



# **Correlation Between Physical & Mental Health**

Aaron Miller, Adriana Garcia, Kylie Hefner, & Lukas Van de Velde





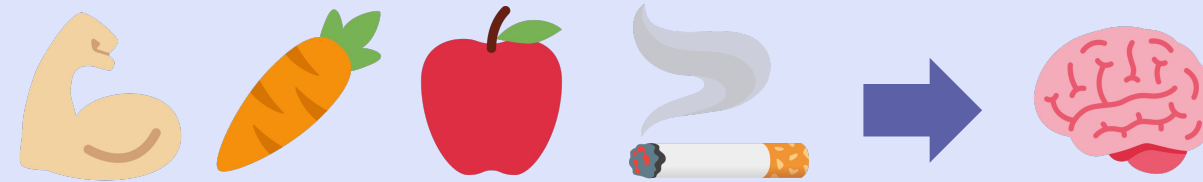
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- Database & Connections
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# About Our Project

## Our Topic



Exploring correlations between physical health indicators and mental health outcomes.

## Why?

Our group had a shared interest in and/or background in the health industry.

# About Our Project

## Data Source



Health-related telephone survey in the US.  
>400k interviews each year – largest continuously  
conducted health survey in the world.

(dataset from the CDC [via Kaggle](#))

# About Our Project

## Questions:

Which health choices & common diseases are most correlated with mental health?

Could you predict mental health outcomes using physical health indicators?

Do other indicators have an impact on mental health?



# Technologies We Used

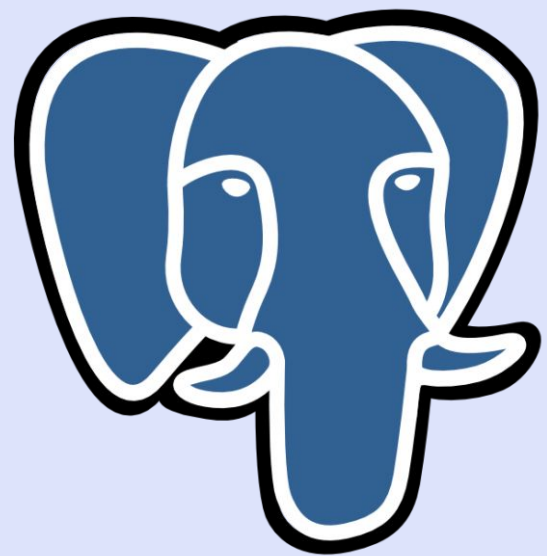
PySpark

pandas

amazon  
RDS

PYCARET

NumPy



PostgreSQL

+ a b l e a u

# Database and Connections

## Data Source

2015 Behavioral Risks Factors Survey



### Codebook

Mapped columns in the dataset to descriptions, frequency, percentages, etc.

## S3 + PySpark

Loaded data into an S3 bucket.

Extracted data using pyspark.

Transformed data and Loaded Tables to SQL DataBase

## Postgres+RDS

Used SQL Database on RDS Server

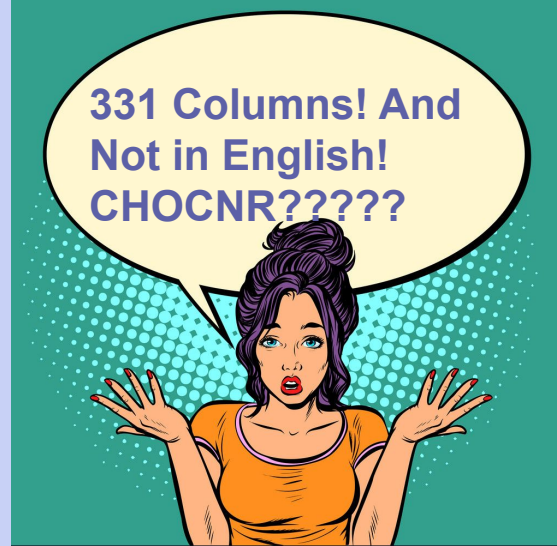
Used **psycopg2** to connect Database to ML model and visualization tools





# Analysis

## Data Exploration ...



## Understanding Data:

PHYSHLTH	POORHLTH	GENHLTH	MENTHLTH	BPHIGH4	TOLDHI2	CVDINFR4	CVDCRHD4	CVDSTRK3	CHCSCNCR	CHCOCNCR	CHCCOPD1	HAVARTH3	C
15	10	5	18	1	1	2	2	2	2	2	1	1	
88	null	3	88	3	2	2	2	2	2	2	2	2	
15	88	4	88	3	1	7	2	1	2	1	2	1	
30	30	5	30	1	1	2	2	2	2	1	2	1	
20	30	5	88	3	2	2	2	2	2	2	2	1	
88	null	2	88	1	2	2	2	2	2	2	2	1	
88	88	2	3	1	1	2	2	2	2	2	2	2	
8	8	5	88	1	1	7	2	2	2	2	2	1	
77	77	5	88	3	null	2	2	2	2	2	2	1	
2	2	2	88	1	1	2	2	2	2	2	2	2	

BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEM CODEBOOK REPORT, 2015 Land-Line and Cell-Phone data				
<b>Could Not See Doctor Because of Cost</b>				
Section: 3.3 Health Care Access		Type: Num		
Column: 99	SAS Variable Name: MEDCOST			
Prologue:				
Description: Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?				
Value	Value Label	Frequency	Percentage	Weighted Percentage
1	Yes	43,514	9.86	13.22
2	No	386,748	89.87	86.46
7	Don't know/Not sure	945	0.21	0.25
9	Refused	248	0.06	0.07
BLANK	Not asked or Missing	1		
Length of time since last routine checkup				
Section: 3.4 Health Care Access		Type: Num		
Column: 100	SAS Variable Name: CHECKUP1			
Prologue:				
Description: About how long has it been since you last visited a doctor for a routine checkup? [A routine checkup is a general physical exam, not an exam for a specific injury, illness, or condition.]				
Value	Value Label	Frequency	Percentage	Weighted Percentage
1	Within past year (anytime less than 12 months ago)	325,432	73.72	69.13
2	Within past 2 years (1 year but less than 2 years ago)	50,529	11.45	13.10
3	Within past 5 years (2 years but less than 5 years ago)	28,570	6.47	8.02
4	5 or more years ago	24,987	6.11	7.28
7	Don't know/Not sure	5,493	1.24	1.18
8	Never	3,843	0.87	1.14
9	Refused	661	0.15	0.15
BLANK	Not asked or Missing	1		

BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEM CODEBOOK REPORT, 2015 Land-Line and Cell-Phone data				
<b>Ever Told Blood Pressure High</b>				
Section: 4.1 Hypertension Awareness		Type: Num		
Column: 101	SAS Variable Name: BPHIGH4			
Prologue:				
Description: Have you EVER been told by a doctor, nurse or other health professional that you have high blood pressure? (If "Yes" and respondent is female, ask "Was this only when you were pregnant?")				
Value	Value Label	Frequency	Percentage	Weighted Percentage
1	Yes	178,188	40.36	31.90
2	Yes, but female told only during pregnancy—Go to Section 05.01 BLOODCHD	3,271	0.74	0.93
3	No—Go to Section 05.01 BLOODCHD	254,318	57.61	66.02
4	Told borderline high or pre-hypertensive—Go to Section 05.01 BLOODCHD	4,312	0.98	5.83
7	Don't know/Not Sure—Go to Section 05.01 BLOODCHD	862	0.20	0.19
9	Refused—Go to Section 05.01 BLOODCHD	504	0.11	0.12
BLANK	Not asked or Missing	1		
Currently Taking Blood Pressure Medication				
Section: 4.2 Hypertension Awareness		Type: Num		
Column: 102	SAS Variable Name: BPMEDS			
Prologue:				
Description: Are you currently taking medicine for your high blood pressure?				
Value	Value Label	Frequency	Percentage	Weighted Percentage
1	Yes	149,034	83.04	77.20
2	No	29,833	16.18	22.48
7	Don't know/Not Sure	258	0.14	0.10
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Prologue:				
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Section: 4.2 Hypertension Awareness		Type: Num		
Column: 102	SAS Variable Name: BPMEDS			
Prologue:				
Description: Are you currently taking medicine for your high blood pressure?				
Value	Value Label	Frequency	Percentage	Weighted Percentage
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Section: 4.1 Hypertension Awareness		Type: Num		
Column: 101	SAS Variable Name: BPHIGH4			
Prologue:				
Description: Have you EVER been told by a doctor, nurse or other health professional that you have high blood pressure? (If "Yes" and respondent is female, ask "Was this only when you were pregnant?")				
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# Analysis

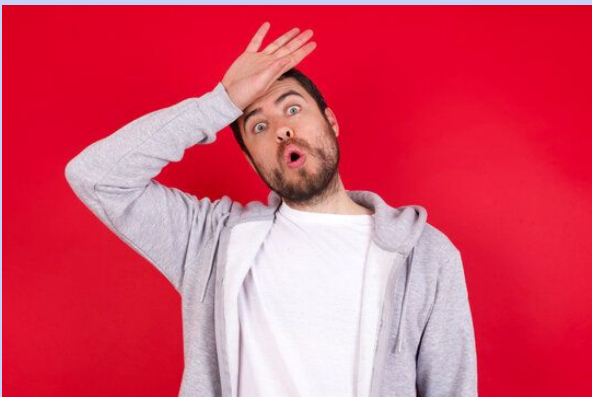
## Data Clean Up ...

### Reviewed DataSet and Classified Relevant Columns

A	B	C	D	E	
ColumnCod	Topic	Question	Score	Relevant	Comments
DISPCODE	Disposition Code		1100 completed	X	only completed Ir
GENHLTH	Health Status/Healthy Days	Would you say that in general your health is---	1=Excellent 2=Very good 3=Good 4=Fair 5=Poor 7=DK/NS 9=Refused	ML?	Remove 7,9
PHYSHLTH	Health Status/Healthy Days	how many days during the past 30 days was your physical health not good? (Moved to Healthy Days in 2004)	__=Number of days 88=None 77=DK/NS 99=Refused	ML	Remove 88, 77,99
MENTHLTH	Health Status/Healthy Days	Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good? (Moved to Healthy Days in 2004)	__=Number of days 88=None 77=DK/NS 99=Refused	Target	132,972 3 btwn 1 but we could also threshold , or con answers see yellow
POORHLTH	Health Status/Healthy Days	you from doing your usual activities, such as self-care, work, or recreation? (Moved to Healthy Days in 2004)	__=Number of days 88=None 77=DK/NS 99=Refused	ML	
BPHIGH4	Hypertension (Awareness)	high blood pressure? (If "Yes" and respondent is female, ask "Was this only when you were pregnant?").	1=Yes 2=Yes, but female told only during pregnancy 3=No 4=Told borderline high or pre-hypertensive 7=DK/NS 9=Refused	ML	Combine Respons
TOLDHI2	Cholesterol (Awareness)	Have you ever been told by a doctor, nurse or other health professional that your blood cholesterol is high? (Change in variable name.)	1=Yes 2=No 7=DK/NS 9=Refused	ML	Remove 7,9
		[Prologue: Now I would like to ask you some questions about cardiovascular disease]. Has a doctor, nurse, or other health professional EVER told you that you had any of the following? For each, tell me "Yes". "No". or you're "Not sure". (Ever told) vou had a			

