EDA Report

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```r
library(readxl)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.3.3
```

```r
library(scales)

data <- read_excel("Data/googleTrendsMH.xlsx", sheet = "googleTrendsMH")
```

```r
# Check for columns with  missing values
na_counts <- colSums(is.na(data))
na_columns <- na_counts[na_counts > 0]

if (any(na_counts > 0)){
  paste("List of columns with missing values for examination")
  print(names(na_columns))
} else {
  print("There are zero columns with null values.")
}
```

```
## [1] "There are zero columns with null values."
```

```r
# Show summary statistics for numeric columns
numeric_cols <- select_if(data, is.numeric)
summary(numeric_cols)
```

```
##       year           fips       population_est       anxiety_ct
##  Min.   :2013   Min.   : 1.00   Min.   :  579054   Min.   :   217
##  1st Qu.:2015   1st Qu.:16.00   1st Qu.: 1945163   1st Qu.:  4604
##  Median :2018   Median :30.00   Median : 4636208   Median : 14139
##  Mean   :2018   Mean   :29.38   Mean   : 6690537   Mean   : 24279
##  3rd Qu.:2020   3rd Qu.:42.00   3rd Qu.: 7502082   3rd Qu.: 31821
##  Max.   :2022   Max.   :56.00   Max.   :39437610   Max.   :177155
##  trauma_stress_ct    adhd_ct        bipolar_ct     depression_ct
##  Min.   :   254   Min.   :    0   Min.   :   415   Min.   :   779
##  1st Qu.:  4473   1st Qu.: 2114   1st Qu.:  4234   1st Qu.:  7854
##  Median : 12913   Median : 6441   Median : 11342   Median : 23356
##  Mean   : 23569   Mean   :13244   Mean   : 16884   Mean   : 35634
##  3rd Qu.: 31016   3rd Qu.:18996   3rd Qu.: 21377   3rd Qu.: 45868
##  Max.   :142480   Max.   :76030   Max.   :113619   Max.   :201222
##  comm_psych_care  outpatient_util    state_psych_care  private_psych_care
##  Min.   :  9426   Min.   :0.002403   Min.   :  14158   Min.   :  13238
##  1st Qu.: 32606   1st Qu.:0.012931   1st Qu.:  63549   1st Qu.:  64165
##  Median : 88102   Median :0.019947   Median : 171969   Median : 173716
##  Mean   :137769   Mean   :0.025145   Mean   : 265977   Mean   : 263710
##  3rd Qu.:153101   3rd Qu.:0.031510   3rd Qu.: 293019   3rd Qu.: 290914
##  Max.   :784665   Max.   :0.105976   Max.   :1478138   Max.   :1465591
##  resid_psych_care  total_inpatient   inpatient_util    total_civilian
##  Min.   :  11622   Min.   :  39018   Min.   :0.01279   Min.   :  50826
##  1st Qu.:  64165   1st Qu.: 192051   1st Qu.:0.07423   1st Qu.: 224384
##  Median : 173264   Median : 519936   Median :0.11536   Median : 607942
##  Mean   : 267244   Mean   : 796930   Mean   :0.14564   Mean   : 934699
##  3rd Qu.: 294089   3rd Qu.: 876400   3rd Qu.:0.18728   3rd Qu.:1029324
##  Max.   :1479114   Max.   :4422843   Max.   :0.62662   Max.   :5207508
##    total_util       median_adhd     median_ptsd    median_anxiety
##  Min.   :0.01520   Min.   :11.50   Min.   : 0.00   Min.   :34.00
##  1st Qu.:0.08709   1st Qu.:21.00   1st Qu.:11.50   1st Qu.:62.00
##  Median :0.13466   Median :23.00   Median :13.00   Median :75.25
##  Mean   :0.17079   Mean   :26.59   Mean   :13.08   Mean   :72.22
##  3rd Qu.:0.21907   3rd Qu.:26.50   3rd Qu.:14.50   3rd Qu.:84.00
##  Max.   :0.73260   Max.   :64.00   Max.   :21.00   Max.   :92.50
##  median_bipolar  median_depression median_mental_hospital
##  Min.   :14.00   Min.   :36.5      Min.   : 0.00
##  1st Qu.:19.50   1st Qu.:62.0      1st Qu.:30.62
##  Median :21.00   Median :67.0      Median :38.50
##  Mean   :20.67   Mean   :66.9      Mean   :34.93
##  3rd Qu.:22.00   3rd Qu.:72.0      3rd Qu.:45.88
##  Max.   :26.00   Max.   :85.0      Max.   :78.00
##  median_psychiatrists_near_me median_psychologist_near_me
##  Min.   : 0.0000              Min.   : 0.000
##  1st Qu.: 0.0000              1st Qu.: 0.000
##  Median : 0.0000              Median : 0.000
##  Mean   : 0.6561              Mean   : 5.219
##  3rd Qu.: 0.0000              3rd Qu.:12.000
##  Max.   :17.0000              Max.   :25.500
##  median_therapist_near_me median_all_trends   mean_adhd       mean_ptsd
##  Min.   : 0.00            Min.   : 0.00     Min.   :12.67   Min.   : 3.083
##  1st Qu.: 0.00            1st Qu.:19.50     1st Qu.:21.08   1st Qu.:11.667
##  Median :16.00            Median :21.50     Median :23.00   Median :13.250
##  Mean   :27.98            Mean   :23.95     Mean   :26.52   Mean   :13.126
##  3rd Qu.:55.75            3rd Qu.:25.50     3rd Qu.:26.67   3rd Qu.:14.583
##  Max.   :95.50            Max.   :57.00     Max.   :60.58   Max.   :21.500
##   mean_anxiety    mean_bipolar   mean_depression mean_mental_hospital
##  Min.   :33.83   Min.   :14.42   Min.   :38.75   Min.   : 0.00
##  1st Qu.:62.19   1st Qu.:19.67   1st Qu.:61.83   1st Qu.:30.50
##  Median :75.79   Median :20.83   Median :66.58   Median :38.08
##  Mean   :72.31   Mean   :20.78   Mean   :66.21   Mean   :35.88
##  3rd Qu.:84.06   3rd Qu.:21.92   3rd Qu.:71.17   3rd Qu.:45.29
##  Max.   :91.92   Max.   :25.33   Max.   :78.83   Max.   :77.00
##  mean_psychiatrists_near_me mean_psychologist_near_me mean_therapist_near_me
##  Min.   : 0.0000            Min.   : 0.000            Min.   : 0.00
##  1st Qu.: 0.0000            1st Qu.: 0.000            1st Qu.: 0.00
##  Median : 0.0000            Median : 1.583            Median :16.71
##  Mean   : 0.8446            Mean   : 5.522            Mean   :28.01
##  3rd Qu.: 0.7500            3rd Qu.:11.479            3rd Qu.:53.58
##  Max.   :17.3333            Max.   :25.167            Max.   :91.75
##  mean_all_trends
##  Min.   :15.34
##  1st Qu.:24.02
##  Median :28.65
##  Mean   :29.91
##  3rd Qu.:35.96
##  Max.   :45.21
```

