Geospatial Mapping

Libraries/Packages

```
#Function to combine the state and county fips codes
combineFips <- function(state_fips, county_fips) {
  state_fips <- as.numeric(state_fips)
  county_fips <- as.numeric(county_fips)

  state_fips_str <- sprintf("%02d", state_fips)
  county_fips_str <- sprintf("%03d", county_fips)

  full_fips_code <- paste0(state_fips_str, county_fips_str)
  #print(full_fips_code)

  return(full_fips_code)
}
```

Fipscodes dataset can be found here:

https://www.census.gov/geographies/reference-files/2021/demo/popest/2021-fips.html

```
gov_fipscodes <- readr::read_csv('data/all-geocodes-v2021.csv', skip = 4)
```

```
New names:
Rows: 43833 Columns: 11
-- Column specification
-------------------------------------------------------- Delimiter: "," chr
(7): Summary Level, State Code (FIPS), County Code (FIPS), County Subdiv... lgl
(4): ...8, ...9, ...10, ...11
i Use `spec()` to retrieve the full column specification for this data. i
Specify the column types or set `show_col_types = FALSE` to quiet this message.
* `` -> `...8`
```

* `` -> `...9`
* `` -> `...10`
* `` -> `...11`

```
gov_fipscodes_clean <- gov_fipscodes |>
  rename(
    county_fips = 'County Code (FIPS)',
    state_fips = 'State Code (FIPS)',
    area_name = 'Area Name (including legal/statistical area description)'
  ) |>
  filter(
    county_fips != "000",
    state_fips != "00"
  ) |>
  mutate(
    state_fips = as.numeric(state_fips),
    county_fips = as.numeric(county_fips)
  ) |>
  select(state_fips, county_fips, area_name)

complete_codes = c(1, 2, 4, 201, 203)

#Fips codes can change over time ...
#So even if R packages are up to date, the data may not be

comp_mapping <- comp_internet |>
  select(
     "county_fips" = "GTCO",
     "Status" = "HUFINAL",
     "state_fips" = "GESTFIPS",
     "CBSAcode" = "GTCBSA",
     "UseDesktop" = "HEDESKTP",
     "UseLaptop" = "HELAPTOP",
     "UseTablet" = "HETABLET",
     "UseSmartphone" = "HEMPHONE",
     "UseWearable" = "HEWEARAB",
     "UseInternet" = "HEINHOME",
     "UseInternetSchool" = "HEINSCHL",
     "UseDataplan" = "HEMOBDAT",
     "UseInternetTrainEdu" = "PEEDTRAI"
      ) |>
  drop_na(state_fips, county_fips) |>
```

```
    filter(
      any(Status == complete_codes),
      county_fips != "0",
    ) |>
    mutate(
      fips = combineFips(state_fips, county_fips),
      state = fips_info(state_fips)$full
    ) |>
    group_by(state_fips, county_fips, fips, state, UseDesktop) |>
    count() |>
    filter(UseDesktop == 1 | UseDesktop == 2) |>
    pivot_wider(
      names_from = UseDesktop,
      values_from = n
    ) |>
    rename( Yes = "1", No = "2" ) |>
    mutate(porportion = Yes/(Yes + No))

  fips_info(01041)
```

```
     full abbr          county  fips
1 Alabama   AL Crenshaw County 01041
```

```
  #Show distribution of country code
  comp_internet |>
    group_by(GTCO) |>
    summarise( count = n())
```

```
# A tibble: 100 x 2
    GTCO count
   <dbl> <int>
 1     0 76179
 2     1  4441
 3     3  4385
 4     5  1690
 5     7   281
 6     9   797
 7    11  1262
 8    13  2380
 9    15   611
```

```
10    17  1362
# i 90 more rows
```

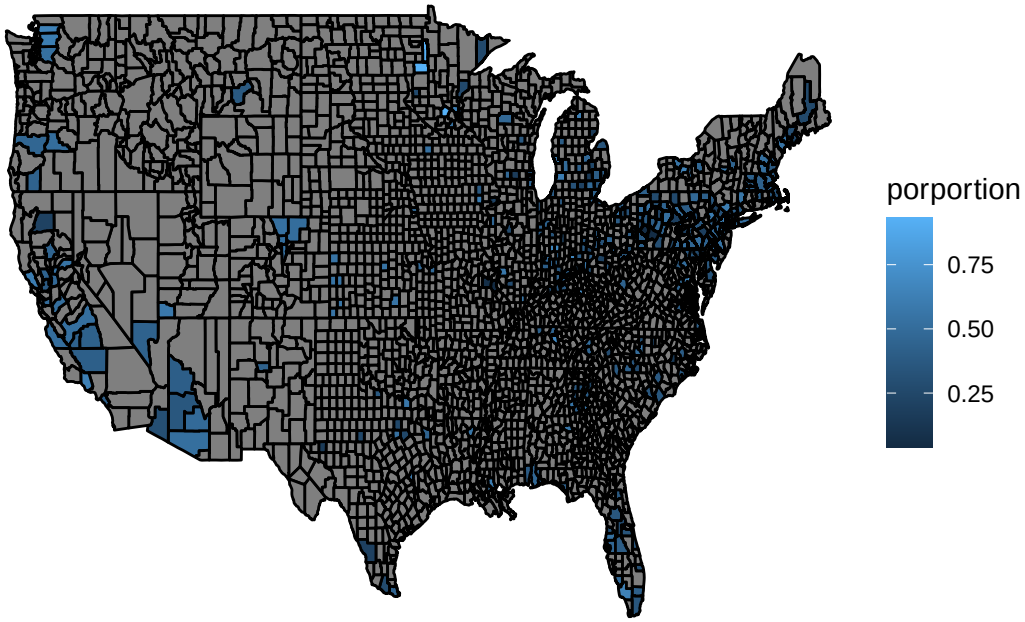
```
#Show how manny nonzero country codes there were
comp_internet |>
  filter(GTCO != 0) |>
  summarise( count = n())
```

```
# A tibble: 1 x 1
  count
  <int>
1 51196
```

```
#Read the books on mapping + spatial viz
county_map <- map_data("county") |>
  rename("state" = "region") |>
  mutate(
    "state" = str_to_title(state),
    "subregion" = str_to_title(subregion)
    )

fipsCoded <- merge(comp_mapping, gov_fipscodes_clean, by = c("state_fips", "county_fips")) |>
  mutate(
    subregion = word(area_name, start = 1, end = 1)
  ) |>
  rename(
    "county" = "area_name"
  ) |>
  mutate(
    "fips" = combineFips(state_fips, county_fips)
  )

#Unfortunately mapping by county isn't particularly useful due to lack of data
internet_map <- fipsCoded |>
  full_join(county_map, by = join_by(subregion == subregion, state == state))
```