### Cleaned Data, removed NA, renamed Columns for Machine Learning Table

GENHLTH	MENTHLTH	PHYSHLTH	SEX	MARITAL_STATUS	EDUCATION	HOME_STATUS	VETERAN	EMPLOYMENT_SITUATION	INTERNET	DISABII
3	88	88	2	2	6	1	2	3	1	
2	88	88	2	3	3	1	2	2	2	
2	3	88	2	3	5	1	2	7	2	
2	88	2	1	1	6	1	2	7	1	
3	88	88	2	3	4	1	2	5	1	
3	88	14	2	3	3	1	2	7	2	
3	88	88	1	1	6	1	1	7	1	
5	99	99	1	2	4	2	1	99	2	
4	30	28	2	1	6	1	2	8	1	
2	5	88	2	1	6	1	2	1	1	
only showing top 10 rows										



### Optimized List Creation For Transformations

SUM	E	F	H	I	J	K	L	M	N
list string	Renamed			List String					
STATE									
'FMONTH',	FMONTH			'FMONTH',					
'FMONTH',	DATE			F20&"'"&"					
'FMONTH',	MONTH			'FMONTH','DATE','MONTH',					
'FMONTH',	DAY			'FMONTH','DATE','MONTH','DAY',					
'FMONTH',	YEAR			'FMONTH','DATE','MONTH','DAY','YEAR',					
'FMONTH',	DISPCODE			'FMONTH','DATE','MONTH','DAY','YEAR','DISPCODE',					
'FMONTH',	PHYSHLTH			'FMONTH','DATE','MONTH','DAY','YEAR','DISPCODE','PHYSHLTH',					
'FMONTH',	POORHLTH			'FMONTH','DATE','MONTH','DAY','YEAR','DISPCODE','PHYSHLTH','POORH					
'FMONTH',	GENHLTH			'FMONTH','DATE','MONTH','DAY','YEAR','DISPCODE','PHYSHLTH','POORH					

### Transform to categorical Values for DashBoard Table

GENHLTH	MENTHLTH	SEX	PHYSHLTH	MARITAL_STATUS	RACE	METRO_CODE	AGE_14LEVEL	AGE_2LEVEL	EDUCATI
Good	88	Female	88	Divorced	White	Not in MSA	50-54	18-64	Graduated
Very Good	88	Female	88	Widowed	White	Not in MSA	70-74	65-Older	Did not Grad
Very Good	3	Female	88	Widowed	White	Center of MSA	70-74	65-Older	Attended
Very Good	88	Male	2	Married	White	Center of MSA	65-69	65-Older	Graduated
Good	88	Female	88	Widowed	White	Inside a Suburban...	70-74	65-Older	Graduated Hi
Good	88	Female	14	Widowed	White	Inside a Suburban...	80-Older	65-Older	Did not Grad
Good	88	Male	88	Married	White	Center of MSA	80-Older	65-Older	Graduated
Poor	99	Male	99	Divorced	White	Center of MSA	Dont know	18-64	Graduated Hi
Fair	30	Female	28	Married	White	Inside a Suburban...	35-39	18-64	Graduated
Very Good	5	Female	88	Married	White	Not in MSA	45-49	18-64	Graduated
Good	88	Female	88	Married	White	Not in MSA	65-69	65-Older	Graduated Hi
Very Good	88	Male	88	Married	White	Center of MSA	50-54	18-64	Attended
Very Good	99	Male	88	Widowed	White	Center of MSA	80-Older	65-Older	Did not Grad
Fair	88	Female	30	Widowed	White	Not in MSA	80-Older	65-Older	Did not Grad
Excellent	88	Female	88	Widowed	African American	Not in MSA	80-Older	65-Older	Attended
Very Good	88	Female	88	Married	White	Center of MSA	40-44	18-64	Graduated
Excellent	88	Male	88	Married	White	Outside Center MSA	75-79	65-Older	Graduated
Fair	88	Female	7	Never Married	African American	Outside Center MSA	Dont know	18-64	Attended
Excellent	88	Male	88	Widowed	White	Inside a Suburban...	80-Older	65-Older	Did not Grad
Excellent	2	Female	88	Married	White	Not in MSA	45-49	18-64	Graduated H

# Load and Connect

## Load Tables to SQL RDS Server

```
# Configure settings for RDS
mode = "append"
jdbc_url="jdbc:postgresql://bootcampproject.cs8v5ggqsbn0.us-west-1.rds.amazonaws.com:5432/postgres"
config = {"user": "postgres",
          "password": password,
          "driver": "org.postgresql.Driver"}
```

```
[ ] #Write Dash DF to active_user table in RDS
#df2.describe()

df2.write.jdbc(url=jdbc_url, table='survey_dash_data_2', mode=mode, properties=config)
```

