Initial Analysis using MSA level data from the CDC

Data:

We were able to obtain data from the CDC that has age adjusted death rates for each urbanization group in a state. We no longer have to use state level data. We believe this data allows us to achieve better what we orginially planned to do with county level data.

Cleaning environment and loading packages

Loading in data and merging MSA deaths data with Medicaid Expansion Status

```
MSA_Level_Deaths_in_States <- read_excel("MSA Level Deaths in States.xlsx")
Medicaid_Expansion_Status <- read_excel("Medicaid_Expansion_Status.xlsx")

MSA_Level_Deaths_in_States <- MSA_Level_Deaths_in_States %>%
  mutate(State = str_trim(State))

Medicaid_Expansion_Status <- Medicaid_Expansion_Status %>%
  mutate(State = str_trim(State))

MSA_Level_Deaths_in_States <- left_join(
  MSA_Level_Deaths_in_States,
  Medicaid_Expansion_Status,
  by = "State"
)
```

Converting Everything to Numeric

```
MSA_Level_Deaths_in_States <- MSA_Level_Deaths_in_States %>%
  mutate(
    `Age Adjusted Rate` = as.numeric(gsub("[^0-9.]", "", `Age Adjusted Rate`))
  )

MSA_Level_Deaths_in_States <- MSA_Level_Deaths_in_States %>%
  mutate(
    `Year of Expansion` = na_if(`Year of Expansion`, "NA")
  )

MSA_Level_Deaths_in_States <- MSA_Level_Deaths_in_States %>%
  mutate(
    `Year of Expansion` = as.numeric(`Year of Expansion`)
  )
```

Initial Plot by Urbanization Group

```
#grouping deaths by year and urban group
urban_deaths_by_year <- MSA_Level_Deaths_in_States %>%
  filter(Year >= 2010, Year <= 2020) %>%
  group_by(Year, `2013 Urbanization`) %>%
  summarise(age_adjusted_death_rate = mean(`Age Adjusted Rate`, na.rm = TRUE), .groups = "drop")

#plot
ggplot(urban_deaths_by_year, aes(x = Year, y = age_adjusted_death_rate, color = `2013 Urbanization`)) +
  geom_line(linewidth = 1.2) +
```

