THE UNIVERSITY of NORTH CAROLINA
GREENSBORO

# Traffic Stops Analytics and Racial Profiling

ISM698 Final Report

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Date: November 30, 2015

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**Problem Background**

Numerous studies have been undertaken in the United States to detect evidence of racial or ethnic bias in policing. Most of this research have focused on examining variations in the frequency or outcome of traffic stops between racial or ethnic groups (Weisel, 2014).

In one of the earliest studies in New Jersey, researchers conducted roadway observations to systematically document the race violators on the Jersey turnpike (Buerger & Farrell, 2002). The researchers calculated the rate of violators by racial group and then compared this ratio with the racial proportion of drivers stopped by troopers and their findings indicated racial disparities. The state of New Jersey claimed that in addition to race there were other relevant factors that affected the likelihood of stops and searches. However, the court rejected that claim, calling it an "after the fact" denial and pointed out that the state is responsible to identify and document factors that could either explain or justify the use of race in the stop and search decisions of troopers.

Many state police agencies began recording data about traffic stops after the court decision in New Jersey in 1998. North Carolina became the first state to mandate the collection of data on traffic stops in 1999 and the State Highway Patrol has been collecting such data since January 1, 2000. This data were made publicly available through NC Department of Justice's website (http://trafficstops.ncdoj.gov/) in 2002 to address the issues related to racially biased policing. By 1999, nine of the nation's 49 state law enforcement agencies were recording race or ethnicity for all traffic stops. This number increased to 16 in 2001 and 22 in 2004 (Hickman, 2005).

Different states require different variables to be recorded in traffic stops. The most documented elements include initial purpose of the traffic stop, race of the driver, outcome of the stop such as arrest, citation, or warning, whether a search was conducted and whether contraband was seized.

The initial purpose of collecting traffic stop data was not clear. Mandating law enforcement personnel to collect data was considered to either show that police actions were biased or to change presumed bias in police behaviors by monitoring the stops (Weisel, 2014). Buerger and Farrell (2002) observed that the purpose of mandating data collection was to determine or

disprove that racial profiling occurs. They pointed out that the type and level of evidence that would be sufficient to establish racial profiling was unknown.

Engel, Calnon, & Bernard (2002) indicated that traffic stop data should be collected and analyzed merely to answer carefully articulated questions. In addition, Farrell and McDevitt (2010) emphasized that data collection by itself is not sufficient to address the problem as findings of numerous racial profiling studies have frustrated both law enforcement officials and members of advocacy communities. Early studies of bias in policing claims that the practice of collecting data did affect police behavior (Weisel, 2014). Warren & Tomaskovic-Devey (2009) found that in North Carolina, the frequency of consent searches of minority drivers decreased while the hit rate for contraband increased.

Findings of racial disparities in stops and searches were determined inadequate evidence of police bias. Engel (2008) mentioned that very few scholars continue to claim that racial/ethnic disparities found in traffic stop studies are evidence of racial discrimination.

Fridell (2004) explained that no method is perfect to measure and establish racial bias and pointed out that the key purpose of collecting and analyzing stop data is to provide an empirical foundation to share concerns and facilitate police-citizen dialogue.

Baumgartner, Epp, Shoub, and Love (2015) claimed there was bias in how NC law enforcement conducted traffic stops. It indicated disparities in the rates at which black drivers, particularly young males, were searched and arrested as compared to similarly situated whites, women, or older drivers. In addition, they pointed out that the degree of racial disparity is growing over time. An analysis of purpose of traffic stop in the city of Greensboro indicated that blacks were more likely to be searched than Whites for all traffic violations except driving while impaired. Furthermore, it showed black men under the age of 30 are searched at rates of about 11 percent compared to white men of that age who see rates of about 6 percent. Women in general were typically below 4 percent (Baumgartner, Epp, & Shoub, 2015). In a similar report on traffic stops in Durham, Baumgartner, Epp, and Love (2014) showed that police behaviors differ dramatically based on race, gender, and age group when stopping a motorist. They concluded that system-

level factors such as agency decisions of where to assign officers to patrol, as well as individual-level factors related to particular officers contributed to the racial disparities.

Ridgeway, (2009) examined Cincinnati Police Department traffic stops and found no evidence of racial differences between the stops of blacks and those of similarly situated nonblack drivers; however, for each year of analysis he found several officers who stop substantially more black drivers than their colleagues do.

**Problem Statement**

In collaboration with Greensboro Police Department (GPD), this report aims to review existing studies of traffic stop data in the US, discuss best practices in traffic stop studies, and analyze traffic stop data collected in Greensboro from 2002 to 2013. The goal is to identify potential police racial bias in law enforcement in the city of Greensboro. It examines various methods to analyze and understand traffic stop data recorded by law enforcement officers to identify problems and develop effective responses.

This report also provides descriptive information about trends in traffic stops in the City of Greensboro, emphasizing on developing standardized and reliable method of analysis. Valid data and reliable tools for analyzing traffic stop data can expand the use of this information for police decision-making, inform policymaking, and enhance relationships between citizens and law enforcement agencies.

Moreover, it helps to identify if there is a department-wide bias in the traffic stops or if there are individual officers who stop a disproportionate number of African Americans. This analysis will also identify if there are racial differences in post-stop outcomes. In addition, this study proposes a predictive method for the Greensboro Police Department to be able to foresee the probability of crime in the future.

The data consists of about 500,000 records of traffic stops collected from 2002 to 2013 in the city of Greensboro. The data includes date and time of the stop, age, sex, race, and ethnicity of

drivers and passengers, initial purpose of stop, enforcement action taken by the officer, type of search, and basis for search. A separate dataset contains the race and gender of officers.

**Objectives**

The purpose of this research is to evaluate traffic stops data collected by the Greensboro Police Department. This evaluation will be realized by implementing the following:

1. Review of literature on the topic of traffic stops
2. Identify the stop and search ratios between white and black drivers and provide benchmarking methods to assess the racial differences
3. Reanalysis of the data and statistical methods for Greensboro
4. Increase the resolution of the analysis with the inclusion of census data
5. Identify potential recommendations for changes in policy, practice, or procedure

**Project Scope**

The scope of this project includes identification of the appropriate analytical tools required to analyze the city traffic stops data. Deployment of these tools and methods will inform the strategies and policies of the Greensboro Police Department to minimize racial discriminations and provide better services for the public.

Several statistical analysis techniques will be deployed. Particularly, cluster analysis, and automation interaction detector will be used for segment determination. Factor analysis will be used for removing multi-collinearity amongst variables if required. Regression analysis will be performed to predict time of crime occurrence. Other bivariate statistical analysis will be used for segment profiling.

Deliverables will include analysis documentations, the segments and validation investigations, and the final predictive models and recommendations for change in policy and practices.

**Project Significance**

Data management and analytics include a broad category of applications and technologies that are designed to facilitate tasks such as data collection, storage, analysis, and deployment. Specifically, in the case of safety and criminology, this information assist police departments with decisions and strategies to improve their performance and provide a safer environment for the people.

Use of analytical tools is critical for police departments because large amount of data need to be handled on a daily basis. In addition, analysis of traffic-stop patterns is needed to investigate whether racial biases influence police activities in the decision to stop, cite, and search vehicles in Greensboro.