## Connect

```
import psycopg2
import pandas as pd

conn = psycopg2.connect(database = 'postgres',
                        user = 'postgres',
                        password = 'password',
                        host = 'bootcampproject.cs8v5ggqsbn0.us-west-1.rds.amazonaws.com',
                        port = '5432')

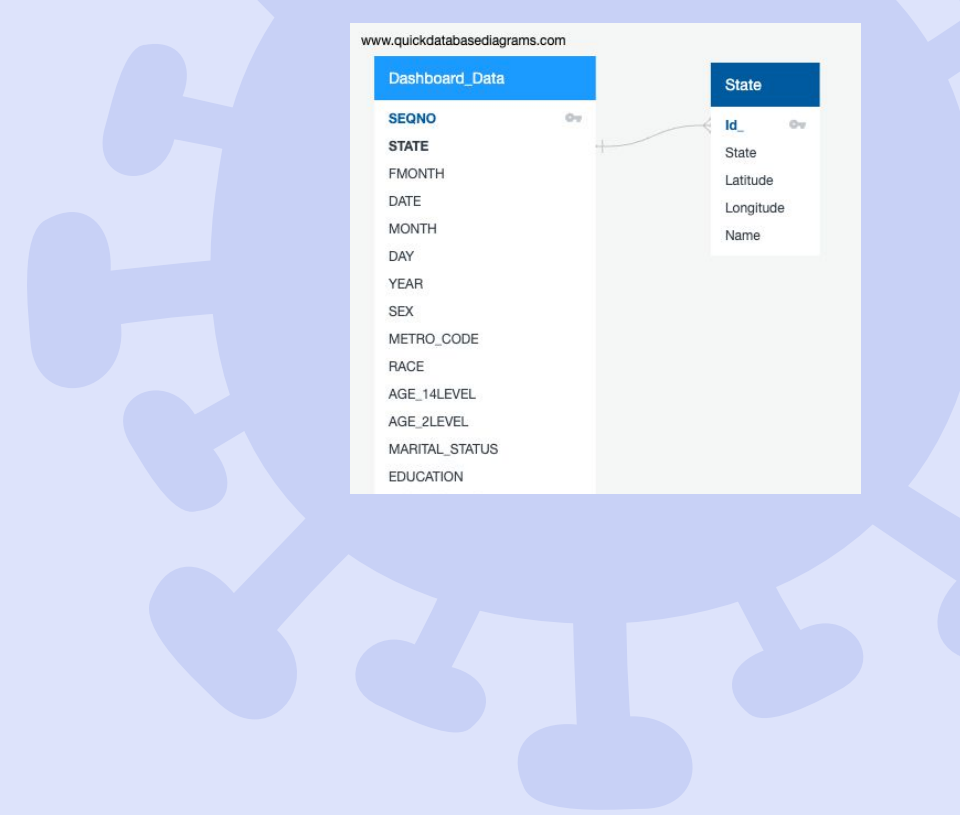
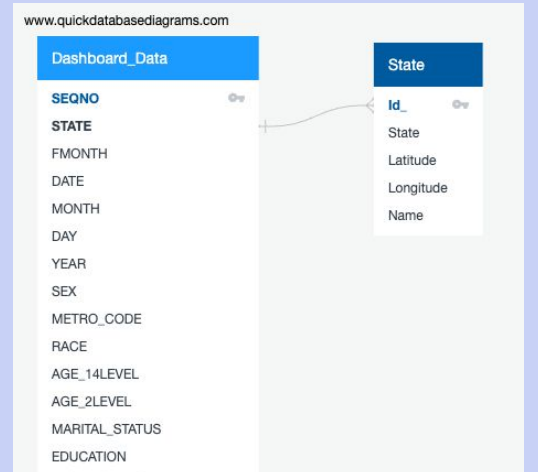
cur = conn.cursor()

cur.execute('''
            SELECT *
            FROM ml_table;
            ''')

data = cur.fetchall()

# Create a dataframe
cols = []
for elt in cur.description:
    cols.append(elt[0])

health_df = pd.DataFrame (data=data,columns=cols)
pd.set_option('display.max_columns', None)
health_df.head(10)
```





# Machine Learning

## Feature Engineering

Changed non-answer codes  
Removed outliers

Binned target variable and features  
with over 12 unique values

### General Health

**Section:** 1.1 Health Status

**Type:** Num

**Column:** 90

**SAS Variable Name:** GENHLTH

**Prologue:**

**Description:** Would you say that in general your health is:

Value	Value Label	Frequency	Percentage	Weighted Percentage
1	Excellent	76,032	17.22	18.68
2	Very good	145,065	32.86	31.78
3	Good	136,975	31.03	31.59
4	Fair	58,962	13.36	13.06
5	Poor	23,175	5.25	4.60
7	Don't know/Not Sure	799	0.18	0.18
9	Refused	446	0.10	0.11
BLANK	Not asked or Missing	2		

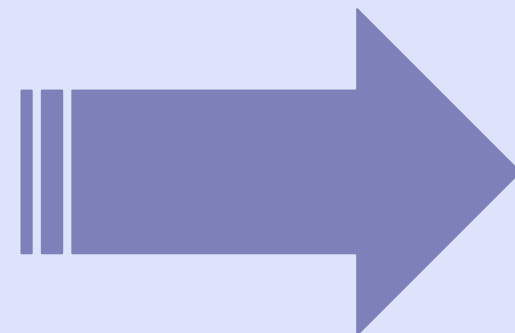
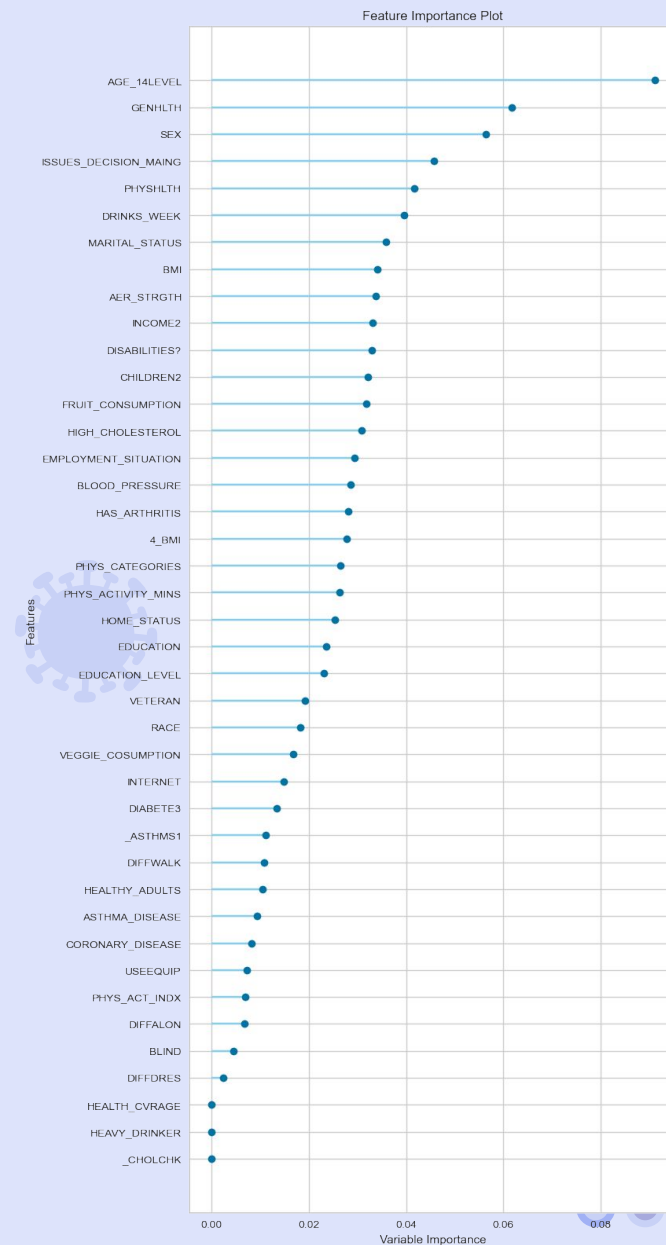
```
# GENHLTH: 7/9 (don't know/refused/missing) changed to the rounded median
GENHLTH_median = round(health_df[(health_df.GENHLTH != 9) & (health_df.GENHLTH != 7)].GENHLTH.median())
health_df['GENHLTH'] = health_df['GENHLTH'].replace({7:GENHLTH_median, 9:GENHLTH_median})
```

