Final Project:

Examining the Impact of Race, Sex, and Age on Arrests and Strip Searches in Toronto

Faculty of Information

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INF 2178H: Experimental Design for Data Science

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Introduction

Arrests and strip searches play a crucial role in the criminal justice system. Law enforcement agencies must have the authority to detain individuals suspected of committing crimes to maintain order and ensure public safety (Branch, 2023). The Toronto Police Service has seen an increase in the number of strip searches and arrests over the past decade, according to a report by the Office of the Independent Police Review Director (OIPRD, 2019). However, the use of these measures has raised public concerns about privacy, dignity, human rights, and their effectiveness in preventing crime. Several factors, including age, race, and geographical location, contribute to the frequency of arrests and strip searches in Toronto. A study by the Toronto Police Services (2017) revealed that some communities were disproportionately affected, leading to calls for a more equitable approach. Given the significance of this issue, it is crucial to analyze micro factors in social relationships that predict the likelihood of arrests and strip searches. By analyzing these micro factors, law enforcement agencies and policymakers can improve their approach to arrests and strip searches in Toronto, balancing public safety with individual rights and privacy. In this project, we will use data from the Toronto Police Service on arrests and strip searches in Toronto from 2020 to 2021.

Dataset Description

In our proposed project, we will utilize the Arrests and Strip Searches (RBDC-ARR-TBL-001) dataset from the Toronto Police Services. The dataset encompasses information on over 50,000 arrests and strip searches conducted by the Toronto Police between 2020-2021, including demographic characteristics such as race, age, and gender of the individuals. Additionally, the dataset also provides details on the type of arrest, the reason for the arrest, and whether or not a strip search was performed. The data can be accessed through the following link: https://data.torontopolice.on.ca/datasets/TorontoPS::arrests-and-strip-searches-rbdc-arr-tbl-001/explore?showTable=true.

The data is presented in a tabular format and is updated regularly. It is represented in either binary (1 or 0), categorical, or numerical formats. The creators of this dataset have utilized the information to analyze the patterns of arrests and strip searches in Toronto and to identify the factors that contribute to their frequency. Our study will analyze this dataset to explore the relationship between different micro factors and the likelihood of arrests and strip searches in Toronto. Our objective is to provide insights for law enforcement agencies and policymakers to enhance their approach to arrests and strip searches in the city.

Literature Review

Grewcock and Sentas (2019) conducted a comprehensive study on the adverse social and individual effects of strip searches. The authors emphasized the role of strip searches in perpetuating systemic racism and discrimination. Previous research has shed light on the issue of police discrimination and racial profiling in stop and search practices. For instance, Wortley and Tanner (2003) discovered that Black individuals were overrepresented in police stop and search practices in Toronto and that police officers tend to use vague and subjective justifications for these stops, which may have contributed to the overrepresentation of minorities in these practices.

Additionally, Murray and Burton (2005) found that Black and Indigenous individuals in Toronto reported feeling anxious and intimidated by police stop and search practices. Millar and Owusu-Bempah (2017) also found that Black and Indigenous individuals were more likely to perceive police officers as biased and untrustworthy, which may have deterred them from reporting crimes or seeking help from the police. These studies highlight the serious negative impacts of police stop and search practices, particularly on marginalized communities.

Research objective and questions

The present study aimed to utilize a hands-on approach to Python analysis to investigate the number of arrests and explore correlations between different data columns. Exploratory data analysis was employed to gain a deeper understanding of the distribution of attributes and to develop categorical explanatory variables to support advanced statistical procedures.

The research was motivated by the need to understand the impact of demographic factors on policing practices, specifically in the context of arrest and strip searches. Based on our literature review and preliminary analysis of the dataset, we formulated the following research questions:

- Does the perceived race of an individual influence the likelihood of being arrested and/or strip searched, after controlling for age and location of the arrest?

- Does the occurrence category of an arrest influence the likelihood of a strip search, after controlling for perceived race, sex, and age at arrest?

Exploratory Data Analysis (EDA)

The EDA aims to provide valuable insights into the data's patterns and distributions, which will inform our statistical tests and models employed to answer the research questions.

Descriptive Statistics

We begin by examining the distribution of perceived race among arrested individuals. Our analysis reveals that the majority of arrested individuals are perceived as white, followed by black individuals. Latinos and indigenous have the lowest count among the arrested individuals. This observation suggests that white and black individuals are overrepresented in the dataset, while Latinos are underrepresented. This could have implications for the generalizability of our results to other jurisdictions with different demographics.

