Crashless in Seattle? Spatial Relationships Between Traffic Stop and Vehicle Accident Locations

Wisnu (Wiz) Sugiarto

Transportation Research Group

Washington State University

PNREC 2024

Motivation

- **Efficiency issue**
  - U.S. law enforcement agencies are grappling with resource constraints.
  - Washington state has its lowest number of officers per capita since 1980 (Perez, 2022).
  - In Seattle, the number of officers has reached the lowest mark in 30 years (Angeli Kakade, 2022).
  - Element of discretion.

Motivation

- **Efficiency issue**
  - U.S. law enforcement agencies are grappling with resource constraints.
  - Washington state has its lowest number of officers per capita since 1980 (Perez, 2022).
  - In Seattle, the number of officers has reached the lowest mark in 30 years (Angeli Kakade, 2022).
  - Element of discretion.
- **Why accidents?**
  - Average over 6 million crashes and 32,404 fatalities annually between 2010 and 2020 (Traffic Safety Facts Annual Report, 2022).

Motivation

- **Efficiency issue**
  - U.S. law enforcement agencies are grappling with resource constraints.
  - Washington state has its lowest number of officers per capita since 1980 (Perez, 2022).
  - In Seattle, the number of officers has reached the lowest mark in 30 years (Angeli Kakade, 2022).
  - Element of discretion.
- **Why accidents?**
  - Average over 6 million crashes and 32,404 fatalities annually between 2010 and 2020 (Traffic Safety Facts Annual Report, 2022).
- **Why traffic stops?**
  - Common policing tool. Over 20 million Americans experience traffic stops each year.
  - One of the most prevalent ways which the public experiences safety enforcement and interacts with police (Langton, Durose, et al., 2013); (Glaser, 2015); (Baumgartner, Epp, & Shoub, 2018); (Davis, Whyde, & Langton, 2018); (Pierson et al., 2020).

Objective

- Examine the efficiency of resource allocations within the context of motor vehicle accident and traffic stop locations in an urban environment.
    - Relationships between traffic stops and accidents.
    - Areas that could use more road safety measures.
    - Factors that affect accident reductions.

Contributions

Data

Accident data

- Source: Washington State Department of Transportation (WSDOT).
- 103,160 reported collisions in 2022.
- Focus on Seattle and presumably preventable accidents by traffic stops: 3,624 cases.

Traffic stop data

- SPD's Computer-Aided Dispatch (CAD) records: all 911, non-emergency, and officer-initiated calls.
- 6,617 traffic stop events in 2022.
- All stops regarded as road safety enforcement regardless of outcomes.

Accident Contributing Circumstances Number of Vehicles Involved in Accidents Accidents by Month and Day/Night

Accidents by Severity Level Traffic Stops by Month and Day/Night Offense by Month Offense by Hour

Summary Statistics

Research Design

- Generate 20,000 random locations in Seattle.
- Map the random locations to the 2020 Seattle census blocks.
- Result in 5,309 unique census blocks.
- Link each unique census block with collected and assembled data.
- Nearest-matching design.
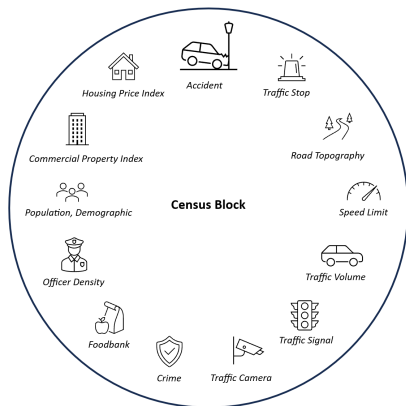
Data collected and assembled for each census block

Identification

- Endogeneity. Instrumental Variables (IV):
  - Relevance and Exogeneity conditions.
  - Instruments: the number of non-categorical and non-violent offenses, trespassing incidents, and population census of racial minorities (Pierson et al., 2020)
  - F-stats for $officer\_density_i$ and $stop\_i$ are 164.2 and 72.04, respectively.

