601 Final

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Introduction

Public schools in America encompass a wide variety of students based on several factors including age, race, sex, religion, and many others. While we celebrate this diversity across America these differences can actually lead to vast differences when comparing communities. These differences, mostly socio-economic, can lead to disparaging conditions in the school systems in each area. Since a significant amount of funding for public schools comes from local taxes, these socio-economics differences can lead to worse school systems.

One of the places where lacking of funding for schools can negatively impact them is in terms of their ability to hire more teachers. Because of their lack of funding, these school districts don't have enough room in the budget to hire more teachers or to pay them a competitive wage, which in turn leads to a lower quality of education for their students.

There have been several studies done researching the effects that student to teacher ratio has on students, one of the most well-regarded being the STAR study done in Tennessee in the 1980s. This study found that with a smaller class size (15 students compared to 22) made significant educational gains in comparison to those in the larger class. The study found that with a 32% decrease in class size students were able to increase their achievement by about 3 months over a course of 4 years (Chingos).

In this paper we will look at how schools with different racial makeups can differ in terms of their student to teacher ratios, which has been shown to have a direct impact on a student's education.

Data

Let's read in the data and see what it looks like:

```
data <- read.csv("C:/Users/wolpe/DACSS601August2021/_data/Public_School_Characteristics_2017-18.csv")
```

How This Data Was Collected

Taken from the NCES website: "The National Center for Education Statistics' (NCES) Common Core of Data (CCD) program is an annual collection of basic administrative characteristics for all public schools, school districts, and state education agencies in the United States. These characteristics are reported by state education officials and include directory information, number of students, number of teachers, grade span, and other conditions. The NCES Education Demographic and Geographic Estimate (EDGE) program develops annually updated point locations (latitude and longitude) for public elementary and secondary schools included in the CCD. The NCES EDGE program collaborates with the U.S. Census Bureau's Education Demographic, Geographic, and Economic Statistics (EDGE) Branch to develop point locations for schools and school district administrative offices based on reported physical addresses" (NCES).

What's in the data?

This dataset looks at the characteristics of various public schools across the United States. Among the variables in the dataset are identifying characteristics such as the name of the school, its school district, and its location; there are also several quantitative variables such as the number of students in each grade, as well as the overall number of students broken down in categories such as race and gender.

The numbers of the data

The data has 79 total columns and just over 100,000 rows. It is unlikely that all of this info will be useful, so in the next section we can see if the data can be cleaned and subset to be more useful to the project.

For this section we need to look deeper into two variables from the dataset, for this I want to look at school type and student to teacher ratio.

School Type

Let's take a look at all the different levels of schools from the original, uncleaned dataset.

```r
data %>%
  group_by(SCHOOL_LEVEL) %>%
  summarise(SCHOOL_LEVEL = SCHOOL_LEVEL, count.type = n()) %>%
  distinct()
```