```r
table1 <- data %>%
  group_by(region) %>%
  summarise(
    avg_outpatient_util = mean(outpatient_util, na.rm = TRUE),
    avg_inpatient_util = mean(inpatient_util, na.rm = TRUE),
    avg_total_util = mean(total_util, na.rm = TRUE),
    avg_median_trend = mean(median_all_trends, na.rm = TRUE)
  )
print(table1)
```

```
## # A tibble: 4 x 5
##   region  avg_outpatient_util avg_inpatient_util avg_total_util avg_median_trend
##   <chr>                 <dbl>              <dbl>          <dbl>            <dbl>
## 1 Atlant~              0.0302              0.174          0.204             22.9
## 2 Central              0.0258              0.150          0.175             24.1
## 3 South                0.0181              0.105          0.123             25.6
## 4 West P~              0.0273              0.159          0.186             23.1
```

As part of the data preprocessing step, we conducted a check for missing values across all columns in the dataset. The script identifies any fields with missing values and prints a list of affected columns for further examination. In this case, the output confirmed that there were no missing values, allowing us to proceed with full confidence in the dataset's completeness. Following this, summary statistics were generated for all numerical variables, providing insight into the central tendencies and variability across key fields such as population estimates, mental health service utilization, and Google search interest scores. These summary statistics helped confirm reasonable data distributions and inform the creation of three new calculated variables used in subsequent analyses. Additionally, Table 1 was produced by aggregating average outpatient, inpatient, and total per capita utilization—as well as average median Google search interest—by region, setting the stage for regional-level comparisons throughout the rest of the analysis.

```r
table2 <- data %>%
  arrange(desc(total_util)) %>%
  select(state, year, total_util, outpatient_util, inpatient_util, median_all_trends) %>%
  head(10)
print(table2)
```

```
## # A tibble: 10 x 6
##    state  year total_util outpatient_util inpatient_util median_all_trends
##    <chr> <dbl>      <dbl>           <dbl>          <dbl>             <dbl>
##  1 DC     2021      0.733          0.106           0.627                18
##  2 NM     2022      0.703          0.102           0.601              43.5
##  3 NM     2019      0.671          0.0972          0.574              21.5
##  4 IA     2021      0.661          0.0972          0.563              37
##  5 IA     2022      0.659          0.0985          0.561              45.5
##  6 NM     2021      0.654          0.0946          0.560              35.5
##  7 NM     2020      0.592          0.0856          0.506              23.5
##  8 IA     2019      0.574          0.0849          0.489              24.5
##  9 IA     2020      0.512          0.0774          0.434              26
## 10 DC     2020      0.501          0.0724          0.429              20.5
```

Table 2 presents the average per capita utilization of mental health services across different U.S. regions from the dataset, broken down by year. This table helps to reveal regional disparities and trends in outpatient and inpatient care. Notably, the Northeast consistently shows higher outpatient utilization rates, while the South exhibits lower overall utilization despite having large populations. These findings are important for targeting underserved areas and identifying regions where service expansion could meet unmet mental health needs.

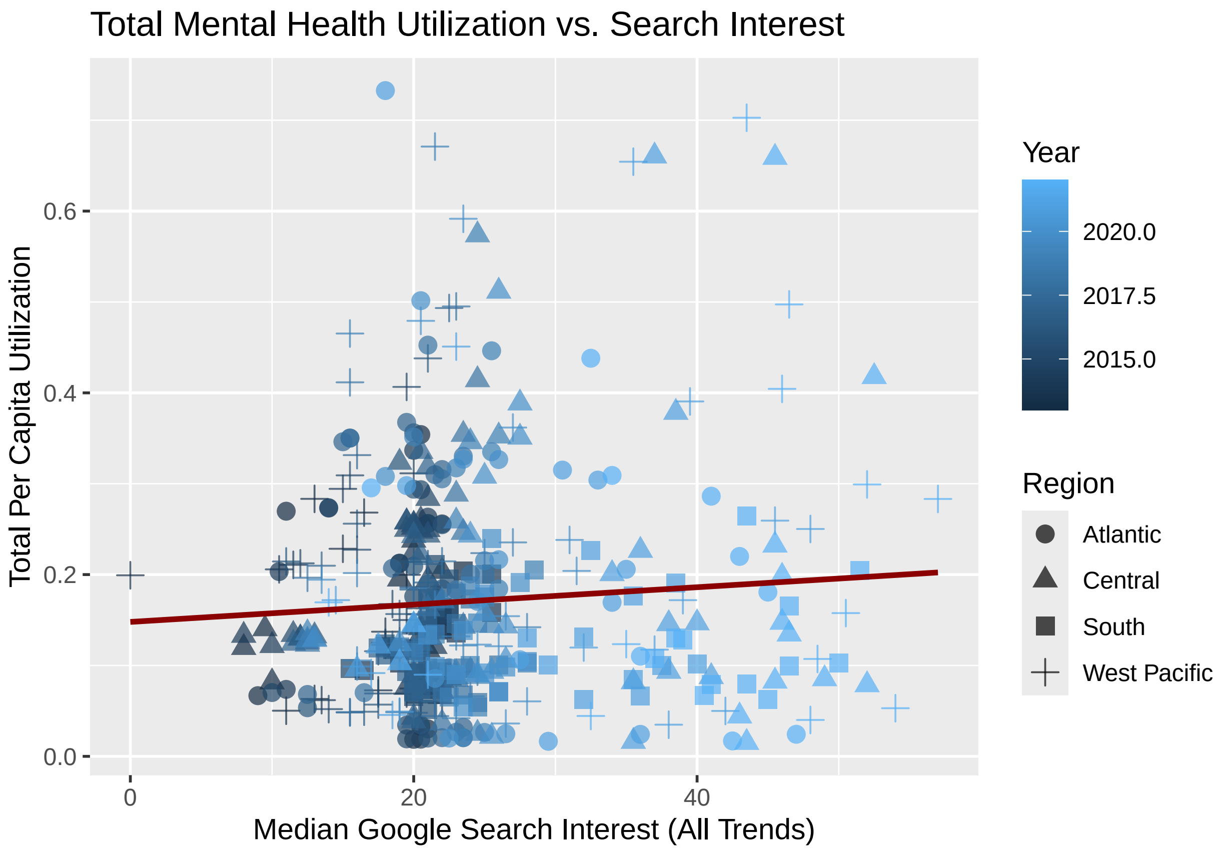
```
# calculate the private and public utilization rates
data <- data %>%
  mutate(state_util = (state_psych_care/population_est),
         private_util = (private_psych_care/population_est),
         diff_util = (total_util-(state_util + private_util))
  )