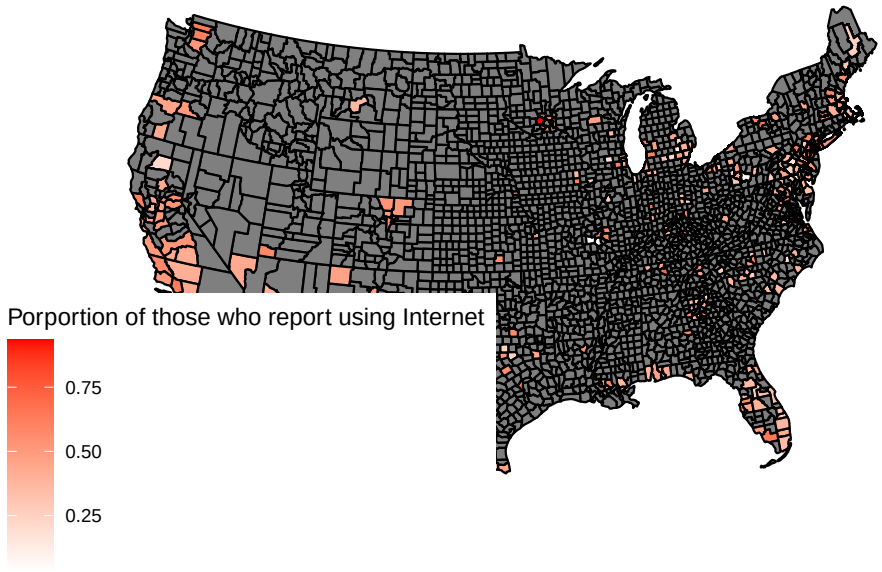
```
Warning in full_join(fipsCoded, county_map, by = join_by(subregion == subregion, : Detected a
i Row 1 of `x` matches multiple rows in `y`.
i Row 22063 of `y` matches multiple rows in `x`.
i If a many-to-many relationship is expected, set `relationship =
  "many-to-many"` to silence this warning.
```

```
internet_map |>
  ggplot(aes(x = long, y = lat, group = group, fill = porportion)) +
  geom_polygon(color = "black") +
  theme_void()
```




```
fips_trimmed <- fipsCoded |>
  select(fips, state, county, porportion)

#Map for porportion of people that report using a desktop by county
plot_usmap(data = fips_trimmed,
           values = "porportion",
           regions = "counties") +
  scale_fill_continuous(low = "white", high = "red", name = "Porportion of those who repor
  labs(title = "County Map")
```

County Map

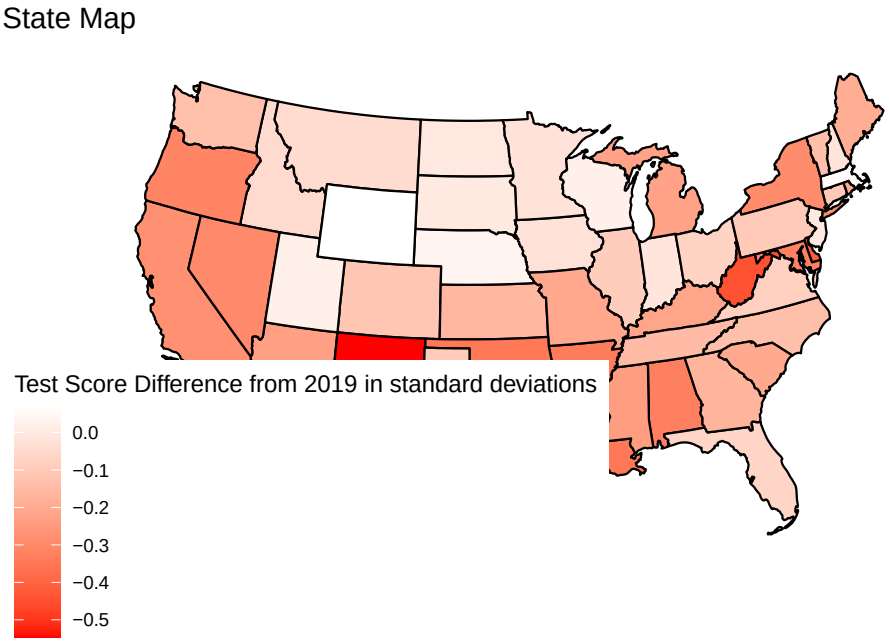



```
#Investigate different map packages
#Plotting two variables on one map is difficult
#Consider mapping two colors for reading and math scores
#geom_maps (maps package)
#Dot Size + color
#Shape + color
#Think about the story I want to tell
#Mapping differences between math & reading scores
#Think about direction of project: modeling/visualizing,deliverables, etc.

#If I am dividing my data, note if there are differences in distributions/analysis
#Potential mapping of district to county?
#Stuff like the "FIPS" issues may be included in a process section, make sure to keep note
#Comparing diferent subjects, use the same scale so it's eaiser to compare standard deivat
#Standard deviations are good for relative comparisons and can't be generalized to absolut
#See if there's another location identifier I could use
#Look into another long scale survey/question internet/education online/enrichment
#Investigate the large number of not specified county codes, possibbly information not pro
#Start bivariate
```

```
state_grouped_all <- test_state_ys |>
  filter(subgroup == "all") |>
  group_by(sedafipsname, subject) |>
  summarise( mean_ol = mean(ys_mn_2022_ol), mean_eb = mean(ys_mn_2022_eb
)) |>
  rename (
    state = sedafipsname
  )
```