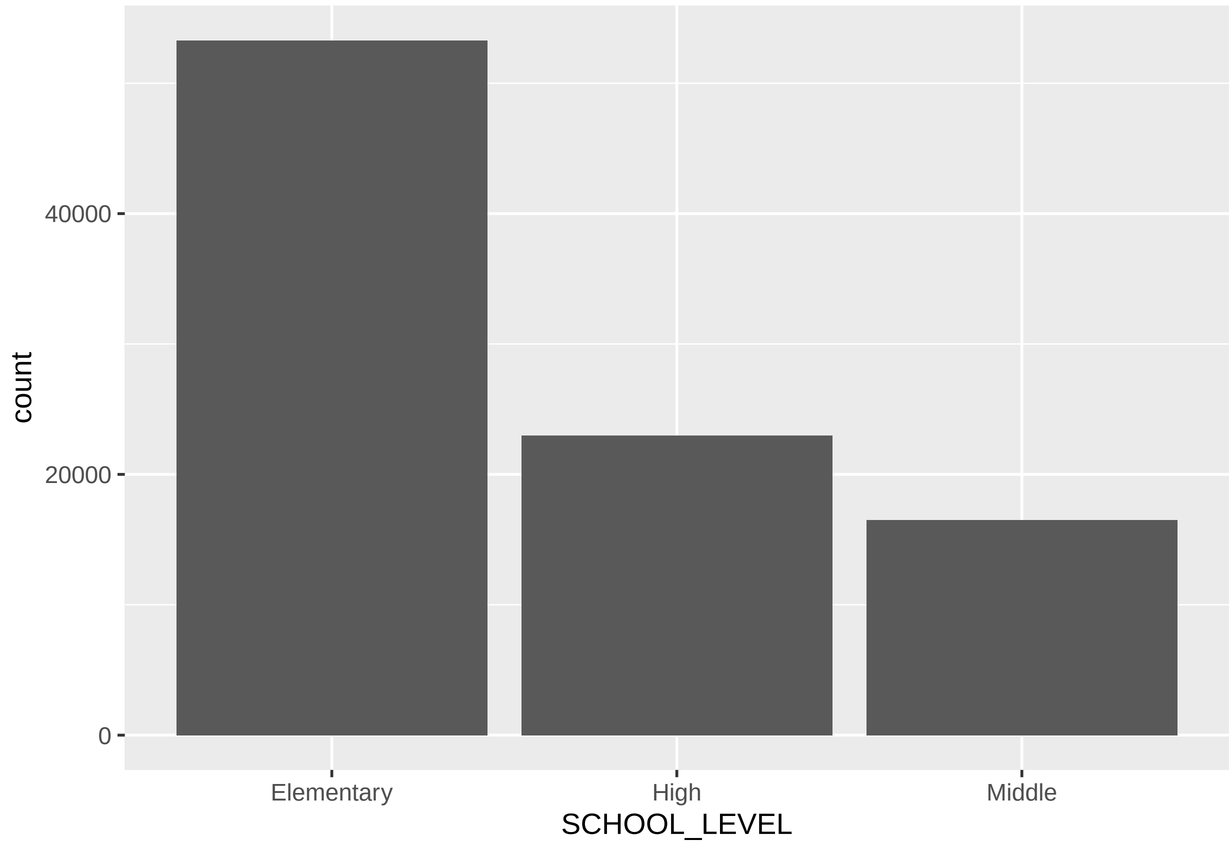
```
## `summarise()` has grouped output by 'SCHOOL_LEVEL'. You can override using the `.groups` argument.
```

```
## # A tibble: 10 x 2
## # Groups:   SCHOOL_LEVEL [10]
##    SCHOOL_LEVEL    count.type
##    <chr>                <int>
##  1 Adult Education         28
##  2 Elementary           53287
##  3 High                 22977
##  4 Middle               16506
##  5 Not Applicable         796
##  6 Not Reported          1113
##  7 Other                 3824
##  8 Prekindergarten       1430
##  9 Secondary              602
## 10 Ungraded               166
```

For the dataset I wanted to focus on the most common types of school, which immediately meant filtering out adult education, secondary, and ungraded schools. This also left not applicable, not reported, and other in the dataset, which also should be removed. The last four remaining categories were elementary, high, middle, and prekindergarten. Prekindergarten schools were then removed to focus on the main three types of public schools as well as because of the number of fewer schools of this type.

Now let's filter out these unwanted categories and look at the breakdown of schook type.

```r
data %>%
  filter(SCHOOL_LEVEL == "High" | SCHOOL_LEVEL == "Middle" | SCHOOL_LEVEL == "Elementary") %>%
  ggplot(aes(x = SCHOOL_LEVEL)) + geom_bar()
```



This looks significantly cleaner and more organized than with all the other unused variables.

Student to Teacher Ratio

Let's start by looking at some summary statistics and a barplot of student to teacher ratio from the unclean dataset:

```
data %>%
  summarise(count = n(), mean.val = mean(STUTERATIO), sd.val = sd(STUTERATIO), median.val = median(STUT
```

```
##    count mean.val sd.val median.val
## 1 100729       NA     NA         NA
```

We see that there are probably a large amount of NA values, so we first need to clean that.

```
data_stuteratio <- data %>%
  filter(!is.na(STUTERATIO))
data_stuteratio %>%
  summarise(count = n(), mean.val = mean(STUTERATIO), sd.val = sd(STUTERATIO), median.val = median(STUT
```

```
##   count mean.val   sd.val median.val
## 1 93894 16.94477 85.73974      15.33
```

Now we are getting valid statistics, but the standard deviation appears to be very large, over 5 times the mean and median! Let's take a look at some quantiles to see what the breakdown is.

```r
quantiles <- c(0, 0.005, 0.025, 0.05, 0.1, 0.25, 0.5, 0.75, 0.9, 0.95, 0.975, 0.995, 1)
data_stuteratio %>%
  summarise(quantiles = quantiles, value = quantile(STUTERATIO, quantiles))
```

```
##    quantiles       value
## 1      0.000     0.00000
## 2      0.005     0.00000
## 3      0.025     5.10325
## 4      0.050     8.02000
## 5      0.100    10.33000
## 6      0.250    12.85000
## 7      0.500    15.33000
## 8      0.750    18.18000
## 9      0.900    22.50000
## 10     0.950    25.11000
## 11     0.975    27.50000
## 12     0.995    50.30070
## 13     1.000 22350.00000
```

