Racial Disparities in Traffic Stops/Citations

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Introduction and Data

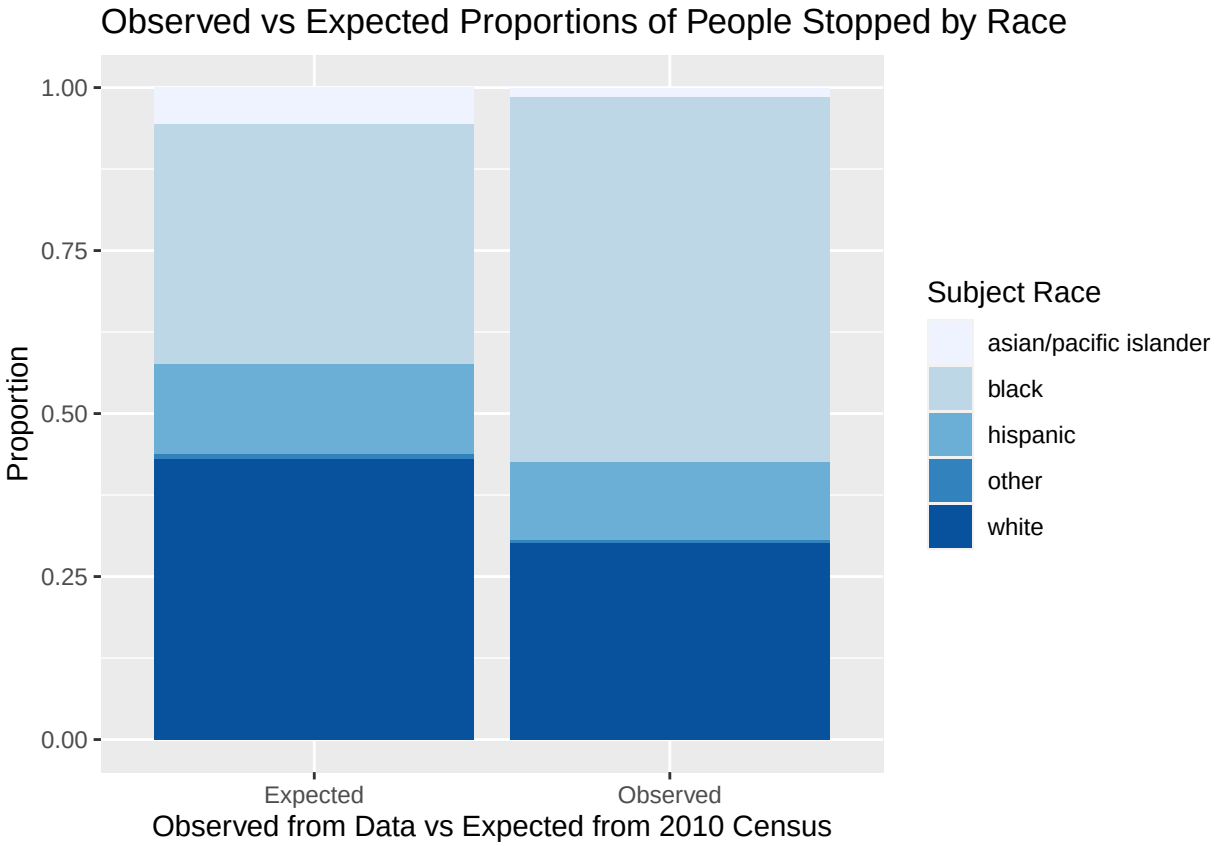
Our data is a census of individual police stops in Durham created by the Stanford Open Policing project. The Stanford Open Policing Project "[collects] and [standardizes] data on vehicle and pedestrian stops from law enforcement departments across the country"(https://openpolicing.stanford.edu/). We would like to see if that same kind of racial bias is evident in police stops in Durham. In doing so, we also wish to examine if other demographic characteristics (such as sex or age) influence traffic stops. Our general research question is the following: what is the relationship between a subject's demographic attributes (sex, race, or age) and the likelihood of being stopped by police in traffic in Durham?

