

# Initial Models Report

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## *#libraries*

```
library(readxl)
library(caret)
library(tidyr)
library(dplyr)
library(corrplot)
library(rvest)
library(glmnet)
library(pls)
```

## *#reading data*

```
# data_GTrends <- read_excel("C:/data_science/DSE63110M/week3_Exploratory Data Analysis/googleTrendsMH")
# acs_data <- load("C:\\data_science\\DSE63110M\\Week4_Pre-processing and Feature Engineering\\ACS_for_")
# Replace with this code to allow quick access regardless of download location
data_GTrends <- read_excel("~/GitHub/DSE63110M_SP2025R2_Data-Science-Capstone/Data/googleTrendsMH.xlsx"
  sheet = "googleTrendsMH")
acs_data <- load("~/GitHub/DSE63110M_SP2025R2_Data-Science-Capstone/Data/ACS_for_MHGoogleTrends.Rdata")

acs_data <- ACS_data
ACS_data <- NULL
```

## *##CORRELATION MATRIX FOR acs\_data*

```
acs_correlation_matrix <- acs_data %>%
  select_if(is.numeric) %>%
  select(-prop_persons_below_poverty_threshold, -prop_veterans_disability) %>%
  cor()

print(acs_correlation_matrix)
```

```
##               year prop_families_below_poverty
## year           1.00000000 -0.1610309
## prop_families_below_poverty -0.16103094 1.0000000
## prop_adults_without_health_insurance -0.35051348 0.1974453
## prop_unemployed_in_labor_force -0.50071692 0.6113240
## prop_without_internet_access 0.31496819 0.3030755
## prop_adult_disability 0.04834553 0.5972604
##               prop_adults_without_health_insurance
## year -0.3505135
```

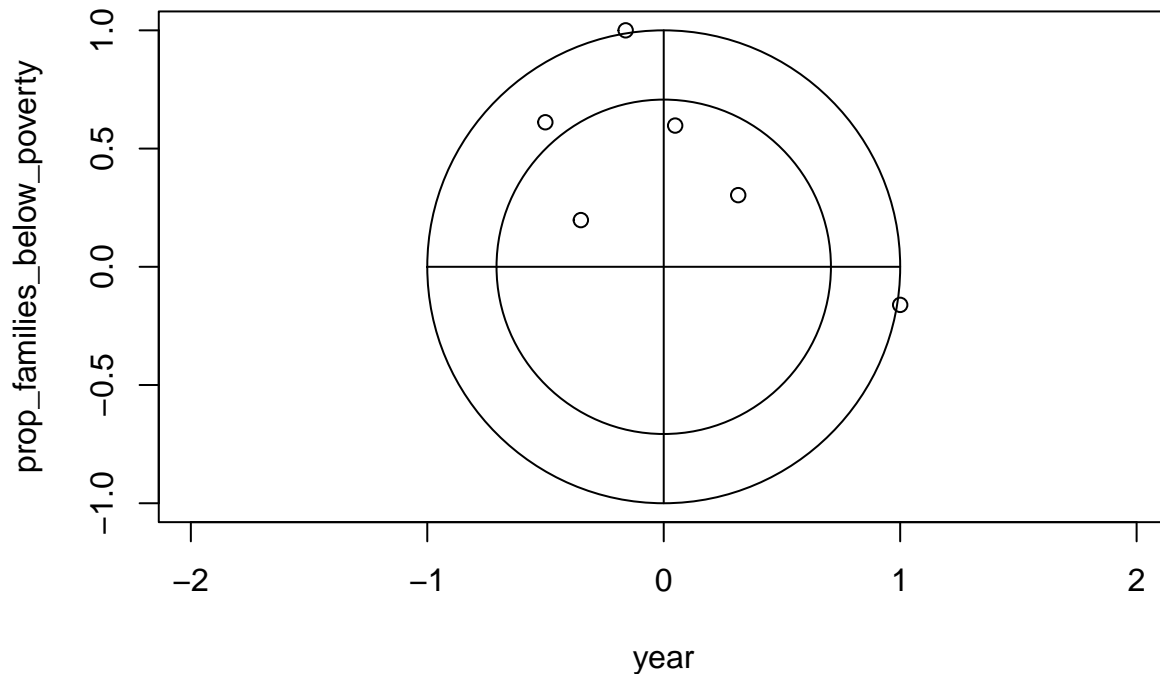
```
## prop_families_below_poverty 0.1974453
## prop_adults_without_health_insurance 1.0000000
## prop_unemployed_in_labor_force 0.2889701
## prop_without_internet_access -0.1226758
## prop_adult_disability 0.1945398
##
## prop_unemployed_in_labor_force
## year -0.5007169
## prop_families_below_poverty 0.6113240
## prop_adults_without_health_insurance 0.2889701
## prop_unemployed_in_labor_force 1.0000000
## prop_without_internet_access -0.1705119
## prop_adult_disability 0.1723363
##
## prop_without_internet_access
## year 0.3149682
## prop_families_below_poverty 0.3030755
## prop_adults_without_health_insurance -0.1226758
## prop_unemployed_in_labor_force -0.1705119
## prop_without_internet_access 1.0000000
## prop_adult_disability 0.3494365
##
## prop_adult_disability
## year 0.04834553
## prop_families_below_poverty 0.59726036
## prop_adults_without_health_insurance 0.19453980
## prop_unemployed_in_labor_force 0.17233629
## prop_without_internet_access 0.34943653
## prop_adult_disability 1.00000000
```

updated code

```
#presenting correlation matrix in graphic format

acs_correlation_matrix <- acs_data %>%
  select_if(is.numeric) %>%
  select(-prop_persons_below_poverty_threshold, -prop_veterans_disability) %>%
  cor() %>%
  corrplot( diag = F,
            tl.cex = 0.7,
            tl.col = "black",
            main = "acs_data correlation matrix",
            mar = c(0,0,1,0))
```

## acs\_data correlation matrix



*#removing correlated features*

```
acs_data_clean <- acs_data %>%
  select(-prop_persons_below_poverty_threshold, -prop_veterans_disability)
```

*# convert state names into abbreviation to match state in data\_GTrends*

```
acs_data_clean$state <- toupper(state.abb[match(tolower(acs_data_clean$state), tolower(state.name))])
```

testing GitHub

*#data transformations ct variables*

*#creating response variable => state\_mentalhealth\_utili = state\_psych\_care / population\_est*

*#state\_mentalhealth\_utili <- data\_GTrends\$state\_psych\_care / data\_GTrends\$population\_est*

```
data_GTrends <- data_GTrends %>%
  mutate(state_mentalhealth_utili = state_psych_care/population_est,
         anxiety_prop = anxiety_ct/ population_est,
         trauma_stress_prop = trauma_stress_ct/population_est,
         adhd_prop = adhd_ct/population_est,
         bipolar_prop = bipolar_ct/population_est,
         depression_prop = depression_ct/population_est)
```

*#data\_GTrends <- data\_GTrends %>%*

*#select(-state\_psych\_care, -anxiety\_ct, -trauma\_stress\_ct, -adhd\_ct, -bipolar\_ct, -depression\_ct) all*

```
#joining both datasets acs_data and data_GTrends
```

```
GTrends_acs_joined <- inner_join(data_GTrends, acs_data_clean, by = c("year", "state"))
```

```
#testing correlation
```

```
correlation_matrix <- GTrends_acs_joined %>%
  select_if(is.numeric) %>%
  select(-fips, -population_est, -private_psych_care, -total_util, -outpatient_util, -mean_anxiety, -res,
    -total_util) %>%
  cor()

print(correlation_matrix)
```

```
##           year  anxiety_ct trauma_stress_ct
## year          1.00000000  0.230563501      0.13366856
## anxiety_ct      0.23056350  1.000000000      0.92240079
## trauma_stress_ct 0.13366856  0.922400795      1.00000000
## adhd_ct         0.01851770  0.847645702      0.87161036
## bipolar_ct      -0.13690754  0.653131435      0.75571956
## depression_ct    0.06120702  0.873780027      0.94087338
## comm_psych_care  0.05264059  0.793626073      0.89977194
## state_psych_care 0.05220254  0.800842275      0.90248691
## mean_adhd        0.75682637  0.192811841      0.08958471
## mean_ptsd        0.62228218  0.090669189      0.04475684
## mean_bipolar     -0.09097469 -0.085128361      -0.08423315
## mean_depression  -0.02390143  0.009319898      -0.02136263
## mean_mental_hospital 0.27777930  0.319455125      0.28112091
## mean_psychiatrists_near_me 0.18697534  0.063526502      0.09919989
## mean_psychologist_near_me 0.64878930  0.404062943      0.38356349
## anxiety_prop      0.25256530  0.575638687      0.40794338
## adhd_prop         0.02582844  0.540119606      0.44884626
## bipolar_prop      -0.27713846  0.402247684      0.39406527
## prop_families_below_poverty -0.31411265 -0.065951520      -0.02266406
## prop_adults_without_health_insurance -0.35036488 -0.120820100      -0.08943951
## prop_unemployed_in_labor_force -0.54031845 -0.047006409      0.07676369
## prop_without_internet_access 0.31423583  0.011777977      -0.03506000
## prop_adult_disability 0.07154859 -0.089418168      -0.12802032
##           adhd_ct  bipolar_ct  depression_ct
## year          0.018517704 -0.13690754  0.06120702
## anxiety_ct      0.847645702  0.65313144  0.87378003
## trauma_stress_ct 0.871610355  0.75571956  0.94087338
## adhd_ct         1.000000000  0.83440163  0.90823233
## bipolar_ct      0.834401629  1.00000000  0.88673220
## depression_ct    0.908232333  0.88673220  1.00000000
## comm_psych_care  0.874225711  0.87090215  0.95667411
## state_psych_care 0.884006979  0.87166405  0.95701158
## mean_adhd       -0.007745775 -0.10866030  0.02253769
## mean_ptsd       -0.124707857 -0.22821302 -0.08131642
## mean_bipolar     -0.082850695 -0.03030126 -0.08659302
## mean_depression  -0.026389005 -0.09361394 -0.02884011
## mean_mental_hospital 0.220054198  0.21655455  0.28147786
```