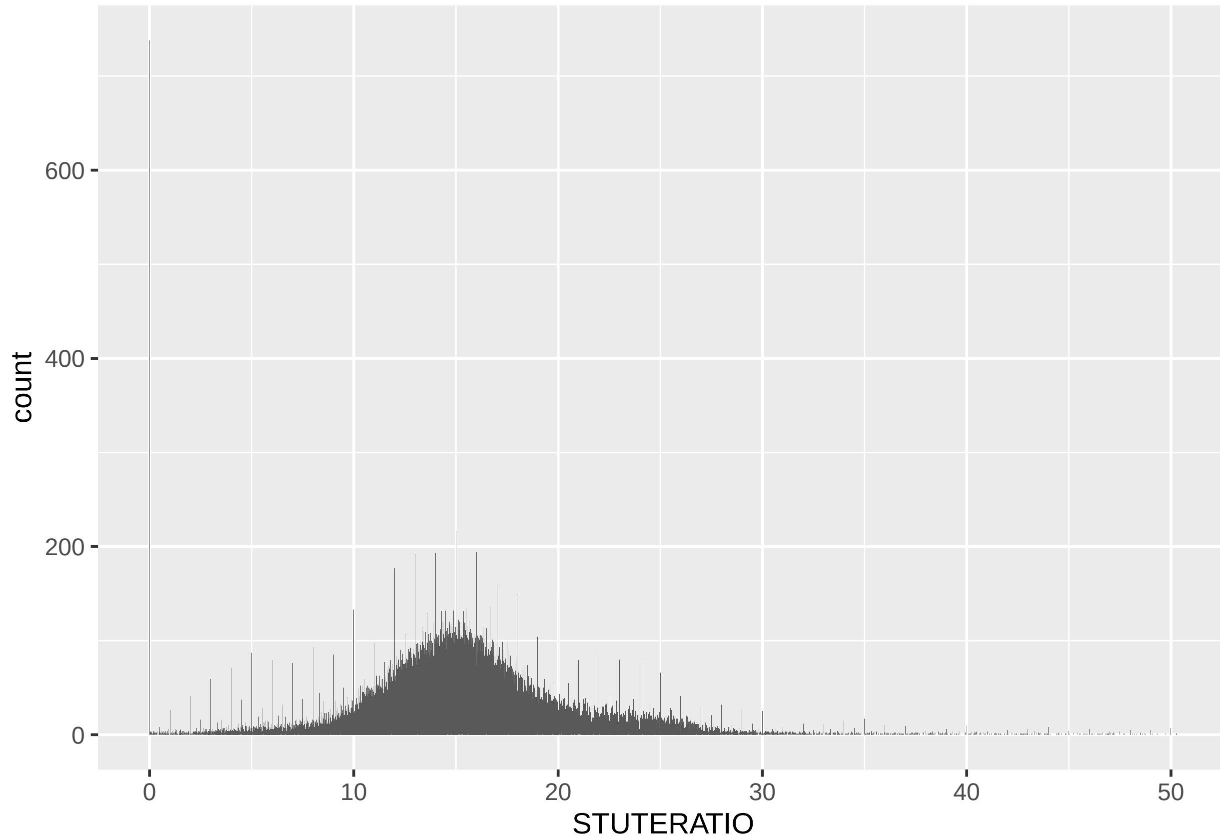
We see that our wide range of values that cause a large standard deviation is probably due to the top 0.5% of values for student to teacher ration, as the bottom 99.5% are all equal to or less than 50.3, with the top 0.5% ranging from that to over 20,000! To look at more meaningful data, we can select the middle 99% of the data to use.

```r
data_stuteratio <- data_stuteratio %>%
  filter(STUTERATIO <= 50.3007)
data_stuteratio %>%
  summarise(count = n(), mean.val = mean(STUTERATIO), sd.val = sd(STUTERATIO), median.val = median(STUT
```

```
##   count mean.val sd.val median.val
## 1 93424 15.71938 5.2405      15.31
```

The standard deviation for this value now makes a lot more sense, and the median has moved closer to the mean. Let's take a look at a barplot to see the distribution.

```r
data_stuteratio %>%
  ggplot(aes(x = STUTERATIO)) + geom_bar()
```



The data still appears somewhat skewed, but not in a way that will negatively affect our analysis.

NOTE: In the actual filtering of data the cutoffs used for STUTERATIO are different because of other filtering, in actuality the cutoffs of 4.82 and 34.4274 will be used.