Opioid Deaths by Urbanization Group (2010...2020)
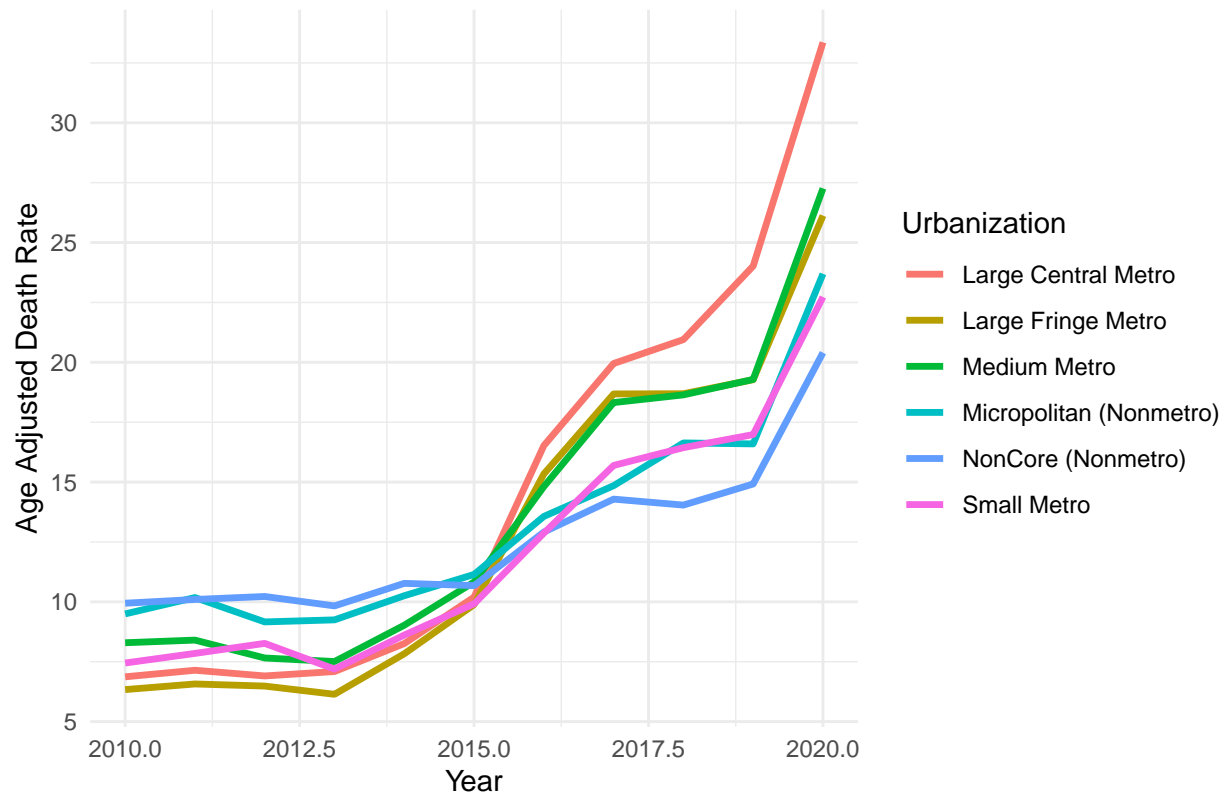
Comparing States that Expanded in 2014 vs States that Didn't Expand in 2014(treated states that expanded later as never expanded)

```r
MSA <- MSA_Level_Deaths_in_States %>%
  mutate(
    group = case_when(
      `Year of Expansion` == 2014 ~ "Expanded in 2014",
      is.na(`Year of Expansion`) ~ "Never Expanded",
      TRUE ~ NA_character_
    )
  ) %>%
  filter(!is.na(group))

trends_2014_vs_never <- MSA %>%
  group_by(Year, group) %>%
  summarise(
    avg_rate = mean(`Age Adjusted Rate`, na.rm = TRUE),
    .groups = "drop"
  )

ggplot(trends_2014_vs_never, aes(x = Year, y = avg_rate, color = group)) +
  geom_line(linewidth = 1.2) +
  geom_point(size = 2) +
  geom_vline(xintercept = 2014, linetype = "dashed") +
  labs(
    title = "Opioid Mortality: 2014 Medicaid Expansion vs Never Expanded States",
```
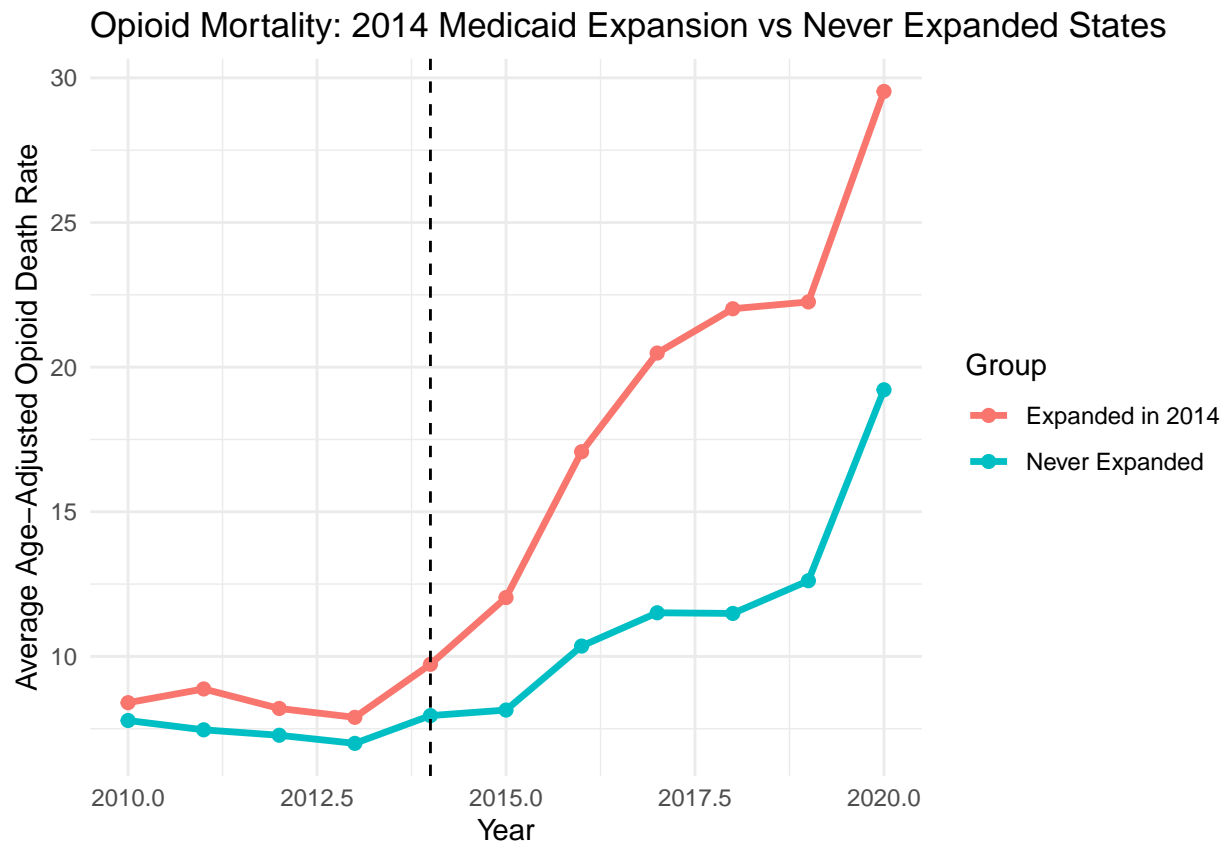
```
    x = "Year",
    y = "Average Age-Adjusted Opioid Death Rate",
    color = "Group"
  ) +
  theme_minimal()
```