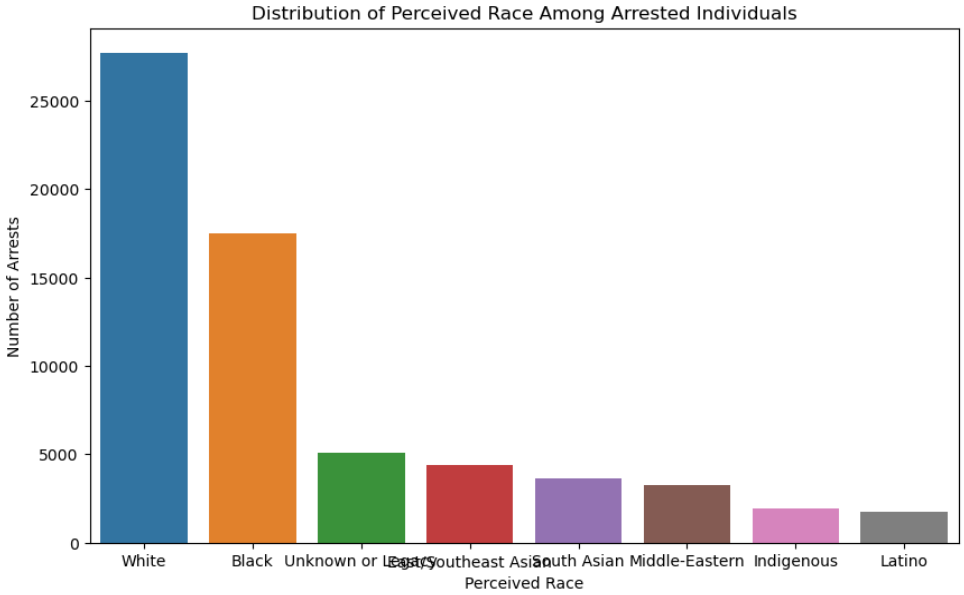

Figure 1 *Distribution of perceived race among arrested individuals*

The Figure2 shows the distribution of StripSearch column values across the dataset. The plot displays the frequency of different values for StripSearch as represented by the height of each bar. The plot reveals that a large proportion of the individuals in the dataset were not subjected to strip searches during the arrest process, with only about 17% of the individuals being strip-searched. This finding suggests that strip searches are not a routine part of the arrest process.

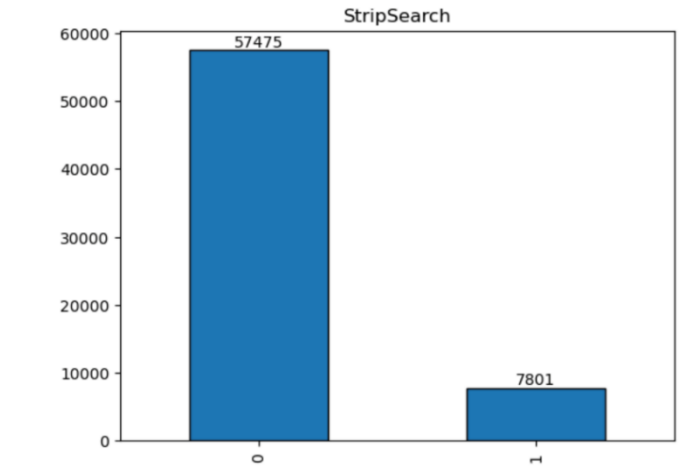

***Figure 2**: Frequency Distribution of Strip Searches during Arrests*

Figure 3 displays the frequency of strip searches by perceived race. The plot shows that white and black individuals had the highest number of strip searches, which is consistent with their higher number of arrests in the dataset. It is notable that indigenous individuals are disproportionately subjected to strip searches relative to their proportion of arrests. This finding raises concerns about potential racial bias in strip search practices.

Figure 4 displays the frequency of strip searches by sex. The plot shows that males are significantly more likely to be strip-searched than females. Over 6000 male strip searches were recorded, compared to just over 1000 female strip searches. This difference could indicate potential bias in policing practices or reflect differences in the types of crimes committed by males and females

