmental Justice, FHWA EJ recommendations, and FTA's EJ policy guidance, all of which encourage agencies to consider their impact on low-income persons. This indicator uses income data from the ACS and includes all persons in the region who have a household income below 200 percent of the national poverty level.

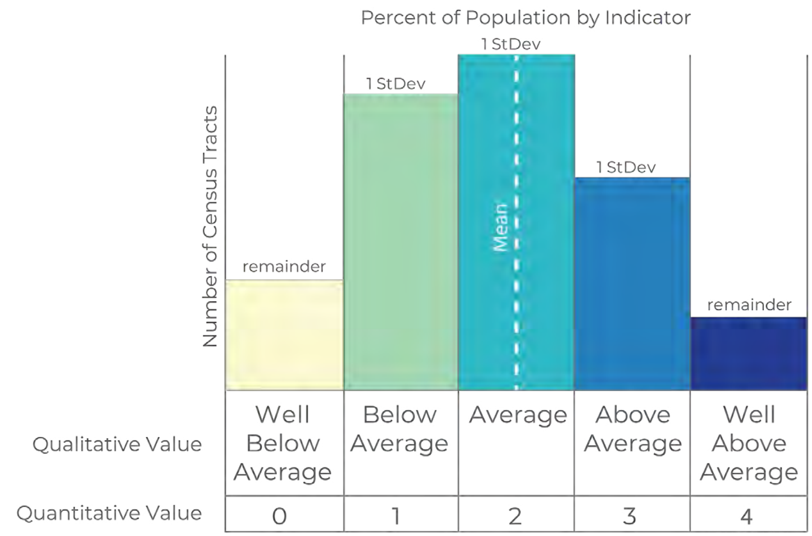
Scoring Methodology

The IPD analysis methodology generates an "IPD score", which is used to meet the Additional Nondiscrimination Requirements and recommendations of Title VI and EJ for DVRPC's plans, programs, and decision-making processes. The score calculation is determined by standard deviations relative to an indicator's regional average. This score classifies the concentration of the populations of interest under Title VI and EJ present in every census tract in the region. These population groups are represented in the nine indicators in the IPD analysis.

The data for each of the indicators in the IPD analysis are split into five bins: well below average (score of 0); below average (score of 1); average (score of 2); above average (score of 3); and well above average (score of 4). See Figure 3.1 on the right. A summary score of all nine indicators for each census tract (ranging from 0 to 36) is used to show regional concentrations of populations of interest under Title VI and EJ.

The "average" bin for each indicator contains census tracts at or near (within a half standard deviation from) the regional average (mean) for that indicator. The other bins are then built out on either side of the average bin; the "below average" and "above average" bins go another full standard deviation on either side of the "average" bin, and the "well below average" and "well above average" bins contain any remaining tracts further out from the "below average" and the "above average" bin, respectively. In cases where the regional average is so low and the distribution of the data around the mean is so dispersed that the "below average" bin would contain census tracts with a zero percent estimate for an indicator's designated population, the tracts with estimates of zero are manually assigned to the "well below average" bin, instead of to the "below average" bin.

FIGURE 3.1 | EXAMPLE OF STANDARD DEVIATIONS AND CORRESPONDING SCORES



The design of this methodology is supported by both FHWA's and FTA's Title VI recommendations to simply identify the protected classes using demographic data from the U.S. Census Bureau as the first step in conducting equity analyses. Additionally, FTA's EJ guidance cautions recipients of federal funds to not be too reliant on population thresholds to determine the impact of a program, plan, or policy to a population group, but rather design a meaningful measure to identify the presence of all protected and considered population groups and then calculate the possibility of discrimination or disproportionately high and adverse effect on these populations.

Additional Measures

In addition to the rates associated with the nine IPDs, the correlation analysis compared crash rates to two additional measures: the summary IPD score (method explained above) and the percentage of carless households in each tract. Household vehicle ownership is collected in the ACS. While not a population protected under any Title VI or EJ guidance, for this study, the same methodology that was applied to calculate the bins for each IPD to the region's census tracts was used for the percentage of households with zero vehicles. Carless household data is often used in transportation planning to identify populations that are most likely to travel by modes other than a personal vehicle. This dataset was used to determine if there is a relationship between where these households are most prevalent in the region and where serious crashes are more common.

DATA PREPARATION

Data on crashes in the Greater Philadelphia region is available from PennDOT and NJDOT. The crash data used for this analysis was limited in several key ways. A five-year dataset was created with 2012-2016 crash data, the most recent years for which crash data was available at the time of analysis. In addition, the crash data was limited to crashes that led to a fatality ("killed") or serious injury (KSI) to align with best practice guidance from state and federal agencies, which stress KSI crashes as those that result in the most severe outcomes. This also helps to align crash data from NJDOT and PennDOT. Limiting the data to KSI crashes removes the less severe crashes where the discrepancy in crash severity definitions makes analysis across the two states problematic.

The crash data was further limited in two additional ways. First, the data was limited to non-interstate crashes. Interstate crashes were removed because of the tendency of interstates to skew the crash data in the census tracts they travel through. Since the volume is so high on interstates, they tend to have a much larger number of crashes compared to local streets. In addition, this study is focused on the varying crash experience in communities of concern; although highways have many negative externalities on neighborhoods, the crash experience on a limited-access highway is disconnected from the community that the highway passes through as compared to the crash experience on the local streets.

Second, a separate crash dataset limited to vulnerable user KSI crashes was also created. A vulnerable user KSI crash is any KSI crash that involves a pedestrian or bicyclist. Prior studies of the relationship between crashes and communities of concern have found a correlation between vulnerable user crashes and communities of concern (see "Literature Review" chapter). In addition, low-income individuals (a key demographic in communities of concern) are more likely to belong to carless households in the Greater Philadelphia region due to the cost of owning a vehicle in addition to other factors. Therefore, low-income individuals are more likely to be involved in a crash as a pedestrian or bicyclist. While highly correlated with each other, not all low-income households are carless, nor are all carless households low-income.

The total KSI and vulnerable user crash datasets—all of which are non-interstate crashes—were joined to the 1,379 census tracts in the region using GIS.[1] A 100-foot buffer was used around each crash to identify affected census tracts. As a result, if a crash occurred within 100 feet of the border between two (or more) census tracts, the crash was assigned to both (or all) census tracts. Often a street forms the border between two census tracts. If a crash occurred along that street, the buffer ensured that it counted toward the crash totals for both census tracts.

In addition to crash data, key road features were also joined to the census tracts; in particular, road miles and traffic volume (annual average daily traffic, or AADT). These features were drawn from DVRPC's Travel Improvement Model 2 (TIM 2) traffic model (see "Determining Traffic Volume by Census Tract" below). As a result, the traffic volume is an estimate generated by the model and not an actual count. Total road miles and total traffic volume (AADT multiplied by the length of each road segment) by census tract were used as the denominator in determining non-interstate and vulnerable user crash rates. Population was also tested as a potential denominator.

Developing crash rates by traffic volume is a standard approach common to many similar analyses, including FHWA Safety Performance Measures. Traffic volume accounts for exposure, or the risk of getting into a crash on a given road segment. This makes it a more effective normalization factor for vehicle-vehicle crashes (which made up 74 percent of non-interstate KSI crashes in the five-year dataset) than the road miles factor, which treats

1 *Census tracts with fewer than 100 people were removed from the final analysis because these tracts lacked a statistically significant population of the IPD factors being tested. As a result, only 1,368 census tracts were included in the final analysis.*

DETERMINING TRAFFIC VOLUME BY CENSUS TRACT

Data from the TIM 2 traffic simulation model developed by DVRPC was used to determine an estimate of traffic volume by census tract. The traffic model produces estimates of 24-hour, weekday traffic volume for every road segment in the region. This value can be converted to vehicle miles traveled using the road segment length and an AADT conversion factor based on the road functional class of each segment. The formula is:

Vehicle Miles Traveled = Weekday 24-hour Volume * Road Segment Length * AADT Conversion Factor

This formula assigned a traffic volume value for each road segment that accounted for variations in traffic by day of week and time of year. These values are based on actual traffic counts performed on road segments throughout the region and then interpolated along with other inputs (like residential and worker populations) to determine an estimated traffic volume by road segment. At the road segment level, these estimates are too rough to be used as a proxy for exposure. When aggregated across a larger geography such as a census tract, however, the estimates become more reliable as data inconsistencies at the segment level are smoothed out.

The vehicle miles traveled estimates were aggregated to the census tract level by joining the road segment polylines in ArcGIS to the corresponding census tract polygons. Similar to the crash data, only non-interstate road segments were joined, and a 100-foot buffer was employed to ensure that the traffic volume assigned to a road segment bordering a census tract was assigned to that census tract even if the polyline associated with the road segment fell just outside the polygon associated with the corresponding census tract.

every road segment as though there is an equivalent chance of experiencing a crash with another vehicle. While robust traffic volume data enables DVRPC to model vehicle traffic volume estimates for the region, the same data is not available for vulnerable user volume—that is, comprehensive counts of walking and biking trips. As a result, road miles was used to normalize this crash data (see "Limitations" section on the next page).

CORRELATION ANALYSIS

A correlation matrix was developed to identify which IPDs have the strongest relationship with crash experience. A correlation matrix is a grid of correlation coefficients, or R-values, between −1 and 1. R-values are used to test the strength and directionality of the linear relationship between two variables. The closer the R-value is to 1 or −1, the stronger the relationship; an R-value of 0 indicates no relationship. A positive R-value indicates that an increase in one variable corresponds to an increase in the other, while a negative R-value indicates an inverse relationship between the variables. Ultimately, four crash factors were compared to the nine IPDs (as well as the percentage of carless households and the summary IPD score for each census tract) in the correlation matrix. The crash factors were:

1. total number of KSI crashes;
2. KSI crashes normalized by population;
3. KSI crashes normalized by traffic volume; and
4. vulnerable user KSI crashes normalized by total road miles.

These were compared to the nine IPDs, plus carless households and the summary IPD score for each census tract. For the purposes of this study, a threshold R-value of 0.3 was used to determine which IPDs have a relationship with crash rates. Statistical analysis commonly considers any correlation coefficient below 0.3 to indicate that there is very little correlation between the variables; a correlation coefficient above 0.3 is considered to indicate a low correlation, whereas one above 0.5 is considered to be moderate and above 0.7 is considered to be high (Hinkle, Wiersma, and Jurs, 2003). Table 3.1 shows the IPDs that met the threshold of an R-value of 0.3; the full correlation matrix is available in Appendix A. R-values above the 0.3 threshold are bolded.

Table 3.1 | Correlated IPDs

IPD	Non-interstate KSI by Traffic Volume	Vulnerable User KSI by Road Mile
Racial Minority	**0.35**	**0.38**
Ethnic Minority	**0.35**	0.29
Disabled	**0.33**	0.28
Low-income	**0.44**	**0.49**
IPD Score	**0.38**	**0.38**
Carless Households	**0.35**	**0.59**

Correlation Matrix Results

Only the KSI rates normalized by traffic volume and road miles correlated with any IPDs; therefore, the absolute number of crashes by census tract and crash rates normalized by population were not pursued for further investigation. Of the IPDs, only racial minority, ethnic minority, disabled, and low-income correlated with crash rates. In addition, the summary IPD score met the R-value threshold, as did the rate of carless households.

Among IPDs, the one that correlates most with crash rates is low-income. This means that census tracts with higher rates of low-income residents tend to also experience higher KSI crash rates. In particular, census tracts with higher rates of low-income residents experience higher rates of vulnerable user crashes normalized by road mile; this combination correlated most strongly among the IPD metrics.

Racial minority, like low-income, met the 0.3 R-value threshold to show some correlation with both total KSI and vulnerable user crash rates. Ethnic minority and disabled rates correlated with the total KSI crash rate, but did not quite meet the threshold for a correlation with the vulnerable user crash rate.

Carless households had the strongest correlation to vulnerable user crash rate of any metric tested and was as strongly correlated to the total KSI crash rate as were the racial minority and ethnic minority IPDs. This is a very important finding. It highlights that in areas where a higher percentage of households lack access to a vehicle, residents are at a greater risk of experiencing a crash involving a vulnerable user. This makes some sense, since these census tracts are also those likeliest to have the most people walking and biking. It also may help to explain some of the other correlations found among the IPDs because there is a very high correlation between carless households and the four IPDs in Table 3.1, especially low-income and racial minority (see Appendix A).

LIMITATIONS

The methodology described in this chapter was determined by the project team to be the best way to measure the relationship between crash experience and communities of concern. Nevertheless, several key limitations were embedded in the methodology due to lack of data, data inconsistencies, and pitfalls in the geospatial analysis.

Volumes

Ideally, vulnerable user crashes would be normalized by a measure of volume to account for exposure, which was the case for the total number of KSI crashes. Unfortunately, quality volume data at the regional level for vulnerable users is not available. The TIM 2 traffic model from which the vehicle volume data is derived does not currently estimate bicycle or pedestrian volumes. Journey-to-work data from the U.S. Census Bureau is sometimes used as a proxy for vulnerable user volume. Its limitations are twofold: a small universe of trips and low sample size. It has a small universe because it accounts for only one subset of the population—workers—and only one type of trip the population makes—commuting. The data significantly overlooks children, older adults, and other non-workers. Because of their smaller mode share, the small sample size of walk and bicycle commute trips drives up the margins of error for estimates of pedestrian and especially bicyclists.

In order to calculate how many census tracts had margins of error greater than their estimates for pedestrian and bicyclist commuters combined, the “successive differences replicate” method, which is recommended by the U.S. Census Bureau, was used. This method uses 80 pseudo-estimates, as well as the U.S. Census Bureau’s official estimate, to calculate the variance, or the spread, of the mode share data. Using this method, a total of 668 tracts were determined to have estimates of pedestrian and bicyclist commuters with a corresponding margin of error that was larger than the estimate. Because nearly half of the region was determined to have an unreliable estimate underlying the calculation of its vulnerable user commute mode share and many trips would be unaccounted for, it was decided that commute mode share should not be used to normalize the number of KSI crashes in a given census tract; a simple measure of road miles was used instead.

The volume output data from the TIM 2 travel demand model was determined to be the best way to normalize the total number of KSI, but still contains several key drawbacks. The model, as previously mentioned, only estimates vehicle traffic volume, which leaves out vulnerable user traffic. In addition, the model output data is an estimate based on a variety of counts and other inputs. These counts may be several years old; indeed, the estimate itself is based on 2015 conditions. The model is calibrated to many key count locations throughout the region, but there are many facilities for which we do not have a count or for which counts are excluded for base model calibration. The estimate is only as good as these inputs and the process used to convert them into an estimate. As previously mentioned, these estimates improve in accuracy as the geography at which they are aggregated becomes larger. A census tract is a large enough geography for most tracts in the region for purposes of this project, but there may be some tracts where the modeled volume is a poor reflection of the actual volume.

Crash Data

Another key limitation derived from inconsistencies between crash data in New Jersey and Pennsylvania. Within the 2012–2016 crash dataset, for instance, New Jersey crash points frequently lack geolocation information. As a result, additional data processing was required to attempt to locate as many crash points in New Jersey as possible. Crash points lacking a geolocation were first mapped based on milepost information, which is accurate to a tenth of a mile. The remaining crashes were mapped based on cross-street information. This method produces the least accurate location for the crash, but because crashes were to be aggregated to the census tract level, exact coordinates were not necessary. Prior to using this cross-street method, only 77 percent of KSI crashes in New Jersey were geolocated. Afterward, approximately 92 percent of KSI crashes in New Jersey were geolocated, as compared to over 99 percent of KSI crashes in Pennsylvania. Crashes missing geolocations could not be incorporated into the analysis, which meant fewer crashes in New Jersey were included in the analysis.

Another challenge derives from differing definitions of crash severity between Pennsylvania and New Jersey. This challenge is most pronounced at the lower end of severity, as Pennsylvania has a higher threshold than New Jersey for what constitutes a "reportable" crash (state databases comprise reportable crashes only). This results in many more reportable crashes in New Jersey than in Pennsylvania. This discrepancy is addressed by limiting the crash dataset to KSI crashes because fatal and severe injury crashes are defined in virtually the same way across the two states.

Mapping

The geospatial analysis used a 100-foot buffer to account for the tendency for crash points that border two census tracts to be randomly assigned to one census tract or the other; instead they are assigned to both. The 100-foot buffer was selected because it is wide enough to allow crashes that may be geolocated anywhere within the right-of-way of a street to be assigned to the two neighboring census tracts, but narrow enough to avoid assigning crashes that occurred on parallel streets to a census tract one block over. Without assigning a buffer on a crash-by-crash basis, however, it was impossible to ensure that every crash was properly assigned regionwide. Assigning a buffer on a crash-by-crash basis would have been similarly impossible, given that there were over 5,600 crashes in the final total KSI dataset and over 1,400 crashes in the final vulnerable user dataset. There are some instances in which crashes may have been incorrectly assigned to fewer census tracts than they should have been; for example, Roosevelt Boulevard in Philadelphia County is wider than 100 feet, which means that some crashes may not have been assigned to multiple census tracts despite occurring along the border of the census tracts. We are confident, however, that the vast majority of crashes were properly assigned to the census tracts to which they belong.

4

FINDINGS

The intersection of Street Road and Knights Road in Bensalem, Pennsylvania, where a pedestrian was killed in a crash in 2015.

The correlation analysis comparing crash rates and IPDs identified six crash rate-IPD combinations for further investigation. The six combinations were:

1. Low-Income and Total KSI Rate;
2. Low-Income and Vulnerable User KSI Rate;
3. Racial Minority and Total KSI Rate;
4. Racial Minority and Vulnerable User KSI Rate
5. Ethnic Minority and Total KSI Rate; and
6. Disabled and Total KSI Rate.

These combinations were investigated further using three primary approaches: mapping, scatterplots, and case studies. The first two approaches are explored in more detail here. The case studies are examined in the following chapter: "Case Studies."

To map the relationship between IPDs and crash rates by census tract, the corresponding crash rate and IPD rate, as well as the IPD and crash rate scores based on the IPD scoring methodology were assigned to each census tract. Using this data, the maps developed for this chapter could be limited to the census tracts that met certain criteria—primarily, that they experienced a crash rate and IPD rate that were either above or well above the average for the region based on a minimum 0.5 standard deviations from the mean (see Chapter 3: "Methodology" for more details about the IPD methodology). While many of the maps are included in this chapter, the full set is available in Appendix B.

To create scatterplots showing the relationship between IPDs and crash rates by census tract, the same data that was used to map the census tracts was analyzed using statistical software. The R-values that populate the correlation matrix are a measure of the strength of the relationship between each IPD and the corresponding crash rate. Scatterplots offer another way to visualize this relationship. Scatterplots of each correlated IPD-crash rate combination demonstrate how each census tract experiences the two correlated rates. The full set of scatterplots for each correlated crash rate and IPD is available in Appendix C.

CRASH RATES AND IPDS

The correlation analysis was designed to answer the question posed by Figure 4.1 in a statistically significant manner: do higher crash rates coincide with places that have higher IPDs? The correlation analysis found that they do; there is a weak-to-moderate, positive relationship between the total IPD scores and both the total KSI and the vulnerable user KSI crash rates. This relationship, however, is the result of certain IPDs more than others.

Figures 4.1 and 4.2 map these two variables to begin to visualize how this relationship plays out across the region. Note that the two crash rates are combined into a single score in Figure 4.2, similar to how the total IPD score is calculated by census tract. Across the two maps, some patterns emerge that support the finding of a relationship between these rates, such as hot spots that crop up in Philadelphia, Camden, and Bucks counties. At the same time, there are clear departures, such as much lower crash rates than IPD rates in Mercer County and vice versa in parts of Delaware and Gloucester counties. The correlation analysis helped to isolate the IPDs that have the strongest relationship to crash trends; this served as the basis for further geospatial analysis.