## mean_psychiatrists_near_me	0.086212620	0.06521304	0.09221333
## mean_psychologist_near_me	0.316683082	0.20732437	0.35169600
## anxiety_prop	0.306023903	0.03211950	0.27306557
## adhd_prop	0.557691198	0.19368296	0.36224924
## bipolar_prop	0.458390120	0.36562312	0.36378200
## prop_families_below_poverty	0.091452450	0.21421452	0.06093810
## prop_adults_without_health_insurance	0.001121328	0.24369742	0.03448441
## prop_unemployed_in_labor_force	0.124358517	0.28278587	0.13217179
## prop_without_internet_access	0.010097643	-0.11859483	-0.03027184
## prop_adult_disability	-0.041620397	-0.11618594	-0.11834226
##	comm_psych_care	state_psych_care	
## year	0.05264059	0.05220254	
## anxiety_ct	0.79362607	0.80084228	
## trauma_stress_ct	0.89977194	0.90248691	
## adhd_ct	0.87422571	0.88400698	
## bipolar_ct	0.87090215	0.87166405	
## depression_ct	0.95667411	0.95701158	
## comm_psych_care	1.00000000	0.99936080	
## state_psych_care	0.99936080	1.00000000	
## mean_adhd	0.01154550	0.01301038	
## mean_ptsd	-0.09505592	-0.09409334	
## mean_bipolar	-0.06243299	-0.06269307	
## mean_depression	-0.04094749	-0.04237320	
## mean_mental_hospital	0.24373032	0.24415647	
## mean_psychiatrists_near_me	0.13571311	0.13354197	
## mean_psychologist_near_me	0.36100819	0.35825438	
## anxiety_prop	0.18813746	0.20049138	
## adhd_prop	0.28982510	0.30527377	
## bipolar_prop	0.30483675	0.31814831	
## prop_families_below_poverty	0.06341390	0.06303851	
## prop_adults_without_health_insurance	0.02920460	0.02820942	
## prop_unemployed_in_labor_force	0.16815934	0.16554652	
## prop_without_internet_access	-0.03609294	-0.03484673	
## prop_adult_disability	-0.15530682	-0.14673191	
##	mean_adhd	mean_ptsd	mean_bipolar
## year	0.756826372	0.62228218	-0.090974692
## anxiety_ct	0.192811841	0.09066919	-0.085128361
## trauma_stress_ct	0.089584712	0.04475684	-0.084233146
## adhd_ct	-0.007745775	-0.12470786	-0.082850695
## bipolar_ct	-0.108660303	-0.22821302	-0.030301260
## depression_ct	0.022537693	-0.08131642	-0.086593022
## comm_psych_care	0.011545502	-0.09505592	-0.062432992
## state_psych_care	0.013010379	-0.09409334	-0.062693072
## mean_adhd	1.000000000	0.42495384	0.179510680
## mean_ptsd	0.424953840	1.000000000	0.193509244
## mean_bipolar	0.179510680	0.19350924	1.000000000
## mean_depression	-0.245750075	0.41128942	0.308755245
## mean_mental_hospital	0.287677009	0.09702821	0.232486981
## mean_psychiatrists_near_me	0.042769431	0.05674090	-0.005280538
## mean_psychologist_near_me	0.415735545	0.23433255	-0.080183845
## anxiety_prop	0.222753634	0.30520691	-0.005956554
## adhd_prop	0.028590323	0.09085592	-0.010212770
## bipolar_prop	-0.159049076	-0.04663275	0.157398435
## prop_families_below_poverty	-0.208577621	-0.20391856	0.293106346

```

## prop_adults_without_health_insurance -0.186412427 -0.24473889 0.233057761
## prop_unemployed_in_labor_force -0.327758496 -0.43653037 0.157300589
## prop_without_internet_access -0.126520915 0.33393361 -0.090016482
## prop_adult_disability 0.109982033 0.10629585 0.222236769
## mean_depression mean_mental_hospital
## year -0.023901425 0.27777930
## anxiety_ct 0.009319898 0.31945513
## trauma_stress_ct -0.021362629 0.28112091
## adhd_ct -0.026389005 0.22005420
## bipolar_ct -0.093613944 0.21655455
## depression_ct -0.028840113 0.28147786
## comm_psych_care -0.040947486 0.24373032
## state_psych_care -0.042373199 0.24415647
## mean_adhd -0.245750075 0.28767701
## mean_ptsd 0.411289416 0.09702821
## mean_bipolar 0.308755245 0.23248698
## mean_depression 1.000000000 -0.10548867
## mean_mental_hospital -0.105488666 1.000000000
## mean_psychiatrists_near_me 0.001374564 0.15614239
## mean_psychologist_near_me -0.098056483 0.41633384
## anxiety_prop 0.050429764 0.02664347
## adhd_prop 0.069487449 -0.06288825
## bipolar_prop 0.026384149 -0.09485722
## prop_families_below_poverty -0.077146712 0.21535926
## prop_adults_without_health_insurance -0.062380502 -0.02688604
## prop_unemployed_in_labor_force -0.348426242 0.10886182
## prop_without_internet_access 0.385215253 0.07508085
## prop_adult_disability -0.081676556 0.16483923
## mean_psychiatrists_near_me
## year 0.186975337
## anxiety_ct 0.063526502
## trauma_stress_ct 0.099199887
## adhd_ct 0.086212620
## bipolar_ct 0.065213036
## depression_ct 0.092213328
## comm_psych_care 0.135713106
## state_psych_care 0.133541968
## mean_adhd 0.042769431
## mean_ptsd 0.056740904
## mean_bipolar -0.005280538
## mean_depression 0.001374564
## mean_mental_hospital 0.156142388
## mean_psychiatrists_near_me 1.000000000
## mean_psychologist_near_me 0.466711912
## anxiety_prop -0.104990533
## adhd_prop -0.105489672
## bipolar_prop -0.156142069
## prop_families_below_poverty -0.185544042
## prop_adults_without_health_insurance -0.257450224
## prop_unemployed_in_labor_force -0.020698183
## prop_without_internet_access 0.051130358
## prop_adult_disability -0.239770625
## mean_psychologist_near_me anxiety_prop
## year 0.64878930 0.252565296

```

## anxiety_ct	0.40406294	0.575638687
## trauma_stress_ct	0.38356349	0.407943378
## adhd_ct	0.31668308	0.306023903
## bipolar_ct	0.20732437	0.032119498
## depression_ct	0.35169600	0.273065574
## comm_psych_care	0.36100819	0.188137462
## state_psych_care	0.35825438	0.200491380
## mean_adhd	0.41573555	0.222753634
## mean_ptsd	0.23433255	0.305206913
## mean_bipolar	-0.08018385	-0.005956554
## mean_depression	-0.09805648	0.050429764
## mean_mental_hospital	0.41633384	0.026643466
## mean_psychiatrists_near_me	0.46671191	-0.104990533
## mean_psychologist_near_me	1.00000000	0.018713136
## anxiety_prop	0.01871314	1.000000000
## adhd_prop	-0.02192663	0.772593545
## bipolar_prop	-0.20102389	0.592973858
## prop_families_below_poverty	-0.16397365	-0.139411004
## prop_adults_without_health_insurance	-0.20618180	-0.202330161
## prop_unemployed_in_labor_force	-0.18536934	-0.244392365
## prop_without_internet_access	0.15990322	0.090420463
## prop_adult_disability	-0.08569762	0.099264075
##	adhd_prop	bipolar_prop
## year	0.02582844	-0.27713846
## anxiety_ct	0.54011961	0.40224768
## trauma_stress_ct	0.44884626	0.39406527
## adhd_ct	0.55769120	0.45839012
## bipolar_ct	0.19368296	0.36562312
## depression_ct	0.36224924	0.36378200
## comm_psych_care	0.28982510	0.30483675
## state_psych_care	0.30527377	0.31814831
## mean_adhd	0.02859032	-0.15904908
## mean_ptsd	0.09085592	-0.04663275
## mean_bipolar	-0.01021277	0.15739843
## mean_depression	0.06948745	0.02638415
## mean_mental_hospital	-0.06288825	-0.09485722
## mean_psychiatrists_near_me	-0.10548967	-0.15614207
## mean_psychologist_near_me	-0.02192663	-0.20102389
## anxiety_prop	0.77259354	0.59297386
## adhd_prop	1.00000000	0.73676449
## bipolar_prop	0.73676449	1.00000000
## prop_families_below_poverty	0.06474605	0.24288704
## prop_adults_without_health_insurance	-0.10333794	0.15947980
## prop_unemployed_in_labor_force	-0.06381305	0.17824936
## prop_without_internet_access	0.10675502	-0.09079816
## prop_adult_disability	0.20587109	0.24830497
##	prop_families_below_poverty	
## year		-0.31411265
## anxiety_ct		-0.06595152
## trauma_stress_ct		-0.02266406
## adhd_ct		0.09145245
## bipolar_ct		0.21421452
## depression_ct		0.06093810
## comm_psych_care		0.06341390

```

## state_psych_care 0.06303851
## mean_adhd -0.20857762
## mean_ptsd -0.20391856
## mean_bipolar 0.29310635
## mean_depression -0.07714671
## mean_mental_hospital 0.21535926
## mean_psychiatrists_near_me -0.18554404
## mean_psychologist_near_me -0.16397365
## anxiety_prop -0.13941100
## adhd_prop 0.06474605
## bipolar_prop 0.24288704
## prop_families_below_poverty 1.00000000
## prop_adults_without_health_insurance 0.60329043
## prop_unemployed_in_labor_force 0.52364772
## prop_without_internet_access 0.12312374
## prop_adult_disability 0.65543780
## prop_adults_without_health_insurance
## year -0.350364883
## anxiety_ct -0.120820100
## trauma_stress_ct -0.089439512
## adhd_ct 0.001121328
## bipolar_ct 0.243697423
## depression_ct 0.034484408
## comm_psych_care 0.029204600
## state_psych_care 0.028209419
## mean_adhd -0.186412427
## mean_ptsd -0.244738889
## mean_bipolar 0.233057761
## mean_depression -0.062380502
## mean_mental_hospital -0.026886042
## mean_psychiatrists_near_me -0.257450224
## mean_psychologist_near_me -0.206181798
## anxiety_prop -0.202330161
## adhd_prop -0.103337943
## bipolar_prop 0.159479797
## prop_families_below_poverty 0.603290434
## prop_adults_without_health_insurance 1.000000000
## prop_unemployed_in_labor_force 0.409465887
## prop_without_internet_access -0.106556672
## prop_adult_disability 0.289928013
## prop_unemployed_in_labor_force
## year -0.54031845
## anxiety_ct -0.04700641
## trauma_stress_ct 0.07676369
## adhd_ct 0.12435852
## bipolar_ct 0.28278587
## depression_ct 0.13217179
## comm_psych_care 0.16815934
## state_psych_care 0.16554652
## mean_adhd -0.32775850
## mean_ptsd -0.43653037
## mean_bipolar 0.15730059
## mean_depression -0.34842624
## mean_mental_hospital 0.10886182

```



```

## mean_psychiatrists_near_me -0.02069818
## mean_psychologist_near_me -0.18536934
## anxiety_prop -0.24439237
## adhd_prop -0.06381305
## bipolar_prop 0.17824936
## prop_families_below_poverty 0.52364772
## prop_adults_without_health_insurance 0.40946589
## prop_unemployed_in_labor_force 1.00000000
## prop_without_internet_access -0.34452758
## prop_adult_disability 0.06756309
## prop_without_internet_access
## year 0.31423583
## anxiety_ct 0.01177798
## trauma_stress_ct -0.03506000
## adhd_ct 0.01009764
## bipolar_ct -0.11859483
## depression_ct -0.03027184
## comm_psych_care -0.03609294
## state_psych_care -0.03484673
## mean_adhd -0.12652092
## mean_ptsd 0.33393361
## mean_bipolar -0.09001648
## mean_depression 0.38521525
## mean_mental_hospital 0.07508085
## mean_psychiatrists_near_me 0.05113036
## mean_psychologist_near_me 0.15990322
## anxiety_prop 0.09042046
## adhd_prop 0.10675502
## bipolar_prop -0.09079816
## prop_families_below_poverty 0.12312374
## prop_adults_without_health_insurance -0.10655667
## prop_unemployed_in_labor_force -0.34452758
## prop_without_internet_access 1.00000000
## prop_adult_disability 0.30396009
## prop_adult_disability
## year 0.07154859
## anxiety_ct -0.08941817
## trauma_stress_ct -0.12802032
## adhd_ct -0.04162040
## bipolar_ct -0.11618594
## depression_ct -0.11834226
## comm_psych_care -0.15530682
## state_psych_care -0.14673191
## mean_adhd 0.10998203
## mean_ptsd 0.10629585
## mean_bipolar 0.22223677
## mean_depression -0.08167656
## mean_mental_hospital 0.16483923
## mean_psychiatrists_near_me -0.23977062
## mean_psychologist_near_me -0.08569762
## anxiety_prop 0.09926407
## adhd_prop 0.20587109
## bipolar_prop 0.24830497
## prop_families_below_poverty 0.65543780

