INF 2178 Midterm Project

Analysis of Arrest and Strip Search in Toronto based on Demographic Factors

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Master of Information
Faculty of Information
INF2178H: Experimental Design for Data Science
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Introduction

1.1 Information about Crime in Toronto

As the largest city in Canada, Toronto is not immune to different kinds of crime, and the situation has tended to become worse in the past two years. According to the Toronto Police Service data portal, in 2022 the city's overall major crime increased by 17.2 per cent, with different percentages of increases in different kinds of crimes [2]. For instance, there was a 28.5 percent of increase in robbery, and 44.2 percent of increase in auto thefts [2]. Many of the major crime indicators (MCI) were increasing according to the data released by Toronto Police Service [6]. Meanwhile, several violent crimes shocked the residents in Toronto at the end of year 2022, and some people started to question and complain about Toronto's safety issues since they kept seeing news reports about the new crimes [2]. Moreover, another argument points out that the issue of increasing crime doesn't only appear in Toronto, instead it is more like a national problem which has various causes and catalysts [3]. Thus, it is important to study the data about crime records in the past two years to determine patterns and relationships among the factors which could bring us more knowledge to understand this social issue.

In this project, the dataset used was posted by Toronto Police Service. It is from the public safety data portal, which records information regarding all arrests and strip searches. Some factors recorded, such as the gender, age groups, race, actions at arrest and the reasons of being searched can be useful to study. Detailed information about the dataset will be provided in the Methods section of this paper. Two research questions were selected as the questions to explore with the data, and more information will be introduced in Section 1.3. The dataset was cleaned to make it suitable for further research, and exploratory data analysis was conducted to provide a first look of all the data, and give information about descriptive statistics. Moreover, hypotheses for the t-tests were set and examined by the tests to determine whether significant difference exists between the means of various groups. Finally, the data was further analyzed by two-way ANOVA tests and post-hoc tests to answer the research questions.

1.2 Literature Review

The government of Toronto also released some reports about violent crime classified by the factors mentioned above. In one attachment released by the government website, trends in police-reported violent crime by different factors were recorded. For instance, one of the factors is age group. The report shows that, from 2009 to 2017, the rate of firearm-related violent crime was always higher for youth between 12 and 17 years old than the rate for adults (older than 18) [1]. It indicates that the rate of certain kinds of violent crime may differ by whether the suspects are youth under 18 years old. Thus, this factor is worthy to be further explored. Another point that is related to this dataset is about strip search. Strip search is a kind of search conducted by the police, and the process may involve removing some or all clothing, and doing visual inspections of the body [5]. According to Toronto Police Service's report, in 2020 about 53.5% of arrests led to a booking, and about 42% of these bookings finally caused a strip search [4]. This ratio was not low, which means the number of strip search cases could be high. The report also mentioned that the ratios of strip searches were different based on some demographic factors (e.g. 46% were perceived as White and 31% were perceived as Black) which might contain the issue of over-representation [4]. This is also a reason for containing this factor in this study, and to make a difference, in this case we wished to make gender and whether the arrested person is youth as explanatory variables.

1.3 Research Question

This study focuses on two research questions. Based on the information provided by the dataset and knowledge we retrieved from our literature review, we focused on how demographic factors would interact with the age of the people arrested and the number of reasons for being strip searched respectively. Thus, we included the following two research questions.

The first question of interest is whether gender and whether youth or not affect the number of search reasons based on arrest records from the city of Toronto in 2020 and 2021. The goal is to determine how the strip search conducted differs by the arrested people's gender and whether they are adults.

The second research question is whether sex and race affect the lower limited boundary of age (above 17 years old) at arrest based on arrest records from the city of Toronto in 2020 and 2021. The study focuses on this question to determine how the two demographic factors interact with the age of the people arrested.

Exploratory data analysis

2.1 Descriptive Statistic data

After cleaning the original dataset, we produced two individual dataset which only contained the variables that were required by the research questions respectively.

Research Question 1:

```
RangeIndex: 7801 entries, 0 to 7800
Data columns (total 3 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   Sex                             7801 non-null   object
 1   Youth_at_arrest__under_18_years  7801 non-null   object
 2   Num_of_Search_Reason            7801 non-null   int64
dtypes: int64(1), object(2)
memory usage: 183.0+ KB
```

	Num_of_Search_Reason
count	7801.000000
mean	1.981156
std	1.209695
min	0.000000
25%	1.000000
50%	2.000000
75%	3.000000
max	4.000000

Figure 2.1 Basic Information about the new dataset for research question 1

According to Figure 2.1, our new dataset for the first research question contains 7801 rows, and the columns include “Sex,” “Youth_at_arrest_under_18_years,” and “Num_of_search_Reason.” The average number of search reasons is about 1.98, which is almost half of the total number of search reasons. Meanwhile, the 50 percent quantile is two. It may indicate that on average every person who was arrested and strip searched had two reasons for being searched. One insight from this point could be that usually the police would strip search the arrested people for two reasons, and the people being searched usually

violated two laws or rules which caused them to be strip searched. However, we can see that the minimum value of search reasons is zero, which means the people arrested were searched without any reason, or their reasons were not recorded by the dataset.