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

```
plot_usmap(data = state_grouped_all |> filter(subject == "mth"), values = "mean_ol", regio
  scale_fill_continuous(low = "red", high = "white", name = "Test Score Difference from 20
  labs(title = "State Map")
```




```
# Neither the maps package or the USMaps package support mapping by district
# I will try mapping districts to counties
# https://www.census.gov/programs-surveys/saipe/guidance-geographies/districts-counties.ht
# If this doesn't work out, will likely have to use the sf package with shapefiles
```

```r
# One thing

# US Census Data on District by County
district_by_county <- read_excel("data/sdlist-21.xls", skip = 2)

# US Census Small Area Income and Poverty Estimates (SAIPE) by District
saipe_district <- read_excel("data/ussd22.xls", skip = 2)
```

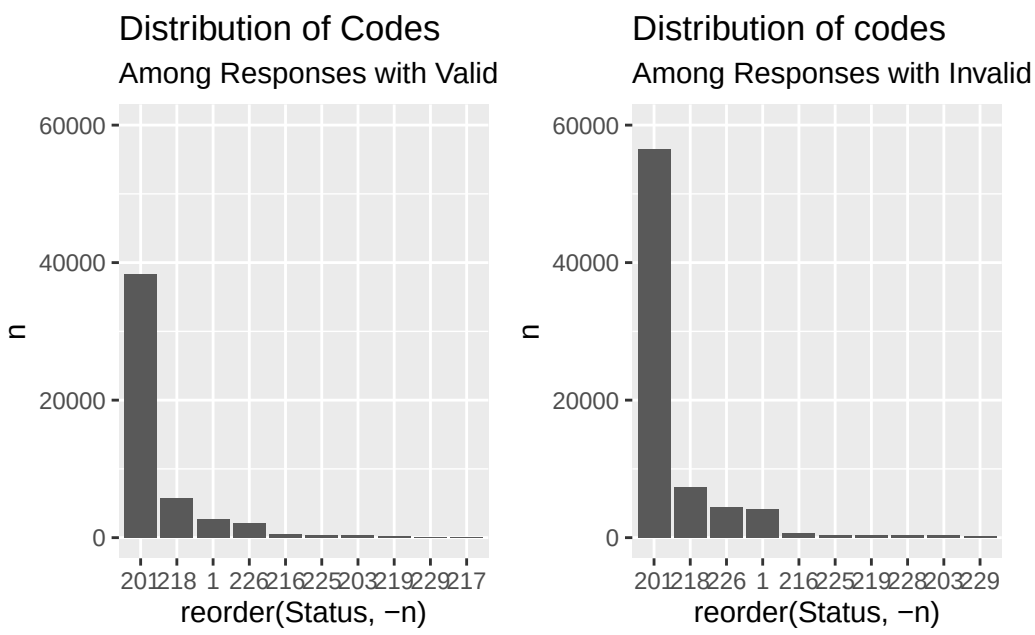
Something to consider, sometimes states can have duplicate county names

https://www.census.gov/programs-surveys/saipe/guidance-geographies/same-name/2022.html

It is really important that I use DistrictID for each unique **SCHOOL** district.

```r
census_clean <- comp_internet |>
  select(
     "county_fips" = "GTCO",
     "state_fips" = "GESTFIPS",
     "Status" = "HUFINAL",
     "CBSAcode" = "GTCBSA",
     "UseDesktop" = "HEDESKTP",
     "UseLaptop" = "HELAPTOP",
     "UseTablet" = "HETABLET",
     "UseSmartphone" = "HEMPHONE",
     "UseWearable" = "HEWEARAB",
     "UseInternet" = "HEINHOME",
     "UseInternetSchool" = "HEINSCHL",
     "UseDataplan" = "HEMOBDAT",
     "UseInternetTrainEdu" = "PEEDTRAI"
      )

valid_county <- census_clean |>
  filter(
    county_fips != 0
  ) |>
  mutate(
    state = fips_info(state_fips)$full,
  ) |>
  group_by(state, Status) |>
  count()
```

```r
valid_county_sum <- valid_county |>
  group_by(Status) |>
  summarise(n = sum(n)) |>
  arrange(-n)

invalid_county <- census_clean |>
  filter(
    county_fips == 0
  ) |>
  mutate(
    state = fips_info(state_fips)$full,
  ) |>
  group_by(state, Status) |>
  count()

invalid_county_sum <- invalid_county |>
  group_by(Status) |>
  summarise(n = sum(n)) |>
  arrange(-n)

valid_county_status_plot <- ggplot(valid_county_sum |> slice(1:10)) +
  geom_col(aes(x = reorder(Status, -n), y = n) ) +
  #geom_col(data = invalid_county_sum) +
  labs(
    title = "Distribution of Codes",
    subtitle = "Among Responses with Valid counties"
  ) +
  scale_y_continuous( limits = c(0, 60000) )

invalid_county_status_plot <- ggplot(invalid_county_sum |> slice(1:10)) +
  geom_col(aes(x = reorder(Status, -n), y = n)) +
  labs(
    title = "Distribution of codes",
    subtitle = "Among Responses with Invalid counties"
  ) +
  scale_y_continuous( limits = c(0, 60000) )

valid_county_status_plot + invalid_county_status_plot
```