**MSITM Course Relevance**

The implementation of this project draws upon various skills and knowledge that I acquired and experienced throughout the MSITM curriculum. This project will demonstrate knowledge in the areas of data management, business analytics, and project management. In order to successfully achieve the objective of this project, store and deploy the data, I will utilize skills learned in data management course. In order to perform these processes effectively and communicate with the officers in the police department to plan and allocate resources, I will utilize the knowledge I learned in project management course. Most importantly I will apply the knowledge and analytical skills that I learned in Models and Methods in Business Analytics course to implement the appropriate analytical methods.

**Anticipated Outcomes**

The project deliverables would be as follows:

1. A report of key findings relative to various analyses performed for this project.
2. Identification & verification of racial biases in stop and search of drivers.

3. Profile analysis with respect to significant variables that distinguish the key characteristics of drivers.
4. More accurate analytical methods with inclusion of geographic locations and identifying the spatial context of the traffic stop, in addition to demographics.
5. Recommendations for changes in policy, practice or procedures for Greensboro Police Department.

**Project Schedule**

The project will be initiated by gaining the approval from MSITM director on project topic and scope. The next few weeks will be spent on planning and meetings with the officers from Greensboro Police Department to plan and understand the project needs and obtaining the appropriate data. Towards the mid-semester the focus will be on identification of the appropriate analytical tools and methods and finally implementing the data management and predictive analytics and infer the results. The last two weeks of the project's life cycle will be dedicated to preparing for the final report and presentation of the study to MSITM director.

**Project Schedule Timeline**

| **Week** | **Due Date** | **Tasks** |
|---|---|---|
| 1 | **8/18/15** | Meeting with MSITM program director to stablish project parameters |
| 2 | **8/28/15** | Investigate and understand the project needs by attending meetings and interview officers form Greensboro Police Department<br>Submit project proposal |

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|---|---|---|
| 3 | **9/2/15** | Project proposal presentation |
| 4 | **9/9/15** | Review appropriate analytical tools to be implemented in this study<br>Submit progress report to MSITM program director |
| 5 | **9/16/15** | Apply analytical methods to identify the profile of the drivers and officers.<br>Submit progress report to MSITM program director<br>Meeting with MSITM director<br>Complete course consulting project survey |
| 6 | **9/23/15** | Profile analysis of the drivers and officers<br>Submit progress report to MSITM program director |
| 7 | **9/30/15** | Implement appropriate queries to view and analyze post stop and search results.<br>Meeting with MSITM director<br>Submit progress report to MSITM program director |
| 8 | **10/7/15** | Finalize the cluster analysis and identify the geographic location of the stops and searches |

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|---|---|---|
| | | Prepare mid-semester report and presentation<br>Submit progress report to MSITM program director |
| 9 | **10/14/15** | Identify the predictors and appropriate estimate to initiate predictive analysis<br>Mid-semester project presentation<br>Submit mid-semester project report to MSITM program director |
| 10 | **10/21/15** | Implement predictive analytics and identify the significant predictors of crime occurrence<br>Submit progress report to MSITM program director |
| 11 | **10/28/15** | Infer results and identify strategies to inform future policies and practices.<br>Submit progress report to MSITM program director<br>Meeting with MSITM director |
| 12 | **11/4/15** | Increase the resolution of the predictive models by incorporating location, time and census data.<br>Submit progress report to MSITM program director |

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|---|---|---|
| 13 | **11/11/15** | Meet with officers to present the results and recommendations<br>Submit progress report to MSITM program director<br>Meeting with MSITM director |
| 14 | **11/18/15** | Revise the report<br>Meet with officers to finalize project completion and prepare the final report<br>Revise final project report and prepare presentation |
| 15 | **12/1/15** | Final project presentation |

## Literature Review

### Methods of Calculating Disparities

Studies on racial and ethnic bias in traffic stops often focus on identifying differences or disparities in the proportion of minorities and four outcome measures are most commonly used to document disparities. These include disparities in traffic stops, disparities in stop outcomes, disparities in searches, and disparities in search outcomes. Each of these explanations of disparity and supporting evidence are described here (Weisel, 2014).

### Evidence of Disparities in Traffic Stops

National surveys confirm that traffic stops are the most common form of citizen contact with police and there is some evidence of racial disparities in stops. In 2011, 10.2% of all drivers in the U.S. reported being stopped by police at least one time within 12 months. The rate was 10%, 13%, and 10% for white, black, and Hispanic drivers respectively. 8.4% of white drivers, 8.8% of black drivers, and 9.1% of Hispanic drivers reported a traffic stop as their most recent contact with police in 2008 (Weisel, 2014).

Disparities in the number of stops for each racial and/or ethnic group were examined since 1990s. Calculations of disparity were initially made by documenting the percent of traffic stops for each racial group relative to a benchmark measure. Census benchmarks and roadway observations have been used by scholars to address disparities.

### Census Benchmarks

Early studies of racial bias focused on traffic stops on major highways and traffic corridors. It was quickly recognized that the racial and ethnic composition of drivers on roadways did not match the racial and ethnic composition of the state or county in which the stop occurred.

It is tempting to use residential census population to calculate racial disparities in the number of stops; however, the racial composition of communities do not reflect the racial and ethnic composition of drivers on roadways accurately (Tilyer, Engel, & Wooldredge, 2008; Fallik & Novak, 2012). Gau (2012) found that only 52% of drivers stopped by police resided in the city in which they were stopped and further studies have shown that the proportion of local versus non-local drivers stopped by police significantly varies from one jurisdiction to another. In Pennsylvania, 25% of drivers stopped by the state police were non-residents and 64% were not residents of the county in which they were stopped (Tillyer & Engel, 2013) and in St. Louis, half of 48,210 stopped drivers were not city residents (Rojek, Rosenfeld, & Decker, 2012). These studies along with others provide evidence that residential census populations are the least reliable benchmark for detecting racial profiling by law enforcement (Tilyer, Engel, & Wooldredge, 2008).

**Roadway Observations**

Because of the inherent weaknesses of census data as a benchmark, researchers tried to establish an accurate count of the race and ethnicity of drivers on the roadway available to be stopped by law enforcement which proved to be a very complex task. Alpert, Smith, & Dunham (2004) indicated that systematic observation and identification of Hispanics was not justified as a research strategy as the data lacks reliability.

**Calculating Disparity in Stop Outcomes**

Outcome of traffic stops has been the focus of research and analysis. Many studies have focused on outcomes with formal actions – arrest or citation of the driver, or informal action – a written or oral warning or the stop may conclude with no action at all (Gaines, 2006).

Although minorities are more likely to be stopped and searched, the observed racial disparities do not provide evidence of racial bias by police. Likewise, the absence of racial disparities do not mean that there is no racial bias by police. There are three major explanations

to racial and ethnic disparities including police bias, deployment practices, differential offending, and other explanatory factors (Weisel, 2014).

**Police Bias**

Research has shown racial disparities in traffic stops based on the demographic characteristics of officers such as their age, experience, gender, and race. In these studies, officer factors have been found to influence stops and outcomes. In Miami-Dade, female officers were more likely to stop black drivers (Alpert, Dunham, & Smith, 2007). White officers were more likely to perform searches in Florida (Close & Mason, 2007) as well as in Cleveland (Tillyer, Klahm, & Engel, 2012); however, officer race did not affect search decisions in Washington state and Richmond, VA, (Pickerill, Mosher, & Pratt, 2009). Stop outcomes vary when the race of officer and driver differ and a search was more likely when the race of an officer differed from that of the driver (Antonovics & Knight, 2009).