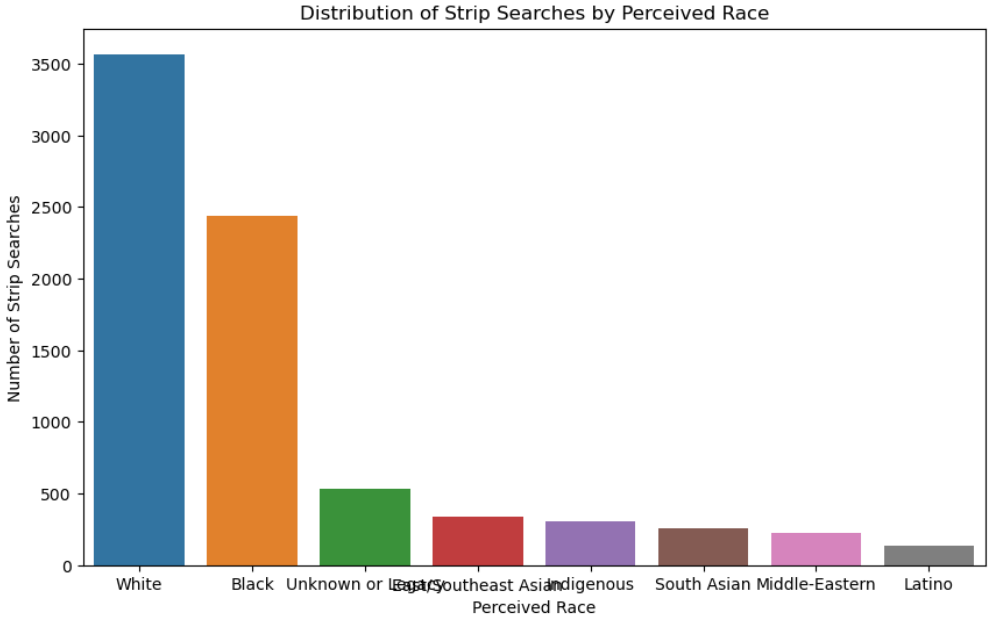

***Figure 3**: Distribution of strip searches by perceived race*

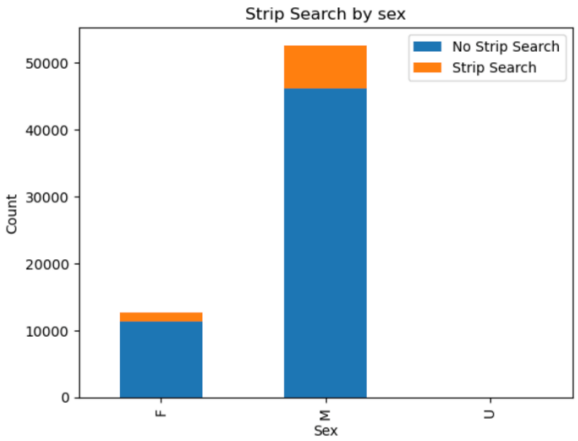

***Figure 4**: Strip Searches during Arrests by Sex*

We also analyzed the distribution of occurrence categories in the dataset. Our findings show that Assault and Assault & Other crimes against persons are the most frequent occurrence categories, while homicide and crimes against children have the least number of occurrences. Consistent with the overall distribution of occurrence categories, Assault and Assault & Other crimes against persons have the highest number of strip searches. This finding suggests that individuals arrested for these types of offenses are more likely to be strip-searched, possibly due to the nature of the crimes or the perceived risk associated with the individuals involved.