```

```
## prop_adults_without_health_insurance      0.28992801
## prop_unemployed_in_labor_force            0.06756309
## prop_without_internet_access              0.30396009
## prop_adult_disability                     1.00000000
```

high correlation variables

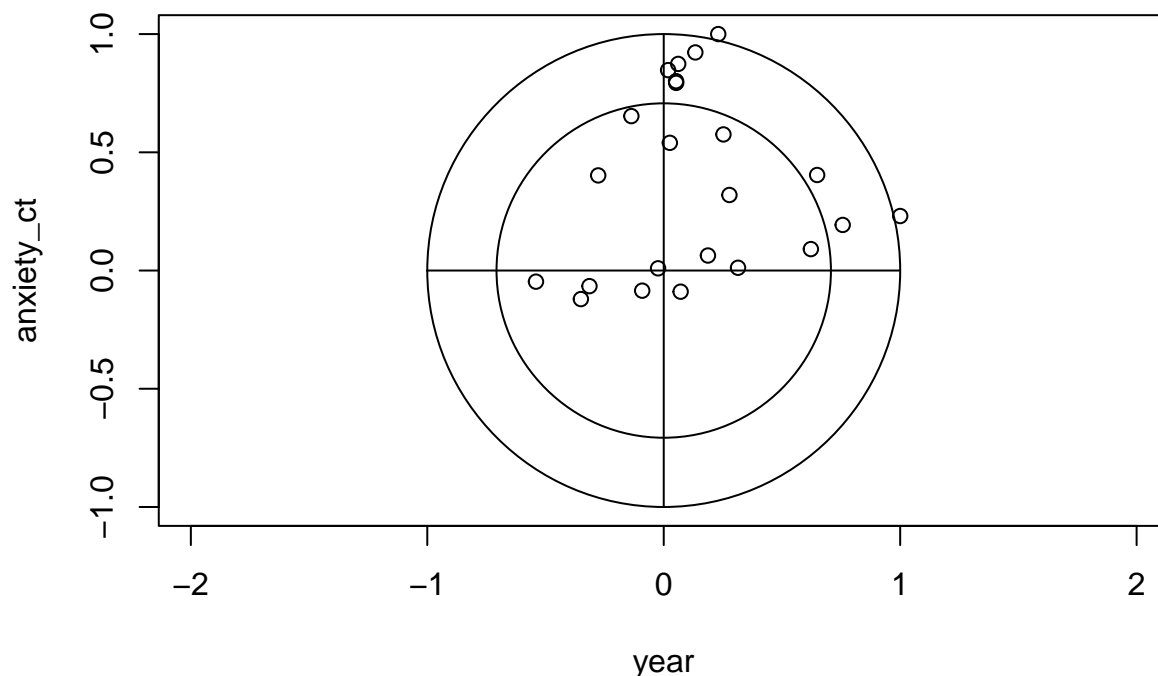
1. private, reside and comm\_psych\_care, 2.inpatient\_util vs outpatient\_util ( i already have state\_mentalhealth\_util) 3.mean\_therapist\_near\_me vs mean\_psychiatrist and mean\_psychologist
- 4.mean\_alltrend vs mean\_adhd, mean\_ptsd, mean\_anxiety, mean\_mentalhospital.
2. mean\_anxiety vs year, mean\_adhd & ptsd 6.outpatient\_util vs total\_util, adhd, bipolar & depression
- 7.total\_util 8.depression prob vs adhd. ptsd, bipolar and trauma\_stress\_prop 9.trauma\_stress\_prop vs adhd, anxiety\_prop and state\_mentalhealth\_util 10.state\_mentalhealth\_util vs adhd, ptsd, bipolar

*#correlation matrix*

```
GTrends_acs_joined %>%
  select_if(is.numeric) %>%
  select(-fips, -population_est, -private_psych_care, -total_util, -outpatient_util, -mean_anxiety, -res,
         -total_util) %>%
  cor() %>%

corrplot(diag = F,
         tl.cex = 0.7,
         tl.col = "black",
         main = "Correlation Matrix of GTrends_acs_joined",
         mar = c(0, 0, 1, 0))
```

## Correlation Matrix of GTrends\_acs\_joined

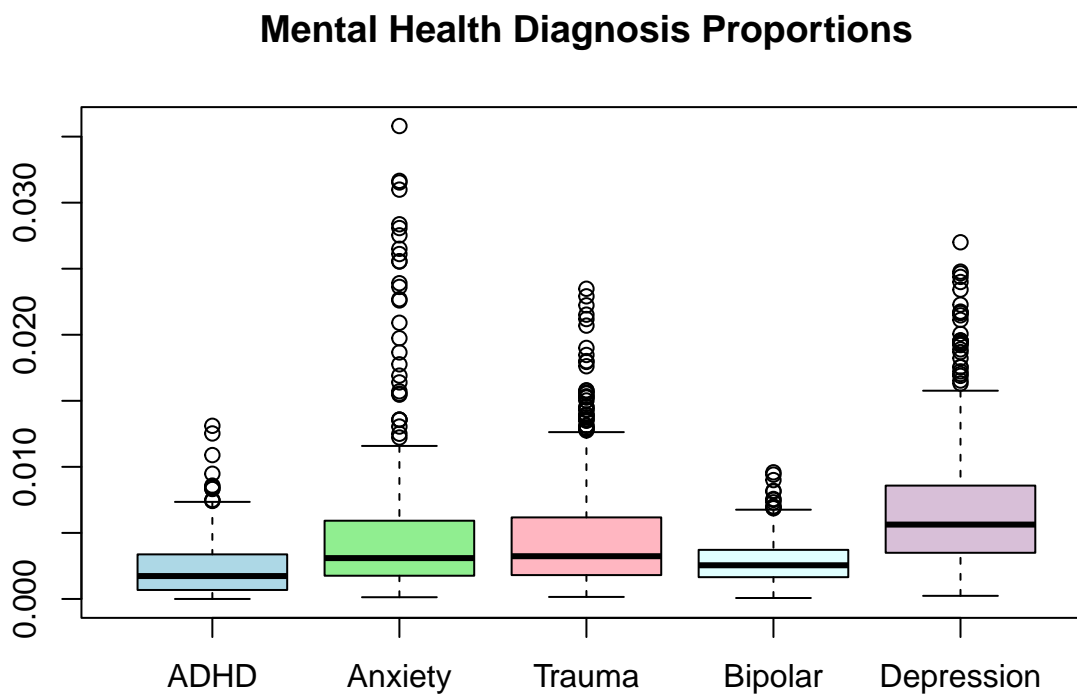


```

data <- data_GTrends
data$adhd_prop= data$adhd_ct/data$population_est
data$anxiety_prop = data$anxiety_ct/data$population_est
data$bipolar_prop = data$bipolar_ct/data$population_est
data$depression_prop = data$depression_ct/data$population_est
data$trauma_prop = data$trauma_stress_ct/data$population_est
data$state_util = data$state_psych_care/data$population_est
data$private_util = data$private_psych_care/data$population_est
data$diff_util = data$total_util-(data$state_util + data$private_util)

boxplot(data[c("adhd_prop", "anxiety_prop", "trauma_prop", "bipolar_prop", "depression_prop")],
  main = "Mental Health Diagnosis Proportions",
  names = c("ADHD", "Anxiety", "Trauma", "Bipolar", "Depression"),
  col = c("lightblue", "lightgreen", "lightpink", "lightcyan", "thistle" ))

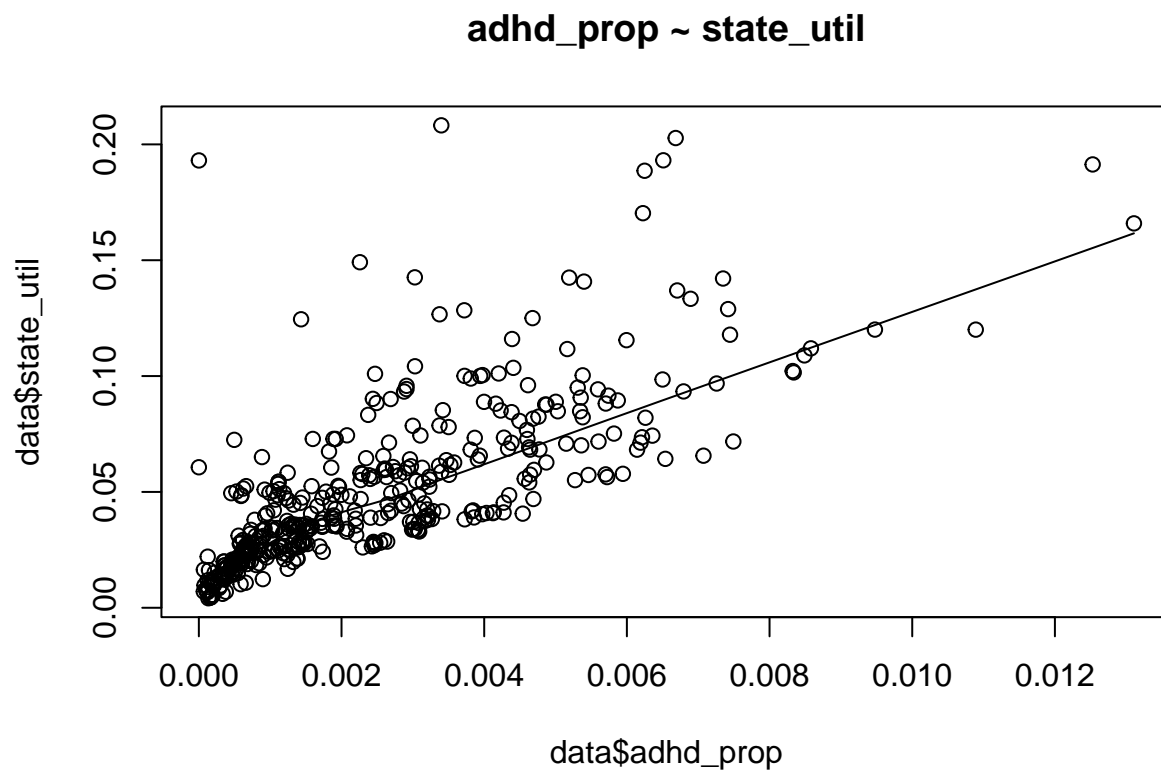
```



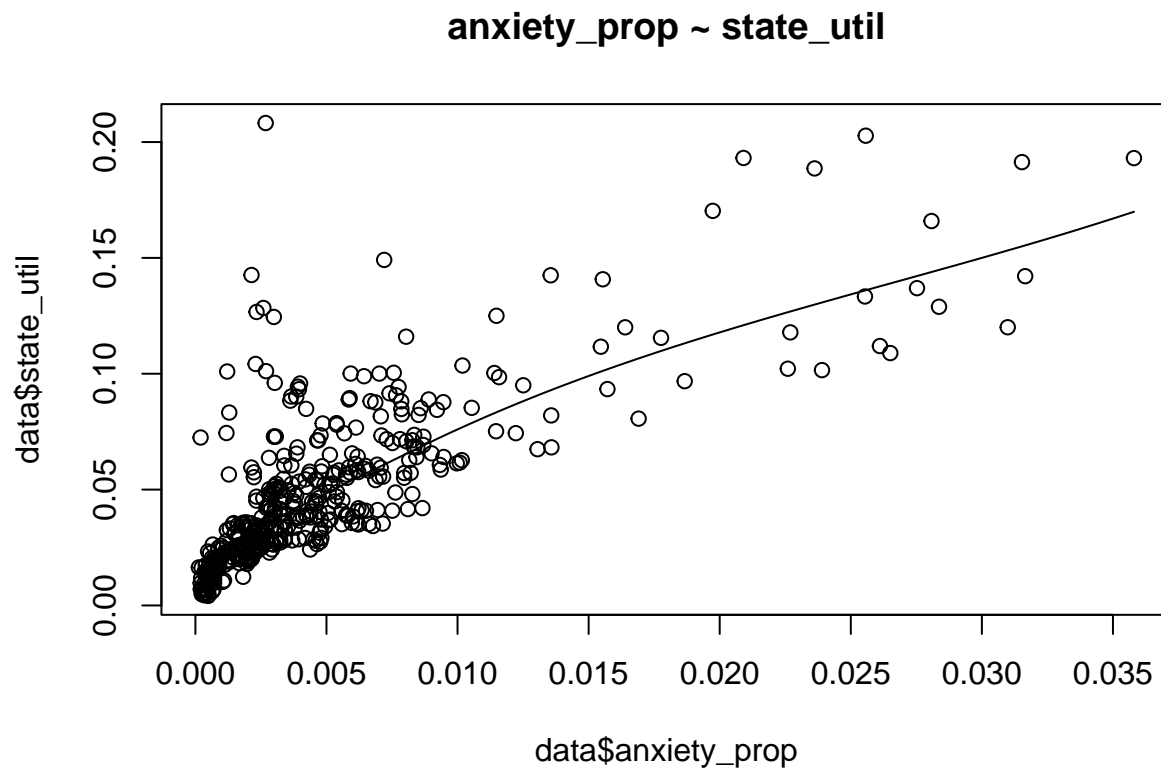
```

par(mfrow=c(1,1)) # divide graph area in 2 columns
scatter.smooth(x=data$adhd_prop, y=data$state_util, main="adhd_prop ~ state_util")

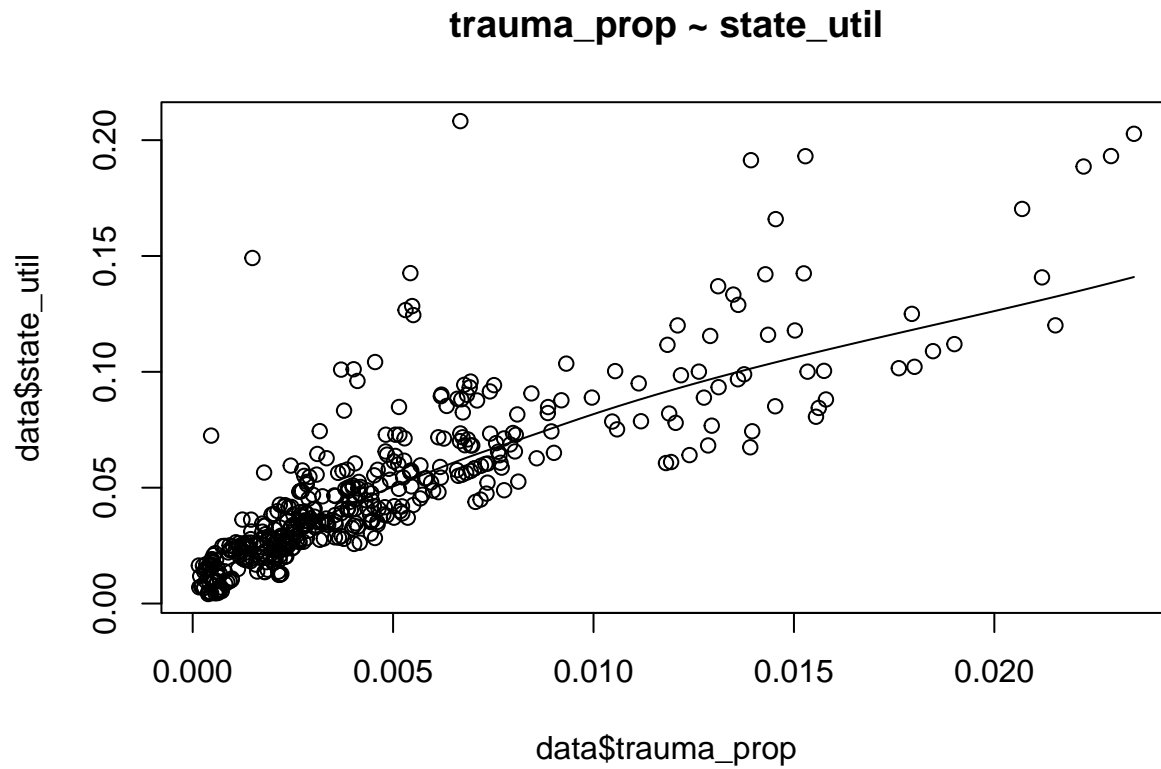
```