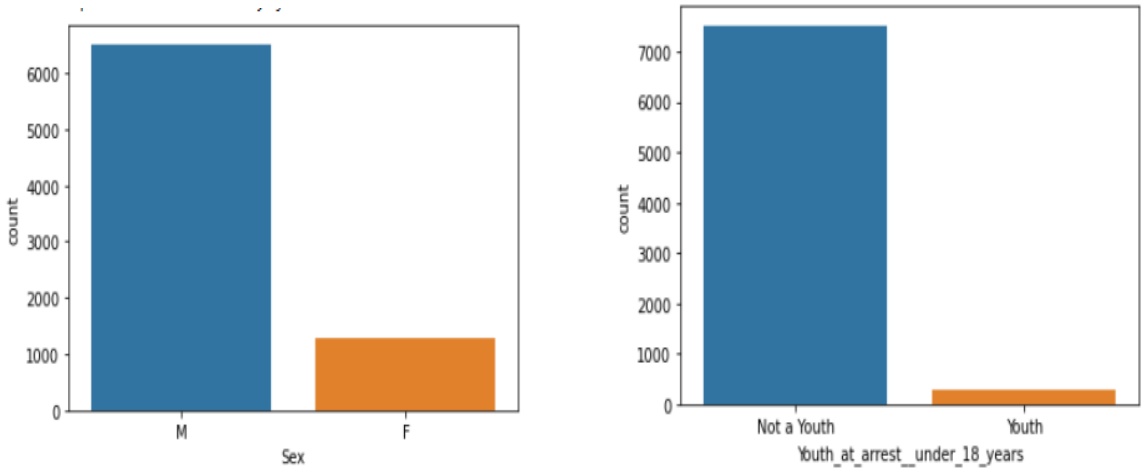


Figure 2.2 Bar Chart for Comparing the Counts based on Sex and Youth

We also compared the number of male and female who were strip searched by the police. According to Figure 2.2, the number of males who were strip searched is much higher than the number of females, which is expected since there were more males in the original dataset. We also compared the number of people who are or are not a youth, and based on the diagram, adults are much more than people who are under age 18.

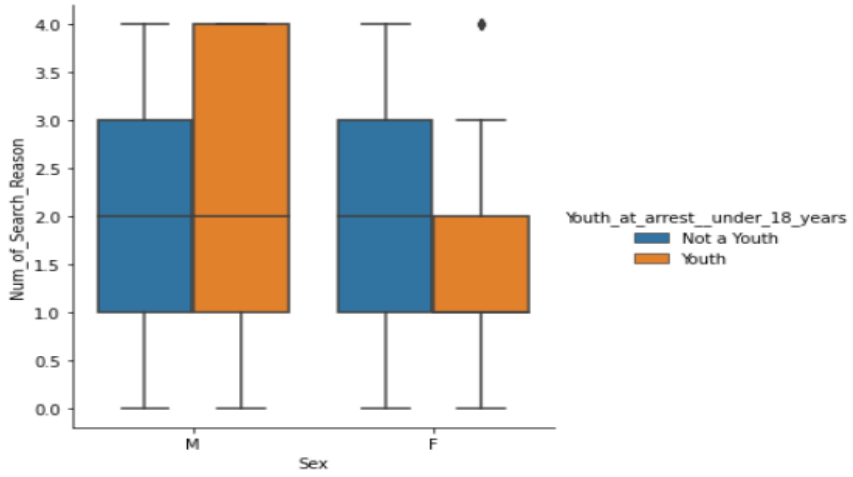


Figure 2.3 Boxplot for Sex and Youth_at_arrest_under_18_years

Next, we used boxplots to see the statistical results regarding male and female adults and youth with the number of search reasons. According to Figure 2.3, male adults and female

adults have the same pattern since they appear to have the same median and quantiles. However, male youths and female youths followed very different patterns. The upper end for male youths is much higher than the upper end for female youths. In addition, there is an outlier in female youth's data.

Research Question 2:

```
Data columns (total 3 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   Sex                             60187 non-null  object
 1   Race                            60187 non-null  object
 2   Lower_bound_interval_arrest_age  60187 non-null  int64
dtypes: int64(1), object(2)
memory usage: 1.4+ MB
```

	Lower_bound_interval_arrest_age
count	60187.000000
mean	31.757755
std	11.874668
min	17.000000
25%	25.000000
50%	25.000000
75%	35.000000
max	65.000000

Figure 2.4 Basic Information about the new dataset for research question 2

According to Figure 2.4, the new dataset for our second research question contains 60,187 records and three columns including "Sex", "Race", and "Lower_bound_interval_arrest_age". The mean of the arrest age is about 32 years old. The standard deviation is about 11.87, which means most of the data values are within a range of 11.87 units above and below the mean. The value of the standard deviation is quite high, but it is expected since the column was transformed from the "Age_group_at_arrest" in the original dataset, and the age groups have a span of 10 units. One notable point is that the values for 25 percent quartile and 50 percent quartile are the same.

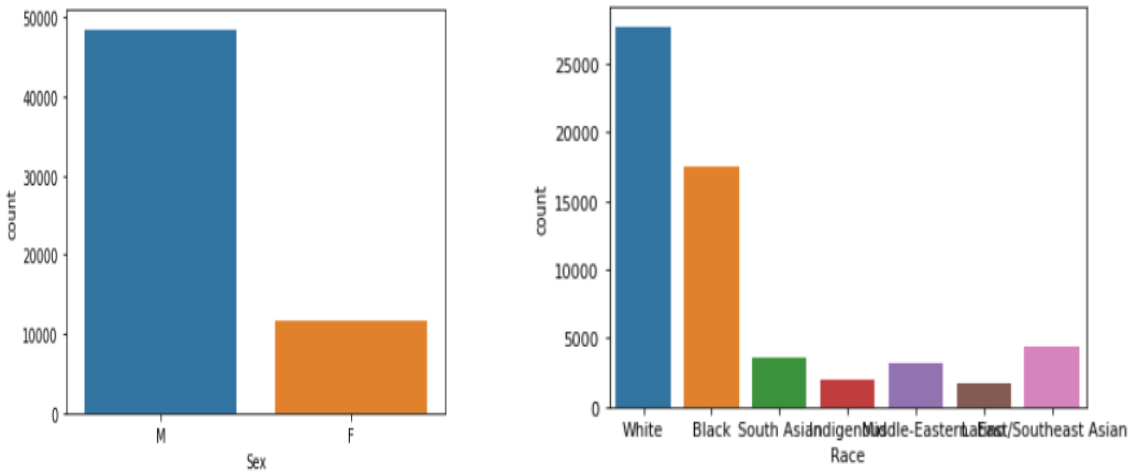


Figure 2.5 Bar Chart for Comparing the Counts based on Sex and Race

We also compared the counts for male and female with Figure 2.5. Similar to the patterns in the original and the first research question's dataset, the number of males is much higher than the number of females. We also compared the counts for every perceived race. The race with the highest amount is White, and the second highest is Black. The other five races have lower amount, and the differences among them are relatively low.

