# City of Alexandria, Virginia

## MEMORANDUM

**DATE:** AUGUST 16, 2017

**TO**: YON LAMBERT, DIRECTOR, DEPARTMENT OF TRANSPORATION & ENVIRONMENTAL SERVICES
CHIEF MICHAEL BROWN, ALEXANDRIA POLICE DEPARTMENT

**THROUGH**: GREG USEEM, CHIEF PERFORMANCE OFFICER

**FROM:** EMILY MOLFINO, PERFORMANCE ANALYST

**SUBJECT:** VEHICLE, BIKE, & PEDESTRIAN CRASH ANALYSIS FOR VISION ZERO

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On January 24, 2016, the City of Alexandria adopted a Vision Zero resolution which set a goal of eliminating traffic deaths and serious injuries by 2028. To inform the plan, the Department of Transportation and Environment Services (TES) asked the Office of Performance and Accountability (OPA) to conduct the crash analysis. OPA analyzed crash data from the Alexandria Police Department (APD). The data include information on crashes that occurred on Alexandria city streets between CY 2011 and CY 2016. For a more detailed discussion of the methodology, see the attached analysis summary (attachment 1: pages 2-3).

## Key Findings

The analysis resulted in ten findings regarding crash trends or high-risks conditions or situations for killed or seriously injured (KSI) crashes.

**1. Crashes and KSI risk has dropped since 2011; action items for vision zero should be tested to ensure they are effectively contributing to this trend**
While this is a positive trend, it is important to know if Vision Zero helps, has no impact, or harms the current decline in KSIs. To accomplish this, as new action items are implemented through Vision Zero, the City should establish a process and methods to test and evaluate if they are effectively contributing to this trend or not (refer to pages 5-7 of attachment 1).

**2. There is a temporal pattern in crash volume and KSI risks**
Time of day, day of week, and season effect crash volume and KSI risks. Crash volumes followed commuting patterns during the weekday and recreational travel during the weekend. Seasonally, more bicycle involved crashes occurred during the spring and summer, and a higher proportion of these crashes were KSI. Additionally, pedestrian involved crashes increased during the spring and fall (refer to pages 8-10 of attachment 1).

**3. There are corridors with elevated KSI risks**
While there were crashes throughout the city, crashes were concentrated in Old Town, West End, and Fairlington/Bradlee areas. For crashes resulting in KSIs, there were corridors in the city with higher risk. These higher risk corridors were Duke Street, Washington Street, West Glebe Road, North Beauregard Street, Seminary Road, and Route 1 (refer to pages 11-12 of attachment 1).

**4. Adverse environmental conditions are high-risk conditions**
Environmental conditions include weather, lighting, and road conditions. Adverse weather, poor lighting during darkness, and poor road conditions all have an increased risk for KSI crashes. Specifically, when it rains, there is a high-risk of pedestrian and bicycle involved crashes. Non-lighted areas were a risk factor for vehicle only crashes. Further, roads with loose material, holes, ruts, bumps were a risk factor for vehicle only crashes (refer to pages 13-14 of attachment 1).

**5. Certain road infrastructure may affect KSI risks**
Traffic control infrastructure, like traffic signals, lane markings, stop signs, etc. may play a role in KSI risks. However, there is not enough data to analyze directly how street design impact KSI crashes. Nevertheless, it is important to note is that most crashes occurred at locations with a traffic signal, with traffic lanes marked, or with no traffic signal. Further, crashes where there was a pedestrian crosswalk or no passing lanes had the highest proportions of KSI crashes (refer to pages 15-16 of attachment 1).

**6. Increased speed increases KSI risks**
The median speed of vehicles in KSI crashes is higher than non-KSI crashes, but the speeds were not significantly different. Vehicles involved in KSI crashes were on average traveling faster. Older drivers were getting into crashes at slower speeds as compared to younger divers (refer to pages 17-18 of attachment 1)

**7. Certain pedestrian paths of travel and locations create high-risk situations**
How and where pedestrians crossed or entered the street effected KSI crash risks. Most pedestrian crashes occurred when pedestrians were crossing at an intersection. However, pedestrian KSIs occurred when pedestrians were crossing the street, but not an intersection When paired with vehicle actions, crossing at an intersection with a signal, with the vehicle making a left turn was also high-risk situation for KSI crashes (refer to pages 19-21 of attachment 1).

**8. Motorcyclists and fixed object events are high-risk situations**
The highest number of crash events involved angles, rear-ends, sideswipes, and fixed objects. In the cases of fixed objects, almost 17% of crashes resulted in KSIs. Additionally, while crashes that involved motorcyclists were generally low in number, they had the highest KSI rate of nearly 28% (refer to pages 22-23 of attachment 1).

**9. The young and old have distinct KSI risks**
Young and old individuals involved in crashes have high KSI percentages. This includes both driving and walking. Most KSIs involving young pedestrians occurred when the young pedestrian was crossing not at an intersection (refer to pages 24-27 of attachment 1).

**10. Poor personal choices increase KSI risks**

This mostly focuses on alcohol use and using a safety restraint. Alcohol use in a crash is a high-risk situation for KSIs. Additionally, not using a safety restraint in a vehicle crash is a high-risk situation for KSIs (refer to pages 28-29)**.**

The in-depth analysis report contains more details on the additional highlights (attachment 3).

## Data Recommendations

The analysis was limited due to data quality and availability. OPA developed four recommendations to be included in the Vision Zero action plan to improve the data quality of crash data. For more detailed description of the data recommendations, see the attached analysis summary (attachment 1: page 30).

- Reduce errors and missing data.
- Accurately and consistently record the location of crashes.
- Track clearly the root cause of crashes.
- Collect more data on bicycle involved crashes.

Attachments

1. Crash Analysis Summary
2. Crash Analysis Variable List
3. Crash Analysis Detailed Report

# Summary of Findings:
# Vehicle, Bike, and Pedestrian Crash Analysis

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Office of Performance and Accountability

August 4, 2017

## Data

To answer this question, OPA analyzed crash data from the Alexandria Police Department (APD). These data originated from Traffic Records Electronic Data Systems (TREDS). TREDS centralizes Virginia's crash data and is designed to be a 'one-stop-shop' to provide accurate, timely and detailed crash information for analysis and reporting. The received data includes information on all crashes that occurred on Alexandria city streets between CY 2011 - CY 2016 with a minimum of $1,500 damage or if an injury occurred. The data only includes crashes where the APD responded. Thus, crashes on interstates and/or where other agencies responded are not included. Additional GIS data were linked to the crash data to provide further context regarding traffic infrastructure and volume. To geocode the crashes, crash locations were ran through Google's geocode API. Many of the locations had to be edited due to invalid intersections, wrong streets entered, and misspellings. 100 crashes out of 9,281 crashes could not be geocoded.

## Definitions

Pedestrian Involved Crashes: Crashes that have at least one person listed as having a pedestrian involved and/or has a pedestrian action listed

Bicycle Involved Crashes: There is no way to fully delineate crashes that involved a bicycle. For these, APD provided a list of crash incident numbers that are listed as involving a bicycle.

Vehicle Only Crashes: Crashes that are not classified as pedestrian involved or bicycle involved crashes.

Killed or Seriously Injured (KSI) Crashes: Crashes involving at least one individual who died before the crash report was made or who suffered a 'bleeding/distorted member/transported' injury

High-risk Conditions and Situations: An environmental, vehicle, or individual characteristic that has a high number/proportion of KSI crashes as compared to other conditions. These do not equate to the cause of crashes, which the data does not capture.

For more information on these methods, see the full analysis report (pages 2-3).

## Description of Methods

The analysis process proceeded with two parts: a descriptive exploration and a statistical analysis.

1) Descriptive exploration of the data examined patterns in the data regarding the conditions during and individual factors of crashes. This process uncovered high-risk conditions and situations in Alexandria. Not shown in these results is analysis that did not lead to meaningful or actionable results.

2) Statistical analysis examined the impact of conditions independently and jointly on the probability a crash results in at least one KSI. A combination of significance tests (chi squared and analysis of variance) and logistic regressions were conducted.

- The significance tests point to factors that when present have more KSI crashes than expected. Yet, these tests do not consider other mitigating factors. The results of these tests can be seen in the full analysis report.

- The logistic model pinpoints conditions that have higher probability of being a KSI crash all else being equal. By controlling for other conditions present during a crash, mitigating factors are control for when looking at the impact of a condition.

All analysis was conducted by calendar year.

Counts found in this study are going to differ from other reports produced by the City, which rely on different data.

This analysis resulted in ten findings.

## Summary of Findings

1. Crashes and KSI risk has dropped since 2011; actions items for Vision Zero should be tested to ensure that they are effectively contributing to this trend.
2. There is a temporal pattern in crash volume and KSI risks.
3. There are corridors with elevated KSI risks.
4. Adverse environmental (weather, lighting, and road) conditions are high-risk conditions.
5. Certain road infrastructure may affects KSI risks.
6. Increased speed increases KSI risks.
7. Certain pedestrian paths of travel and locations create high-risk situations.
8. Motorcyclist and fixed object events are high-risk situations.
9. The young and old have distinct KSI risks.
10. Poor personal choices (lack of safety restraint or drinking) increase KSI risks.

## Data Recommendations

- Reduce errors and missing data.
- Accurately and consistently record the location of crashes.
- Track clearly the root cause of crashes.
- Collect more data on bicycle involved crashes.

For more details on this finding, refer to the full analysis report pages 12-15.

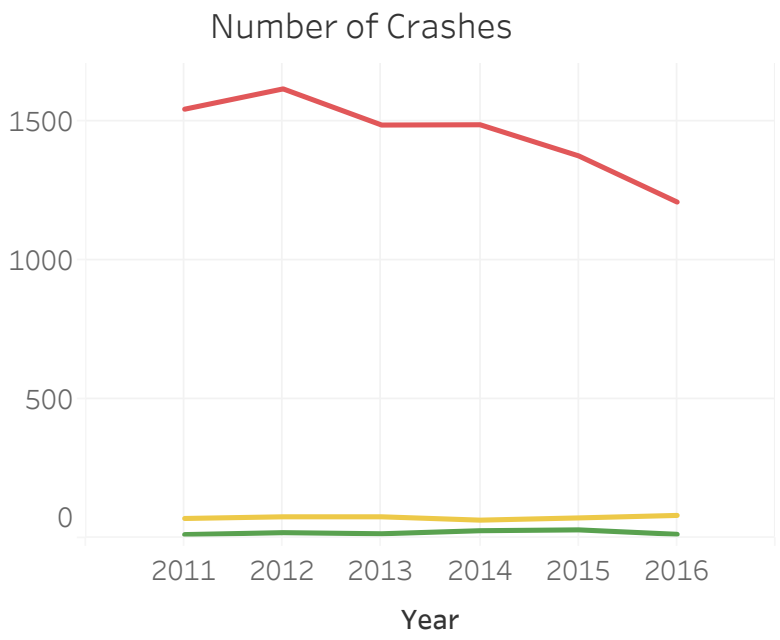
1. Crashes and KSI risk has dropped since 2011; actions items for Vision Zero should be tested to ensure that they are effectively contributing to this trend.

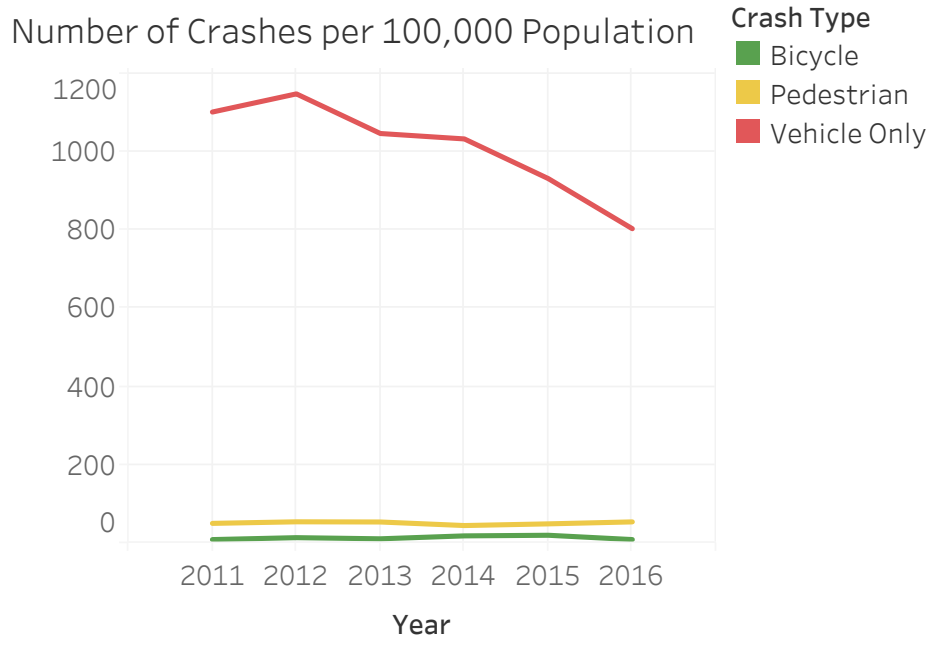
The number of vehicle only crashes has dropped through the years. Pedestrian involved crashes and bicycle involved crashes have not seen the same drop in numbers. Population changes do not appear to drive these changes. Population numbers come from Planning and Zoning.

# All Crashes

## Crash Count by Crash Type

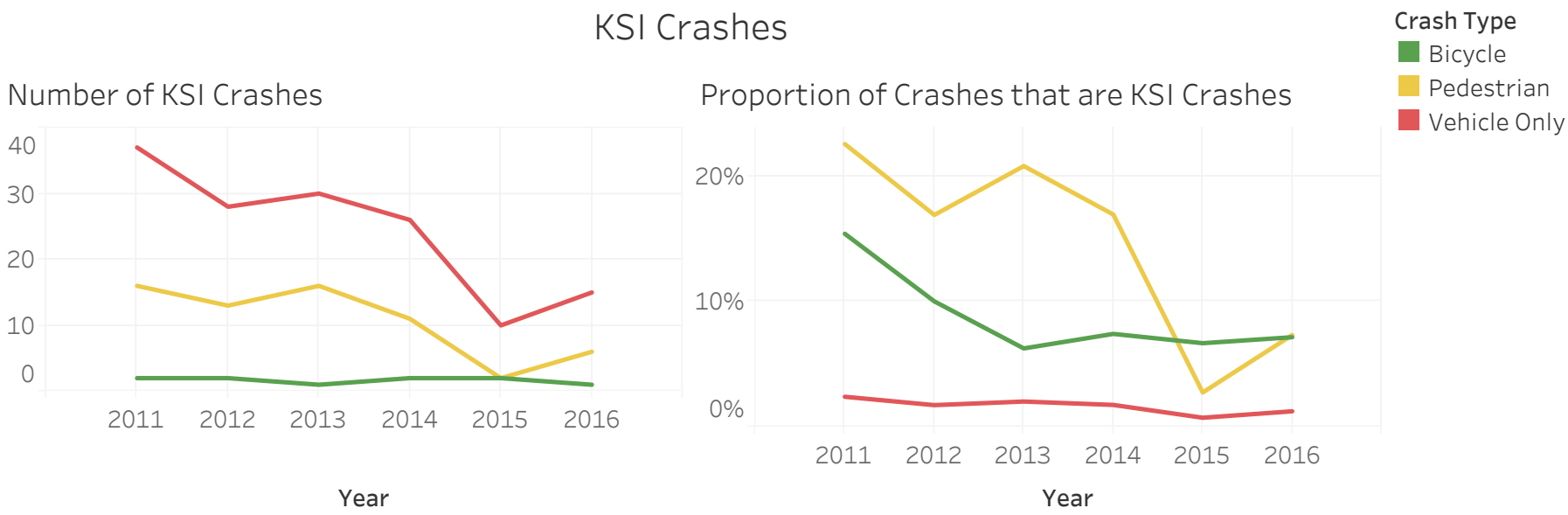
| Year | Bicycle | Pedestrian | Vehicle Only | Total Crashes | Previous Year Difference |
|---|---|---|---|---|---|
| 2011 | 13 | 71 | 1,543 | 1,627 | |
| 2012 | 20 | 77 | 1,616 | 1,713 | 5.29% |
| 2013 | 16 | 77 | 1,486 | 1,579 | -7.82% |
| 2014 | 27 | 65 | 1,487 | 1,579 | 0.00% |
| 2015 | 30 | 73 | 1,375 | 1,478 | -6.40% |
| 2016 | 14 | 82 | 1,209 | 1,305 | -11.71% |
| Grand Total | 120 | 445 | 8,716 | 9,281 | |



Shown here are KSI crashes only. While KSI crashes have decreased in 2015 for both pedestrian involved and vehicle only crashes, there was an increase in 2016 in both crash types. Overall, crashes have resulted in proportionally less KSI crashes. In 2016, the proportion that are KSI crashes increased slightly for bicycle involved and vehicle only crashes and by 4% increase for pedestrian involved crashes. Population changes do not appear to drive these changes. With this downward trend, action plans and future tracking should be tested to ensure that they are effectively contributing to this trend.

# KSI Crashes



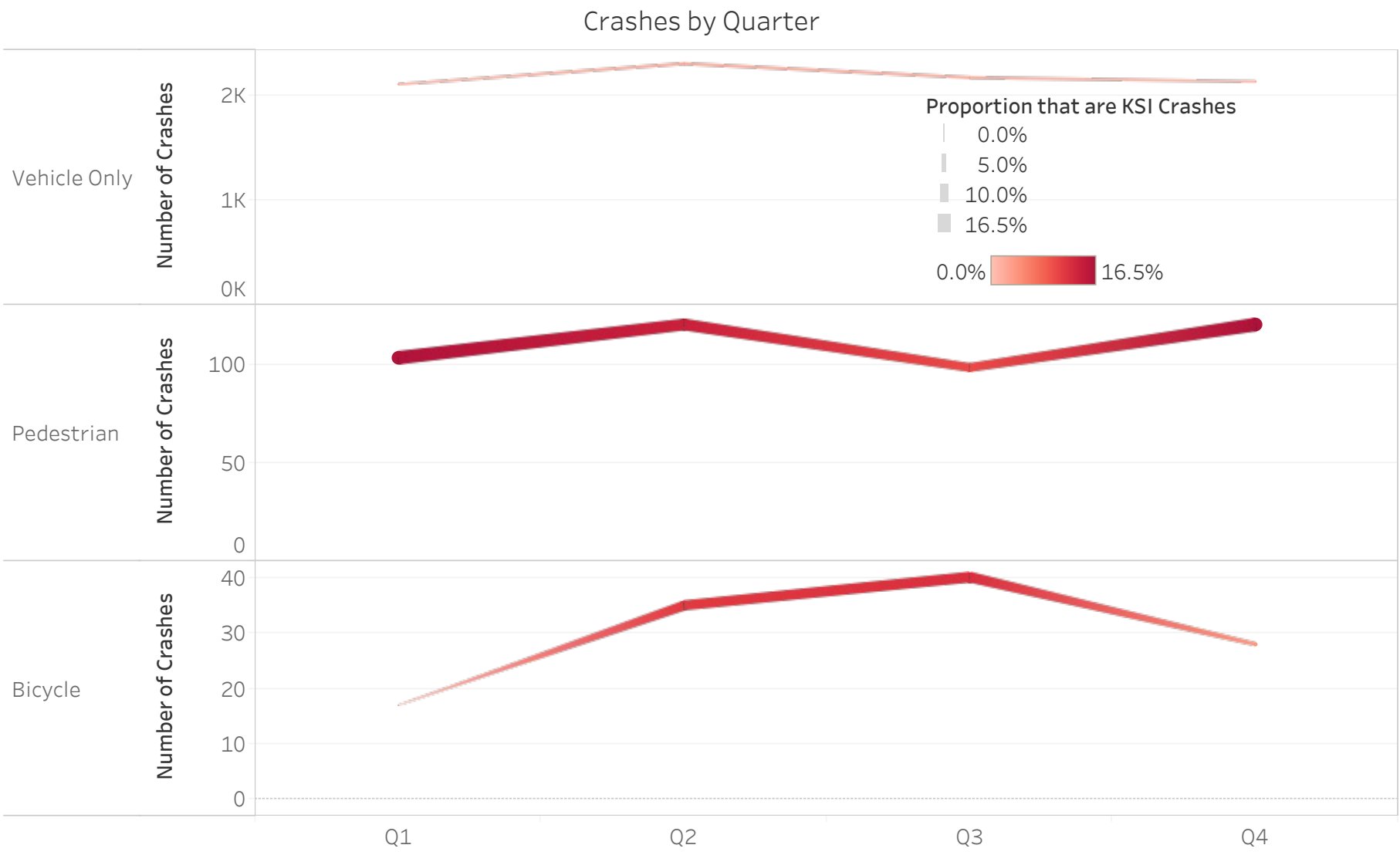

## KSI Crash Count by Crash Type

| Year | Bicycle | Pedestrian | Vehicle Only | Total KSI Crashes | Previous Year Difference |
|---|---|---|---|---|---|
| 2011 | 2 | 16 | 37 | 55 | |
| 2012 | 2 | 13 | 28 | 43 | -21.82% |
| 2013 | 1 | 16 | 30 | 47 | 9.30% |
| 2014 | 2 | 11 | 26 | 39 | -17.02% |
| 2015 | 2 | 2 | 10 | 14 | -64.10% |
| 2016 | 1 | 6 | 15 | 22 | 57.14% |
| Grand Total | 10 | 64 | 146 | 220 | |

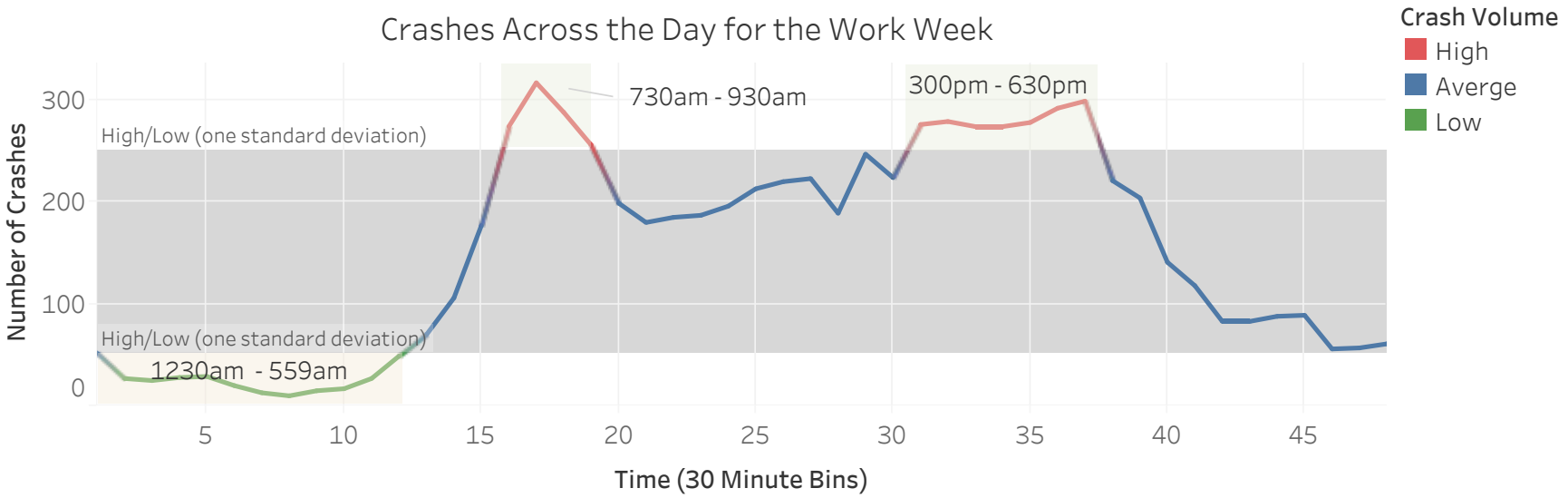
For more details on this finding, refer to the full analysis report pages 16-18.

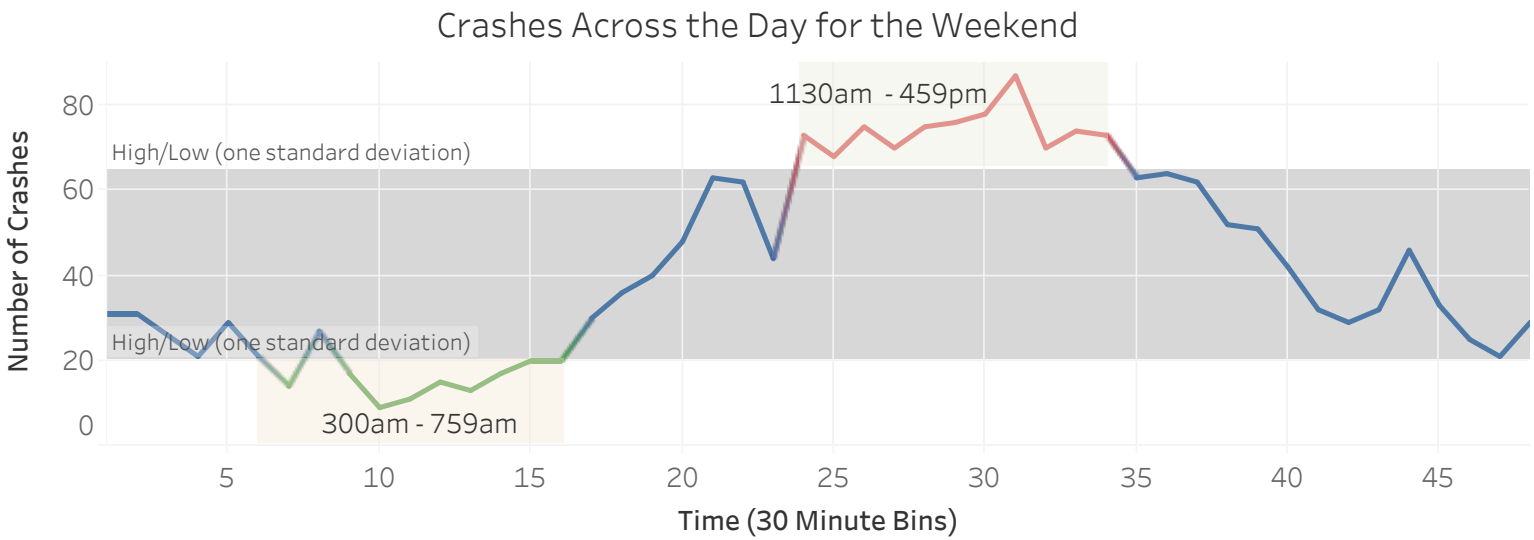
## 2. There is a temporal pattern in crash volume and KSI risks.