Cleaning Data

The data is definitely unclean, let's filter out some stuff so that we have more complete data.

```
data_clean <- data %>%
  filter(!is.na(TOTAL) & TOTAL > 0 & !is.na(FTE) & FTE > 0 & STUTERATIO < 500) %>%
  filter(SCHOOL_TYPE_TEXT == "Regular school" & VIRTUAL == "Not a virtual school") %>%
  filter(SCHOOL_LEVEL == "High" | SCHOOL_LEVEL == "Middle" | SCHOOL_LEVEL == "Elementary") %>%
  filter((is.na(G13) | G13 == 0) & (is.na(PK) | PK == 0)) %>%
  filter(!is.na(STABR) & !is.na(SCH_NAME))
head(data_clean)
```

```
##         ï..X        Y OBJECTID     NCESSCH                     NMCNTY  SURVYEAR
## 1 -151.0701 60.49144        3 20039000448     Kenai Peninsula Borough 2017-2018
## 2 -151.2791 60.56828        4 20039000463     Kenai Peninsula Borough 2017-2018
## 3 -166.5224 53.86895       15 20072000340 Aleutians West Census Area 2017-2018
## 4 -166.5296 53.87267       16 20072000661 Aleutians West Census Area 2017-2018
## 5 -161.7707 60.80436       18 20000100207         Bethel Census Area 2017-2018
## 6 -161.7704 60.80258       19 20000100208         Bethel Census Area 2017-2018
##   STABR  LEAID ST_LEAID                                LEA_NAME
## 1    AK 200390    AK-24 Kenai Peninsula Borough School District
```

```
## 2    AK 200390    AK-24 Kenai Peninsula Borough School District
## 3    AK 200720    AK-47           Unalaska City School District
## 4    AK 200720    AK-47           Unalaska City School District
## 5    AK 200001    AK-31         Lower Kuskokwim School District
## 6    AK 200001    AK-31         Lower Kuskokwim School District
##                              SCH_NAME                     LSTREET1 LSTREET2
## 1    Soldotna Montessori Charter School              158 E Park Ave
## 2 Kaleidoscope School of Arts & Science             549 N Forest Dr
## 3       Eagle's View Elementary School            503 East Broadway
## 4           Unalaska Jr/Sr High School                55 E Broadway
## 5               Gladys Jung Elementary 1007 Ron Edwards Memorial Dr
## 6          Bethel Regional High School 1006 Ron Edwards Memorial Dr
##   LSTREET3    LCITY LSTATE  LZIP LZIP4         PHONE GSLO GSHI
## 1          Soldotna     AK 99669    NA (907)260-9221   KG   06
## 2             Kenai     AK 99611    NA (907)283-0804   KG   05
## 3          Unalaska     AK 99685    NA (907)581-3979   PK   06
## 4          Unalaska     AK 99685    NA (907)581-1222   07   12
## 5            Bethel     AK 99559    NA (907)543-4440   03   06
## 6            Bethel     AK 99559    NA (907)543-3957   07   12
##                VIRTUAL TOTFRL FRELCH REDLCH PK KG G01 G02 G03 G04 G05 G06 G07
## 1 Not a virtual school     43     23     20 NA 23  23  27  22  25  28  19  NA
## 2 Not a virtual school     69     50     19 NA 40  43  42  46  46  43  NA  NA
## 3 Not a virtual school     53     35     18  0 32  30  36  33  31  26  29  NA
## 4 Not a virtual school     38     27     11 NA NA  NA  NA  NA  NA  NA  NA  30
## 5 Not a virtual school    294    294      0 NA NA  NA  NA  97  75  79  90  NA
## 6 Not a virtual school    373    373      0 NA NA  NA  NA  NA  NA  NA  NA  94
##   G08 G09 G10 G11 G12 G13 TOTAL MEMBER  AM HI BL  WH HP TR   FTE   LATCOD
## 1  NA  NA  NA  NA  NA  NA   167    167   8  5  0 136  0 15 10.35 60.49144
## 2  NA  NA  NA  NA  NA  NA   260    260  16 14  3 168  0 56 16.75 60.56828
## 3  NA  NA  NA  NA  NA  NA   217    217  23 30  2  56 13  3 13.50 53.86895
## 4  25  26  38  36  29  NA   184    184  24 21  0  38  8  0 14.50 53.87267
## 5  NA  NA  NA  NA  NA  NA   341    341 284  6  1  44  0  1 22.13 60.80436
## 6  90 106  52  63  70  NA   475    475 418  7  1  38  0  2 33.05 60.80258
##      LONCOD          ULOCALE STUTERATIO        STITLEI AMALM AMALF ASALM ASALF
## 1 -151.0702  33-Town: Remote      16.14 Not Applicable     4     4     0     3
## 2 -151.2791  33-Town: Remote      15.52 Not Applicable    10     6     1     2
## 3 -166.5225 43-Rural: Remote      16.07 Not Applicable    11    12    52    38
## 4 -166.5296 43-Rural: Remote      12.69 Not Applicable    12    12    52    41
## 5 -161.7707 41-Rural: Fringe      15.41            Yes   141   143     2     3
## 6 -161.7704 41-Rural: Fringe      14.37            Yes   221   197     5     4
##   HIALM HIALF BLALM BLALF WHALM WHALF HPALM HPALF TRALM TRALF TOTMENROL
## 1     2     3     0     0    58    78     0     0     7     8        71
## 2     6     8     3     0    82    86     0     0    26    30       128
## 3    14    16     0     2    26    30     7     6     1     2       111
## 4    12     9     0     0    23    15     4     4     0     0       103
## 5     4     2     0     1    21    23     0     0     0     1       168
## 6     4     3     0     1    20    18     0     0     1     1       251
##   TOTFENROL STATUS UG AE SCHOOL_TYPE_TEXT        SY_STATUS_TEXT SCHOOL_LEVEL
## 1        96      1 NA NA   Regular school Currently operational   Elementary
## 2       132      1 NA NA   Regular school Currently operational   Elementary
## 3       106      1 NA NA   Regular school Currently operational   Elementary
## 4        81      1 NA NA   Regular school Currently operational         High
## 5       173      1 NA NA   Regular school Currently operational   Elementary
## 6       224      1 NA NA   Regular school Currently operational         High
```

```
##   AS CHARTER_TEXT MAGNET_TEXT
## 1  3          Yes          No
## 2  3          Yes          No
## 3 90           No          No
## 4 93           No          No
## 5  5           No          No
## 6  9           No          No
```