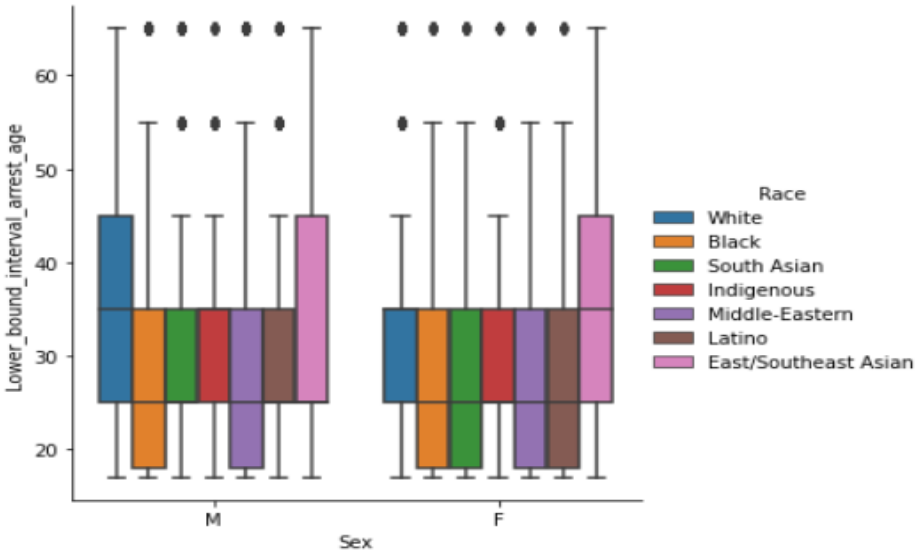


Figure 2.6 Side-by-side boxplots for research question 2

Moreover, boxplots were used to visualize the central tendency, outliers, and skew. According to the graph, we found that most of the values for all the races are at the similar level, which is between 25 and 35 years old, and there are outliers in most of the data groups. The lower whisker ends for all the races are above 17, because the age group under 18 years was

removed in the data cleaning step. For males, the race “White” and “East/Southeast Asian” have higher third quartile and upper whisker end than the other races, and they don’t have any outliers. It may indicate that the distribution range of the data may be more spread out, and people in other races who were arrested tend to be in younger age groups. In addition, the race “Black” and “Middle-Eastern” have lower first quartile than other races, which may show that the general level of age group for these people might be lower. For females, the race “East/Southeast Asian” has higher third quartile and upper whisker end than any other races. More races have lower first quartiles which are lower than 20 years old, so compared with the boxplots for males, the general level of arrest age for females in all races appears to be lower.

2.2 T tests

For further exploration of the data, we conducted t-tests for some variables to see if the differences are significant between the levels. Since we made two different dataset for our research questions respectively, we conducted t tests for them separately.

Research Question 1 contains two independent variables. The first one is “Sex” which contains values “M” or “F”. A t-test was conducted to see if the means of the outcome variable for each of them are statistically significant. Our null hypothesis is that the average number of reasons for being strip searched by police officers are equal between male and female. Our alternative hypothesis is the average number of reasons for being strip searched for the arrested males and females are not equal. The t-test result shows that the p-value is 9.150787627848595e-05, which is lower than the alpha level (0.05), 95% CI [0.0708, 0.2125]. Thus, we can reject our null hypothesis and conclude that the difference between the two means are statistically significant. The average number of reasons for being strip searched for male (M = 2.0044, SD = 1.2149) is higher than the number for females (M = 1.8628, SD = 1.1763).

The second variable is “Youth_at_arrest__under_18_years” which contains values “Youth” or “Not a Youth.” Our null hypothesis is that the average number of reasons for being strip searched by police officers are equal between youths and adults, and our alternative hypothesis is that the average number of reasons for them are different. The t-test result

shows that the p-value is 2.302657291812624e-06, which is lower than the alpha level (0.05), 95% CI [0.2132, 0.5075]. Therefore, we can reject our null hypothesis. The difference between the two means is statistically significant. The average number of reasons for being strip searched for youths (M = 2.3286, SD = 1.2295) are higher than the number of reasons for adults (M = 1.9682, SD = 1.2071).

In our second research question, we conducted a t-test for the variable “Sex” again, because the “Sex” column in the dataset for this question is different from the dataset for Research Question 1. Our null hypothesis is that the average lower bound interval arrest age is the same for male and females, and our alternative hypothesis is that the mean of the lower bound interval arrest age is different for males and females. According to the t-test result, the p-value is 1.5685980630153008e-29, which is lower than the alpha level (0.05), 95% CI [1.1109, 1.5770]. Thus, we can reject the null hypothesis and conclude that the difference in the means is statistically significant. The average lower bound interval arrest age for male (M = 32.0186, SD = 11.9646) is higher than the mean for females (M = 30.6746, SD = 11.4306).

Methodology

3.1 Dataset Description & Data Cleaning

The dataset was released by Toronto Police Service’s Public Safety Data Portal in a CSV format. The dataset contains 65,275 entries and 25 columns. Each entry is a record of a person arrested, and the columns contain information about the time (year and season) of each arrest, and the arrested people’s identity information and arrest record details (strip search records, booking, actions at arrest, reasons for being searched, items found, and object ID).

To make the dataset suitable for exploring the two research questions, we cleaned the data by removing missing values and dropping unnecessary columns.

The first research question requires “Sex” and “Youth_at_arrest__under_18_years” as independent variables. Firstly, since we only needed to focus on the people who were strip searched, we cleaned the data by removing people who were not searched, which means removing the rows that contain “0” in the “StripSearch” column. The column “Sex” contains

“M” and “F”, and there is no missing value. Nevertheless, some of the rows were recorded as unknown and were represented by “U”, so these rows were dropped so that we could concentrate on the useful records. The column “Youth_at_arrest__under_18_years” has no missing value. The levels in this column include “Not a youth”, “Youth (aged 17 and younger)”, and “Youth (aged 17 and under).” The last two levels both represent the age under 18, which means these two levels have the same meaning. Therefore, these two levels were combined, and a new column called “Youth” was created to represent ages under 18. Finally, the outcome variable is the number of reasons for being strip searched. The raw dataset only provided five columns which represent five kinds of search reasons, and the values are binary (1 means the person was searched because of this reason, 0 means it is not why the person was strip searched). Thus, we created a new column called Num_of_Search_Reason by getting the sum of the records in search reason columns. For example, if a person was striped searched by reason number 1, 3, and 4, the Num_of_Search_Reason will be three since he was searched because of three reasons. This new column is continuous and acts as our outcome variable.