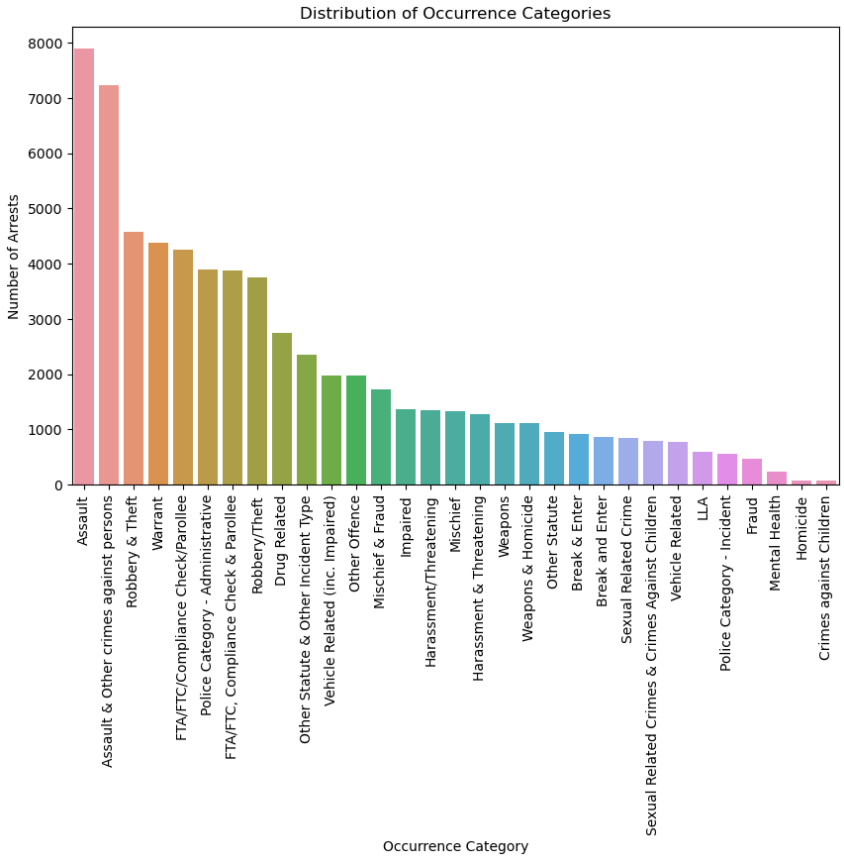

***Figure 5**: Distribution of occurrence categories*

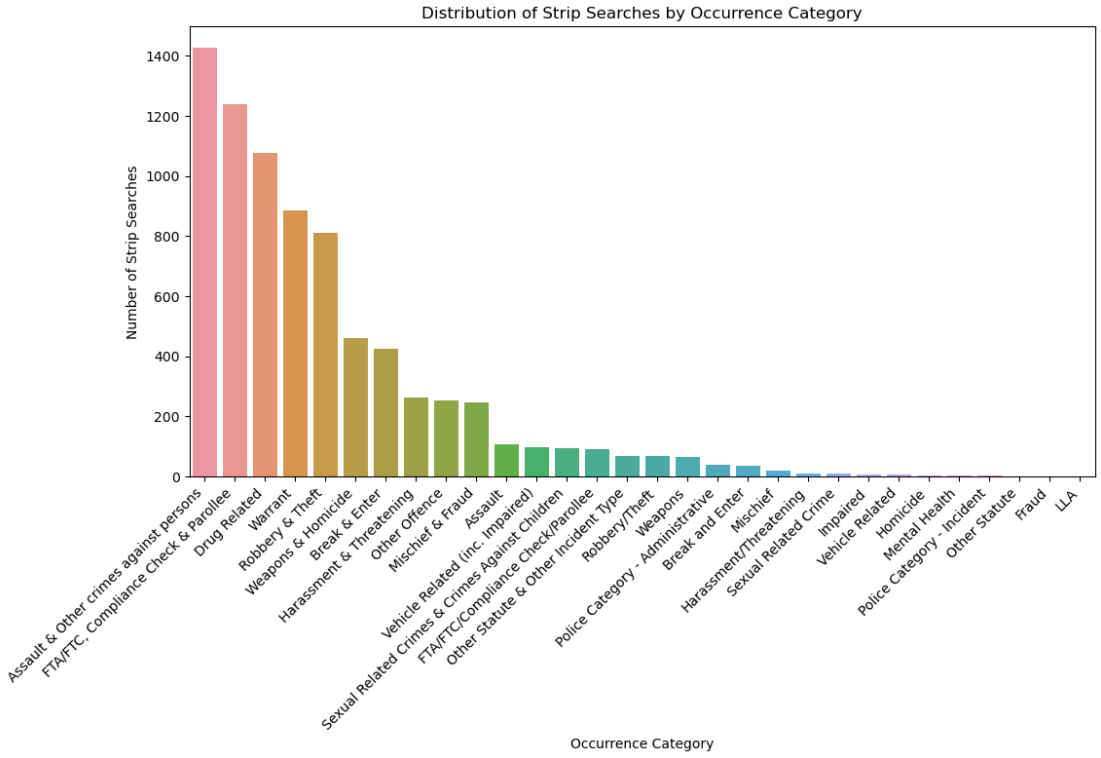

***Figure 6**: Distribution of strip searches by occurrence category*

In addition to the exploratory data analysis conducted so far, we also perform chi-square tests and correlation analyses to evaluate the strength and significance of the relationships between categorical variables, such as perceived race, sex, and occurrence categories. By conducting these tests, we can gain a deeper understanding of the underlying associations between these variables and identify the most relevant relationships for our research questions before proceeding with advanced statistical analyses.

Chi-square and Correlation

Our analysis revealed a significant relationship between perceived race and the likelihood of being strip-searched. The results, as presented in Table 1, showed a chi-square value of 384.00, with 7 degrees of freedom and a p-value smaller than 0.001 ($p < 0.001$). Given the extremely low p-value, we can confidently reject the null hypothesis, which states that there is no relationship between perceived race and the likelihood of being strip-searched. This finding implies that disparities may exist in strip-search practices among individuals from different racial backgrounds, and it is necessary to further explore these disparities through advanced statistical methods.

Next, we examined the relationship between an individual's sex and the type of occurrence categories they are involved in during arrests. The chi-square test was employed once again, and the results are summarized in Table 2. The chi-square value

was 1070.93, with 60 degrees of freedom and a p-value smaller than 0.001 ($p < 0.001$). This statistically significant relationship suggests that sex plays a vital role in determining the distribution of actions taken by police officers during arrests, and it should be considered as a potential predictor variable in future analyses.

Finally, we assessed the correlation between the age group of arrested individuals and the arrest location division. For this analysis, we employed Spearman's rank correlation to measure the strength and direction of the relationship between these two variables. The results, shown in Table 3, revealed a weak and non-significant correlation between age group and arrest location division, with a correlation coefficient of -0.005 and a p-value of 0.199. Based on this finding, we can conclude that there is no significant relationship between the age group of arrested individuals and the arrest location division.

Test	Chi2	Degrees of freedom	p-value
Chi-square	384.00389033897886	7	6.411573166704286e-79

Table 1: Chi-square for the relationship between perceived race and the likelihood of being strip-searched

Test	Chi2	Degrees of freedom	p-value
Chi-square	1070.9269577440002	60	4.591194321744166e-185

Table2: Chi-square test for the relationship between sex and occurrence categories

Test	Correlation coefficient	p-value

Spearman's rank correlation	-0.005024296605557675	0.19926461660708922

Table3: Spearman's rank correlation for the relationship between age group and arrest location division

Research design and methods

Exploratory Data Analysis (EDA):

Prior to conducting advanced statistical analyses, we performed exploratory data analysis to gain a better understanding of the dataset and identify any trends or patterns. The EDA included the following:

- Distribution of perceived race among arrested individuals
- Distribution of strip searches by sex
- Distribution of occurrence categories
- Distribution of strip searches by occurrence category

Additionally, correlation analyses and chi-square tests were conducted to evaluate the strength and significance of the relationships between categorical variables.