Identification

- Endogeneity. Instrumental Variables (IV):
  - Relevance and Exogeneity conditions.
  - Instruments: the number of non-categorical and non-violent offenses, trespassing incidents, and population census of racial minorities (Pierson et al., 2020)
  - F-stats for $officer\_density_i$ and $stop\_i$ are 164.2 and 72.04, respectively.

Identification

- Endogeneity. Instrumental Variables (IV):
  - Relevance and Exogeneity conditions.
  - Instruments: the number of non-categorical and non-violent offenses, trespassing incidents, and population census of racial minorities (Pierson et al., 2020)
  - F-stats for $officer\_density_i$ and $stop\_i$ are 164.2 and 72.04, respectively.
- Characteristics of Count Data
  - Discrete, non-negative, and skewed.
  - IV Poisson Generalized Method of Moments GMM) approach.
  - Allows some endogenous regressors.
 - Estimated coefficients interpreted as semi-elasticities.

Results

	IV-2SLS	S.E.	IV Poisson GMM	S.E.
officer_density	0.31***	(0.05)	0.09***	(0.03)
total_stop	-0.58*	(0.34)	-0.01***	(< 0.00)
gross_acres	0.47***	(0.06)	0.06**	(0.03)
daily_traffic	0.82***	(0.21)	0.03***	(0.01)
people_moving	-0.15***	(0.03)	-0.02	(0.73)
people_staying	0.18***	(0.04)	0.02*	(0.01)
speed_limit	0.16*	(0.09)	0.01***	(< 0.00)
number_of_lane	-0.85*	(0.47)	0.01	(0.13)
road_segment_length	0.87	(0.55)	-0.01	(0.24)
avg_officer_exp	0.23***	(0.03)	0.03***	(0.01)
housing_price_index	-0.13***	(0.03)	-0.02***	(< 0.00)
burglary	-0.42***	(0.09)	0.01	(0.01)
theft_robbery	0.38***	(0.06)	0.06*	(0.04)
hit_and_run	-0.17	(0.12)	-0.09	(0.17)
dui	-0.30	(1.30)	0.06	(0.06)
drugs	-0.27**	(0.11)	-0.02***	(< 0.00)
cam_tickets_2022	-0.57***	(0.13)	-0.01	(0.01)

Simulation - IV-2SLS
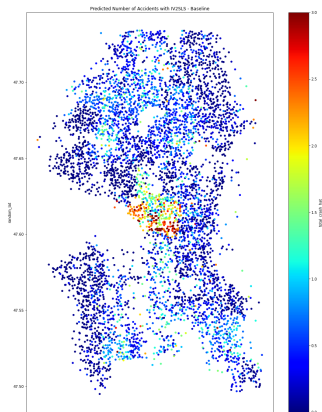
Predicted number of accidents using IV-2SLS estimator.
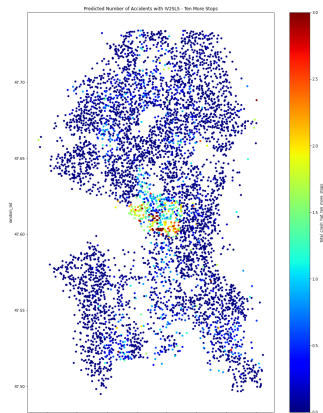
Predicted number of accidents using IV-2SLS estimator with ten additional traffic stops.

Conclusions

- Efficiency of public resource allocations in the context of traffic stop and accident locations.
- Novel datasets and census block level analysis.
- Inverse relationship between stop and accident frequencies.
- Spatial heterogeneity in the effect of increasing traffic stops.
  - Downtown and higher daily volume locations benefit more from increased stops.
  - More affluent areas benefit less from increased stops.

Thank You

wisnu.sugiarto@wsu.edu

Contributions

- **Spatial analysis on traffic stops and accidents at the census block level.**
  - Previous studies are at the municipality level (Makowsky & Stratmann, 2011), the county level (Garrett & Wagner, 2009), and the state level (DeAngelo & Hansen, 2014).
  - Discretion, enforcement locations.