The second research question requires “Sex” and “Perceived_Race” as independent variables. The “Sex” column has been cleaned in the previous research question. In the raw dataset, the “Perceived Race” column contains four missing values, and some of the records are “Unknown or Legacy.” We dropped the columns with these records to clean the data, and changed the name of the column to “Race.” The outcome variable is the “Lower bound interval arrest ages” of the arrested people. We created this column based on the “Age_group_at_arrest” column. The original column contains age groups (aged 25 to 34, aged 35 to 44, etc.), and we took the lower limit of each age group and assumed them to be the lower bound. For instance, for level “Aged 25 to 34 years,” we took the number “25” and put it in the new column. In addition, similar to the “Youth_at_arrest__under_18_years” column, the original age group column also contains two levels with the same meaning (“aged 17 and younger” and “aged 17 and under”), so we removed these two levels since their values in the new column would be 0 which would not be suitable for the analysis. The new column was used as a continuous variable and acted as our dependent variable.

3.2 Two-Way ANOVA Tests & Post-Hoc Tests

3.2.1 Two-Way ANOVA: Interest 1

The question of Interest 1: will sex and whether youth or not affect the number of search reasons based on arrest records from the city of Toronto in 2020 and 2021.

Fundamental Elements of Statistics Analysis

- Observational Unit:

  The individual arrest record from the city of Toronto in 2020 and 2021.

- Response variable:

  The number of search reasons for the individual arrest record from the city of Toronto in 2020 and 2021.

- Factors and their levels:

  Sex as Factor A with 2 levels - F and M

  Type of Age as Factor B with 2 levels - Y and N

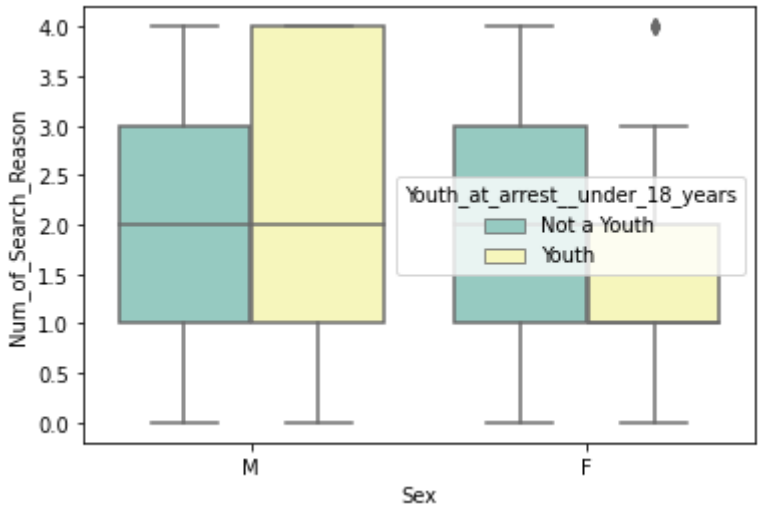
  (*F=Female, M=Male, Y=Youth, N=Not a Youth)

- Treatments:

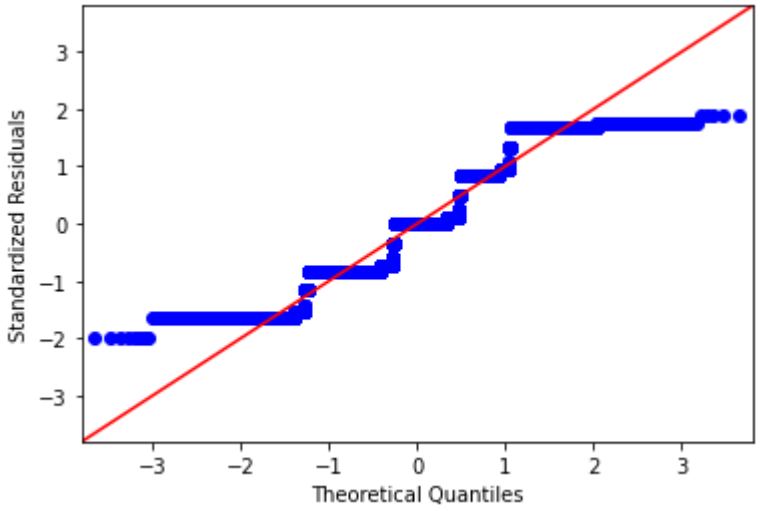
  4 treatments - (F, Y), (F, N), (M, Y), (M, N)

Model Diagnostic Analysis

Using the diagnostic plots to determine whether the data fit the Two-Way ANOVA assumptions.



(Boxplot3.2.1.0)



(Normal Q-Q plot 3.2.1.1)

Firstly, we need to check the assumptions for Two-Way ANOVA:

1. Normality:

   From Normal Q-Q plot 3.2.1.1, we see that the pattern is not shown in a straight line, therefore there is not enough evidence to conclude residuals follow Normal Distribution.

2. Outliers check:

   From Boxplot 3.2.1.0, we observe one far outlier in Youth & Females.

3. Constant Variance:

   From Boxplot 3.2.1.0, we see that the observations of group Not a Youth & Malels, Not a Youth & Females, and Youth & Females are approximately symmetric boxplots, which means it is reasonable to assume the constant variance. However, we will find that the group Youth & Males is negatively skewed(skewed left). Therefore there is not enough evidence to conclude the constant variance since not all of the patterns are approximately symmetric.