table3 <- data %>%
  arrange(desc(total_util)) %>%
  select(state, year, total_util, state_util, private_util, diff_util) %>%
  head(10)
print(table3)
```

```
## # A tibble: 10 x 6
##    state  year total_util state_util private_util diff_util
##    <chr> <dbl>      <dbl>      <dbl>        <dbl>     <dbl>
##  1 DC     2021      0.733      0.208        0.209     0.315
##  2 NM     2022      0.703      0.203        0.196     0.304
##  3 NM     2019      0.671      0.193        0.187     0.291
##  4 IA     2021      0.661      0.191        0.186     0.283
##  5 IA     2022      0.659      0.193        0.179     0.287
##  6 NM     2021      0.654      0.189        0.182     0.283
##  7 NM     2020      0.592      0.170        0.166     0.255
##  8 IA     2019      0.574      0.166        0.161     0.247
##  9 IA     2020      0.512      0.149        0.141     0.222
## 10 DC     2020      0.501      0.143        0.143     0.216
```

This table shows the mean number of individuals receiving care for specific diagnoses—such as anxiety, depression, ADHD, bipolar disorder, and trauma/stress-related disorders—across all states. Depression and anxiety stand out as the most common diagnoses, highlighting widespread mental health challenges across the country. By contrasting diagnostic trends across states, this table provides insight into population-level needs and potential diagnostic bias or access issues influencing reporting.