We hypothesize that race and the likelihood of being stopped by police in traffic in Durham are related, with black people representing disproportionately more of the people being stopped relative to their proportion within the population. We hypothesize that younger people (roughly 18-30) have a disproportionately higher chance of being stopped in traffic (not necessarily due to bias but other lurking variables, such as inexperienced driving). We also hypothesize that sex has no significant relationship with being stopped in traffic. To find the true population proportions of people by race, sex, and age in Durham, we will utilize the 2010 Durham census data (https://www.census.gov/quickfacts/fact/table/durhamcountynorthcarolina/RHI625219#RHI625219).

Additionally, we will examine whether race, sex, or age are related to the outcome of the traffic stop (whether a citation will be issued). We hypothesize that race and the likelihood of receiving a citation are related, with black people more likely to receive a citation upon being stopped. We additionally hypothesize that younger people have a higher chance of receiving a citation upon being stopped and that sex has no significant relationship with being stopped in traffic.

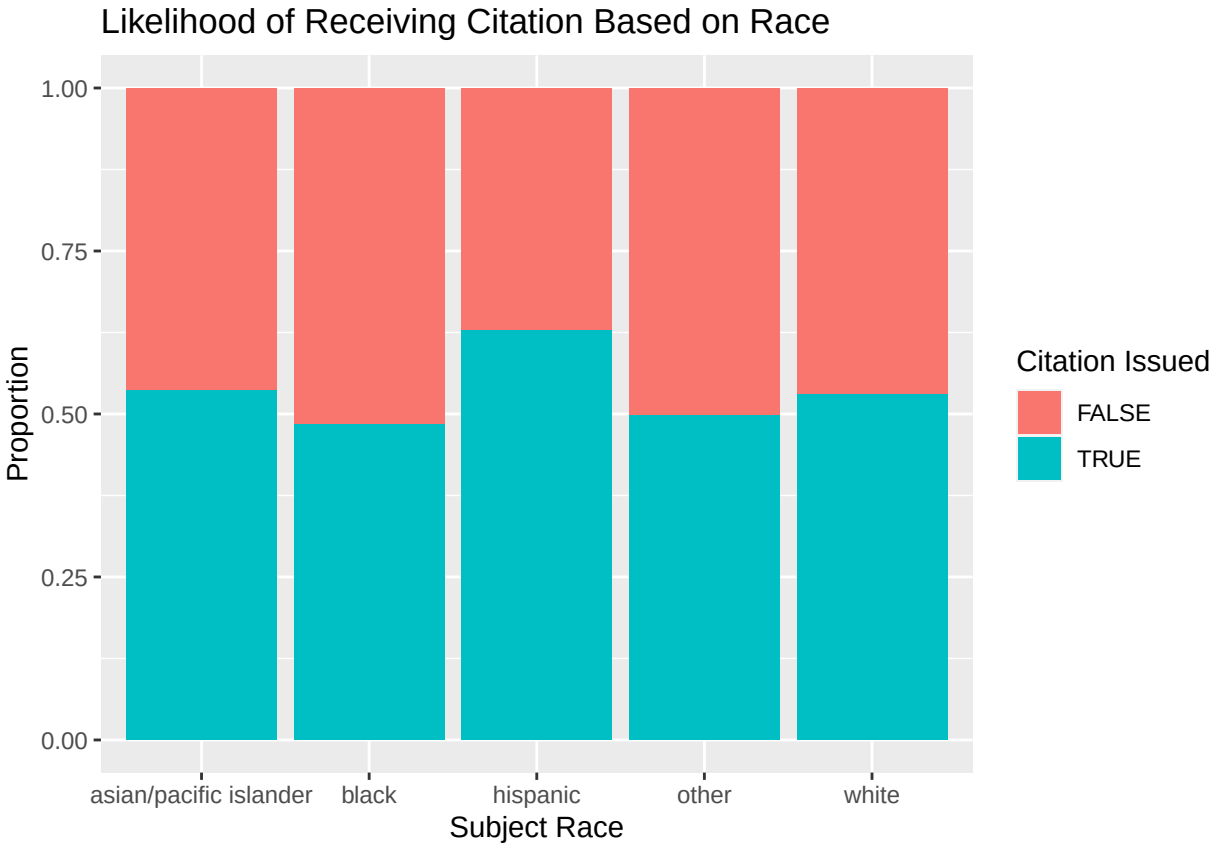
It has 29 variables and 323147 observations, and each observation in the data set is an individual police stop recorded in Durham during 2001 to 2015. A categorical variable in the data set is `subject_race`, which describes the race of the subject involved in the traffic stop. A discrete numerical variable in the data set is `subject_age`, which describes the age of the subject at the time of the traffic stop. A continuous numerical variable in the data set is `time`, which describes the hour, minute, and second that the stop was recorded. Other variables in the data set include `outcome`, which is what resulted from the stop (a warning or a citation, for example); `reason_for_stop`, which describes what the violation leading to the stop was; and `search_conducted`, whether a search of the subject was conducted during the stop.