Contributions

- **Spatial analysis on traffic stops and accidents at the census block level.**
  - Previous studies are at the municipality level (Makowsky & Stratmann, 2011), the county level (Garrett & Wagner, 2009), and the state level (DeAngelo & Hansen, 2014).
  - Discretion, enforcement locations.
- **Novel datasets**
  - Comprehensive datasets from the Seattle Police Department (SPD): crime events, officers' daily assignments, and Computer Aided Dispatch (CAD) records from 2021 and 2022.
  - Assembled dataset of location characteristics and road topography.

Contributions

- **Spatial analysis on traffic stops and accidents at the census block level.**
  - Previous studies are at the municipality level (Makowsky & Stratmann, 2011), the county level (Garrett & Wagner, 2009), and the state level (DeAngelo & Hansen, 2014).
  - Discretion, enforcement locations.
- **Novel datasets**
  - Comprehensive datasets from the Seattle Police Department (SPD): crime events, officers' daily assignments, and Computer Aided Dispatch (CAD) records from 2021 and 2022.
  - Assembled dataset of location characteristics and road topography.
- **Traffic stops by an urban police department**
  - Differences in primary jurisdictions.
  - Urban characteristics present different challenges.

Summary Statistics

- Based on 5,309 randomly identified census blocks.
- Officer density is the ratio of policy quantity and sector area size.
- Quantity of offenses are normalized by average daily traffic.

	Mean	SD	Min	25%	50%	75%	Max
total crash	0.39	1.08	0	0	0	0	16
officer density	16.31	24.92	2.19	5.57	8.57	16.2	334.63
total stop	0.75	3.01	0	0	0	0	85
avg. officer exp.	11.33	1.29	7.1	10.47	11.25	12.46	13.42
assault	0.0003	0.0019	0	0	0	0.0001	0.1159
dui	< 0.0000	0.0002	0	0	0	0	0.0055
drugs	< 0.0000	0.0002	0	0	0	0	0.0084
homicide	< 0.0000	< 0.0000	0	0	0	0	0.0021
theft & robbery	0.0011	0.0096	0	0.0001	0.0003	0.0009	0.6276

Sensitivity Analysis - Changing the Functional Form

The dependent variable $= accident_i / daily\_traffic_i$.

	IV-2SLS	S.E.	IV Poisson GMM	S.E.
officer_density	0.37***	(0.09)	0.02	(0.10)
total_stop	0.26	(0.54)	-0.01**	(0.01)
gross_acres	0.45***	(0.10)	0.09	(0.23)
people_moving	-0.18***	(0.04)	0.01	(0.01)
people_staying	0.24***	(0.06)	-0.04	(0.12)
speed_limit	-0.18	(1.47)	0.01***	(< 0.00)
number_of_lane	-0.24***	(0.07)	0.06	(0.15)
road_segment_length	0.16*	(0.09)	-0.07	(0.28)
avg_officer_exp	0.25***	(0.07)	-0.06	(0.11)
housing_price_index	-0.18***	(0.05)	-0.02***	(< 0.00)
burglary	-0.23	(0.14)	0.03	(0.02)
theft_robbery	0.54***	(0.10)	0.03***	(0.01)
hit_and_run	-0.93***	(0.19)	-0.01	(0.03)
dui	0.29***	(0.02)	0.01*	(0.01)
drugs	-0.38**	(0.17)	-0.03	(0.02)
cam_tickets_2022	-0.64**	(0.21)	-0.04***	(0.01)