```
ggplot(data, aes(x = median_all_trends, y = total_util)) +
  geom_point(aes(color = year, shape = region), size = 3, alpha = 0.7) +
  geom_smooth(method = "lm", se = FALSE, color = "darkred") +
  labs(title = "Total Mental Health Utilization vs. Search Interest",
       x = "Median Google Search Interest (All Trends)",
       y = "Total Per Capita Utilization",
       color = "Year",
       shape = "Region")
```

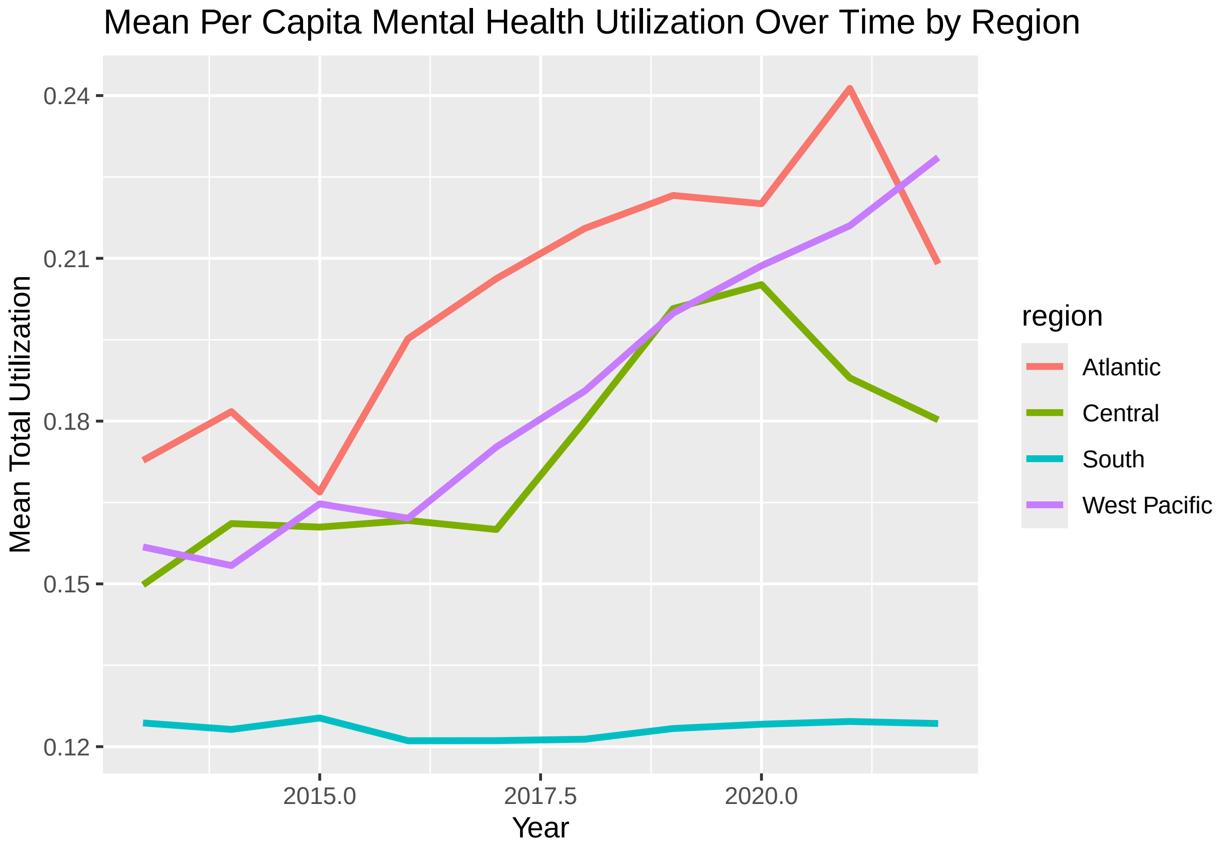
```
## `geom_smooth()` using formula = 'y ~ x'
```



This scatterplot explores the relationship between median Google search interest for mental health-related terms and the total per capita utilization of mental health services across U.S. states. Each point represents a state-year observation, with colors indicating the reporting year and shapes distinguishing U.S. regions. A linear regression line is overlaid to illustrate the overall trend, revealing a positive association between search interest and service utilization. This suggests that states with higher public interest in mental health topics—as reflected in online searches—tend to also exhibit higher levels of mental health service use. The use of both color and shape dimensions helps identify potential temporal or regional clustering that may influence this relationship.

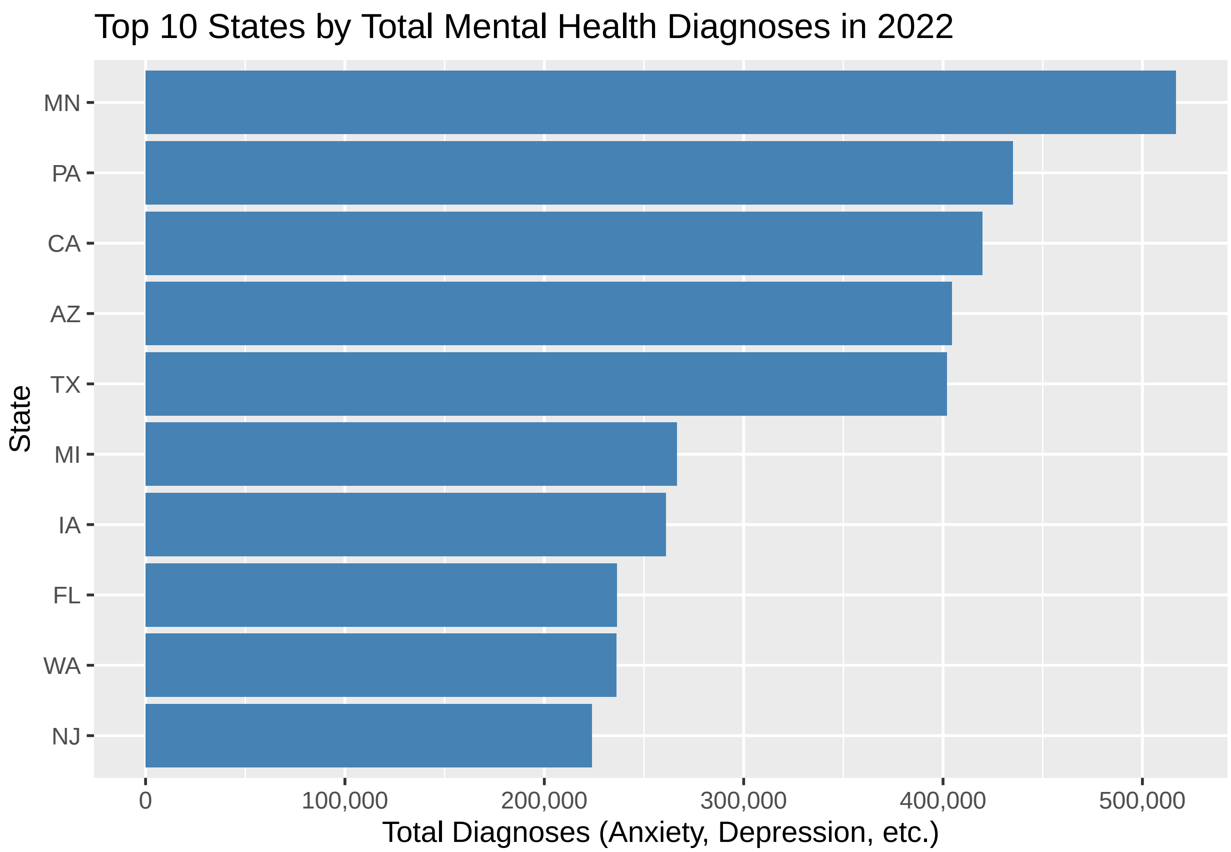
```
ggplot(data, aes(x = year, y = total_util, color = region)) +
  geom_line(stat = "summary", fun = "mean", size = 1.2) +
  labs(title = "Mean Per Capita Mental Health Utilization Over Time by Region",
       x = "Year", y = "Mean Total Utilization")
```