Methodology

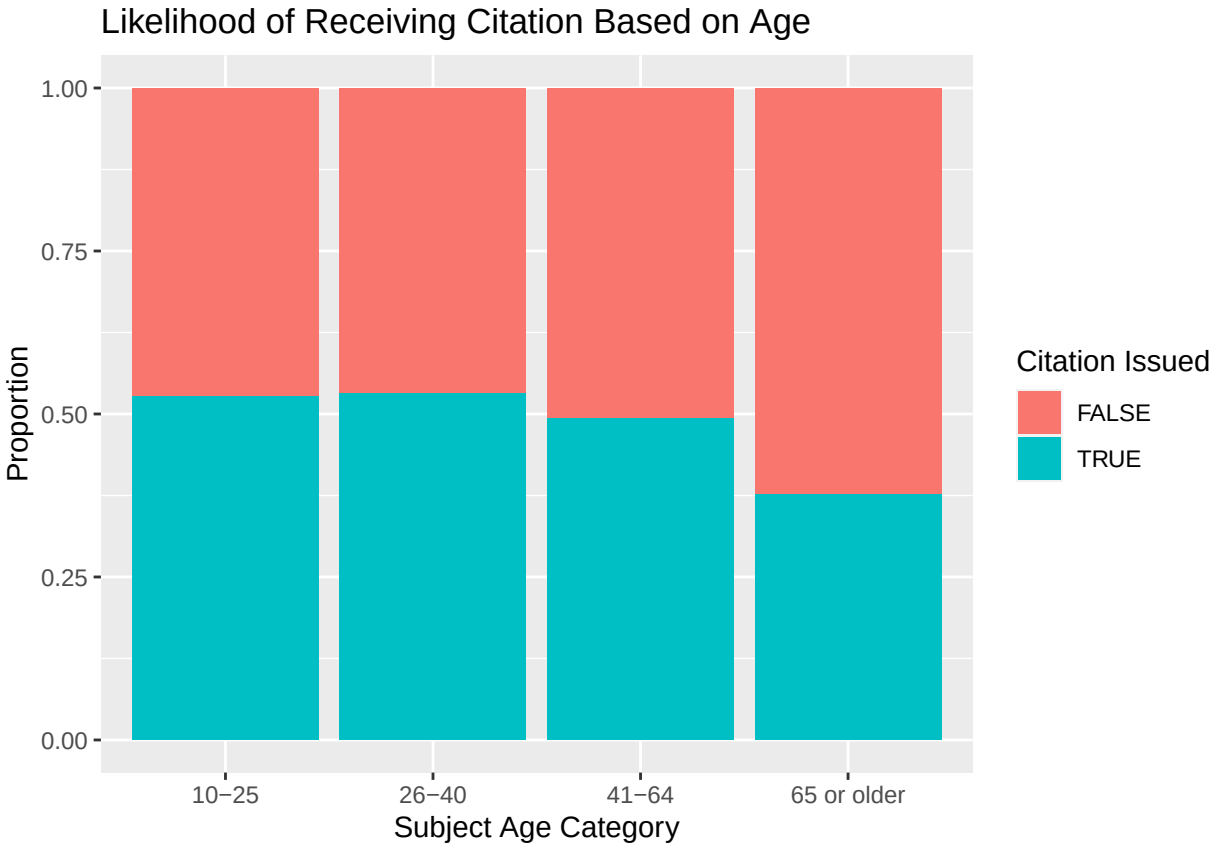


The variables we use to address the research question are `subject_race`, `subject_sex`, and `citation_issued`. For these variables we filter out any unknown and NA values. We also mutate a new categorical variable `age_category` based on values of `subject_age` with the age categories "10-25", "25-40", "40-64", and "65 or older."

To begin with, we visualize a segmented bar graph with the probability of citation based on race below.