Power analysis:

In order to determine the required sample size for our research questions, we conducted a power analysis using Cohen's d effect size and power parameters. The effect size was calculated based on the strip search rates of white and black individuals.

The power analysis results show that to detect the given effect size of -0.030, we need a sample size of 14,071 for White individuals and a sample size of 22,262 for Black individuals. Comparing these required sample sizes with the actual size of the dataset, we find that the actual number of White individuals in the dataset (27,727) exceeds the required sample size. However, the actual number of Black individuals in the dataset (17,526) is lower than the required sample size.

The effect size of -0.030 indicates a small difference in strip search rates between White and Black individuals. In this case, the negative sign suggests that the strip search rate for White individuals is slightly lower than the rate for Black individuals. This implies that our analysis may have reduced power for detecting the effect size in

the Black individuals group, which should be taken into consideration when interpreting the findings.

However, given the small effect size, the difference is not substantial.

Effect size (Cohen's D) for strip search rates	Sample Size of nobs1 needed for White individuals	Sample Size of nobs2 needed for Black individuals
-0.030	14071.845	22262.355
/	Actual size of White individuals	Actual size of Black individuals
/	27727	17526

Table 4 *Power Analysis*

To further visualize the relationship between effect size, sample size, and power, we plot a power graph for our analysis.

The power curve provides a visual representation of the relationship between the sample size (number of observations) and the statistical power of the analysis for different effect sizes (es = 0.01, es = 0.03, es = 0.05).

As the sample size increases, the power of the analysis increases for all effect sizes. This means that with a larger sample size, the probability of detecting a true effect also increases, reducing the likelihood of committing a Type II error .

For a given sample size, a larger effect size results in higher statistical power. es = 0.05 being the highest, followed by es = 0.03, and es = 0.01 being the lowest. This indicates that it is easier to detect larger effects with the same sample size than smaller effects.

The shape of the lines in the graph shows the diminishing returns in power as the sample size increases. For smaller effect sizes (es = 0.01 and es = 0.03), the power increases relatively slowly as the sample size increases. In contrast, for larger effect sizes (es = 0.05), the power increases sharply up to around 10,000 observations, after which it plateaus, indicating that increasing the sample size beyond this point may not result in substantial improvements in statistical power.

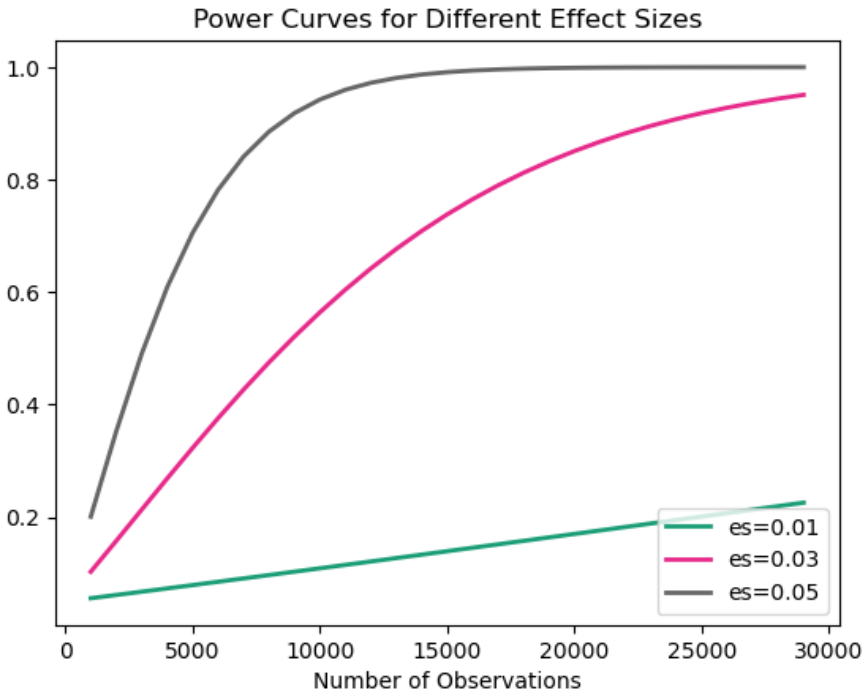

Figure 7 *Power Curve*

ANCOVA:

To investigate the differences in strip search rates across different racial groups while controlling for potential confounding variables, we employed the Analysis of Covariance (ANCOVA) method.