# Machine Learning

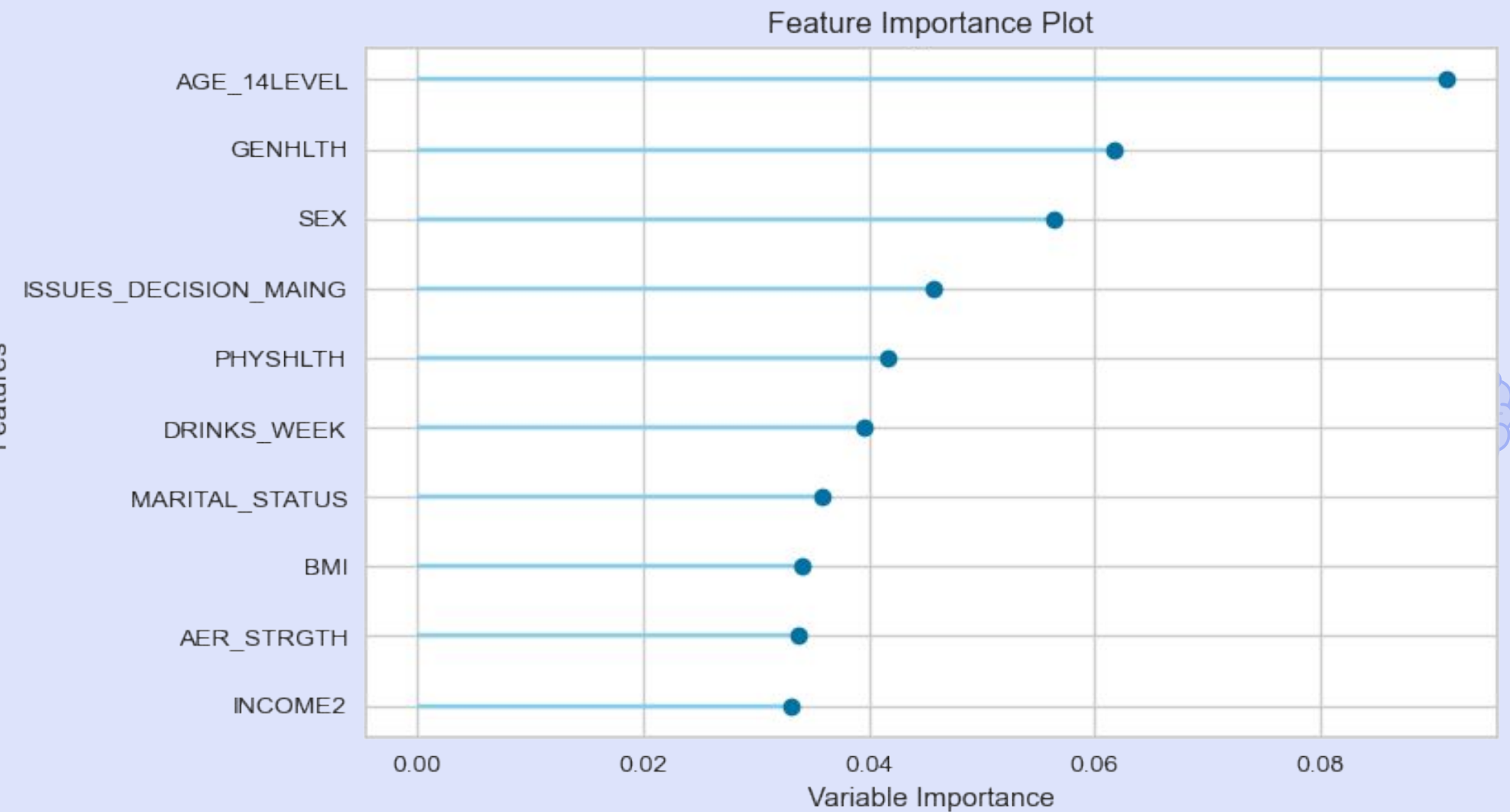
## Feature Selection

Created feature importance chart

Set a cutoff of 0.02 variable feature importance due to drop-off  
23/41 features were kept for modeling