There does not appear to be a significant difference in the completion code distribution between respondents in valid counties vs invalid counties

Code Mappings for "Status"

1: Fully Complete CATI (computer-assisted telephone interviewing)

2: Partially Complete CATI

201: CAPI (computer-assisted personal interviewing)

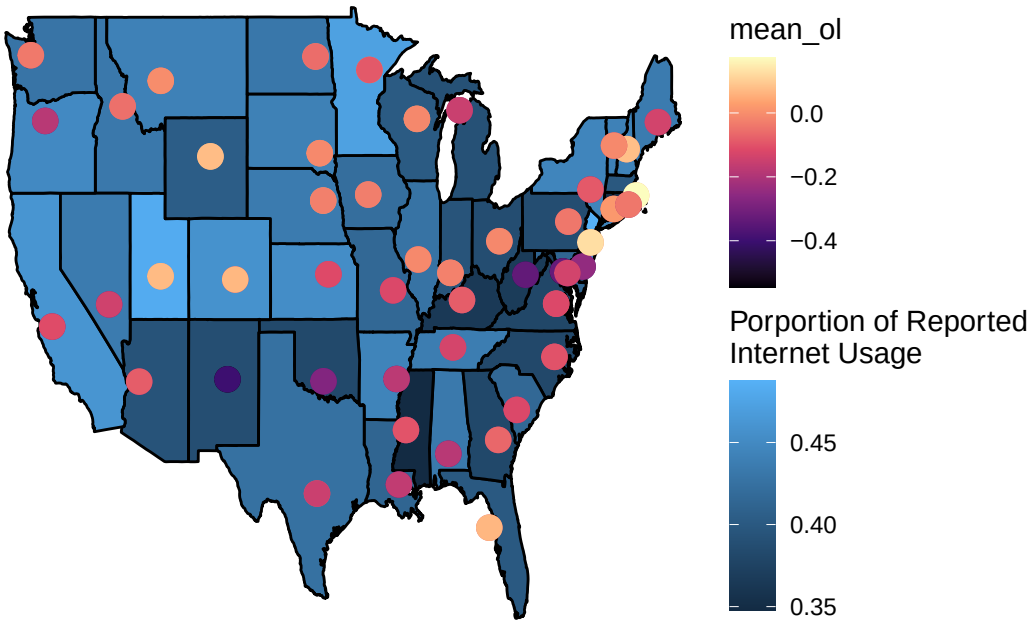
There appears to be no correlation between the interview completion

```
#Mapping by state since county data is very incomplete
comp_state_mapping <- comp_internet |>
  select(
     "county_fips" = "GTCO",
     "Status" = "HUFINAL",
     "state_fips" = "GESTFIPS",
     "CBSAcode" = "GTCBSA",
     "UseDesktop" = "HEDESKTP",
     "UseLaptop" = "HELAPTOP",
     "UseTablet" = "HETABLET",
     "UseSmartphone" = "HEMPHONE",
```

```
      "UseWearable" = "HEWEARAB",
      "UseInternet" = "HEINHOME",
      "UseInternetSchool" = "HEINSCHL",
      "UseDataplan" = "HEMOBDAT",
      "UseInternetTrainEdu" = "PEEDTRAI"
       ) |>
  drop_na(state_fips, county_fips) |>
  filter(
    any(Status == complete_codes)
  ) |>
  mutate(
    state = fips_info(state_fips)$full
  ) |>
  group_by(state, UseDesktop) |>
  count() |>
  filter(UseDesktop == 1 | UseDesktop == 2) |>
  pivot_wider(
    names_from = UseDesktop,
    values_from = n
  ) |>
  rename( Yes = "1", No = "2" ) |>
  mutate(porportion = Yes/(Yes + No))

state_map <- map_data("state") |>
  mutate(
  "region" = str_to_title(region),
  )

internet_map <- comp_state_mapping |>
  left_join(state_map, by = join_by(state == region))

state_centroids <- state_map|>
  group_by(region) |>
  summarise( long = mean (long), lat = mean(lat))

score_map <- state_grouped_all |>
  left_join(state_centroids, by = join_by(state == region))


ggplot(internet_map, aes(x = long, y = lat)) +
    geom_polygon(aes(group = group, fill = porportion), color = "black") +
```

```
    geom_point(data = score_map, size = 4, aes(color = mean_ol)) +
    scale_color_viridis_c(option = "A") +
    theme_void() +
    labs(
      fill = "Porportion of Reported\nInternet Usage"
    )
```

```
Warning: Removed 4 rows containing missing values (`geom_point()`).
```



Unfortunately, it's really hard to make meaningful conclusions or analysis about state metrics

```
#Since county codes did not cover a significant geographic portion of the US, I want to se

#Show distribution of country codes
comp_internet |>
  group_by(GTCO) |>
  summarise( count = n())
```

```
# A tibble: 100 x 2
```

```
    GTCO count
   <dbl> <int>
 1     0 76179
 2     1  4441
 3     3  4385
 4     5  1690
 5     7   281
 6     9   797
 7    11  1262
 8    13  2380
 9    15   611
10    17  1362
# i 90 more rows
```

```
  #Show how manny nonzero country codes there were
  comp_internet |>
    filter(GTCO != 0) |>
    summarise( count = n())
```

```
# A tibble: 1 x 1
  count
  <int>
1 51196
```

```
  #Distribution of CBSA codes
  comp_internet |>
    group_by(GTCBSA) |>
    count() |>
    arrange(-n)
```

```
# A tibble: 261 x 2
# Groups:   GTCBSA [261]
   GTCBSA     n
    <dbl> <int>
 1      0 33615
 2  35620  5025
 3  47900  3815
 4  31080  3464
 5  16980  2516
 6  37980  2283
```

```
 7  14460  2189
 8  19100  2010
 9  26420  1888
10  33100  1525
# i 251 more rows
```