With filtering, we now have a subset of the original data that will be much more useful for analysis. The schools were filtered to include only regular, non-virtual schools at the elementary, middle, and high school levels. It also removed any schools that had students younger than kindergarten (PK) or those past their senior year of high school (G13).

There is still an issue however with student to teacher ratios, so let's look at a distribution of that:

```
data_clean %>%
  summarise(quantile = c(0, 0.005, 0.025, 0.5, 0.975, 0.995, 1), quant.val = quantile(STUTERATIO, c(0, 
```

```
##   quantile quant.val
## 1    0.000    0.1900
## 2    0.005    4.8200
## 3    0.025    8.1800
## 4    0.500   15.7700
## 5    0.975   27.0000
## 6    0.995   34.4274
## 7    1.000  485.0000
```

Looking at the distribution, we see that 99% of the dataset falls between a student to teacher ratio of 4.82 and 34.4274, which we can use as a boundary to remove outliers of this variable from the dataset.

```
data_clean <- data_clean %>%
  filter(STUTERATIO >= 4.82 & STUTERATIO <= 34.4274)
```

Subsetting Columns

Now let's subset the columns in the dataset to only include those that interest this project.

```
data_sub <- data_clean %>%
  select(SCH_NAME, STABR, GSLO, GSHI, G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12, TOTAL
head(data_sub)
```

```
##                                 SCH_NAME STABR GSLO GSHI G01 G02 G03 G04 G05 G06
## 1    Soldotna Montessori Charter School    AK   KG   06  23  27  22  25  28  19
## 2 Kaleidoscope School of Arts & Science    AK   KG   05  43  42  46  46  43  NA
## 3        Eagle's View Elementary School    AK   PK   06  30  36  33  31  26  29
## 4            Unalaska Jr/Sr High School    AK   07   12  NA  NA  NA  NA  NA  NA
## 5                Gladys Jung Elementary    AK   03   06  NA  NA  97  75  79  90
## 6           Bethel Regional High School    AK   07   12  NA  NA  NA  NA  NA  NA
##   G07 G08 G09 G10 G11 G12 TOTAL  AM HI BL  WH HP TR   FTE STUTERATIO AMALM
## 1  NA  NA  NA  NA  NA  NA   167   8  5  0 136  0 15 10.35      16.14     4
## 2  NA  NA  NA  NA  NA  NA   260  16 14  3 168  0 56 16.75      15.52    10
## 3  NA  NA  NA  NA  NA  NA   217  23 30  2  56 13  3 13.50      16.07    11
```

```
## 4  30  25  26  38  36  29   184  24 21  0  38  8  0 14.50      12.69    12
## 5  NA  NA  NA  NA  NA  NA   341 284  6  1  44  0  1 22.13      15.41   141
## 6  94  90 106  52  63  70   475 418  7  1  38  0  2 33.05      14.37   221
##   AMALF ASALM ASALF HIALM HIALF BLALM BLALF WHALM WHALF HPALM HPALF TRALM TRALF
## 1     4     0     3     2     3     0     0    58    78     0     0     7     8
## 2     6     1     2     6     8     3     0    82    86     0     0    26    30
## 3    12    52    38    14    16     0     2    26    30     7     6     1     2
## 4    12    52    41    12     9     0     0    23    15     4     4     0     0
## 5   143     2     3     4     2     0     1    21    23     0     0     0     1
## 6   197     5     4     4     3     0     1    20    18     0     0     1     1
##   TOTMENROL TOTFENROL SCHOOL_LEVEL
## 1        71        96   Elementary
## 2       128       132   Elementary
## 3       111       106   Elementary
## 4       103        81         High
## 5       168       173   Elementary
## 6       251       224         High
```