Sensitivity Analysis - Injuries and Fatalities

	IV-2SLS	S.E.	IV Poisson GMM	S.E.
officer_density	0.16***	(0.03)	0.06***	(0.02)
total_stop	-0.57**	(0.19)	-0.01**	(0.01)
gross_acres	0.27***	(0.04)	0.07**	(0.03)
daily_traffic	0.37***	(0.12)	0.06***	(0.01)
people_moving	-0.78***	(0.16)	-0.02***	(0.01)
people_staying	0.84***	(0.22)	0.02	(0.01)
speed_limit	0.16***	(0.05)	0.02***	(< 0.00)
number_of_lane	-0.28	(0.27)	0.02	(0.02)
road_segment_length	0.29	(0.32)	0.04	(0.27)
avg_officer_exp	0.11***	(0.03)	0.02***	(0.01)
housing_price_index	-0.56***	(0.20)	-0.01***	(< 0.00)
burglary	-0.16***	(0.05)	0.01	(0.01)
theft_robbery	0.17***	(0.04)	0.01*	(0.01)
hit_and_run	-0.13*	(0.07)	0.07	(0.06)
dui	-0.12	(0.75)	0.03	(0.06)
drugs	-0.98	(0.63)	-0.02**	(0.01)
cam_tickets_2022	-0.28***	(0.07)	-0.03**	(0.02)

OLS - Factors on Accident Reductions

	IV-2SLS	S.E.	IV Poisson GMM	S.E.
gross_acres	-0.20	(0.13)	-0.12	(0.13)
daily_traffic	0.21**	(0.10)	0.12	(0.10)
downtown	0.13***	(0.02)	0.28	(0.23)
people_moving	-0.29	(0.26)	-0.57	(2.47)
people_staying	0.17	(6.96)	-0.30	(0.66)
speed_limit	-0.33	(0.30)	0.58	(2.85)
number_of_lane	-0.78	(1.11)	0.22	(1.05)
road_segment_length	0.40*	(0.24)	0.86	(2.23)
road_surface_width	0.12*	(0.07)	0.11*	(0.07)
avg_officer_exp	0.09*	(0.05)	0.61	(4.31)
housing_price_index	-0.38*	(0.20)	-0.80	(18.97)
burglary	-0.12	(0.21)	-0.30	(0.20)
theft_robbery	0.90	(0.94)	0.34***	(0.09)
hit_and_run	-0.92	(3.31)	-0.24	(0.31)
dui	0.11	(0.27)	0.12	(0.26)
drugs	-0.65	(2.05)	-0.61	(1.94)

Simulation - IV Poisson GMM
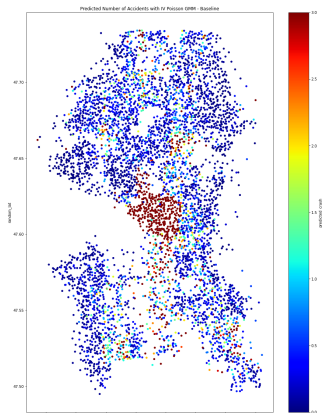
Predicted number of accidents using IV Poisson GMM with Multiplicative Error estimator.
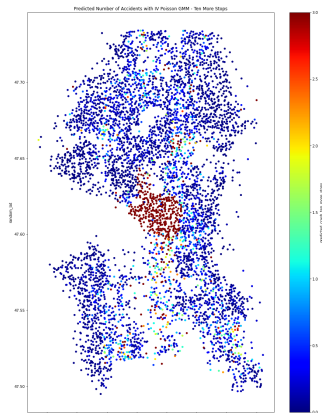
Predicted number of accidents using IV Poisson GMM with Multiplicative Error estimator with ten additional traffic stops.

Back

Simulation - IV-2SLS on Injuries and Fatalities
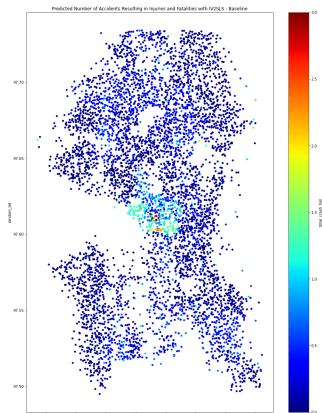
Predicted number of accidents resulting in injuries and fatalities using IV-2SLS estimator.
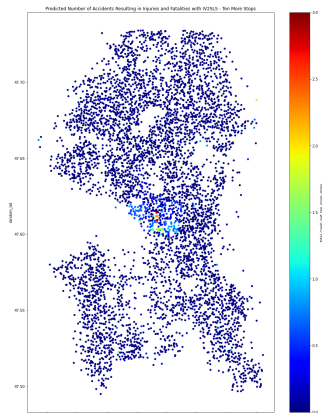
Predicted number of accidents resulting in injuries and fatalities using IV-2SLS estimator with ten additional traffic stops.