Figure 4.1 | Indicators of Potential Disadvantage by Census Tract, DVRPC Region

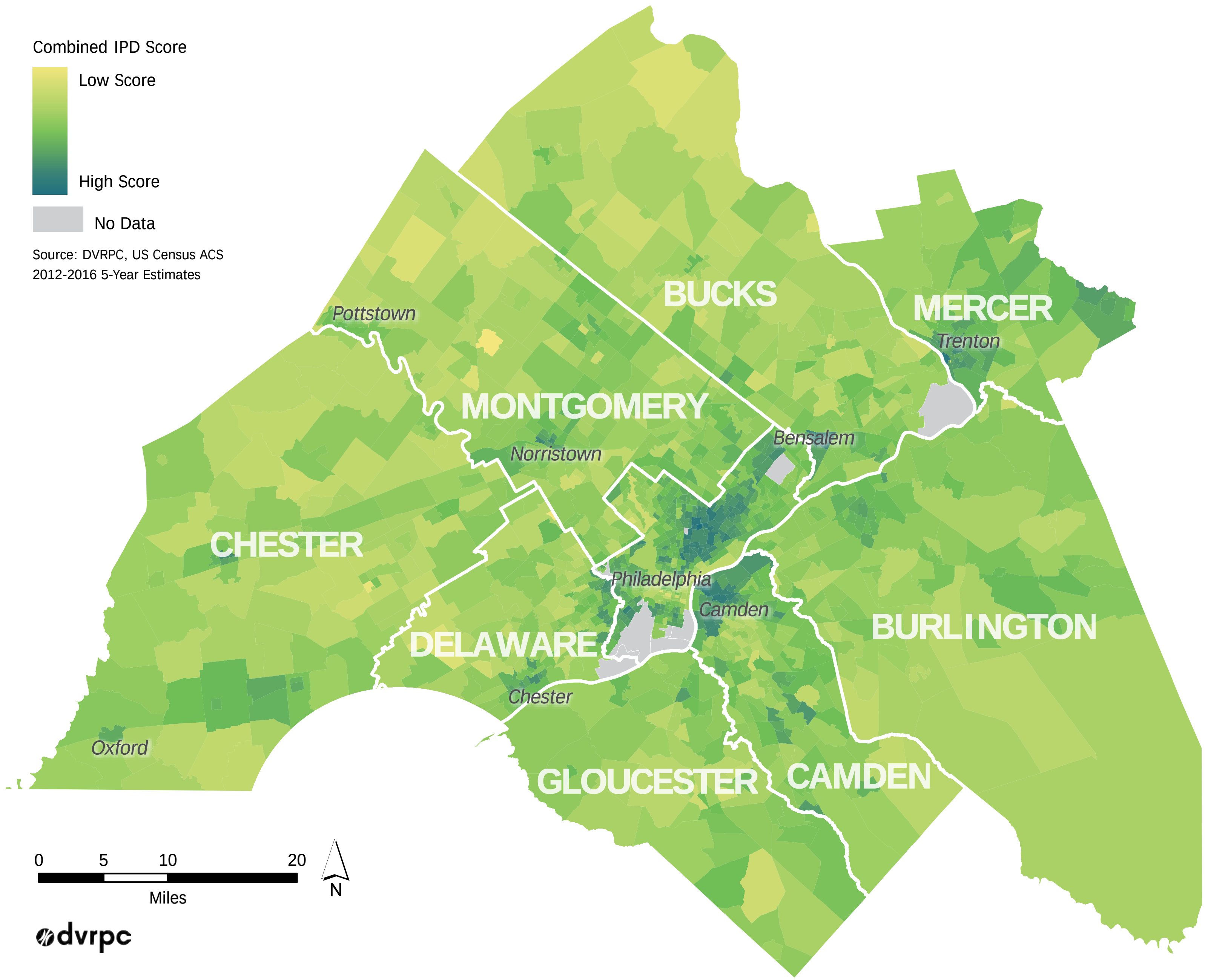
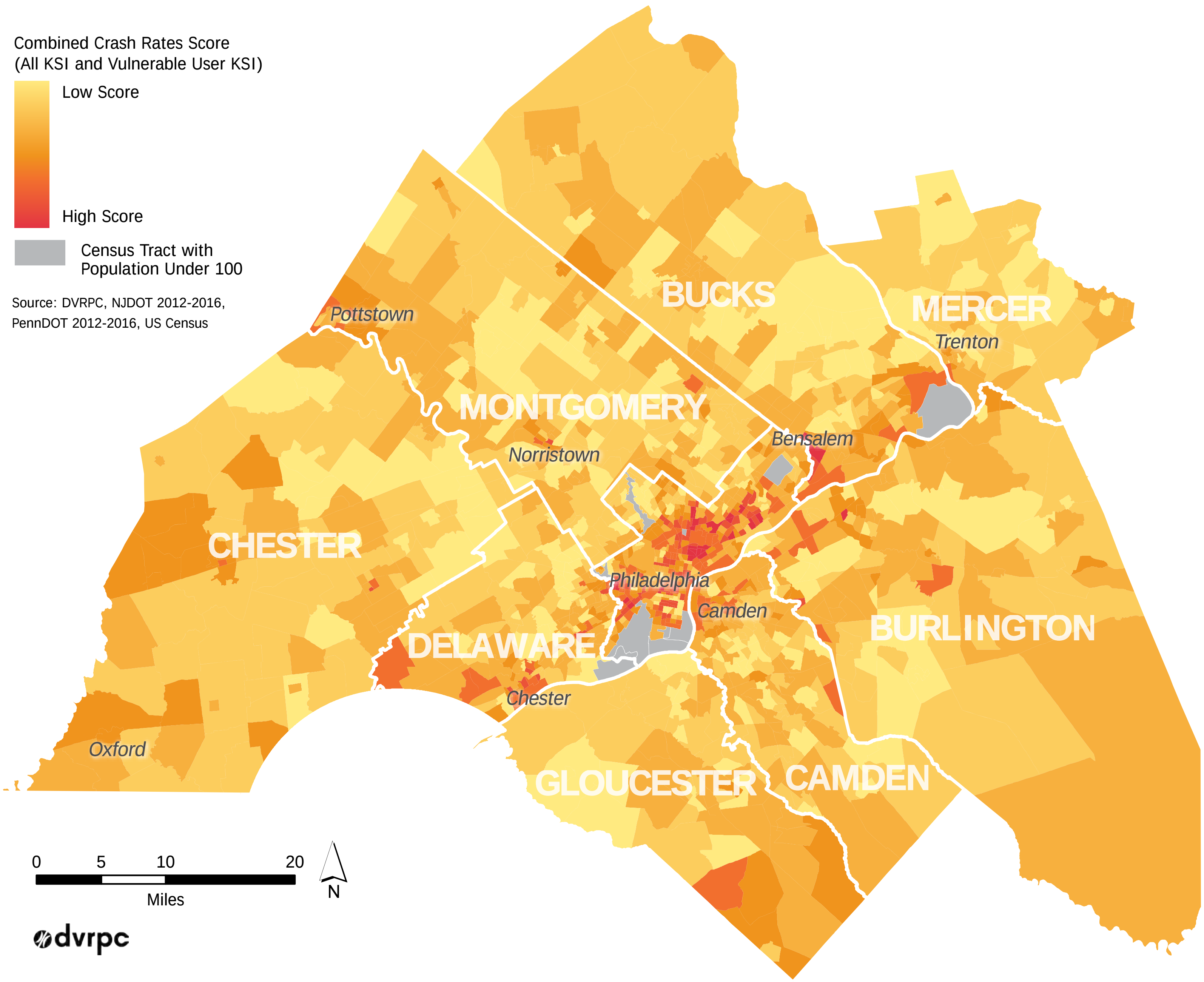


Figure 4.2 | Combined Crash Rates by Census Tract, DVRPC Region



COMPARING CRASH RATES

The two selected crash rates—total KSI crash rate by vehicle miles traveled and vulnerable user KSI rate by road miles—demonstrate different patterns in their distribution across the region. Generally speaking, the vulnerable user KSI rate tends to concentrate in more densely populated areas of the region than the total KSI rate. This is not surprising since, all else being equal, densely populated areas tend to have more people walking and biking than less densely populated areas.

Figure 4.3 maps only the census tracts that scored above or well above average for the total KSI rate, regardless of how the census tract scored on the vulnerable user KSI rate. There are 228 census tracts in the region that meet this criterion. Of these census tracts, 168—74 percent— also scored above or well above average for at least one of the four correlated IPDs (low-income, racial minority, ethnic minority, and disabled). In comparison, out of the 1,368 census tracts studied, 593—43 percent—scored above or well above average for at least one of these IPDs.

Census tracts that have above or well above average vulnerable user KSI rates are mapped in Figure 4.4 (note that the map shows the combined score for these tracts). These census tracts are much more concentrated in Philadelphia County than the census tracts with above or well above average total KSI rates. There are 173 census tracts in the region that meet this criterion, and 154 of them—89 percent—scored above or well above average for at least one correlated IPD.

Figure 4.5 shows the census tracts that score above or well above average for both crash rates. A total of 124 census tracts met this criterion; 113 of these census tracts—91 percent—also scored above or well above average for at least two of the four correlated IPDs. The case study census tracts were selected from these tracts.

Figure 4.3 | Census Tracts with Above Average Total KSI Crash Rates

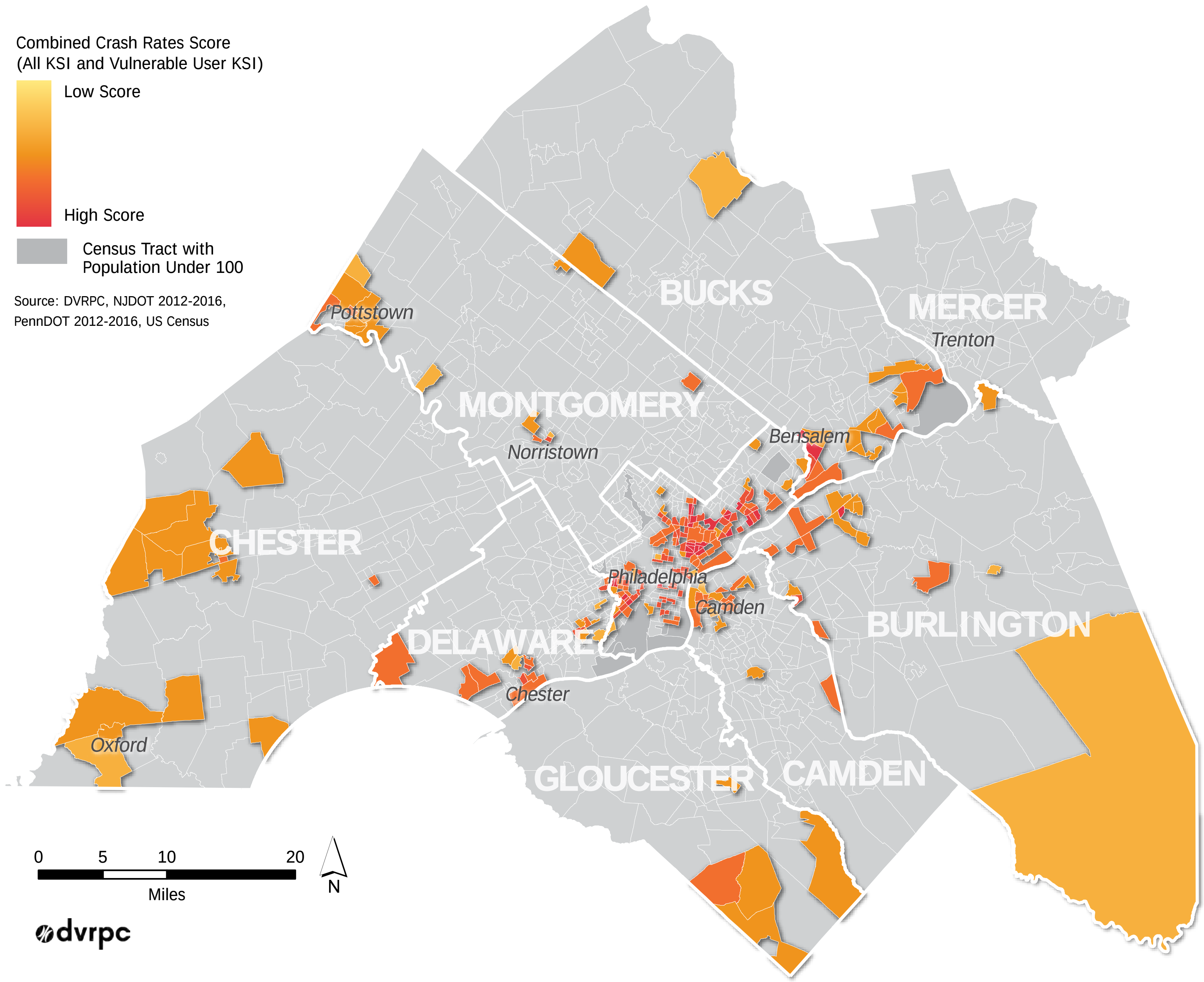


FIGURE 4.4 | CENSUS TRACTS WITH ABOVE AVERAGE VULNERABLE USER KSI CRASH RATES

Figure 4.5 | Census Tracts with Above Average Total KSI and Vulnerable User KSI Crash Rates

CRASH RATES BY IPDS

This section considers the relationship between all KSI and vulnerable user crash rates and each of the correlated IPDs: low-income, racial minority, ethnic minority, and disabled.

Low-Income

The low-income IPD had the strongest correlation with both the total KSI crash rate and the vulnerable user KSI crash rate of all the IPDs (although carless households—which is not an IPD—and the vulnerable user crash rate had the strongest correlation). This relationship is explored in detail in the scatterplots and maps below.

Scatterplot

Figure 4.6 shows census tracts plotted by low-income population rates on the x-axis and total KSI crash rates along the y-axis. The data shows a moderate but distinct upward trend: as the proportion of the census tract's population that is low-income increases, the total KSI crash rate does, too. There are more points grouped toward the lower end of the graph with both lower rates of low-income populations and lower total KSI crash rates. Census tracts with above average proportions of low-income population are less clustered on the graph, but generally see higher crash rates. This is true across all of the scatterplots to varying degrees, with the greatest clustering at the lower end of the scale.

Figure 4.6 also includes a trend line, which describes how the increase in the proportion of the population that is low-income corresponds to an increase in total KSI crash rates generally across the region. It shows how a census tract with an approximately average low-income population of about 30 percent experiences a crash rate of approximately 1.5 KSI crashes per 10,000 vehicle miles traveled, while a census tract with an above average low-income population of 60 percent experiences a KSI crash rate of 2.5 per 10,000 vehicle miles traveled.

FIGURE 4.6 | LOW-INCOME IPD AND TOTAL KSI CRASH RATE SCATTERPLOT

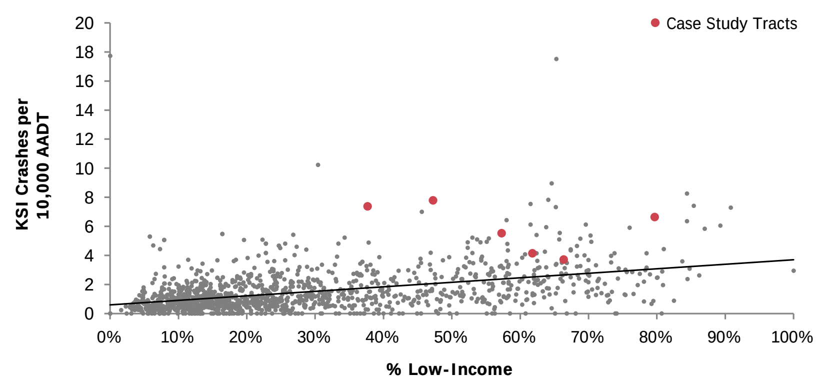
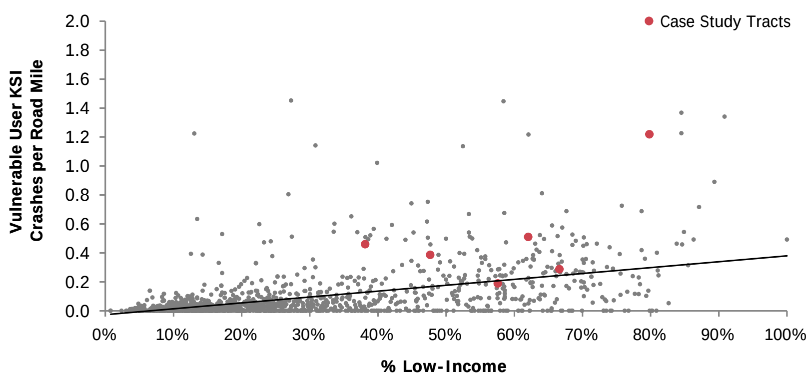


Figure 4.7 plots all census tracts in the region by the low-income population rate along the x-axis (the same as Figure 4.6) and the vulnerable user KSI rate along the y-axis. It follows a generally similar pattern to Figure 4.6, with the greatest clustering at the lower end of the graph and a moderate, but upward trend. For vulnerable user KSI, a census tract with an average low-income population percentage (30 percent) experienced a rate of 0.10 crashes per mile of road in the census tract across the five-year period, versus 0.22 crashes per mile for a census tract in which 60 percent of the population is low-income.

Vulnerable user KSI rates had a higher R-value in relation to the low-income IPD than the total KSI rate did (in fact, it had the highest R-value of any IPD-KSI rate comparison). This is reflected in the tight clustering of census tracts points around the trend line, which shows that most census tracts are consistent with the trend. At the same time, the few outliers in vulnerable user crash rates are farther from the trend line than they are with the total KSI rate. This is likely due to the extreme clustering of vulnerable user crashes in the most urban areas of the region, where the most walking and biking trips are made. In a few of the most urbanized census tracts, vulnerable user crash rates are much higher than the rest of the region. These outliers would likely be brought closer to the trend line if they were normalized by vulnerable user volume data, rather than simply by road miles.

Figure 4.7 | Low-Income IPD and Vulnerable User KSI Crash Rate Scatterplot



Mapping

Figure 4.8 maps the census tracts that scored above average or well above average for both the low-income IPD and the total KSI crash rate, and had a minimum of five KSI crashes. This represents 134 of the 1,379 census tracts in the region. They are heavily focused in the region's larger cities and towns, including Philadelphia (especially North and West Philadelphia), Camden, Chester, and Norristown. Only Trenton is conspicuously absent. Despite the apparent urban bias, there are a number of census tracts in more suburban and rural parts of the region that meet these criteria, as well, including parts of western Chester County and southeastern Bucks County. This was an important finding because it suggests that the correlation between high IPD scores and high crash rates is more than simply a reflection of two things that co-occur in areas of higher density; rather, since the phenomenon continues in less dense areas—even if to a lesser degree—it is likely not just an urban issue, but something that must be addressed at a regional scale.

Figure 4.9 maps census tracts that scored above average or well above average for low-income IPD and the vulnerable user KSI rates. Even more than in Figure 4.8, the census tracts that meet this criterion are overwhelmingly in the most urban census tracts in the region, including parts of Philadelphia, Norristown, Chester, Camden, and, in this case, Trenton. This stands to reason since the greatest vulnerable user exposure occurs in urban areas; in urban areas in the Greater Philadelphia region, approximately 22 percent of trips are made by walking or biking, compared to only 9 percent of trips in suburban areas and 4.5 percent of trips in rural areas (DVRPC, 2015).[2] The same areas of North and West Philadelphia appear in this map as in Figure 4.8, but they have grown to encompass an even greater area. More of Norristown is also accounted for, but notably less of Camden and Chester cities meet this criterion. This suggests that for large areas of these cities, the vulnerable user KSI trend is not so severe when compared to the vulnerable user KSI trend across the region; it is close to or even below average.