Examining the number of crashes and the proportion of crashes that are KSI by quarter allows for looking for seasonality effects (Q1: Winter; Q2: Spring; Q3: Summer; Q4: Fall). There is little seasonality for vehicle only crashes. Pedestrian involved crashes have larger numbers in Q2 (spring) and Q4 (fall). The proportion that are KSI shift from 16% in winter to 14%-10% in spring and summer, and increases back up in the fall to 17%. Bicycle crashes increase in both number and KSI proportion when nicer weather hits during spring and Q3 summer.



High crash volume is defined above one standard deviation; low crash volume is below one standard deviation. There is a pattern of crashes across the day that follows commuting patterns in the city and differs between the workweek and weekend. High crash volumes are seen during commuting hours with a slight decrease during the day. During the weekend, high crash volume starts much later and ends earlier. Low crash volumes are seen in the early mornings, but this low volume starts later during the weekend compared to the work week. Breaking down crash volume across the day by crash type revels similar workweek patterns with varying start and end times depending on the crash type. There is no such trends for KSI crashes.



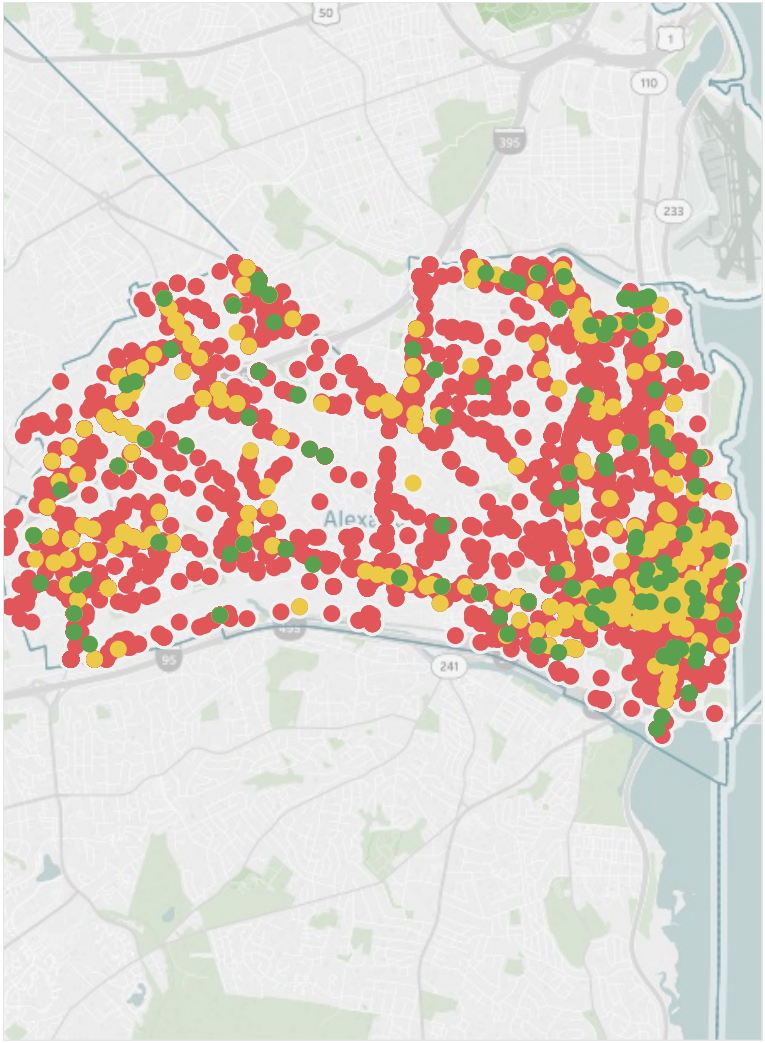



For more details on this finding, refer to the full analysis report pages 22-25.

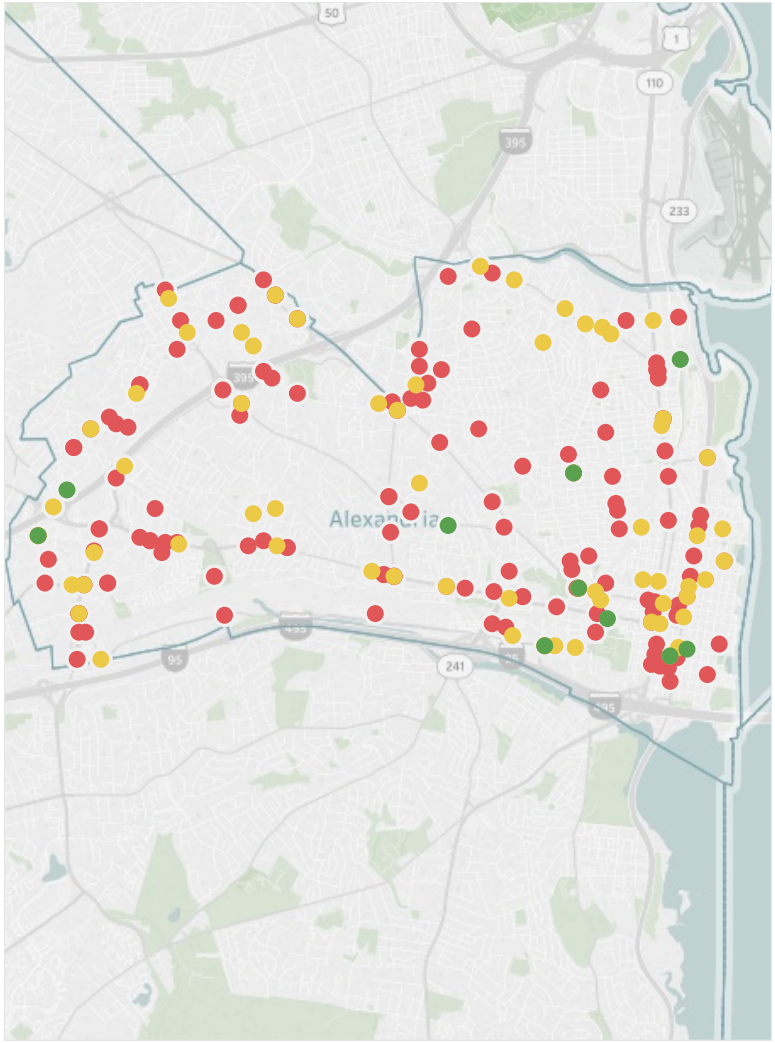
# 3. There are corridors with elevated KSI risks.

Crashes occur throughout the city. Breaking crashes down by type reveals that pedestrian involved crashes and bicycle involved crashes have higher percentages occurring in the Old Town area. Vehicle only crashes appear throughout the City, but the Old Town area has the highest density. The location of KSI crashes are concentrated in Old Town, West End and Fairlington/Bradlee areas. Corridors that seem to have higher percentages of KSI include the Duke Street, Washington Street, West Glebe Road, North Beauregard Street, Seminary Road, and Route 1. For more discussion on how the location of crashes were derived and potential errors in the locations, see the full analysis report.

## All Crashes




## KSI Crashes



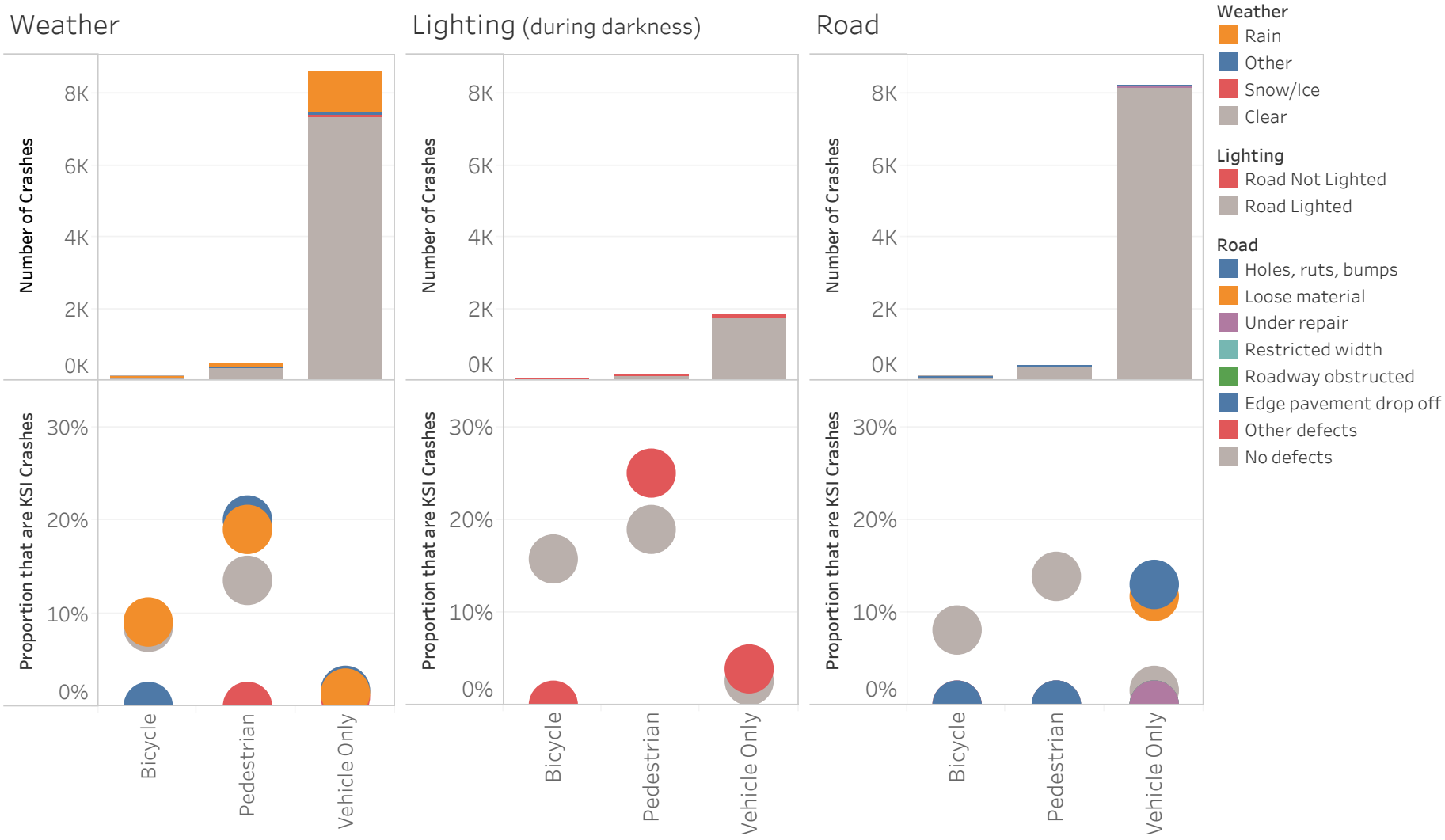

Crash Type
- Bicycle
- Pedestrian
- Vehicle Only

For more details on this finding, refer to the full analysis report pages 19-21.

4. Adverse environmental (weather, lighting, and road) conditions are high-risk conditions.

Breaking down crashes based on environmental conditions reveal high-risk environmental conditions. Pedestrian involved crashes that occur in rain or other adverse weather conditions excluding snow and bicycle involved crashes occurring in rain have high rates of KSI. The same is true for pedestrian involved or vehicle only crashes in non-lighted areas during darkness. For vehicle only crashes, crashes occurring on roads with loose material or holes, ruts, bumps are high-risk. See full analysis report for more discussion on potential errors with these data.

## Environmental Conditions



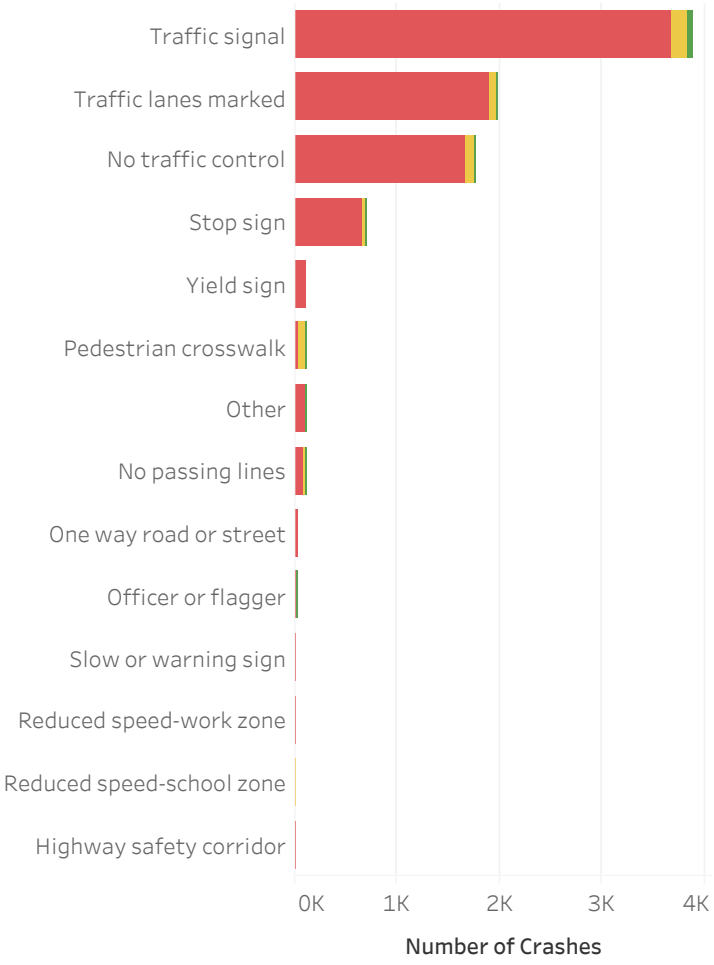
For more details on this finding, refer to the full analysis report pages 22-25.

## 5. Certain road infrastructure may affect KSI risks.

Crashes have listed a traffic control feature that was present at the site of the crash. The stated infrastructure was not necessarily the root cause, or even a large factor, of the crash. The data does not contain information on how the infrastructure impacted the crash and potential KSI (e.g., running a red light or making an unprotected left turn). Most crashes occur at locations with a traffic signal, traffic lanes marked, or no traffic signal. Pedestrian crosswalk, and no passing lanes have the high proportion of KSI. Officer or flagger also has a high KSI proportion but the total numbers are low.

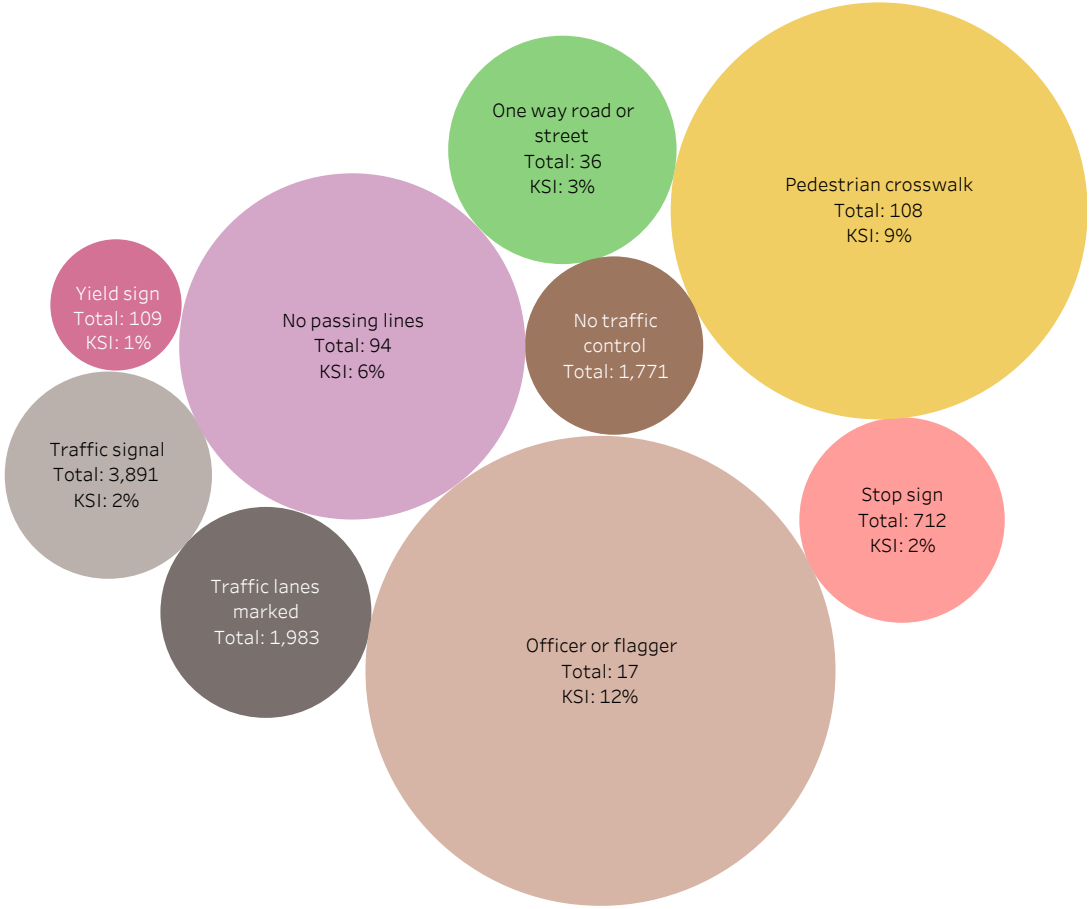
# Infrastructure Conditions

## Crash by Infrastucture Type




## Infrastructure Type and KSI

(Size based on Proportion of Crashes that are KSI)



For more details on this finding, refer to the full analysis report pages 26-30.

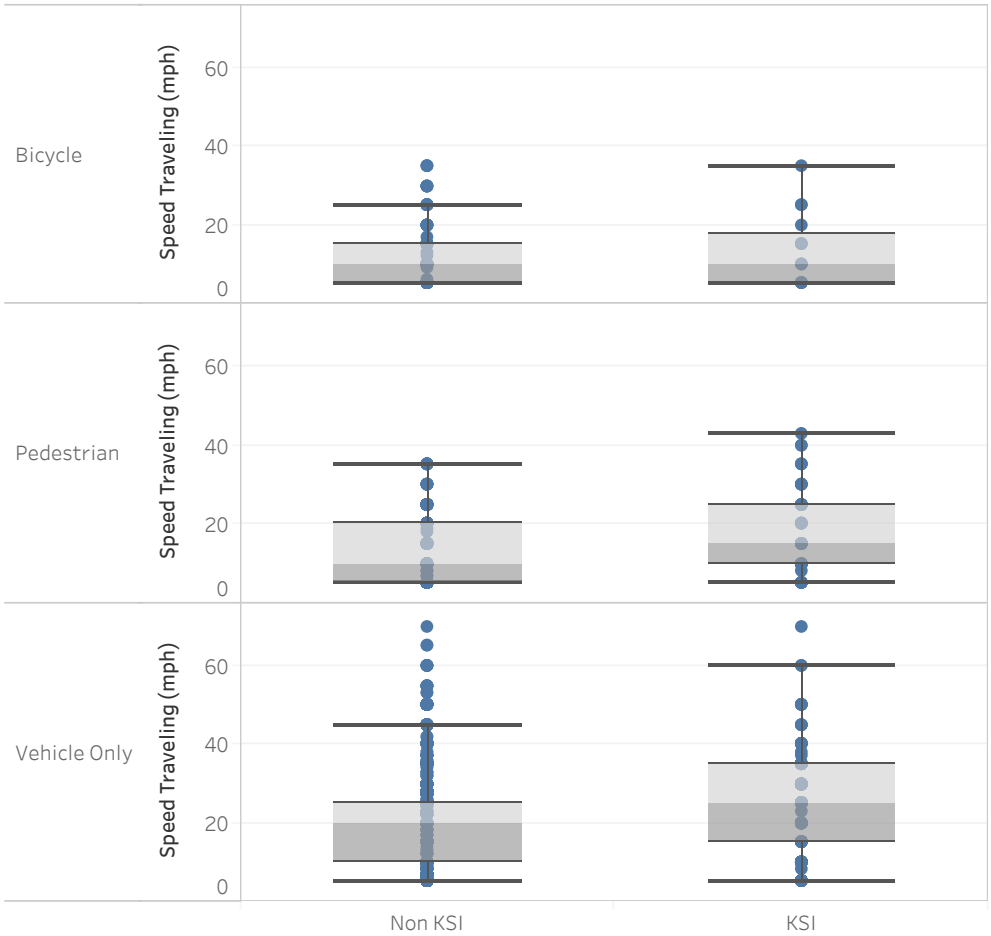
# 6. Increased speed increases KSI risks.

There is no major difference in the speeds in non KSI crashes vs KSI crashes. However, the median speed of vehicle only and pedestrian involved KSI crashes were higher. In the chart to the left, the box goes from the first to the third quartile. A line is drawn at the Q2, the median of the data. Two whiskers extend to the smallest and largest non-outlier. A large percentage of the vehicles involved in crashes were in speed limits 25 or 35 MPH (see full analysis report). If a vehicle was speeding during a pedestrian involved crash increased the probability of a KSI occurring (see model results in full analysis report). There is a significant and negative relationship between age and speed traveling. The older a driver is, the slower the speed traveling during a crash. A similar trend was relationship was found between speed limit and age. Vehicles that were parked, stopped in traffic, traveling less than 10 mph were excluded, had drivers 14 years old or younger, and were not listed as the primary or secondary vehicle involved.

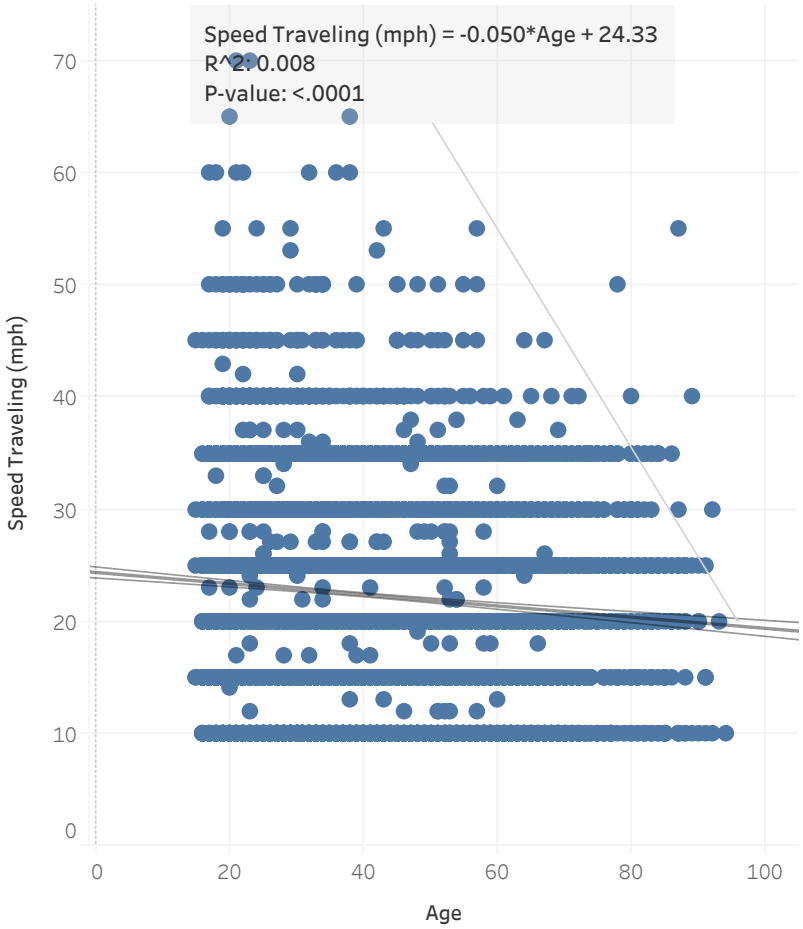
# Vehicle Speed

(Unit of Analysis: Vehicle)

## Speed Travling by KSI



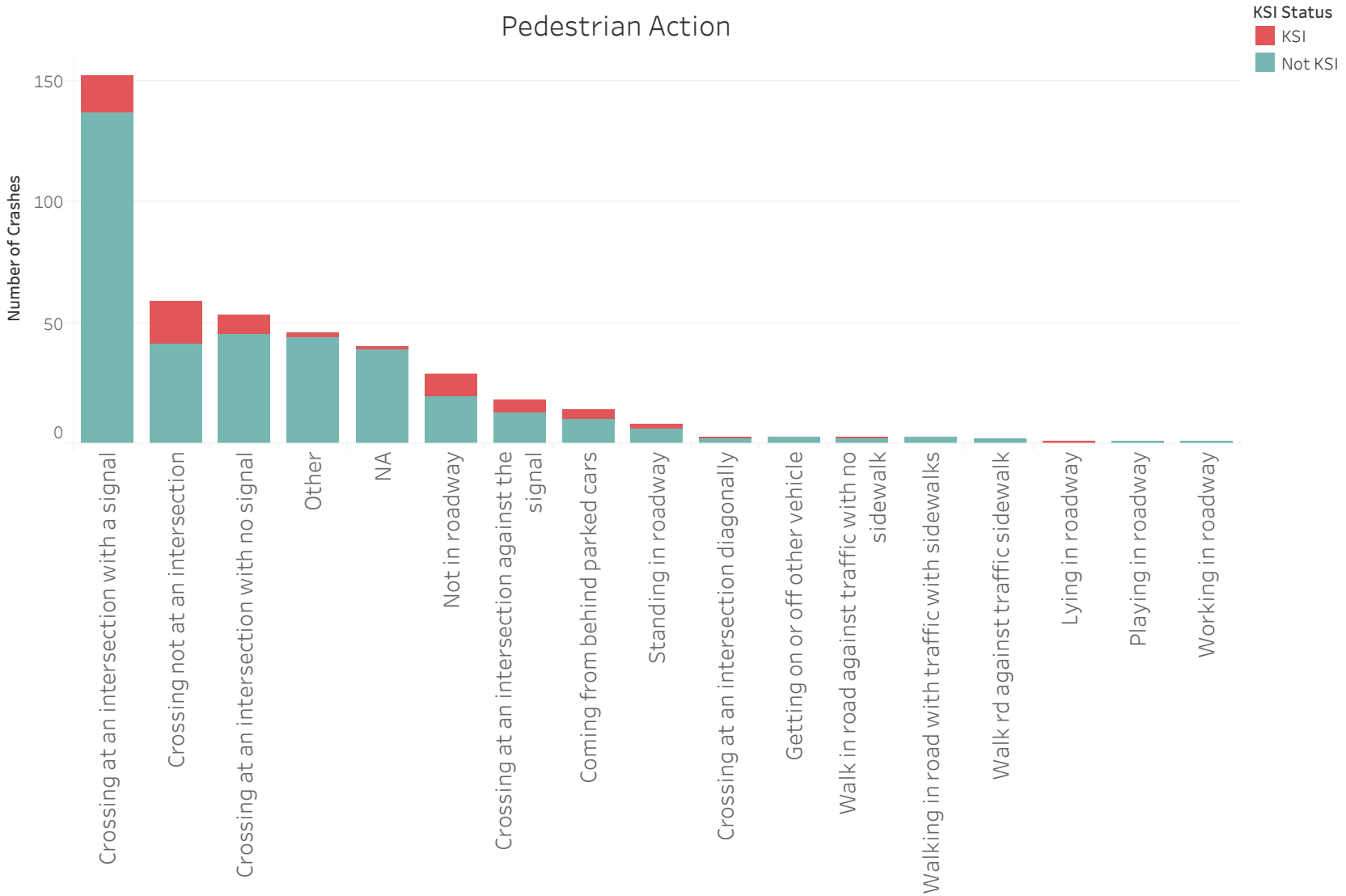

## Speed Traveling and Age of Driver



For more details on this finding, refer to the full analysis report pages 31-34.