Arranging Some Data

It may be useful to be the top several rows for certain columns, in this script, we look at the top 6 schools ordered based on their student to teacher ratio.

```
data_stuteratio <- data_sub %>%
  arrange(STUTERATIO, by_group = TRUE)
head(data_stuteratio)
```

```
##                          SCH_NAME STABR GSLO GSHI G01 G02 G03 G04 G05 G06 G07
## 1            George Jr Republic HS    PA   09   12  NA  NA  NA  NA  NA  NA  NA
## 2          Medicine Bow Elementary    WY   KG   06   1   4   0   3   2   1  NA
## 3 LONE STAR UNDIVIDED HIGH SCHOOL    CO   09   12  NA  NA  NA  NA  NA  NA  NA
## 4           VERDIGRE MIDDLE SCHOOL    NE   07   08  NA  NA  NA  NA  NA  NA   4
## 5           Judith Gap High School    MT   09   12  NA  NA  NA  NA  NA  NA  NA
## 6         Mobile Elementary School    AZ   KG   08   5   0   5   1   3   1   0
##   G08 G09 G10 G11 G12 TOTAL AM HI  BL WH HP TR   FTE STUTERATIO AMALM AMALF
## 1  NA  54  54  88  83   279  1 36 135 80  0 26 57.94       4.82     1     0
## 2  NA  NA  NA  NA  NA    11  0  0   0 11  0  0  2.28       4.82     0     0
## 3  NA  16   5   4   4    29 NA  3  NA 26 NA NA  6.01       4.83    NA    NA
## 4  10  NA  NA  NA  NA    14  2  0   0 12  0  0  2.90       4.83     1     1
## 5  NA   4   3   3   3    13  0  1   0 12  0  0  2.68       4.85     0     0
## 6   2  NA  NA  NA  NA    19  0  4   5  9  0  1  3.90       4.87     0     0
##   ASALM ASALF HIALM HIALF BLALM BLALF WHALM WHALF HPALM HPALF TRALM TRALF
## 1     1     0    36     0   135     0    80     0     0     0    26     0
## 2     0     0     0     0     0     0     4     7     0     0     0     0
## 3    NA    NA     2     1    NA    NA    13    13    NA    NA    NA    NA
## 4     0     0     0     0     0     0     5     7     0     0     0     0
## 5     0     0     1     0     0     0     5     7     0     0     0     0
## 6     0     0     3     1     2     3     5     4     0     0     0     1
##   TOTMENROL TOTFENROL SCHOOL_LEVEL
## 1       279         0         High
## 2         4         7   Elementary
## 3        15        14         High
## 4         6         8       Middle
```

```
## 5         6         7         High
## 6        10         9   Elementary
```

And now we look at the bottom 6 schools with the highest student-teacher ratio.

```
data_stuteratio <- data_sub %>%
  arrange(STUTERATIO)
tail(data_stuteratio)
```

```
##                                        SCH_NAME STABR GSLO GSHI G01 G02
## 58631                        College of So. NV HS East    NV   11   12  NA  NA
## 58632                              Everest High School    OH   09   12  NA  NA
## 58633                         Birch Grove Intermediate    CA   03   06  NA  NA
## 58634                        John C. Fremont Elementary    CA   KG   08  85  76
## 58635 Aspire Benjamin Holt College Preparatory Academy    CA   09   12  NA  NA
## 58636                             Hamburg Middle School    IA   06   08  NA  NA
##       G03 G04 G05 G06 G07 G08 G09 G10 G11 G12 TOTAL AM  HI BL WH HP TR   FTE
## 58631  NA  NA  NA  NA  NA  NA  NA  NA 102  68   170 NA  85 23 42  4  5  5.00
## 58632  NA  NA  NA  NA  NA  NA  20  24  17   7    68  0   4 37 24  0  3  2.00
## 58633 109 118 119 112  NA  NA  NA  NA  NA  NA   458  1 180 28 52  6 29 13.40
## 58634  77  95 115 113  91 102  NA  NA  NA  NA   867 13 759 26 33  4  6 25.24
## 58635  NA  NA  NA  NA  NA  NA 122 130  94  72   418  5 184 23 83  3 16 12.17
## 58636  NA  NA  NA  14  18  13  NA  NA  NA  NA    45 NA   7 NA 37 NA  1  1.31
##       STUTERATIO AMALM AMALF ASALM ASALF HIALM HIALF BLALM BLALF WHALM WHALF
## 58631      34.00    NA    NA     3     8    42    43     5    18    17    25
## 58632      34.00     0     0     0     0     1     3    27    10    15     9
## 58633      34.18     1    NA    93    69    95    85    12    16    30    22
## 58634      34.35     8     5    14    12   400   359    16    10    19    14
## 58635      34.35     1     4    55    49    87    97    10    13    35    48
## 58636      34.35    NA    NA    NA    NA     3     4    NA    NA    17    20
##       HPALM HPALF TRALM TRALF TOTMENROL TOTFENROL SCHOOL_LEVEL
## 58631     1     3     2     3        70       100         High
## 58632     0     0     1     2        44        24         High
## 58633     5     1    18    11       254       204   Elementary
## 58634     1     3     4     2       462       405   Elementary
## 58635     3    NA     4    12       195       223         High
## 58636    NA    NA    NA     1        20        25       Middle
```