Back to Sensitivity Analysis Injuries Fatalities

Locations with at least One Accident

Areas with at least One Accident
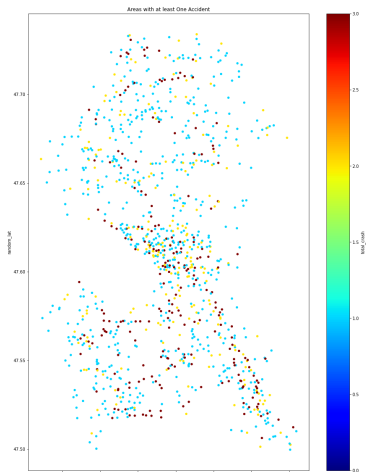
Summary of Data Sources

Data Type	Source	Time Period
Accidents	WSDOT	2022
Commercial Properties	OfficeSpace.com	2023
Demographic	US Decennial Census	2020
Downtown Coordinates	Google Maps	2023
Emergency Food Locations	Seattle Open Data - Community	2022
Highway Locations	Seattle Open Data - Transportation	2023
Housing	Zillow.com	2023
Lane Counts	Puget Sound Regional Council (PSRC)	2018
Offenses	Seattle Police Department	2021-2022
Officers' Assignments	Seattle Police Department	2021-2022
Park Locations	Google Maps API	2023
Pavement Conditions	Seattle Open Data - Seattle Streets	2023
Public Life	Seattle Open Data - Transportation	2017-2020; 2022
Road Segment Length	Seattle Open Data - Seattle Streets	2023
Road Slope	Seattle Open Data - Seattle Streets	2023
Road Weather Info Stations	Seattle Open Data - Public Safety	2019-2020

Summary of Data Sources Continued

Data Type	Source	Time Period
School Assessments	US Department of Education - ED*Facts*	2018-2019
School Attendance	Seattleschools.org	2022-2023
School Characteristics	National Center for Education Statistics	2021-2022
Speed Limits	Seattle Open Data - Seattle Streets	2023
Surface Width	Seattle Open Data - Seattle Streets	2023
Traffic Camera Infractions	Seattle Open Data - Public Safety	2022
Traffic Counts	Seattle Open Data - Transportation	2018
Traffic Stops	Seattle Police Department	2022
Traffic Signals	Seattle Open Data - Transportation	2022-2023
Water Body Locations	Google Maps API	2023

Contributing Circumstances

Contributing Circumstance	Count	Contributing Circumstance	Count
Unknown distraction	897	Did not grant right of way to vehicle	726
Improper turn/merge	359	Under influence of alcohol	350
Disregard traffic sign and signals	296	Follow too closely	240
Exceeding reasonable safe speed	166	Did not grant right of way to non motorist	133
Exceeding stated speed limit	131	Other distractions	128
Operating recklessly or aggressively	119	Under influence of drugs	113
Distractions outside vehicle	78	Improper passing	75
Improper backing	74	Improper u-turn	67
Apparently asleep or fatigued	62	Operating defective equipment	56
Overcorrecting/oversteering	49	Operating handheld cell phone	31
Lost in thought/day dreaming	23	Distracted by other occupant	18
Distracted by adjusting vehicle controls	17	Operating other electronic devices	10
Apparently emotional (depressed, angry)	9	Disregard flagger/officer	8
Eating or drinking	8	Improper parking location	7
Failing to signal	7	Had taken medication	5
Improper signal	5	Light violation; no light/fail to dim	5
Racing	5	Operating hands-free cell phone	4
Smoking	1		