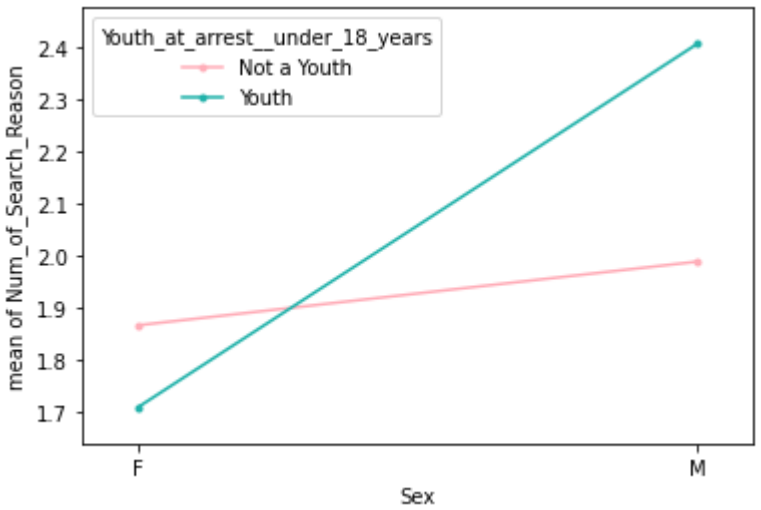
   From Boxplot 3.2.1.0, the spread rank is Youth & Males > Not a Youth & Males ≈Not a Youth & Females > Youth & Females.

4. Independence:

   We assume that each observation is sampled independently.

Interaction Plot Analysis

The interaction plot is to determine whether the interaction effect exists preliminarily. We still need to construct an interaction model after.



From the interaction plot shown above, the lines intersect, which means that some combinations of the factors F/M and Not a Youth/Youth affected the number of search reasons(response values), so interaction is likely to present.

Construct Model with Interaction

We assume the validity of the model assumptions required for interest 1 satisfied.

$Y_{ijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + e_{ijk}$

Y_{ijk} = the i^{th} observation from the j^{th} level of Factor A: Sex and k^{th} level of Factor B: Type of Age.

μ = grand mean

α_j = main effect of j^{th} level of Sex

β_k = main effect of k^{th} level of Type of Age

$(\alpha\beta)_{jk}$ = interaction effect of j^{th} level of Sex and k^{th}level of Type of Age

e_{ijk} = the i^{th} error of the number of search reasons of j^{th} Sex and k^{th} the Type of Age.

Hypothesis Test: Test for Interaction Effect

H_0: $(\alpha\beta)_{jk} = 0$ for all (j, k) VS $H_a = (\alpha\beta)_{jk} \neq 0$ for at least one (j, k)

	df	sum_sq	mean_sq	F	PR(>F)
C(Sex)	1.0	20.009295	20.009295	13.745209	0.000211
C(Youth_at_arrest__under_18_years)	1.0	33.560293	33.560293	23.053947	0.000002
C(Sex):C(Youth_at_arrest__under_18_years)	1.0	8.850526	8.850526	6.079791	0.013695
Residual	7797.0	11350.316740	1.455729	NaN	NaN

$F^* = 6.0798 \sim$ under H_0

p-value = 0.0137 < α=0.05

According to the result, we can reject H_0 and we have enough evidence to conclude that there is an interaction effect, which means that the number of search reasons depended on Sex differently for different levels of Type of Age and vice-versa.

Next, we need to do the Post-hoc test to differ the means with rejecting H_0, since we do not know which combinations of Sex and Type of Age are significantly different from each other.

Post-Hoc Test: Tukey HSD

	group1	group2	Diff	Lower	Upper	q-value	p-value
0	(M, Not a Youth)	(M, Youth)	0.417108	0.216771	0.617444	7.565968	0.001000
1	(M, Not a Youth)	(F, Not a Youth)	0.121901	0.025931	0.217872	4.615804	0.006077
2	(M, Not a Youth)	(F, Youth)	0.278837	-0.279365	0.837040	1.815247	0.564703
3	(M, Youth)	(F, Not a Youth)	0.539009	0.323885	0.754134	9.105050	0.001000
4	(M, Youth)	(F, Youth)	0.695945	0.105472	1.286418	4.283031	0.013166
5	(F, Not a Youth)	(F, Youth)	0.156936	-0.406743	0.720615	1.011736	0.883598

From the result of the Tukey HSD test provided above, we note that between

group(M, Not a Youth)& group (M, Youth), group(M, Not a Youth)& group (F, Not a Youth), group(M, Youth)& group (F, Not a Youth), group(M, Youth)& group (F, Youth),

p-value<α=0.05, therefore reject H_0.

There is enough evidence for us to conclude that, within 4 groups shown below, the effect of a change in the level of Sex on the number of search reasons depends on the level of Type of Age:

1. Adult Males and Underage Males
2. Underage Males and Underage Females
3. Underage Males and Adult Females
4. Underage Males and Underage Females

3.2.2 Two-Way ANOVA: Interest 2

The question of Interest 2: will sex and race affect the lower limited boundary of age(above 17 years old) at arrest based on arrest records from the city of Toronto in 2020 and 2021.

Fundamental Elements of Statistics Analysis

- Observational Unit:

  The individual arrest record from the city of Toronto in 2020 and 2021.

- Response variable:

The lower limited boundary of age (above 17 years old) at arrest for the individual arrest record from the city of Toronto in 2020 and 2021.

- Factors and their levels:

  Sex as Factor A with 2 levels - F and M

  Race as Factor B with 7 levels - W, B, SA, I, ME, L, and EA

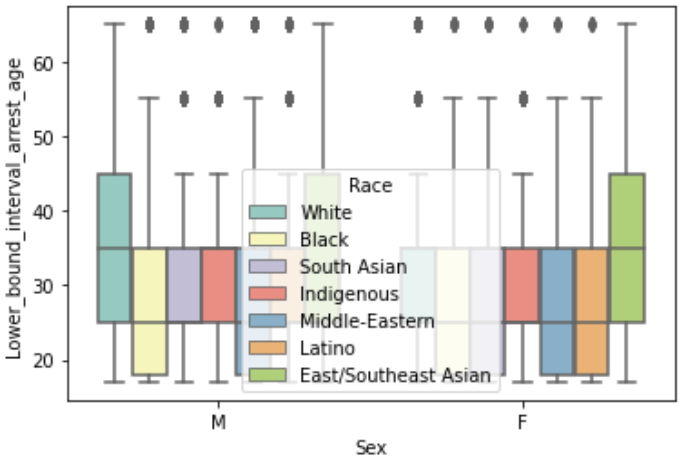
  (*F=Female, M=Male,W=White, B=Black, SA=South Asian, I=Indigenous, ME=Middle-Eastern, L=Latino, EA=East/Southeast Asian)

- Treatments:

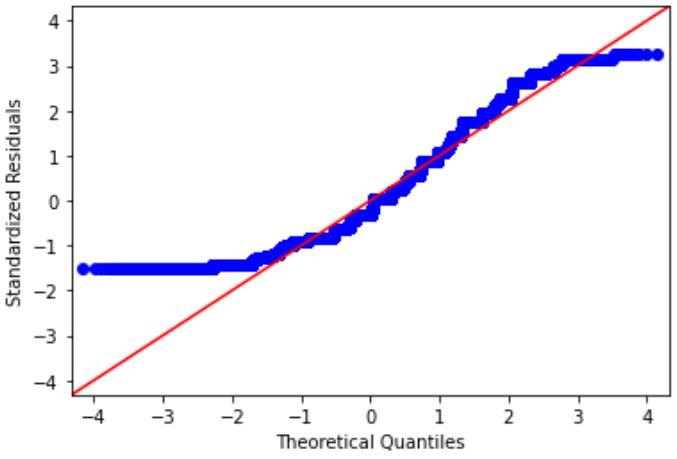
  14 treatments - (F, W), (F, B), (F, SA), (F, I), (F, ME), (F, L) (F, EA), (B, W), (M, B), (M, SA), (M, I), (M, ME), (M, L) (M, EA)

Model Diagnostic Analysis

Using the diagnostic plots to determine whether the data fit the Two-Way ANOVA assumptions.



(boxplot 3.2.2.0)



(Normal Q-Q plot 3.2.2.1)

Two-Way ANOVA assumptions:

1. Normality:

   According to the Normal Q-Q plot 3.2.2.0, we can observe that the central portion of the graph is roughly represented by a straight line. However, the

whole pattern does not conform to a straight line. As a result, we cannot confidently infer that the residuals adhere to a Normal Distribution.

2. Outliers check:

   From Boxplot 3.2.2.0, we observe several outliers including few extremely far outliers existing except in Male&White and Females & East/Southeast Asian.

3. Constant Variance:

   From Boxplot3.2.2.0, we observe that all of the observations of the group are approximately symmetric boxplots, which means it is reasonable to assume the constant variance.

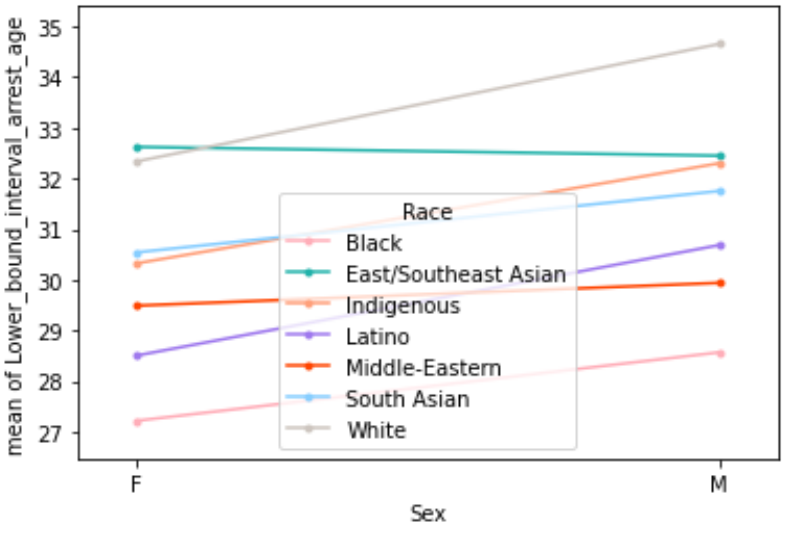
   From Boxplot 3.2.2.0, the spread rank is Males & White ≈ Males & Black ≈ Males & Middle-Eastern ≈ Males & East/Southeast Asian ≈ Females & Black ≈ Females & South Asian ≈ Females & Middle Eastern ≈Females & Latino ≈ Females & East/Southeast Asian > Males & South Asian ≈ Males & Indigenous ≈ Males & Latino ≈ Females & White ≈ Females & Indigenous.

4. Independence:

   We assume that each observation is sampled independently.

Interaction Plot Analysis

The interaction plot is to determine whether the interaction effect exists preliminarily. We still need to construct an interaction model after.



From the interaction plot shown above, some lines intersect and some lines approximately are paralleled.

Note that the lines of factors Black/South Asian and F/M are approximately paralleled; therefore, it presents that there is no interaction effect since the mean response is not affected by the combinations of the factors.

Besides, the rest of the lines of factors at least have slight slopes to make them intersect, which represents that some combinations of the factors Race and Sex affected the response variable-lower limited boundary of age (above 17 years old); therefore, the interaction effect is likely to present.

Construct Model with Interaction

We assume the validity of the model assumptions required for interest 2 satisfied.

$Y_{ijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + e_{ijk}$

Y_{ijk} = the i^{th} observation from the j^{th} level of Factor A: Sex and k^{th} level of Factor B: Race.

μ = grand mean

α_j = main effect of j^{th} level of Sex

β_k = main effect of k^{th} level of Race

$(\alpha\beta)_{jk}$ = interaction effect of j^{th} level of Sex and k^{th}level of Race

e_{ijk} = the i^{th} error of the lower limited boundary of age (above 17 years old) of j^{th} Sex and k^{th} the Race.

Hypothesis Test: Test for Interaction Effect

H_0: $(\alpha\beta)_{jk} = 0$ for all (j, k) VS $H_a = (\alpha\beta)_{jk} \neq 0$ for at least one (j, k)

	df	sum_sq	mean_sq	F	PR(>F)
C(Sex)	1.0	2.884891e+04	28848.913536	215.015943	1.341475e-48
C(Race)	6.0	3.912263e+05	65204.386386	485.979571	0.000000e+00
C(Sex):C(Race)	6.0	4.985908e+03	830.984597	6.193472	1.645770e-06
Residual	60173.0	8.073474e+06	134.171044	NaN	NaN

F^{*}=6.1935 ~ under H_0

p-value = 1.6458×10^{-6} < α=0.05

Reject H_0, we have enough evidence to conclude that there is an interaction effect, which means that the lower limited boundary of age (above 17 years old) depends on Sex differently for different levels of Race and vice-versa.