**Deployment Practices**

There is substantial evidence to support the hypothesis that there are important variations in police stops, searches, and seizures within sub-areas of jurisdictions. In Charlotte, researchers found that calls for service explained part of the differences in stop rates among blacks in police districts (Smith, Davison, Zingraff, Rice, & Bissler, 2004) and in Portland, citizen-initiated calls for service within neighborhoods explained racial variations in traffic stops (Renauer, 2012). In Houston, Roh & Robinson (2009) found that variations in search rates reflected police deployment.

**Differential Offending**

Differential offending suggests that driving and other behaviors is likely to vary between racial groups therefore putting some persons at greater risk for either being stopped or the

outcome of a stop. A study by Tillyer (2012) indicates that drivers with a criminal history are nearly five times more likely to be searched than those without a criminal history.

Other explanatory factors include driver characteristics, vehicle features, location and situational context, officer characteristics, and characteristics of the law enforcement agency.

Vehicle age is associated with drivers of lower income levels and may be more prevalent among minority drivers (Miller, 2009). Another important factor is time of day. Drivers stopped at night are more likely to be cited, searched, and arrested (Eith & Durose, 2011; Smith, et al., 2004).

In Cincinnati, blacks were less likely to be stopped during the daytime in contrast to what would occur if officer perceptions of race influenced their stop decisions (Ridgeway, 2009).

In addition to recording traffic and pedestrian stops, other approaches used by law enforcement agencies to address racial policing include expanding camera systems, increasing professionalism, diversifying and screening personnel and increasing training, increasing professionalism, partnering with community groups, identifying problem employees, focusing on problems, and increasing efficiency (Weisel, 2014).

**Calculating Disparity in Search Rates**

In order to calculate racial disparities in searches, the number of searches of a racial group is divided by the number of stops of that racial group. The relative proportions between different groups are then compared to each other. It is assumed that in the absence of bias, each racial and group would display a similar proportion of searches. Studies indicate that racial disparities are stronger among drivers who were searched than among drivers who were stopped. In 2011, 3.5% of traffic stops resulted in the search of a driver nationwide, which is 2.3% of white drivers, 6.3% of black drivers, and 6.6% of Hispanic drivers (Langton & Durose, 2013).

About 10% of drivers are stopped each year for a traffic stop. In 2011, 88% of drivers in traffic stops believed in proper police behavior whereas among searched drivers, only 61% felt police behaved properly (Langton & Durose, 2013).

The majority of searches are carried out with the consent of the driver (Eith & Durose, 2011). In 2008, 58% of searches of drivers (and 60% of searches of vehicles) were conducted with the consent of the driver. Consent searches have been the focus of much of the research on disparities as they involve more officer discretion and they precede an arrest. Research has increasingly distinguished between searches that are classified in one of two ways, high-discretion searches and low discretion searches (Pickerill, Mosher, & Pratt, 2009). In Pennsylvania, two-thirds of consent requests from state police resulted in a search; 63% of white drivers consented, compared to 74% of black and 84% of Hispanic drivers (Engel, 2008).

**Calculating Disparity in Search Outcomes**

Hit rate is the success of a search in terms of a seizure of contraband (outcome of the search). It is the proportion of all searches that result in a "hit" or finding of contraband. Lower hit rates indicate racial bias, particularly when these low hit rates are associated with higher search rates. Outcome test assumes that lower hit rates are evidence of police bias in conducting searches. Numerous researchers have examined hit rates and compared search success rates between different racial and ethnic groups. Warren & Tomaskovic-Devey (2009) found that in North Carolina about 1/3 of searches resulted in contraband; 36% and 31% for black and white drivers respectively. In Riverside, CA, 18.4% of whites were searched, as were 20.1% of blacks, and 22.0% of Hispanics. The overall hit rate was 10.47%, but it was 12.6% for white drivers, 9.2% for black drivers, and 9.6% for Hispanic drivers.

Tillyer & Klahm (2011) found that hit rates for discretionary searches were surprisingly higher than hit rates for mandatory searches; and hit rates for discretionary searches of blacks were twice as high as those for whites.

## Results

### Examination of traffic stops in Greensboro

In this report 488,758 records of traffic stops recorded by Greensboro Police Department from January 2002 to December 2013 were analyzed.

The data elements of stops that did not result in a search include the following:

- Stop identifying information including name of the law enforcement agency, city and/or county of stop, the date and time, officer's unique identification number.
- Descriptive information about the driver including driver's race, ethnicity, age, and gender.
- Stop characteristics include one of 10 initial reasons of stop, one of the five actions taken at the conclusion of the stop that is arrest, verbal or written warning, citation issued or no action taken. If an arrest was made, the officer must identify whether the driver or passenger was arrested. Additional information documented includes whether physical resistance was encountered, whether the officer used force, and if the driver, passenger, or officer was injured.

In case of a search, additional information recorded include: type of search, basis of search, subject of search, passengers demographics, contraband, and property seized.

### Descriptive Analysis

Table 1 shows number of stops by race. As demonstrated in figure 1, about 50% of the stops are African Americans and 46% are whites.

Table 1: Distribution of stops by race of the drivers

| Race | Counts | % |
|---|---|---|
| White | 225,166 | 46.1 |
| Black | 243,305 | 49.8 |
| Native American | 1,936 | 0.4 |
| Asian | 8,256 | 1.7 |

| | | |
|---|---|---|
| Other/Unknown | 10,095 | 2.1 |
| Total | 488,758 | 100 |

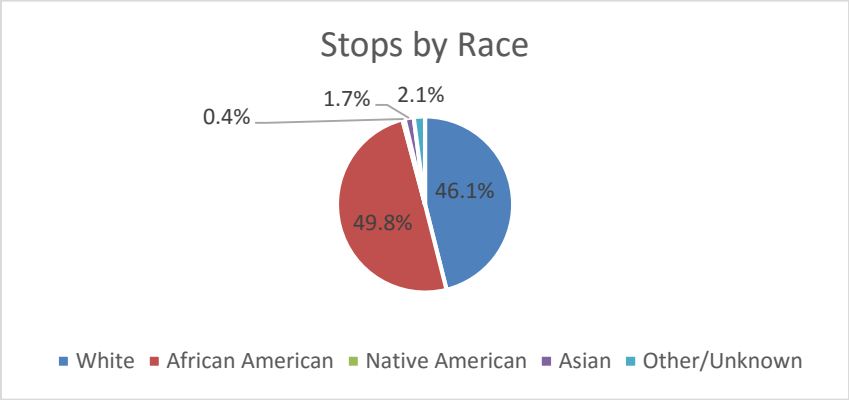



Figure 1: Stops by Race

297,349 of stops were male whereas 191,405 of stops were female. As shown in figure 2, male and female drivers are about 60% and 40% of the traffic stops respectively.