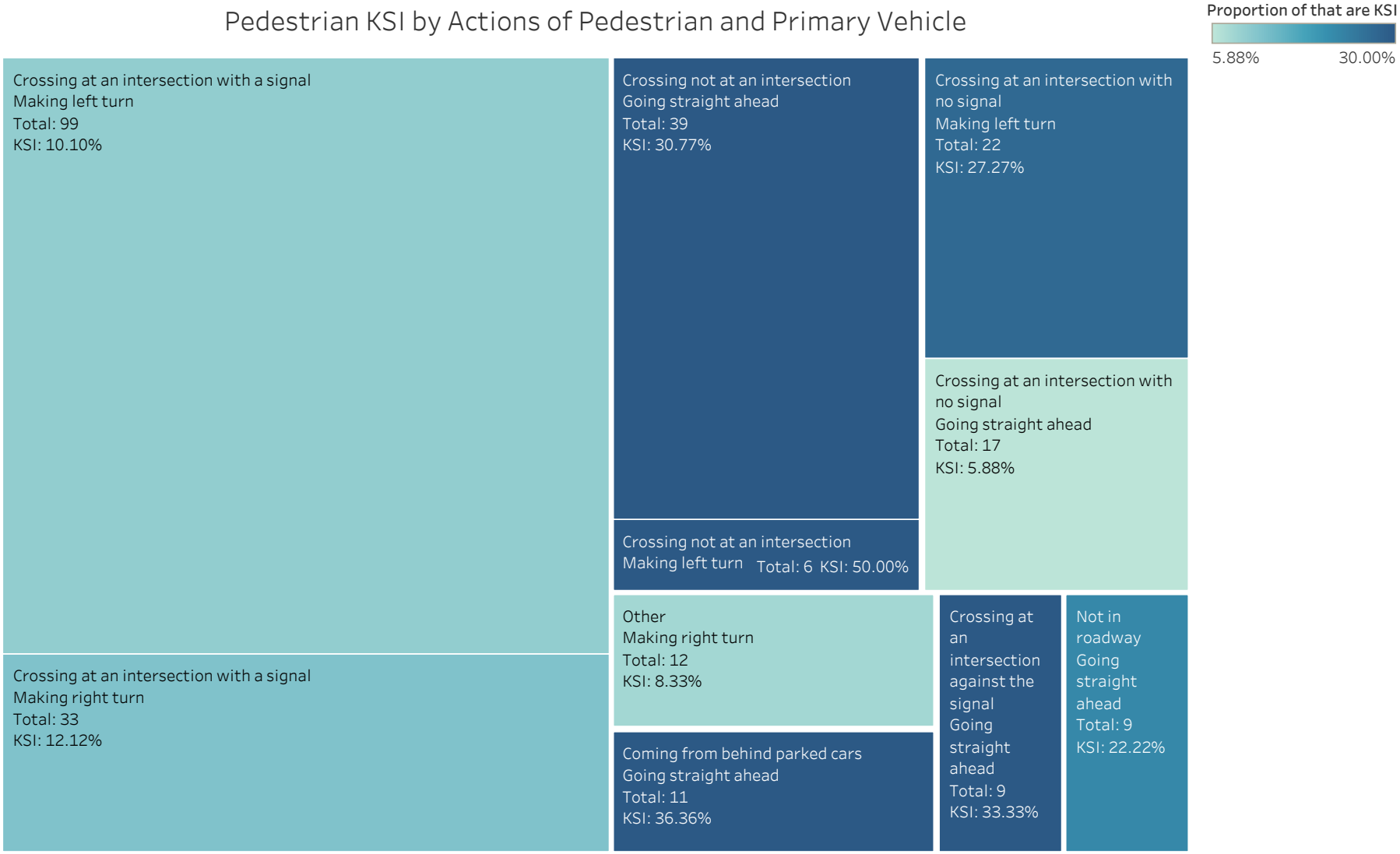
## 7. Certain pedestrian paths of travel and locations create high-risk situations.

It is difficult to examine the root cause of pedestrian involved crashes with the available data. The data include information on pedestrian action. The full context around why a pedestrian traveled in a particular way is unknown. Pedestrians crossing at an intersection occur most frequently in the data followed by crossing not at an intersection and crossing at an intersection with no signal. Most KSIs are occurring though with pedestrians crossing not at an intersection.



In examining both the actions of the pedestrian and the primary vehicle involved, the highest number of crashes occurred while the pedestrian is crossing at an intersection with a signal. Yet, the crashes with the highest proportion of KSI are those where the pedestrian is crossing not at an intersection, crossing at intersection with no signal and a vehicle is turning left, where the pedestrian is not crossing at an intersection and the vehicle is making a left, crossing at an intersection by against the signal, and when the pedestrian is coming from behind parked cars. Other conditions with high KSI proportions are low in frequency.

## Pedestrian KSI by Actions of Pedestrian and Primary Vehicle

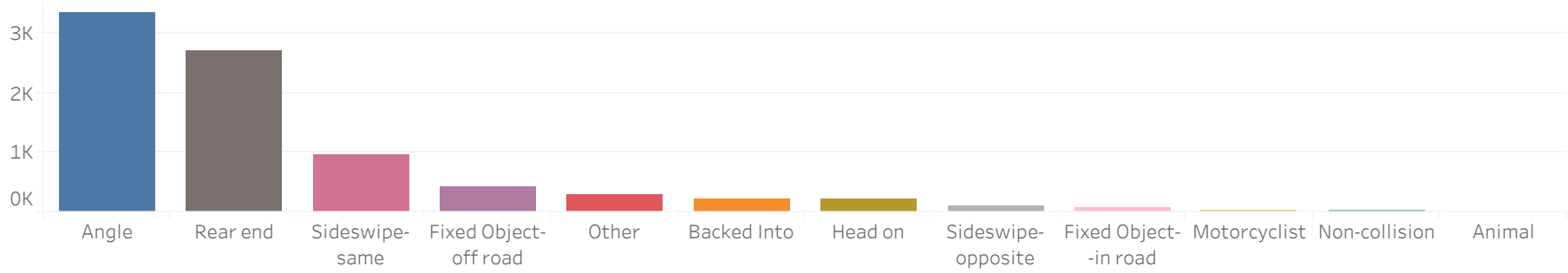


For more details on this finding, refer to the full analysis report pages 35-39.

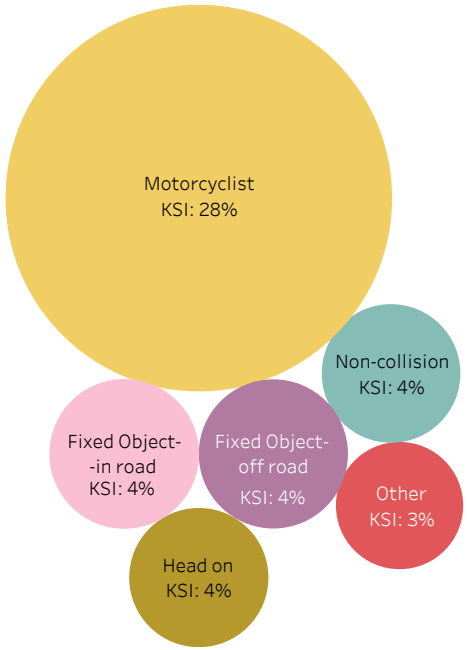
## 8. Motorcyclist and fixed object events are high risk situations.

Primary event describes the type of crash an incident was. This analysis is limited to only vehicle only as pedestrian crashes are often listed as a pedestrian event type. Just as with the environmental conditions, it is up to the officer on which even type to choose. While low in number, crashes involving a motorcyclist have high rates of KSI. Other events that are high-risk include head on, fixed object off road, and fixed object in road crashes. Adding adverse weather into the analysis (excluding event-weather combinations of only 1), reveals that fixed object of road and adverse weather conditions are a high-risk combination. When examining adverse conditions for motorcycle events, no trend emerge. However, this might be due to low frequency of motorcyclist events (36 crashes).

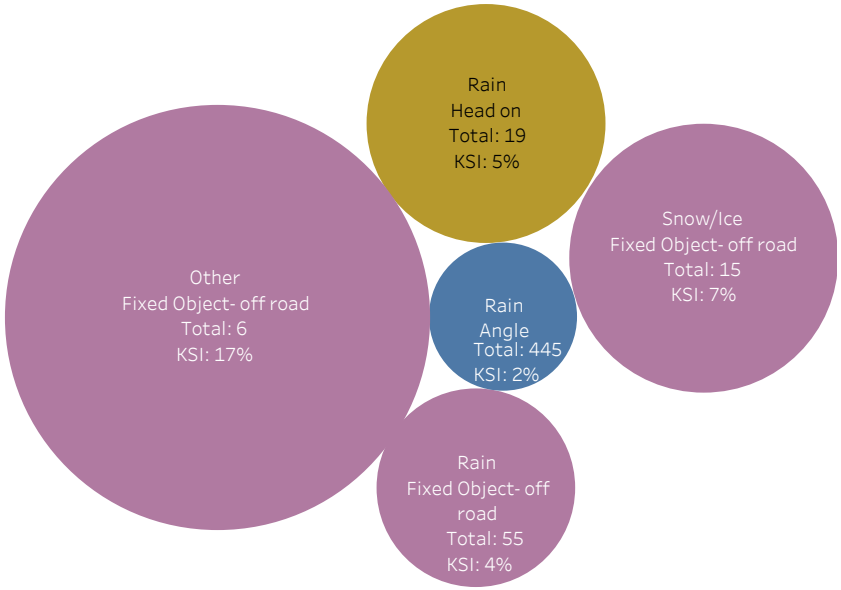
## Number of Crashes by Primary Crash Event




## Highest Propotion of KSI by Primary Event




## Proportion of KSI Crashes by Event and Weather

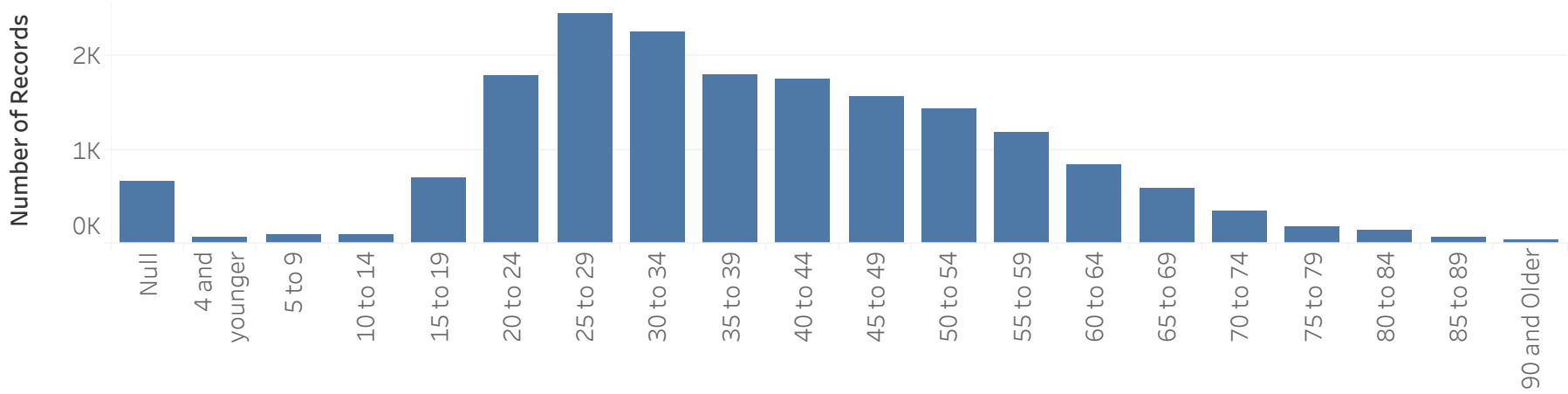


For more details on this finding, refer to the full analysis report pages 40-43.

# 9. The young and old have distinct KSI risks.

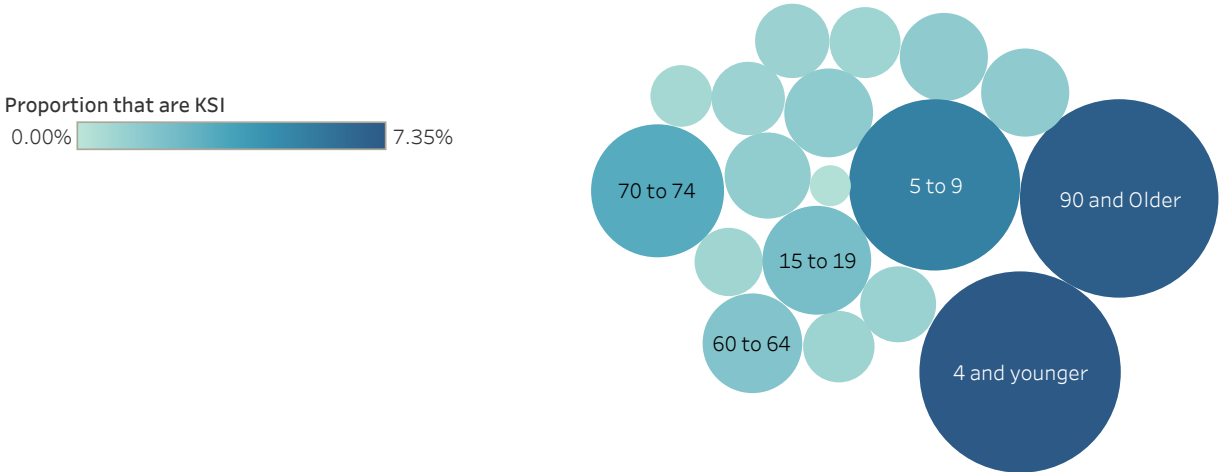
Looking at the ages of individual involved in a crash, a traditional bell-shaped curve is found where the young and old are low in numbers compared to the middle ages. However, the young and old age groups also have higher KSI proportions.

## Ages of Individuals Involved in a Crash



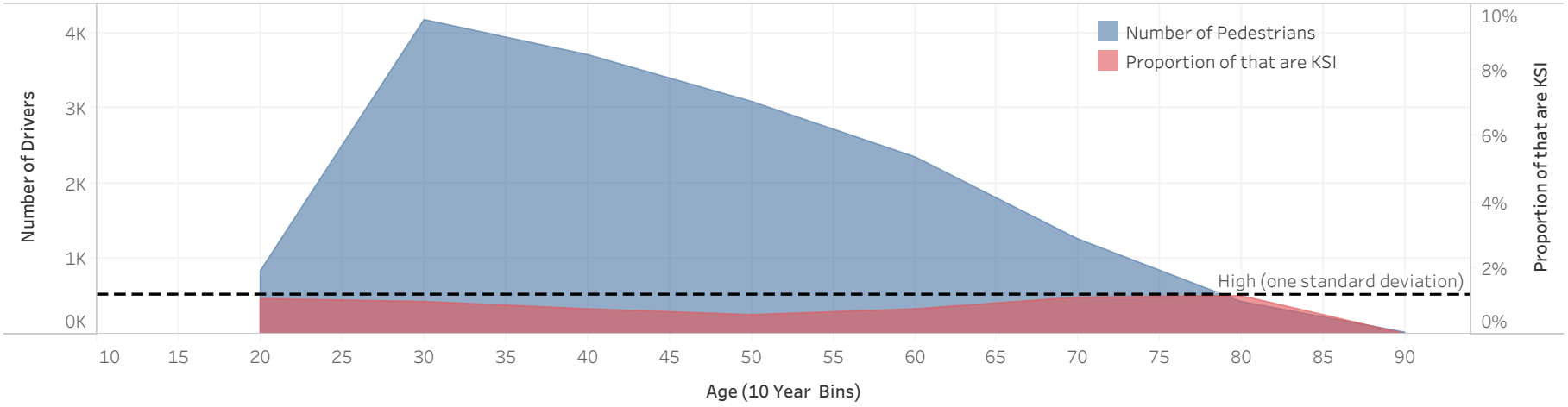

## Ages of Individuals Invovled in a Crash by KSI

(Size and color based on Proportion of Crashes that are KSI)

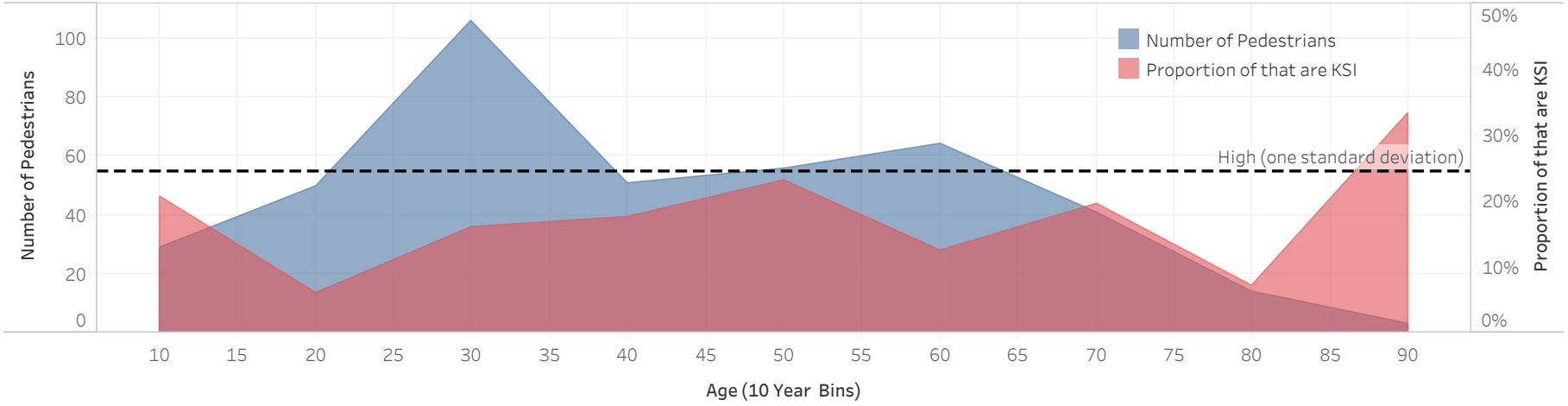


Most of the vehicle drivers and pedestrians involved in an accident are in their twenties or thirties. KSI risks rise for vehicle drivers over 70. However, these driver ages are also less common. KSI risks for pedestrians increase at 45 years old and after 70 years old, but they are very low in number. 15 to 24-year-old drivers are seen to be 'risky' drivers in past crash analysis. This age group did have high KSI proportions, especially when compared to middle aged (40-55) drivers.

## Age of Vehicle Drivers and KSI Proportion




## Age of Pedestrian and KSI Proportion



Young and old pedestrians are at a particular risk. There are more pedestrians involved in a crash that were 9 years old or younger during nicer weather (Q2 Spring and Q3 Summer). Nevertheless, the number of young pedestrians experiencing being KSI does not fluctuate across the year. Most of the young pedestrians involved in a crash were crossing an intersection with a signal or crossing not at an intersection. But crossing not at an intersection results in the most KSI for child pedestrian. Similar results were seen when looking at pedestrians 18 years and younger. Older pedestrians involved in a crash were crossing at an intersection with or without a signal.

## Path of Travel/Location by Quarter and KSI for Pedestrians 9 Years Old and Younger

| | | Crossing not at intersection | Crossing at an intersection with a signal | Coming from behind parked cars | Crossing at an intersection with no signal | NA | Not in roadway | Other | Getting on or off other vehicle | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Not KSI | Q1 | 1 | | | 2 | | | | | 3 |
| | Q2 | 2 | 3 | 2 | 1 | 2 | | 1 | | 11 |
| | Q3 | 1 | 3 | | | | 1 | 1 | 1 | 7 |
| | Q4 | | | 1 | | | | | | 1 |
| KSI | Q1 | 1 | | | | | 1 | | | 2 |
| | Q2 | 1 | | 1 | | | | | | 2 |
| | Q3 | 1 | | | | | | | | 1 |
| | Q4 | 1 | | | | | | | | 1 |
| Grand Total | | 8 | 6 | 4 | 3 | 2 | 2 | 2 | 1 | 28 |

## Path of Travel/Location and KSI for Pedestrians 65 Years Old and Older

| | Crossing at an intersection with a signal | Crossing at an intersection with no signal | Other | NA | Walk in road against traffic with no sidew.. | Crossing not at intersection | Coming from behind parked cars | Not in roadway | Standing in roadway | Crossing at an intersection against the si.. | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not KSI | 14 | 7 | 5 | 3 | 2 | 1 | | 1 | 1 | 1 | 35 |
| KSI | | 2 | | | 1 | 1 | 1 | | | | 5 |
| Grand Total | 14 | 9 | 5 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 40 |

For more details on this finding, refer to the full analysis report pages 44-47.

## 10. Poor personal choices (lack of safety restraint or drinking) increase KSI risks.

When looking at individual's use of safety restraints in vehicle only crashes, there are higher rates of KSI with individuals (whether driver or occupant) not using a safety restraint.Regarding alcohol use, drinking does increase KSI risk as compared to those who had not been drinking.

# Drinking and Safety Restraints

## Alcohol Use

| | Bicycle | Pedestrian | Vehicle Only |
|---|---|---|---|
| Drinking | 8 | 38 | 440 |
| Had not been drinking | 202 | 737 | 14,754 |
| NA & Unknown | 17 | 85 | 1,732 |

Proportion of that are KSI

0.7% 9.3%

## Safety Restraint Use by Person Type

| | Vehicle Driver | Vehicle Occupant |
|---|---|---|
| No restraint used | 140 | 64 |
| Restraint used | 15,829 | 893 |

Proportion of that are KSI

0.0% 12.5%

For more details on these recommendations, refer to the full analysis report page 48.

## Data Recommendations

This analysis was limited due to data availability and quality. OPA developed four recommendations to improve data quality:

- Reduce errors and missing data. The data used for the analysis were collected during an older record management system (RMS) at APD. This RMS could not be directly linked to the TREDS software, which meant that TREDS reports were printed out and manually entered at a later point. This created both a lag in data availability and more errors. The new RMS eliminates this extra step by directly linking to the TREDS software. This directly link should be fully exploited so that additional data can be attached to the crash data and data quality promoted.

- Accurately and consistently record the location of crashes. Many of the crash locations had to be edited to be geocoded due to invalid intersections, wrong streets, or had additional data attached (e.g., ramp). These errors meant that Google's Geocode API had to be used to geolocate the crashes over internal GIS geocoding software. When Google cannot find an exact location match, it will estimate a nearby location. This hurts the trustworthiness of attached GIS data. There needs to be a consistent way to indicate where crashes and whether they occurred at intersections, midblock, or on ramps. These problems are currently being addressed with the new RMS system.

- Track clearly the root cause of crashes. The data does not allow for looking at the root cause of crashes. Without such data, assumptions must be made about the connection between high-risks conditions and situations to the causes of crashes. The National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) database provides a good illustration on how this might look like.

- Collect more data on bicycle involved crashes . Such data needs to include a standard way to indicate: incidents that involved a bicycle, if an individual involved was a bicycylist versus vehicle driver/occupant, and the type of bicyclist maneuver (e.g. riding in bike lane, turning left at stop sign not in a bike lane).