2 *The "urban," "suburban," and "rural" classifications are based on a population density analysis developed by DVRPC. This system ensured that sampling methods used for the 2012-2013 Household Travel Survey represented each classification in equal proportion to the number of households present in each category.*

Figure 4.8 | Low-Income and Total KSI Census Tracts

Figure 4.9 | Low-Income and Vulnerable User KSI Census Tracts

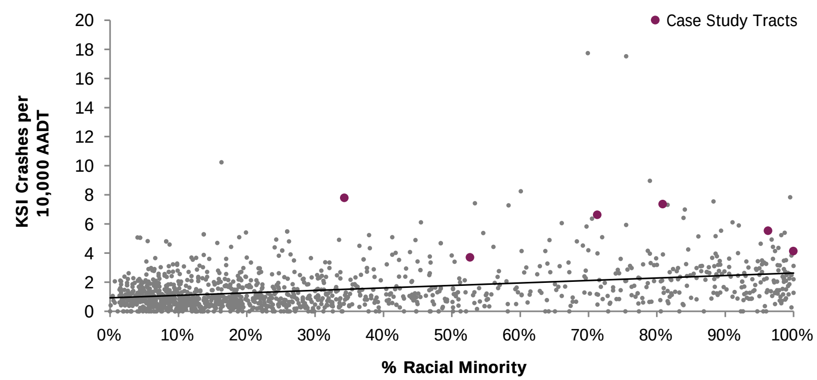
Racial Minority

Figure 4.10 plots the total KSI rate against the percentage of the census tract that is a racial minority. This relationship had a somewhat weaker correlation than the low-income and total KSI rates. It also has a more gradual slope, which means that an increase in the percentage of racial minority is not associated with as substantial an increase in the crash rate as the same increase in percentage of low-income would show, although there is nevertheless a notable increase.

Furthermore, the racial minority graph is the only dataset to "recluster" at the high end of the trend line. All other scatterplots have their greatest clustering at the low end of the trend line and a gradual dissipation of points farther along the trend line. In the case of racial minority (and this holds true for the vulnerable user scatterplot as well), the points come back together around the trend line as the percentage of racial minority approaches 100 percent.

This phenomenon is likely the result of the history of racial segregation in the region, which has resulted in many more census tracts with populations that are nearly 100 percent racial minority than can be found for any other IPD. It also highlights that these most segregated census tracts generally have a disproportionate crash experience, although not in every case.

Figure 4.10 | Racial Minority IPD and Total KSI Crash Rate Scatterplot



Ethnic Minority

Figure 4.11 considers the census tracts with an above or well above average total KSI rate and an above or well above average rate of the ethnic minority IPD. This combination has a pattern distinct from the low-income IPD and crash rate maps. The West Philadelphia census tracts that met the criteria in Figures 4.8 and 4.9, for instance, do not have above average rates of the ethnic minority IPD. In addition, census tracts in western Chester County and northern Camden County qualify under this criterion, but not under the low-income IPD criteria.

The ethnic minority IPD does not reach the 0.3 R-value threshold to demonstrate a correlation with the vulnerable user KSI rate (the R-value was 0.29). Therefore, no map or scatterplot was developed to show this relationship.

Disabled

Similarly to ethnic minority, the disabled IPD reached the R-value threshold to show a weak correlation with the total KSI crash rate, but not with the vulnerable user KSI rate. It had the weakest R-values of the four correlated IPDs, indicating that the correlation is the most tenuous of the four IPDs that show some correlation. Nevertheless, the fact that it did clear the threshold for the total KSI rate (and got very close at 0.28 for the vulnerable user KSI rate) was a significant finding. Many people with disabilities face greater challenges in negotiating dangerous road conditions when they are not in a vehicle than individuals who are not living with disabilities. Issues like poor sidewalk maintenance and missing curb ramps, for instance, become much more dangerous for individuals in wheelchairs. This finding highlights the need to ensure that road design decisions are always made with the safety of individuals with disabilities as a primary focus, especially in communities of concern.

Carless Households

Carless households are not considered an IPD in DVRPC's current Title VI and EJ analysis. Nevertheless, it is an indicator of great interest to safety planning, particularly as it relates to vulnerable user KSI crashes since there is a high likelihood that individuals that live in carless households will travel as either a pedestrian or a bicyclist for at least part of their trips (e.g., walking to transit). The correlation analysis found by far the strongest correlation between the carless household rate and the vulnerable user KSI rate with an R-value of 0.59. There was a weaker correlation to the total KSI rate of 0.35.

The carless households rate also has a strong correlation with the low-income rate, with an R-value of 0.81, as well as moderate-to-strong correlations with the racial minority and disabled IPDs (see Appendix A). The correlations between these three IPDs and high crash rates may be partially explained by the high rates of carless households in these communities. As a result, these communities are more likely to have high rates of vulnerable users, creating conditions that put more people at a greater risk of experiencing a KSI crash if road conditions are not designed to accommodate vulnerable users in the safest way possible.

Figure 4.11 | Ethnic Minority and All KSI Census Tracts

5

CASE STUDIES

The intersection of B Street and Lehigh Avenue in Fairhill, Philadelphia, where a pedestrian was seriously injured in a crash in 2012.

CASE STUDY SELECTION

Six census tracts were selected to be further analyzed as case studies. Each selected census tract had to:

- **be at least above average for both the total KSI and vulnerable user KSI rates;**
- **be at least above average for at least two out of the four correlated IPD measures; and**
- **have at least five KSI.**

The census tracts in red and orange in Figure 5.1 met all of these criteria. In order to narrow down the census tracts and pick the final case study locations, a more qualitative approach was used. Ultimately, the following criteria were met as well:

- **Each correlated IPD was at least above average in at least two case study tracts.**
- **Each case study tract was well above average for the total KSI rate.**

The final case study tracts were located in Bensalem, Pennsylvania; Chester, Pennsylvania; Cobbs Creek (Philadelphia, Pennsylvania); Fairhill (Philadelphia, Pennsylvania); Norristown, Pennsylvania; and Willingboro, New Jersey, indicated by the census tracts that are labeled in Figure 5.1 (two comparison case study tracts are also labeled; see section on "Comparison to High-IPD, Low-Crash Census Tracts"). This group of tracts was also chosen as it is a mix of urban and suburban and represents both New Jersey and Pennsylvania. In this way, patterns that were applicable to the entire region could become apparent, instead of those applicable to only Philadelphia, where most of the candidate case study tracts were concentrated.

The case study analysis examined built environment factors, such as land use and functional class of roads, to determine whether there were any discernible patterns in land use and functional class across the case study tracts that may contribute to the higher number of KSI crashes in those locations. Collision type was also examined in order to determine whether any one collision type was overrepresented in a given location, suggesting that certain safety improvements may be more effective in that location than in others. A table comparing the IPD percentages, crash rates, land use, functional class, and collision type of the case study tracts is available in Appendix D.

Land Use

Land use is the type of activity that occurs in a certain area. For the purposes of this analysis, six land use categories were used:

- **Commercial:** Commercial land use includes businesses, restaurants, and office space. Approximately 7 percent of the land in the region is used for commercial purposes.
- **Industrial:** Industrial land use includes warehouses, distribution centers, and factories. Approximately 4 percent of the land in the region is industrial.
- **Recreation:** Recreational land use includes playgrounds and sports fields. Approximately 7 percent of the land in the region is used for recreational purposes.
- **Residential:** Residential land use includes a variety of different housing types, from single-family detached homes to multi-family apartment buildings. The majority of the land in the region (approximately 67 percent) is used for residences.
- **Institutional:** Institutional land use includes schools, churches, and hospitals. Institutional land makes up approximately 5 percent of the land in the region.

Figure 5.1 | High-Crash, High-IPD Locations

- **Undeveloped:** Undeveloped land use includes vacant lots, wooded areas, and parks. Approximately 9 percent of the land in the region is undeveloped.

In order to determine whether crashes occurred near certain land uses more frequently than near others, a spatial analysis in GIS was used to assign crashes to their nearest land use. However, occasionally, a crash could be assigned to more than one adjacent land use, in which case the percentages by land use would not add up to 100 percent.

Functional Class

Functional class is a descriptor given to a road that identifies the level of access it provides. Functional class designation determines road width, number of lanes, travel speeds, and traffic volume. For the purposes of this analysis, four functional classifications were used:

- **Principal Arterial:** Principal arterials are the highest classification used in this analysis. Limited-access highways, interstates, and expressways (which have been excluded from this analysis) are always considered to be principal arterials, although principal arterials can include other high-volume roadways, particularly those in urban areas. Principal arterials' main function is to enable mobility, not access. They serve to move people quickly from place to place, but a motorist will need to leave the arterial in order to enter residential neighborhoods. Examples of principal arterials in the case study tracts are US 130 in Willingboro, Market Street in Cobbs Creek, and Street Road in Bensalem (see Figure 5.2).

Figure 5.2 | Street Road in Bensalem, Pennsylvania

• **Minor Arterial:** Minor arterials are similar to principal arterials but have lower volume and lower speed limits, and intersections are placed closer together to improve access. Because of their similarities, minor and principal arterials are often referred to collectively as "arterials" in this report. Examples of minor arterials in the case study tracts are Knights Road in Bensalem, Route 13 in Chester, and Tabor Avenue in Lawncrest (see Figure 5.3).

Figure 5.3 | Tabor Avenue in Lawncrest, Philadelphia

• **Collector:** Collector roads connect arterial roads with local roads, providing access from lower-activity areas, such as residential neighborhoods, to higher-activity areas, such as commercial corridors. Collector roads may be distinguished from minor arterials by having fewer lanes in each direction or by having fewer signalized intersections. Examples of collector roads in the case study tracts are Mechanicsville Road in Bensalem, West 7th Street in Chester, and North Front Street in Fairhill (see Figure 5.4).

Figure 5.4 | North Front Street in Fairhill, Philadelphia

• **Local:** Local roads are primarily used for shorter trips, providing circulation within residential neighborhoods. Local roads make up the vast majority of the regional road network.

Collision Type

There are multiple types of crashes. By looking at where crashes tend to occur and their collision type, in addition to characteristics of the road, roadway owners can begin to make targeted improvements to prevent that type of collision. The collision types used in this analysis include:

- **Rear-End:** "Rear-end" crashes occur when a vehicle crashes into the vehicle in front of it. Rear-end crashes are often due to distracted driving, when the driver does not notice that the vehicle in front of it has slowed or stopped.
- **Head-On:** "Head-on" crashes occur when the front ends of two vehicles hit each other while traveling in opposite directions. These crashes are often due to lane departure, in which one driver crosses the median or centerline into oncoming traffic.
- **Sideswipe:** "Sideswipe" crashes occur when the sides of two vehicles come into contact with each other. Sideswipe crashes are often further classified as "same-direction" sideswipe crashes, when the two vehicles are traveling next to each other in the same direction, or as "opposite-direction" sideswipe crashes, when the two vehicles are traveling in opposite directions.
- **Hit Fixed Object:** "Hit fixed object" crashes occur when a vehicle hits a stationary object such as a tree or utility pole. Like head-on crashes, these crashes are often due to lane departure, in which the vehicle leaves the roadway.
- **Angle:** "Angle" crashes include broadside or "T-bone" crashes, in which the side of one of the vehicles involved is impacted by the front end of another vehicle. These crashes are most common at intersections and at driveway curb cuts where vehicles are entering traffic.
- **Hit Pedestrian:** "Hit pedestrian" crashes occur when a vehicle and pedestrian come into contact with each other, regardless of which direction the pedestrian and vehicle are traveling in, or where the pedestrian is struck.

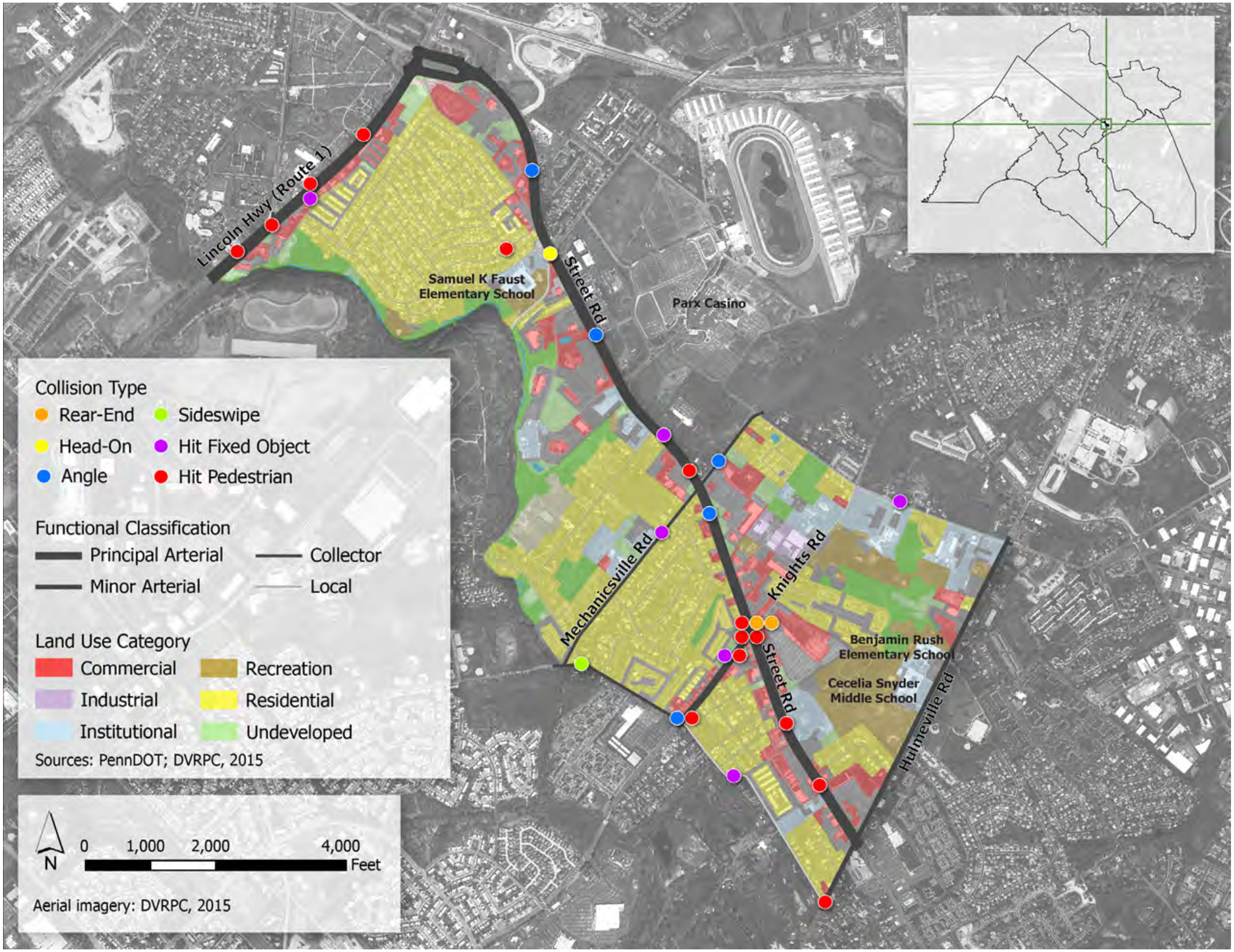
Case Study Organization

Accompanying each case study is a map of the tract, showing its location within the region, its land use, the functional classification of its roads, and the collision type and location of each KSI crash. Major roads are labeled, as are places such as schools and parks, as well as other "trip generators," such as shopping centers or hospitals, which attract more traffic than other places. KSI crashes near schools and parks are particularly of concern because children are more likely to be pedestrians or bicyclists and are also less likely to survive a pedestrian-vehicle crash than an adult.

BENSALEM

Census Tract 1002.08 in Bensalem is located at the southeastern corner of Bucks County, adjacent to Philadelphia County (see Figure 5.5). Approximately 5,725 people lived there in 2015. It is characterized by medium-density, single- and multi-family housing developments and auto-oriented commercial development along the major roadways. While the building itself is east of the census tract, the main entrance to the Parx Casino is located on Street Road, where it forms the eastern boundary of the case study tract. There are three schools in the area: Samuel K. Faust Elementary School, located off of Street Road; Benjamin Rush Elementary School; and Cecelia Snyder Middle School, both located off of Hulmesville Road. A number of SEPTA bus routes serve this census tract, including Routes 1, 50, 128, 129, 130, and 150.

Figure 5.5 | Bensalem, Pennsylvania



IPDs

The case study tract was above the regional average for the low-income and ethnic minority IPDs, and in the average range for the racial minority and disabled IPDs (see Table 5.1).

Table 5.1 | IPD Percentages and Crash Rates in Bensalem Case Study Tract and Region

	Bensalem	Regional Average
Low-Income (%)	47%	29%
Racial Minority (%)	34%	33%
Ethnic Minority (%)	24%	9%
Disabled (%)	11%	13%
Non-Interstate KSI Rate	7.77	1.48
Vulnerable User KSI Rate	0.38	0.09

Crash Rates

There were 29 KSI crashes, of which 16 involved a vulnerable user, in the case study tract between 2012 and 2016, resulting in a KSI rate and a vulnerable user KSI rate well above the regional averages.

Functional Class

As seen in Figure 5.5, most of the KSI crashes (79 percent) occurred along arterials, such as Lincoln Highway (Route 1) and Street Road, despite arterials making up only 31 percent of the road miles in the Bensalem case study tract.

Collision Type

The intersection of Street and Knights roads is particularly dangerous (see Figure 5.6). There, 60 percent of the KSI crashes were "hit pedestrian." "Hit pedestrian" crashes made up 45 percent of the case study tracts's KSI overall. The second most common collision type for KSI crashes in the tract overall was "hit fixed object," and the third was "angle."

Figure 5.6 | Intersection of Street Road and Knights Road in Bensalem, Pennsylvania

Pedestrians waiting to cross Knights Road.

Land Use

Although commercial land uses only make up 21 percent of land uses, as can be seen in Figure 5.5, 44 percent of KSI crashes occurred adjacent to areas zoned for commercial land use.

CHESTER

Census Tract 4051 in Chester is located in Delaware County, along the I-95 corridor (interstate crashes were removed from this analysis, so no crashes are mapped on I-95). US Route 13 (West 9th Street) also bisects this census tract (see Figure 5.7). Approximately 2,300 people lived there in 2015. This census tract is mostly residential, with medium-density, single- and multi-family housing. STEM Academy, a charter school for grades 7 through 12, has its campus on West 10th Street, and Crozer Park is located in the northeastern corner of the census tract. The 114 and 117 SEPTA bus routes run along West 9th Street, while the 119 bus runs along West 7th Street.

IPDs

The case study tract was above the regional average for the low-income, racial minority, and disabled IPDs, and in the average range for the ethnic minority IPD (see Table 5.2).

Crash Rates

There were five KSI crashes, of which three involved a vulnerable user, in the tract between 2012 and 2016, resulting in a KSI rate well above the regional average and a vulnerable user KSI rate above the regional average.

Functional Class

As seen in Figure 5.7, most of the KSI crashes occurred along arterials, such as West 9th Street (Route 13) and Kerlin Street, despite arterials making up only 18 percent of the road miles in the case study tract. Eighty percent of crashes occurred on an arterial.

Collision Type

Two out of the five KSI crashes were "hit pedestrian," both of which occurred along West 9th Street, and two out of the five KSI crashes were categorized as "rear-end" crashes, even though one of them involved two pedestrians. An "angle" KSI crash occurred at the intersection of Kerlin and West 9th Streets.