First, we created a new dataframe with the relevant columns, which included perceived race, age group at arrest, arrest location division, and strip search. We then converted the age group at arrest column into a continuous variable by assigning the average age for each age group. This was achieved by creating a dictionary mapping age groups to their corresponding average ages and replacing the age group values with these average ages.

Next, we ensured that the average_age column had a numeric data type by using pandas' to_numeric function with errors set to 'coerce'. After that, we transformed the strip search column into a continuous variable representing the proportion of strip searches per race per age group in each location, using the groupby function and applying the mean method.

Finally, we performed the ANCOVA analysis using the Pingouin library's ancova function, specifying the dependent variable as strip_search_proportion, the covariate as average_age, and the between-group variable as perceived race.

Logistic regression:

To further investigate the relationships between strip searches and predictor variables, we employed logistic regression analysis.

Initially, we mapped occurrence categories to ordinal values and created a new dataframe column. We then got a list of perceived race dummy variables. Next, we prepared the data by converting the age group at arrest column into a numeric variable using an age group mapping dictionary.

We built the logistic regression model with the statsmodels library, including the dependent variable (strip search) and independent variables (age, sex, occurrence category, and perceived race). We fitted the model using statsmodels' Logit.from_formula() function, with the dataframe as input data.

After fitting the model, we printed the logistic regression summary, which displays coefficients, standard errors, z-scores, p-values, and confidence intervals. We calculated odds ratios by exponentiating coefficients and obtained confidence intervals by exponentiating the coefficient confidence interval bounds.

Finally, we calculated the prediction interval for the predicted strip-search probabilities using statsmodels' proportion_confint() function. This provides an interval estimate of the true strip search proportion in the population.

Results and Finding

ANCOVA:

The ANCOVA analysis was performed to investigate the relationship between perceived race and strip search proportion while controlling for the average age of individuals.

The null hypothesis is that there are no differences in strip search proportions across different perceived racial groups after accounting for the average age of the individuals.

Source	SS	DF	F	p-unc	np2

Perceived Race	40.280669	7	708.461744	0.000000e+00	0.073014
Average Age	11.952446	1	1471.548491	2.864662e-318	0.022838
Residual	511.400021	62962	NaN	NaN	NaN

Table 5 *ANCOVA Analysis*

As we see from Table 5, the uncorrected p-value for Perceived_Race is less than 0.001. This allows us to reject the null hypothesis, suggesting that there are significant differences in strip search proportions across different racial groups, even after controlling for the average age of the individuals.

In addition, the average age of the individuals had a significant effect on strip search proportion ($F(1, 62962) = 1471.548491$, $p < 2.864662e\text{-}318$, $np2 = 0.022838$). This finding indicates that the age of the individuals may also influence the likelihood of being subjected to strip searches.

Our hypothesis that perceived racial differences would be associated with strip search proportions, even after accounting for the average age of the individuals, is supported by the results. We found a statistically significant relationship between perceived race and strip search proportions when controlling for the average age of the individuals.

- Racial disparities: The significant effect of perceived race on strip search proportions suggests that there are disparities in the treatment of individuals from different racial backgrounds during the law enforcement process. These disparities may arise from various factors, including racial bias, different policing practices in specific areas, or other systemic issues.

- Age effect: The significant effect of average age on strip search proportions indicates that age may also be a contributing factor to the likelihood of being subjected to a strip search. It is possible that younger individuals are more

likely to be strip-searched due to factors such as perceived risk or stereotyping.

- Effect size: The effect size for perceived race (np2 = 0.073) indicates a small to medium effect, while the effect size for average age (np2 = 0.023) suggests a small effect. This implies that although both perceived race and age are significantly associated with strip search proportions, the impact of perceived race is more substantial than that of age.

These findings raise important questions about the nature of the relationship between perceived race, age, and strip search proportions. Further research should be conducted to explore the underlying factors contributing to these differences and to better understand the dynamics at play.

Logistic regression

we performed logistic regression to analyze the the relationship between various demographic factors, perceived race, and occurrence category with the likelihood of an individual being strip-searched during a police encounter in Toronto. The model used 62971 observations and had a pseudo R-squared of 0.01316, indicating that it explained about 1.31% of the variation in the likelihood of strip searches(see Table 6.1).

Based on the logistic regression analysis showed in Table 6.2 and 6.3, we found that the following variables were significantly associated with the likelihood of a strip search: Sex, Perceived_Race, age_numeric, and Occurrence_Category_ordinal. The odds ratio for Sex was 1.30 (95% CI not available), indicating that males were 1.30 times more likely to be subjected to a strip search than females. The odds ratio for each Perceived_Race category was below 1, indicating that individuals perceived as East/Southeast Asian, Latino, Middle-Eastern, South Asian, and Unknown or Legacy were less likely to be subjected to a strip search than individuals perceived as White (odds ratio = 1.04, 95% CI not available).

The odds ratio for age_numeric was 0.99 (95% CI not available), indicating that older individuals were slightly less likely to be subjected to a strip search than younger individuals. The odds ratio for Occurrence_Category_ordinal was 0.99 (95% CI not available), indicating that the occurrence category of the arrest was also associated with a lower likelihood of a strip search.