# Data Description for Crash Analysis

## Crash level data

Total number of crashes: 9,281

Note: Calculated fields are highlighted in blue; Fields attached through GIS are highlighted in orange

| Variable Name | Description | Percent of Crashes Missing Data |
|---|---|---|
| Incident Number | Unique identifier for crashes | 0% |
| Crash Type | Describes the type of crash an incident was.<br><br>*Pedestrian Involved Crashes:* Crashes that have at least one person listed as a pedestrian involved and/or has a pedestrian action listed.<br><br>*Bicycle Involved Crashes:* There is no way to fully delineate crashes that involved a bicycle. For these crashes, the Alexandria Police Department provided a list of incident numbers from their RMS that are listed as involving a bicycle involved crashes.<br><br>*Vehicle Only Crashes*: Crashes that are not classified as pedestrian or bicycle involved. | 0% |
| ACCIDTT | Date of crash from which month and year are derived | 0% |
| ACCIDTM | Time of crash in 24hr format | 0% |
| ACCIDDAY | Day of week crash occurred | 0% |
| Main Event | Describes the primary event for crash. Derived from EVENT_1 in original data. Many pedestrian involved crashes were listed as pedestrian under EVENT_1. Thus, pedestrian involved crashes do not have Main Event listed.<br><br>Angle, Animal, Backed Into, Bicyclist, Fixed Object- in road, Fixed Object- off road, Head on, Motorcyclist, Non-collision, Other Pedestrian, Rear end, Sideswipe- opposite direction, Sideswipe- same direction | 3% |

| | | |
|---|---|---|
| External light | Describes the external lighting condition for crashes that occurred in darkness. | 79% |
| Weather | Describes weather conditions during a crash. Derived from A_WEATHER in original data.<br><br>Rain, Snow/Ice, Other, Clear | 1% |
| Road Effect | Describes the road conditions a crash occurred on (only choice allowed).<br><br>Edge pavement drop off; Holes, ruts, bumps, Loose material; Restricted Width; Roadway obstructed; Slick pavement; Under repair; No defects | 3% |
| Traffic Control | Describes the type of traffic control that was present during a crash (only choice allowed).<br><br>Highway safety corridor, no passing lines, no traffic control, officer or flagger, one way road or street, pedestrian crosswalk, reduced speed-school zone, reduced speed work zone, slow or warning sign, stop sign, traffic lanes marked, traffic signal, yield sign, other | 5% |
| Injury Crash | Flag if at least one individual was injured in the crash. Derived from N_INJURY. Injury is defined as having one of the following injuries: died before crash report was made; bleeding/distorted member/transported; bruises/abrasions/swelling/limping; or no visible/pain/loss consciousness. | 0% |
| KSI Crash | Flag if at least one individual was killed or seriously injured (KSI) in the crash. Derived from N_INJURY. KSI is defined as having one of the following injuries: died before crash report was made or bleeding/distorted member/transported. | 0% |
| Location | Intersection or exact address of crash location | 0% |
| Latitude / Longitude | The coordinates of a crash location. Data comes from Google Geocode API, which the location of crashes was run through. These coordinates where used to merge on additional data by GIS. | 1% |
| Street Type | Describes the type of street a crash occurred on. Derived from STREETCLASSIFICATION.<br><br>Local neighborhood road, rural road, city street; Secondary road; Primary road; Other | 1% |

| | | |
|---|---|---|
| Transit Route | Flag if a crash occurred on a bus transit route | 1% |
| One-way | Flag if a crash occurred on a one-way street | 1% |
| Divided Street | Flag if a crash occurred on a street divided by a median | 1% |
| Number of Lanes | Number of traffic lanes on street where a crash occurred | 4% |
| AADT 2015 | 2015 average annual daily traffic on the street segments a crash occurred on. | 16% |

## Individual Level: Vehicle Only Crashes

Total number of individuals: 16,926

Note: Calculated fields are highlighted in blue

| Variable Name | Description | Percent of Individuals Missing Data |
|---|---|---|
| Incident Number | Unique identifier for crashes | 0% |
| Vehicle Sequence | Describes the sequence that a vehicle was in during a crash. First in the sequence is primary at fault. Derived from SEQUENCE. | 0% |
| Speed Traveling | Describes the speed (mph) a vehicle was traveling during a crash. | 26% |
| Speed Limit | Describes the posted speed limit the vehicle was in during crash. | 4% |
| Speeding Flag | Flag if there was at least one vehicle had a Speed Traveling higher than Speed Limit | 26% |
| Maneuver Type | Describes the maneuver the vehicle was doing during a crash.<br><br>Backing, Changing lanes, Entering street from parking lot, Going straight ahead, Making left turn, Making right turn, Making U-turn, Merging into traffic lane, Other, Parked, Passing<br>Ran off road – left, Ran off road – right, Slowing or stopping, Starting from parked position<br>Starting in traffic lane, Stopped in traffic lane | 1% |
| Maneuver combo | Describes the maneuver of the primary and secondary vehicle involved during a crash. Derived from Maneuver type. | 1% |
| Drinking | A flag on whether the individual was drinking before Crash. Derived from N ALCOHOLUSE. | 0% |

| | | |
|---|---|---|
| KSI | Flag if individual was killed or seriously injured (KSI) in the crash. Derived from N_INJURY. KSI is defined as having one of the following injuries: died before crash report was made or bleeding/distorted member/transported. | 1% |
| Safety Restraint | Flag if individual used a safety restraint. Derived from N_SAFETY. | 5% |
| Age | Age of individual | 3% |
| Person Type | Describes the role the individual played in crash. Derived from N PERSONTYPE and N_PEDESTRIAN.<br><br>Vehicle Driver, Vehicle Occupant | 0% |

## Individual Level: Pedestrian Involved Crashes

Total number of individuals: 860

Note: Calculated fields are highlighted in blue

| Variable Name | Description | Percent of Individuals Missing Data |
|---|---|---|
| Incident Number | Unique identifier for crashes | 0%summary |
| Vehicle Sequence | Describes the sequence that a vehicle was in during a crash. First vehicle in the sequence is primary at fault. Pedestrians are listed as second in the sequence even is at fault. Derived from SEQUENCE. | 0% |
| Speed Traveling | Describes the speed (mph) a vehicle was traveling. | 17% of non-pedestrians |
| Speed Limit | Describes the posted speed limit the vehicle was in during crash. | 37% |
| Speeding Flag | Flag if there was at least one vehicle had a Speed Traveling higher than Speed Limit | 5% of non-pedestrians |
| Primary Vehicle Maneuver | Describes the maneuver the primary vehicle was doing during a crash.<br><br>Backing, Changing lanes, Entering street from parking lot, Going straight ahead, Making left turn, Making right turn, Making U-turn, Merging into traffic lane, Other, Parked, Passing<br>Ran off road – left, Ran off road – right, Slowing | 8% |

| | | |
|---|---|---|
| | or stopping, Starting from parked position Starting in traffic lane, Stopped in traffic lane | |
| Pedestrian Action | Describes the action of a pedestrian during a crash.<br><br>Coming from behind parked cars, Crossing at intersection diagonally, Crossing at intersection with no signal, Crossing at intersection with signal, Crossing not at intersection rural, Crossing not at intersection urban, Getting on or off other vehicle, Lying in roadway, Not in roadway, Other, Playing in roadway, Standing in roadway, Walk along road against traffic no sidewalk, Walk along road against traffic sidewalk, Walking along road with traffic sidewalks, Working in roadway, Crossing at intersection against signal | 9% of pedestrians |
| Drinking | A flag on whether the individual was drinking before Crash. Derived from N ALCOHOLUSE. | 10% |
| KSI | Flag if individual was killed or seriously injured (KSI) in the crash. Derived from N_INJURY. KSI is defined as having one of the following injuries: died before crash report was made or bleeding/distorted member/transported. | 9% |
| Age | Age of individual | 6% |
| Person Type | Describes the role the individual played in a crash. Derived from N PERSONTYPE and N_PEDESTRIAN.<br><br>Vehicle Driver, Vehicle Occupant, Pedestrian | 0% |

# Vehicle, Bike, and Pedestrian Crash Analysis

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August 4, 2017

## How can the City of Alexandria reduce killed or seriously injured crashes to zero?

### Data:

To answer this question, OPA analyzed crash data from the Alexandria Police Department (APD). These data originated from Traffic Records Electronic Data Systems (TREDS). TREDS centralizes Virginia's crash data and is designed to be a 'one-stop-shop' to provide accurate, timely and detailed crash information for analysis and reporting. The received data includes information on all crashes that occurred on Alexandria city streets between CY 2011 - CY 2016 with a minimum of $1,500 damage or if an injury occurred. The data only includes crashes where the APD responded. Thus, crashes on interstates and/or where other agencies responded are not included. Additional GIS data were linked to the crash data to provide further context regarding traffic infrastructure and volume. To geocode the crashes, crash locations were ran through Google's geocode API. Many of the locations had to be edited due to invalid intersections, wrong streets entered, and misspellings. 100 crashes out of 9,281 crashes could not be geocoded. Missing data is a significant problem in the data and limits analysis. It is not known whether missing data are missing at random or if there are underlying reasons some data are missing.

### Definitions:

Pedestrian Involved Crashes: Crashes that have at least one person listed as having a pedestrian involved and/or has a pedestrian action listed

Bicycle Involved Crashes: There is no way to fully delineate crashes that involved a bicycle. For these, APD provided a list of crash incident numbers that are listed as involving a bicycle.

Vehicle Only Crashes: Crashes that are not classified as pedestrian involved or bicycle involved crashes.

Killed or Seriously Injured (KSI) Crashes: Crashes involving at least one individual who died before the crash report was made or who suffered a 'bleeding/distorted member/transported' injury

High-risk Conditions and Situations: An environmental, vehicle, or individual characteristic that has a high number/proportion of KSI crashes as compared to other conditions. These do not equate to the cause of crashes, which the data does not capture.

## Description of Methods

The analysis process proceeded with two parts: a descriptive exploration and a statistical analysis.

1) Descriptive exploration of the data examined patterns in the data regarding the conditions during and individual factors of crashes. This process uncovered high-risk conditions and situations in Alexandria. Not shown in these results is analysis that did not lead to meaningful or actionable results.

2) Statistical analysis examined the impact of conditions independently and jointly on the probability a crash results in at least one KSI. A combination of significance tests (chi squared and analysis of variance) and logistic regressions were conducted.

- The significance tests point to factors that when present have more KSI crashes than expected. Yet, these tests do not consider other mitigating factors.

- The logistic model pinpoints conditions that have higher probability of being a KSI crash all else being equal. By controlling for other conditions present during a crash, mitigating factors are control for when looking at the impact of a condition.

All analysis was conducted by calendar year.

* Counts found in this study are going to differ from other reports produced by the City. Crash data are entered once the investigation is closed. For more complex crashes, there can be a significant gap between when a crash occurred and when the data enters TREDS. This means that data pulled for that period will differ depending on when the two data were executed in relation to the crash and investigation. The report Alexandria Fire Department Response to Pedestrians Struck and Bicycle Crashes by the Alexandria Health Department used data on Alexandria Fire Department (AFD) responses to pedestrians struck and data from the Virginia Office of the Chief Medical Examiner. While there is overlap between the data, TREDS data will not include all crashes listed in the AFD data as police are not called or are required for every incident.

## Statistical Analysis Notes

For the significance tests, chi square tests were conducted unless the condition is numeric (speed limit, number lanes, travel density, age) where analysis of variance tests were conducted. For those that had low frequency (<10 per a cell in the contingency table), p-values were computed using Monte Carlo simulation based on 2,000 replicates. Significance is calculated at the 95% (or p<.05) level.

The logistic model pinpoints conditions that have higher probability of being a KSI crash all else being equal. By controlling for other conditions present during a crash, mitigating factors are control for when looking at the impact of a condition. Significance is calculated at the 95% (or p<.05) level. Boardlinge significance is calculated at the between the 94% to 90% levels. These are listed as there might be a data reason why significance drops rather than something observed.

Formula of Vehicle Only Logit: KSI Status ~ Year + Adverse Light * Speeding + Adverse Weather * Speeding + Adverse Road * Speeding +Traffic Control: Speed Zone * Speeding + Traffic Control: Warning Sign * Traffic Control: Traffic Signal * Speeding + Traffic Control: Other * Speeding + Traffic Control: Cross Walk * Speeding + Traffic Control: No Control * Speeding + Event: Side Sweep * Speeding +Event: Rear End * Speeding + Event: Motorcyclist * Speeding + Event: Other * Speeding +Event: Head On * Speeding +Event: Fixed Object * Speeding + Event: Backed Into * Speeding + Event: Angle * Speeding + Street Type: Other * Speeding + Street Type: Other Primary * Speeding + Street Type: Other Secondary * Speeding + Transit Route *Speeding + One-way Street * Speeding + Divided Street * Speeding + Number of Lanes * Speeding + Speed Limit * Speeding + Travel Density * Speeding + Drinking + Speeding + Youngest Driver Age * Speeding

Formula of Pedestrian Inolved Logit: KSI Status ~ Year + Adverse Light + Adverse Weather + Adverse Road + Traffic Control: Signal + Traffic Control: Cross Walk + Traffic Control: No Control + Traffic Control: Special Speed Zone + Street Type: Other + Street Type: Primary + Street Type: Secondary + Transit Route + One Way Street + Divided Street + Number of Lanes + Speed Limit + Travel Density + Drinking + Age of Youngest Pedestrian + Pedestrian Action: Other + Pedestrian Action: Coming from Behind Parked Vehicles + + Pedestrian Action: Not in Roadway + Pedestrian Action: Crossing Diagonally + Pedestrian Action: Crossing Not at an Intersection + Pedestrian Action: Crossing with no Signal + Pedestrian Action: Crossing With a Signal + Pedestrian Action: Crossing Against the Signal + Was a Vehicle Involved Speeding

Bicycle Involved Logit was not significantly better than a basic model of KSI crashes. (Results are not shown)

A positive relationship: the appearance of the condition or the larger the condition leads to more KSI crashes observed than expected (significance tests) or a higher probability of KSI (logistic model).

This analysis resulted in ten findings. Development action items for the Vision Zero action plan need to address these areas to help reduce fatal or seriously injury crashes in Alexandria.

## Summary of Findings

1. Crashes and KSI risk has dropped since 2011; Actions items for Vision Zero should be tested to ensure that they are effectively contributing to this trend.
2. There is a temporal pattern in crash volume and KSI risks.
3. There are corridors with elevated KSI risks.
4. Adverse environmental (weather, lighting, and road) conditions are high-risk conditions.
5. Certain road infrastructure affects KSI risks.
6. Increased speed increases KSI risks.
7. Certain pedestrian paths of travel and locations create high-risk situations.
8. Motorcyclist and fixed object events are high-risk situations.
9. The young and old have distinct KSI risks.
10. Poor personal choices (lack of safety restraint or drinking) increase KSI risks.

## Data Recommendations

- Reduce errors and missing data.
- Accurately and consistently record the location of crashes.
- Track clearly the root cause of crashes.
- Collect more data on bicycle involved crashes.

## Key Next Steps

- Finalize this draft.
- Develop action items focused on findings above.
- OPA to develop indicators and dashboard.

1. Crashes and KSI risk has dropped since 2011; Actions items for Vision Zero should be tested to ensure that they are effectively contributing to this trend.

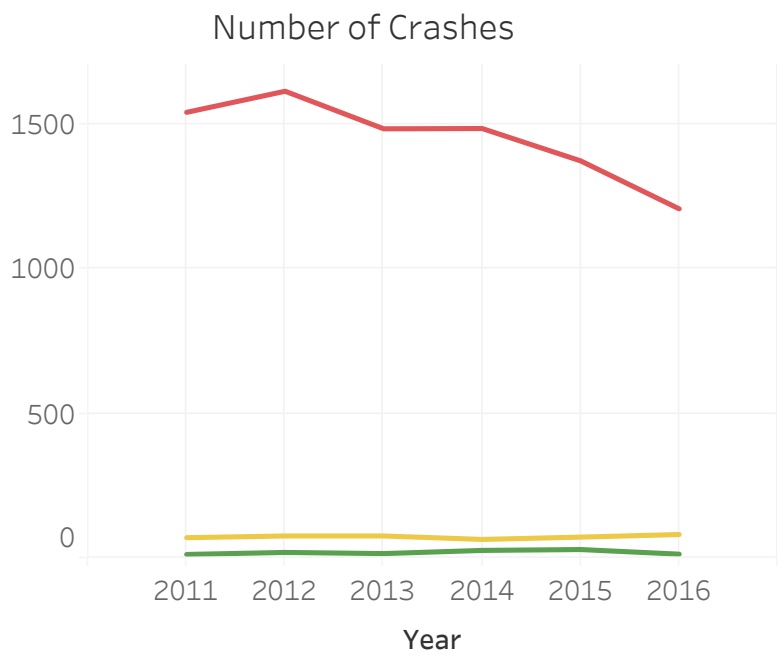
The number of vehicle only crashes has dropped through the years. Pedestrian involved crashes and bicycle involved crashes have not seen the same drop in numbers. Population changes do not appear to drive these changes. Population numbers come from Planning and Zoning.

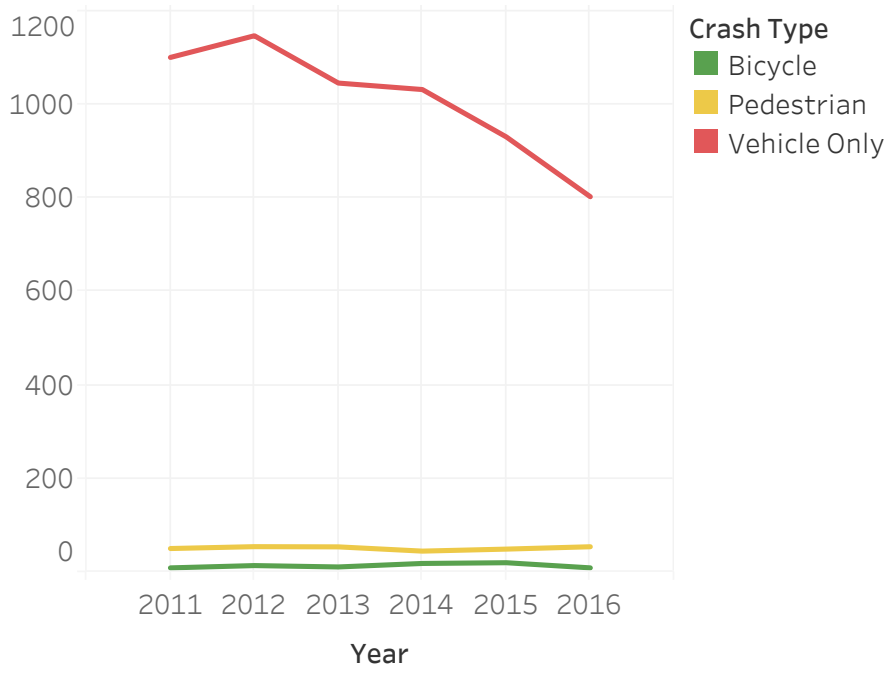
# All Crashes

| Total KSI Crashes | Previous Year Difference |
|---|---|
| 1,627 | |
| 1,713 | 5.29% |
| 1,579 | -7.82% |
| 1,579 | 0.00% |
| 1,478 | -6.40% |
| 1,305 | -11.71% |
| **9,281** | |

## Crash Count by Crash Type

| Year | Bicycle | Pedestrian | Vehicle Only |
|---|---|---|---|
| **2011** | 13 | 71 | 1,543 |
| **2012** | 20 | 77 | 1,616 |
| **2013** | 16 | 77 | 1,486 |
| **2014** | 27 | 65 | 1,487 |
| **2015** | 30 | 73 | 1,375 |
| **2016** | 14 | 82 | 1,209 |
| **Grand Total** | **120** | **445** | **8,716** |

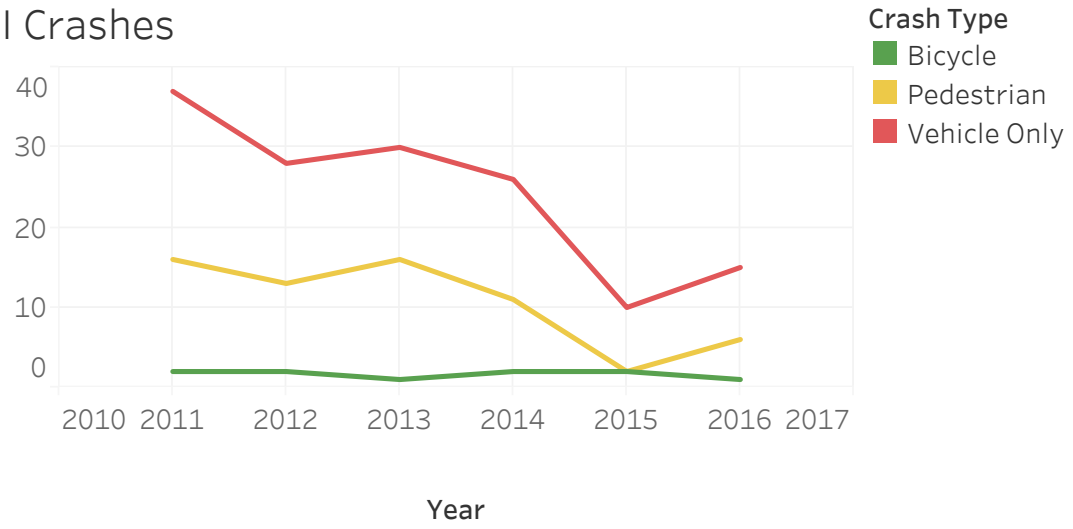


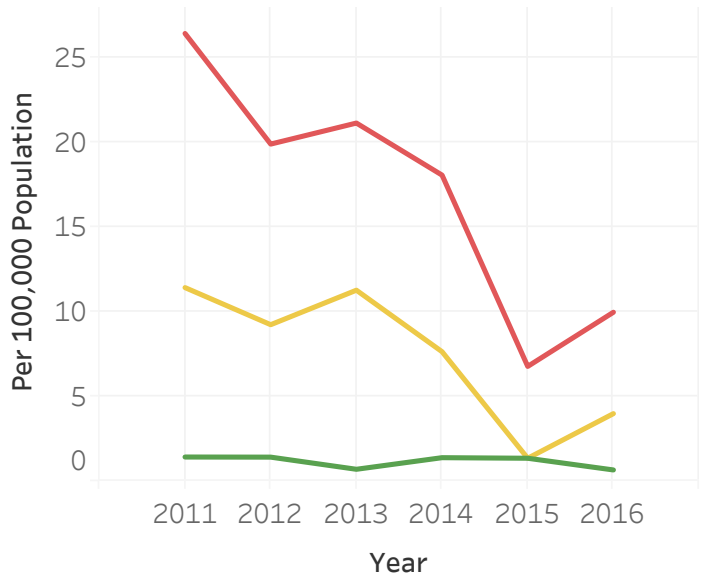



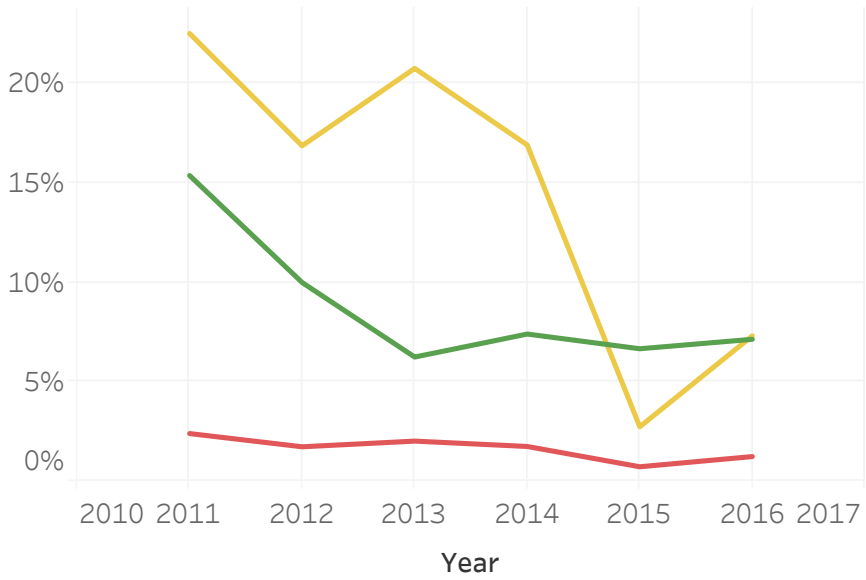
Shown here are KSI crashes only. While KSI crashes have decreased in 2015 for both pedestrian involved and vehicle only crashes, there was an increase in 2016 in both crash types. Overall, crashes have resulted in proportionally less KSI crashes. In 2016, the proportion that are KSI crashes increased slightly for bicycle involved and vehicle only crashes and by 4% increase for pedestrian involved crashes. Population changes do not appear to drive these changes. Population numbers come from Planning and Zoning. Theoretically, nothing needs to be done to reduce KSI crashes beyond doing what is currently being done. Action plans and future tracking must make sure that the are directly impacting future downward trends.

## KSI Crashes

| Year | Bicycle | Pedestrian | Vehicle Only |
|---|---|---|---|
| 2011 | 2 | 16 | 37 |
| 2012 | 2 | 13 | 28 |
| 2013 | 1 | 16 | 30 |
| 2014 | 2 | 11 | 26 |
| 2015 | 2 | 2 | 10 |
| 2016 | 1 | 6 | 15 |
| Grand Total | 10 | 64 | 146 |



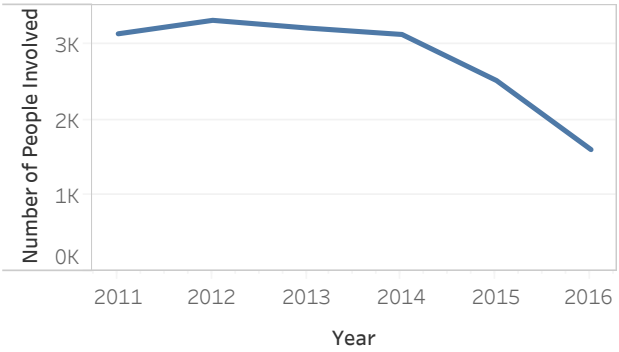



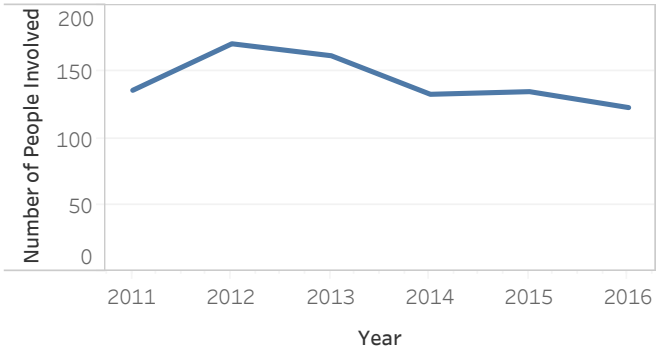
Looking at the number of inviduals directly involved in a crash, the same downward trend is seen across the different crash types at different rates.