Contributing circumstances to accidents on city streets and their number of occurrences in 2022 in Seattle, Washington

Back to Data

Accidents by Timing, Jurisdictions, and Conditions

Timing Occurrences	Count	Jurisdictions	Count
Day	2,165	City street	3,624
Night	1,459		
Weather Conditions	Count	Road Surface Conditions	Count
Clear or partly cloudy	2,375	Dry	2,707
Overcast	643	Wet	804
Raining	500	Unknown	45
Fog/Smog/Smoke	29	Snow/Slush	34
Snowing	24	Ice	29
Other	22	Standing Water	2
Unknown	22	Other	2
Sleet/Hail/Freezing Rain	9	Sand/Mud/Dirt	1
Light Conditions	Count	Light Conditions	Count
Daylight	2,121	Dark, street lights on	1,180
Dusk	124	Dawn	67
Unknown	43	Dark, unknown lighting	32
Dark, no street lights	30	Dark, street lights off	22
Other	5		

Hedonic Regression Models

$$ln(house\_price)_i = \alpha + \eta_{\ non\_studio_i} + \beta_1 \ _{ln(non\_studio*beds)_i} + \beta_2 \ _{ln(baths)_i}$$
$$+ \beta_3 \ ln(size)_i + \gamma_1 \ ln(hs\_puptea\_ratio)_i + \gamma_2 \ ln(hs\_pctprof\_math)_i$$
$$+ \gamma_3 \ ln(hs\_pctprof\_rla)_i + \rho_1 \ ln(ms\_puptea\_ratio)_i$$
$$+ \rho_2 \ ln(ms\_pctprof\_math)_i + \rho_3 \ ln(ms\_pctprf\_rla)_i$$
$$+ \sigma_1 \ ln(es\_puptea\_ratio)_i + \sigma_2 \ ln(es\_pctprof\_math)_i$$
$$+ \sigma_3 \ ln(es\_pctprof\_rla)_i + \delta_1 \ ln(dist\_water)_i + \delta_2 \ ln(dist\_park)_i$$
$$+ \delta_3 \ ln(dist\_hwy)_i + \delta_4 \ ln(dist\_dtn)_i + \phi_i + \epsilon_i \quad (1)$$

$$ln(comprop\_price)_i = \alpha + \eta \ sale_i + \beta_1 \ ln(size)_i + \beta_2 \ ln(day\_on\_market)_i$$
$$+ \beta_3 \ ln(age)_i + \beta_4 \ ln(floors)_i + \beta_5 \ ln(buildings)_i + \delta_1 \ ln(dist\_water)_i$$
$$+ \delta_2 \ ln(dist\_park)_i + \delta_3 \ ln(dist\_hwy)_i + \delta_4 \ ln(dist\_dtn)_i + \phi_i + \epsilon_i \quad (2)$$