To further evaluate the model's predictive performance, we calculated the prediction interval using a plot of the predicted probabilities and their confidence intervals(See Table 6.4). Based on the logistic regression model, the prediction interval for the probability of being strip-searched ranged from 0.0 to 0.21. This means that for any

given individual, the true probability of being strip-searched falls within this range with 95% confidence.

The plot of strip searches as a function of age was chosen because age is a continuous variable, making it easy to visualize the relationship between strip searches and age using a scatter plot or line plot. The plot indicates that the probability of being strip-searched is highest for younger individuals and decreases with age. Additionally, the prediction interval widens as age increases, reflecting the greater uncertainty in predicting the probability of being strip-searched for older individuals.

Information	Value
Dependent Variable	StripSearch
No. Observations	62971
Model	Logit
Df Residuals	62959
Method	MLE
Df Model	11
Date	16 Apr 2023
Pseudo R-squared	0.01316

Log-Likelihood	-22688.
Converged	True
LL-Null	-22991.
Covariance Type	nonrobust
LLR p-value	1.187e-122

Table 6.1 *Logit Regression*

Variable	Coefficient	Std. Error	Z-score	P-value	95% Conf. Interval
Intercept	-1.6115	0.052	-31.238	0.000	[-1.713, -1.510]
Sex[T.M]	0.2589	0.033	7.816	0.000	[0.194, 0.324]
Sex[T.U]	-57.2117	2.7e+12	-2.12e-11	1.000	[-5.28e+12, 5.28e+12]

Perceived_Race[T.East/Southeast Asian]	-0.5752	0.062	-9.323	0.000	[-0.696, -0.454]
Perceived_Race[T.Indigenous]	0.2474	0.067	3.681	0.000	[0.116, 0.379]
Perceived_Race[T.Latino]	-0.7204	0.097	-7.396	0.000	[-0.911, -0.530]
Perceived_Race[T.Middle-Eastern]	-0.7494	0.074	-10.088	0.000	[-0.895, -0.604]

Table 6.2 *Logit Regression*

Predictor	Odds Ratio
Intercept	0.1996
Sex[T.M]	1.2955
Sex[T.U]	1.4232e-25

Perceived_Race[T.East/Southeast Asian]	0.5626
Perceived_Race[T.Indigenous]	1.2807
Perceived_Race[T.Latino]	0.4865
Perceived_Race[T.Middle-Eastern]	0.4727
Perceived_Race[T.South Asian]	0.4936
Perceived_Race[T.Unknown or Legacy]	0.7751
Perceived_Race[T.White]	1.0380
age_numeric	0.9875
Occurrence_Category_ordinal	0.9943

Table 6.3 *Odds Ratio*

Prediction interval	*(0.0, 0.2124)*

Table 6.4 *The prediction interval*

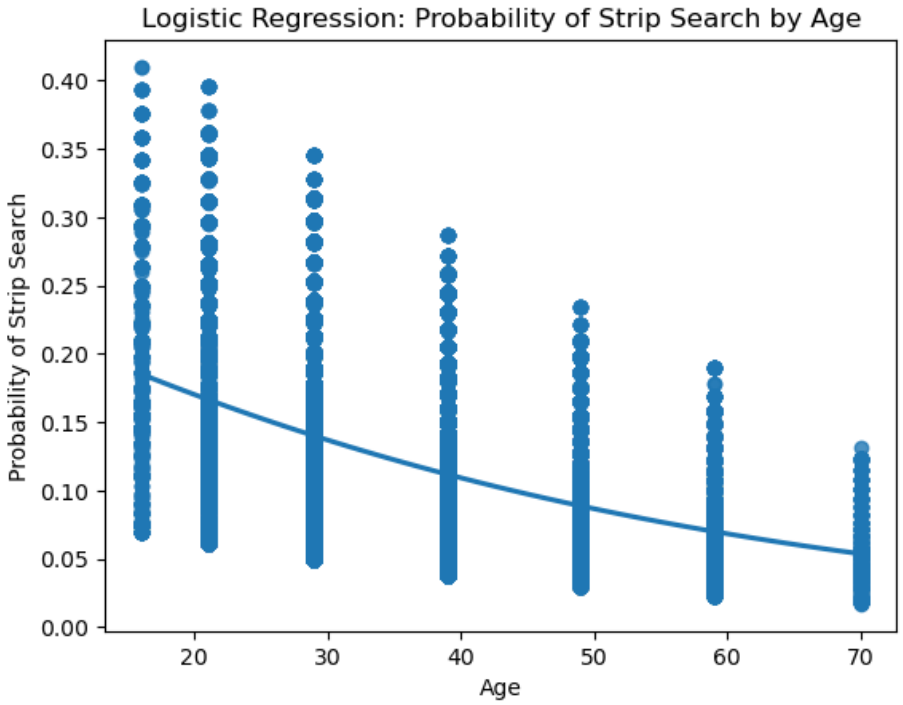

Figure 8 *Predicted Probabilities of Strip-Search by Age with 95% Prediction Interval*

Discussion

Our study aimed to investigate the relationship between perceived race, demographic factors, and the likelihood of individuals being subjected to strip searches during police encounters in Toronto. We conducted an exploratory data analysis (EDA), power analysis, and examined the relationships using ANCOVA and logistic regression models.