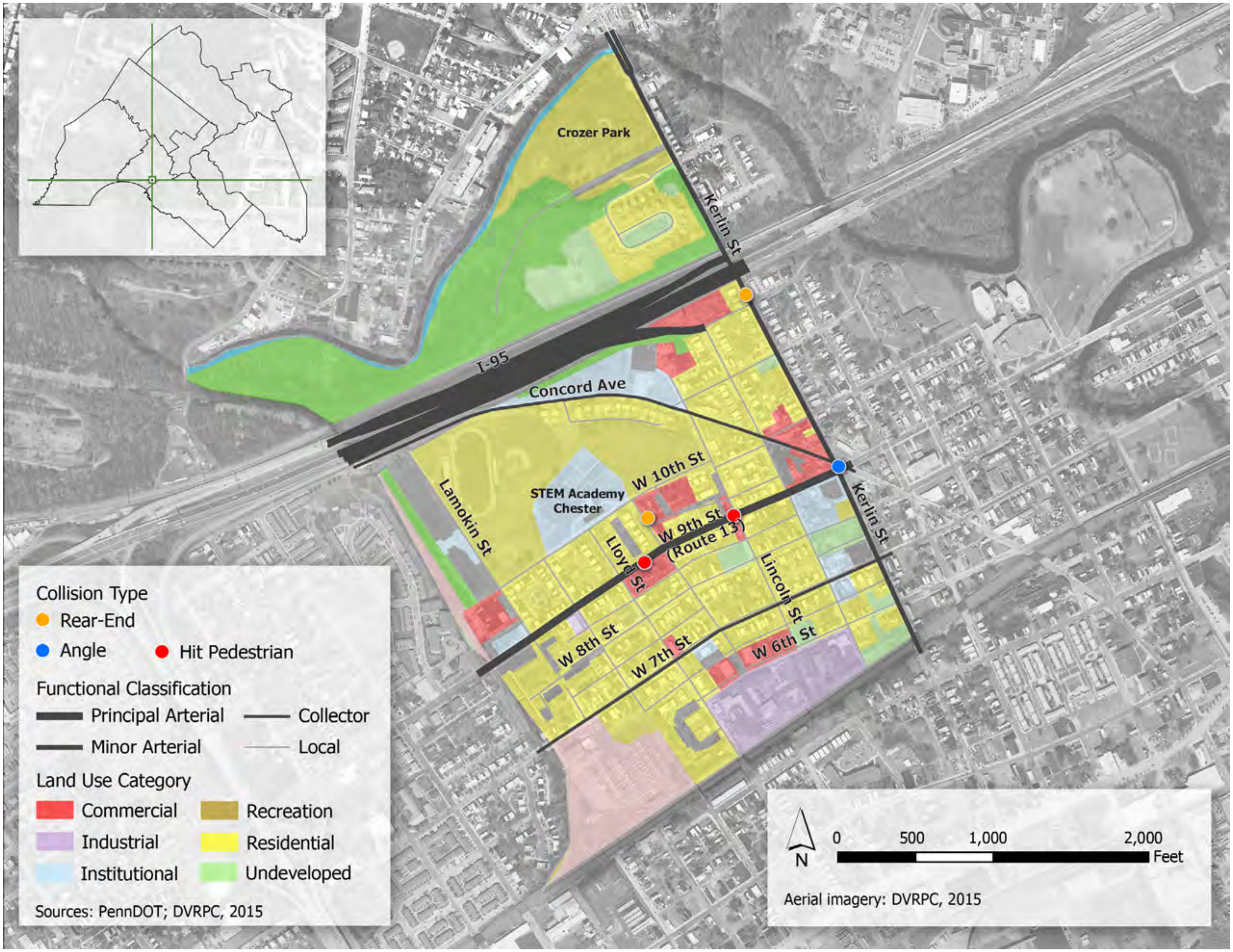
Land Use

Although commercial land uses only make up 7 percent of land uses, as can be seen in Figure 5.7, 100 percent of KSI crashes occurred adjacent to areas zoned for commercial land use.

Table 5.2 | IPD Percentages and Crash Rates in Chester Case Study Tract and Region

	Chester	Regional Average
Low-Income (%)	57%	29%
Racial Minority (%)	96%	33%
Ethnic Minority (%)	13%	9%
Disabled (%)	18%	13%
Non-Interstate KSI Rate	5.51	1.48
Vulnerable User KSI Rate	0.19	0.09

Figure 5.7 | Chester, Pennsylvania



COBBS CREEK

Census Tract 83.01 in the neighborhood of Cobbs Creek is located in West Philadelphia, bordered by Market Street to the north and Cedar Avenue to the south (see Figure 5.8). Approximately 4,500 people lived there in 2015. Medium-density, attached single-family housing (the most common typology is the Philadelphia rowhouse) dominates the neighborhood, but there are also multi-family housing developments throughout. Commercial development lines 60th and Market streets, and the William C. Bryant Promise Academy, a school for kindergarteners through eighth grade, is located at the intersection of 61st Street and Cedar Avenue. Sayre High School is located right outside the census tract, taking up the block between 58th and 59th streets and Locust and Walnut streets. In addition, two recreation centers are located in close proximity to the tract: the Morris Recreation Center on the 5800 block of Spruce Street and the Cobbs Creek Recreation Center near the intersection of Cobbs Creek Parkway and Spruce Street. In addition, there is a stop on the Market-Frankford line at 60th and Market, which provides access to Center City from the neighborhood. A number of SEPTA bus routes serve the census tract, including Routes 21, 42, and 46.

IPDs

The case study tract was above the regional average for the low-income, racial minority, and disabled IPDs, and in the average range for the ethnic minority IPD (see Table 5.3).

Crash Rates

There were eight KSI crashes, of which five involved a vulnerable user, in the tract between 2012 and 2016, resulting in a KSI rate and a vulnerable user KSI rate well above the regional averages.

Table 5.3 | IPD Percentages and Crash Rates in Cobbs Creek Case Study Tract and Region

	Cobbs Creek	Regional Average
Low-Income (%)	62%	29%
Racial Minority (%)	100%	33%
Ethnic Minority (%)	3%	9%
Disabled (%)	17%	13%
Non-Interstate KSI Rate	4.13	1.48
Vulnerable User KSI Rate	0.51	0.09

Functional Class

As seen in Figure 5.8, most of the KSI crashes occurred along arterials, such as Market, Chestnut, and Walnut streets, despite making up only 14 percent of the road miles in case study tract. Seventy-five percent of crashes occurred on an arterial.

Collision Type

Five of the KSI crashes were "hit pedestrian," while the other three KSI crashes were "angle" crashes. Three of the hit pedestrian crashes occurred along Market Street (see Figure 5.9).

Land Use

Although commercial land use only makes up 20 percent of land uses, as can be seen in Figure 5.8, 63 percent of KSI crashes occurred adjacent to areas zoned for commercial land use.

Figure 5.8 | Cobbs Creek, Philadelphia, Pennsylvania

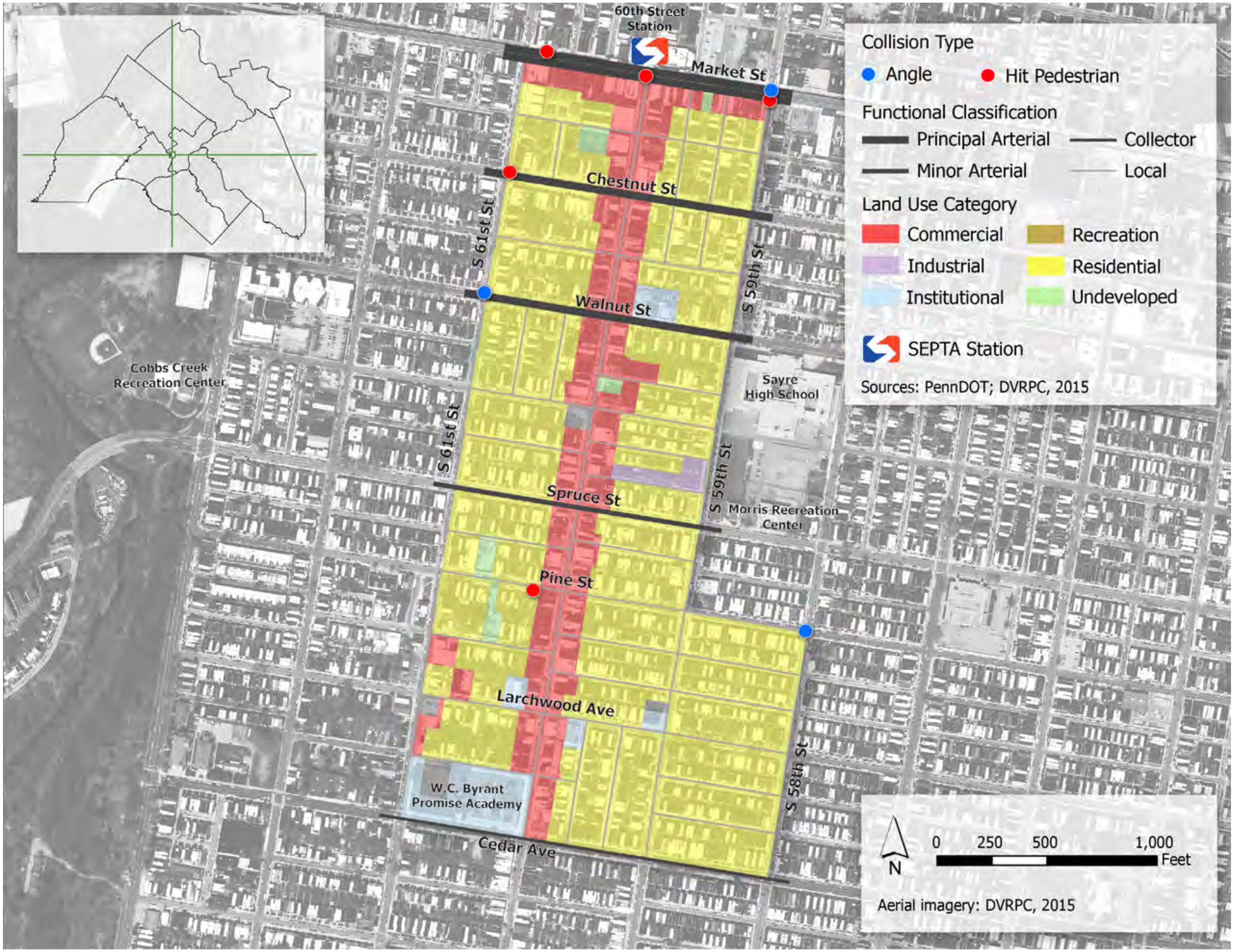


Figure 5.9 | Median Along Market Street in Cobbs Creek, Philadelphia, Pennsylvania

The median along Market Street, which was added during construction work on the Market-Frankford Line in 2012, acts as a pedestrian refuge island and allows pedestrians to cross one direction of traffic at one time. In addition, it acts as a traffic-calming device by preventing vehicles from executing sharp left turns or U-turns. One KSI crash did still occur at the intersection of Market Street and 60th Street, shown to the right in the photo. It is also worth noting that the median only acts as, but actually is not, a pedestrian refuge island and does not have curb cuts; therefore, it does not offer the same safety benefit to disabled pedestrians.

FAIRHILL

Census Tract 176.01 in the neighborhood of Fairhill is located in North Philadelphia, bordered by the Conrail rail lines to the north, North 5th Street to the west, and West Lehigh Avenue to the south (see Figure 5.10). Approximately 6,000 people lived there in 2015. The area is mostly residential, with attached, single-family dwellings in addition to larger, multi-family developments, but there is commercial development along West Lehigh Avenue and North 5th Street and some industrial uses adjacent to the Conrail tracks and on 2nd and Hancock streets. In addition, Temple University Hospital - Episcopal Campus is on the south side of West Lehigh Avenue near the southeastern corner of the census tract. There are numerous schools in the area, including Visitation BVM Catholic School, Julia De Burgos Elementary School, Fairhill Community High School, Pan American Academy Charter School, Potter-Thomas Elementary, and Issac A. Sheppard Elementary School. A stop on the Market-Frankford line is located nearby at the intersection of Kensington Avenue, B Street, and East Huntington Street. In addition, the 54, 47, and 57 SEPTA bus routes serve this tract.

IPDs

The case study tract was above the regional average for all four IPDs (see Table 5.4).

Crash Rates

There were 22 KSI crashes, of which 17 involved a vulnerable user, in the tract between 2012 and 2016, resulting in a KSI rate and a vulnerable user KSI rate well above the regional averages.

Figure 5.10 | Fairhill, Philadelphia, Pennsylvania

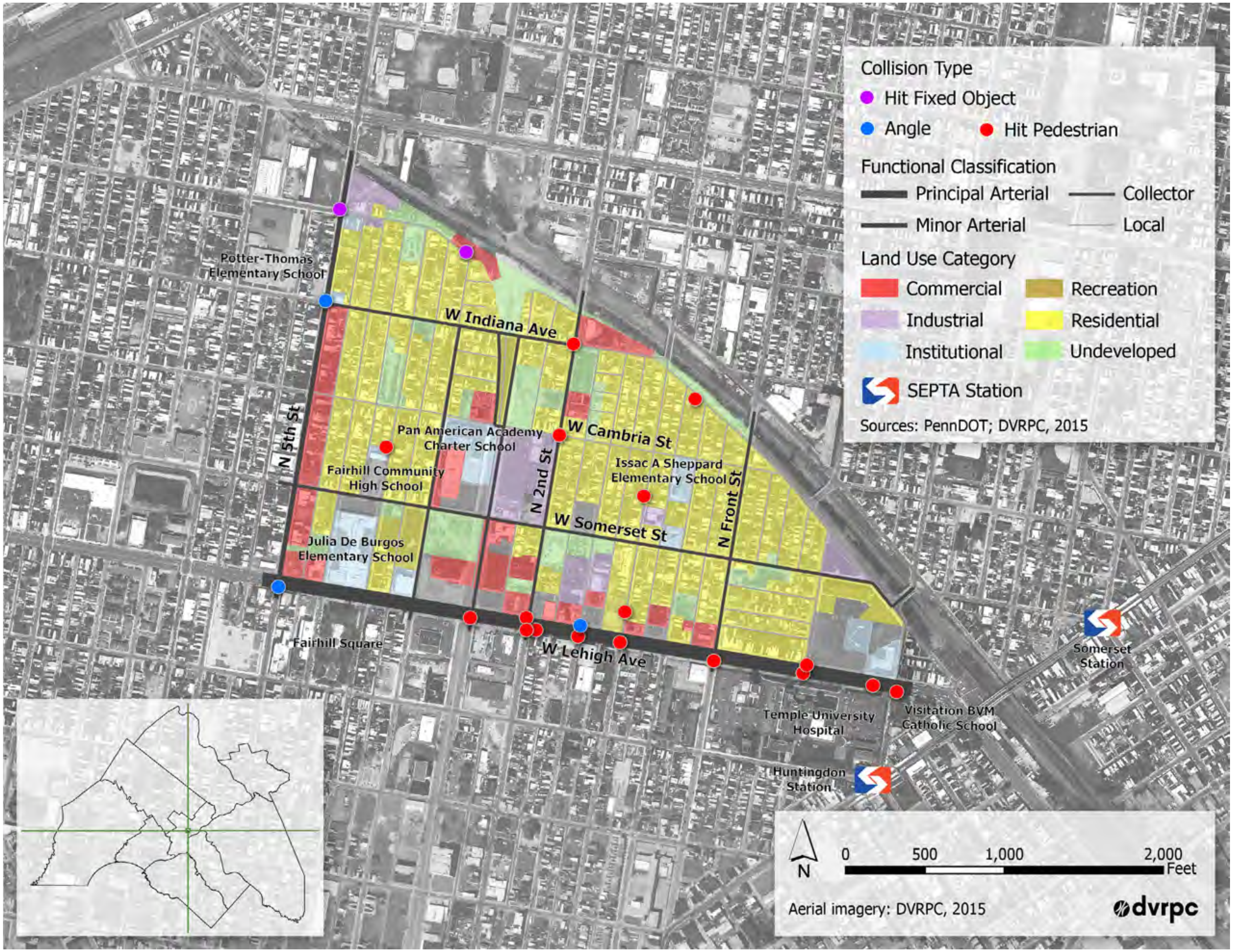


Table 5.4 | IPD Percentages and Crash Rates in Fairhill Case Study Tract and Region

	Fairhill	Regional Average
Low-Income (%)	80%	29%
Racial Minority (%)	71%	33%
Ethnic Minority (%)	92%	9%
Disabled (%)	21%	13%
Non-Interstate KSI Rate	6.61	1.48
Vulnerable User KSI Rate	1.22	0.09

Functional Class

As seen in Figure 5.10, most of the KSI crashes occurred along arterials such as West Lehigh Avenue, despite arterials making up only 16 percent of the road miles in the case study tract. Sixty-eight percent of crashes occurred on an arterial. Thirteen out of the 22 KSI crashes (more than half) occurred along West Lehigh Avenue alone.

Collision Type

The most common collision type was "hit pedestrian," which made up 77 percent of KSI crashes in the tract. Eleven pedestrian crashes occurred along West Lehigh Avenue alone (see Figure 5.11). Fourteen percent of KSI crashes were "angle" crashes, and 9 percent of KSI crashes were "hit fixed object."

Land Use

Although commercial land use only makes up 15 percent of land uses, as can be seen in Figure 5.10, 50 percent of KSI crashes occurred adjacent to areas zoned for commercial land use.

Figure 5.11 | Intersection of North 2nd Street and West Lehigh Avenue in Fairhill, Philadelphia, Pennsylvania

The crosswalk across West Lehigh Avenue at North 2nd Street is faded and vehicles were observed stopping in the faded crossing (for example, the SUV blocking the crosswalk in the image above), forcing pedestrians to walk around them and into the intersection.

NORRISTOWN

Census Tract 2039.1 is located in Norristown, which is in Montgomery County. The neighborhood is bordered by Stony Creek to the west, Airy Street to the south, Elm Street to the north, and Arch Street to the east (see Figure 5.12). Approximately 3,500 people lived there in 2015. The neighborhood is primarily residential, but commercial development is concentrated around DeKalb and Swede streets, and the Gotwals Elementary School is located at the intersection of Oak and Swede streets. Gotwals Elementary School is just one of several institutions dispersed throughout the neighborhood. There are also several nearby parks, including Scagg Cottman Park and Cherry Street Park, in addition to the Walnut Street Playground, which is within walking distance of the neighborhood. The Elm Street station, the terminus of the Manayunk/Norristown Regional Rail line, is adjacent to the neighborhood, bringing residents to Center City Philadelphia in 50 minutes. A number of SEPTA bus routes serve this tract, including the 90, 96, 97, 98, and 131 buses.

IPDs

The case study tract was above the regional average for low-income, racial minority, and ethnic minority IPDs, and in the average range for the disabled IPD (see Table 5.5).

Crash Rates

There were five KSI crashes, of which three involved a vulnerable user, in the tract between 2012 and 2016, resulting in a KSI rate well above the regional average and a vulnerable user KSI rate above the regional average.