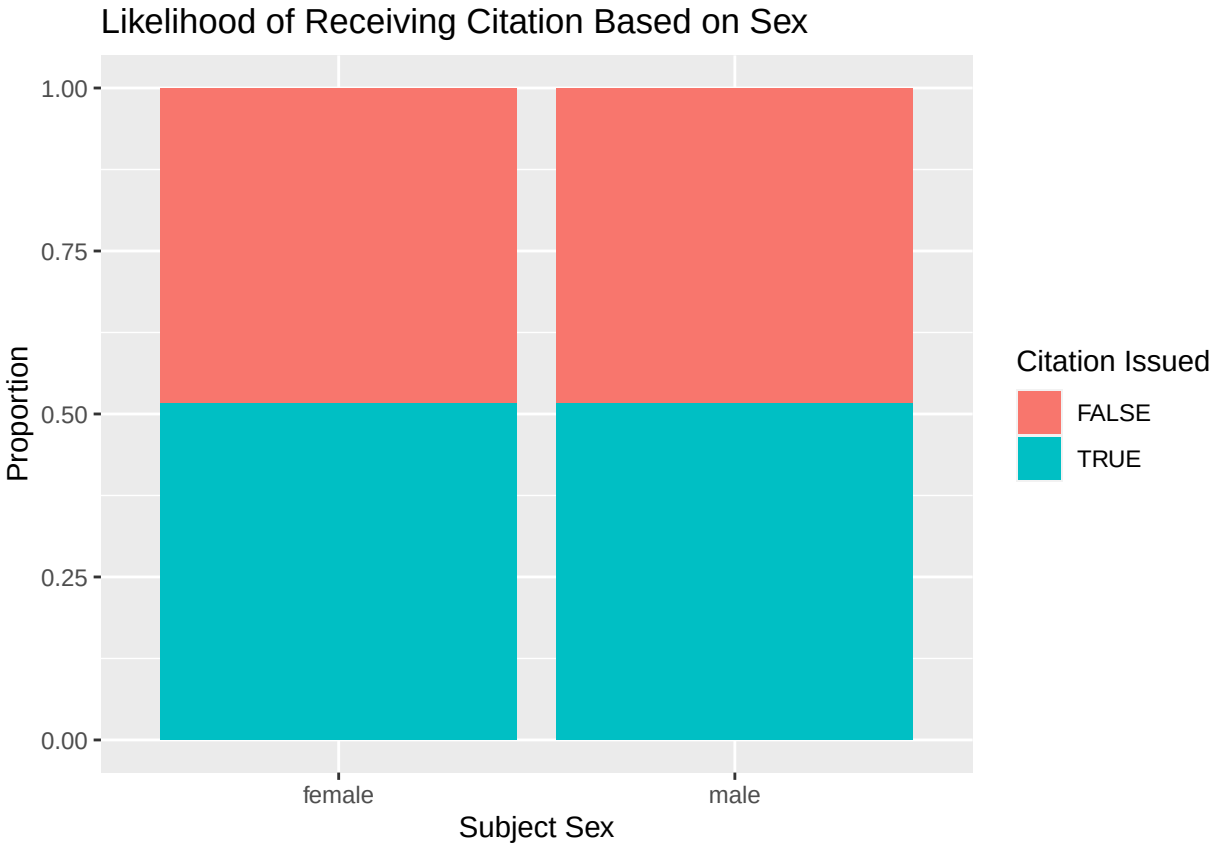


According to the chart, it appears that Hispanics are the race with the highest proportion of citations issued. We also visualize a segmented bar graph with the probability of citation based on age below.



Based on this graph, it appears that there is a roughly equal proportion of citations issued to those in the 10-25 age group and 25-40 age group. The proportion of citations issued then begins to decrease in the next two age groups, with the citation proportion of the 40-64 age group being less than the previous groups' proportions and the 65 or older group's proportion being less than the 40-64 group's citation proportion.

Lastly, we visualize a segmented bar graph with the probability of citation based on sex below.



Based on this chart, the proportion of citations issued for females and males appears to be roughly equal.

To answer our research question, we utilize the chi-square test. We selected this test because we want to determine whether there is an association between two variables where we have more than two samples.

We perform three chi-square tests. For the first, we ask whether there is an association between someone's race status and whether a citation was issued. For the second, we ask whether there is an association between someone's age category and whether a citation was issued. For the third, we ask whether there is an association between someone's sex and whether a citation was issued.

With each chi-square test, we compare observed versus the expected counts that we would expect if each H_0 were true. If these total differences are "large enough," then we reject the null hypothesis. We will perform each chi-square test at the $\alpha = 0.05$ significance level.

Results

We first investigated the research question in reference to stop rates. Our exploratory data analysis indicated that black people appeared to be stopped at a disproportionately higher rates compared to their proportion within the Durham County population. Since the attempted census of 323147 observations is far too large to create a bootstrapped