Summary Data

Now let's take a look at some summary of the dataset in terms of its student-teacher ratio in each state.

```
data_stats <- data_sub %>%
  group_by(STABR) %>%
  summarise(STABR = STABR, AvgRatio = mean(STUTERATIO), SDRatio = sd(STUTERATIO))
```

```
## `summarise()` has grouped output by 'STABR'. You can override using the `.groups` argument.
```

```
data_summary <- distinct(data_stats)
data_summary
```

```
## # A tibble: 53 x 3
## # Groups:   STABR [53]
##    STABR AvgRatio SDRatio
##    <chr>    <dbl>   <dbl>
##  1 AK        16.0    3.02
##  2 AL        18.1    2.64
##  3 AR        13.2    2.81
##  4 AZ        18.9    3.77
##  5 CA        23.4    3.47
##  6 CO        16.4    3.71
##  7 CT        12.0    1.92
##  8 DC        13.1    4.02
##  9 DE        14.9    2.63
## 10 FL        17.2    3.66
## # ... with 43 more rows
```

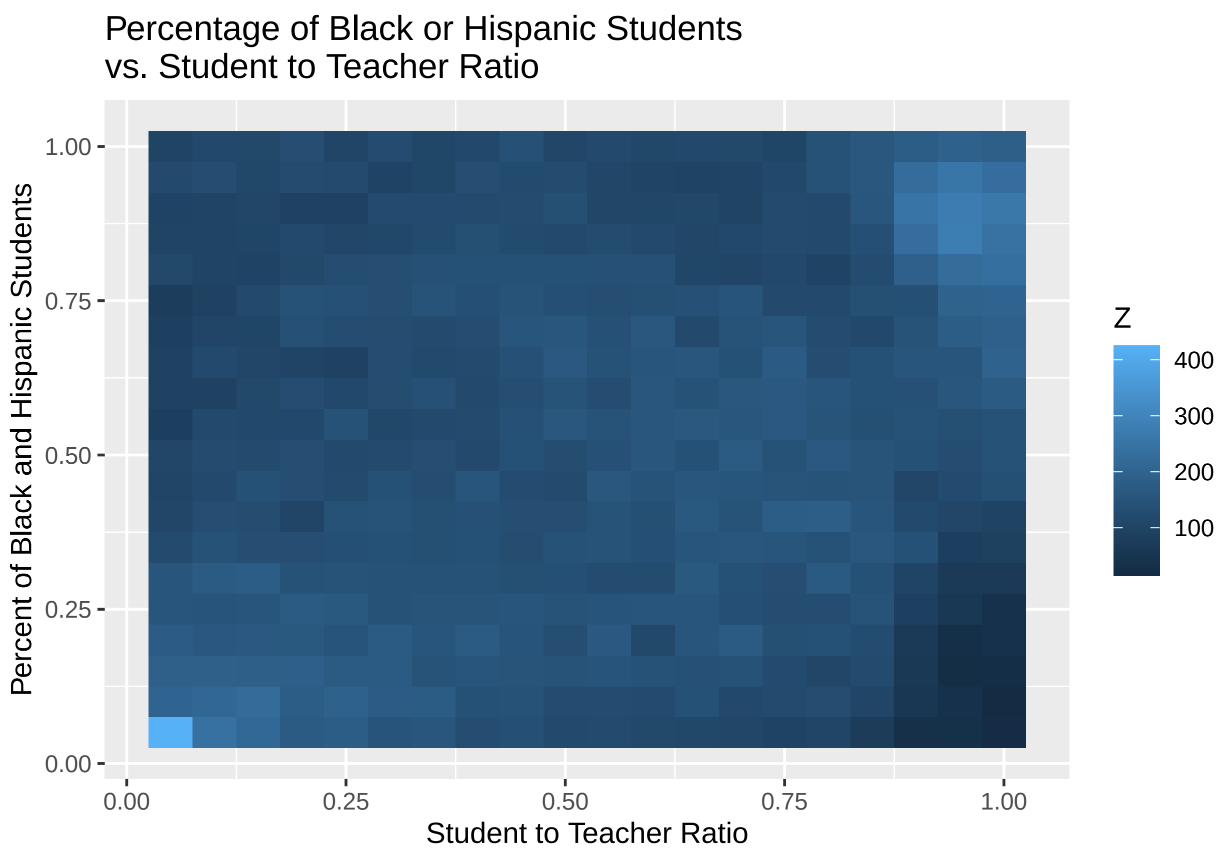
Analysis

Let's take a look at student to teacher ratio in relation to the percentage of black and hispanic students in the school.

```
quant <- c()
axis_val <- c()
count <- 1
heat.data <- data_sub %>%
  summarise(SCH_NAME, STUTERATIO, BLHI_PCT = (BL + HI)/TOTAL) %>%
  filter(!is.na(BLHI_PCT))
while (count <= 20) {
  count2 <- 1
  while (count2 <= 20) {
    cur.data <- heat.data %>%
      filter(STUTERATIO >= quantile(STUTERATIO, prob = c((count2-1)*0.05)) & STUTERATIO < quantile(STUT
    quant <- append(quant, nrow(cur.data))
    count2 <- count2 + 1
  }
  axis_val <- append(axis_val, 0.05*count)
  count <- count + 1
}
data <- expand.grid(X=axis_val, Y=axis_val)
data$Z <- quant
print(axis_val)
```

```
##  [1] 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75
## [16] 0.80 0.85 0.90 0.95 1.00
```

```
ggplot(data, aes(X, Y, fill= Z)) +
  geom_tile() + labs(title = "Percentage of Black or Hispanic Students \nvs. Student to Teacher Ratio",
```



Looking at the generated heatmap, we can see that the bottom right, where schools have the highest student to teacher ratio and lowest percentage of black and hispanic are the least common. However, it appears that the most common combnation is a high student to teacher ratio and a high percentage of black and hispanic students. The heat map was used to convey the number of schools whose student to teacher ratio and black and hispanic percentage matched the x and y axes for those values. It would have been nice if there was more robust racial statistics available for the schools as more specific heatmaps could be created.

We can know see if there is any kind of statistically significant correlation between the two.

```r
model <- lm(heat.data, formula = STUTERATIO ~ BLHI_PCT)
summary(model)
```

```
##
## Call:
## lm(formula = STUTERATIO ~ BLHI_PCT, data = heat.data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -13.2873  -3.1183  -0.5833   2.7228  18.4625
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 15.53747    0.02945  527.53   <2e-16 ***