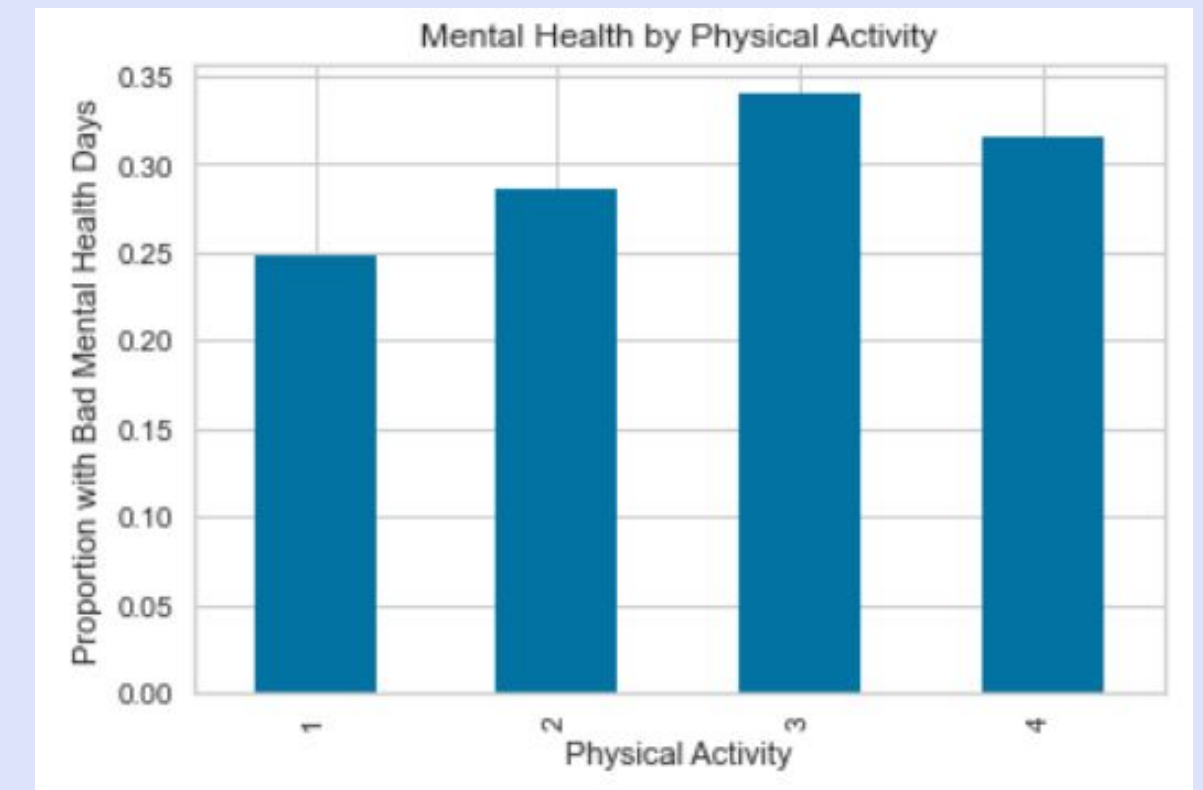
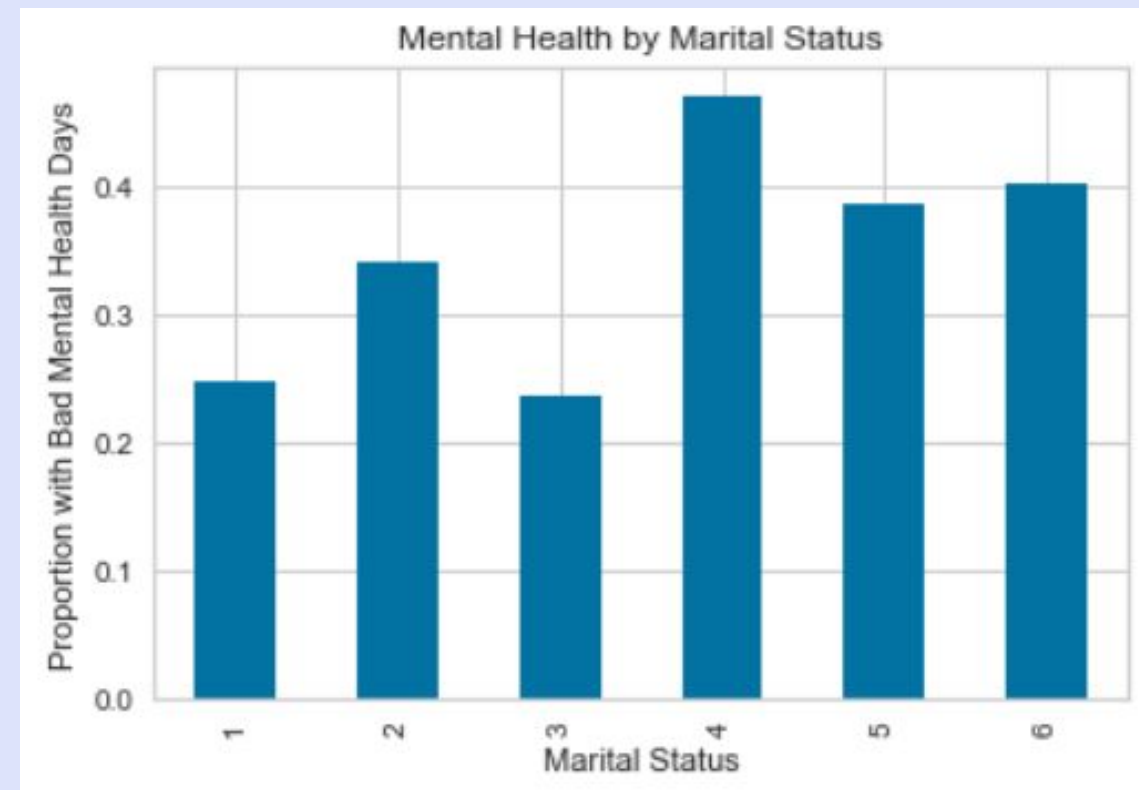
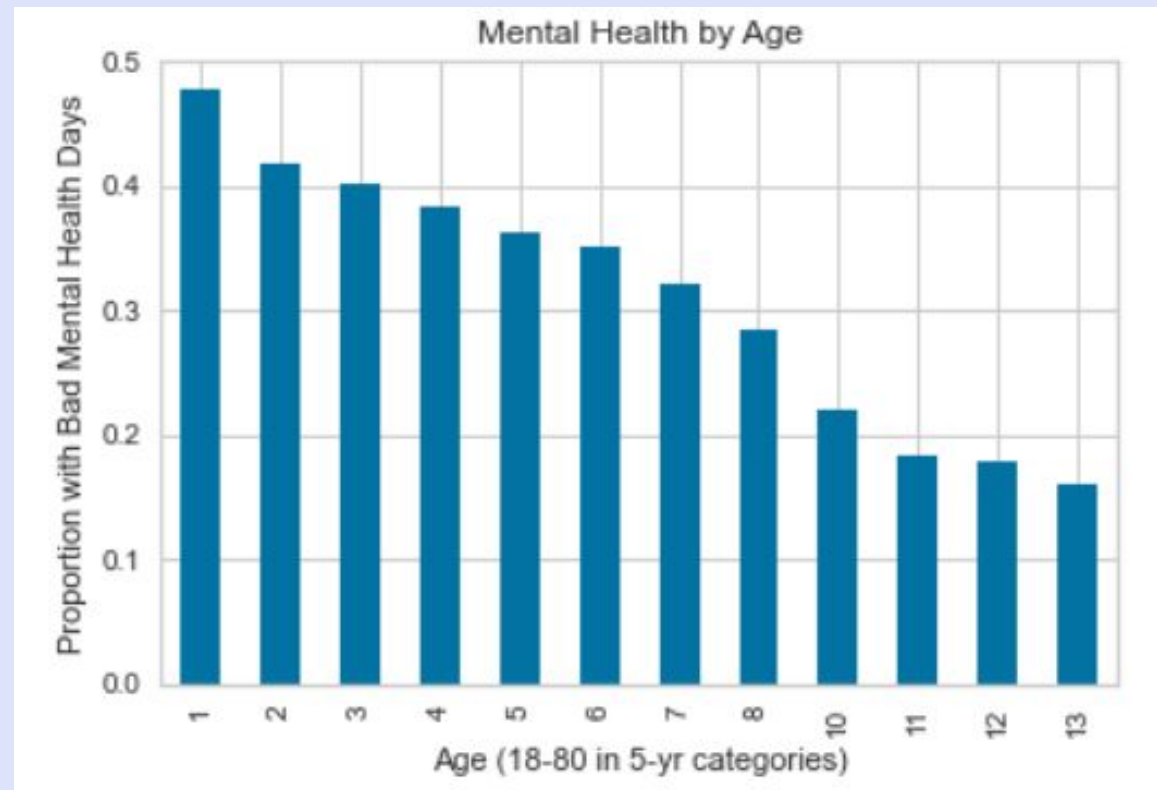
Features