Table 5.5 | IPD Percentages and Crash Rates in Norristown Case Study Tract and Region

	Norristown	Regional Average
Low-Income (%)	66%	29%
Racial Minority (%)	53%	33%
Ethnic Minority (%)	48%	9%
Disabled (%)	12%	13%
Non-Interstate KSI Rate	3.69	1.48
Vulnerable User KSI Rate	0.29	0.09

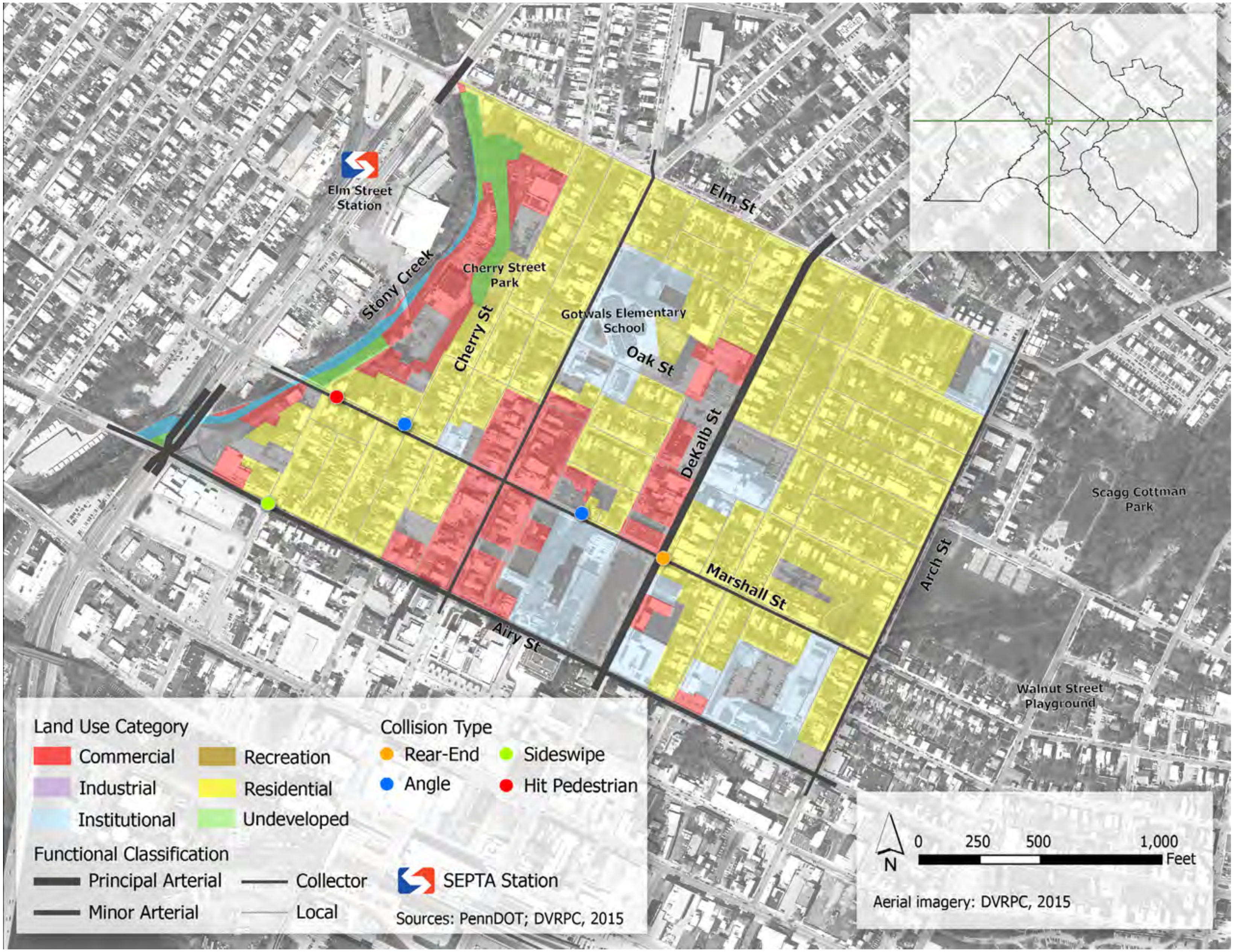
Functional Class

As seen in Figure 5.12, the Norristown case study tract is unlike the other case study tracts in that most of the KSI crashes occurred along Marshall Street, which is not an arterial. Only 40 percent of KSI crashes occurred along arterials, such as Airy and DeKalb streets, despite arterials making up a similar percentage of road miles (15 percent) as other case study tracts. Still, arterials accounted for a disproportionate share of KSI crashes relative to their share of road miles.

Collision Type

The Norristown case study tract is also unique because the most common collision type was "angle," not "hit pedestrian," despite three of the five KSI crashes involving a vulnerable user. There was one "hit pedestrian" crash; the other two vulnerable user KSI

Figure 5.12 | Norristown, Pennsylvania



crashes involved bicyclists. One of the KSI crashes that involved a bicyclist was an "angle" crash, while the other was a sideswipe crash. The two vehicle-vehicle KSI crashes included an "angle" crash and a rear-end crash.

Land Use

The Norristown case study tract is like the other case study tracts in that KSI crashes occurred disproportionately adjacent to areas zoned for commercial land use. Although commercial land use only makes up 18 percent of land uses, as can be seen in Figure 5.12, 40 percent of KSI crashes occurred adjacent to areas zoned for commercial land use.

WILLINGBORO

Census Tract 7028.09 is located in Willingboro, New Jersey, which is in Burlington County. The neighborhood is bordered by Beverly-Rancocas Road to the west, US 130 to the north, Pennypacker Drive and Mill Creek to the east (see Figure 5.13). Approximately 1,700 people lived there in 2015. As a suburban neighborhood, single-family attached housing is the main type of residential development, but there is also the Avery Townhome Apartments, a higher-density housing development located off the Burlington Pike. Alpha Baptist Church is located at the intersection of Rose and Pine streets and the Cathedral of Love Church (and Preschool) is located on Beverly-Rancocas Road, next to Sportsman Field. Commercial development lines the Burlington Pike on the north side of the neighborhood. The 409 bus stops at the intersections of US 130 and Beverly-Rancocas Road, US 130 and Pennypacker Drive (southbound), and Beverly-Rancocas Road and Rose Street.

IPDs

The case study tract was well above the regional average for racial minority IPD, above the regional average for the disabled IPD, and in the average range for the low-income and ethnic minority IPDs (see Table 5.6).

Table 5.6 | IPD Percentages and Crash Rates in Willingboro Case Study Tract and Region

	Willingboro	Regional Average
Low-Income (%)	38%	29%
Racial Minority (%)	81%	33%
Ethnic Minority (%)	12%	9%
Disabled (%)	17%	13%
Non-Interstate KSI Rate	7.35	1.48
Vulnerable User KSI Rate	0.46	0.09

Crash Rates

There were six KSI crashes, of which three involved a vulnerable user, in the tract between 2012 and 2016, resulting in a KSI rate and a vulnerable user KSI rate well above the regional averages.

Figure 5.13 | Willingboro, New Jersey

Functional Class

As seen in Figure 5.13, all of the KSI crashes occurred along US 130 and Beverly-Rancocas Road, which are principal arterials, despite making up only 36 percent of the road miles in the case study tract. The Willingboro case study tract has the highest percentage of principal arterials out of all of the case study tracts, and also has the highest percentage of KSI crashes occurring on a principal arterial (100 percent).

Collision Type

The most common collision type was "hit pedestrian," which made up half of the KSI crashes that occurred in the tract. These "hit pedestrian" crashes occurred along US 130 (see Figure 5.14).

Land Use

Willingboro is unique in that 83 percent of KSI crashes in the case study tract occurred adjacent to undeveloped land, which is a much higher percentage than in the other case study tracts. This may be due to the fact that undeveloped land makes up 40 percent of land uses in the Willingboro case study tract, compared to 1 to 21 percent in the other case study tracts. In addition, undeveloped land lies between commercial and residential land uses in this tract, so residents likely have to pass undeveloped land to get to commercial areas and vice versa. However, KSI crashes still occurred disproportionately adjacent to commercial land use. Commercial land use only makes up 5 percent of land uses, but 50 percent of KSI crashes occurred adjacent to areas zoned for commercial land use.

Figure 5.14 | Route 130 in Willingboro, New Jersey

There are no sidewalks along Route 130, forcing pedestrians to walk either in the grass or along the shoulder of the road. Furthermore, there are no crossings between the intersection with Beverly-Rancocas Road and the intersection with Pennypacker Drive, nor a safe place for pedestrians to wait if they cross mid-block, as a Jersey barrier separates northbound and southbound traffic. There is also not a marked crosswalk at the intersection with Pennypacker Drive, despite a bus stop being located there.

TRENDS

These case study census tracts demonstrate some of the built environment factors, such as land use and functional class, that appear to play a role in increasing the prevalence of severe crashes in communities of concern. Each of the case study tracts was bordered or bisected by principal arterials, which tend to be wider than other roads, resulting in faster traffic and longer distances for pedestrians trying to cross the street. "Hit pedestrian" crashes, in fact, are the most common collision type among the case studies, and these crashes frequently occur adjacent to commercial land uses, which are likely to attract greater pedestrian traffic than other land use types. The case study tracts, with the exception of those in Chester and Willingboro, had higher than average percentages of commercial land use. In the average census tract in the region, commercial land use makes up 7.5 percent of land uses, whereas it makes up almost twice that (14.3 percent) in the average case study tract.

Comparison to High-IPD, Low-Crash Census Tracts

As such, we expect census tracts with a higher percentage of local and collector roads and a lack of commercial land use to have lower KSI rates. In order to determine the effect of these built environment factors on KSI rates, census tracts were chosen with socioeconomic and demographic attributes similar to those of the case study tracts, but with vastly different crash experiences.

Two comparison census tracts were chosen by limiting the census tracts to those that had below average all KSI and vulnerable user KSI rates, but were well above average for at least two of the four IPDs. Ten census tracts fit these criteria. Of these, seven census tracts had at least average or above average rates for all four IPDs: three in Trenton, two in Philadelphia, one in Camden, and one in Darby Township (Delaware County). Each of these census tracts had one or fewer KSI crashes during the five-year period.

A census tract in the Pennington/Prospect neighborhood of Trenton and one in the Lawncrest neighborhood in North Philadelphia were ultimately chosen in order to have one census tract from Pennsylvania and one from New Jersey. The Pennington/Prospect census tract had the highest summary IPD score of the three census tracts in Trenton, and the Lawncrest census tract had the highest summary IPD score of the three remaining census tracts in Pennsylvania.

Despite being above average for all four IPDs, the census tract in Lawncrest only had one KSI crash during the five-year study period. Similarly, the census tract in Trenton only had one KSI crash, despite being well above average for the low-income, racial minority, and disabled IPDs. Neither of these KSI crashes involved a vulnerable user and neither one was fatal.

In the census tract in Lawncrest, the effect of the built environment is obvious; commercial land use made up only 5 percent of land uses, compared to 93 percent for residential land use (see Figure 5.15). This is also reflected in the functional class percentages in the tract; local roads make up the vast majority (86 percent) of the road miles in the tract. Furthermore, there are no principal arterials either bisecting or bordering the tract. By having lower traffic volume and lower speeds, the crash experience in Lawncrest is drastically different from census tracts with similar demographic and socioeconomic characteristics.

The census tract in Trenton, on the other hand, is very similar to the case study tracts, not only in its demographics, but also in its built environment. Thirteen percent of land uses in the tract are made up of commercial land use, and a major principal arterial (Route 31, also known as Pennington Road) bisects the neighborhood; the tract's sole KSI crash is located along this

Figure 5.15 | Lawncrest, Philadelphia, Pennsylvania

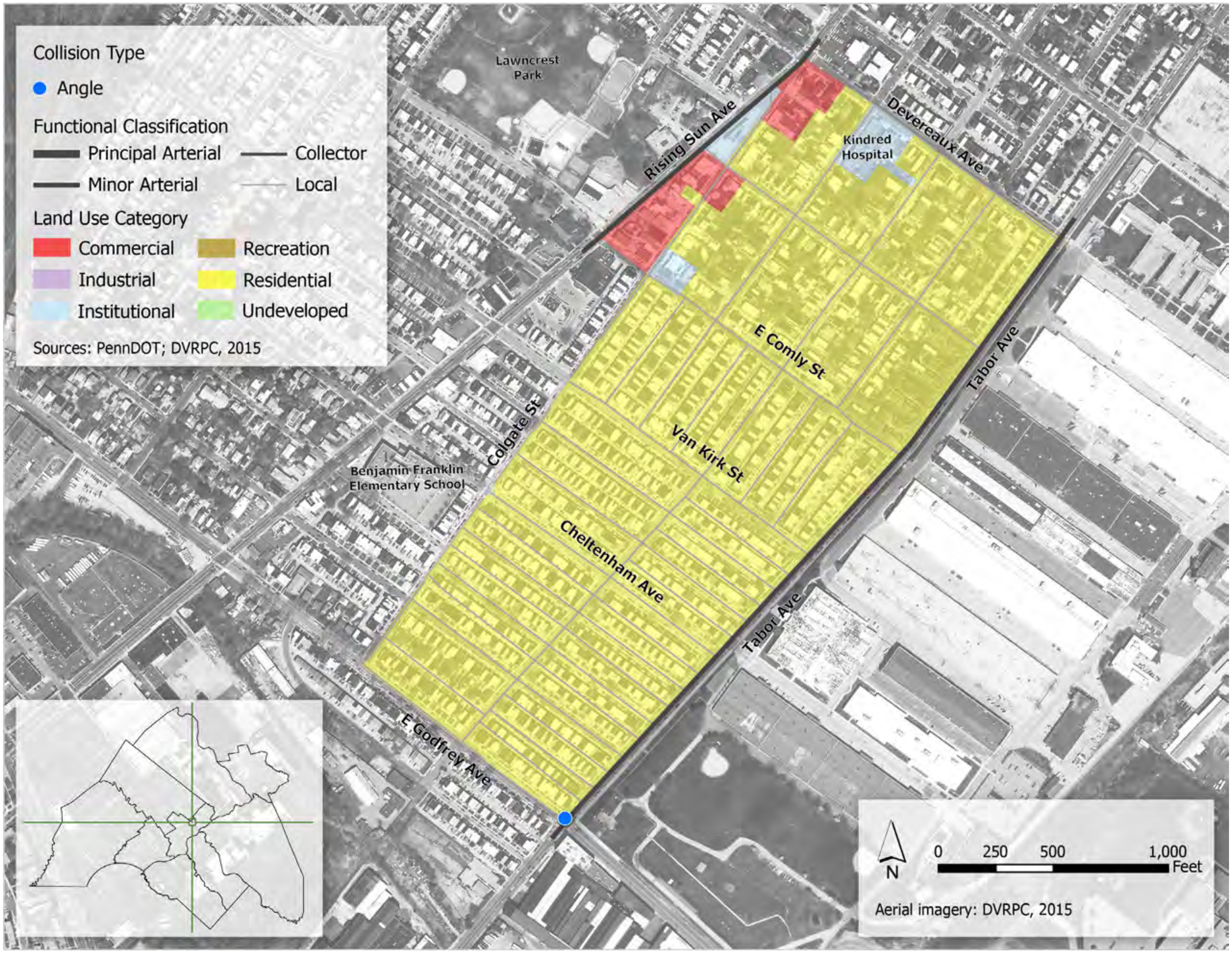
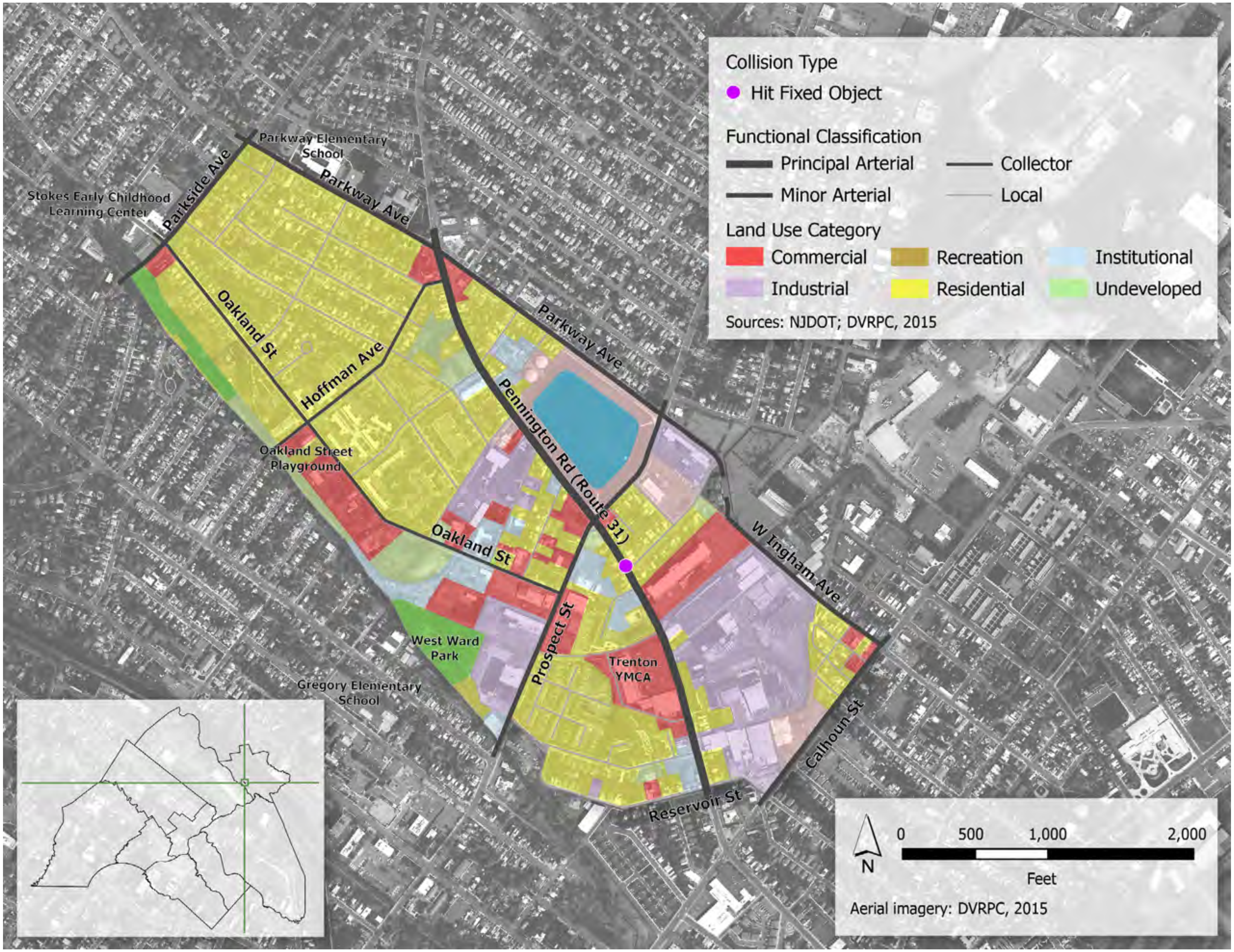


Figure 5.16 | Pennington/Prospect, Trenton, New Jersey



road (see Figure 5.16). Minor arterials border the tract on three sides (Parkside Avenue, Parkway Avenue, West Ingham Avenue, and Calhoun Street) and another minor arterial (Prospect Street) intersects with Route 31 in the middle of the tract. In fact, arterials make up 29 percent of the road miles in the tract.

However, the section of Route 31 that passes through the tract has a speed limit of 25 mph and has only one travel lane in each direction, so whereas it may function as an arterial in other parts of the county, Route 31 functions similarly to a collector in this area. It also has lower traffic volume than other principal arterials; for example, US 130 in Willingboro carries about 20,000 vehicles per day on average, compared to 6,000 for Route 31. This stark difference demonstrates the limitations of using functional class instead of cross-section type to classify roads.

Key Takeaway

The case study analysis suggests that the prevalence of arterial roads and commercial land use in a census tract leads to a greater incidence of severe crashes, particularly those that involve vulnerable users. Of course, both arterial roads and commercial land use are critical to the economic vitality of these neighborhoods and the greater region. Nevertheless, safety investments are needed in these locations—and likely in many other high-IPD, high-crash communities—that can slow vehicles where arterials bisect residential areas from the stores and other commercial land uses that generate local pedestrian trips. As shown in the Trenton example above, the detailed design and speed controls on a given roadway can greatly influence safety.

The final chapter of this report recommends potential safety improvements for roads that meet these conditions and proposes mechanisms to direct transportation safety investments to the communities that need these safety improvements the most.

6

CONCLUSION

Rising Sun Avenue in Lawncrest, Philadelphia.

Roads that carry heavy, fast-moving traffic present the greatest risk to pedestrians and bicyclists and frequently experience higher crash rates than slower, neighborhood streets. This report found that census tracts with above average KSI and vulnerable user KSI rates are nearly twice as likely to be above average for one of the four IPDs identified in our analysis than the average census tract in the region (see Chapter 4: "Findings"). This is not universal, though, as several census tracts that were above average for most or all of these IPDs had below average crash rates (see Chapter 5: "Case Studies"). When comparing these census tracts with the census tracts selected as high-crash case studies, the key factor distinguishing them is clear: arterial roads that tend to enable vehicles to travel at faster speeds.

In order to address the disproportionate number of severe crashes in these communities of concern, this study recommends two primary interventions in the delivery of safety investments in the region:

1. consideration of systemic safety measures designed to slow traffic and protect vulnerable users on arterials that cross communities with above average rates of low-income, racial minority, ethnic minority, and/or disabled populations, and above average crash rates; and

2. prioritization of safety investment dollars to projects that will directly benefit communities with above average rates of low-income, racial minority, ethnic minority, and/or disabled populations, and above average crash rates.