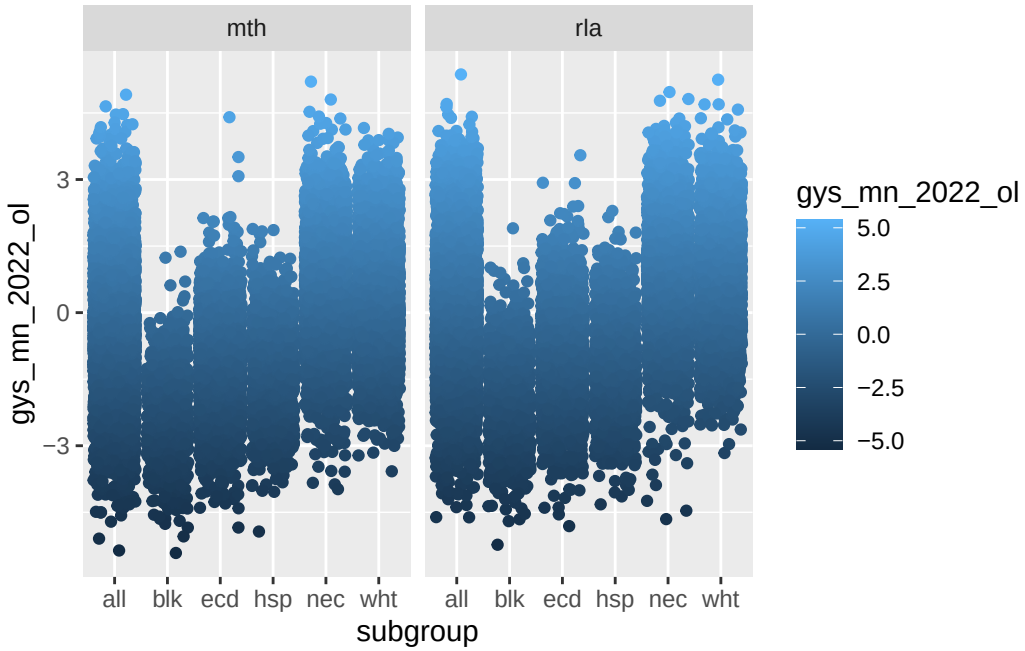
```
#Show how many nonzero CBSA codes
comp_internet |>
  filter(GTCBSA != 0) |>
  count()
```

```
# A tibble: 1 x 1
      n
  <int>
1 93760
```

In conclusion, while there are fewer invalid/incomplete CBSA codes, a vast majority of other datasets tend to use districts or counties. As such, I will not be moving forward with CBSA codes.

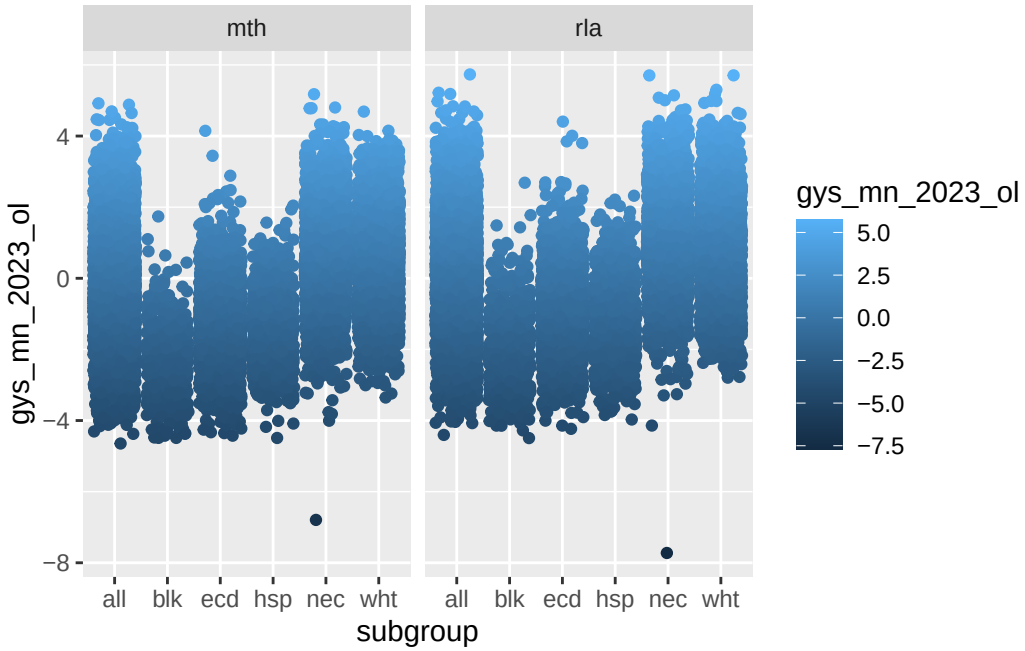
The Educational Opportunity Project Standardizes their data with the Stanford Education Data Archive (SEDA). They created their own identifier for each district, `SEDA Administrative District ID`, which details can be found here: https://edopportunity.org/methods/

```
test_admindist_gys <- test_admindist_gys |>
  mutate(
    diff22_23 = gys_mn_2023_ol - gys_mn_2022_ol
  )

ggplot(test_admindist_gys) +
  geom_jitter(
    aes(
      x = subgroup,
      y = gys_mn_2022_ol,
      color = gys_mn_2022_ol
      ),
    ) +
  facet_grid(
    cols = vars(subject)
  )
```




```
ggplot(test_admindist_gys) +
  geom_jitter(
    aes(
      x = subgroup,
      y = gys_mn_2023_ol,
      color = gys_mn_2023_ol
      ),
    ) +
  facet_grid(
    cols = vars(subject)
  )
```