Opioid Mortality: 2014 Medicaid Expansion vs Never Expanded States

We split the type of area into either rural or urban and then compared the trends pre and post expansion

```
##urban vs rural plot code
MSA_plot <- MSA_Level_Deaths_in_States %>%
  mutate(
    `Age Adjusted Rate` = as.numeric(`Age Adjusted Rate`),
    `Year of Expansion` = as.numeric(`Year of Expansion`),
    rural = ifelse(`2013 Urbanization Code` >= 4, "Rural", "Urban"),
    group = case_when(
      `Year of Expansion` == 2014 ~ "Expanded in 2014",
      is.na(`Year of Expansion`) ~ "Never Expanded",
      TRUE ~ NA_character_
    )
  ) %>%
  filter(!is.na(group))

grouped_trends <- MSA_plot %>%
  group_by(Year, group, rural) %>%
  summarise(
    avg_rate = mean(`Age Adjusted Rate`, na.rm = TRUE),
```

```
    .groups = "drop"
  )

ggplot(grouped_trends, aes(x = Year, y = avg_rate, color = group, linetype = rural)) +
  geom_line(linewidth = 1.2) +
  geom_point(size = 2) +
  geom_vline(xintercept = 2014, linetype = "dashed", color = "gray40") +
  labs(
    title = "Opioid Mortality Trends: 2014 Medicaid Expansion vs Never, by Area Type",
    x = "Year",
    y = "Average Age-Adjusted Opioid Death Rate",
    color = "Expansion Group",
    linetype = "Area Type"
  ) +
  theme_minimal()
```