We need to do the Post-hoc test to differ the means with rejecting H_0, since we do not know which combinations of Sex and Race are significantly different from each other.

Post-Hoc Test: Tukey HSD

index	group1	group2	Diff	Lower	Upper	q-value	p-value
0	M,W	M,B	6.0868	5.6696	6.5041	69.1985	0.0010
1	M,W	M,SA	2.9026	2.1567	3.6484	18.4587	0.0010
2	M,W	M,I	2.3550	1.2467	3.4633	10.0786	0.0010
3	M,W	M,ME	4.7155	3.9439	5.4871	28.9869	0.0010
4	M,W	M,L	3.9701	2.9337	5.0065	18.1687	0.0010
5	M,W	M,EA	2.2052	1.5113	2.8992	15.0719	0.0010
6	M,W	F,W	2.3215	1.7602	2.8827	19.6195	0.0010
7	M,W	F,B	7.4387	6.6827	8.1948	46.6667	0.0010
8	M,W	F,SA	4.1151	2.3730	5.8573	11.2036	0.0010
9	M,W	F,I	4.3331	2.7616	5.9045	13.0785	0.0010
10	M,W	F,ME	5.1656	3.1123	7.2190	11.9322	0.0010
11	M,W	F,L	6.1536	3.7480	8.5592	12.1331	0.0010
12	M,W	F,EA	2.0319	0.5842	3.4796	6.6570	0.0010
13	M,B	M,SA	3.1843	2.4160	3.9526	19.6590	0.0010
14	M,B	M,I	3.7318	2.6083	4.8554	15.7545	0.0010
15	M,B	M,ME	1.3713	0.5780	2.1646	8.1991	0.0010
16	M,B	M,L	2.1167	1.0641	3.1694	9.5374	0.0010
17	M,B	M,EA	3.8816	3.1636	4.5996	25.6402	0.0010
18	M,B	F,W	3.7654	3.1747	4.3561	30.2339	0.0010
19	M,B	F,B	1.3519	0.5737	2.1301	8.2396	0.0010
20	M,B	F,EA	4.0550	2.5956	5.5144	13.1788	0.0010
21	M,SA	M,ME	1.8130	0.8072	2.8187	8.5499	0.0010
22	M,SA	F,B	4.5362	3.5423	5.5300	21.6480	0.0010
23	M,SA	F,L	3.2510	0.7605	5.7416	6.1913	0.0010
24	M,I	M,ME	2.3605	1.0630	3.6580	8.6288	0.0010
25	M,I	F,B	5.0837	3.7953	6.3721	18.7159	0.0010
26	M,I	F,L	3.7986	1.1766	6.4206	6.8714	0.0010
27	M,ME	M,EA	2.5103	1.5423	3.4782	12.3010	0.0010
28	M,ME	F,W	2.3941	1.5164	3.2717	12.9385	0.0010
29	M,ME	F,B	2.7232	1.7098	3.7366	12.7462	0.0010
30	M,ME	F,EA	2.6836	1.0864	4.2809	7.9693	0.0010
31	M,L	M,EA	1.7648	0.5750	2.9547	7.0353	0.0010
32	M,L	F,W	1.6486	0.5310	2.7663	6.9967	0.0010
33	M,L	F,B	3.4686	2.2415	4.6957	13.4075	0.0010
34	M,EA	F,B	5.2335	4.2779	6.1891	25.9767	0.0010
35	M,EA	F,ME	2.9604	0.8255	5.0953	6.5771	0.0010
36	M,EA	F,L	3.9484	1.4728	6.4239	7.5650	0.0010
37	F,W	F,B	5.1173	4.2533	5.9813	28.0922	0.0010
38	F,W	F,ME	2.8442	0.7487	4.9397	6.4377	0.0010
39	F,W	F,L	3.8321	1.3905	6.2738	7.4442	0.0010
40	F,B	F,SA	3.3236	1.4617	5.1855	8.4666	0.0010
41	F,B	F,I	3.1056	1.4024	4.8089	8.6485	0.0010
42	F,B	F,EA	5.4068	3.8170	6.9966	16.1313	0.0010
43	F,L	F,EA	4.1217	1.3392	6.9043	7.0258	0.0010
44	M,EA	F,I	2.1278	0.4512	3.8044	6.0196	0.0017
45	F,ME	F,EA	3.1337	0.6494	5.6181	5.9829	0.0019
46	F,W	F,I	2.0116	0.3855	3.6378	5.8674	0.0027
47	M,I	F,ME	2.8106	0.5075	5.1138	5.7882	0.0034
48	M,B	F,SA	1.9717	0.2198	3.7236	5.3382	0.0118
49	M,L	F,EA	1.9382	0.1975	3.6789	5.2814	0.0137
50	M,B	F,I	1.7538	0.1716	3.3360	5.2574	0.0146
51	M,I	M,L	1.6151	0.1446	3.0856	5.2094	0.0165
52	F,I	F,EA	2.3012	0.1976	4.4048	5.1886	0.0174
53	F,B	F,ME	2.2731	0.1172	4.4290	5.0010	0.0276
54	M,SA	F,ME	2.2631	0.1108	4.4154	4.9872	0.0285
55	M,I	F,I	1.9781	0.0919	3.8642	4.9741	0.0294
56	M,EA	F,SA	1.9099	0.0723	3.7475	4.9298	0.0327
57	F,W	F,SA	1.7937	0.0020	3.5853	4.7485	0.0494
58	F,SA	F,EA	2.0833	-0.1508	4.3173	4.4230	0.0978
59	M,SA	M,L	1.0675	-0.1533	2.2883	4.1476	0.1640
60	M,I	F,SA	1.7601	-0.2705	3.7907	4.1114	0.1748