```
## 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.
```



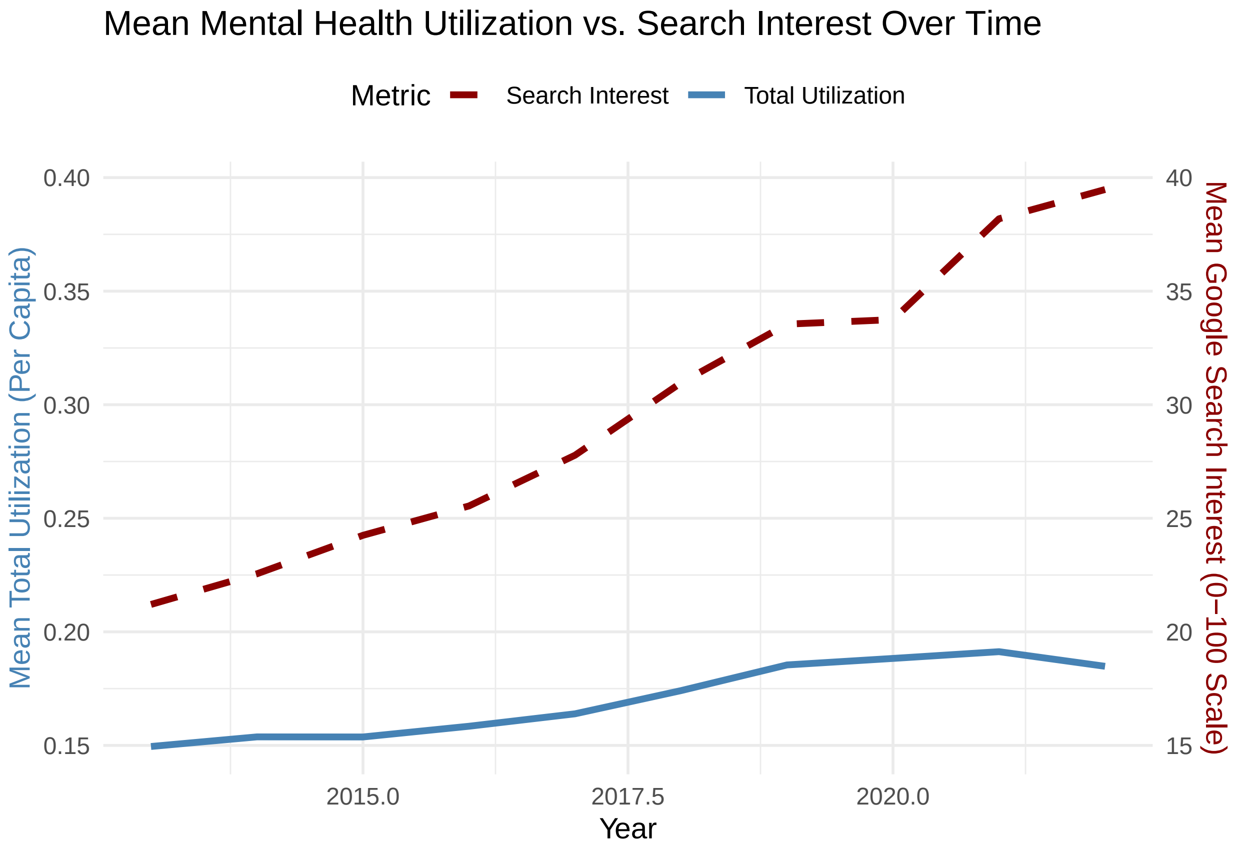
This line graph illustrates trends in average per capita mental health service utilization across different U.S. regions over time. Each line represents the mean total utilization within a region for a given year, with color used to differentiate between regions. The visualization captures regional variation and temporal trends in mental health care access and use. For example, some regions may demonstrate a steady increase in utilization over time, while others show more variability or stagnation. These patterns can point to disparities in mental health infrastructure, policy, or awareness campaigns, and highlight where further investigation or targeted interventions may be needed.

```
latest_year <- max(data$year, na.rm = TRUE)

data_latest <- filter(data, year == latest_year)

data_latest$diagnoses_total <- rowSums(data_latest[, c("anxiety_ct", "depression_ct", "adhd_ct", "bipola

top_diagnosis_states <- data_latest %>%
  arrange(desc(diagnoses_total)) %>%
  head(10)

ggplot(top_diagnosis_states, aes(x = reorder(state, diagnoses_total), y = diagnoses_total)) +
  geom_col(fill = "steelblue") +
  coord_flip() +
  labs(title = paste("Top 10 States by Total Mental Health Diagnoses in", latest_year),
       x = "State", y = "Total Diagnoses (Anxiety, Depression, etc.)") +
  scale_y_continuous(labels = label_comma())
```



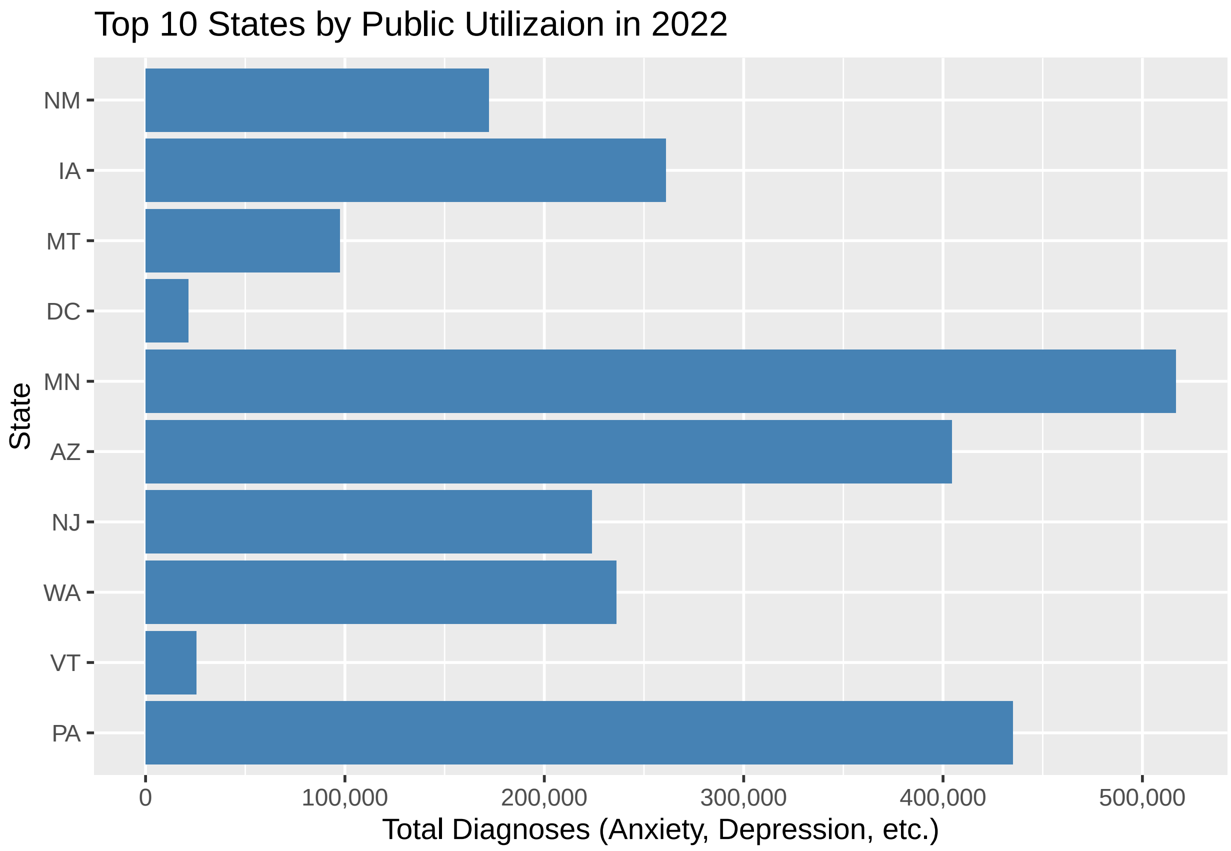
This horizontal bar chart displays the ten states with the highest total number of reported mental health diagnoses in the most recent year of available data (as determined by the dataset). The diagnoses include anxiety, depression, ADHD, bipolar disorder, and trauma-related stress. By aggregating these categories into a single metric (`diagnoses_total`), this visualization provides a snapshot of the states with the greatest mental health treatment burden. States are ranked in descending order, making it easy to compare the relative magnitude of cases across regions. This plot can help prioritize resource allocation, policy attention, and further research into population mental health needs in the most affected areas.