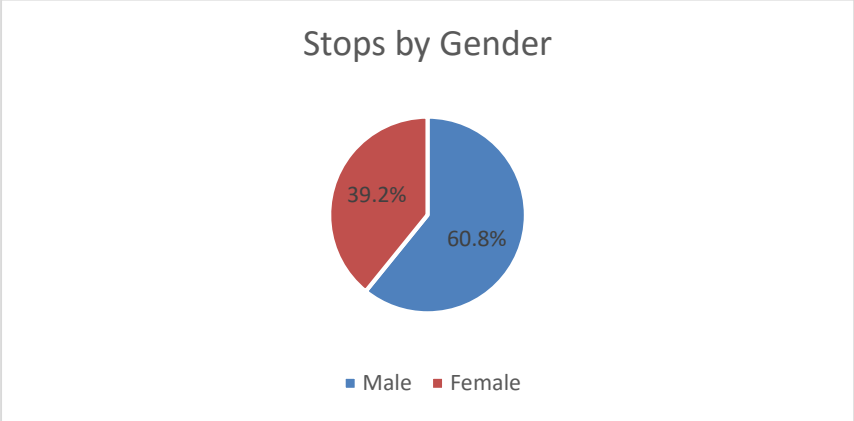



Figure 2: Stops by Gender

**Stops by Types of Traffic Stops (Purpose)**

Table 2 demonstrates number of stops for each traffic stop violation. During 13 years, about 42% of all traffic stops in Greensboro were for speeding compared to 46.5% of all traffic stops in the U.S. in 2011 and 48.8% in 2008 (Eith & Durose, 2011; Langton & Durose, 2013). As shown

in figure 3, it's followed by Vehicle Regulatory and Vehicle Equipment violations that make up about 21% and 10% of the stops respectively. Safe movement and investigation make up about 8% and 6% of the stops respectively. Stop sign/light violations are the reason for about 5.6% of the stops followed by seat belt which make up about 4% of the stops.

Table 2: Traffic Stops by Purpose

| **Purpose of Stops** | **Counts** |
|---|---|
| SPD: Speed Limit Violation | 205,186 |
| STPLT: Stop Light/Sign Violation | 27,590 |
| DWI: Driving While Impaired | 2,030 |
| SAFE: Safe Movement Violation | 38,526 |
| VEHQP: Vehicle Equipment Violation | 48,448 |
| VEHRG: Vehicle Regulatory Violation | 101,406 |
| STBLT: Seat Belt Violation | 19,200 |
| INV: Investigation | 30,085 |
| OT: Other Motor Vehicle Violation | 16,287 |

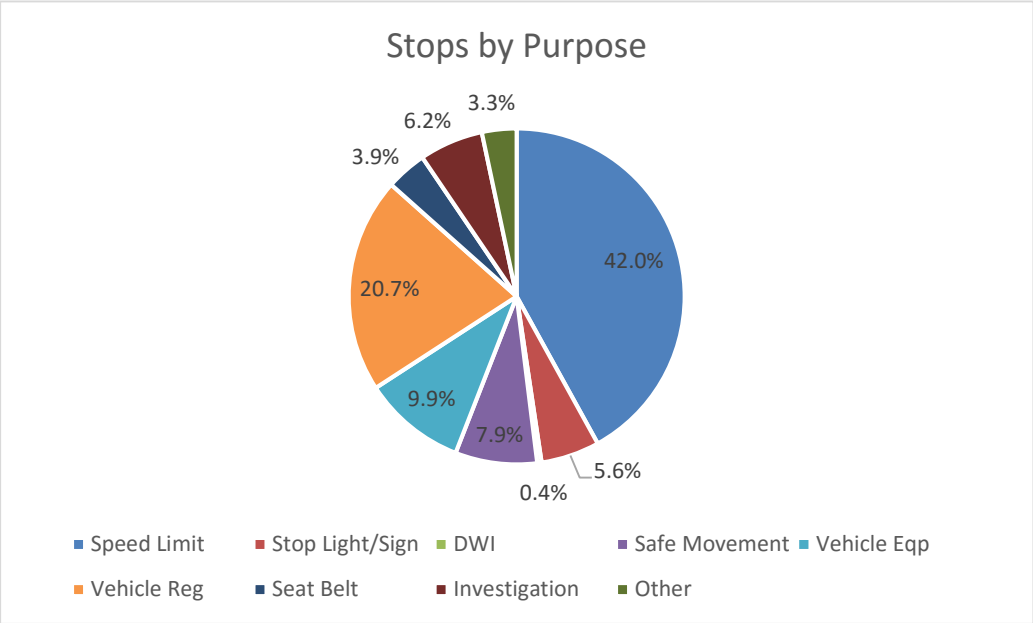



Figure 3: Stops by Purpose

Traffic stops by initial purpose of stop and race are indicated in table 3. Speed limit violation accounts for 34.6% and 49.7% of stops for blacks and whites respectively. Vehicle regulatory

violation accounts for 24.4% and 17.4% of stops for blacks and whites respectively. Vehicle equipment violation accounts for 12.2% and 7.4% of stops for blacks and whites respectively.

Table 3: Stops by Purpose and Race

| Purpose of Stop | Black | White | Asian | Native American | Other/Unknown | Total |
|---|---|---|---|---|---|---|
| SPD: Speed Limit Violation | 84,156 | 111,795 | 3,966 | 796 | 4,473 | 205,186 |
| STPLT: Stop Light/Sign Violation | 13,170 | 12,773 | 747 | 116 | 784 | 27,590 |
| DWI: Driving While Impaired | 784 | 1,076 | 40 | 5 | 125 | 2,030 |
| SAFE: Safe Movement Violation | 19,056 | 17,594 | 879 | 195 | 802 | 38,526 |
| VEHQP: Vehicle Equipment Violation | 29,759 | 16,567 | 788 | 225 | 1,109 | 48,448 |
| VEHRG: Vehicle Regulatory Violation | 59,435 | 39,149 | 992 | 369 | 1,461 | 101,406 |
| STBLT: Seat Belt Violation | 10,210 | 8,272 | 273 | 62 | 383 | 19,200 |
| INV: Investigation | 17,798 | 11,286 | 352 | 123 | 526 | 30,085 |
| OT: Other Motor Vehicle Violation | 8,937 | 6,654 | 219 | 45 | 432 | 16,287 |
| Total | 243,305 | 225,166 | 8,256 | 1,936 | 10,095 | 488,758 |

41% of those who were stopped for speed limit violation are black and 54.5% are white. 38.6% of those who were stopped for DWI, are black and 53% are white.

61.4% of those who were stopped for vehicle equipment violation are black and 34.2% are white.

58.6% of those who were stopped for vehicle regulatory violation are black and 38.6% are white.

53.2% of those who were stopped for seat belt violation are black and 43.1% are white.

59.2% of those who were stopped for investigation are black and 37.5% are white.

Table 4 shows traffic stops by initial purpose of stop and gender.

Table 4: Stops by Purpose and Gender

| Purpose of Stop | Male | Female |
|---|---|---|
| SPD: Speed Limit Violation | 117,079(57.1%) | 88,106(42.9%) |
| STPLT: Stop Light/Sign Violation | 17,378(63%) | 10,212(37%) |
| DWI: Driving While Impaired | 1,551(76.4%) | 479(23.6%) |
| SAFE: Safe Movement Violation | 25,281(65.6%) | 13,245(34.4%) |
| VEHQP: Vehicle Equipment Violation | 31,535(65.1%) | 16,912(34.9%) |

| | | |
|---|---|---|
| VEHRG: Vehicle Regulatory Violation | 59,882(59.1%) | 41,523(40.9%) |
| STBLT: Seat Belt Violation | 13,177(68.6%) | 6,023(31.4%) |
| INV: Investigation | 20,857(69.3%) | 9,227(30.7%) |
| OT: Other Motor Vehicle Violation | 10,609(65.1%) | 5,678(34.9%) |
| Total | 297,349(60.8%) | 191,405(39.2%) |

Note: numbers in parentheses are the percentages of total for that category.