Housing and Commercial Property Price Indexes

- Indicators for local economic conditions and availability of local amenities.
- Housing Price Index include:
  - House size and features.
  - Proximity to amenities: water body, park, highway, downtown.
  - School quality: pupil-teacher ratio, math proficiency, reading/language arts proficiency.
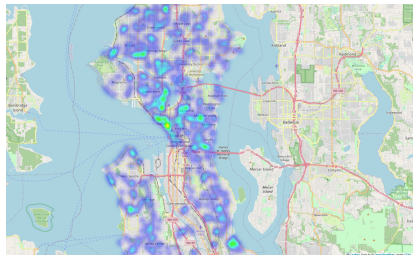
933 house listings in Seattle collected in 2023
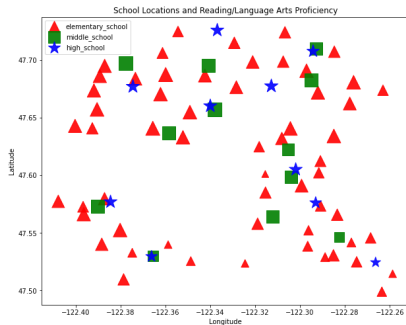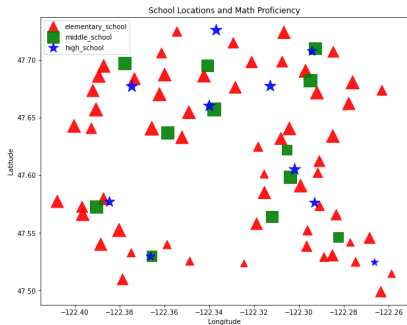
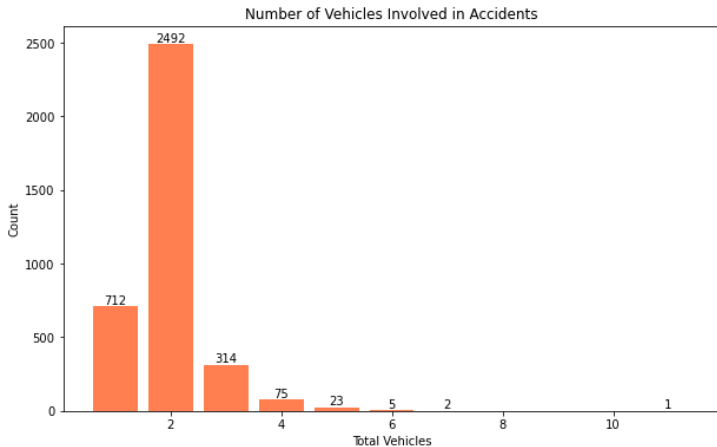# Housing Price Index: School Locations
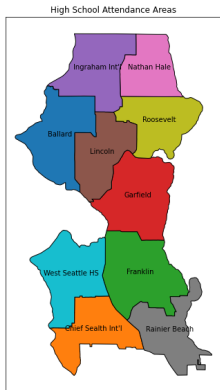
High schools in Seattle
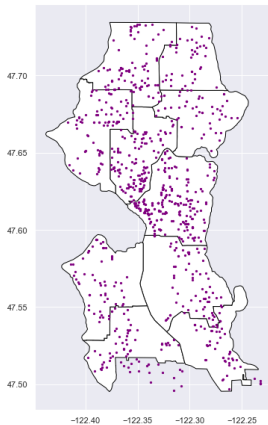
House listings and nearest school

Housing Price Index: School Quality

Number of Vehicles Involved in Accidents

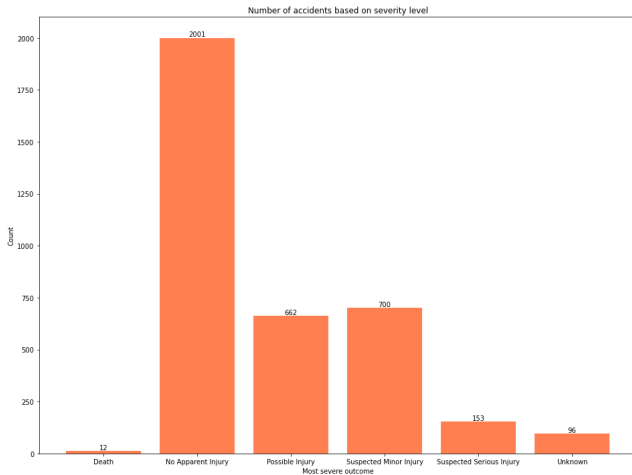Number of vehicles involved in accidents on city streets in 2022 in Seattle, Washington