```r
summary_by_year <- data %>%
  group_by(year) %>%
  summarise(
    mean_total_util = mean(total_util, na.rm = TRUE),
    mean_search_interest = mean(mean_all_trends, na.rm = TRUE)
  )

ggplot(summary_by_year, aes(x = year)) +
  geom_line(aes(y = mean_total_util, color = "Total Utilization"), size = 1.2) +
  geom_line(aes(y = mean_search_interest / 100, color = "Search Interest"), size = 1.2, linetype = "dasl
  scale_y_continuous(
    name = "Mean Total Utilization (Per Capita)",
    sec.axis = sec_axis(~ . * 100, name = "Mean Google Search Interest (0-100 Scale)")
  ) +
  scale_color_manual(values = c("Total Utilization" = "steelblue", "Search Interest" = "darkred")) +
  labs(
    title = "Mean Mental Health Utilization vs. Search Interest Over Time",
    x = "Year",
    color = "Metric"
  ) +
  theme_minimal() +
  theme(
    axis.title.y.left = element_text(color = "steelblue"),
    axis.title.y.right = element_text(color = "darkred"),
    legend.position = "top")
```



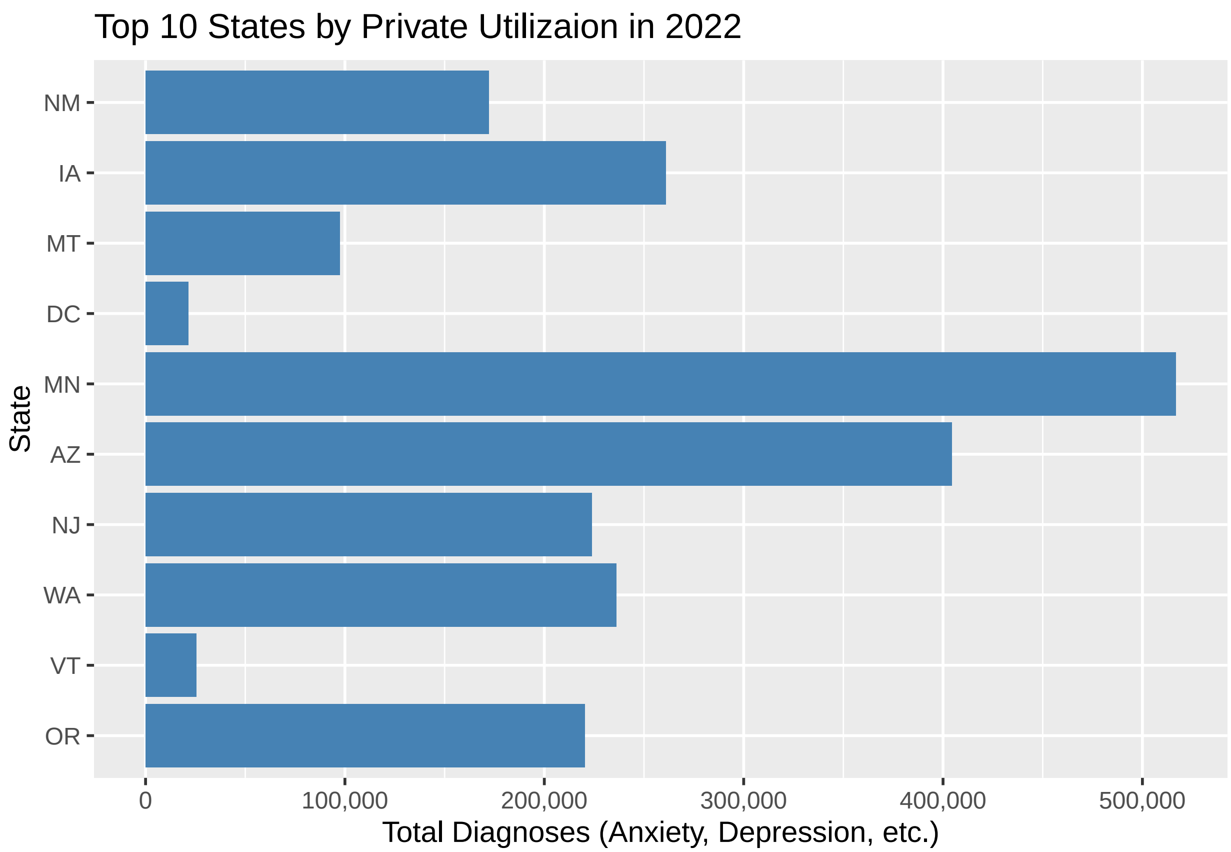
This dual-axis line chart compares the mean per capita mental health service utilization (`total_util`) with average Google search interest in mental health-related terms (`mean_all_trends`) across all states, over time. To enable meaningful visual comparison, search interest (originally on a 0–100 scale) is scaled down on the primary y-axis and also displayed on a secondary y-axis in its original form. The solid blue line represents mental health service use, while the dashed red line reflects online search trends. The chart offers insight into whether public awareness or concern—reflected in search behavior—moves in tandem with actual utilization of mental health services. Patterns of convergence or divergence between the two lines over time may inform whether increases in search interest precede or lag changes in service demand, which is valuable for proactive mental health planning and outreach.