# Machine Learning

## Feature Selection

Interesting Correlations Discovered through Feature Importance Plot:





# Machine Learning

## Model Choice

Used PyCaret's function `compare_models()`, which runs 12 ML models  
A gradient boosting classifier model was chosen to balance accuracy and interpretability  
Initial Accuracy: 74.63% Initial F1: 0.7248

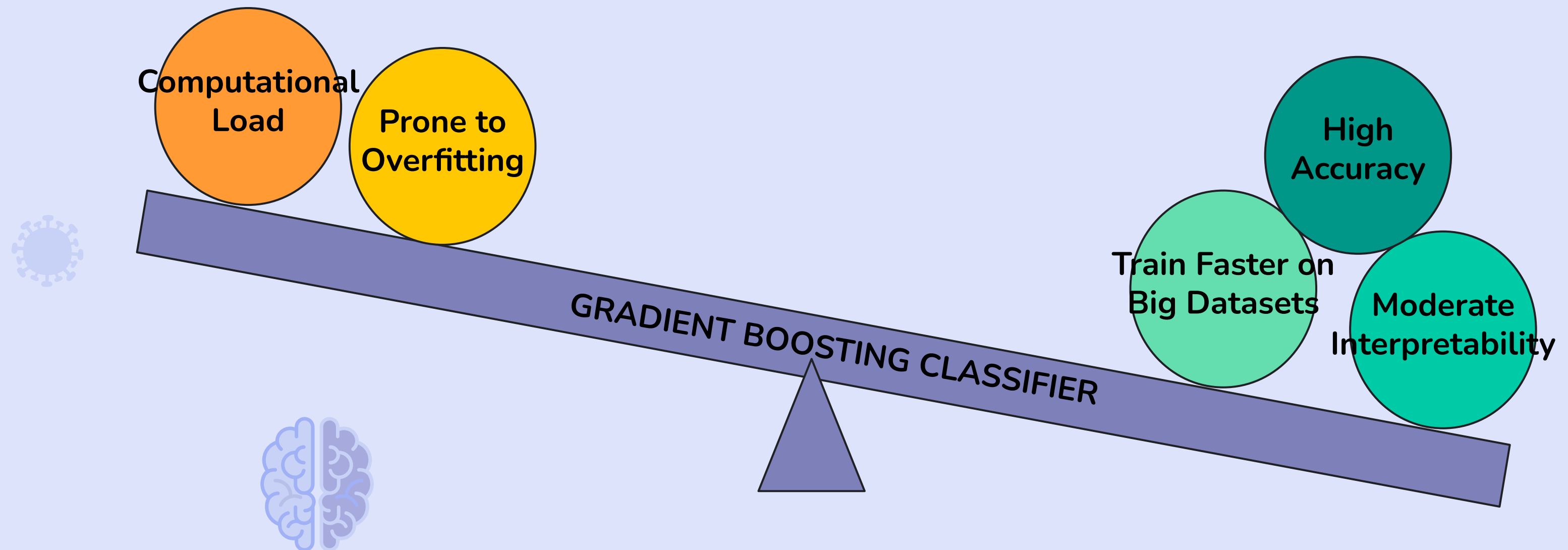
	Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	TT (Sec)
<b>lightgbm</b>	Light Gradient Boosting Machine	0.7524	0.7409	0.7524	0.7291	0.7211	0.2982	0.3253	4.1350
<b>gbc</b>	Gradient Boosting Classifier	0.7463	0.7365	0.7463	0.7230	0.7248	0.3132	0.3262	77.0060
<b>rf</b>	Random Forest Classifier	0.7332	0.7053	0.7332	0.7024	0.7075	0.2673	0.2817	21.5730
<b>et</b>	Extra Trees Classifier	0.7193	0.6895	0.7193	0.6904	0.6986	0.2491	0.2572	22.5210
<b>ada</b>	Ada Boost Classifier	0.6833	0.6934	0.6833	0.7032	0.6895	0.2873	0.2913	6.5870
<b>dt</b>	Decision Tree Classifier	0.6340	0.5798	0.6340	0.6457	0.6395	0.1500	0.1503	1.4990
<b>qda</b>	Quadratic Discriminant Analysis	0.6247	0.6874	0.6247	0.7065	0.6607	0.2262	0.2336	0.5660
<b>nb</b>	Naive Bayes	0.5885	0.6771	0.5885	0.7019	0.6350	0.1856	0.1976	3.9590
<b>lr</b>	Logistic Regression	0.5583	0.6979	0.5583	0.7151	0.6203	0.2064	0.2262	24.3200
<b>lda</b>	Linear Discriminant Analysis	0.5562	0.6965	0.5562	0.7140	0.6180	0.2047	0.2247	0.6530
<b>ridge</b>	Ridge Classifier	0.5548	0.0000	0.5548	0.7147	0.6181	0.2033	0.2235	0.2500
<b>svm</b>	SVM - Linear Kernel	0.5457	0.0000	0.5457	0.7121	0.6104	0.1891	0.2095	1.5120
<b>dummy</b>	Dummy Classifier	0.2775	0.5000	0.2775	0.0770	0.1206	0.0000	0.0000	0.1770