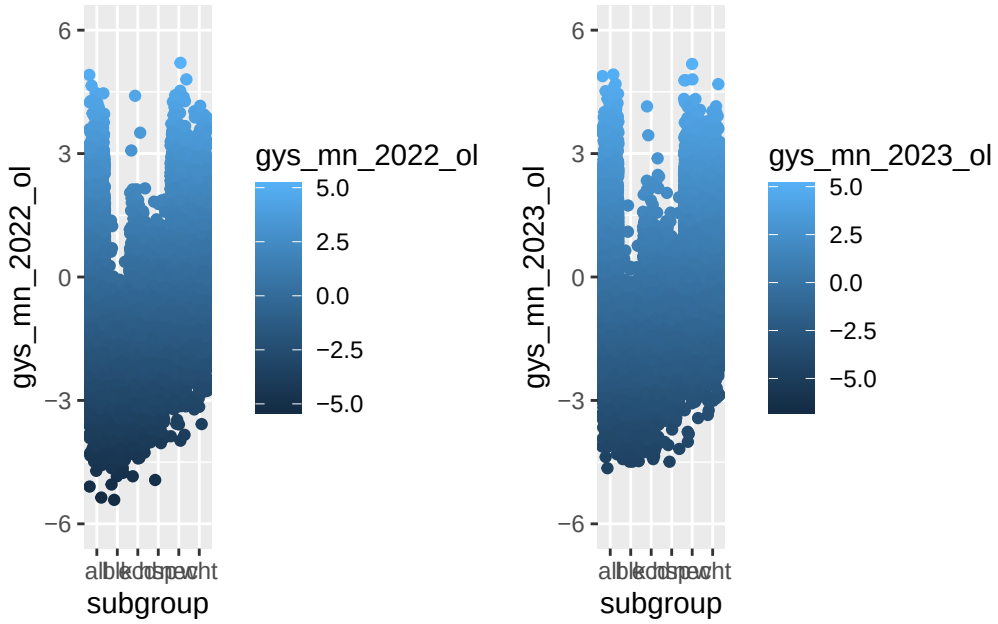
```
Warning: Removed 9374 rows containing missing values (`geom_point()`).
```




```
ggplot(test_admindist_gys |> filter (subject == "mth")) +
  geom_jitter(
    aes(
      x = subgroup,
      y = gys_mn_2022_ol,
      color = gys_mn_2022_ol
      ),
    ) +
  scale_y_continuous(
    limits = c(-6, 6)
  ) +

ggplot(test_admindist_gys |> filter (subject == "mth")) +
  geom_jitter(
    aes(
      x = subgroup,
      y = gys_mn_2023_ol,
      color = gys_mn_2023_ol
      ),
    ) +
  scale_y_continuous(
    limits = c(-6, 6)
```

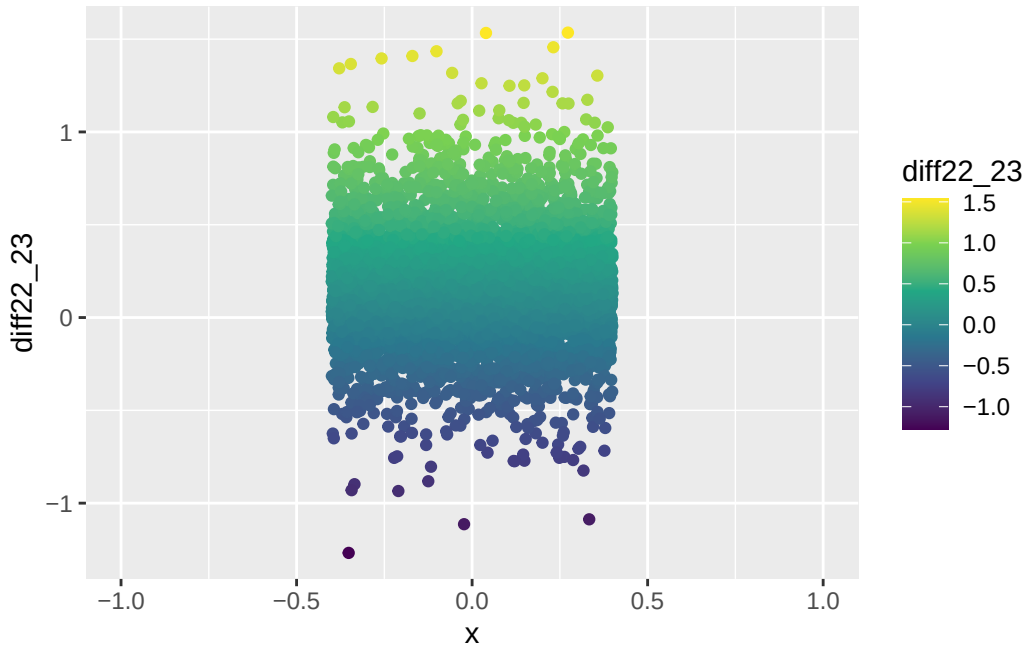
```
  )
```

```
Warning: Removed 4959 rows containing missing values (`geom_point()`).
```




```
ggplot(test_admindist_gys|> filter (subject == "mth", subgroup == "all")) +
  geom_jitter(
    aes(
      x = 0,
      y = diff22_23,
      color = diff22_23,
      ),
    ) +
  scale_x_continuous(limits = c(-1,1)) +
  scale_color_viridis_c()
```

```
Warning: Removed 1463 rows containing missing values (`geom_point()`).
```




```
mean(na.omit(test_admindist_gys$gys_mn_2022_ol))
```

```
[1] -0.2498951
```

```
median(na.omit(test_admindist_gys$gys_mn_2022_ol))
```