# Number of Individuals Involved in Crashes

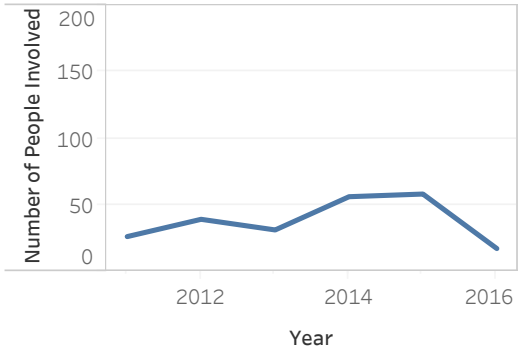
## Vehicle Only




## Pedestrian Involved




## Bicycle Involved




## Vehicle Only

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Grand Total |
|---|---|---|---|---|---|---|---|
| Vehicle Driver | 2,968 | 3,128 | 2,913 | 2,882 | 2,493 | 1,583 | 15,967 |
| Vehicle Occupant | 170 | 188 | 301 | 247 | 27 | 24 | 957 |
| Grand Total | 3,138 | 3,316 | 3,214 | 3,129 | 2,520 | 1,607 | 16,924 |

## Pedestrian Involved

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Grand Total |
|---|---|---|---|---|---|---|---|
| Pedestrian | 69 | 87 | 79 | 61 | 67 | 73 | 436 |
| Vehicle Driver | 67 | 82 | 80 | 69 | 67 | 50 | 415 |
| Vehicle Occupant | | 2 | 3 | 3 | 1 | | 9 |
| Grand Total | 136 | 171 | 162 | 133 | 135 | 123 | 860 |

## Bicycle Involved

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Grand Total |
|---|---|---|---|---|---|---|---|
| Vehicle Driver | 26 | 39 | 30 | 56 | 58 | 17 | 226 |
| Vehicle Occupant | | | 1 | | | | 1 |
| Grand Total | 26 | 39 | 31 | 56 | 58 | 17 | 227 |

For vehicle only crashes, year is shown to have a negative relationship to the probability a crash is KSI even when controlling for other conditions.

## Significance Tests for Vehicle Only

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Drinking | 0.00000 |
| | | Speeding Involved | 0.00000 |
| | | Event: Fixed Object | 0.00015 |
| | | Event: Motorcyclist | 0.00050 |
| | | Street Group: Secondary | 0.00824 |
| | | Event: Head on | 0.03548 |
| | Negative Relationship | Event: Rear End | 0.00002 |
| | | Event: Side Sweep | 0.01685 |
| Borderline Significant | Positive Relations.. | Event: Other | 0.09325 |
| | Negative Relationship | Event: Backed Into | 0.05497 |
| | | Number of Lanes | 0.05778 |

## Vehicle Only Log Model

| | | |
|---|---|---|
| (Intercept) | 387.2 (129.8) | ** |
| Year | -0.2 (0.1) | ** |
| Drinking | 1.3 (0.3) | *** |
| Event: Motorcyclist | 2.3 (0.7) | *** |
| Event: Rear End | -1.3 (0.5) | ** |
| Event: Side Sweep | -1.5 (0.7) | * |
| Was a Speeding Vehicle Involved * Adverse Weather | -2.1 (1.1) | . |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

For pedestrian involved crashes, year is also shown to have a negative relationship to the probability a crash is KSI even when controlling for other conditions.

## Significance Tests for Pedestrian Involved

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Pedestrian Action: Crossing Not At An Intersection | 0.00042 |
| | | Speeding Involved | 0.02849 |
| | | One Way | 0.03711 |
| Borderline Significant | Positive Relationship | Pedestrian Action: Not In Roadway | 0.07246 |
| | | Traffic Control: Other | 0.09195 |
| | Negative Rela.. | Street Group: Local Roads | 0.08011 |

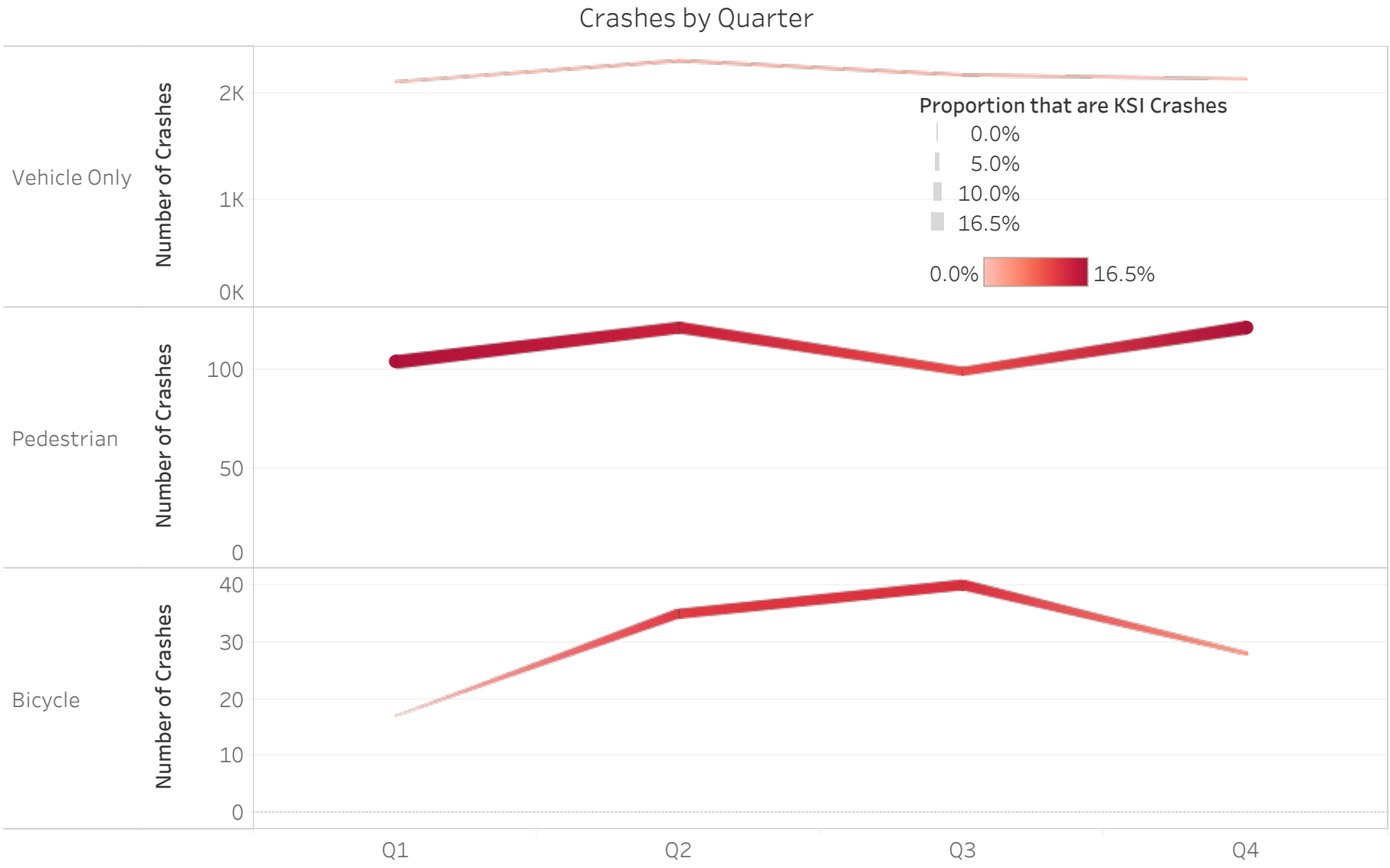
## Pedestrian Involved Log Model

| | | |
|---|---|---|
| (Intercept) | 572.5 (229.1) | * |
| Year | -0.3 (0.1) | * |
| Pedestrian Action: Crossing Against Signal | 2.9 (1.3) | * |
| Pedestrian Action: Crossing Diagonally | 3.8 (2.0) | . |
| Pedestrian Action: Crossing With No signal | 2.8 (1.3) | * |
| Pedestrian Action: Crossing Not At An Intersection | 3.1 (1.2) | * |
| Pedestrian Action: Coming from Behind Parked Vehicles | 2.6 (1.2) | * |
| Pedestrian Action: Not In Roadway | 1.9 (0.9) | * |
| Was a Vehicle Involved Speeding | 2.5 (0.8) | ** |
| Drinking | -1.9 (0.9) | * |
| Speed Limit | 0.1 (0.1) | * |
| Divided Street | -2.1 (0.8) | ** |
| One Way Street | 1.3 (0.6) | * |
| Street Group: Other (Compared to Local Streets) | 3.6 (1.8) | * |

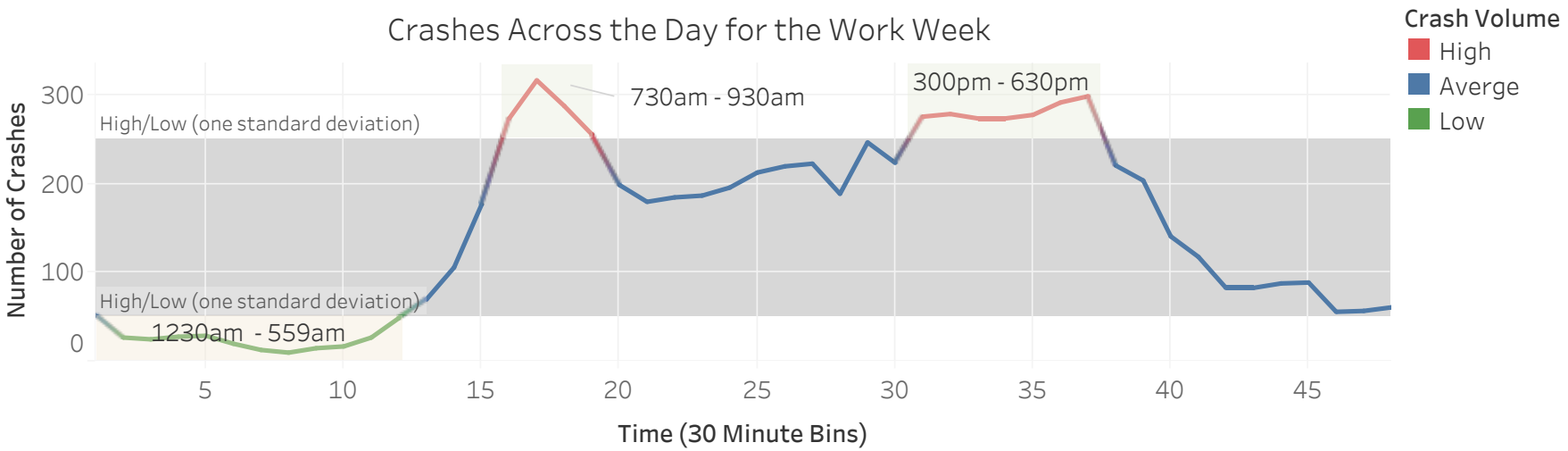
Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

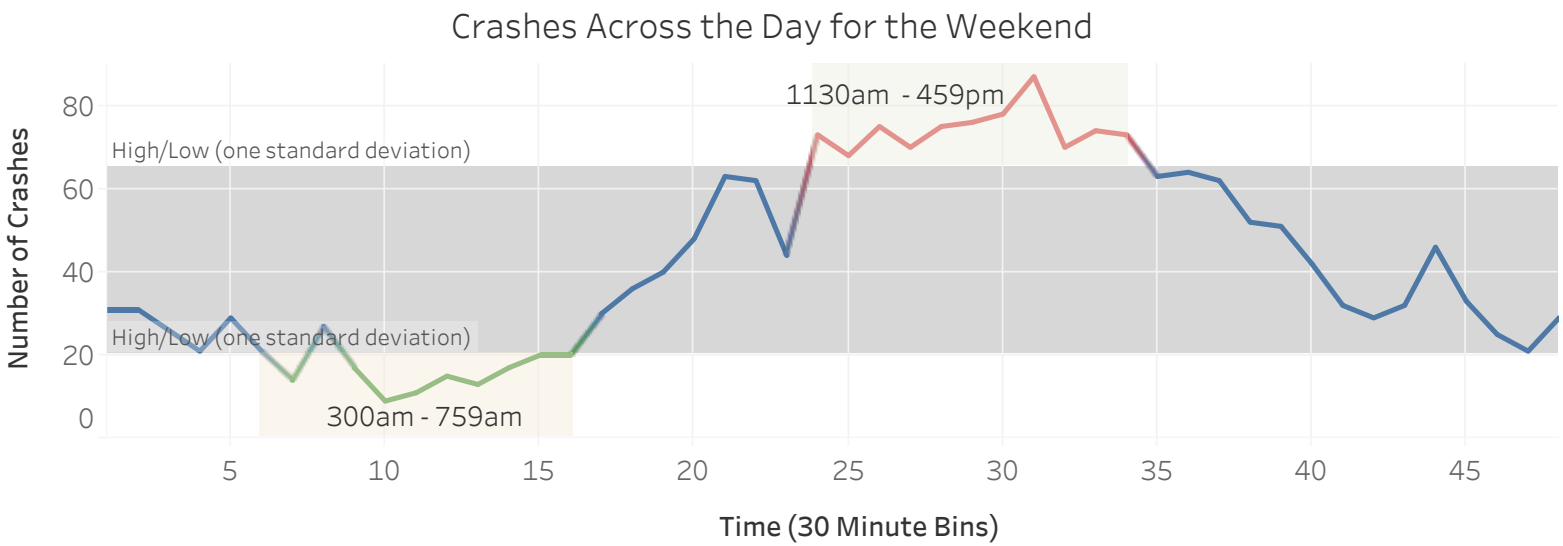
2. There is a temporal pattern in crash volume and KSI risks.

Examining the number of crashes and the proportion of crashes that are KSI by quarter allows for looking for seasonality effects (Q1: Winter; Q2: Spring; Q3: Summer; Q4: Fall). There is little seasonality for vehicle only crashes. Pedestrian involved crashes have larger numbers in Q2 (spring) and Q4 (fall). The proportion that are KSI shift from 16% in winter to 14%-10% in spring and summer, and increases back up in the fall to 17%. Bicycle crashes increase in both number and KSI proportion when nicer weather hits during spring and Q3 summer.

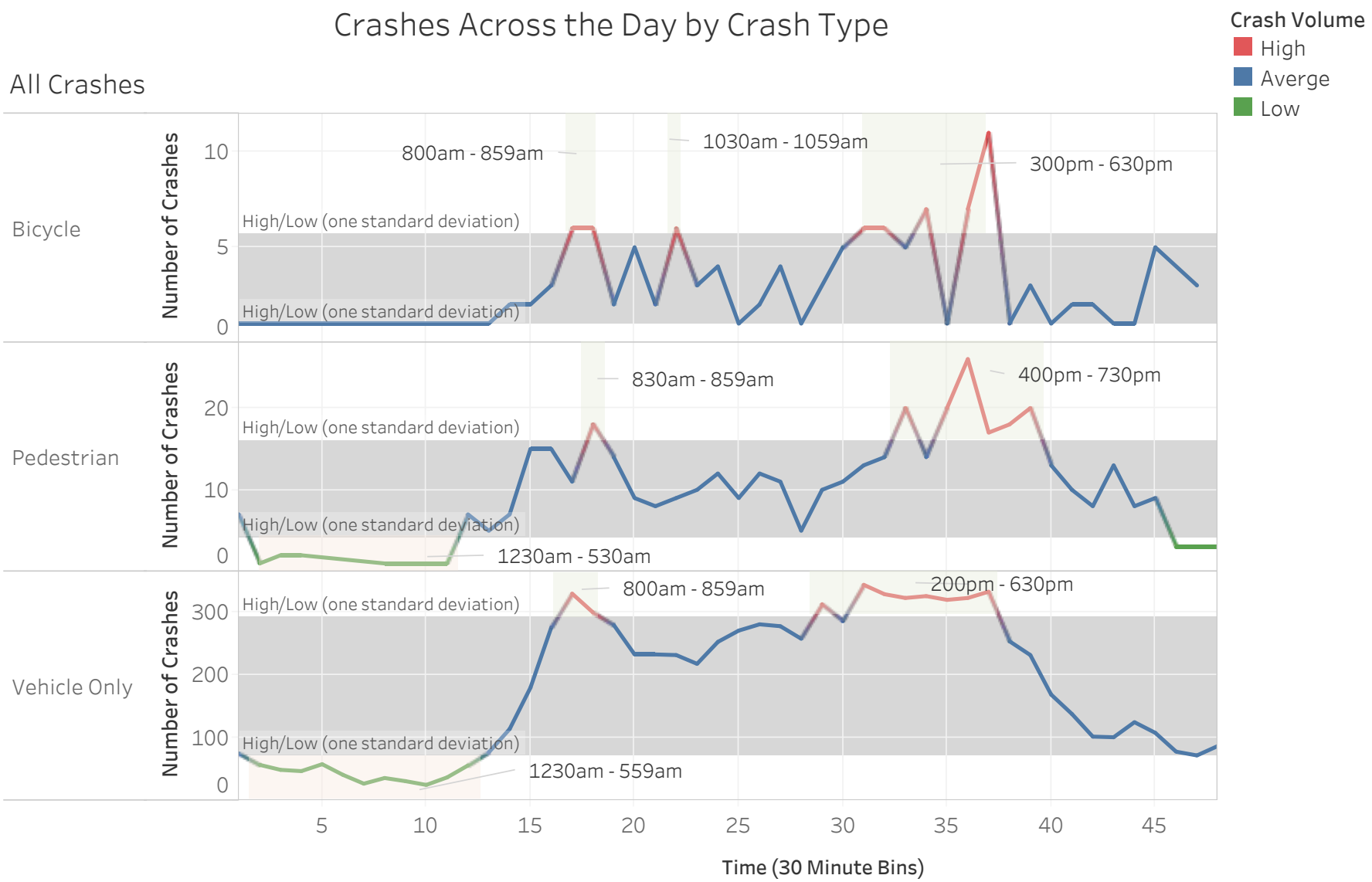


Crash times are often estimates, which results in unusual groupings around 'even' time (especially 0). Grouping crash times into 30 minutes absorbs some of this error. High crash volume is defined above one standard deviation; low crash times are below one standard deviation. As expected, there is a pattern of crashes across the day that follows commuting patterns in the city and differs between the workweek and weekend. High crash volumes are seen during commuting hours with a slight decrease during the day. During the weekend, high crash volume starts much later and ends earlier. Low crash volumes are seen in the early mornings, but this low volume starts later during the weekend compared to the work week. The same pattern is not seen when breaking down KSI crashes across the day (not shown).



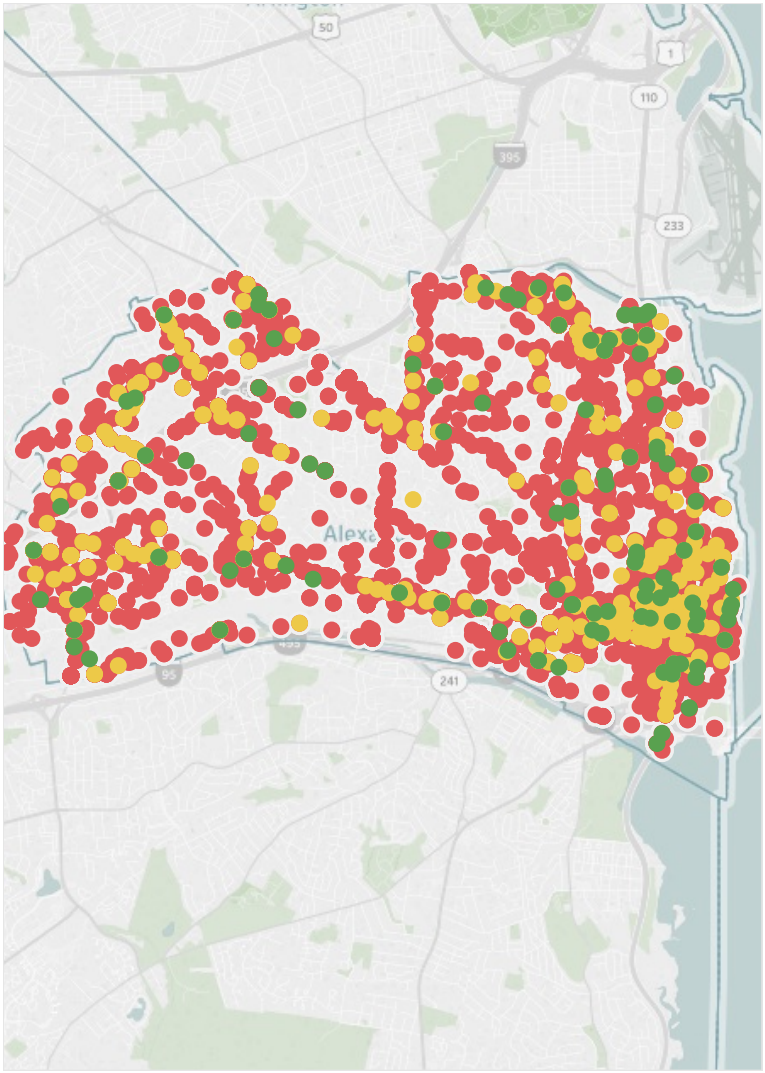
Breaking down the number of crashes across the day by crash type reveals that bicycle involved crashes and pedestrian involved crashes vary in crash volume patterns. Pedestrian involved crashes have a later high volume time compared to the other two crash types. Bicycle involved crashes experience multiple points of high volume: in the morning, early afternoon, and evening. Vehicle only crashes follows the pattern seen previously.



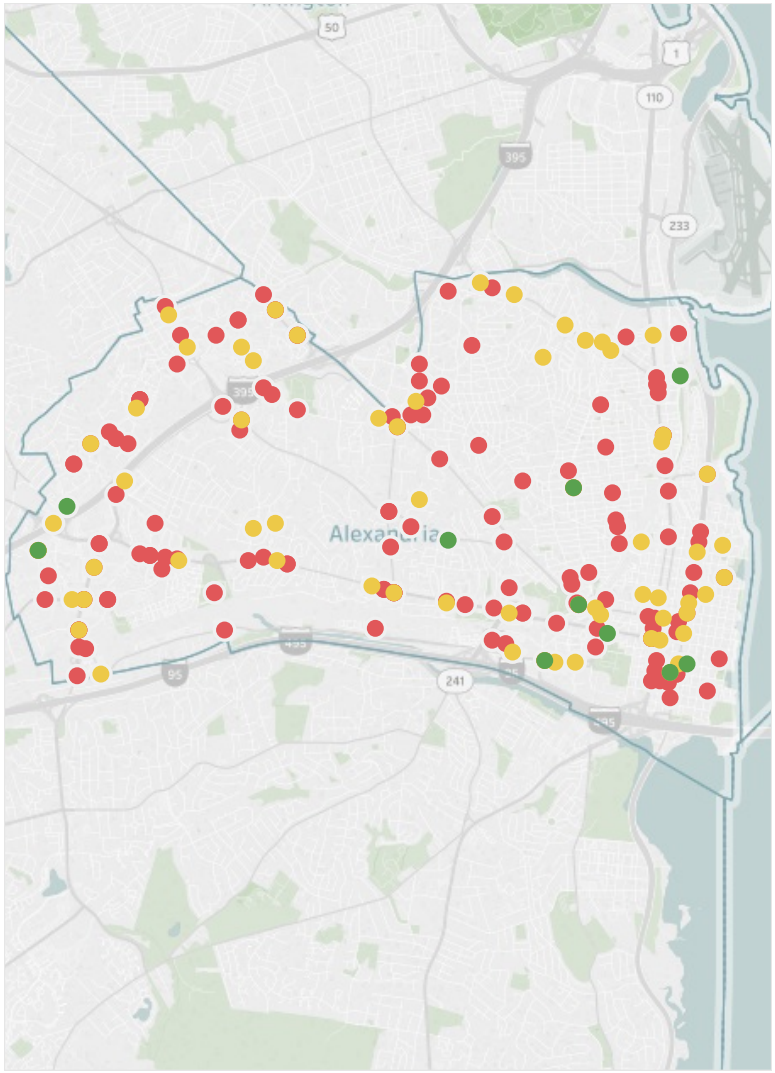
3. There are corridors with elevated KSI risks

Crashes occur throughout the city. Breaking crashes down by type reveals that pedestrian involved crashes and bicycle involved crashes have higher percentages occurring in the Old Town area. Vehicle only crashes appear throughout the City, but the Old Town area has the highest density. The location of KSI crashes are concentrated in Old Town, West End and Fairlington/Bradlee areas. Corridors that seem to have higher percentages of KSI include the Duke Street, Washington Street, West Glebe Road, North Beauregard Street, Seminary Road, and Route 1.