Speed limit violation accounts for 39.4% and 46% of stops for men and women respectively.

Vehicle regulatory violation accounts for about 20% and 21% of stops for men and women respectively.

Seat belt violation accounts for about 4.4% and 3.1% of stops for men and women respectively.

Safe movement accounts for about 8.5% and 6.9% of stops for men and women respectively.

Of those who were stopped for DWI, 76.4% are men and 23.6% are women. Of those who were stopped for Investigation, about 70% are men and about 30% are women.

**Stops by Stop Dispositions (Action)**

Table 5 shows number of stops by action taken by the officer. Traffic stops result in varied dispositions including warnings, citations, arrests or no action at all. As shown in figure 4, the most common outcome for a traffic stop is a citation or ticket that makes up about 60% of the cases followed by verbal and written warnings with approximately 29% and 6% respectively. There is an information gap between documentation of the nature of a traffic stop and its outcome. The initial purpose of a stop is reported and the outcome of the stop, but the sequence of events remains largely unknown. For example, a driver may be stopped for speeding but cited for a registration violation, arrested for DUI, or something else.

Table 5: Stops by Action

| **Officer's Action** | **Counts** |
|---|---|
| Verbal Warning | 141,852 |
| Written Warning | 29,813 |
| Citation | 292,335 |
| Arrest | 10,458 |
| No Action | 14,300 |
| Total | 488,758 |

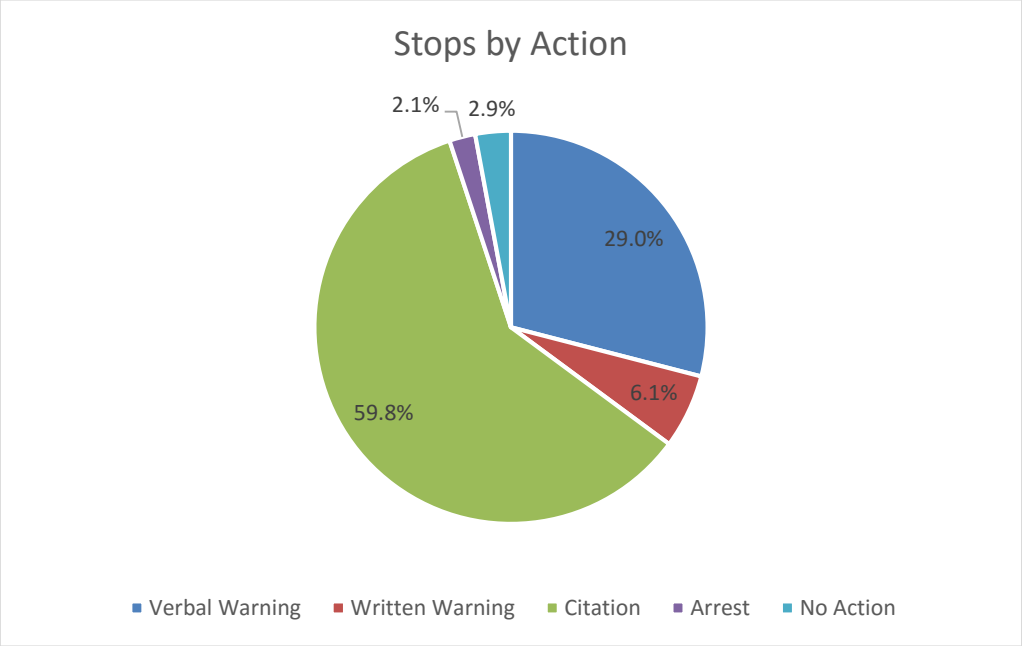



Figure 4: Stops by Action

Traffic stops by action and race is shown in table 6. Verbal warning was given to 31.6% and 26.2% of Blacks and Whites respectively. Written warning was given to 6% of Black and 6% of Whites. Citation was issued for 56% of blacks and 63.6% of whites.

Table 6: Stops by Action and Race

| Action | Black | White | Asian | Native American | Other/Unknown | Total |
|---|---|---|---|---|---|---|
| Verbal Warning | 76,965 | 59,202 | 2,512 | 655 | 2,518 | 141,852 |
| Written Warning | 14,918 | 13,935 | 468 | 114 | 378 | 29,813 |
| Citation | 136,236 | 143,381 | 4,981 | 1,064 | 6,673 | 292,335 |
| Arrest | 6,621 | 3,401 | 73 | 43 | 320 | 10,458 |
| None | 8,565 | 5,247 | 222 | 60 | 206 | 14,300 |
| Total | 243,305 | 225,166 | 8,256 | 1,936 | 10,095 | 488,758 |

4.1% of all black drivers and 2.8% of all white drivers got arrested. Table 7 shows the traffic stops arrests by race.

Table 7: Arrests by Race

| | Black | White | Asian | Native American | Other/Unknown | Total |
|---|---|---|---|---|---|---|
| **Arrested** | 10,099 | 6,386 | 186 | 52 | 502 | 17,225 |
| **Not arrested** | 233,206 | 218,780 | 8,070 | 1,884 | 9,593 | 471,533 |
| **Total** | 243,305 | 225,166 | 8,256 | 1,936 | 10,095 | 488,758 |

Officers encountered force from drivers in 795 of the stops and got injured in 85 of them. They encountered force from 614 blacks, 160 whites, 6 Asians, and 4 Native Americans. Officers engaged force with 190 blacks, 53 whites, 3 Asians, and 0 Native Americans and drivers got injured in 142 of the encounters. Drivers were not arrested in more than 96% of the stops. The passengers were arrested in only in 0.44% of stops.

Table 8: Stops by Action and Gender

| Action | Male | Female |
|---|---|---|
| **Verbal Warning** | 88,091(62%) | 53,761(38%) |
| **Written Warning** | 16,596(56%) | 13,216(44%) |
| **Citation** | 175,217(60%) | 117,116(40%) |
| **Arrest** | 8,406(80%) | 2,052(20%) |
| **None** | 9,039 | 5,260 |
| **Total** | 297,349 | 191,405 |

Note: numbers in parentheses are the percentages of total of that category.

As shown in table 8, verbal warning was given to 29.6% of men and 28.1% of women and written warning was given to 5.6% of men and 6.9% of women. Citation was issued for about 59% of male drivers and about 61% of female drivers.

2.1% of male and 1.1% of female drivers were arrested. 80% of those who have been arrested are male while 20% are female.

**Stops by Age**

The average age is about 34 years old and the median age is 31. The youngest person stopped were 10 years old whereas the oldest was 103 years old. As shown in figure 5, about 22% of those stopped are between 20 to 24 years old. The second most stopped age group is 40 to 49 with about 17% followed by 25-29 with 16% and 35 to 39 with about 11%.