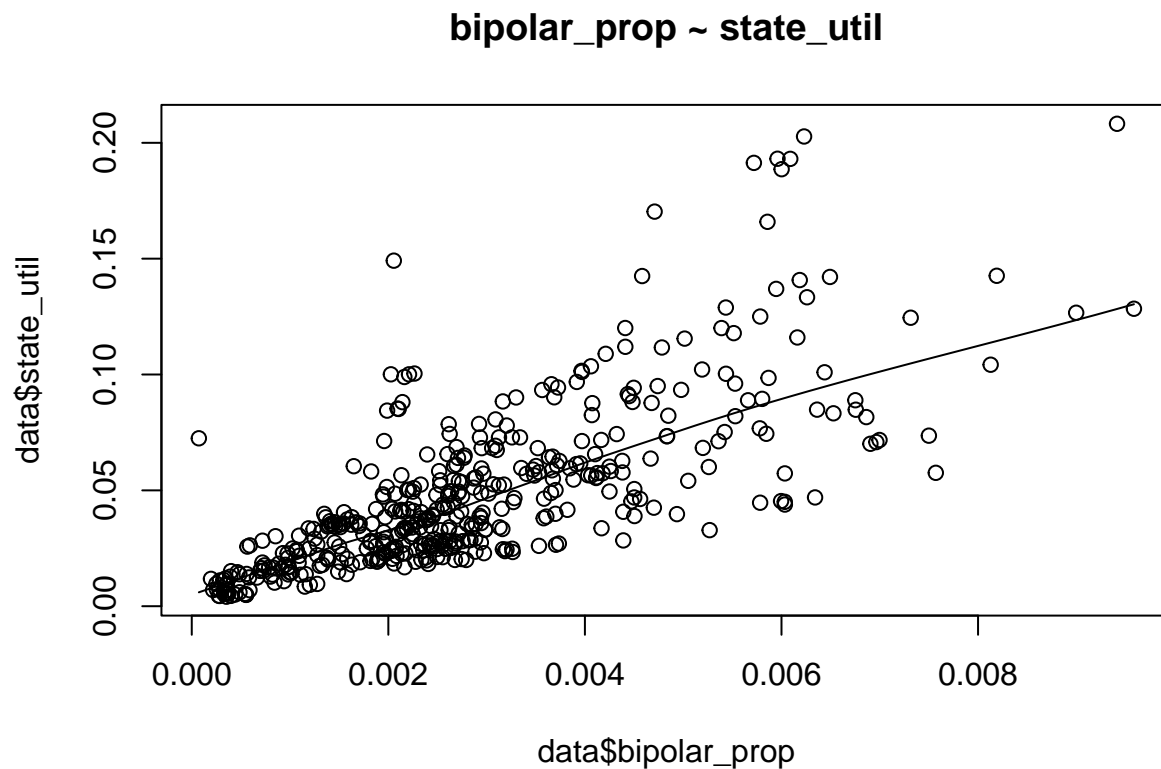
```
scatter.smooth(x=data$anxiety_prop, y=data$state_util, main="anxiety_prop ~ state_util")
```



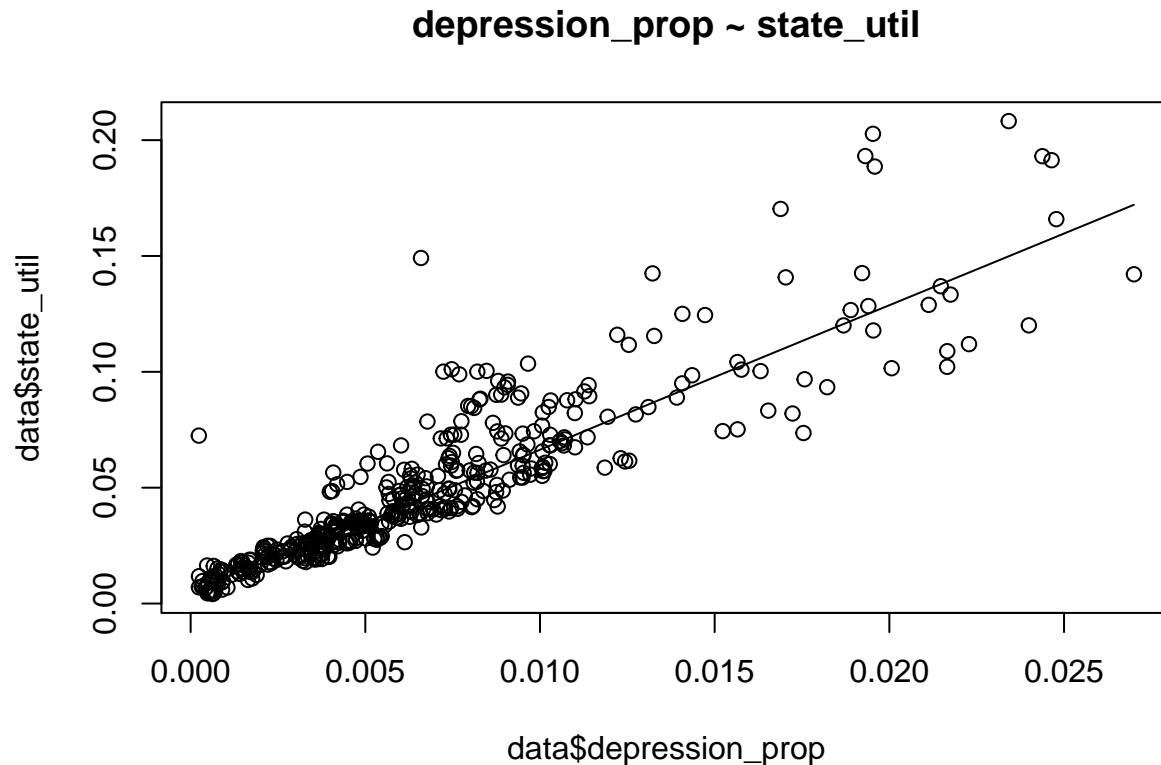
```
scatter.smooth(x=data$trauma_prop, y=data$state_util, main="trauma_prop ~ state_util")
```



```
scatter.smooth(x=data$bipolar_prop, y=data$state_util, main="bipolar_prop ~ state_util")
```



```
scatter.smooth(x=data$depression_prop, y=data$state_util, main="depression_prop ~ state_util")
```



```
library(e1071)
```

```
## Warning: package 'e1071' was built under R version 4.3.3
```

```
par(mfrow=c(1, 1))
```

```
# Create a density plot that shows public, private, and total mental healthcare utilization rate  
# frequency
```

```
plot(density(data$state_util),  
     main = "Public, Private Facility, & Total Utilization Density",  
     ylab = "Frequency",  
     xlab = "Utilization Rate",  
     col = "green",  
     lwd = 2,  
     sub = paste("Skewness (State):", round(e1071::skewness(data$state_util), 2)))
```

```
# Fill the first density with polygon
```

```
polygon(density(data$state_util), col = adjustcolor("lightgreen", alpha.f = 0.5), border = NA)
```

```
# Add second density line
```

```
lines(density(data$private_util), col = "blue", lwd = 2)
```

```
polygon(density(data$private_util), col = adjustcolor("lightblue", alpha.f = 0.5), border = NA)
```

```
# Add third density line
```

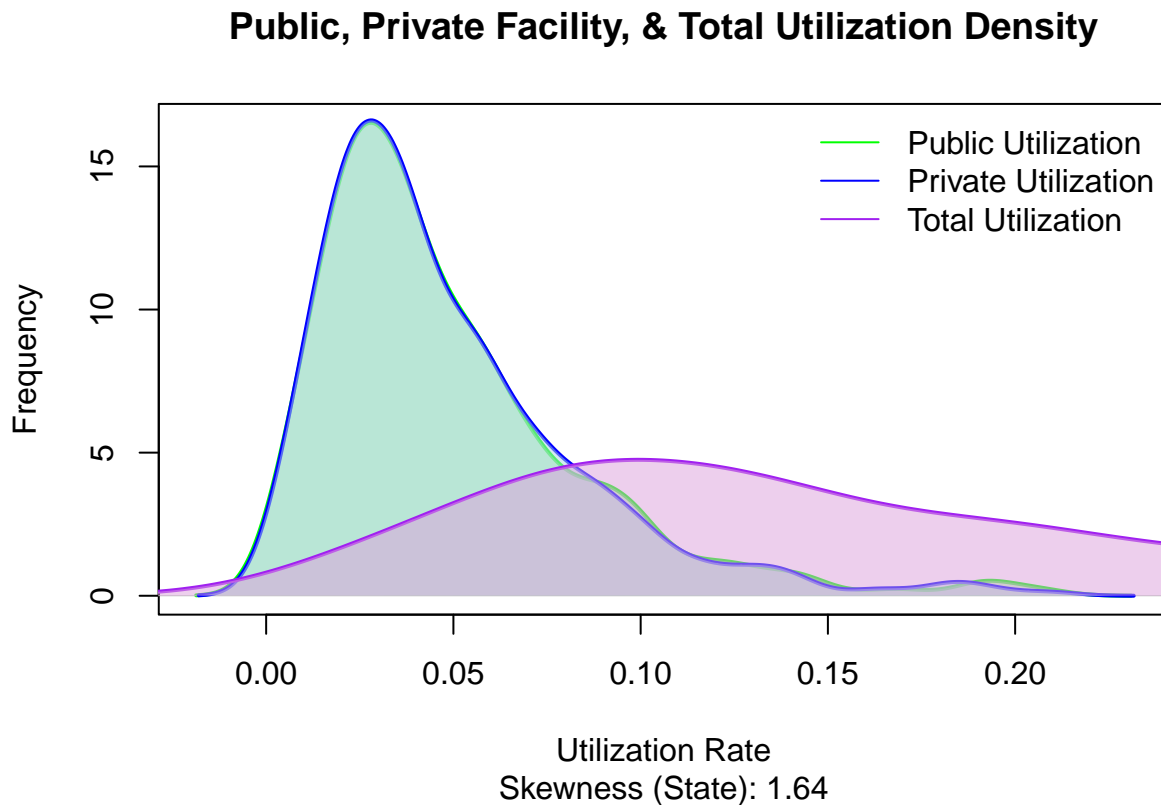
```
lines(density(data$total_util), col = "purple", lwd = 2)
```

```

polygon(density(data$total_util), col = adjustcolor("plum", alpha.f = 0.5), border = NA)

# Add legend
legend("topright", legend = c("Public Utilization", "Private Utilization", "Total Utilization "),
      col = c("green", "blue", "purple"), lwd = 1, bty = "n")