Systemic safety measures, such as those recommended by the FHWA, should be implemented to make these roads safer. These safety improvements can be funded through a variety of local investment vehicles, such as the Transportation Improvement Program (TIP), the Highway Safety Improvement Program (HSIP), the Transportation and Community Development Initiative (TCDI), and other sources.

In keeping with the finding that severe crashes are more concentrated in communities of concern identified in the IPD analysis, the implementation of these measures should be prioritized in census tracts with potentially disadvantaged populations, especially those shown to correlate with high crash rates: racial minorities, ethnic minorities, low-income individuals, and disabled individuals.

Critically, these populations are not only more likely to live in a part of the region that experiences higher crash rates, but it is also more likely for walking to be their primary mode of transportation than for other populations: low-income, racial minority, ethnic minority, and disabled are the only IPDs to correlate with carless households (see Appendix A). Roads that enable drivers to speed pose the greatest risk to pedestrians in particular. As a driver's speed increases, the likelihood of a crash increases. At higher speeds, stopping distances increase, which decreases the time that a driver has to avoid a crash. In addition, as speed increases, so does pedestrian crash severity: nine out of 10 pedestrians die when hit by a vehicle moving at 40 miles per hour or more, whereas only one out of 10 die when hit by a vehicle moving at 20 miles per hour. Fifty-three percent of the KSI crashes in the case study tracts were "hit pedestrian"; of those, 69 percent occurred along arterials, where speeds are higher. Pedestrian safety investments focused on arterials that pass through these communities of concern are the most important tool for addressing the elevated crash rates that impact these communities of concern in the region.

RECOMMENDATIONS

This section details the two primary recommendations for policymakers and roadway owners:

1. the promotion of and implementation of systemic safety measures to improve pedestrian safety and calm traffic in communities of concern; and

2. the incorporation of the four correlated IPDs into the scoring systems of regional safety investment programs in order to maximize the benefit to communities of concern.

Systemic Safety Measures

Site-specific safety improvements aim to reduce the incidence and severity of crashes at "hot-spots," or locations with a history of crashes. The systemic approach, on the other hand, attempts to minimize risk across the entire roadway system—not just where crashes have already occurred—by implementing safety countermeasures wherever appropriate. For example, the New York State Department of Transportation identified the characteristics of roads where lane departure crashes were most likely to occur based on crash data and recommended some of the FHWA's proven safety countermeasures for lane departure (high-friction surface treatment, enhanced delineation, etc.) for implementation on roads with those characteristics.

Some of the FHWA's proven safety countermeasures for pedestrian safety include:

- **Leading Pedestrian Intervals (LPIs):** LPIs allow pedestrians to enter an intersection before vehicles are given a green light, which increases the visibility of pedestrians crossing the intersection and increases the likelihood that turning drivers will yield to the pedestrians. LPIs have been shown to reduce "hit pedestrian" crashes that occur in intersections by 60 percent.
- **Medians and Pedestrian Crossing Islands:** Medians and pedestrian crossing islands allow pedestrians to cross one direction of traffic at a time, and provide a safe place for pedestrians to wait to cross the other direction of traffic. This countermeasure is especially useful at mid-block crossings. Raised medians reduce "hit pedestrian" crashes by 46 percent, and pedestrian crossing islands reduce "hit pedestrian" crashes by 56 percent. Medians can also help to prevent head-on or opposite sideswipe crashes between two vehicles.
- **Pedestrian Hybrid Beacons:** Pedestrian hybrid beacons stop oncoming traffic at mid-block crossings, increasing the visibility of crossing pedestrians and reducing "hit pedestrian" crashes by 69 percent.
- **Walkways:** The separation of pedestrians from vehicles can reduce "hit pedestrian" crashes by up to 89 percent. DVRPC is currently conducting a regional sidewalk inventory to identify gaps in the pedestrian network in the region.

Safe crossings are particularly important in areas with high volumes of pedestrian traffic, such as transit stops (see Figure 6.1 on the next page).

The implementation of traffic calming measures in communities of concern to reduce speeds on these roads and make them safer for all road users—not just pedestrians—is also recommended. Some of the FHWA's proven safety countermeasures for speeding are:

- **Road Diets:** Road diets reconfigure roadways by reducing or narrowing travel lanes and replacing them with on-street parking, bicycle lanes, or a dedicated center turn lane. Not only do road diets reduce the number of "hit pedestrian" crashes by decreasing the crossing distance, but they also decrease rear-

Figure 6.1 | Bus Stop at Knights Road and Street Road Intersection

There is a bus stop on the northeast corner of Street Road and Knights Road in Bensalem, but there are no sidewalks on the south side of Street Road or on Knights Road south of Street Road. There were three "hit pedestrian" crashes at this intersection between 2012 and 2016, despite the presence of other pedestrian facilities, such as marked crosswalks and pedestrian signals.

end and angle crashes. Converting a four-lane roadway to a three-lane roadway can reduce the total number of crashes by up to 47 percent. FHWA provides practical guidance on where road diets will be most successful, which typically involves roads with an AADT of less than 20,000, and where driveways and side streets create left-turn demand.

- **Roundabouts:** Roundabouts are circular intersections, in which there is no signal, but entering vehicles yield to vehicles already in the roundabout. By requiring drivers to slow down as they approach and travel through the intersection, roundabouts have 78 percent fewer severe crashes than signalized intersections. At two-way, stop-controlled intersections, roundabouts can reduce severe crashes by up to 82 percent. Moreover, by not forcing drivers to stop, traffic flow is not impeded by the installation of a roundabout; it is actually improved.

There are other safety measures that can promote pedestrian safety and reduce speeding in communities of concern, although they are not currently considered to be proven safety countermeasures by the FHWA. These include:

- **Curb Bump-Outs:** Curb bump-outs extend the curb into the street, decreasing the curb radii, which forces drivers to turn slower, while also shortening the crossing distance for pedestrians. In addition, pedestrians waiting on the curb extension are no longer obscured by parked cars, making them more visible to approaching drivers, which also improves the pedestrian's sight line of oncoming vehicles.

- **Left-Turn Traffic Calming:** The New York City Department of Transportation (NYCDOT) has pioneered traffic calming that targets left turns from minor onto major streets, where the greater street width on the receiving major street allows left-turning vehicles to turn at a wide radius, leading to higher speeds. To protect pedestrians crossing the major street, NYCDOT installed flexible delineator posts along the centerline of the receiving major street to tighten and thus calm left-turning traffic, decreasing exposure to pedestrians and increasing their visibility (NYCDOT, 2018; see Figure 6.2 on the next page).

- **Modified Channelized Right-Turn Lanes:** Channelized right-turn lanes are commonly known as slip lanes and are designed to increase the vehicle throughput of intersections.

Figure 6.2 | Hardened Centerline on Tremont Street in Boston, Massachusetts

In the Back Bay neighborhood of Boston, flexible delineator posts prevent drivers from crossing the centerline of Tremont Street as they turn from Aquadilla Street, which is a one-way, one-lane street.

These right-turn lanes allow vehicles turning right to bypass the intersection and merge directly into traffic on the cross street. Slip lanes usually have large turning radii, which encourages drivers to increase speed through the turn, increasing the likelihood that they may fail to yield to pedestrians in the crosswalk. Minimizing the curb radius and the angle at which the slip lane intersects the cross street reduces speeding and improves the visibility of pedestrians and oncoming traffic. Still, channelized right-turn lanes are not recommended for areas with high levels of pedestrian and bicycle activity.

- **Raised Crossings and Intersections:** Raised crossings and intersections operate similarly to speed humps, which rocks cars up and down, causing them to slow down; however, raised crossings and intersections have much more gradual slopes, and as such, have a higher design speed of 25 to 30 miles per hour, compared to 15 to 20 miles per hour for speed humps. Moreover, because raised crossings and intersections raise the crosswalk to be level with the sidewalk, mobility for disabled pedestrians is improved.
- **Protected Bicycle Lanes:** Protected bicycle lanes separate bicycle and vehicle traffic with vertical elements in addition to a painted buffer. Common applications include planters, a raised curb, delineator posts, or even parked cars (see Figure 6.3). This separation prevents “dooring,” which occurs when motorists open their doors into the bicycle lane, causing a bicyclist to crash. When implemented as part of a road diet, bicycle lanes have trickle-down benefits to other types of users by narrowing lanes and slowing traffic.
- **Pedestrian-Scale Lighting:** Pedestrian-scale lighting increases the visibility of pedestrians by being lower than traditional street lighting, as well as being spaced together more closely. Between 2012 and 2016, 58 percent of crashes resulting in a pedestrian fatality or major injury occurred at night.

Each of these safety measures may not be appropriate on every road. Road Safety Audits (RSAs) are a tool used by transportation agencies, such as DVRPC, to assess roads and determine whether safety investment is warranted, and if so, which safety measures are appropriate. Pedestrian RSAs are similar to traditional RSAs, but they place a special emphasis on pedestrian safety issues, which may not have been considered during the original design and planning of the road.

Figure 6.3 | Chestnut Street Bike Lane in West Philadelphia, Pennsylvania

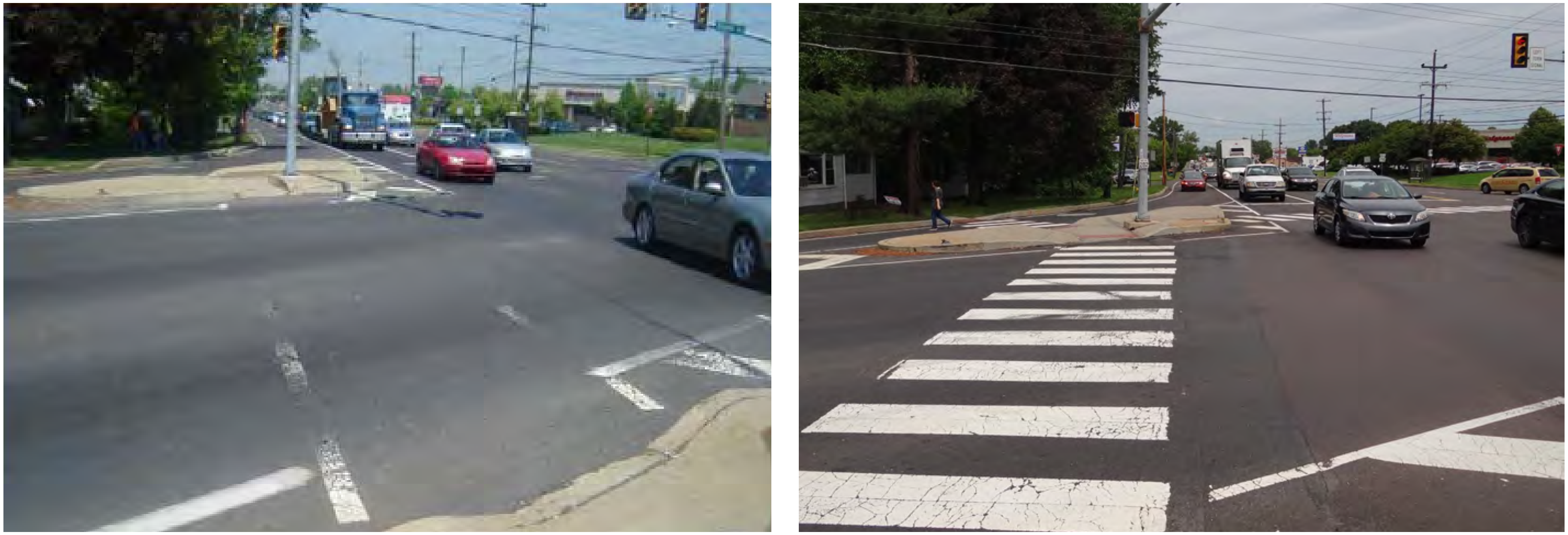
The Chestnut Street Bike Lane is a parking-protected bike lane in the City of Philadelphia, opened in August 2017. Chestnut Street is on the High Injury Network (see page 72 for more information about the High Injury Network) and nearly 75 percent of the crashes that occurred on Chestnut Street occurred along the one-mile stretch between 34th and 45th streets, where the new bike lane was installed. The parking-protected bike lane is expected to reduce the number and severity of crashes among all road users without worsening vehicular congestion, despite requiring the removal of one travel lane.

Photo courtesy of the Bicycle Coalition of Greater Philadelphia.

The result of an RSA is a series of recommendations that are then presented to the roadway owner. RSAs focus on low-cost solutions with the highest safety benefit in order to encourage implementation of the recommended safety measures. For example, DVRPC conducted an RSA of Street Road, a principal arterial in the case study tract in Bensalem, in 2008. As a result, the pedestrian amenities at the Knight Road intersection were improved, most notably by upgrading the crosswalks from standard crosswalks to higher-visibility continental crosswalks (see Figure 6.4 on the next page).

When implemented along high-crash corridors that impact communities of concern in the region, systemic safety measures can begin to lessen the burden of severe crashes borne disproportionately by these communities.

Figure 6.4 | Knights Road and Street Road Intersection, Before and After



The crosswalk across Knights Road, south of the intersection with Street Road, was repainted and upgraded from a standard crosswalk to a continental crosswalk. The photo on the left is from May 2008, while the photo on the right is from June 2018. Also visible in the photo on the right is the addition of a pedestrian countdown timer, which lets pedestrians know when it is safe to cross and how much time they have left to do so.

Safety Investment Prioritization

Safety investment programs, such as the TIP, HSIP, and TCDI, frequently use a scoring system to determine which projects to prioritize. Score multipliers that give projects that address road safety in communities with the IPD populations correlated with higher crash rates (racial minority, ethnic minority, disabled, and low-income) a higher score can help direct safety investment towards those communities of concern that stand to benefit most.

Transportation Improvement Program (TIP)

The TIP is federally mandated under the Fixing America's Surface Transportation Act (FAST Act) and lists all transportation projects in the DVRPC region that will or are expected to receive federal funds, in addition to those that will not receive federal funds but are of regional significance. The list is multimodal; in addition to the more traditional highway and public transit projects, it also includes bicycle, pedestrian, and freight-related projects. DVRPC updates the Pennsylvania and New Jersey TIPs every other year, in alternate years.

The TIP is administered by DVRPC, which is guided by Title VI of the Civil Rights Act of 1964 and the 1994 President's Executive Order on Environmental Justice. These regulations require that the TIP be non-discriminatory and that it does not have a disproportionate impact on minority and low-income populations (see Chapter 3: "Methodology" for more information about Title VI and EJ guidelines). DVRPC complies with these regulations by using the full set of IPDs as a criterion to evaluate potential projects for inclusion in the TIP. Projects are given an EJ rating depending on the summary IPD score of the communities through which a project passes, and the length of that project in each community. In addition, after all of the projects for a new TIP are selected, the entire program of mappable investments is evaluated by census tract, again, using the IPD analysis to help determine if communities of concern are experiencing disproportionate impacts from TIP projects, or are not experiencing an equitable level of benefit compared to the rest of the region. It is also important to note that EJ and Title VI are considered early and continuously in the project delivery process before a project is authorized for construction. Local agencies and project sponsors are required to evaluate projects under the National Environmental Policy Act (NEPA) process to address potential environmental impacts of a transportation project.

The TIP Evaluation Criteria also promote traffic safety and multimodal projects, including building new and maintaining existing facilities for pedestrians and bicyclists. Projects are awarded points for safety improvement in high-crash locations identified by PennDOT and NJDOT, and per FHWA proven safety countermeasures and other safety countermeasures with demonstrated crash reduction benefits above a certain level. Multimodal projects are awarded points for serving areas with high pedestrian and bicycle traffic; for improving connections to transit services; for building new facilities; and for maintaining, improving, and/or connecting to existing facilities.

Highway Safety Improvement Program (HSIP)

The HSIP is a core federal-aid program administered by the states (New Jersey and Pennsylvania) through their departments of transportation. It funds data-driven safety projects that will reduce traffic fatalities and/or serious injuries on all public roads, designed to advance state safety goals as described in their Strategic Highway Safety Plans (SHSP). States must have a current SHSP to be eligible to receive HSIP funds. Specifically, the HSIP is each state's program of infrastructure-related highway safety improvement projects, funding a wide range of projects like traffic signal upgrades, road diets, roundabouts, high-friction surface treatments, and other engineering measures proven to reduce traffic fatalities and serious injuries. Both Pennsylvania's and New Jersey's SHSPs place special emphasis on pedestrian safety, thus directing more investment to pedestrian safety projects through the HSIP.

The National Highway Traffic Safety Administration (NHTSA) provides grant funds for primarily non-infrastructure efforts like traffic safety educational outreach; localized high-visibility enforcement; and special enforcement activities to address aggressive driving, impaired driving, and occupant protection (seatbelt use). NHTSA grants, like HSIP funds, are administered through state governments.

Pennsylvania aims to reduce its 2014–2018 rolling average for traffic fatalities to 1,177 from the 2012–2016 rolling average of 1,220, while New Jersey has set a goal of reducing traffic fatalities and serious injuries by 2.5 percent each year. The HSIP for each state is updated yearly.

Transportation and Community Development Initiative (TCDI)

The TCDI was developed in 2002 to reverse disinvestment in older communities in the region while supporting the goals of DVRPC's long-range plan (currently *Connections 2045*). Since then, DVRPC has invested $18 million in projects throughout the region via the TCDI, including many safety projects. The TCDI accepts applications on a biennial basis, and unlike the other safety investment vehicles discussed here, TCDI grants can only be used for planning purposes.

The TCDI expressly advances equity by requiring applicants to identify affected IPD populations in the proposed project area and describe how they plan to engage these populations during the planning process. If an applicant can demonstrate that their proposed project will directly benefit one of these populations, they can receive up to 20 bonus points. Projects are evaluated based on a total score of 120 points; therefore, these 20 available bonus points have the potential to significantly increase a project's score. In the 2019 fiscal year, all of the projects selected received bonus points for benefiting IPD populations, including a pedestrian safety study for Vision Zero Philadelphia.

Vision Zero Philadelphia

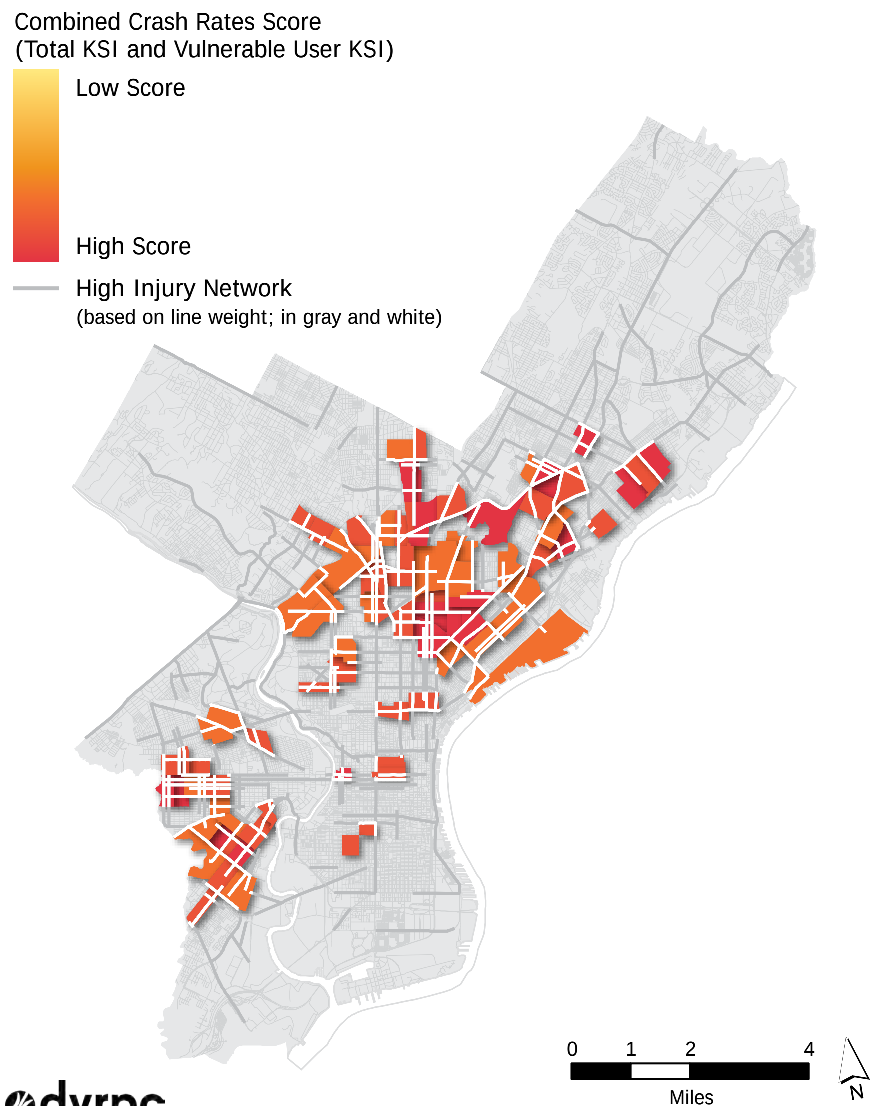
Vision Zero is an international movement with the goal of eliminating traffic fatalities. Vision Zero promotes the idea that traffic fatalities are preventable, that they are not "accidents," and that they are therefore unacceptable. Philadelphia adopted Vision Zero in 2016, joining 26 other American cities with Vision Zero policies. Equity is one of Vision Zero Philadelphia's five priorities, in addition to evaluation, engineering, education, and enforcement. As such, the Three-Year Action Plan, released in the fall of 2017, acknowledged that low-income neighborhoods are disproportionately affected by severe crashes and committed to prioritize safety investment in those neighborhoods. The first step in this process was to create the High Injury Network, which identifies areas most in need of investment. Because crash rates are correlated with higher proportions of low-income population, these areas also tend to be in the low-income neighborhoods in which the Three-Year Action Plan aims to prioritize investment.