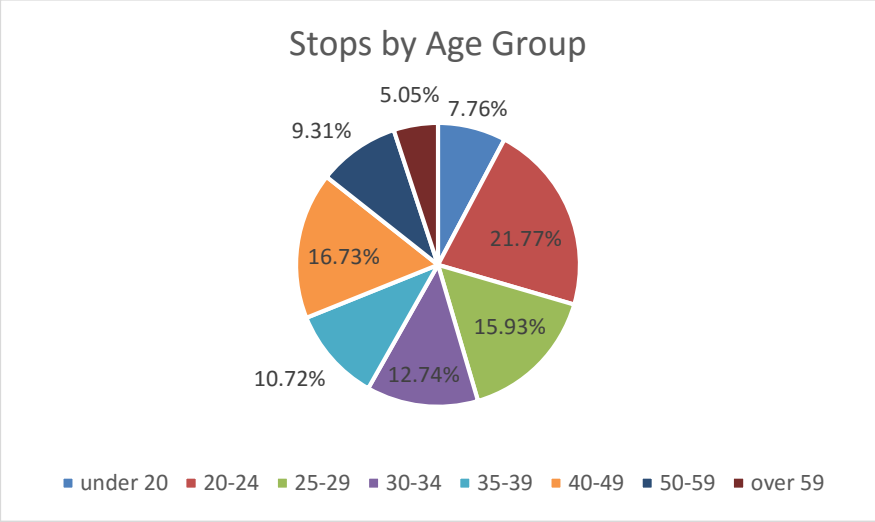



Figure 5: Stops by Age Group

**Trend of Stops**

Figure 6 shows the trend of stops by race from 2002 to 2013. The chart shows that overall the percentage of blacks has been increasing from 2002 to 2013. 47.6% of those stopped in 2002 were black and 45% were white. In 2013 however, 55% were black and 42% were white.

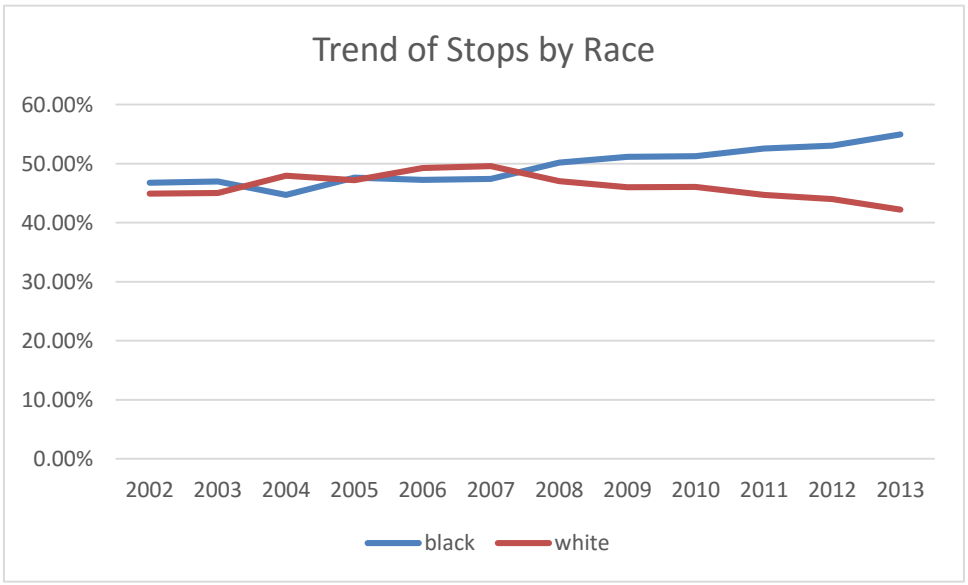



Figure 6: Trend of Stops by Race

**Search Rates**

In Greensboro, the rate of searches arising from all traffic stops from 2002 to 2013 was 5.2%. In 2002, 6% of all traffic stops resulted in a search; however by 2013, this proportion dropped to 4%. Nationally, 5% of traffic stops in 2008 resulted in a search (Eith & Durose, 2011); this rate dropped to 3.5% in 2011 (Langton & Durose, 2013).

As illustrated in figure 7, in 2002, blacks and whites were searched at rates of 7.6% and 4.% respectively. In 2013, this rate dropped to 5.1% and 2.5% for blacks and whites respectively; however, blacks are still searched almost twice as much as whites.

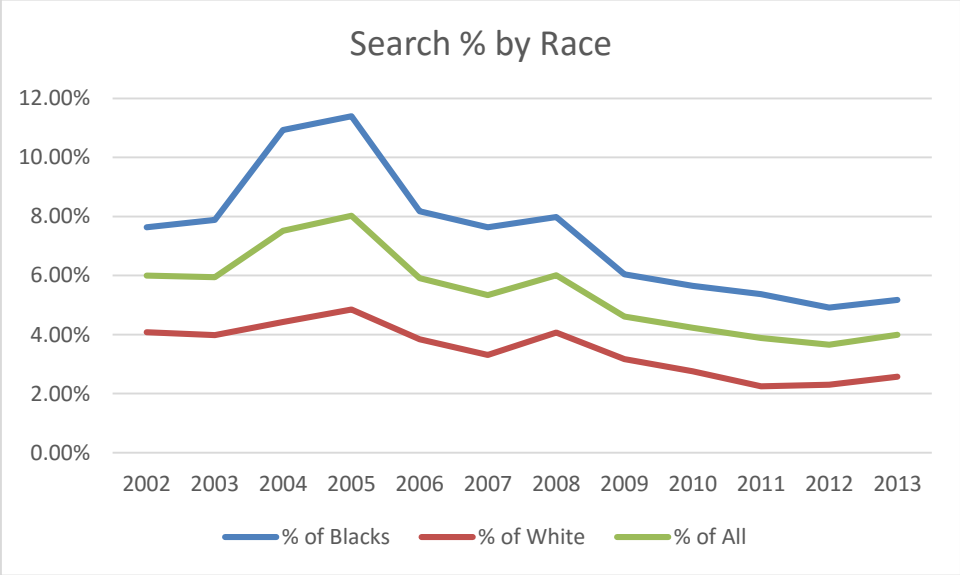



Figure 7: Search % by Race

Of the total 488,758 drivers stopped, there were 25,695 searches. Types of searches include consent search, search conducted after an arrest, and probable cause by officer. Consent searches were the most common type accounting for 57.7% of all searches which is close to the national average of 58%. One or more types of contraband were found in 7,478 of the 25,595 searches giving an overall "hit rate" of 29.2%.

As shown in figure 8, hit rate was almost the same for blacks and whites in 2002. From 2003 to 2008, the hit rate has been higher for blacks; however, this rate has been higher for whites since 2008. Interesting point is that although there were fewer searches in 2012 and 2013, they yielded a higher hit rate.

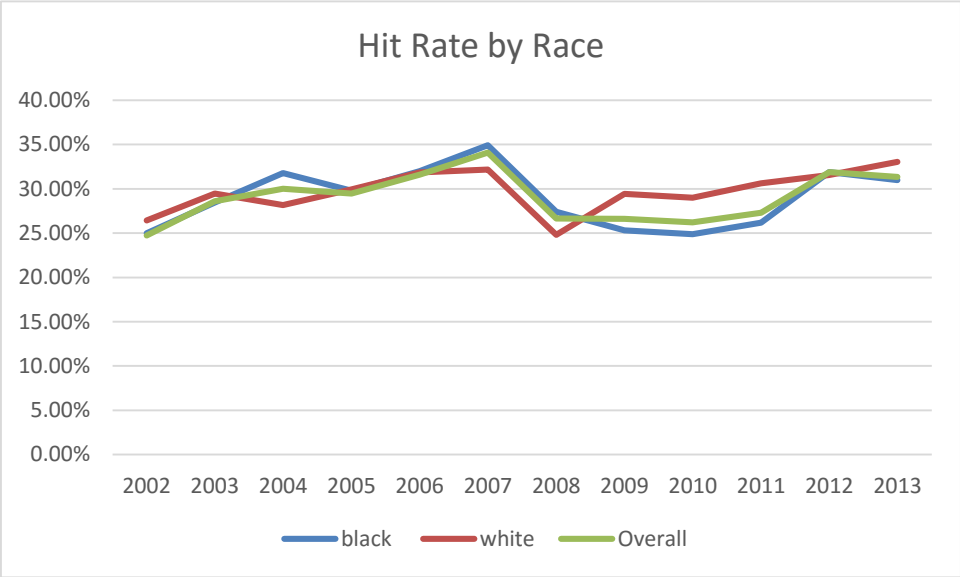



Figure 8: Hit Rate by Race

**Officer Race Analysis**

To understand the possibility of bias in terms of the officer's race with regards to searching the drivers, a chi-square analysis is conducted. As illustrated in table 9, results of this analysis show that of all the searches, black officers searched 76% black drivers and 24% white drivers. On the other hand, white officers searched 32% white drivers while they searched only 68% black drivers.