null distribution to check the statistical significance of the proportions, we crated a stratified proportional sample of 3231 observations, roughly 1% of the original dataset. We decided to check if this difference between the observed and expected proportion (based on Durham County population) was statistically significant through simulation:

Let ρ equal the true proportion of stopped drivers who were black within Durham County.

$H_0 : \rho = 0.369$. The true proportion of stopped drivers who were black within Durham County is equal to the true proportion of black people within Durham County (0.369).

$H_A : \rho > 0.369$. The true proportion of stopped drivers who were black within Durham County is greater than the true proportion of black people within Durham County.

$\alpha = 0.05$

```
## [1] 0
```

Because our p-value of 0 is less than our alpha of 0.05, we reject the null hypothesis. There is sufficient evidence to indicate that the true proportion of people who are stopped within Durham County that are black is greater than the proportion of black people within the Durham County population (0.369).

We then investigated the second element of our research question and conducted a series of chi-square tests of independence to determine if a person's race or sex is associated with a higher chance of receiving a citation upon being stopped.

H_0 : Race and the likelihood of receiving a citation upon being stopped are not associated.

H_A : Race and the likelihood of receiving a citation upon being stopped are associated.

$\alpha = 0.05$.

```
## # A tibble: 1 x 3
##   statistic chisq_df p_value
##       <dbl>    <int>   <dbl>
## 1     2785.        4       0
```

The chi-squared test for independence outputted a statistic of 2785.354. The distribution of the test statistic is a chi-squared distribution, which is unimodal and right-skewed with 4 degrees of freedom.

Since our p-value of 0 is less than our alpha of 0.05, we reject the null hypothesis. There is sufficient evidence to indicate that race and the likelihood of receiving a citation upon being stopped are associated.