## All Crashes



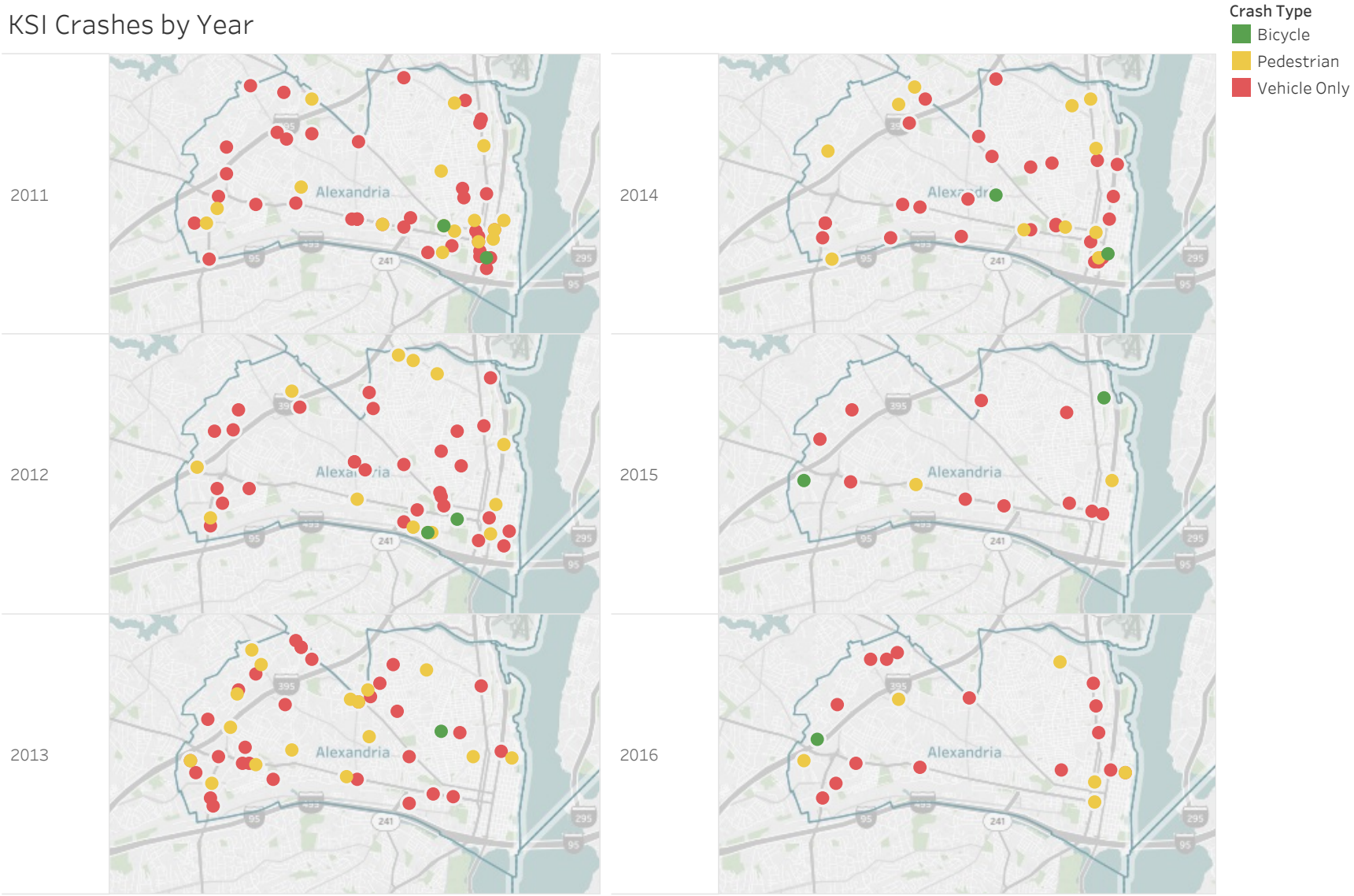

## KSI Crashes




Crash Type
- Bicycle
- Pedestrian
- Vehicle Only

Looking at the location of KSI crashes across the year reveals that a sizable percentage of the KSI crashes in the West End occur in 2011 to 2013 as compared to more recent years. However, in 2016, the crashes appear to split between the West End and Old Town areas. Duke Street and Route 1 still appear as high-risk corridors in recent years.

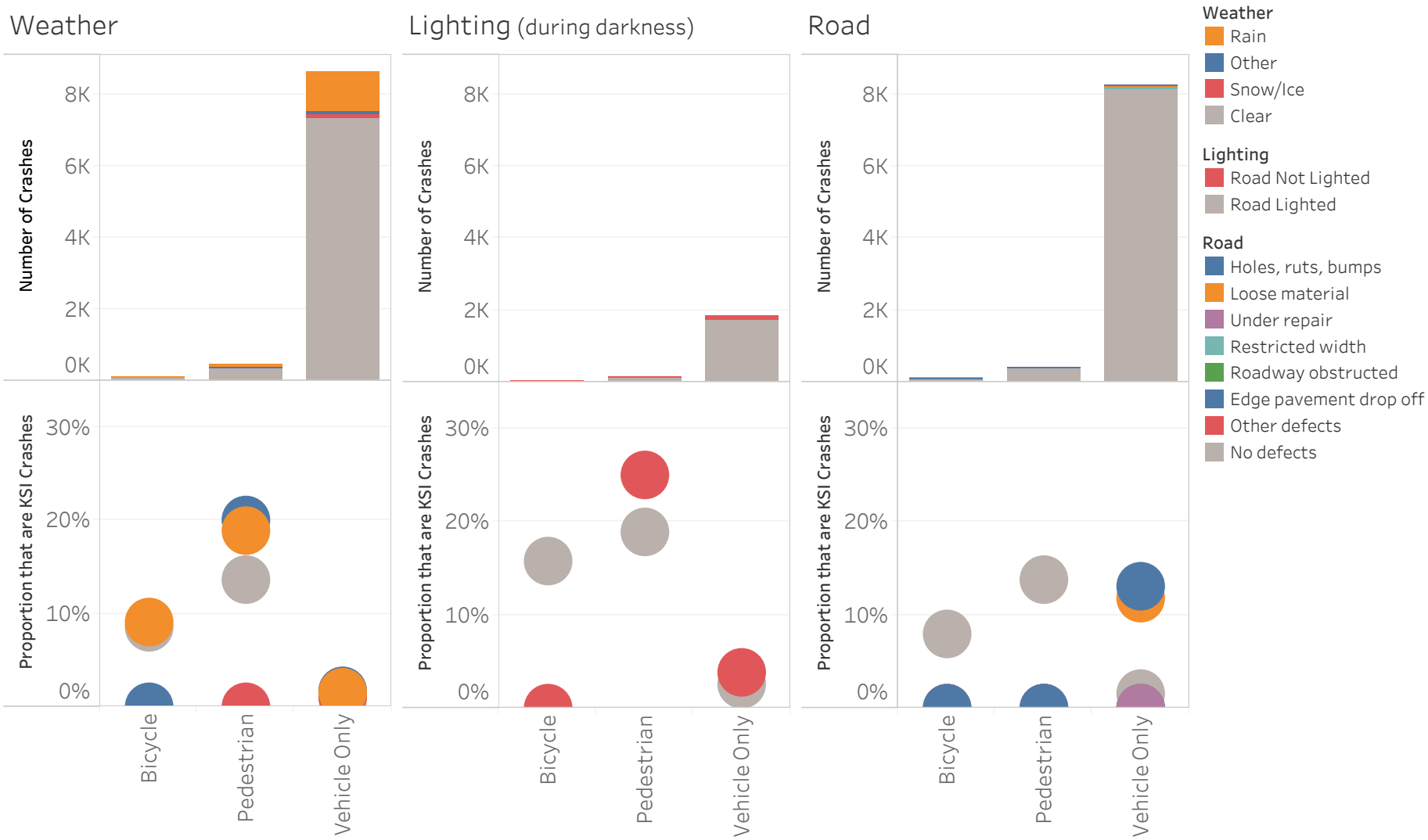
## KSI Crashes by Year



4. Adverse environmental (weather, lighting, and road) conditions are high-risk conditions.

Breaking down crashes based on environmental conditions reveal high-risk environmental conditions. Note that data on environmental conditions are subjective. It is up to the officer to enter a single condition with no set guidelines or definitions provided. In the case of road conditions, the choices are not necessarily mutually exclusive. Pedestrian involved crashes that occur in rain or other adverse weather conditions excluding snow and bicycle involved crashes occurring in rain have high rates of KSI. The same is true for pedestrian involved or vehicle only crashes in non-lighted areas during darkness. For vehicle only crashes, crashes occurring on roads with loose material or holes, ruts, bumps are high-risk. In checking if recent road improvement measures have effected crashes levels, no significant trend was seen between crashes on adverse road conditions across time. However, this number has been slowly dropping since 2012; more data in t..

# Environmental Conditions



For vehicle only models, adverse environmental conditions drop out of signficance during testing. (The high number of missing data is a factor in this lack of signifance.) Yet, speeding in adverse weather is less likely to result in a KSI than speeding or adverse weather alone. Possible due to less vehicles on the road during this time.

## Significance Tests for Vehicle Only

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Drinking | 0.00000 |
| | | Speeding Involved | 0.00000 |
| | | Event: Fixed Object | 0.00015 |
| | | Event: Motorcyclist | 0.00050 |
| | | Street Group: Secondary | 0.00824 |
| | | Event: Head on | 0.03548 |
| | Negative Relationship | Event: Rear End | 0.00002 |
| | | Event: Side Sweep | 0.01685 |
| Borderline Significant | Positive Relations.. | Event: Other | 0.09325 |
| | Negative Relationship | Event: Backed Into | 0.05497 |
| | | Number of Lanes | 0.05778 |

## Vehicle Only Log Model

| | | |
|---|---|---|
| (Intercept) | 387.2 | ** |
| | (129.8) | |
| Year | -0.2 | ** |
| | (0.1) | |
| Drinking | 1.3 | *** |
| | (0.3) | |
| Event: Motorcyclist | 2.3 | *** |
| | (0.7) | |
| Event: Rear End | -1.3 | ** |
| | (0.5) | |
| Event: Side Sweep | -1.5 | * |
| | (0.7) | |
| Was a Speeding Vehicle Involved * Adverse Weather | -2.1 | . |
| | (1.1) | |

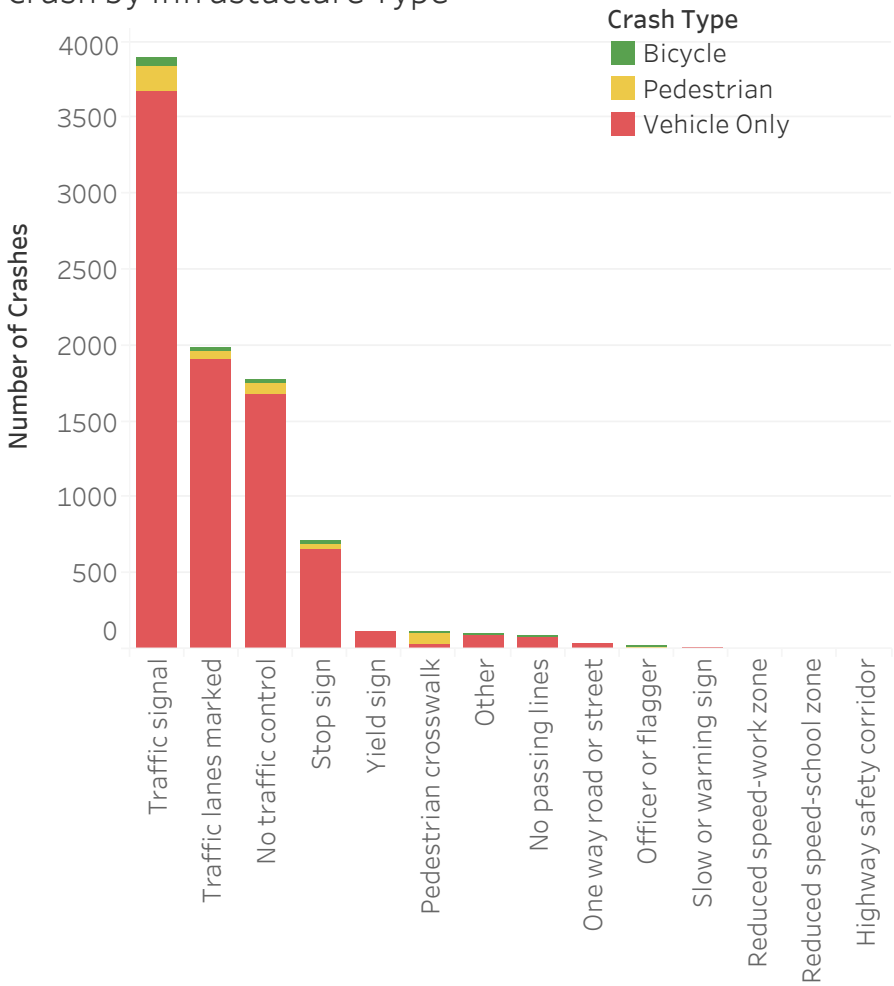
Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

5. Certain road infrastructure may affect KSI risks.

Crashes have listed a traffic control feature that was present at the site of the crash. Just as before, the officer can only enter one condition even if multiple conditions are present. Moreover, the stated infrastructure was not necessarily the root cause, or even a large factor, of the crash. Breaking down the analysis by crash type, most crashes occur at locations with a traffic signal, traffic lanes marked, or no traffic signal. Pedestrian crosswalk, and no passing lanes have the high proportion of KSI. Officer or flagger also has a high KIS proportion but the total numbers are low. Breaking down these further into the proportion of KSI crashes by crash type is problematic due to low numbers.

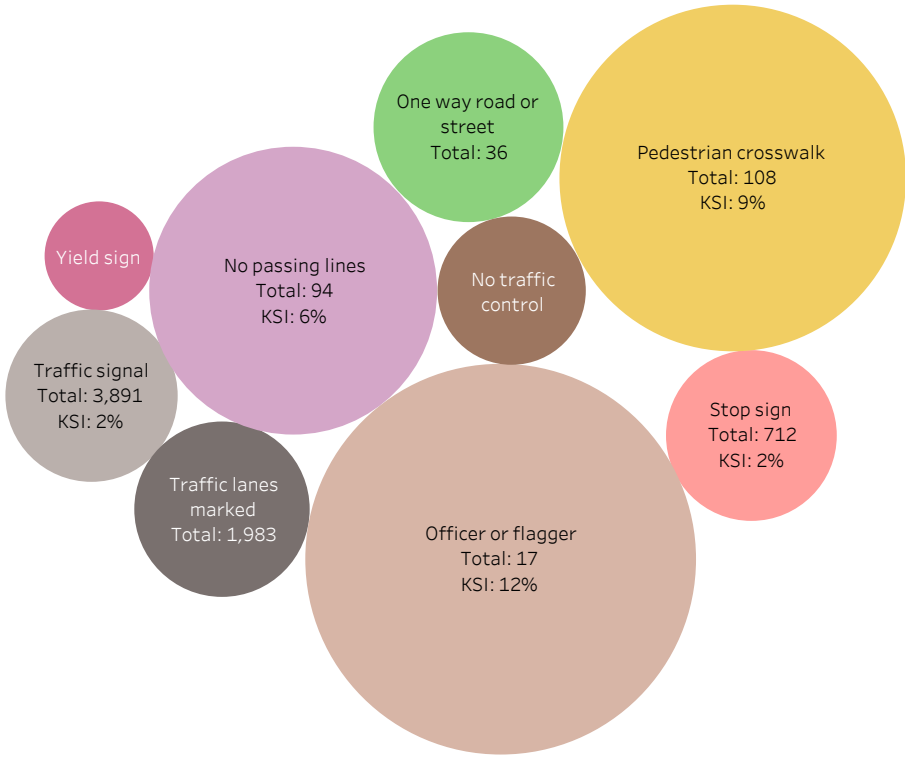
# Infrastructure Conditions

## Crash by Infrastucture Type




## Infrastructure Type and KSI

(Size based on Proportion of Crashes that are KSI)



In the statistical tests, the impact of traffic control infrastructure drop out of significance. More KSI crashes occur on secondary street than expected. While boarder-line significant, less KSI crashes occur on streets with high number of lanes than expected. When considered jointly with other conditions, these infrastructure conditions fall out of significance.

## Significance Tests for Vehicle Only

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Drinking | 0.00000 |
| | | Speeding Involved | 0.00000 |
| | | Event: Fixed Object | 0.00015 |
| | | Event: Motorcyclist | 0.00050 |
| | | Street Group: Secondary | 0.00824 |
| | | Event: Head on | 0.03548 |
| | Negative Relationship | Event: Rear End | 0.00002 |
| | | Event: Side Sweep | 0.01685 |
| Borderline Significant | Positive Relations.. | Event: Other | 0.09325 |
| | Negative Relationship | Event: Backed Into | 0.05497 |
| | | Number of Lanes | 0.05778 |

## Vehicle Only Log Model

| | |
|---|---|
| (Intercept) | 387.2 ** (129.8) |
| Year | -0.2 ** (0.1) |
| Drinking | 1.3 *** (0.3) |
| Event: Motorcyclist | 2.3 *** (0.7) |
| Event: Rear End | -1.3 ** (0.5) |
| Event: Side Sweep | -1.5 * (0.7) |
| Was a Speeding Vehicle Involved * Adverse Weather | -2.1 . (1.1) |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

For pedestrian involved crashes, one way streets increase KSI risks overall. All else equal, divided streets have lower KSI probabilities while other street types have high KSI probabilities as compared to local street.

## Significance Tests for Pedestrian Involved

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Pedestrian Action: Crossing Not At An Intersection | 0.00042 |
| | | Speeding Involved | 0.02849 |
| | | One Way | 0.03711 |
| Borderline Significant | Positive Relationship | Pedestrian Action: Not In Roadway | 0.07246 |
| | | Traffic Control: Other | 0.09195 |
| | Negative Rela.. | Street Group: Local Roads | 0.08011 |

## Pedestrian Involved Log Model

| | |
|---|---|
| (Intercept) | 572.5 * (229.1) |
| Year | -0.3 * (0.1) |
| Pedestrian Action: Crossing Against Signal | 2.9 * (1.3) |
| Pedestrian Action: Crossing Diagonally | 3.8 . (2.0) |
| Pedestrian Action: Crossing With No signal | 2.8 * (1.3) |
| Pedestrian Action: Crossing Not At An Intersection | 3.1 * (1.2) |
| Pedestrian Action: Coming from Behind Parked Vehicles | 2.6 * (1.2) |
| Pedestrian Action: Not In Roadway | 1.9 * (0.9) |
| Was a Vehicle Involved Speeding | 2.5 ** (0.8) |
| Drinking | -1.9 * (0.9) |
| Speed Limit | 0.1 * (0.1) |
| Divided Street | -2.1 ** (0.8) |
| One Way Street | 1.3 * (0.6) |
| Street Group: Other (Compared to Local Streets) | 3.6 * (1.8) |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

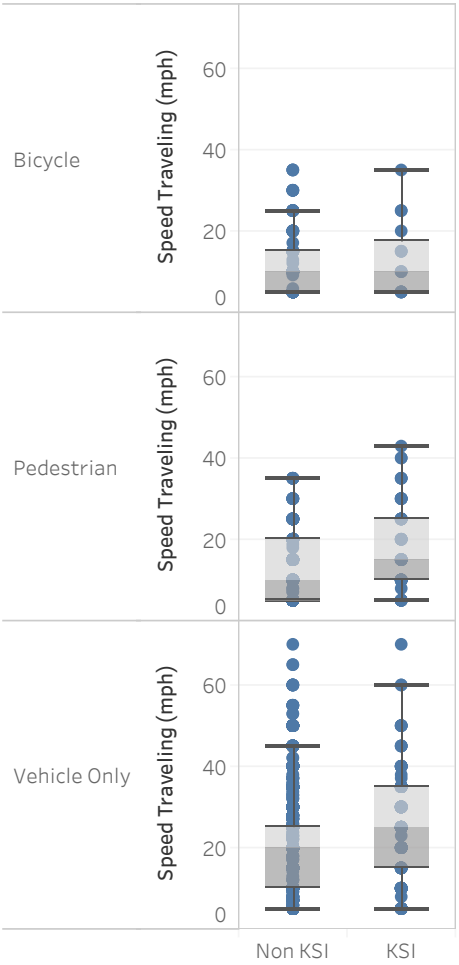
6. Increased speed increases KSI risks.

Vehicles that were parked, stopped in traffic, traveling less than 10 mph were excluded, had drivers 14 years old or younger, and were not listed as the primary or secondary vehicle involved. There is no major difference in the speeds in non KSI crashes vs KSI crashes. However, the median speed of vehicle only and pedestrian involved KSI crashes were higher. In the chart to the left, the box goes from the first to the third quartile. A line is drawn at the Q2, the median of the data. Two whiskers extend to the smallest and largest non-outlier. A large percentage of the vehicles involved in crashes were in speed limits 25 or 35. There is a significant and negative relationship between age and speed traveling. The older a driver is, the slower the speed traveling during a crash. A similar trend was relationship was found between speed limit and age.

# Vehicle Speed

(Unit of Analysis: Vehicle)

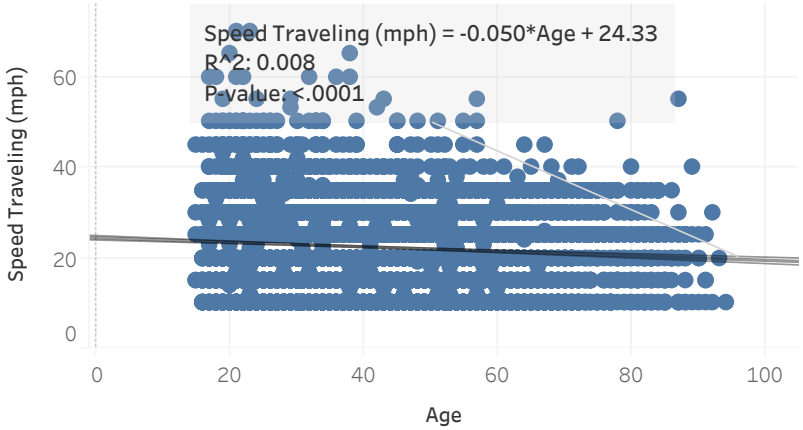
## Speed Travling by KSI



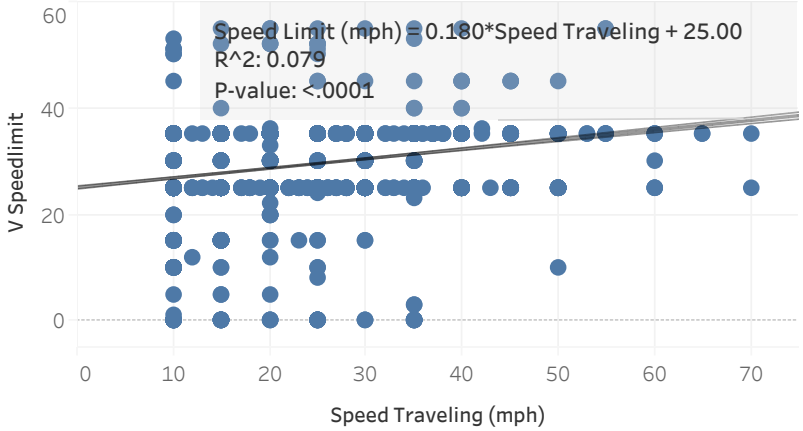

## Number of Vehicles by Speed Limit They Were In

| | Non KSI | | | KSI | | |
|---|---|---|---|---|---|---|
| | Bicycle | Pedestrian | Vehicle Only | Bicycle | Pedestrian | Vehicle Only |
| Under 5 | 23 | 15 | 233 | 3 | | 6 |
| 3 | | | 3 | | | |
| 5 | 2 | 10 | 84 | | | 2 |
| 8 | | | 1 | | | |
| 10 | 2 | 4 | 67 | | | |
| 12 | | | 2 | | | |
| 15 | 5 | 6 | 163 | | 1 | 2 |
| 20 | 1 | | 10 | | | |
| 22 | | 1 | | | | |
| 23 | | | 1 | | | |
| 24 | | | 2 | | | |
| 25 | 123 | 238 | 7,104 | 12 | 40 | 121 |
| 30 | | 2 | 115 | | | 2 |
| 33 | | | 1 | | | |
| 35 | 36 | 63 | 4,773 | 2 | 20 | 89 |
| 36 | | | 2 | | | |
| 40 | | | 5 | | | |
| 45 | | | 15 | | | |
| 50 | | | 3 | | | |
| 51 | | | 8 | | | |
| 52 | | | 8 | | | |
| 53 | | | 3 | | | |
| 55 | | | 11 | | | |

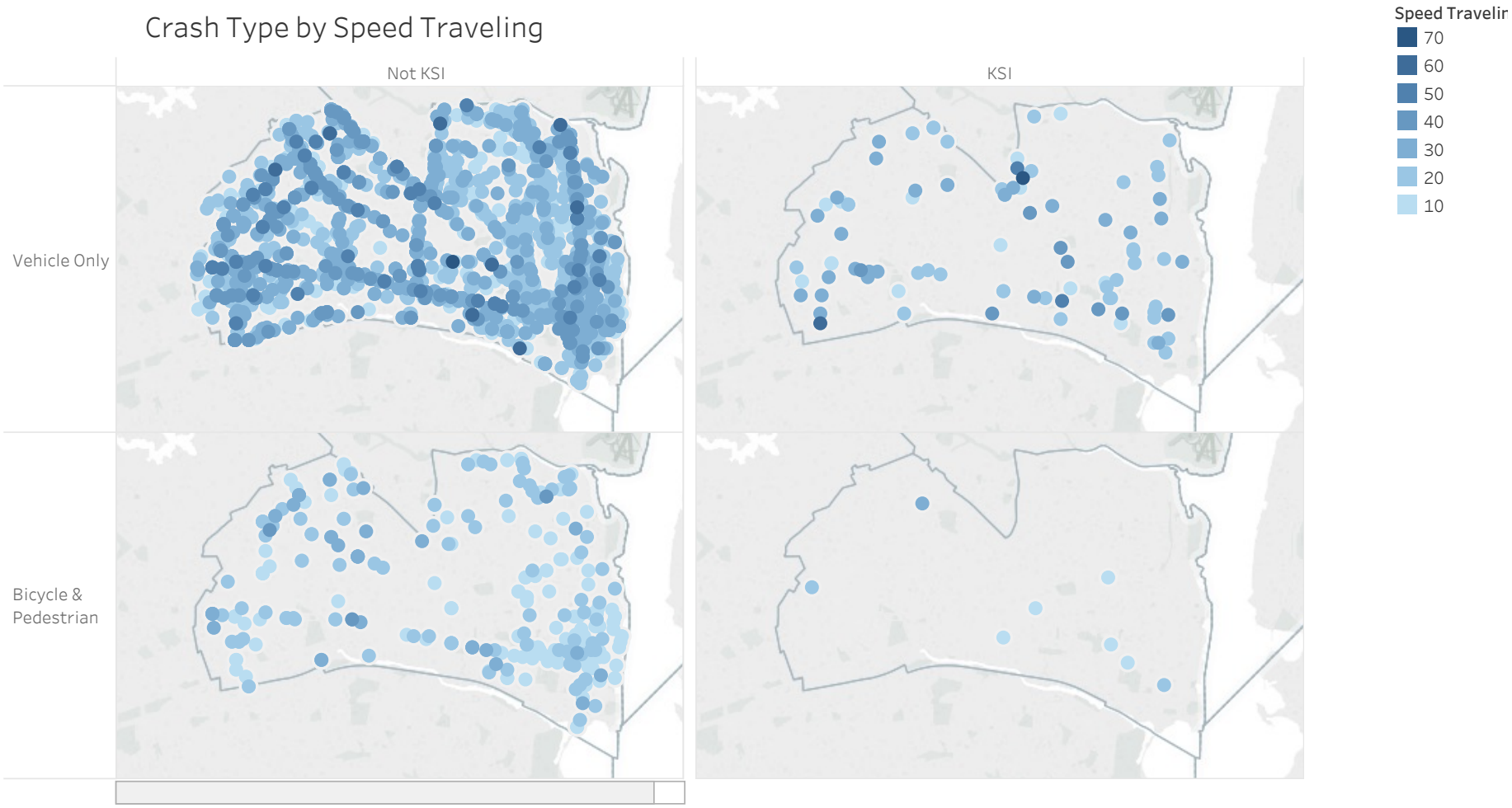
## Speed Traveling and Age of Driver




## Speed Limit and Speed Traveling



Mapping crashes by speed traveling reveals that higher speeds in vehicle only KSI crashes occurred in the West End, Fairlington/Bradlee, and Duke Street corridor. Non KSI crashes for bicycle involved and pedestrian involved tended to have slower seep than vehicle only non KSI crashes. Breaking down the effect of speeding on KSI by road conditions revealed some potential of increased risk with higher speeds on roads with road defects. But the numbers of these crashes are low. Better data will help uncover is this pattern holds.