Table 9: Driver's Race vs. Officer's Race

| | **Officer Race** | | |
|---|---|---|---|
| **Driver Race** | **Black** | **White** | **Grand Total** |
| **Black** | 75.88% | 67.98% | 69.45% |
| **White** | 24.12% | 32.02% | 30.55% |
| **Grand Total** | 100.00% | 100.00% | 100.00% |

Results of chi-square independence analysis shows that the race of the officers has no significant impact on their decision to search drivers based on their race (p-value = 0.946).

| ***Chi-Square Statistic*** | |
|---|---|
| **Chi-Square** | 0.0045 |
| **p-Value** | 0.9467 |

**Clustering and Segmentation**

In order to understand the profile of those who were arrested, a cluster analysis model was developed in SAS EM (Appendix A). The total number of drivers who have been arrested from 2002 to 2013 is 7,381. Cluster analysis identified two significant clusters.

As shown in table 10, the first cluster includes 3912 drivers 53% of the drivers ($n_1$ =3912), while cluster 2 comprise of 47% of the drivers ($n_2$ =3469). Figure 9 shows that the most important variable that contributed to the difference between the two clusters is Contraband. Other important variables in this cluster analysis are identified as passenger search, property search, type and age. Race of the passengers is identified as the least important variable. This shows that race is not an important factor when it comes to arresting the drivers.

Table 10: Clustering of Arrested Drivers

| | Frequency | Contraband | Passenger search | Property search | Search conducted after arrest | Consent search | Vehicle searched | Mean Age |
|---|---|---|---|---|---|---|---|---|
| Cluster 1 | 3,912 | 6% | 4% | 37% | 67% | 23% | 78% | 32.3 |
| Cluster 2 | 3,469 | 80% | 55% | 76% | 32% | 37% | 99.8% | 28 |
| Overall | 7,381 | 40% | 28% | 56% | 50% | 29% | 88% | 30.3 |

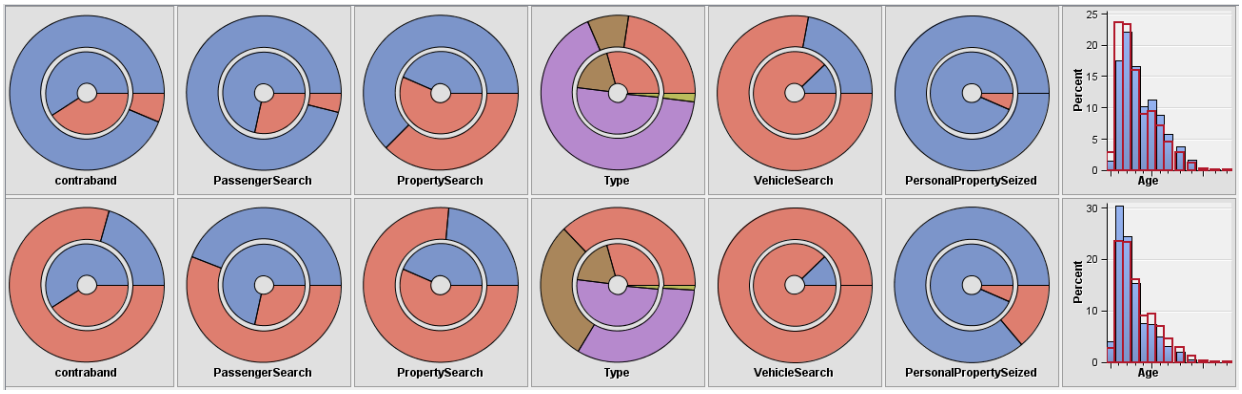



Figure 9: Clustering of Arrested Drivers

**Time Series Analysis**

Time series analysis is performed on 2013 search database (Appendix B). The dataset includes 1,815 drivers who were searched.

As shown in figure 10, white drivers have a higher chance of being searched between 4:00am (34%) and 6:00 am (62.5%). This rate drops significantly at 8:00am.

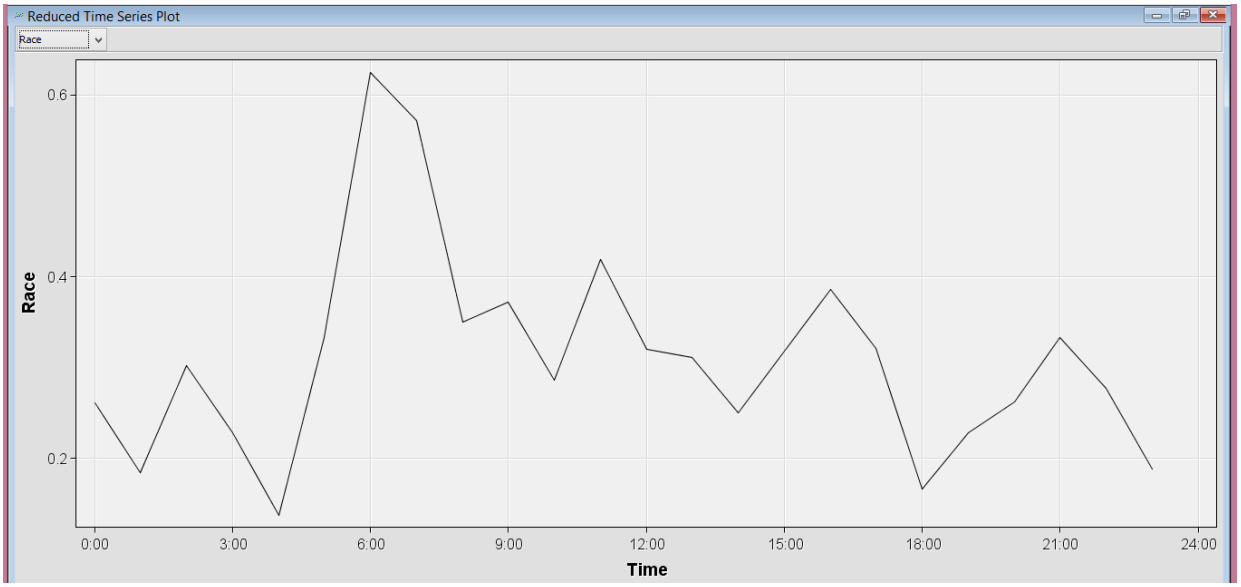



Figure 10: Race Time Series

Time series analysis shows that the average age of the drivers who have been searched early morning between 4:00 am and 7:00 am is between 31 years to 45 years. Figure 11 shows that

younger drivers have a higher chance of being searched at night, specifically between 9:00PM to 3:00am.