## BLHI_PCT     2.78925    0.05926   47.07   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 4.49 on 54678 degrees of freedom
## Multiple R-squared:  0.03895,    Adjusted R-squared:  0.03893
## F-statistic:  2216 on 1 and 54678 DF,  p-value: < 2.2e-16
```

It is evident from the summary of the t-test on the regression equation that the coefficient for student to teacher ratio is statistically significant, with a t value of 47.07 and a p value of nearly 0. Thus for every additional unit increase in percent of black and hispanic students in a school we expect the student to teacher ratio to increase by 0.028, which although small is a significant correlation between the two variables.

Discussion of Results

From looking at the results of the analysis, we can now begin to draw some conclusions on the relation between black and hispanic population at a school and the student to teacher ratio for the school.

First looking at the heatmap, there are several observations that are important to point out. First, we see the highest amount of schools on the graph for the lowest percentile in student to teacher ratio and black and hispanic percentage, meaning that the schools with the fewest number of these students and the best student to teacher ratios are incredibly common. It is also clear that the area of the graph with the fewest schools is the area with a high student to teacher ratio and a low number of black and hispanic students, meaning that these schools are uncommon when looking at the country's public schools. Lastly, the area with a high black and hispanic population and student to teacher ratio are also very common. What this heatmap shows is that it is more common for schools with lower percentages of black and hispanic students to have better learning environments, and they are also very uncommon to have poorer learning conditions. In addition to this, schools with higher amounts of black and hispanic students are more likely to have a high student to teacher ratio.

When looking at the analysis of the regression, there is a weak yet statistically sginificant positive correlation between the percentage of black and hispanic students and the school's student to teacher ratio. This per percentage point increase of 0.028, while small, does provide evidence that schools with higher percentages of black and hispanic students tend to have higher student to teacher ratios.

Works Cited

Chingos, Matthew; Whitehouse, Grover."ClassSize : WhatResearchSaysandWhatitMeansforStatePolicy".https : //www.brookings.edu/research/class − size − what − research − says − and − what − it − means − for − state − policy/

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