Opioid Mortality Trends: 2014 Medicaid Expansion vs Never, by Area Type
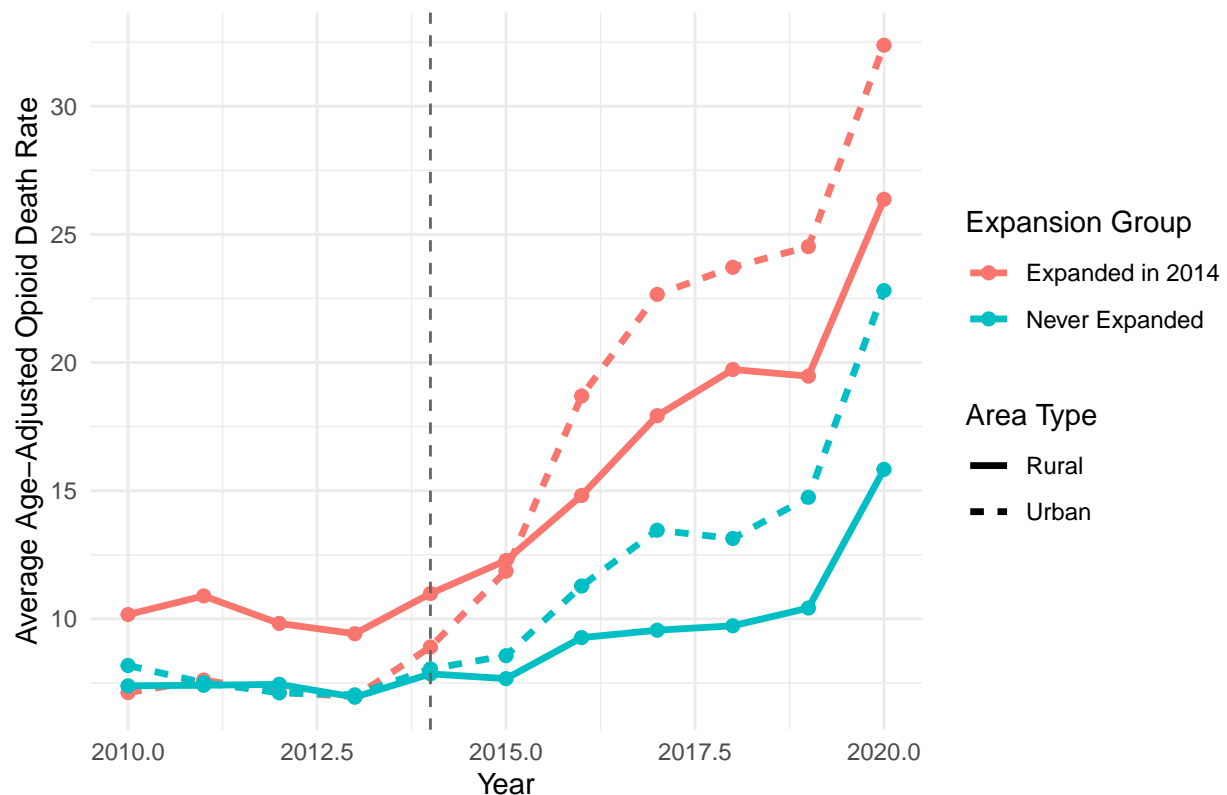

```
# Filter for PA and Virginia only

MSA_Level_Deaths_in_States <- MSA_Level_Deaths_in_States %>%
  mutate(rural = ifelse(MSA_Level_Deaths_in_States$`2013 Urbanization Code` >= 4, "Rural", "Urban"))

pa_va_data <- MSA_Level_Deaths_in_States %>%
  filter(State %in% c("Pennsylvania", "Florida"), Year >= 2010 & Year <= 2020)

# Group by State, Year, AreaType
```

```
plot_data <- pa_va_data %>%
  group_by(State, Year, rural) %>%
  summarise(
    avg_rate = mean(as.numeric(`Age Adjusted Rate`), na.rm = TRUE),
    .groups = "drop"
  )

# Plot
ggplot(plot_data, aes(x = Year, y = avg_rate, color = State, linetype = rural)) +
  geom_line(size = 1.2) +
  geom_vline(xintercept = 2015, linetype = "dashed", color = "gray") +
  labs(
    title = "Opioid Mortality Trends: Florida (Never) vs Pennsylvania (2015), by Area Type",
    x = "Year",
    y = "Average Age-Adjusted Opioid Death Rate",
    color = "State",
    linetype = "Area Type"
  ) +
  theme_minimal()
```

```
## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.
```