Histogram of Collision Count by Month and Day/Night
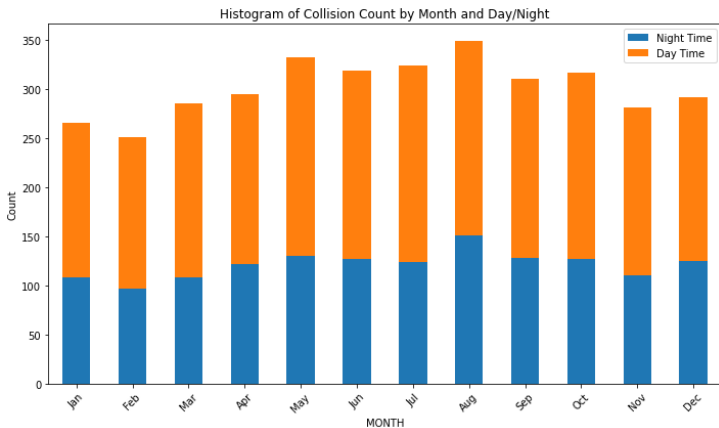
Accident county by month and day/night in 2022 in Seattle, Washington
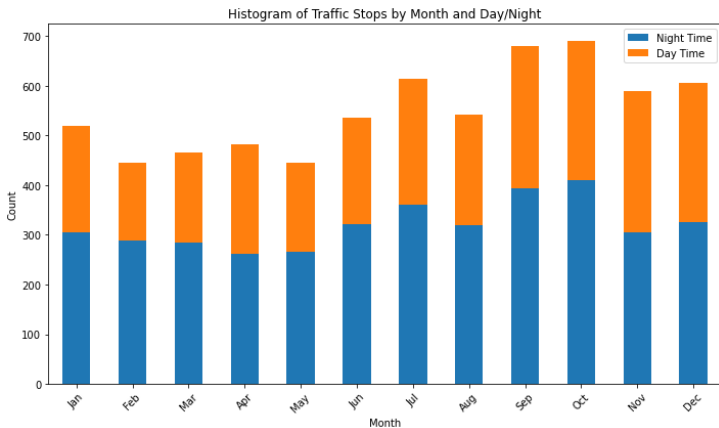
Back to Data

Number of Accidents Based On Severity Level
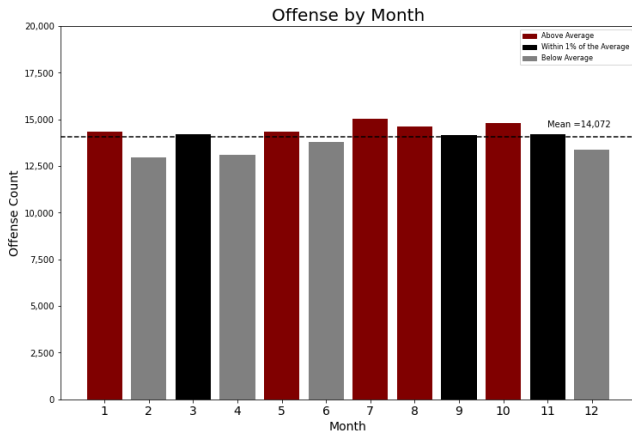

Number of accidents based on severity level

Histogram of Traffic Stops by Month and Day/Night

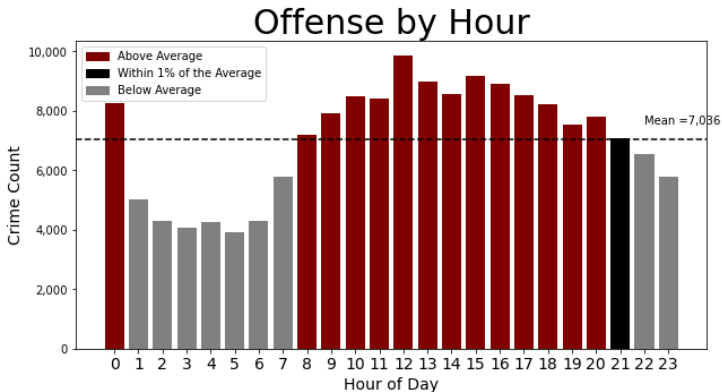Traffic stop count by month and day/night in 2022 in Seattle, Washington

Back to Data

Offense by Month

Total number of offenses in 2021 and 2022 by month in Seattle, Washington

Total number of offenses in 2021 and 2022 by hour in Seattle, Washington

Back to Data