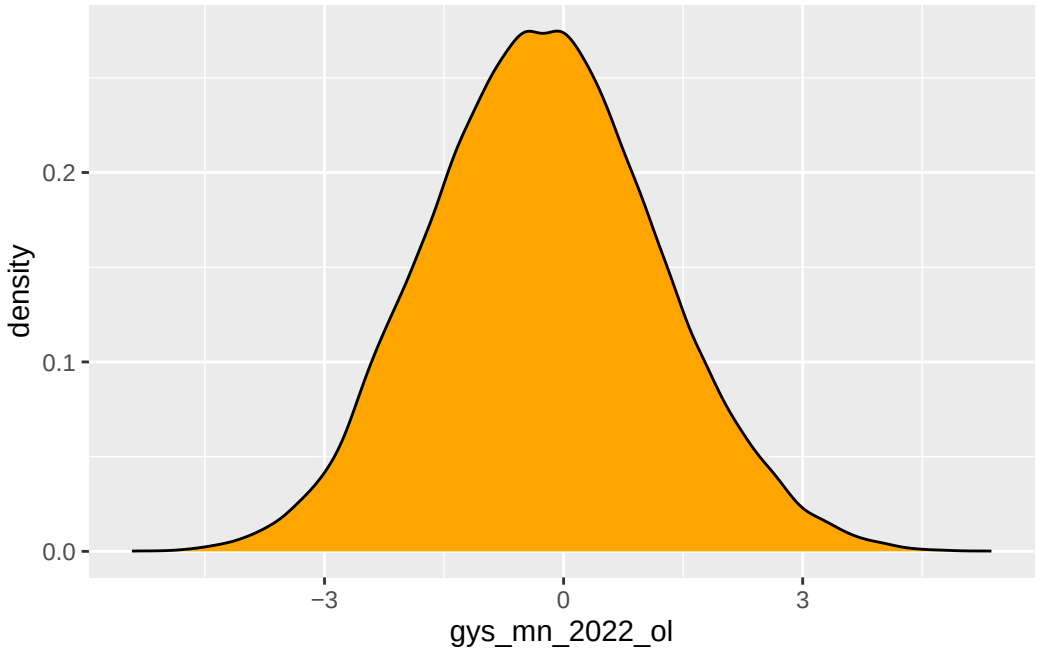
```
[1] -0.2672775
```

```
median(na.omit(test_admindist_gys$gys_mn_2023_ol))
```

```
[1] -0.0795574
```

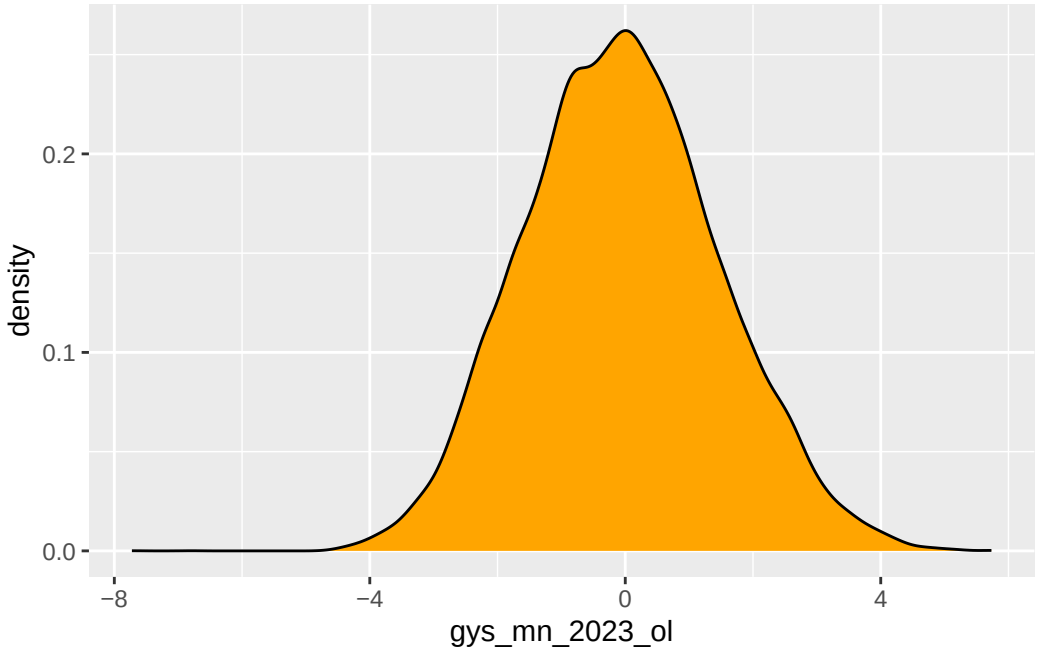
```
ggplot(test_admindist_gys) +
  geom_density(
    aes(
      x = gys_mn_2022_ol,
      ),
    fill = "orange"
```

```
  )
```