We then tested if a driver's sex is associated with the likelihood of receiving a citation.

H_0 : Sex and the likelihood of receiving a citation upon being stopped are not associated.

H_A : Sex and the likelihood of receiving a citation upon being stopped are associated.

$\alpha = 0.05$.

```
## # A tibble: 1 x 3
##   statistic chisq_df p_value
##       <dbl>    <int>   <dbl>
## 1  0.000593        1   0.981
```

The chi-squared test for independence outputted a statistic of 0.001. The distribution of the test statistic is a chi-squared distribution, which is unimodal and right-skewed with 1 degree of freedom.

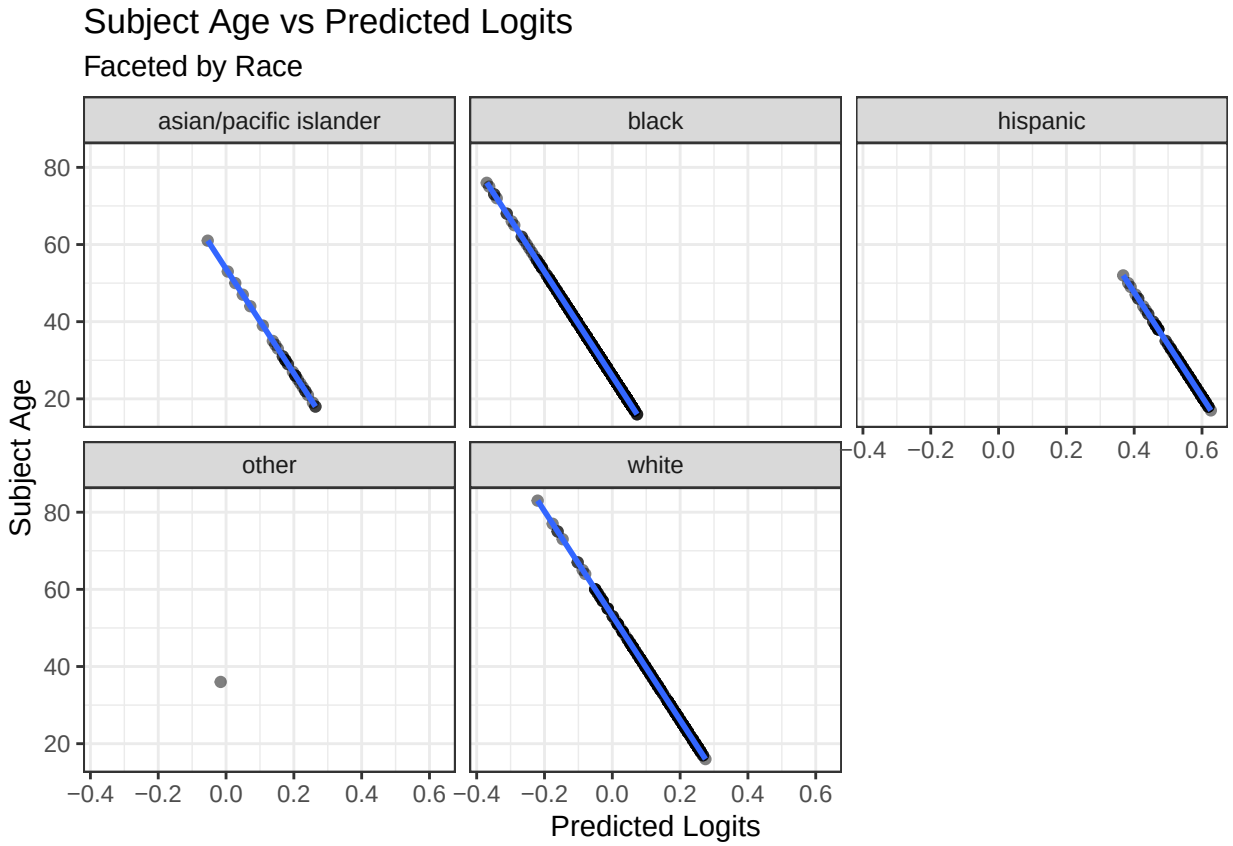
Since our p-value of 0.981 is greater than our alpha of 0.05, we fail to reject the null hypothesis. The data does not provide sufficient evidence to indicate that sex and the likelihood of receiving a citation upon being stopped are associated.