Crashes where speeding was involved experienced more KSI crashes than expected in vehicle only crashes. When controlling for other conditions though, wether speeding was invovled drops out of signifance. Speeding in adverse weather is less likely to result in a KSI than speeding or adverse weather alone. Possible due to less vehicles on the road.

## Significance Tests for Vehicle Only

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Drinking | 0.00000 |
| | | Speeding Involved | 0.00000 |
| | | Event: Fixed Object | 0.00015 |
| | | Event: Motorcyclist | 0.00050 |
| | | Street Group: Secondary | 0.00824 |
| | | Event: Head on | 0.03548 |
| | Negative Relationship | Event: Rear End | 0.00002 |
| | | Event: Side Sweep | 0.01685 |
| Borderline Significant | Positive Relations.. | Event: Other | 0.09325 |
| | Negative Relationship | Event: Backed Into | 0.05497 |
| | | Number of Lanes | 0.05778 |

## Vehicle Only Log Model

| | | |
|---|---|---|
| (Intercept) | 387.2 | ** |
| | (129.8) | |
| Year | -0.2 | ** |
| | (0.1) | |
| Drinking | 1.3 | *** |
| | (0.3) | |
| Event: Motorcyclist | 2.3 | *** |
| | (0.7) | |
| Event: Rear End | -1.3 | ** |
| | (0.5) | |
| Event: Side Sweep | -1.5 | * |
| | (0.7) | |
| Was a Speeding Vehicle Involved * Adverse Weather | -2.1 | . |
| | (1.1) | |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Whether a vehicle involved in a pedestrian involved crashes was speeding increases KSI risks independently and jointly with other conditions. Speed limit also increases KSI probabilities, but the impact is much less.

## Significance Tests for Pedestrian Involved

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Pedestrian Action: Crossing Not At An Intersection | 0.00042 |
| | | Speeding Involved | 0.02849 |
| | | One Way | 0.03711 |
| Borderline Significant | Positive Relationship | Pedestrian Action: Not In Roadway | 0.07246 |
| | | Traffic Control: Other | 0.09195 |
| | Negative Rela.. | Street Group: Local Roads | 0.08011 |

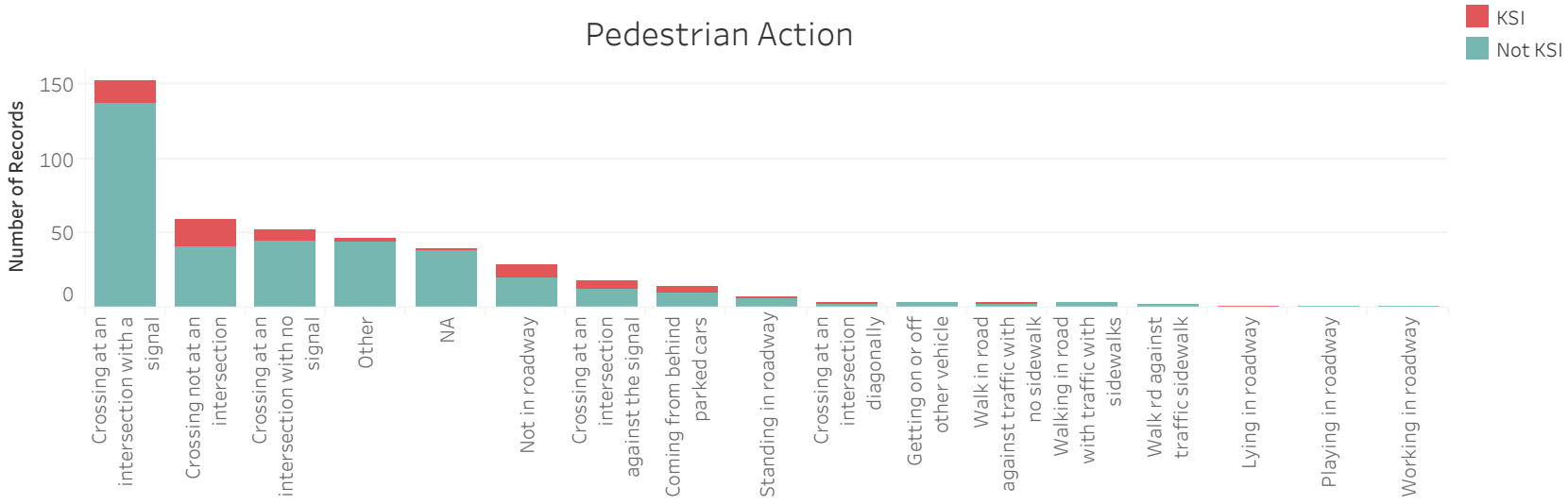
## Pedestrian Involved Log Model

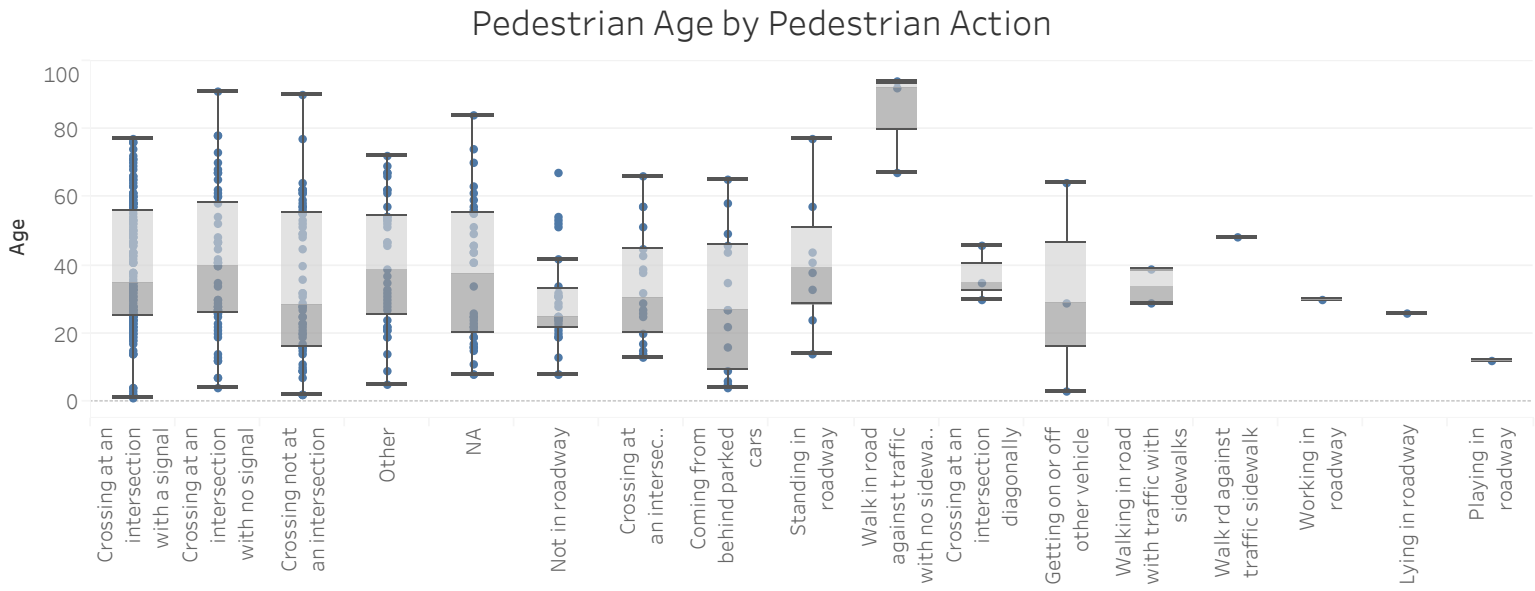
| | |
|---|---|
| (Intercept) | 572.5 * (229.1) |
| Year | -0.3 * (0.1) |
| Pedestrian Action: Crossing Against Signal | 2.9 * (1.3) |
| Pedestrian Action: Crossing Diagonally | 3.8 . (2.0) |
| Pedestrian Action: Crossing With No signal | 2.8 * (1.3) |
| Pedestrian Action: Crossing Not At An Intersection | 3.1 * (1.2) |
| Pedestrian Action: Coming from Behind Parked Vehicles | 2.6 * (1.2) |
| Pedestrian Action: Not In Roadway | 1.9 * (0.9) |
| Was a Vehicle Involved Speeding | 2.5 ** (0.8) |
| Drinking | -1.9 * (0.9) |
| Speed Limit | 0.1 * (0.1) |
| Divided Street | -2.1 ** (0.8) |
| One Way Street | 1.3 * (0.6) |
| Street Group: Other (Compared to Local Streets) | 3.6 * (1.8) |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

7. Certain pedestrian paths of travel and locations create high-risk situations.

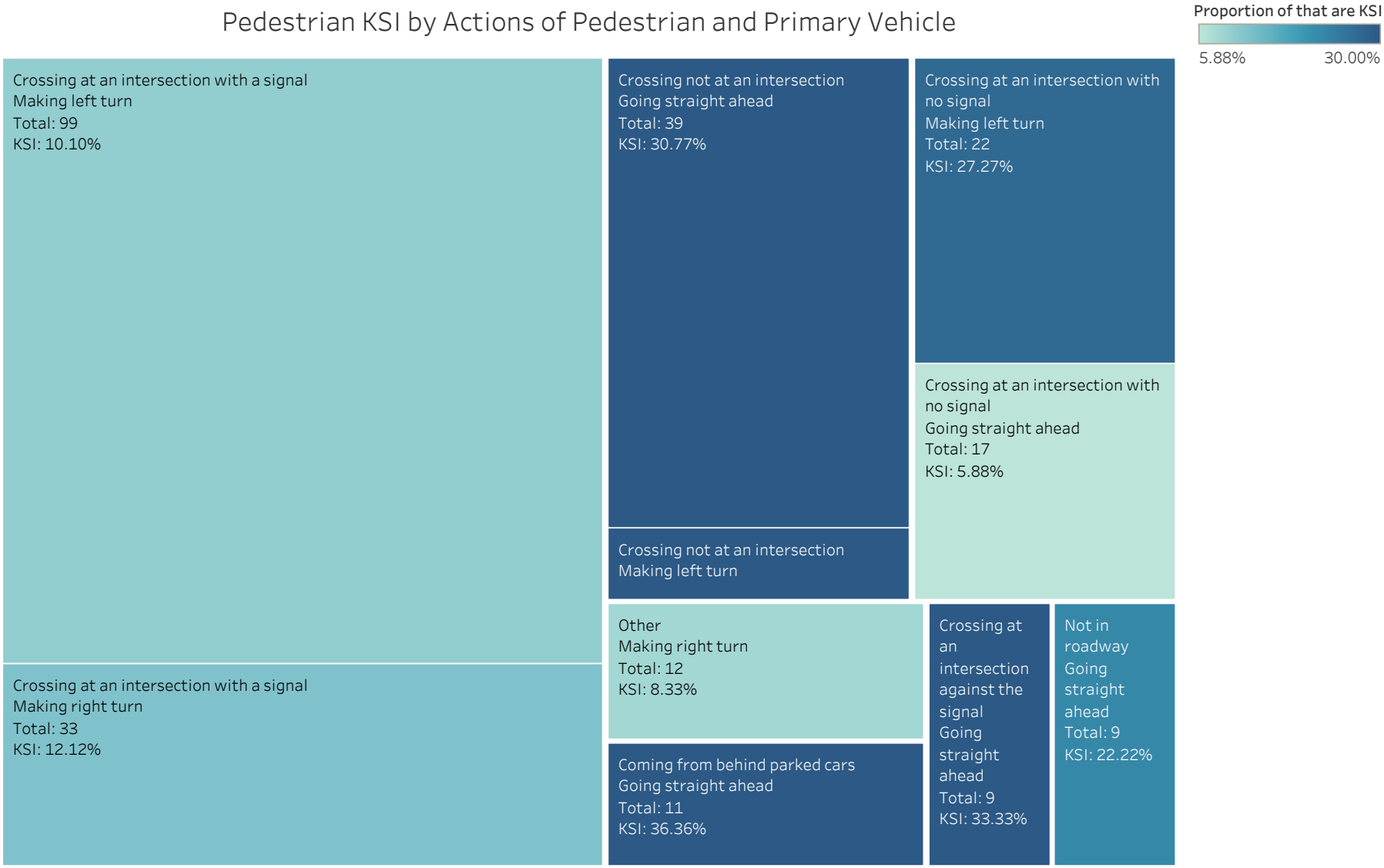
It is difficult to examine the root cause of pedestrian involved crashes with the available data. Listed. The data include information on pedestrian action. The full context around why a pedestrian traveled in a particular way is unknown. Pedestrians crossing at an intersection occur most frequently in the data followed by crossing not at an intersection and crossing at an intersection with no signal. Most KSIs are occurring though with pedestrians crossing not at an intersection. Examining the ages of pedestrians by pedestrian action reveals that there is little significant difference between the ages ranges of pedestrians doing a certain action overall.



In examining both the actions of the pedestrian and the primary vehicle involved, the highest number of crashes occurred while the pedestrian is crossing at an intersection with a signal. Yet, the crashes with the highest proportion of KSI are those where the pedestrian is crossing not at an intersection, crossing at intersection with no signal and a vehicle is turning left, where the pedestrian is not crossing at an intersection and the vehicle is making a left, crossing at an intersection by against the signal, and when the pedestrian is coming from behind parked cars. Other conditions with high KSI proportions are low in frequency.

## Pedestrian KSI by Actions of Pedestrian and Primary Vehicle



Pedestrians crossing not at an intersection significantly increases KSI risks. Other pedestrian actions that increase KSI probabilities (all else equal) include: crossing against the signal, crossing diagonally, crossing with no signal, crossing not at an intersection, and coming from behind parked vehicles.

## Significance Tests for Pedestrian Involved

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Pedestrian Action: Crossing Not At An Intersection | 0.00042 |
| | | Speeding Involved | 0.02849 |
| | | One Way | 0.03711 |
| Borderline Significant | Positive Relationship | Pedestrian Action: Not In Roadway | 0.07246 |
| | | Traffic Control: Other | 0.09195 |
| | Negative Rela.. | Street Group: Local Roads | 0.08011 |

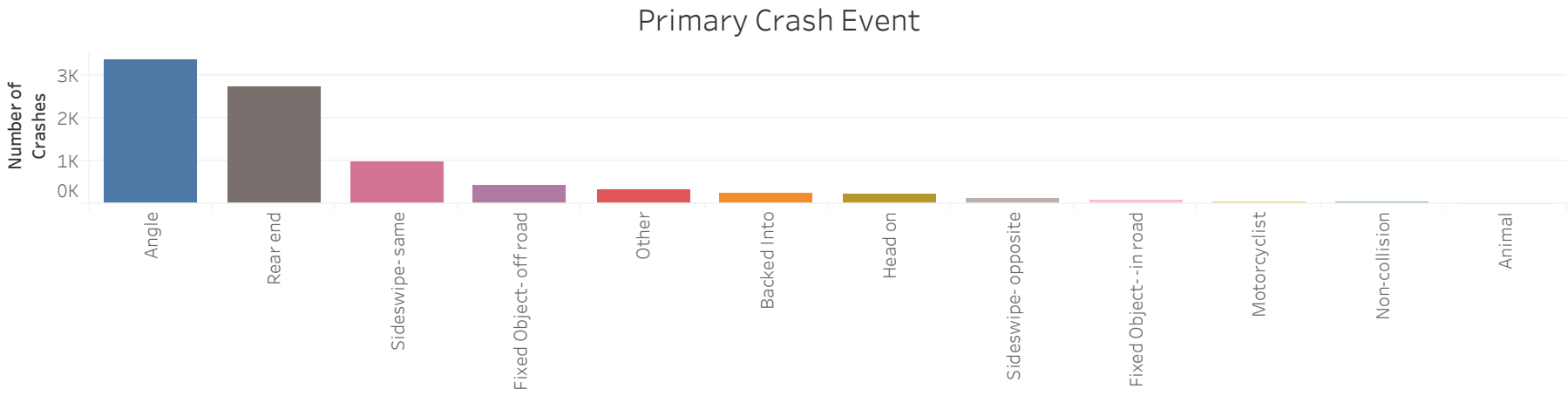
## Pedestrian Involved Log Model

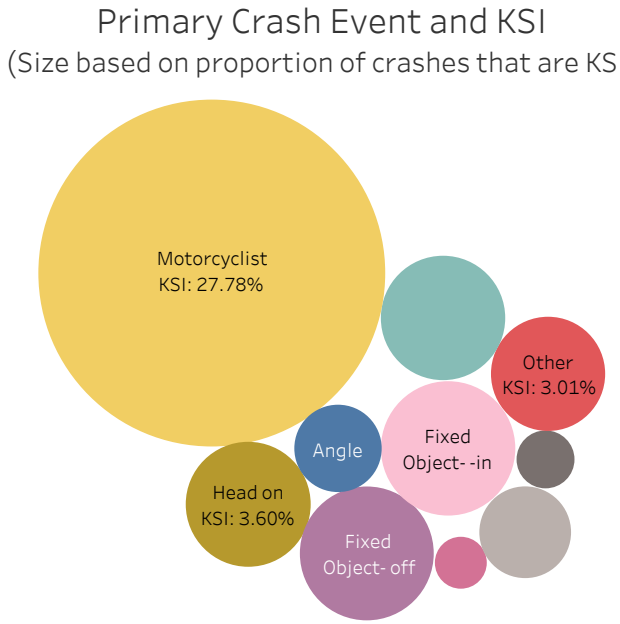
| | |
|---|---|
| (Intercept) | 572.5 * (229.1) |
| Year | -0.3 * (0.1) |
| Pedestrian Action: Crossing Against Signal | 2.9 * (1.3) |
| Pedestrian Action: Crossing Diagonally | 3.8 . (2.0) |
| Pedestrian Action: Crossing With No signal | 2.8 * (1.3) |
| Pedestrian Action: Crossing Not At An Intersection | 3.1 * (1.2) |
| Pedestrian Action: Coming from Behind Parked Vehicles | 2.6 * (1.2) |
| Pedestrian Action: Not In Roadway | 1.9 * (0.9) |
| Was a Vehicle Involved Speeding | 2.5 ** (0.8) |
| Drinking | -1.9 * (0.9) |
| Speed Limit | 0.1 * (0.1) |
| Divided Street | -2.1 ** (0.8) |
| One Way Street | 1.3 * (0.6) |
| Street Group: Other (Compared to Local Streets) | 3.6 * (1.8) |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

8. Motorcyclist and fixed object events are high risk situations.

Primary event describes the type of accident an incident was. This analysis is limited to only vehicle only as pedestrian crashes are often listed as a pedestrian event type. Just as with the environmental conditions, it is up to the officer on which even type to choose. While low in number, crashes involving a motorcyclist have high rates of KSI. Other events that are high-risk include head on, fixed object off road, and fixed object in road crashes.



Adding adverse weather into the analysis (excluding event-weather combinations of only 1), reveals that fixed object of road and adverse weather conditions are a high-risk combination. When examining adverse conditions for Motorcyclist events, no trend emerge. However, this might be due to low frequency of motorcyclist events (36 crashes). Looking at the maneuvers of the primary and secondary vehicles involved by primary event and KSI risks actions that are high-risk. However, there are high number of missing data.

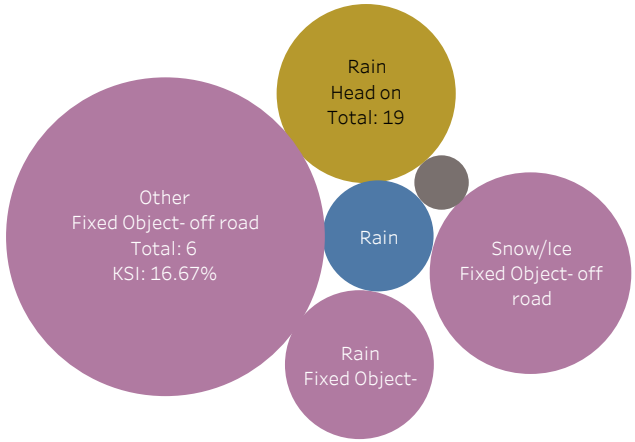
## Vehicle Manuevers of Primary and Secondary Vehicles by Primary Event

(Showing top KSI Proportions)

| | Angle | Fixed Object- off road | Head on | Motorcyclist | NA | Other | Sideswipe- opposite direction |
|---|---|---|---|---|---|---|---|
| Going straight ahead - Making left turn | | | | 9 - 22.2% | | | |
| Going straight ahead - Making right turn | | | | | 15 - 6.7% | | |
| Going straight ahead - NA | | | | | 4 - 25.0% | | |
| Making left turn - Going straight ahead | | | | 16 - 18.8% | | | 31 - 6.5% |
| Making right turn - Going straight ahead | | | | 4 - 25.0% | | | |
| NA | | | | 10 - 40.0% | | | |
| Parked - Parked | | | 4 - 25.0% | | | | |
| Ran off road - right - Going straight ahead | | 8 - 12.5% | | | | | |
| Slowing or stopping - Making right turn | 4 - 25.0% | | | | | | |
| Stopped in traffic lane - Going straight ahead | | | | | | 9 - 11.1% | |

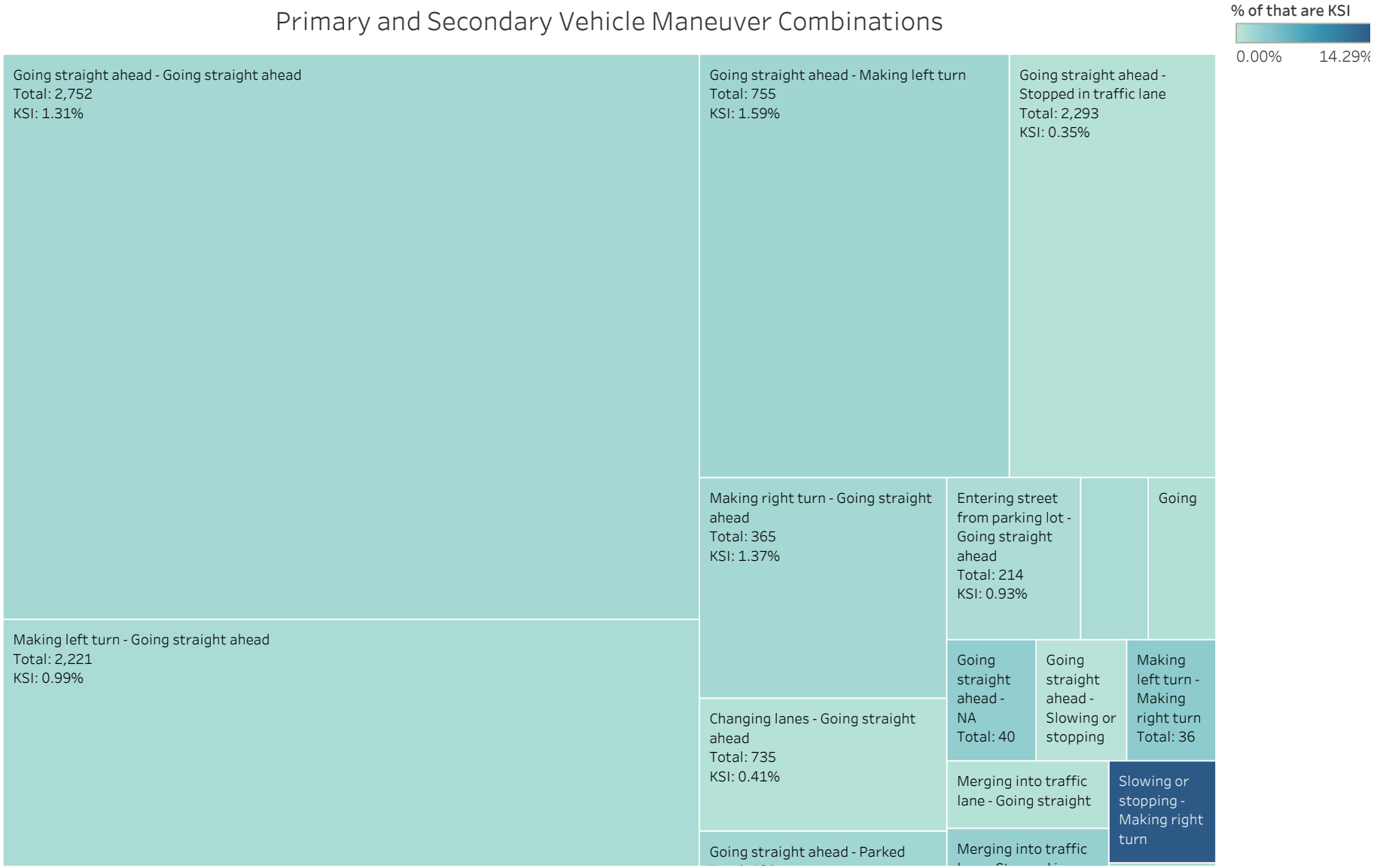
## Primary Crash Event, Weather, and KSI

(Size based on proportion of crashes that are KSI)



Vehicles in the data are sequenced with the primary at fault listed first. This allows for evaluating vehicle maneuvers for the primary and secondary vehicle. Combinations with less than three incidents were removed. The total is the number of individuals involved. While individuals involved in crashes where both vehicles are going straight ahead or one of the vehicles were making a left turn comprised most of the vehicle only crashes, these proportionally did not result in many KSIs. The highest proportion of individuals being KSI in vehicle only crashes come when the primary vehicle was running off road to the right and the secondary vehicle was going straight and when the primary vehicle was slowing or stopping which the secondary vehicle was making a right turn, but these are lower in numbers.