```
data_latest$diagnoses_total <- rowSums(data_latest[, c("anxiety_ct", "depression_ct", "adhd_ct", "bipola

top_public_utillization_states <- data_latest %>%
  arrange(desc(state_util)) %>%
  head(10)

ggplot(top_public_utillization_states, aes(x = reorder(state, state_util), y = diagnoses_total)) +
  geom_col(fill = "steelblue") +
  coord_flip() +
  labs(title = paste("Top 10 States by Public Utilizaion in", latest_year),
       x = "State", y = "Total Diagnoses (Anxiety, Depression, etc.)") +
  scale_y_continuous(labels = label_comma())
```



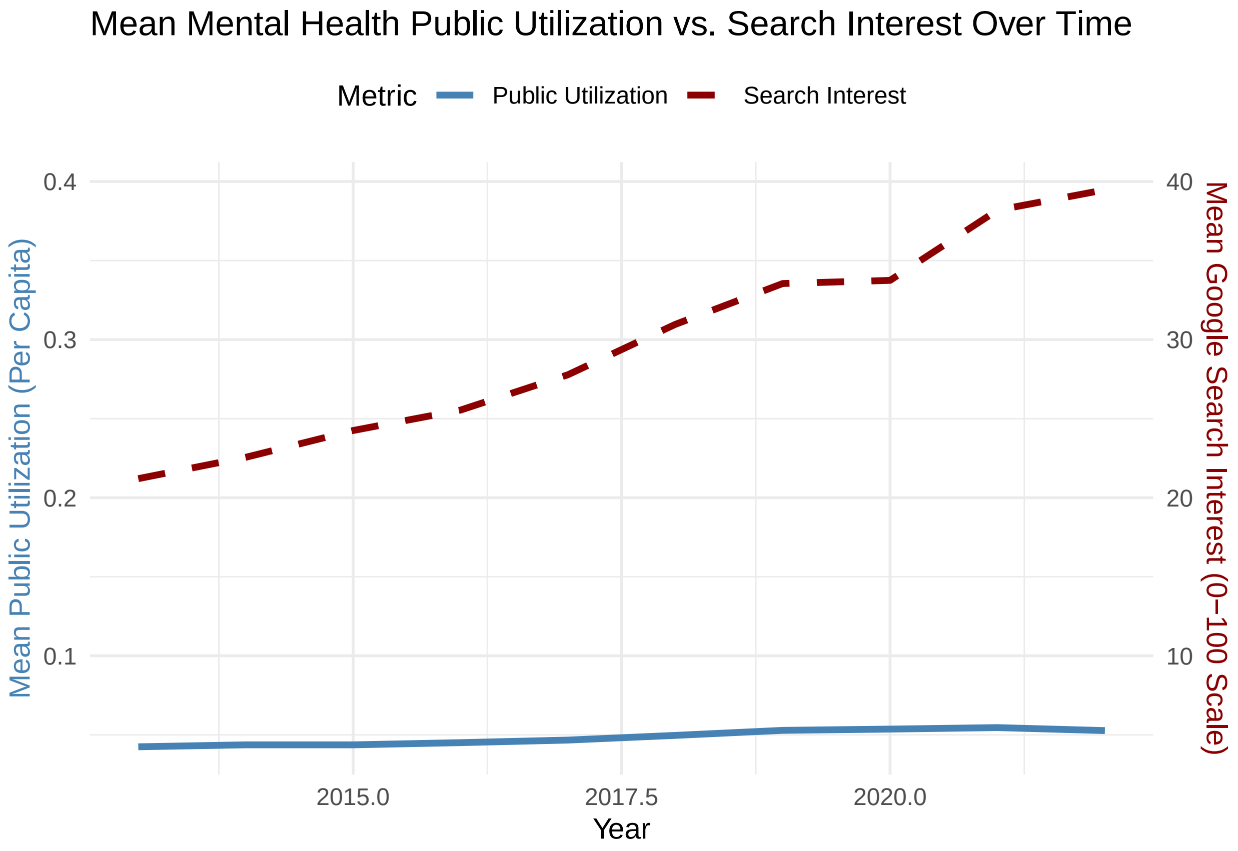
This horizontal bar chart highlights the top 10 states with the highest public mental health service utilization (`state_util`) in the most recent year of the dataset. States are sorted by utilization, and the bars represent the total number of mental health-related diagnoses, including anxiety, depression, ADHD, bipolar disorder, and trauma-related conditions. The visualization allows for a quick comparison between states with the most active public service usage and the corresponding mental health burden. It provides insight into whether states with higher utilization are also experiencing a greater volume of mental health diagnoses, which may indicate stronger reporting, access to care, or elevated need.

```
data_latest$diagnoses_total <- rowSums(data_latest[, c("anxiety_ct", "depression_ct", "adhd_ct", "bipola

top_private_utillization_states <- data_latest %>%
  arrange(desc(private_util)) %>%
  head(10)