Opioid Mortality Trends: Florida (Never) vs Pennsylvania (2015), by Area Type
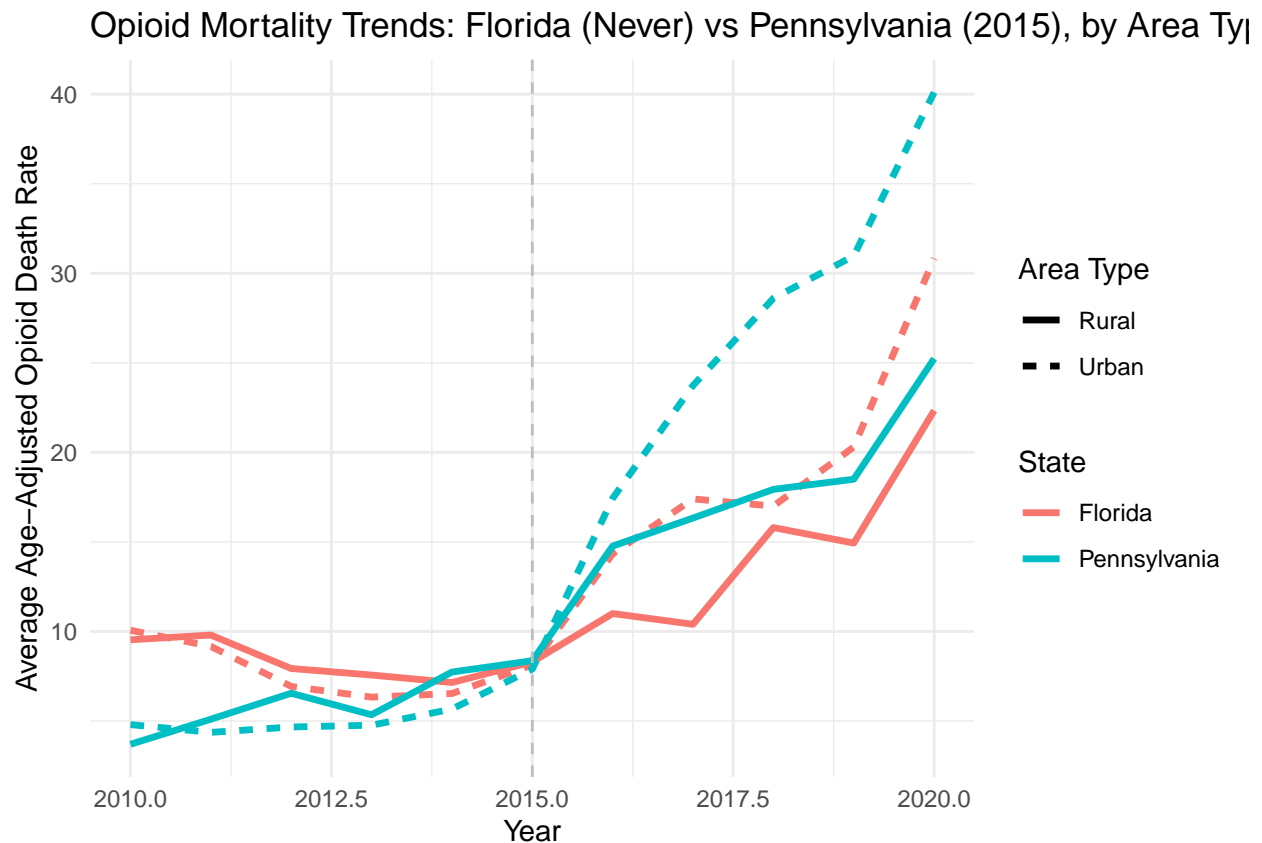
```
##expansion trends

# Group data by expansion year
MSA_exp <- MSA_Level_Deaths_in_States %>%
  filter(!is.na(`Year of Expansion`) & `Year of Expansion` %in% c(2014,2015, 2016, 2019,2020)) %>%
  mutate(exp_group = paste("Expanded in", `Year of Expansion`)) %>%
  group_by(Year, exp_group) %>%
  summarise(avg_rate = mean(`Age Adjusted Rate`, na.rm = TRUE), .groups = "drop")

# Plot
ggplot(MSA_exp, aes(x = Year, y = avg_rate, color = exp_group)) +
  geom_line(linewidth = 1.2) +
  geom_vline(xintercept = c(2014,2016,2019), linetype = "dashed", color = "gray40") +
  labs(
    title = "Opioid Mortality Trends by Medicaid Expansion Year",
    x = "Year",
    y = "Average Age-Adjusted Death Rate",
    color = "Expansion Group"
  ) +
  theme_minimal()
```


Opioid Mortality Trends by Medicaid Expansion Year