## Primary and Secondary Vehicle Maneuver Combinations



Vehicle only crashes listed as a motorcyclist event have an increased KSI risk independent and jointly with other conditions. Rear end and side sweep crashes have decreased KSI risks overall. Fixed object crashes experience more KSI crashes than expected, but the impact of this drops out of significance when controlling for other factors.

## Significance Tests for Vehicle Only

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Drinking | 0.00000 |
| | | Speeding Involved | 0.00000 |
| | | Event: Fixed Object | 0.00015 |
| | | Event: Motorcyclist | 0.00050 |
| | | Street Group: Secondary | 0.00824 |
| | | Event: Head on | 0.03548 |
| | Negative Relationship | Event: Rear End | 0.00002 |
| | | Event: Side Sweep | 0.01685 |
| Borderline Significant | Positive Relations.. | Event: Other | 0.09325 |
| | Negative Relationship | Event: Backed Into | 0.05497 |
| | | Number of Lanes | 0.05778 |

## Vehicle Only Log Model

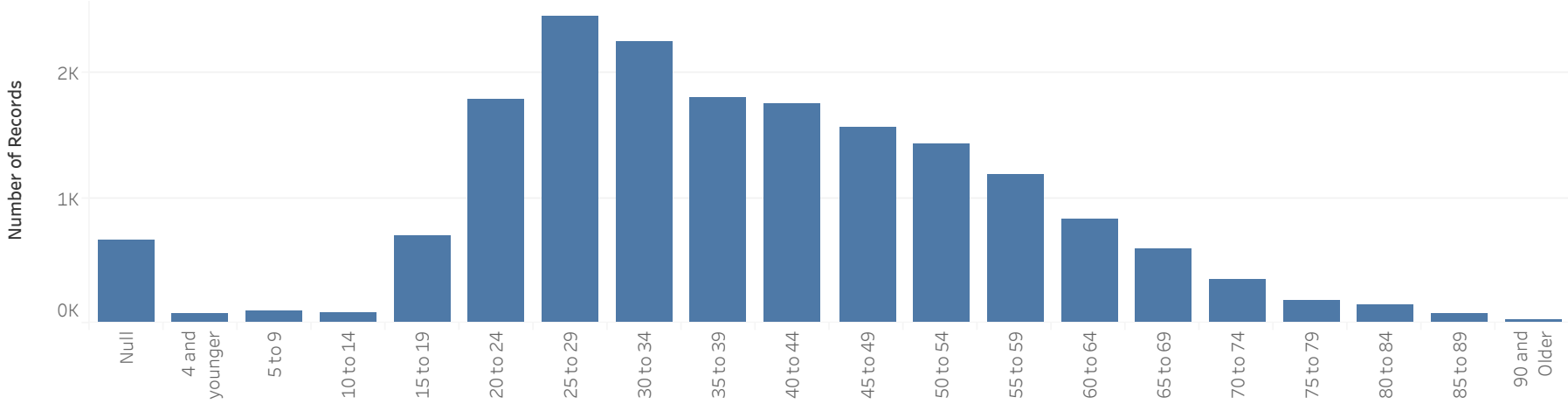
| | | |
|---|---|---|
| (Intercept) | 387.2 | ** |
| | (129.8) | |
| Year | -0.2 | ** |
| | (0.1) | |
| Drinking | 1.3 | *** |
| | (0.3) | |
| Event: Motorcyclist | 2.3 | *** |
| | (0.7) | |
| Event: Rear End | -1.3 | ** |
| | (0.5) | |
| Event: Side Sweep | -1.5 | * |
| | (0.7) | |
| Was a Speeding Vehicle Involved * Adverse Weather | -2.1 | . |
| | (1.1) | |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

9. The young and old have dinstinct KSI risks.

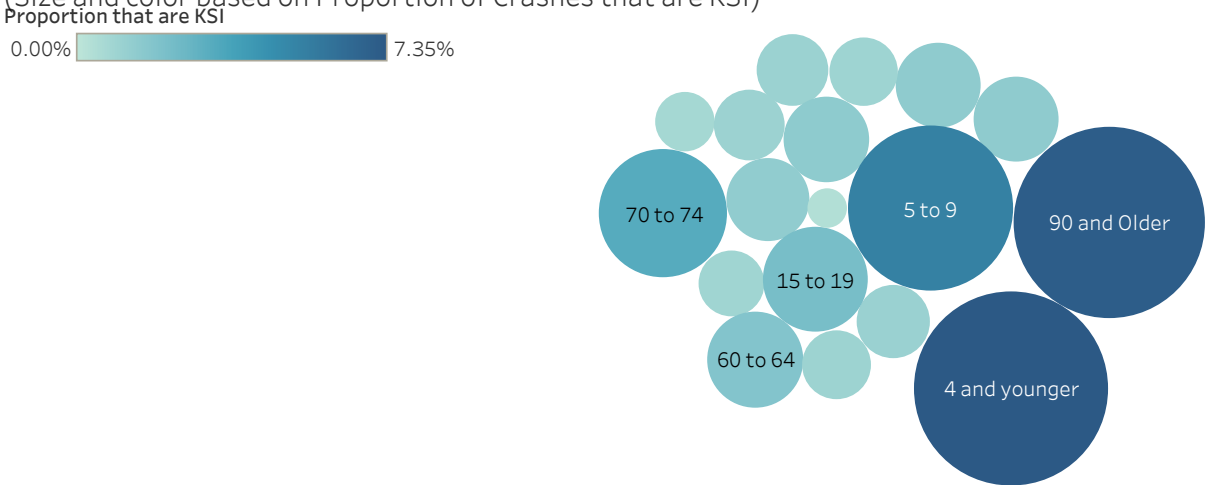
Looking at the ages of individual involved in a crash, a traditional bell-shaped curve is found where the young and old are low in numbers compared to the middle ages. However, the young and old age groups also have higher KSI proportions.

## Ages of All Involved



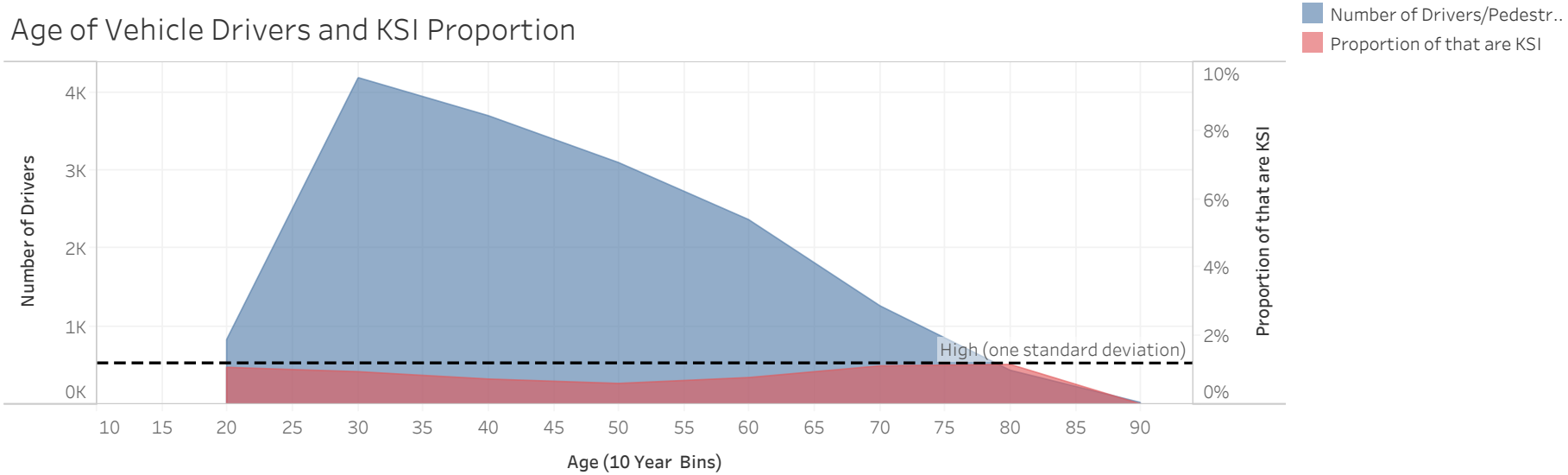

## Ages of Individuals Invovled in a Crash by KSI

(Size and color based on Proportion of Crashes that are KSI)

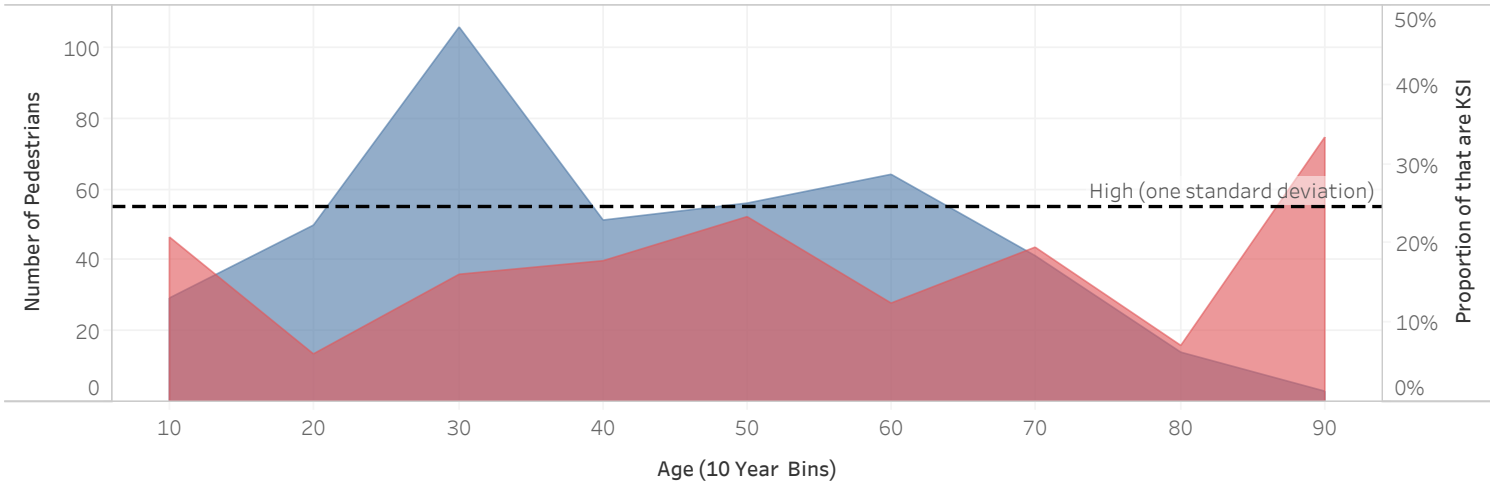


Most of the vehicle drivers and pedestrians involved in an accident are in their twenties or thirties. KSI risks rise for vehicle drivers over 70. However, these driver ages are also less common. KSI risks for pedestrians increase at 45 years old and after 70 years old, but they are very low in number. 15 to 24-year-old drivers are seen to be 'risky' drivers in the research. This age group did have high KSI proportions, especially when compared to middle aged (40-55) drivers.

## Age of Vehicle Drivers and KSI Proportion




## Age of Pedestrian and KSI Proportion



Young and old pedestrians are at a particular risk. There are more pedestrians involved in a crash 18 years old or younger during nicer weather (Q2 Spring and Q3 Summer). Nevertheless, the number of young pedestrians experiencing being KSI does not fluctuate across the year. Most of the young pedestrians involved in a crash were crossing an intersection with a signal or crossing not at an intersection. But crossing not at an intersection results in the most KSI for child pedestrian. Older pedestrians involved in a crash were crossing at an intersection with or without a signal.

## Path of Travel/Location by Quarter and KSI for Pedestrians 9 Years Old and Younger

| | | Crossing not at intersection | Crossing at an intersection with a signal | Coming from behind parked cars | Crossing at an intersection with no signal | NA | Not in roadway | Other | Getting on or off other vehicle | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Not KSI | Q1 | 1 | | | 2 | | | | | 3 |
| | Q2 | 2 | 3 | 2 | 1 | 2 | | 1 | | 11 |
| | Q3 | 1 | 3 | | | | 1 | 1 | 1 | 7 |
| | Q4 | | | 1 | | | | | | 1 |
| KSI | Q1 | 1 | | | | | 1 | | | 2 |
| | Q2 | 1 | | 1 | | | | | | 2 |
| | Q3 | 1 | | | | | | | | 1 |
| | Q4 | 1 | | | | | | | | 1 |
| Grand Total | | 8 | 6 | 4 | 3 | 2 | 2 | 2 | 1 | 28 |

## Path of Travel/Location and KSI for Pedestrians 65 Years Old and Older

| | Crossing at an intersection with a signal | Crossing at an intersection with no signal | Other | NA | Walk in road against traffic with no sidew.. | Crossing not at intersection | Coming from behind parked cars | Not in roadway | Standing in roadway | Crossing at an intersection against the si.. | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not KSI | 14 | 7 | 5 | 3 | 2 | 1 | | 1 | 1 | 1 | 35 |
| KSI | | 2 | | | 1 | 1 | 1 | | | | 5 |
| Grand Total | 14 | 9 | 5 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 40 |

10. Poor personal choices (lack of safety restraint or drinking) increase KSI risks.

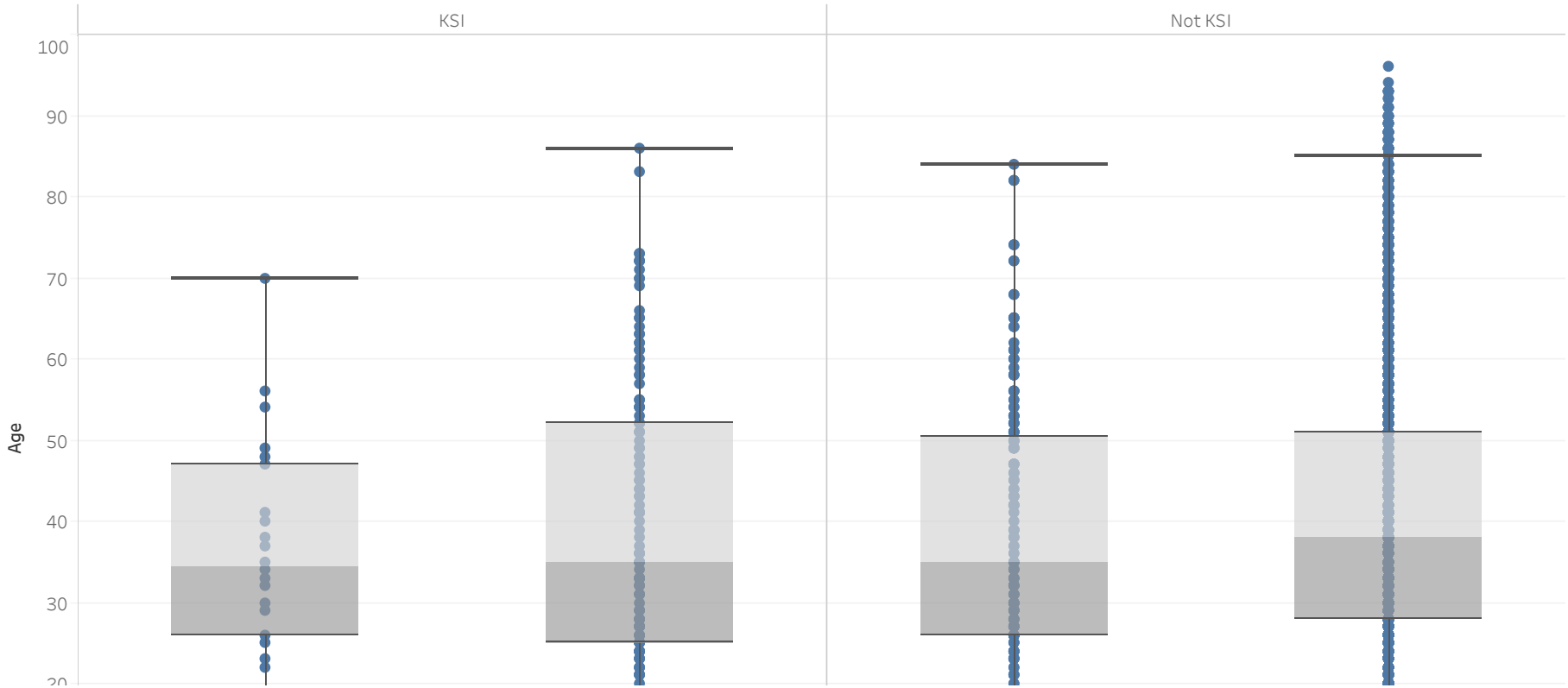
When looking at individual's use of safety restraints in vehicle only crashes, there are higher rates of KSI with individuals (whether driver or occupant) not using a safety restraint. Breaking this down by age, there are not many children involved in crashes that were not using a restraint overall. The age range is not significantly different from those who used a restraint and being KSI.

# Safety Restraint Use

## Safety Restraint Use by Person Type

| | Vehicle Driver | Vehicle Occupant |
|---|---|---|
| No restraint used | 140 | 64 |
| Restraint used | 15,829 | 893 |

Proportion of that are KSI
0.7% 9.3%



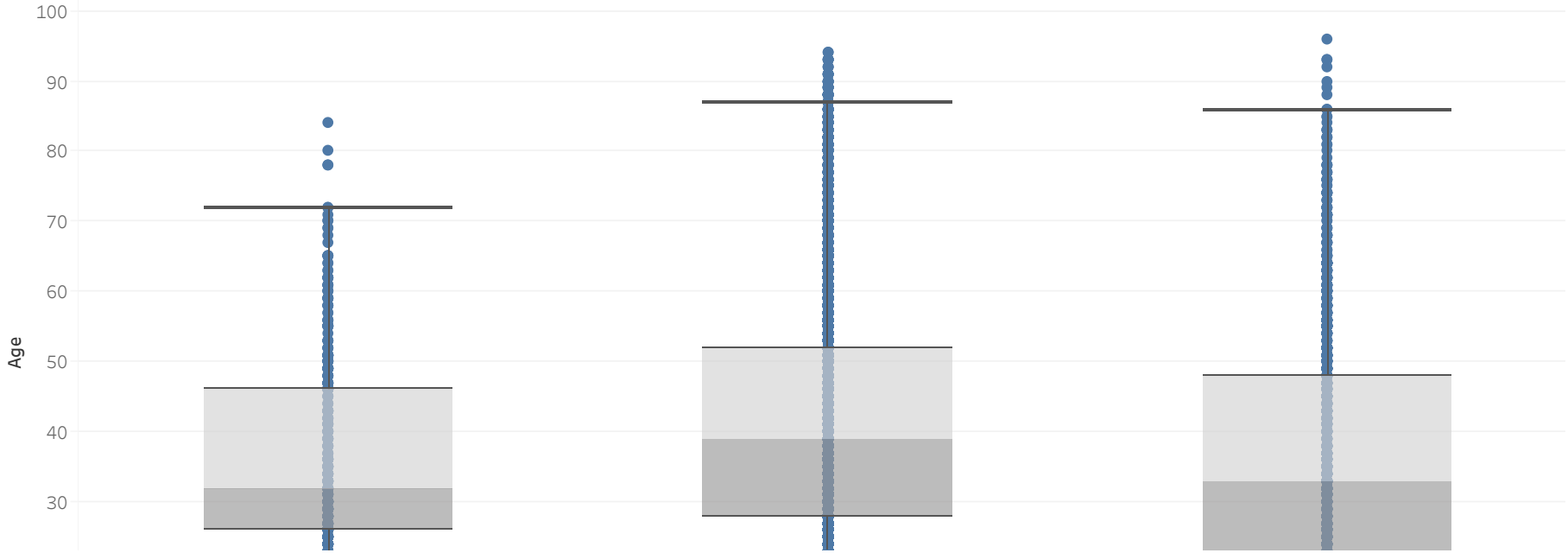
Regarding alcohol use, drinking does increase KSI risk as compared to those who had not been drinking. Though the distribution of ages between those that drank before a crash and those that had not been drinking were not largely different, the mean of those that had been drinking is 6 years less, even though those that had not been drinking include many more younger ages.

## Alcohol Use

| | Bicycle | Pedestrian | Vehicle Only |
|---|---|---|---|
| Drinking | 8 | 38 | 440 |
| Had not been drinking | 202 | 737 | 14,754 |
| NA & Unknown | 17 | 85 | 1,732 |

Proportion of that are KSI
0.0% 12.5%

## Age by Alcohol Use



In the statistical tests, drinking is also shown to increase KSI risk in vehicle only crashes.

## Significance Tests for Vehicle Only

| | | | |
|---|---|---|---|
| Significant | Positive Relationship | Drinking | 0.00000 |
| | | Speeding Involved | 0.00000 |
| | | Event: Fixed Object | 0.00015 |
| | | Event: Motorcyclist | 0.00050 |
| | | Street Group: Secondary | 0.00824 |
| | | Event: Head on | 0.03548 |
| | Negative Relationship | Event: Rear End | 0.00002 |
| | | Event: Side Sweep | 0.01685 |
| Borderline Significant | Positive Relations.. | Event: Other | 0.09325 |
| | Negative Relationship | Event: Backed Into | 0.05497 |
| | | Number of Lanes | 0.05778 |

## Vehicle Only Log Model

| | | |
|---|---|---|
| (Intercept) | 387.2 (129.8) | ** |
| Year | -0.2 (0.1) | ** |
| Drinking | 1.3 (0.3) | *** |
| Event: Motorcyclist | 2.3 (0.7) | *** |
| Event: Rear End | -1.3 (0.5) | ** |
| Event: Side Sweep | -1.5 (0.7) | * |
| Was a Speeding Vehicle Involved * Adverse Weather | -2.1 (1.1) | . |

Notes: Estimate;
Standard errors in parenthesis;
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Data Recommendations

This analysis was limited due to data availability and quality. OPA developed recommendations to improve data quality. Better data collection will aid in future analysis and tracking.

Recommendations:

- Reduce errors and missing data. The analysis was limited due to data quality and availability. It is not known whether missing data are missing at random or if there are underlying reasons some data are missing.The data used for the analysis were collected during an older record management system (RMS) at APD. This RMS could not be directly linked to the TREDS software, which meant that TREDS reports were printed out and manually entered at a later point. This created both a lag in data availability and more errors. The new RMS eliminates this extra step by directly linking to the TREDS software. This directly link should be fully exploited so that additional data can be attached to the crash data and data quality promoted.

- Accurately and consistently record the location of crashes. Many of the crash locations had to be edited to be geocoded due to invalid intersections, wrong streets, or had additional data attached (e.g., ramp). These errors meant that Google's Geocode API had to be used to geolocate the crashes over internal GIS geocoding software. When Google cannot find an exact location match, it will estimate a nearby location. This hurts the trustworthiness of attached GIS data. There needs to be a consistent way to indicate where crashes and whether they occurred at intersections, midblock, or on ramps. These problems are currently being addressed with the new RMS system.

- Track clearly the root cause of crashes. The data does not allow for looking at the root cause of crashes. Without such data, assumptions must be made about the connection between high-risks conditions and situations to the causes of crashes. The National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) database provides a good illustration on how this might look like.

- Collect more data on bicycle involved crashes . Such data needs to include a standard way to indicate: incidents that involved a bicycle, if an individual involved was a bicyclist versus vehicle driver/occupant, and the type of bicyclist maneuver (e.g. riding in bike lane, turning left at stop sign not in a bike lane).