OVERLAP WITH HIGH INJURY NETWORK

The High Injury Network (HIN), similar to this analysis, uses non-interstate KSI crash data from 2012 to 2016, with a weight for vulnerable user crashes, to determine which roads have the highest KSI crash rates in the city of Philadelphia. These roads make up just 12 percent of Philadelphia's street network, but 50 percent of all traffic fatalities and serious injuries occurred on them. The HIN will receive the first safety improvements outlined in the Three-Year Action Plan, and, as can be seen in Figure 6.5, the HIN overlaps heavily with those census tracts identified in this analysis as high-crash, high-IPD locations.* In fact, 41 percent of the HIN is within 100 feet of one of these census tracts, despite these census tracts making up only 22 percent of all census tracts in Philadelphia.

*High-crash, high-IPD locations are census tracts that have two out of the four IPDs (racial minority, ethnic minority, disabled, and low-income) above the regional average, have a vulnerable user KSI crash rate and a total KSI crash rate above the regional average, and at least five KSI crashes between 2012 and 2016.

Figure 6.5 | Overlap Between High-Crash, High-IPD Locations and Philadelphia's High Injury Network



Source: City of Philadelphia, DVRPC

Next Steps

This section discusses areas that could warrant exploring further analysis, but for which such analysis was not possible given the scope of this project.

Use a Smaller Unit of Analysis

Further analysis could use a smaller unit of analysis in order to gain a better understanding of the local nature of the relationship between crash rates and communities of concern. For the case studies, for example, an analysis of the land use and IPD populations within a 100-foot buffer would have proved more useful than the analysis of this data across an entire census tract, as areas of a given tract may be far removed from the locations of a crash and therefore their characteristics would have little bearing on the crash.

Account for All Affected Populations

One disadvantage of ACS data is that it provides data only for the residents of a given tract, even though non-residents that visit that tract are likely to be affected by high crash incidence and severity in that tract also. Workers that commute to that tract from other tracts are more likely to be involved in daytime crashes, in particular. Census Transportation Planning Products (CTPP) could be used to analyze the demographics of these workers to determine, for example, whether workers' income or race in a given tract is correlated with the crash rate in that tract.

Classify Roads Differently

Our case study analysis and the comparison of case study tracts to high-IPD, low-crash tracts illustrates that there is tremendous variation among arterials, even within the principal arterial category itself. Further analysis could use cross-section type instead of functional classification in order to better identify and target the characteristics of a road (presence of a median, presence and width of shoulders, number of lanes, etc.) that contribute most to the crash experience in communities of concern. Additionally, a regional analysis of either functional class or cross-section type, similar to the one conducted of land use, could help determine whether high-IPD, high-crash locations have an unusually high proportion of arterials compared to what is typical for a census tract in the region.

Broaden Applicability

In the future, a regression model could be developed using the variables explored in this study (IPDs, land use, and functional class) as well as other additional variables. A regression model would have the benefit of testing the relative explanatory strength of each of the variables used, thereby determining which variables have the most effect on crash rate. Should the regression model sufficiently explain crash rates, it can be used to identify areas with elevated crash risk, but without a history of severe crashes. RSAs could then be conducted in these areas to identify problem locations that would be prime candidates for the systemic safety improvements recommended by this study. In addition, a regression model could be applied to areas outside of the Greater Philadelphia region to help planners in other regions who seek to prioritize their safety investments.

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APPENDIX A

FULL CORRELATION MATRIX

	Non-Interstate KSI	KSI per 10,000 People	KSI per 10,000 AADT	KSI per Road Mile	Racial Minority	Ethnic Minority	Disabled
Non-Interstate KSI	1						
KSI per 10,000 People	0.730	1					
KSI per 10,000 AADT	0.407	0.328	1				
KSI per Road Mile	0.274	0.255	0.458	1			
Racial Minority	0.003	0.042	0.353	0.379	1		
Ethnic Minority	0.099	0.044	0.352	0.294	0.317	1	
Disabled	0.053	0.103	0.326	0.280	0.474	0.292	1
Low-Income	0.032	0.080	0.436	0.487	0.769	0.508	0.610
Youth	0.056	−0.092	0.159	−0.086	0.250	0.317	0.040
Older	−0.025	0.014	−0.200	−0.179	−0.297	−0.332	0.120
Female	−0.029	-0.015	−0.011	0.066	0.167	−0.109	0.129
Foreign-Born	0.019	−0.026	0.033	0.155	0.198	0.332	−0.054
Limited English Proficiency	0.066	−0.006	0.229	0.285	0.281	0.733	0.204
Combined IPD Score	0.045	0.022	0.382	0.382	0.807	0.599	0.585
Carless Households	−0.012	0.034	0.354	0.588	0.721	0.307	0.505

Low-Income	Youth	Older	Female	Foreign-Born	Limited English Proficiency	Combined IPD Score	Carless Households
1							
0.240	1						
-0.365	−0.361	1					
0.148	0.112	0.258	1				
0.156	0.007	−0.129	−0.072	1			
0.434	0.191	−0.237	−0.106	0.774	1		
0.799	0.367	−0.182	0.267	0.447	0.628	1	
0.813	0.039	−0.230	0.191	0.095	0.268	0.651	1

APPENDIX B

CORRELATION MAPS

Figure B.1 | Low-Income and Total KSI Census Tracts

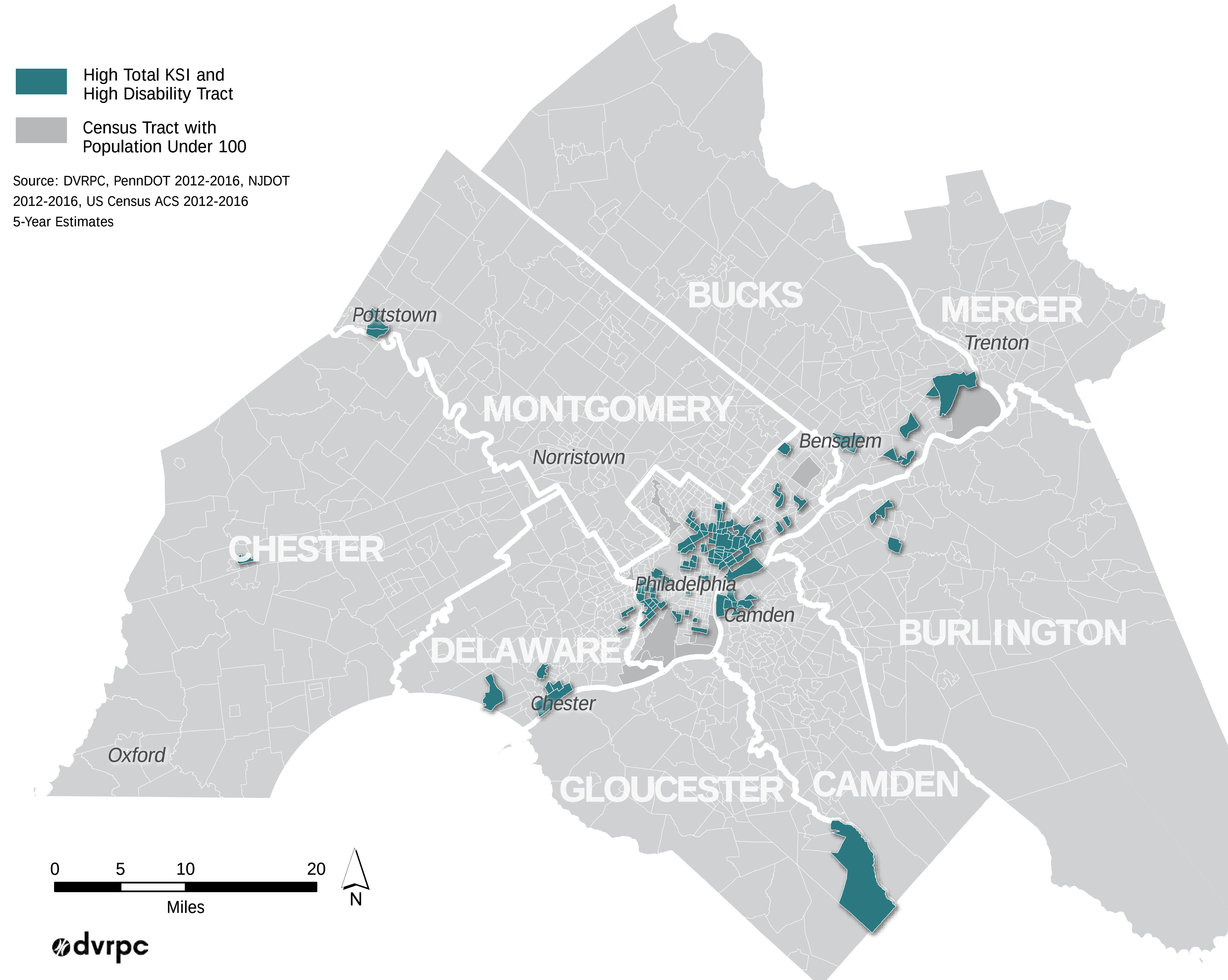
Figure B.2 | Low-Income and Vulnerable User KSI Census Tracts