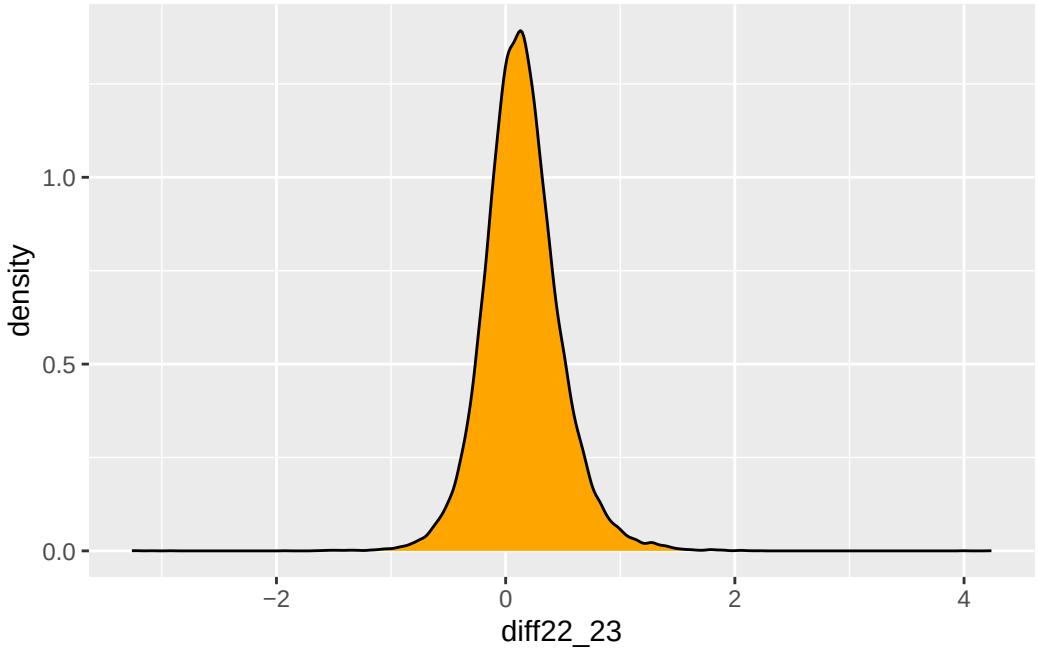

```
ggplot(test_admindist_gys) +
  geom_density(
    aes(
      x = gys_mn_2023_ol,
      ),
    fill = "orange"
  )
```

```
Warning: Removed 9374 rows containing non-finite values (`stat_density()`).
```




```
ggplot(test_admindist_gys) +
  geom_density(
    aes(
      x = diff22_23,
      ),
    fill = "orange"
  )
```

```
Warning: Removed 9374 rows containing non-finite values (`stat_density()`).
```



More Resources to Consider

Additional Census Data:

- Household income in the past year
  https://data.census.gov/table/ACSST1Y2021.S2503?t=Financial%20Characteristics&g=010XX00US$0500000&y=2021&tp=true
- Age + Race Demographics
  https://data.census.gov/table/ACSDP1Y2021.DP05?g=010XX00US$0500000&y=2021&tp=true
- Characteristics of Foreign Born Population
  https://data.census.gov/table/ACSST1Y2021.S0501?g=010XX00US$0500000&y=2021&tp=true

School Budget/School Opening/State Funding

https://about.burbio.com/#sign-up

Absenteeism

https://www.future-ed.org/tracking-state-trends-in-chronic-absenteeism/

Additional Metrics

- Literacy/Active Reading in Households

- Education level of parents/family
  - Bachelor's %
- General COVID statistics (cases, deaths, etc.)
- Recovery Strategies
  - Look into outliers in the trends and what they are doing
- Inner-district disparities among schools

Referenced Reports/Resources

- https://www.nytimes.com/interactive/2024/01/31/us/pandemic-learning-loss-recovery.html
- https://www.nytimes.com/interactive/2024/02/01/upshot/learning-loss-school-districts.html
- https://www.nytimes.com/2023/12/09/opinion/education-learning-loss.html
- https://www.nytimes.com/2023/11/17/us/chronic-absenteeism-pandemic-recovery.html
- https://educationrecoveryscorecard.org/
- https://edopportunity.org/

General Plan:

- How to handle changing districts
  - Look into other reports
  - Census website
  - Maybe just pick a specific year
  - Take aggregate measurement over time periods
  - Possibly look at the data across years and determine if there's enough variability
- Main Visualization:
  - Scatterplot (based on https://educationrecoveryscorecard.org/)
    - Y: Reading/Math Scores
    - X: Some metric
    - Filters: other metrics (location, income, race, etc.)

  - Scatterplot
    - Y: Reading Score
    - X: Math score
    - Filters: metrics

- Look into district level data
  - What data the project uses
    - https://edopportunity.org/help-faq/#how-is-ses
    - For socioeconomic status, they use data from the American Community Survey (found on data.census.gov)
    - data/ACS_SchoolDistricts_Socioeconomic_2021/ACSDP1Y2021.DP04-Data.csv
      - Monthly Owner Costs
      - Monthly Owner Costs as percentage of household income
      - Owner-occupied units value
  - Their methodology
    - https://edopportunity.org/docs/seda2023_documentation_20240130.pdf
  - How I can merge in outside datasets
    - Census datasets have data per school district

- Percent of counties with multiple districts
  - Determines how important it is to get district level data

- SEDA Technical Document
  - What is a SEDA Administrative District?
    - In 4.1, they used geographic districts
      - If you had magnet/charter schools, it could have been operated in district A but managed by district B
    - In 5.0, they are using administrative districts
      - An administrative districts represents all schools that are managed by the district
  - Should be really easy to map SEDA Admin district to ACS School District

- Mapping in Shiny
  - Hard to avoid re-rendering the map every time a selection is changed
    - side note: maybe find a way to reduce render time
  - Maps package options: (sf, usmaps, maps, leaflet)
    - sf: Probably the most robust and customizable
      - I can get shapefiles from government websites for school districts
    - usmaps: More intuitive to use, but lack of division options
    - maps: Less intuitive
    - leaflet: More functionality (zoom, pre-rendering)
- Scatterplot in Shiny
  - Look into hovering/clicking functionality for plotted points
    - Be able to register that a click occurred and where
- Todo:
  - Data Joining (ACS to Academic Performance)
    - If any issues, try to find quick fixes
    - Even if there issues, keep moving forward
  - Create the scatterplot comparing some socioeconomic metric (x) to reading/math scores (y)
    - Include other aesthetics once the point distribution is good
  - Create antoher scatterplot that compares reading score (x) to math score (y)
    - Try to put in additional aesthetics (socioeconomic)
  - Start working on the app
    - Put one of my nice plots into the app