```



```

#data split: train and test dataset

clean_GTrends_acs_joined <- GTrends_acs_joined %>%
  select(-fips, -population_est, -private_psych_care, -total_util,
        -outpatient_util, -region, -mean_anxiety, -resid_psych_care,
        -mean_all_trends, -mean_therapist_near_me, -depression_prop,
        -trauma_stress_prop, -inpatient_util,
        -contains(c("median", "total")), -total_util) #i have added region as part of eliminated featu

test_n <- (1/sqrt(19))*nrow(clean_GTrends_acs_joined)
test_prop <- round((1/sqrt(19))*nrow(clean_GTrends_acs_joined)/nrow(clean_GTrends_acs_joined), 2)
train_prop <- 1-test_prop

paste("The ideal split ratio is", train_prop, ":", test_prop, " training : testing")

## [1] "The ideal split ratio is 0.77 : 0.23  training : testing"

# Show the dimensions of the dataframe and the column names.
dim(clean_GTrends_acs_joined)

## [1] 433 25

```

```
names(clean_GTrends_acs_joined)
```

```
## [1] "year"
## [2] "state"
## [3] "anxiety_ct"
## [4] "trauma_stress_ct"
## [5] "adhd_ct"
## [6] "bipolar_ct"
## [7] "depression_ct"
## [8] "comm_psych_care"
## [9] "state_psych_care"
## [10] "mean_adhd"
## [11] "mean_ptsd"
## [12] "mean_bipolar"
## [13] "mean_depression"
## [14] "mean_mental_hospital"
## [15] "mean_psychiatrists_near_me"
## [16] "mean_psychologist_near_me"
## [17] "state_mentalhealth_util"
## [18] "anxiety_prop"
## [19] "adhd_prop"
## [20] "bipolar_prop"
## [21] "prop_families_below_poverty"
## [22] "prop_adults_without_health_insurance"
## [23] "prop_unemployed_in_labor_force"
## [24] "prop_without_internet_access"
## [25] "prop_adult_disability"
```

```
#write the merged dataframe to a CSV file with a time stamp in the name.
```

```
# This way we don't overwrite the file in case someone else is working on the file.
```

```
# TimeStamp <- format(Sys.time(), "%Y%m%d_%H%M%S")
```

```
# file_name <- paste("~/GitHub/DSE63110M_SP2025R2_Data-Science-Capstone/Data/clean_GTrends_acs_joined_")
```

```
# write.csv(clean_GTrends_acs_joined, file_name, row.names = FALSE)
```

```
train <- createDataPartition(clean_GTrends_acs_joined$state_mentalhealth_util,
                             p = 0.77,
                             list = FALSE,
                             times = 1)
```

```
GTrend_training_set <- clean_GTrends_acs_joined[train, ]
```

```
test_set <- clean_GTrends_acs_joined[-train, ]
```

```
dim(GTrend_training_set)
```

```
## [1] 336 25
```

```
dim(test_set)
```

```
## [1] 97 25
```



## TARGET ENCODING OF STATE BY Njagi

```
unique(clean_GTrends_acs_joined$state)
```

```
## [1] "AL" "AZ" "AR" "CA" "CO" "CT" "DE" "FL" "HI" "ID" "IL" "IN" "IA" "KS" "KY"  
## [16] "LA" "MA" "MS" "MO" "MT" "NE" "NV" "NJ" "NM" "NY" "NC" "ND" "OH" "OK" "OR"  
## [31] "PA" "RI" "SC" "SD" "TN" "TX" "UT" "VT" "VA" "WA" "WI" "WY" "MN" "MI" "AK"  
## [46] "GA"
```

```
is.factor(clean_GTrends_acs_joined$state) #checking whether region is a factor = false
```

```
## [1] FALSE
```

```
GTrend_training_set$state <- factor(GTrend_training_set$state)  
  
class(GTrend_training_set$state)
```

```
## [1] "factor"
```

```
levels(GTrend_training_set$state)
```

```
## [1] "AK" "AL" "AR" "AZ" "CA" "CO" "CT" "DE" "FL" "GA" "HI" "IA" "ID" "IL" "IN"  
## [16] "KS" "KY" "LA" "MA" "MI" "MN" "MO" "MS" "MT" "NC" "ND" "NE" "NJ" "NM" "NV"  
## [31] "NY" "OH" "OK" "OR" "PA" "RI" "SC" "SD" "TN" "TX" "UT" "VA" "VT" "WA" "WI"  
## [46] "WY"
```

```
# we are going to apply target encoding (state_mentalhealth_util). To avoid overfitting we are going to  
#smoothed version of target encoding
```

```
main_mean <- mean( GTrend_training_set$state_mentalhealth_util)
```

```
smoothing_factor <- 10
```

```
#calculating the smoothed state means from the training set
```

```
state_encoded_by_smoothedmean <- GTrend_training_set %>%  
  group_by(state) %>%  
  summarise(state_encoded = (mean(state_mentalhealth_util) * n() + main_mean * smoothing_factor) / (n() + 1))
```

```
#merging the smoothed encoded state means with the training set
```

```
GTrend_training_set_f <- GTrend_training_set %>%  
  left_join(state_encoded_by_smoothedmean, by = "state") %>%  
  select(-state)
```

```
#merging smoothed encoded state means with the test_set
```

```
test_set$state <- factor(test_set$state)

test_set_f <- test_set%>%
  left_join(state_encoded_by_smoothedmean, by = "state") %>%
  select(-state)
```

```
dim(test_set_f)
```

```
## [1] 97 25
```

```
#center and scale
```

```
test_set_f[, c(-10)] <- scale(test_set_f[, c(-10)],
                             center = apply(GTrend_training_set_f[, c(-10)], 2, mean),
                             scale = apply(GTrend_training_set_f[, c(-10)], 2, sd))
```

```
#(-10) is the state_mentalhealth_util, i want to exclude it from center and scale since its already a p
```

```
GTrend_training_set_f[, -10] <- scale(GTrend_training_set_f[, -10])
```

```
head(GTrend_training_set_f)
```

```
## # A tibble: 6 x 25
##   year anxiety_ct trauma_stress_ct adhd_ct bipolar_ct depression_ct
##   <dbl>      <dbl>          <dbl>   <dbl>      <dbl>      <dbl>
## 1 -1.55    -0.344          -0.515   0.126    0.0468    -0.138
## 2 -1.55     0.601           0.769   1.54     1.77      0.409
## 3 -1.55    -0.614          -0.567  -0.429   -0.196    -0.475
## 4 -1.55    -0.828          -0.852  -0.781   -0.799    -0.897
## 5 -1.55    -0.401           0.0959  0.576    1.88      0.914
## 6 -1.55    -0.832          -0.809  -0.812   -0.806    -0.867
## # i 19 more variables: comm_psych_care <dbl>, state_psych_care <dbl>,
## #   mean_adhd <dbl>, mean_ptsd <dbl>, mean_bipolar <dbl>,
## #   mean_depression <dbl>, mean_mental_hospital <dbl>,
## #   mean_psychiatrists_near_me <dbl>, mean_psychologist_near_me <dbl>,
## #   state_mentalhealth_util <dbl>, anxiety_prop <dbl>, adhd_prop <dbl>,
## #   bipolar_prop <dbl>, prop_families_below_poverty <dbl>,
## #   prop_adults_without_health_insurance <dbl>, ...
```

```
#generating codebook
```

```
library(tibble)
```

```
codebook <- tibble(
  variable = names(clean_GTrends_acs_joined),
  class = sapply(clean_GTrends_acs_joined, class),
  "Number of Missing Values" = sapply(clean_GTrends_acs_joined, function(x) sum(is.na(x))),
  "Number of Unique Values" = sapply(clean_GTrends_acs_joined, function(x) length(unique(x)))
)
```

```
print(codebook)
```

```
## # A tibble: 25 x 4
##   variable      class   'Number of Missing Values' Number of Unique Values
##   <chr>         <chr>          <int>                <int>
## 1 year         numeric          0                  10
## 2 state        character        0                  46
## 3 anxiety_ct   numeric          0                 433
## 4 trauma_stress_ct numeric          0                 431
## 5 adhd_ct       numeric          0                 423
## 6 bipolar_ct    numeric          0                 430
## 7 depression_ct numeric          0                 432
## 8 comm_psych_care numeric          0                 432
## 9 state_psych_care numeric          0                 433
## 10 mean_adhd    numeric          0                 205
## # i 15 more rows
## # i abbreviated name: 1: 'Number of Unique Values'
```

## INITIAL MODELS BY Njagi

### 1. LINEAR REGRESSION (ELASTIC NET REGULARIZATION)

```
# DEVELOPING THE MODEL (LR. ENR)

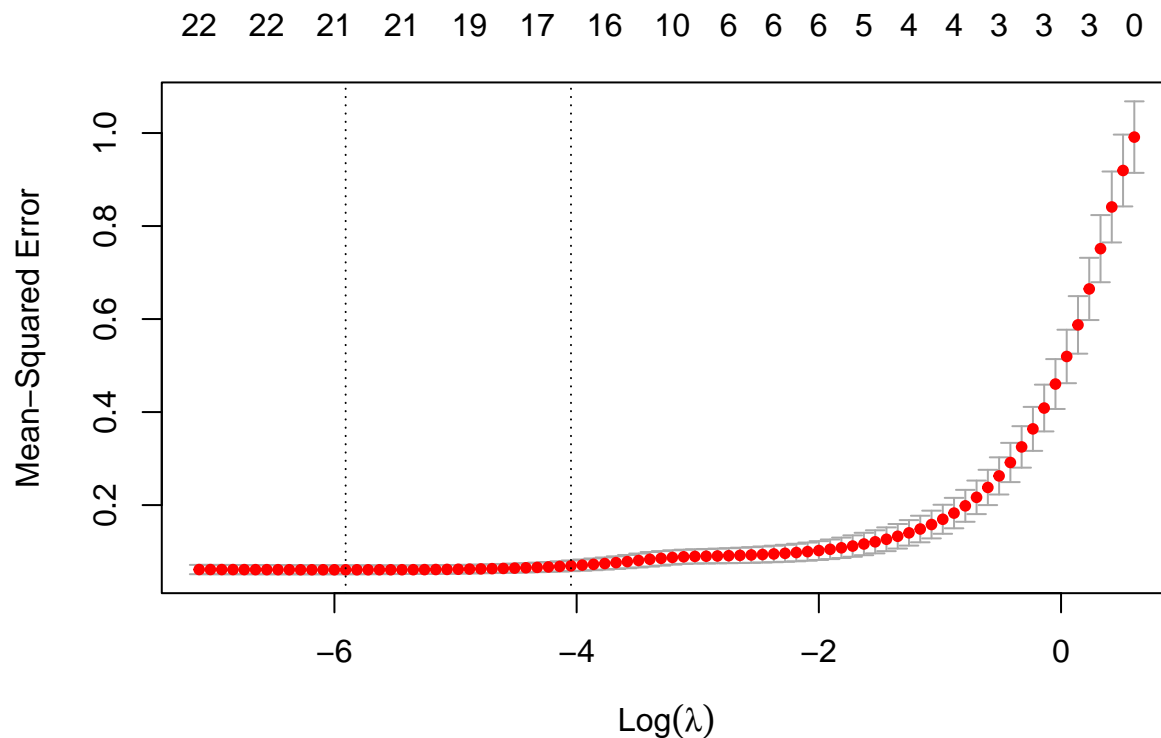
x <- model.matrix(state_mentalhealth_util ~ ., data = GTrend_training_set_f, intercept = FALSE)
y <- GTrend_training_set_f$state_mentalhealth_util

#Performing cross_validation to find the best lambda

set.seed(123) # for consistent and replicable results

cv_model <- cv.glmnet(x, y, alpha = 0.5, family = "gaussian", nfolds = 5)

plot(cv_model) #plotting cross-validation curve
```



```
#getting the best/ optimal lambda

best_lambda <- cv_model$lambda.min
best_lambda_1se <- cv_model$lambda.1se

#developing the model using the best lambda

model_min <- glmnet(x, y, alpha = 0.5, lambda = best_lambda, family = "gaussian")
model_lambda_1se <- glmnet(x, y, alpha = 0.5, lambda = best_lambda_1se, family = "gaussian")

#preparing the test set into matrix

x_test <- model.matrix(state_mentalhealth_util ~ ., data = test_set_f, intercept = FALSE)
y_test <- test_set_f$state_mentalhealth_util

#ensure x and x_test have the same number of columns. its a good practise after using model.matrix

common_columns <- intersect(colnames(x), colnames(x_test))
x <- x[, common_columns]
x_test <- x_test[, common_columns]

# use test set to make predictions, use lambda min and lambda_1se

y_pred_min <- predict(model_min, newx = x_test)
y_pred_1se <- predict(model_lambda_1se, newx = x_test)

#calculate the mean squared error
```

```
mse_min <- mean((y_test - y_pred_min)^2)
mse_1se <- mean((y_test - y_pred_1se)^2)
```

```
print(paste("MSE (MIN):", mse_min))
```

```
## [1] "MSE (MIN): 0.0365309987956067"
```

```
print(paste("MSE (1SE):", mse_1se))
```

```
## [1] "MSE (1SE): 0.0483330720701727"
```