FIGURE B.3 | RACIAL MINORITY AND TOTAL KSI CENSUS TRACTS

Figure B.4 | Racial Minority and Vulnerable User KSI Census Tracts

Figure B.5 | Ethnic Minority and Total KSI Census Tracts

FIGURE B.6 | DISABLED AND TOTAL KSI CENSUS TRACTS



APPENDIX C

SCATTERPLOTS

Figure C.1 | Low-Income and Total KSI Crash Rate Scatterplot

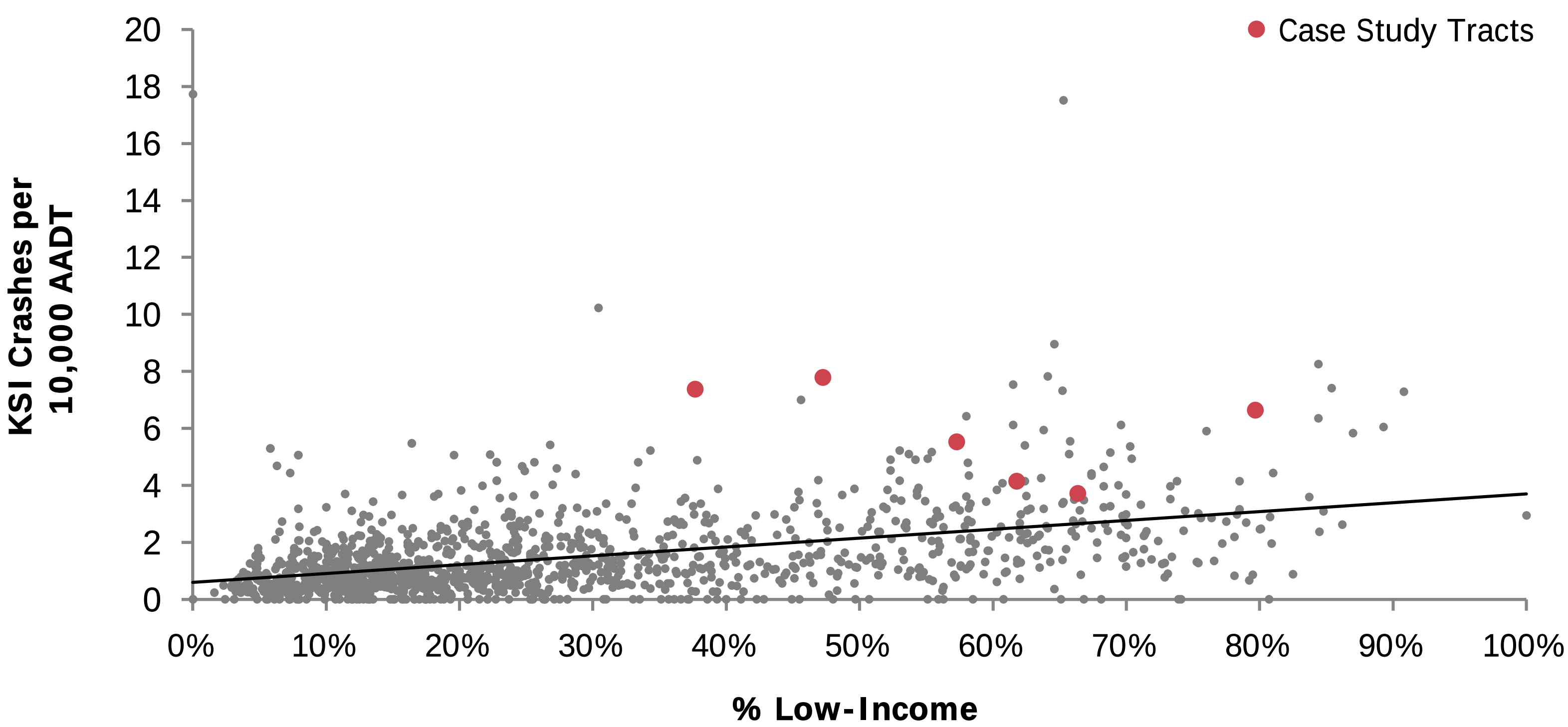


Figure C.2 | Low-Income and Vulnerable User KSI Crash Rate Scatterplot

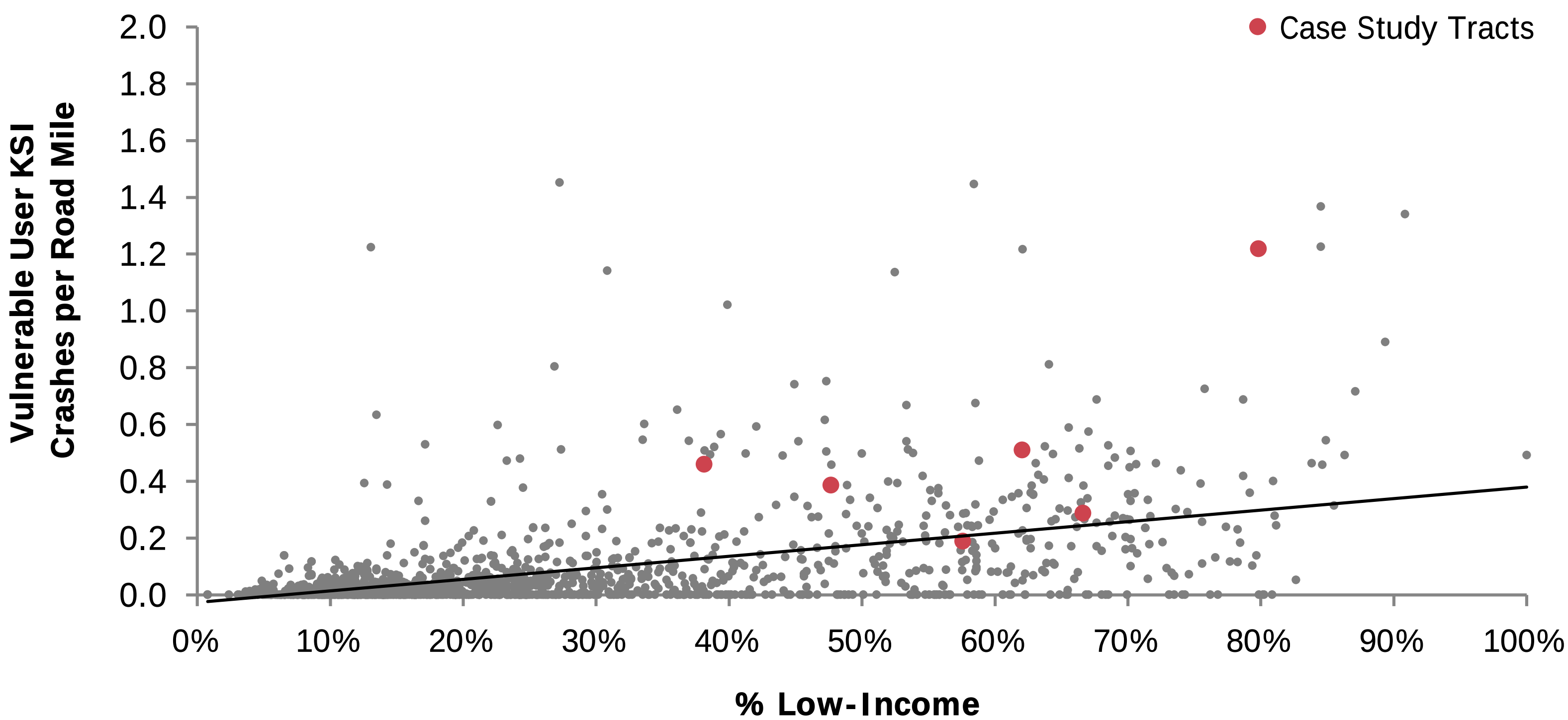


Figure C.3 | Racial Minority and Total KSI Crash Rate Scatterplot

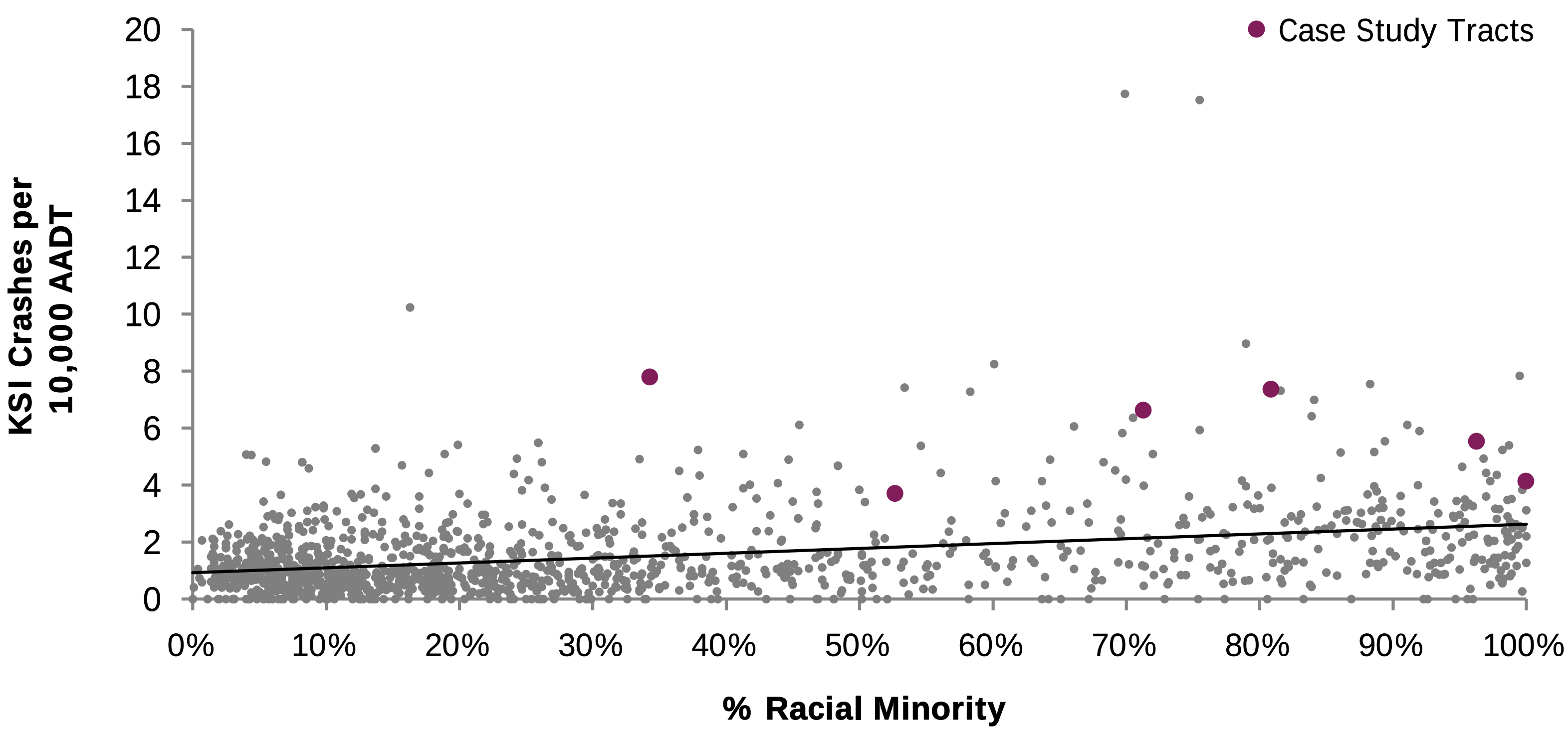


Figure C.4 | Racial Minority and Vulnerable User KSI Crash Rate Scatterplot

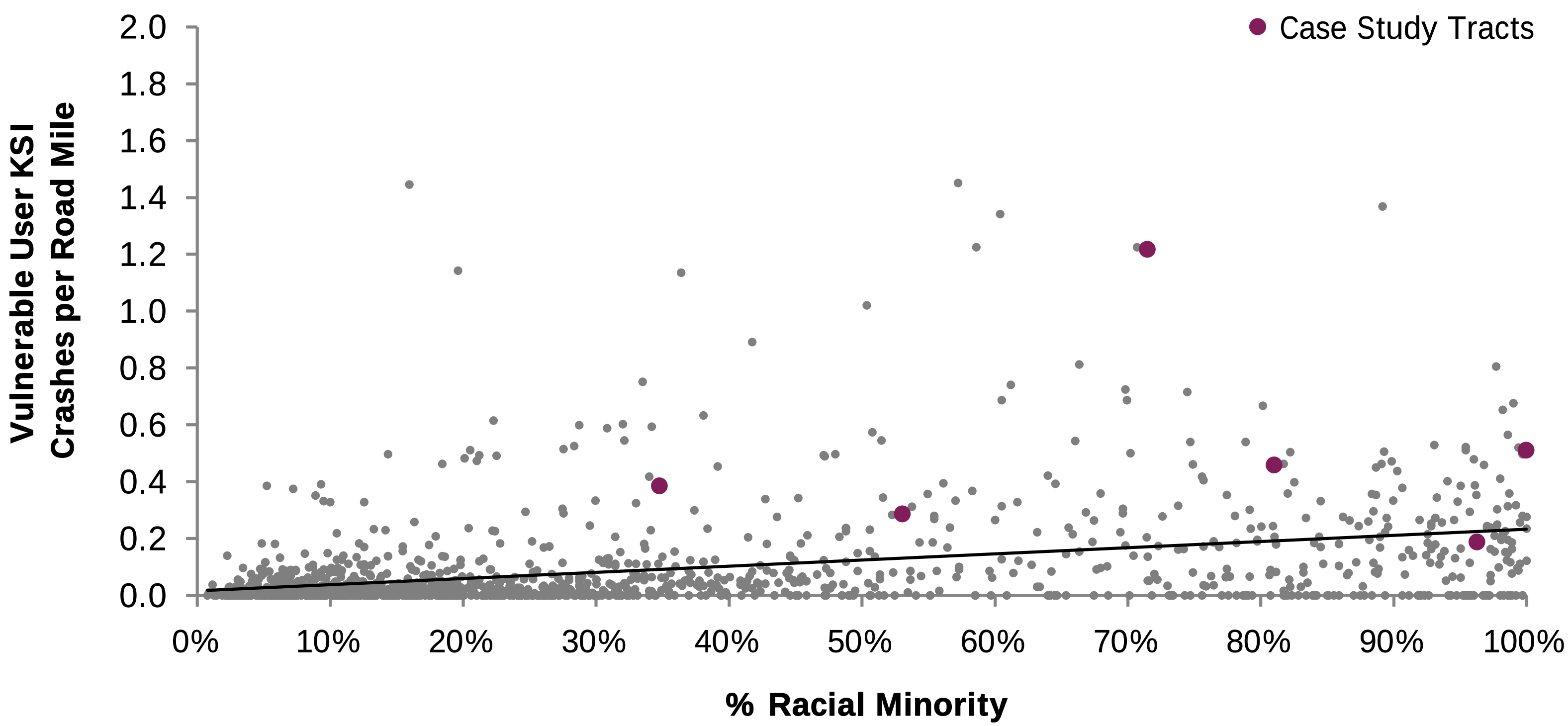


Figure C.5 | Ethnic Minority and Total KSI Crash Rate Scatterplot

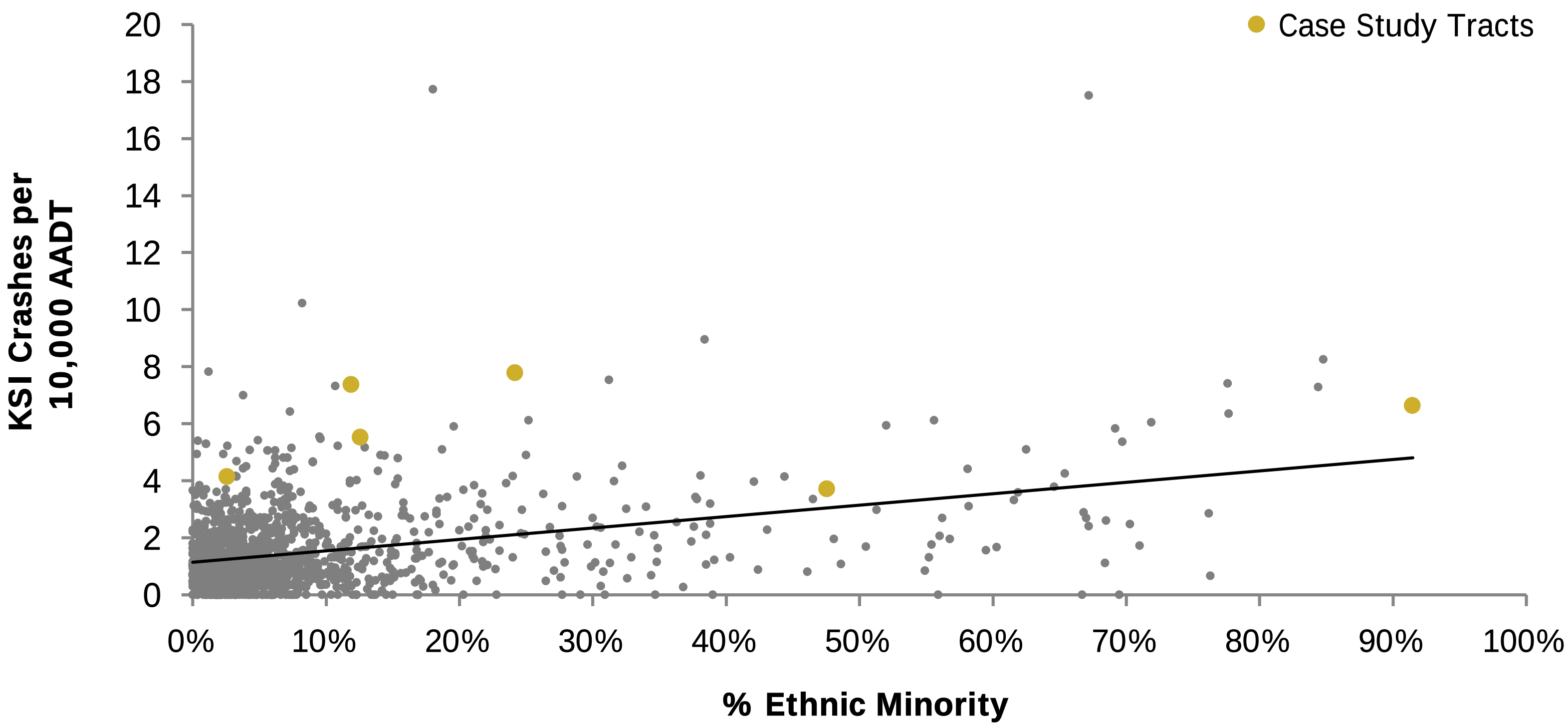
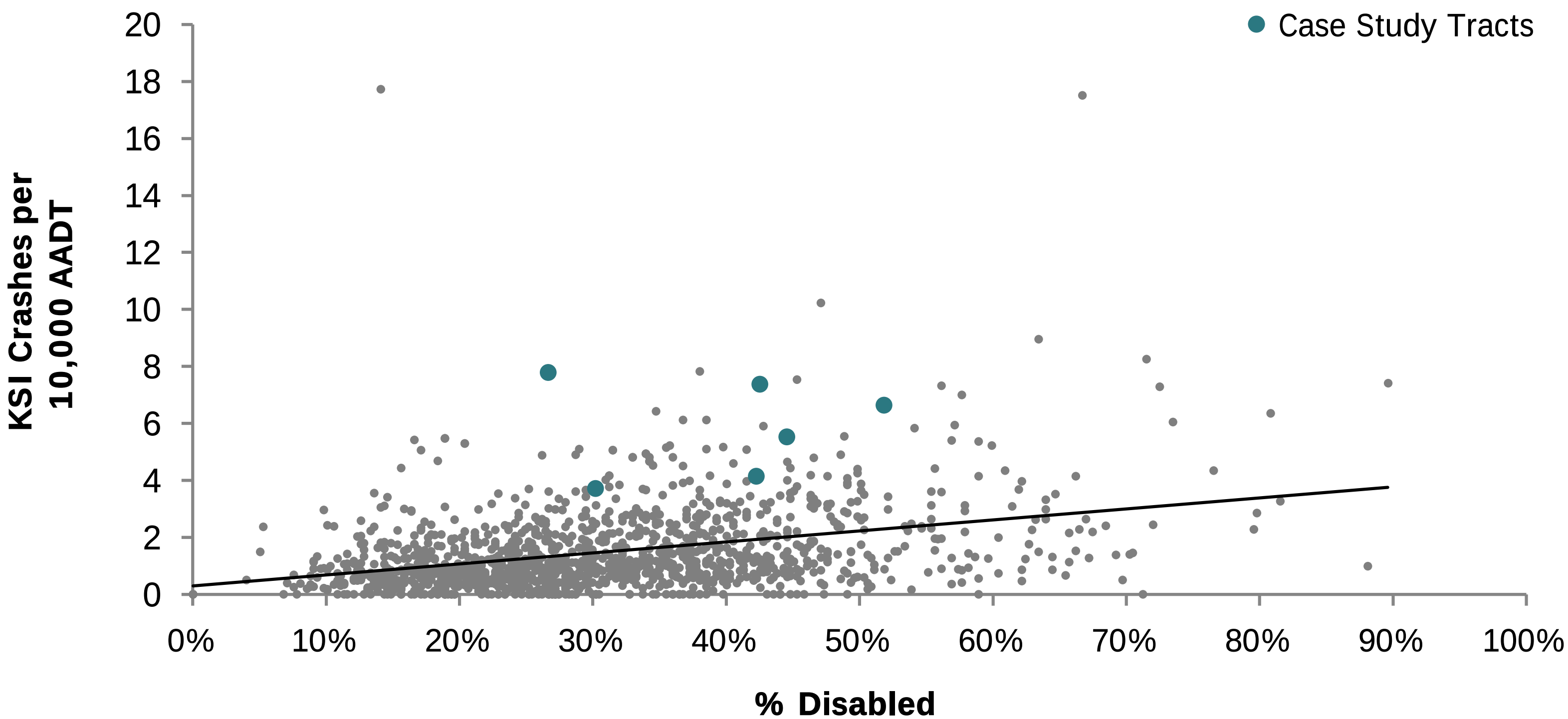


Figure C.6 | Disabled and Total KSI Crash Rate Scatterplot



APPENDIX D

CASE STUDY DATA

		Bensalem	Chester	Cobbs Creek	Fairhill	Norristown	Willingboro	Lawncrest	Trenton	Regional Average
IPDs	Low-Income Score	3	3	4	4	4	2	4	4	-
	Low-Income (%)	47%	57%	62%	80%	66%	38%	60%	65%	29%
	Racial Minority Score	2	4	4	3	3	4	4	4	-
	Racial Minority (%)	34%	96%	100%	71%	53%	81%	78%	96%	33%
	Ethnic Minority Score	3	2	2	4	4	2	3	2	-
	Ethnic Minority (%)	24%	13%	3%	92%	48%	12%	28%	2%	9%
	Disabled Score	2	3	3	3	2	3	3	4	-
	Disabled (%)	11%	18%	17%	21%	12%	17%	17%	23%	13%
Crashes	KSI Score	4	4	4	4	4	4	1	1	-
	KSI Rate	7.77	5.51	4.13	6.61	3.69	7.35	0.000062	0.000035	1.48
	Vulnerable User KSI Score	4	3	4	4	3	4	1	1	-
	Vulnerable User KSI Rate	0.38	0.19	0.51	1.22	0.29	0.46	0	0	0.09
	Total KSI	29	5	8	22	5	6	1	1	5.74
	Number of Fatal KSI	10	3	1	8	0	3	0	0	1619
	Fatal KSI (%)	34%	60%	13%	36%	0%	43%	0%	0%	28%
	Total Vulnerable User KSI	16	3	5	17	3	3	0	0	1.57

Functional Class		Bensalem	Chester	Cobbs Creek	Fairhill	Norristown	Willingboro	Lawncrest	Trenton	Regional Average
	Principal Arterial (Feet)	41,906	2,770	5,285	7,875	3,235	2	0	4,477	-
	Principal Arterial (%)	25%	7%	11%	12%	7%	38%	0%	8%	-
	# of KSI crashes	18	3	6	13	1	4	0	1	-
	% of KSI crashes	62%	60%	75%	59%	20%	81%	0%	100%	-
	Minor Arterial (Feet)	10,110	4,800	1,321	2,712	3,338	2	4,758	11,293	-
	Minor Arterial (%)	6%	11%	3%	4%	8%	12%	14%	21%	-
	# of KSI crashes	5	1	0	2	1	3	1	0	-
	% of KSI crashes	17%	20%	0%	9%	20%	17%	100%	0%	-
	Collector (Feet)	7,576	2,703	1,881	13,345	6,961	4	0	5,657	-
	Collector (%)	5%	6%	4%	20%	16%	7.35	0%	10%	-
	# of KSI crashes	3	0	0	2	3	4	0	0	-
	% of KSI crashes	10%	0%	0%	9%	60%	0.46	0%	0%	-
	Local (Feet)	107,411	32,215	37,972	43,764	30,911	6	29,933	33,623	-
	Local (%)	64%	76%	82%	65%	70%	3	86%	61%	-
	# of KSI crashes	3	1	2	5	0	43%	0	0	-
	% of KSI crashes	10%	20%	25%	23%	0%	3	0%	0%	-

		Bensalem	Chester	Cobbs Creek	Fairhill	Norristown	Willingboro	Lawncrest	Trenton	Regional Average
Collision Type	Rear-End	7%	40%	0%	0%	20%	17%	0%	0%	9%
	Head-On	3%	0%	0%	0%	0%	17%	0%	0%	8%
	Angle	17%	20%	38%	14%	40%	0%	100%	0%	24%
	Sideswipe	3%	0%	0%	0%	20%	0%	0%	0%	5%
	Hit Fixed Object	21%	0%	0%	9%	0%	17%	0%	100%	25%
	Hit Pedestrian	45%	40%	63%	77%	20%	43%	0%	0%	21%
	Unknown/Other	3%	0%	0%	0%	0%	0%	0%	0%	8%
Land Use	Residential (Acres)	458	76	75	77	63	88	86	118	-
	Residential (%)	46%	38%	73%	55%	58%	47%	92%	55%	50%
	# of KSI crashes	15	4	4	12	5	1	1	1	-
	% of KSI crashes	52%	80%	50%	55%	100%	17%	100%	100%	-
	Commercial (Acres)	209	14	21	21	20	10	4	32	-
	Commercial (%)	21%	7%	20%	15%	18%	5%	4%	15%	8%
	# of KSI crashes	21	5	5	11	2	3	0	0	-
	% of KSI crashes	72%	100%	63%	50%	40%	50%	0%	0%	-

Land Use	Bensalem	Chester	Cobbs Creek	Fairhill	Norristown	Willingboro	Lawncrest	Trenton	Regional Average
Institutional (Acres)	112	20	5	14	21	8	3	12	-
Institutional (%)	11%	10%	5%	10%	19%	4%	3%	6%	6%
# of KSI crashes	6	1	0	9	1	1	0	0	-
% of KSI crashes	21%	20%	0%	41%	20%	17%	0%	0%	-
Industrial (Acres)	11	9	1	9	0	0	0	38	-
Industrial (%)	1%	5%	1%	6%	0%	0%	0%	18%	3%
# of KSI crashes	0	0	0	4	0	1	0	0	-
% of KSI crashes	0%	0%	0%	18%	0%	17%	0%	0%	-
Undeveloped (Acres)	134	42	1	16	3	76	0	9	-
Undeveloped (%)	13%	21%	1%	11%	3%	40%	0%	4%	4%
# of KSI crashes	4	0	0	3	0	5	0	0	-
% of KSI crashes	14%	0%	0%	14%	0%	83%	0%	0%	-
Recreational (Acres)	78	38	0	4	2	7	0	5	-
Recreational (%)	8%	19%	0%	3%	2%	4%	0%	2%	5%
# of KSI crashes	2	0	0	2	0	1	0	0	-
% of KSI crashes	7%	0%	0%	9%	0%	17%	0%	0%	-

CRASHES AND COMMUNITIES OF CONCERN IN THE GREATER PHILADELPHIA REGION

Publication Number 18022

Date Published December 2018

Geographic Area Covered The nine-county Greater Philadelphia region, which includes the counties of Burlington, Camden, Gloucester, and Mercer in New Jersey; and Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania.

Key Words Crash Data, Equity, Environmental Justice, Vision Zero, Crash Analysis, Safety, Indicators of Potential Disadvantage, Title VI, Bensalem, Chester, Cobbs Creek, Fairhill, Norristown, Willingboro, Philadelphia

Abstract This report is a study of the regional inequities in crash incidence, using a correlation analysis to determine which federally protected classes ("communities of concern") are at the greatest risk of severe vehicle crashes in the Greater Philadelphia region. Its main finding is that census tracts with above average rates of low-income, racial minority, ethnic minority, and disabled populations correlate with census tracts that have above average crash rates in the region. This study recommends interventions in the delivery of safety investments in the region in order to address the disproportionate number of severe crashes in these communities of concern.

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