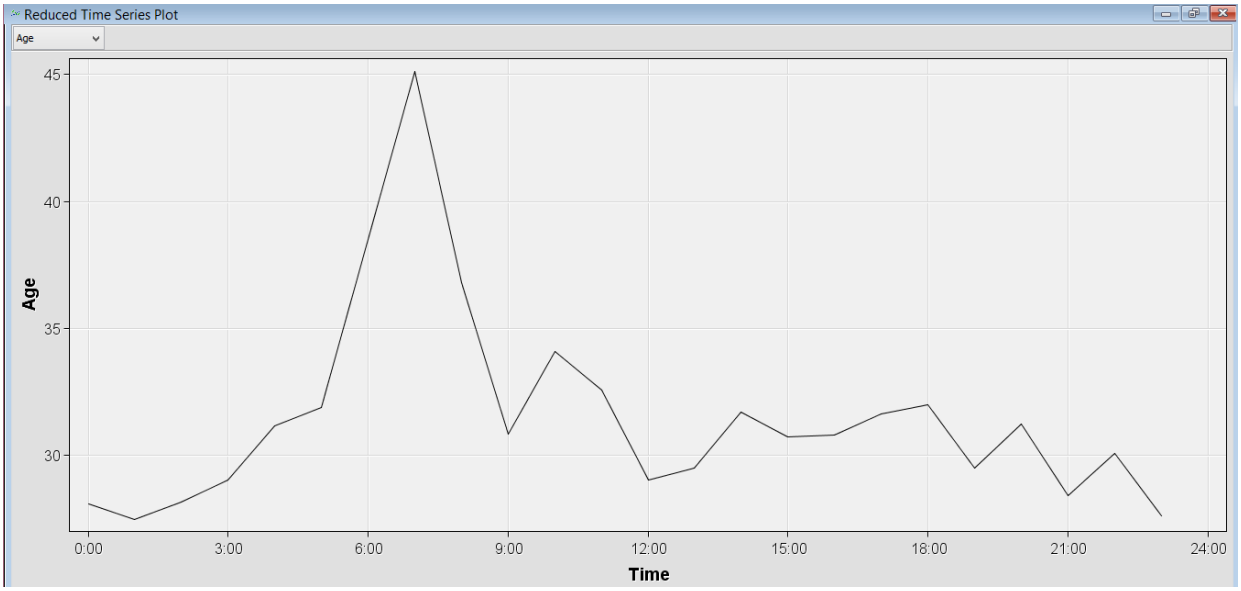



Figure 11: Age Time Series

As shown in figure 12, the chance of getting arrested increases between 2:00am and 4:00am. Arrest rates at midnight is about 28% and it picks up to 57% at 3am. This rate decreases to 33% at 5:00 am. Once again the rate of arrests increases and reaches its peek (62%) at about 6:00 am. The minimum arrest rate is 15% at 8am.

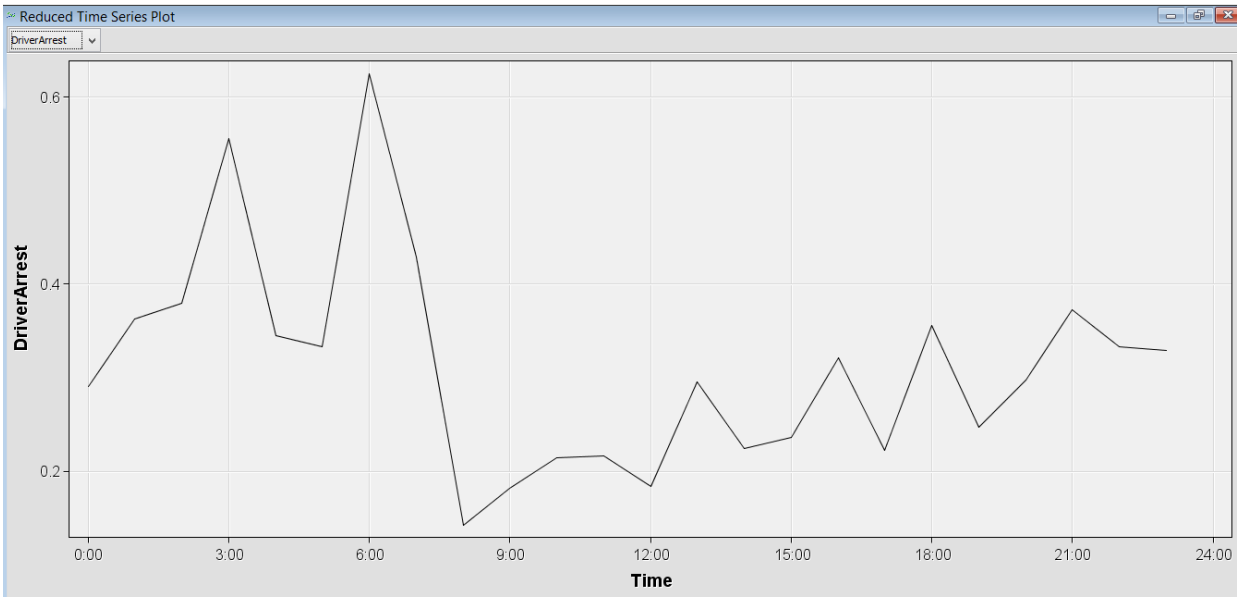



Figure 12: Arrested Driver Time Series

The distribution of searches in 2013 were random across weekdays throughout the year and no significant pattern was found.

**Conclusions**

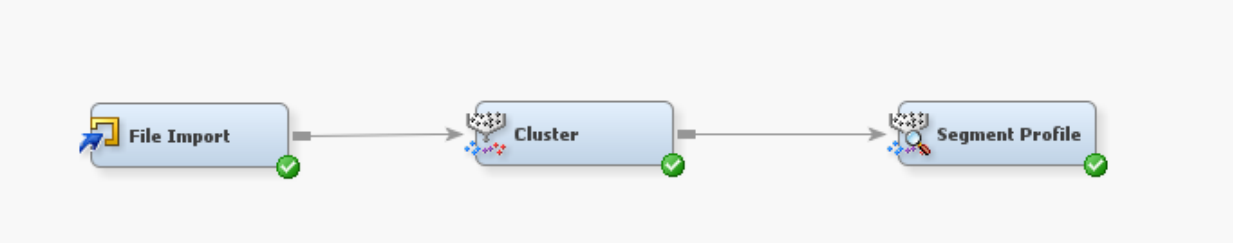
This research investigates the traffic stops in Greensboro from 2002 to 2013. It provides a better understanding of observed traffic stop disparities. The results show that although there are some disparities observed in traffic stops and stop outcomes, there is inadequate evidence of racial discrimination by the officers. Thus, it indicates that the race of the drivers who have been searched is independent from the race of the officers. In terms of the success of the search, the hit rate for black and white drivers are very close to each other.

The most important factor that contributes to classifying drivers who have been arrested is having a contraband. The contraband plays major role in arresting the drivers while race is least important. In addition, the results of time series analysis shows that younger drivers are arrested mostly between Midnight and 3:00am. Older white drivers have been searched mostly in the early morning hours between 5:00 – 6:00am.

This study does not provide any information about the location of the stops and the socio-economic status of the drivers. This is a limitation of the dataset. Collecting the make and model of the car by the officers as well as stop locations can contribute to enhance the implications of this study.

## Appendices

### Appendix A




### Appendix B

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