## Principal Component Regression (PCR)

```
pcr_m_selected <- 1
```

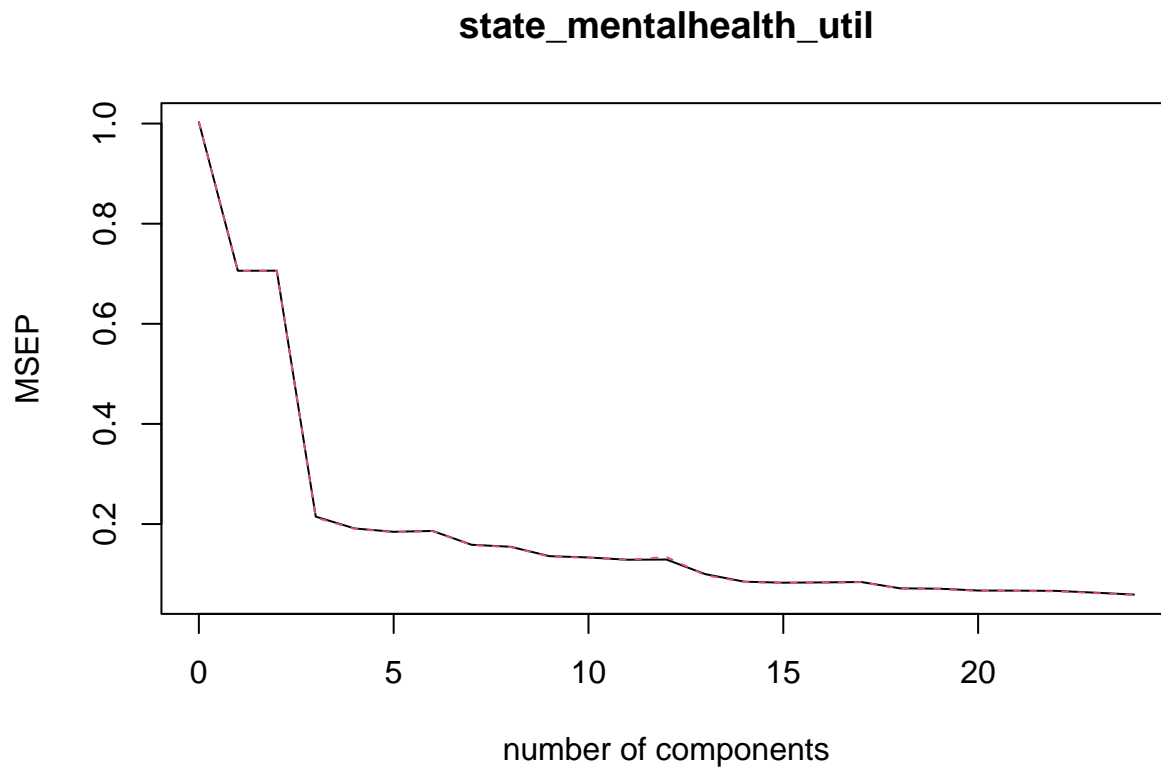
```
# Get the PCR fit for the training data set
pcr_fit <- pcr(state_mentalhealth_util ~ ., data = GTrend_training_set_f ,
               scale=TRUE, validation="CV")
```

```
# Show the summary of the PCR fit.
summary(pcr_fit)
```

```
## Data:      X dimension: 336 24
## Y dimension: 336 1
## Fit method: svdpc
## Number of components considered: 24
##
## VALIDATION: RMSEP
## Cross-validated using 10 random segments.
##      (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
## CV           1.001  0.8402  0.8403  0.4635  0.4372  0.4295  0.4315
## adjCV        1.001  0.8399  0.8403  0.4615  0.4365  0.4287  0.4311
##      7 comps  8 comps  9 comps 10 comps 11 comps 12 comps 13 comps
## CV       0.3982  0.3932  0.3685  0.3651  0.3587  0.3593  0.3160
## adjCV    0.3976  0.3925  0.3673  0.3645  0.3582  0.3664  0.3126
##      14 comps 15 comps 16 comps 17 comps 18 comps 19 comps 20 comps
## CV       0.2912  0.2878  0.2888  0.2901  0.2675  0.2662  0.2592
## adjCV    0.2900  0.2867  0.2878  0.2897  0.2662  0.2650  0.2579
##      21 comps 22 comps 23 comps 24 comps
## CV       0.2588  0.2578  0.2509  0.2431
## adjCV    0.2574  0.2563  0.2494  0.2415
##
## TRAINING: % variance explained
##      1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
## X           30.69  47.03  59.41  69.14  75.89  81.00
## state_mentalhealth_util 29.78  30.31  79.47  81.56  82.51  82.51
##      7 comps  8 comps  9 comps 10 comps 11 comps
## X           85.32  88.27  90.45  92.32  93.72
## state_mentalhealth_util 85.17  85.68  87.47  87.81  88.50
##      12 comps 13 comps 14 comps 15 comps 16 comps
```

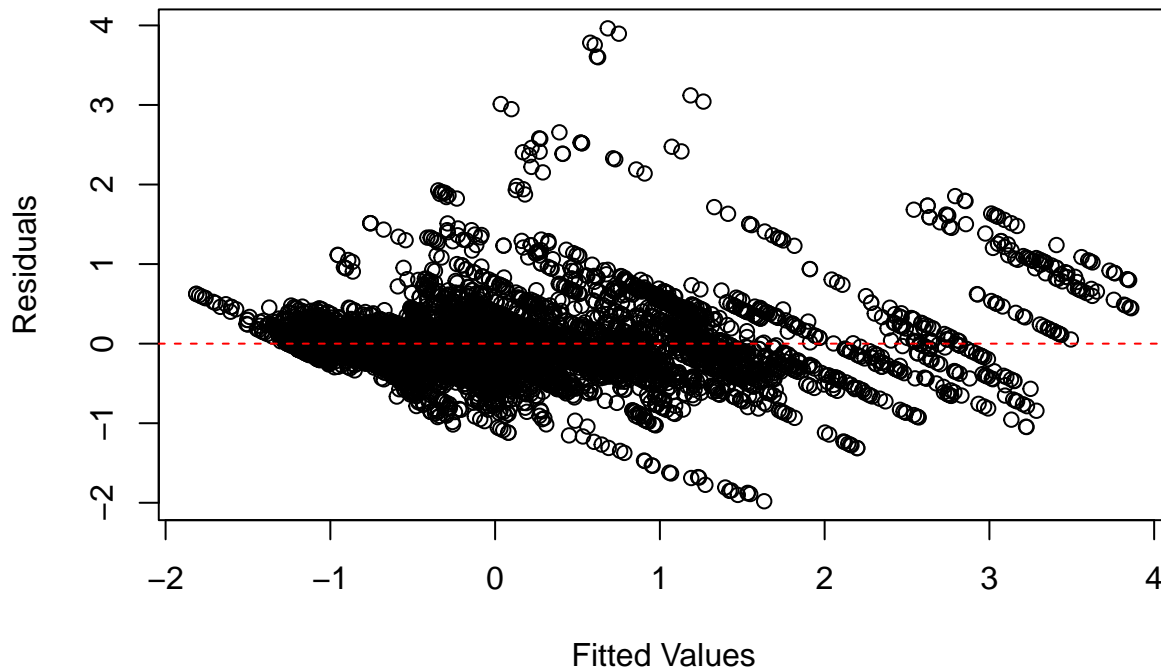
## X	94.93	96.08	97.08	97.85	98.4
## state_mentalhealth_util	88.64	91.43	92.52	92.80	92.8
##	17 comps	18 comps	19 comps	20 comps	21 comps
## X	98.88	99.27	99.51	99.71	99.86
## state_mentalhealth_util	92.88	93.96	94.08	94.52	94.58
##	22 comps	23 comps	24 comps		
## X	99.94	100.00	100.00		
## state_mentalhealth_util	94.76	95.04	95.48		

```
# Show the validation plot.
validationplot(pcr_fit, val.type="MSEP")
```



```
# Plot the residuals vs the fitted values.
pcr_fitted_vals <- as.vector(fitted(pcr_fit, ncomp=5))
pcr_residuals <- as.vector(residuals(pcr_fit, ncomp=5))
plot(pcr_fitted_vals, pcr_residuals,
     xlab = "Fitted Values",
     ylab = "Residuals",
     main = "PCR: Residuals vs Fitted")
abline(h = 0, col = "red", lty = 2)
```

## PCR: Residuals vs Fitted



```
# Get the predictions
pcr_preds <- predict(pcr_fit, data=test_set, ncomp=pcr_m_selected)

# Store and print the pcr mean square error for M_selected.
pcr_mse <- mean((pcr_preds-test_set$state_mentalhealth_util)^2)
```

```
## Warning in pcr_preds - test_set$state_mentalhealth_util: longer object length
## is not a multiple of shorter object length
```

```
paste("PCR MSE for M Selected:",pcr_m_selected,"is", pcr_mse)
```

```
## [1] "PCR MSE for M Selected: 1 is 0.297047642997087"
```