By itself, the chi-squared test only provides evidence for the association of two variables but does not inform us of the exact nature of the association. In order to investigate the exact nature of the association between race and the likelihood of receiving a citation, we created a logistic regression model. We also added age as a predictor on the model to control for the effect of age on citations. However, we excluded sex from the model, as the above chi-squared test for independence indicated that the data does not provide a statistically significant association between a subject's sex and the likelihood of receiving a citation.

Conditions of Logistic Regression:

1. Independence - Each traffic stop is independent of other traffic stops; one traffic stop resulting in a citation does not affect the likelihood that other traffic stops result in citations.

2. Linearity - Below, we have depicted scatterplots of the relationship between age and the log-odds of receiving a citation, faceting by race to isolate the linear predictor. The Linearity Assumption is met because there is a linear relationship between the age of a subject and the log-odds of receiving a citation when other predictors (race in this context) are held constant.



Conditions met. Proceed with a logistic regression model.

```
## # A tibble: 6 x 5
##   term                                estimate std.error statistic   p.value
##   <chr>                                  <dbl>     <dbl>     <dbl>     <dbl>
## 1 (Intercept)                          0.393    0.0122      32.2   4.74e-227
## 2 subject_raceasian/pacific islander   0.00369  0.0293       0.126 9.00e-  1
## 3 subject_raceblack                   -0.202    0.00801    -25.2   4.27e-140
## 4 subject_racehispanic                 0.359    0.0124      28.9   4.21e-183
## 5 subject_raceother                   -0.143    0.0567      -2.52  1.18e-  2
## 6 subject_age                         -0.00739  0.000279   -26.5   1.32e-154
```

The logistic regression model has outputted the following equations to predict the likelihood of receiving a citation:

Predicted Citation Log-Odds = 0.393 + 0.004 * subject_raceasian/pacific islander - 0.007 * age

Predicted Citation Log-Odds = 0.393 - 0.202 * subject_raceblack - 0.007 * age

Predicted Citation Log-Odds = 0.393 + 0.359 * subject_racehispanic - 0.007 * age

Predicted Citation Log-Odds = 0.393 - 0.143 * subject_raceother - 0.007 * age

This model yields a few key conclusions:

1. Holding age constant, we expect the odds that a Hispanic person will receive a citation upon being

stopped by police in Durham County to be 1.4318968 times the odds that a white person will receive a citation upon being stopped by police. The coefficient is also statistically significant (p-value < 0.01), meaning there is less than a 1% chance such a coefficient or more extreme would be found in the data if race and the likelihood of receiving a citation were not associated.

2. Holding age constant, we expect the odds that a black person will receive a citation upon being stopped by police in Durham County to be 0.8170949 times the odds that a white person will receive a citation upon being stopped by police. The coefficient is also statistically significant (p-value < 0.01).

3. Holding race constant, for every additional year of age, we expect the odds of receiving a citation upon being stopped to multiply by 0.9926402. The coefficient is also statistically significant (p-value < 0.01), indicating that the data does provide sufficient evidence that the driver's age and the likelihood of receiving a citation are associated (slope 0).

The implications of this model will be further discussed in the "Discussion" section of the report.

Fail to reject null...

Discussion

Though black people are disproportionately more likely to be stopped for a traffic violation, they were not the most likely to receive a citation upon being stopped–Hispanics were the most likely to receive a citation after being stopped.