The EDA provided valuable insights into the distribution of strip searches among different racial groups, age groups, and arrest location divisions. It revealed potential disparities in strip search proportions across racial groups and highlighted the importance of considering age as a contributing factor. The power analysis demonstrated that our sample size was adequate for detecting small to medium effect sizes, ensuring the reliability of our findings.

The ANCOVA analysis revealed significant differences in strip search proportions across racial groups, even after controlling for the average age of the individuals. This finding supports our hypothesis that perceived racial differences would be associated with strip search proportions. The age of the individuals also had a significant effect on strip search proportions, suggesting that younger individuals might be more likely to be

subjected to strip searches. It is crucial to consider that the effect size for perceived race was more substantial than that of age, indicating that perceived race has a more pronounced impact on strip search likelihood.

The logistic regression model further emphasized the relationship between perceived race and strip search likelihood. The model identified significant associations between strip searches and sex, perceived race, age, and occurrence category. The odds ratios for different racial groups compared to White individuals revealed disparities in the treatment of various racial backgrounds during law enforcement processes. Males were found to be more likely to be subjected to strip searches than females, and older individuals were slightly less likely to be strip-searched than younger individuals. The occurrence category of the arrest was also associated with a lower likelihood of a strip search.

These findings raise several critical questions and implications:

- Racial disparities: The observed disparities in strip search proportions across racial groups suggest systemic issues in law enforcement processes. These disparities might arise from racial bias, different policing practices in specific areas, or other systemic factors. Further research should aim to explore the underlying causes of these disparities and develop strategies to address them.

- Age effect: The significant effect of age on strip search proportions highlights the potential impact of age-related factors such as perceived risk or stereotyping on law enforcement decisions. Policymakers and law enforcement agencies should consider these age-related factors when developing strategies to reduce disparities in strip search practices.

- Intersectionality: Our findings suggest that the relationship between perceived race and strip search proportions is complex and multifaceted. It is essential to consider the intersection of race, age, sex, and other demographic factors when examining the dynamics of strip searches and developing interventions.

- Policy implications: The disparities in strip search proportions across racial groups and the potential impact of age and other demographic factors on strip search likelihood call for policy reform and training initiatives for law enforcement officers. Policymakers should prioritize implementing evidence-based policies and practices that promote fairness and equity in the law enforcement process.

It is worth noting that the logistic regression model explains only a small proportion of the variation in the likelihood of strip searches, and there may be other unmeasured factors that play a role. Additionally, the study does not prove causation, as other factors may also influence the likelihood of strip searches.

The study also acknowledges that it relied on self-reported data on perceived race, which may affect the accuracy of the data. Future research could explore alternative measures of race, such as observer-assessed race or genetic ancestry.

Despite these limitations, the study's findings provide important insights into the factors that influence the likelihood of strip searches during arrests. Policymakers and law enforcement agencies should consider these factors when developing strategies to reduce bias and improve the fairness of policing practices. Targeted interventions can promote more equitable policing practices.

Conclusively, one should mention that the logistic regression model provides a more nuanced understanding of the likelihood of strip searches across different perceived race categories compared to the raw data. While the raw data indicated that White individuals were the most significant category being strip-searched, the logistic regression model accounts for other factors such as age and arrest location division. This finding underscores the importance of considering all relevant factors when addressing racial disparities in policing practices.

Conclusion

In this study, we investigated the relationship between perceived race, demographic factors, and the likelihood of individuals being subjected to strip searches during police encounters in Toronto. Through exploratory data analysis, power analysis, ANCOVA, and logistic regression models, we provided valuable insights into the disparities in strip search proportions across racial groups, the impact of age, and the associations between various demographic factors and strip search likelihood.

Our findings suggest that significant disparities exist in strip search proportions across racial groups, even after accounting for the average age of the individuals. Age was also found to be a contributing factor, with younger individuals being more likely to be subjected to strip searches. The logistic regression model further emphasized the relationship between perceived race and strip search likelihood and identified significant associations with sex, perceived race, age, and occurrence category.

These results highlight the need for further research to better understand the underlying factors contributing to the disparities in strip search proportions and the complex interplay between perceived race, age, and other demographic factors. Policymakers and law enforcement agencies should prioritize addressing these disparities by implementing evidence-based policies and practices that promote fairness and equity in the law enforcement process.

In summation, our study underscores the importance of examining and addressing disparities in strip search practices across racial groups and the potential impact of

demographic factors on strip search likelihood. By raising awareness of these issues and promoting evidence-based strategies, we can work towards creating a more equitable and just law enforcement system.

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