## Partial Least Squares Regression (PLSR)

```
# Set the PLS M selected value.
plsr_M_selected <- 15

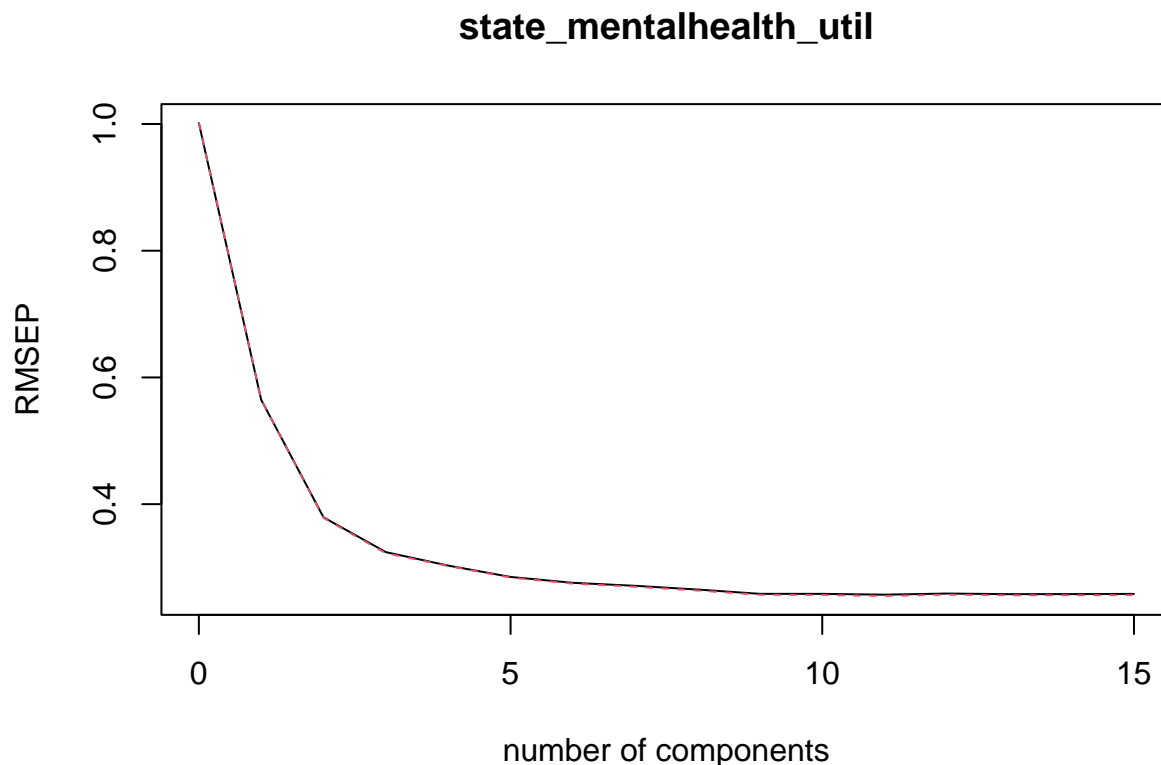
# Get the PCR fit for the training data set
plsr_fit <- plsr(state_mentalhealth_util ~ ., data=GTrend_training_set_f ,
                scale=TRUE, validation="CV", ncomp=plsr_M_selected)

# print the summary of the partial least square regression fit.
summary(plsr_fit)
```

```
## Data:      X dimension: 336 24
## Y dimension: 336 1
```

```
## Fit method: kernelpls
## Number of components considered: 15
##
## VALIDATION: RMSEP
## Cross-validated using 10 random segments.
##      (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
## CV           1.001   0.5648   0.3792   0.3243   0.3031   0.2851   0.2759
## adjCV         1.001   0.5646   0.3783   0.3226   0.3023   0.2841   0.2746
##      7 comps  8 comps  9 comps 10 comps 11 comps 12 comps 13 comps
## CV           0.2712   0.2653   0.2585   0.2584   0.2572   0.2590   0.2580
## adjCV         0.2697   0.2638   0.2569   0.2567   0.2552   0.2572   0.2562
##      14 comps 15 comps
## CV           0.2581   0.2584
## adjCV         0.2563   0.2565
##
## TRAINING: % variance explained
##              1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
## X              26.61   42.78   48.45   59.75   67.85   74.40
## state_mentalhealth_util 69.43   86.72   90.89   92.26   93.31   93.85
##              7 comps  8 comps  9 comps 10 comps 11 comps
## X              79.53   83.02   84.50   86.67   89.01
## state_mentalhealth_util 94.15   94.41   94.71   94.80   94.87
##              12 comps 13 comps 14 comps 15 comps
## X              92.49   93.66   94.88   95.83
## state_mentalhealth_util 94.91   94.98   95.01   95.03
```

```
# Show the validation plot
validationplot(plsr_fit)
```



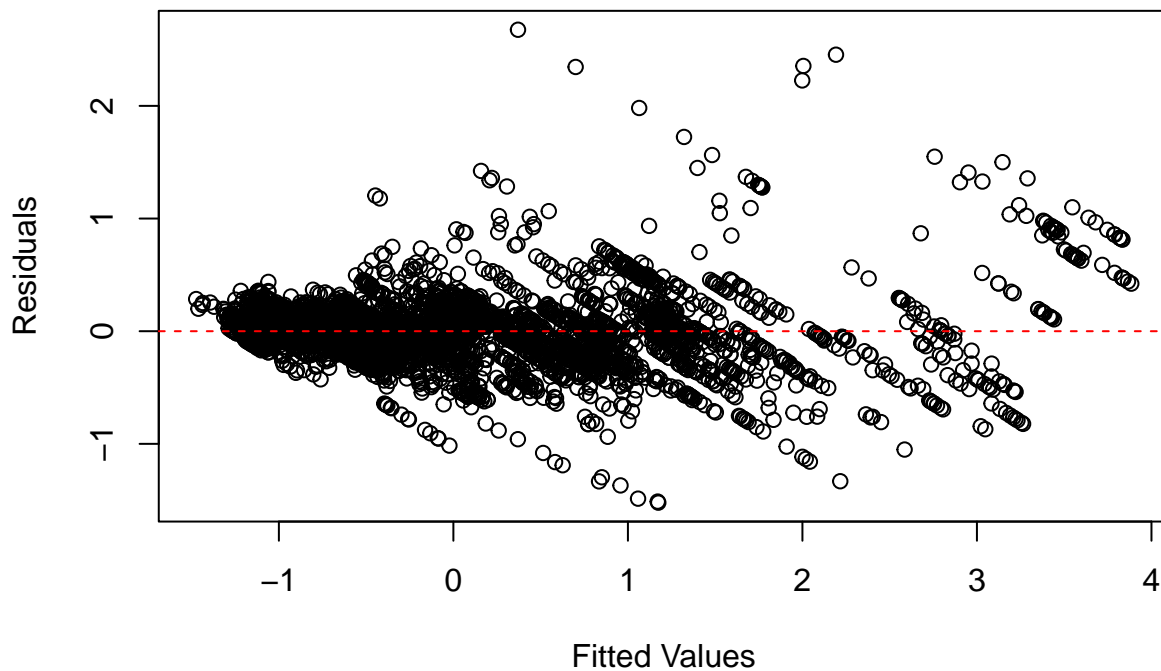


```

# Plot the residuals vs the fitted values.
plsr_fitted_vals <- as.vector(fitted(plsr_fit, ncomp=5))
plsr_residuals <- as.vector(residuals(plsr_fit, ncomp=5))
plot(plsr_fitted_vals, plsr_residuals,
     xlab = "Fitted Values",
     ylab = "Residuals",
     main = "PLSR: Residuals vs Fitted")
abline(h = 0, col = "red", lty = 2)

```

## PLSR: Residuals vs Fitted



```

# Get the predictions
plsr_preds <- predict(plsr_fit, data=test_set, ncomp=plsr_M_selected)

# Store and print the MSE value for the PLSR
plsr_mse <- mean((plsr_preds-test_set$state_mentalhealth_util)^2)

```

```

## Warning in plsr_preds - test_set$state_mentalhealth_util: longer object length
## is not a multiple of shorter object length

```

```

paste("PLSR MSE for M Selected:", plsr_M_selected, "is", plsr_mse)

```

```

## [1] "PLSR MSE for M Selected: 15 is 0.944507842217449"

```

## Best Subset Selection

```

# Load library needed for regsubsets() function
library(leaps)

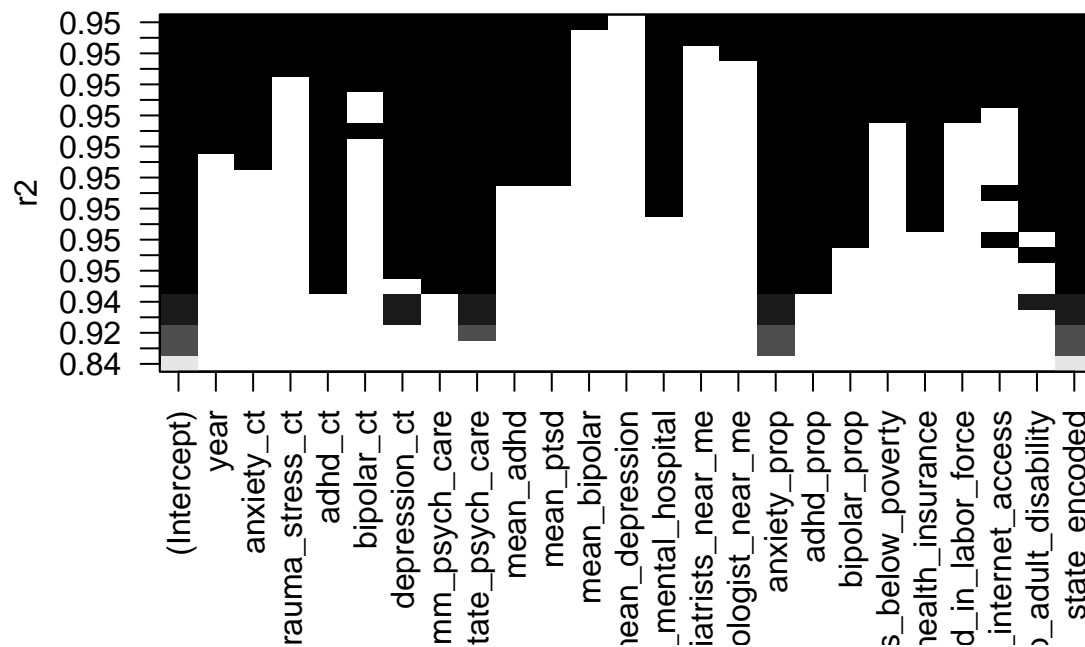
```

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

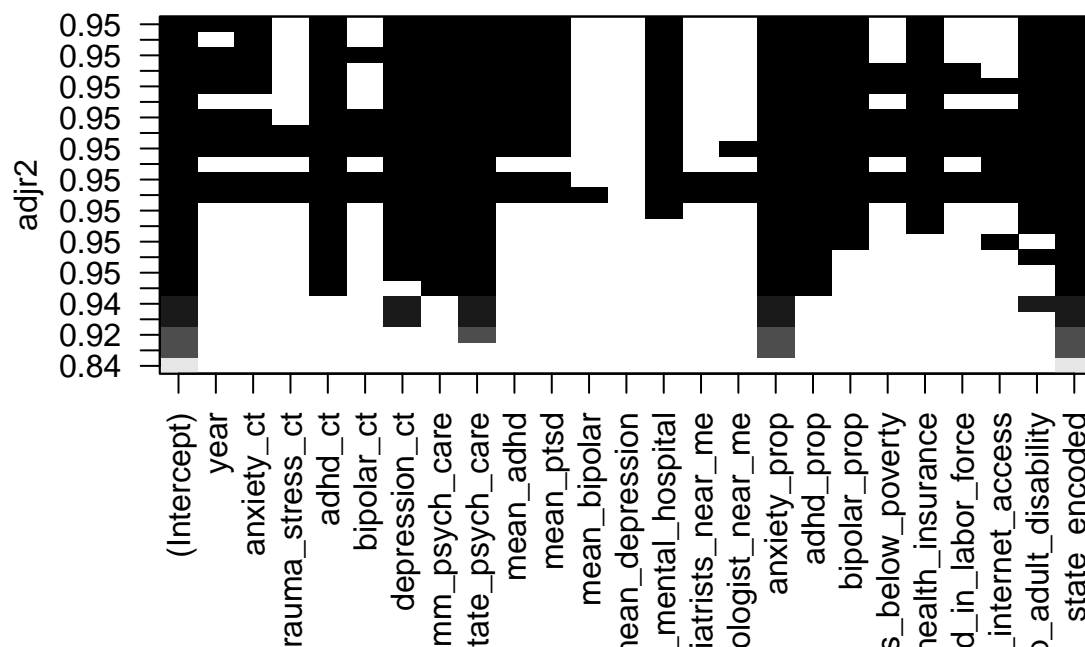
```
# The regsubsets() function (part of the leaps library) performs best sub- set selection  
# by identifying the best model that contains a given number of predictors, where best  
# is quantified using RSS.
```

```
reg_fit_train <- regsubsets(state_mentalhealth_util ~ ., data=GTrend_training_set_f, nvmax=23)
```