61	M,L	F,L	2.1835	-0.4090	4.7760	3.9949	0.2121
62	M,SA	F,I	1.4305	-0.2682	3.1292	3.9942	0.2123
63	M,SA	M,EA	0.6973	-0.2502	1.6448	3.4906	0.4349
64	F,SA	F,L	2.0385	-0.9081	4.9850	3.2814	0.5340
65	M,SA	F,W	0.5811	-0.2740	1.4362	3.2234	0.5602
66	M,SA	F,SA	1.2126	-0.6452	3.0704	3.0959	0.6178
67	F,I	F,L	1.8205	-1.0284	4.6694	3.0310	0.6471
68	M,ME	M,L	0.7454	-0.4913	1.9821	2.8589	0.7249
69	M,ME	F,L	1.4381	-1.0603	3.9365	2.7301	0.7831
70	M,SA	F,EA	0.8707	-0.7143	2.4556	2.6056	0.8394
71	M,L	F,ME	1.1955	-1.0739	3.4650	2.4987	0.8877
72	M,B	F,ME	0.9212	-1.1404	2.9828	2.1194	0.9000
73	M,B	F,L	0.0668	-2.3459	2.4794	0.1312	0.9000
74	M,SA	M,I	0.5475	-0.7348	1.8299	2.0252	0.9000
75	M,I	M,EA	0.1498	-1.1032	1.4027	0.5669	0.9000
76	M,I	F,W	0.0336	-1.1510	1.2181	0.1343	0.9000
77	M,I	F,EA	0.3231	-1.4613	2.1075	0.8589	0.9000
78	M,ME	F,SA	0.6004	-1.2679	2.4686	1.5242	0.9000
79	M,ME	F,I	0.3825	-1.3277	2.0926	1.0607	0.9000
80	M,ME	F,ME	0.4501	-1.7113	2.6115	0.9878	0.9000
81	M,L	F,SA	0.1451	-1.8472	2.1373	0.3453	0.9000
82	M,L	F,I	0.3630	-1.4819	2.2078	0.9332	0.9000
83	M,EA	F,W	0.1162	-0.6940	0.9265	0.6803	0.9000
84	M,EA	F,EA	0.1734	-1.3879	1.7346	0.5267	0.9000
85	F,W	F,EA	0.2896	-1.2173	1.7965	0.9115	0.9000
86	F,B	F,L	1.2851	-1.2086	3.7788	2.4444	0.9000
87	F,SA	F,I	0.2179	-2.0982	2.5341	0.4463	0.9000
88	F,SA	F,ME	1.0505	-1.6162	3.7172	1.8684	0.9000
89	F,I	F,ME	0.8326	-1.7259	3.3910	1.5435	0.9000
90	F,ME	F,L	0.9880	-2.1526	4.1285	1.4921	0.9000

(*F=Female, M=Male,W=White, B=Black, SA=South Asian, I=Indigenous, ME=Middle-Eastern, L=Latino, EA=East/Southeast Asian)

From the result that Tukey test provided above, we observe that,

within the combinations of top 57 (which is highlight in red), p-value<α=0.05, reject H_0.

Therefore, there is enough evidence for us to conclude that we have 57 combinations of groups that show obvious differences that affect the lower limited boundary of age (above 17 years old), which presents the effect of a change in the level of Sex on the limited lower boundary of arrest age depends on the level of Race:

(* index 53:

(F, B) (F, ME) means the combination of Black Females and Middle-Eastern Females.

p-value=0.0276< α=0.05, reject H_0. It is reasonable to conclude that Black Females and Middle-Eastern Females have differences in affecting the lower limited boundary of age (above 17 years old.)

*index 70:

(M, SA) (F, EA) means the combination of South Asian Males and East/Southeast Asian Females.

p-value=0.8394> α=0.05, Fails to Reject(FTR) H_0. We have enough evidence to conclude that South Asian Males and East/Southeast Asian Females do not have

differences in affecting the lower limited boundary of age (above 17 years old.))

Results and Findings

4.1 Research Question 1

According to the results of our analysis, since interaction effect exists in the model, we can suggest that the effect on our dependent variable (the arrested people's number of reasons of being strip searched) of a change in one of our independent variables (the gender of the arrested people or whether they are adults) will depend on the level of the other variable. It means in this dataset the influence caused by the two different genders will depend on whether the arrested person is an adult or not, and vice versa. If the arrested person is a male adult, the mean of the number of reasons for being strip searched will differ from another person who is a female adult, or a male youth. If the arrested person is a male and under 18 years old, the average of the number of reasons for being strip searched will be different from the mean of the search reason amount for a person who is female and not a youth, or a female adult. However, the causation of the differences is unclear, and further demographic and criminological studies can be conducted to learn more about the reasons.

4.2 Research Question 2

According to the results of our analysis, the interaction effect exists in this case and is statistically significant. We can suggest that the impacts on the outcome variable (the lower bound interval arrest age) caused by changes in one of the explanatory variables (gender or race of the arrested person) will depend on the level of the other. It indicates that in this dataset the influence caused by whether the arrested person is male or female will be influenced by the race of the person, and vice versa. There are 14 treatments which generated 90 columns of comparison groups in our post-hoc test. The differences in the means of 58 groups are statistically significant, and the rest of the groups generated p-values which are larger than the alpha level, so their differences may not be statistically significant. Further analysis needs to be conducted to determine any useful patterns from it.

Conclusion and Discussion

In conclusion, we explored the impacts caused by different demographic factors (sex, youth or adult, race) on some information (number of reasons of being strip searched by police officers, lower bound interview age of being arrested) of people who were arrested based on a dataset provided by Toronto Police Service Public Safety Data Portal. Two research questions were studied using Two-Way ANOVA with interaction models followed by post-hoc tests, and for each question we successfully identified that the difference among some of the means of the groups were statistically significant. However, there are also some limitations in the study caused by different factors. One of them is based on the assumptions for Two-Way ANOVA. For the first research question, we found that in our normal Q-Q plot the points did not follow a perfect straight line, so the normality assumption may not be satisfied. Moreover, there is also an outlier in the box plot, and in some groups the constant variance assumption is not satisfied. These factors were majorly caused by the original dataset, and may negatively impact the reliability of the results. However, we can still report the descriptive statistics, and utilize more different kinds of tests to produce more reliable results. Similar problems also apply for our analysis for Research Question 2. Since the points on the normal Q-Q plot only follow a straight line very roughly, it may suggest that the normality assumption is not perfectly met. There are also several outliers, and some of them are extreme. Another factor is that, the outcome variable for Research Question 2 was converted from a categorical variable in the original dataset. It may influence the distribution of the data points and impact the results of the tests. In general, the reliability of the results of our study were influenced by several factors, and more studies and tests need to be conducted to explore the outcomes.

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