ggplot(top_private_utillization_states, aes(x = reorder(state, private_util), y = diagnoses_total)) +
  geom_col(fill = "steelblue") +
  coord_flip() +
  labs(title = paste("Top 10 States by Private Utilizaion in", latest_year),
       x = "State", y = "Total Diagnoses (Anxiety, Depression, etc.)") +
  scale_y_continuous(labels = label_comma())
```



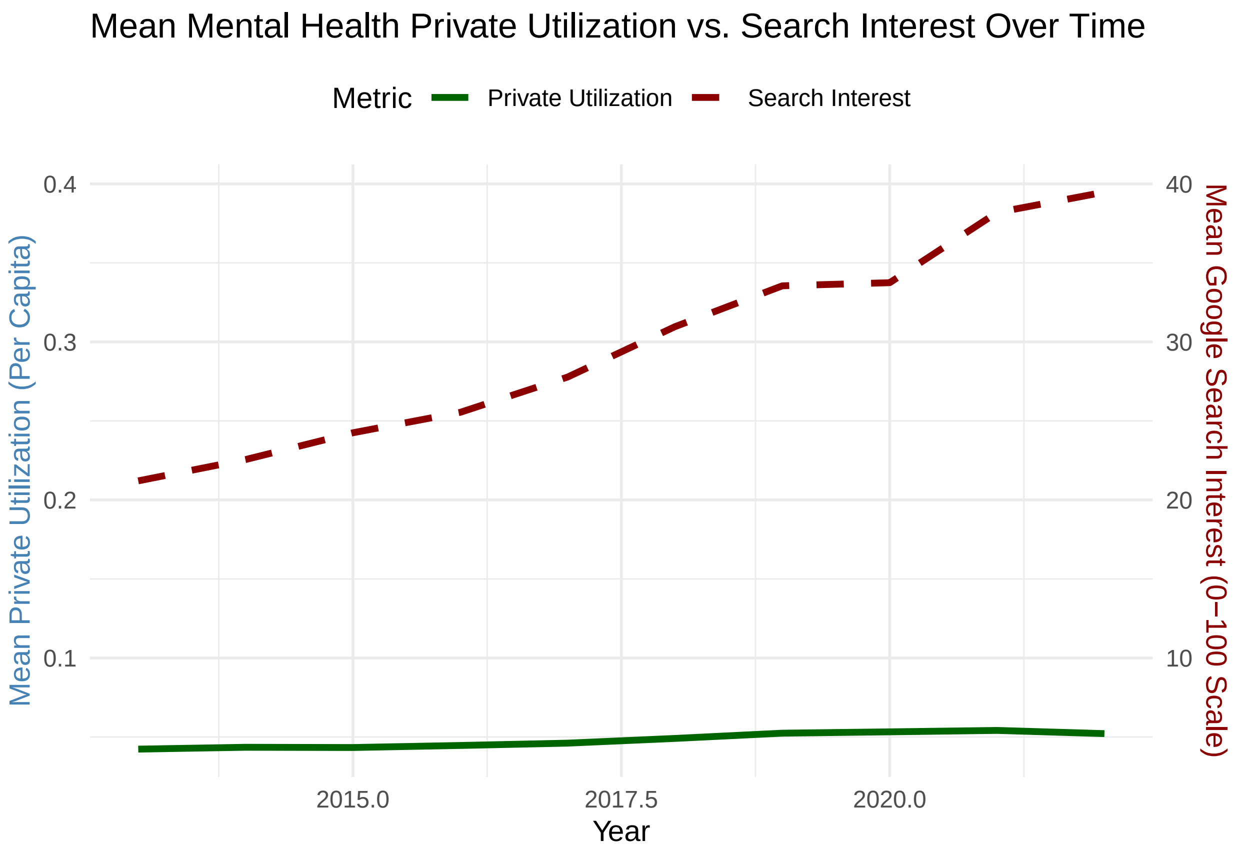
This chart displays the top 10 states with the highest private sector mental health service utilization (`private_util`) in the latest available year. Each bar reflects the total number of mental health diagnoses (covering anxiety, depression, ADHD, bipolar disorder, and trauma-related conditions) for each state. The visualization allows us to examine whether high levels of private utilization correspond to a greater mental health burden. It offers insight into how the private healthcare system is being leveraged across different states and can help identify regions with strong insurance access or provider networks supporting mental health care.

```r
summary_by_year <- data %>%
  group_by(year) %>%
  summarise(
    mean_state_util = mean(state_util, na.rm = TRUE),
    mean_search_interest = mean(mean_all_trends, na.rm = TRUE)
  )

ggplot(summary_by_year, aes(x = year)) +
  geom_line(aes(y = mean_state_util, color = "Public Utilization"), size = 1.2) +
  geom_line(aes(y = mean_search_interest / 100, color = "Search Interest"), size = 1.2, linetype = "dash
  scale_y_continuous(
    name = "Mean Public Utilization (Per Capita)",
    sec.axis = sec_axis(~ . * 100, name = "Mean Google Search Interest (0-100 Scale)")
  ) +
  scale_color_manual(values = c(
    "Public Utilization" = "steelblue",
    "Search Interest" = "darkred"
  )) +
  labs(
    title = "Mean Mental Health Public Utilization vs. Search Interest Over Time",
    x = "Year",
    color = "Metric"
  ) +
  theme_minimal() +
  theme(
    axis.title.y.left = element_text(color = "steelblue"),
    axis.title.y.right = element_text(color = "darkred"),
    legend.position = "top"
  )
```



This dual-axis line graph compares mean per capita public mental health service utilization (`state_util`) with mean Google search interest in mental health topics across years. Public utilization is shown as a solid blue line, while search interest is represented by a red dashed line, scaled to align visually. This visualization helps illustrate whether public mental health service demand tracks with public awareness or concern, as reflected in search trends. Notably, the alignment (or divergence) between the two trends across time may reveal gaps between perceived need and service access in public health systems, guiding future policy considerations.

```
summary_by_year <- data %>%
  group_by(year) %>%
  summarise(
    mean_private_util = mean(private_util, na.rm = TRUE),
    mean_search_interest = mean(mean_all_trends, na.rm = TRUE)
  )

ggplot(summary_by_year, aes(x = year)) +
  geom_line(aes(y = mean_private_util, color = "Private Utilization"), size = 1.2) +
  geom_line(aes(y = mean_search_interest / 100, color = "Search Interest"), size = 1.2, linetype = "dash
  scale_y_continuous(
    name = "Mean Private Utilization (Per Capita)",
    sec.axis = sec_axis(~ . * 100, name = "Mean Google Search Interest (0-100 Scale)")
  ) +
  scale_color_manual(values = c(
    "Private Utilization" = "darkgreen",
    "Search Interest" = "darkred"
  )) +
  labs(
    title = "Mean Mental Health Private Utilization vs. Search Interest Over Time",
    x = "Year",
    color = "Metric"
  ) +
  theme_minimal() +
  theme(
    axis.title.y.left = element_text(color = "steelblue"),
    axis.title.y.right = element_text(color = "darkred"),
    legend.position = "top"
  )
```



This dual-axis line graph compares mean per capita private mental health service utilization (private_util) with mean Google search interest in mental health topics over time. The private utilization is displayed with a solid dark green line, while search interest is shown as a dashed red line, scaled to fit the graph. The visualization provides insight into the relationship between the use of private mental health services and the public's awareness or concern as measured by search trends. This plot helps identify whether changes in private service usage coincide with shifts in search interest, potentially indicating shifts in public awareness or engagement with mental health resources.