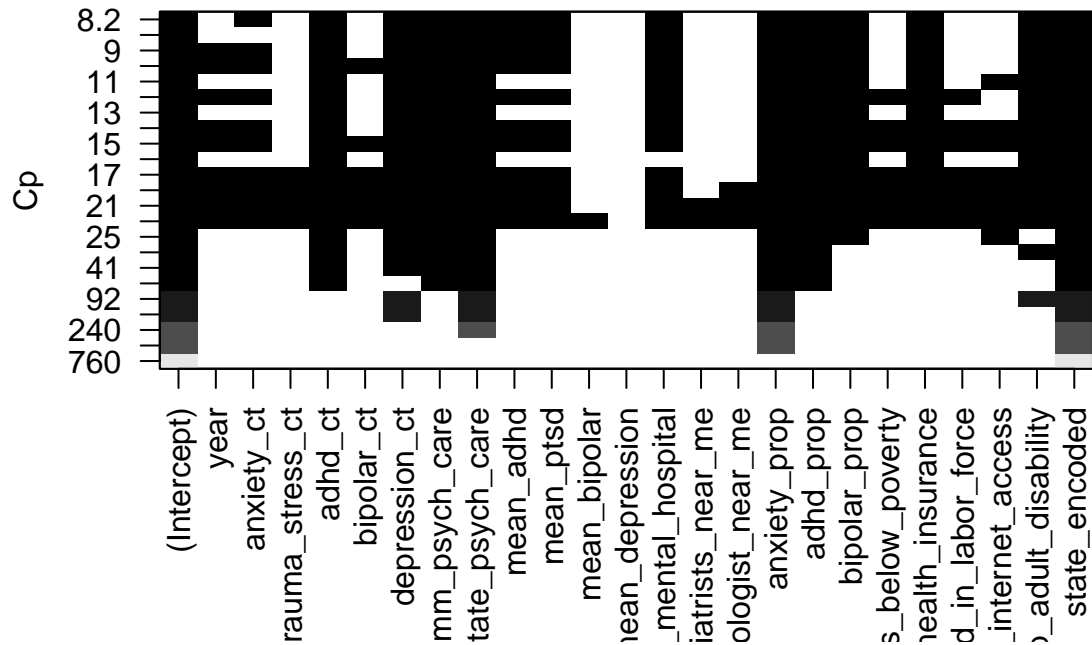
```
plot(reg_fit_train, scale="r2")
```



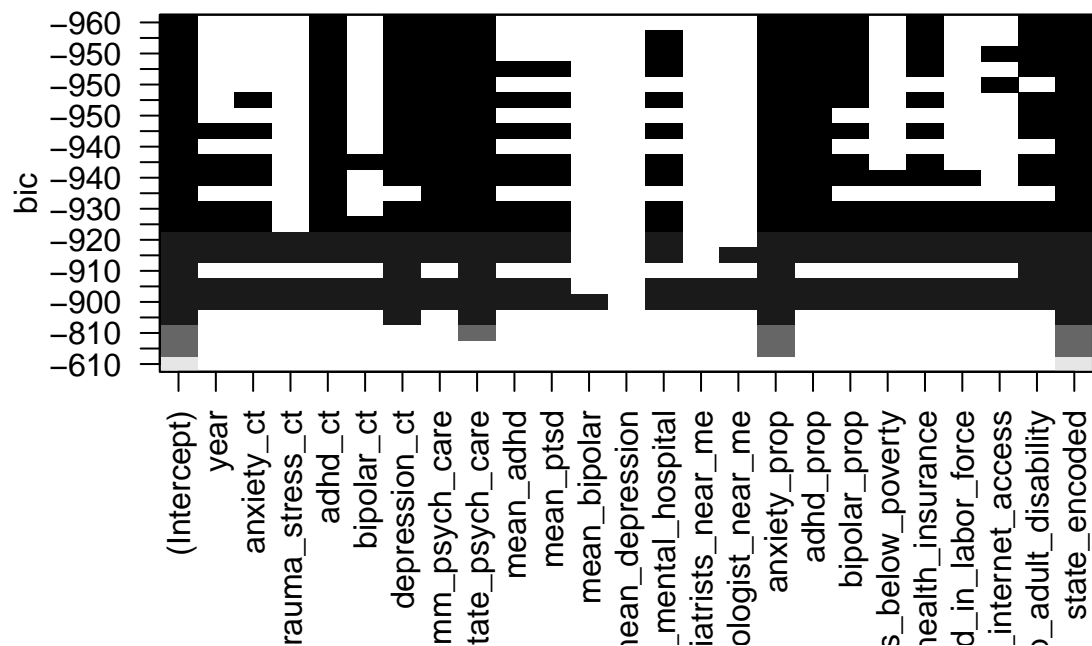
```
plot(reg_fit_train, scale="adjr2")
```



```
plot(reg_fit_train, scale="Cp")
```



```
plot(reg_fit_train, scale="bic")
```



```
# The summary() command outputs the best set of variables for each model size.
reg.summary <- summary(reg_fit_train)
print(reg.summary)
```

```
## Subset selection object
## Call: regsubsets.formula(state_mentalhealth_util ~ ., data = GTrend_training_set_f,
```

```

##      nvmax = 23)
## 24 Variables (and intercept)
##
##      Forced in Forced out
## year                FALSE      FALSE
## anxiety_ct          FALSE      FALSE
## trauma_stress_ct    FALSE      FALSE
## adhd_ct             FALSE      FALSE
## bipolar_ct          FALSE      FALSE
## depression_ct       FALSE      FALSE
## comm_psych_care     FALSE      FALSE
## state_psych_care    FALSE      FALSE
## mean_adhd           FALSE      FALSE
## mean_ptsd           FALSE      FALSE
## mean_bipolar        FALSE      FALSE
## mean_depression     FALSE      FALSE
## mean_mental_hospital FALSE      FALSE
## mean_psychiatrists_near_me FALSE FALSE
## mean_psychologist_near_me FALSE FALSE
## anxiety_prop        FALSE      FALSE
## adhd_prop           FALSE      FALSE
## bipolar_prop        FALSE      FALSE
## prop_families_below_poverty FALSE FALSE
## prop_adults_without_health_insurance FALSE FALSE
## prop_unemployed_in_labor_force FALSE FALSE
## prop_without_internet_access FALSE FALSE
## prop_adult_disability FALSE      FALSE
## state_encoded       FALSE      FALSE
## 1 subsets of each size up to 23
## Selection Algorithm: exhaustive
##      year anxiety_ct trauma_stress_ct adhd_ct bipolar_ct depression_ct
## 1 ( 1 ) " " " " " " " " " "
## 2 ( 1 ) " " " " " " " " " "
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## 23 ( 1 ) "*" "*" "*" "*" "*" "*" " "
##      comm_psych_care state_psych_care mean_adhd mean_ptsd mean_bipolar

```

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## 2	( 1 )	" "	" "	" "	" "	" "
## 3	( 1 )	" "	"*"	" "	" "	" "
## 4	( 1 )	" "	"*"	" "	" "	" "
## 5	( 1 )	" "	"*"	" "	" "	" "
## 6	( 1 )	"*"	"*"	" "	" "	" "
## 7	( 1 )	"*"	"*"	" "	" "	" "
## 8	( 1 )	"*"	"*"	" "	" "	" "
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## 11	( 1 )	"*"	"*"	" "	" "	" "
## 12	( 1 )	"*"	"*"	" "	" "	" "
## 13	( 1 )	"*"	"*"	"*"	"*"	" "
## 14	( 1 )	"*"	"*"	"*"	"*"	" "
## 15	( 1 )	"*"	"*"	"*"	"*"	" "
## 16	( 1 )	"*"	"*"	"*"	"*"	" "
## 17	( 1 )	"*"	"*"	"*"	"*"	" "
## 18	( 1 )	"*"	"*"	"*"	"*"	" "
## 19	( 1 )	"*"	"*"	"*"	"*"	" "
## 20	( 1 )	"*"	"*"	"*"	"*"	" "
## 21	( 1 )	"*"	"*"	"*"	"*"	" "
## 22	( 1 )	"*"	"*"	"*"	"*"	" "
## 23	( 1 )	"*"	"*"	"*"	"*"	"*"
##		mean_depression	mean_mental_hospital	mean_psychiatrists_near_me		
## 1	( 1 )	" "	" "	" "		
## 2	( 1 )	" "	" "	" "		
## 3	( 1 )	" "	" "	" "		
## 4	( 1 )	" "	" "	" "		
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## 11	( 1 )	" "	"*"	" "		
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## 14	( 1 )	" "	"*"	" "		
## 15	( 1 )	" "	"*"	" "		
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## 17	( 1 )	" "	"*"	" "		
## 18	( 1 )	" "	"*"	" "		
## 19	( 1 )	" "	"*"	" "		
## 20	( 1 )	" "	"*"	" "		
## 21	( 1 )	" "	"*"	" "		
## 22	( 1 )	" "	"*"	"*"		
## 23	( 1 )	" "	"*"	"*"		
##		mean_psychologist_near_me	anxiety_prop	adhd_prop	bipolar_prop	
## 1	( 1 )	" "	" "	" "	" "	
## 2	( 1 )	" "	"*"	" "	" "	
## 3	( 1 )	" "	"*"	" "	" "	
## 4	( 1 )	" "	"*"	" "	" "	
## 5	( 1 )	" "	"*"	" "	" "	
## 6	( 1 )	" "	"*"	"*"	" "	

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##
##      prop_families_below_poverty prop_adults_without_health_insurance
## 1 ( 1 ) " " " "
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## 22 ( 1 ) "*" "*"
## 23 ( 1 ) "*" "*"
##
##      prop_unemployed_in_labor_force prop_without_internet_access
## 1 ( 1 ) " " " "
## 2 ( 1 ) " " " "
## 3 ( 1 ) " " " "
## 4 ( 1 ) " " " "
## 5 ( 1 ) " " " "
## 6 ( 1 ) " " " "
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## 9 ( 1 ) " " "*"
## 10 ( 1 ) " " " "
## 11 ( 1 ) " " " "
## 12 ( 1 ) " " "*"

```

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## 13 ( 1 ) " " " "
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## 16 ( 1 ) " " " "
## 17 ( 1 ) "*" " "
## 18 ( 1 ) "*" "*"
## 19 ( 1 ) "*" "*"
## 20 ( 1 ) "*" "*"
## 21 ( 1 ) "*" "*"
## 22 ( 1 ) "*" "*"
## 23 ( 1 ) "*" "*"
##
##      prop_adult_disability state_encoded
## 1 ( 1 ) " " "*"
## 2 ( 1 ) " " "*"
## 3 ( 1 ) " " "*"
## 4 ( 1 ) " " "*"
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```

```
names(reg.summary)
```

```
## [1] "which" "rsq" "rss" "adjr2" "cp" "bic" "outmat" "obj"
```

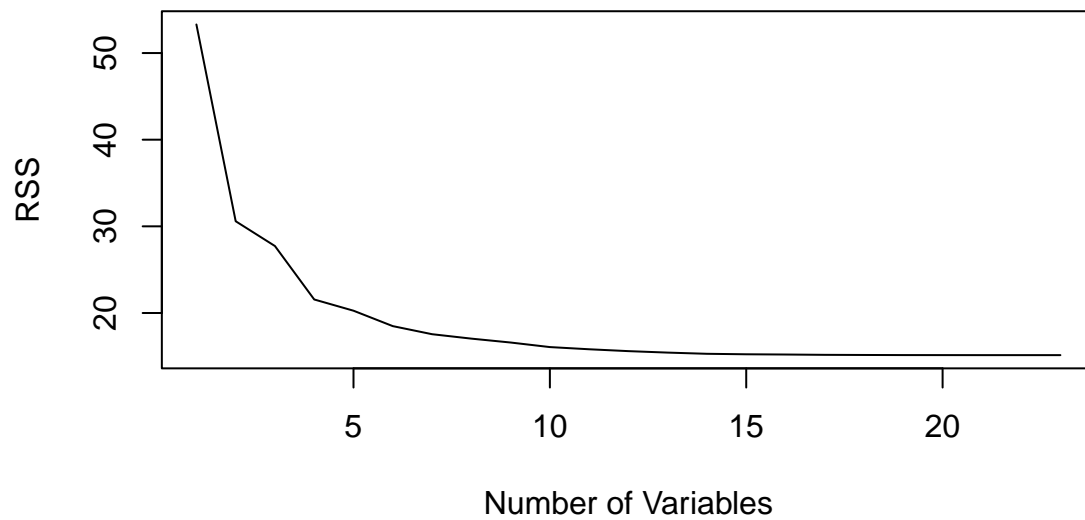
```
#Print the R^2 statistic
reg.summary$rsq
```

```
## [1] 0.8408960 0.9086876 0.9172348 0.9356482 0.9395110 0.9448241 0.9476010
## [8] 0.9491264 0.9504757 0.9520454 0.9527919 0.9534369 0.9539487 0.9543586
## [15] 0.9545206 0.9546088 0.9547159 0.9547648 0.9548005 0.9548098 0.9548164
## [22] 0.9548169 0.9548175

```

```
#par(mfrow=c(1,2))
plot(reg.summary$rss, xlab="Number of Variables", ylab="RSS", type="l")

```



```
plot(reg.summary$adjr2 , xlab = "Number of Variables",ylab = "Adjusted RSq", type = "l")
# which.max(reg.summary$adjr2)
plot(reg.summary$adjr2 , xlab = "Number of Variables", ylab = "Adjusted RSq", type = "l")
points(which.max(reg.summary$adjr2), reg.summary$adjr2[which.max(reg.summary$adjr2)],
       col = "red", cex = 2, pch = 20)
```