# Machine Learning

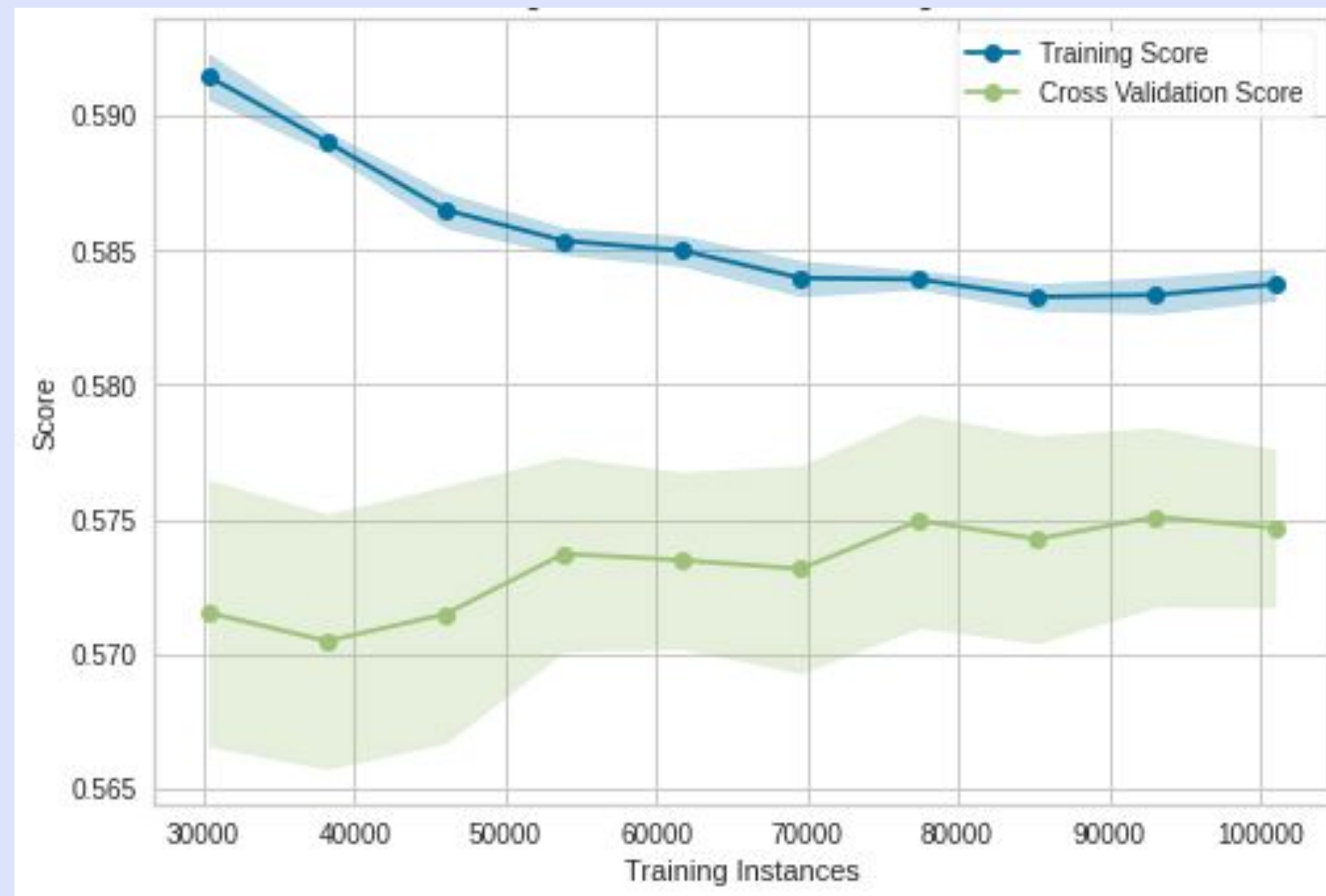
## Model Choice

Used PyCaret's function `compare_models()`, which runs 12 ML models  
A gradient boosting classifier model was chosen to balance accuracy and interpretability  
Initial Accuracy: 74.63%

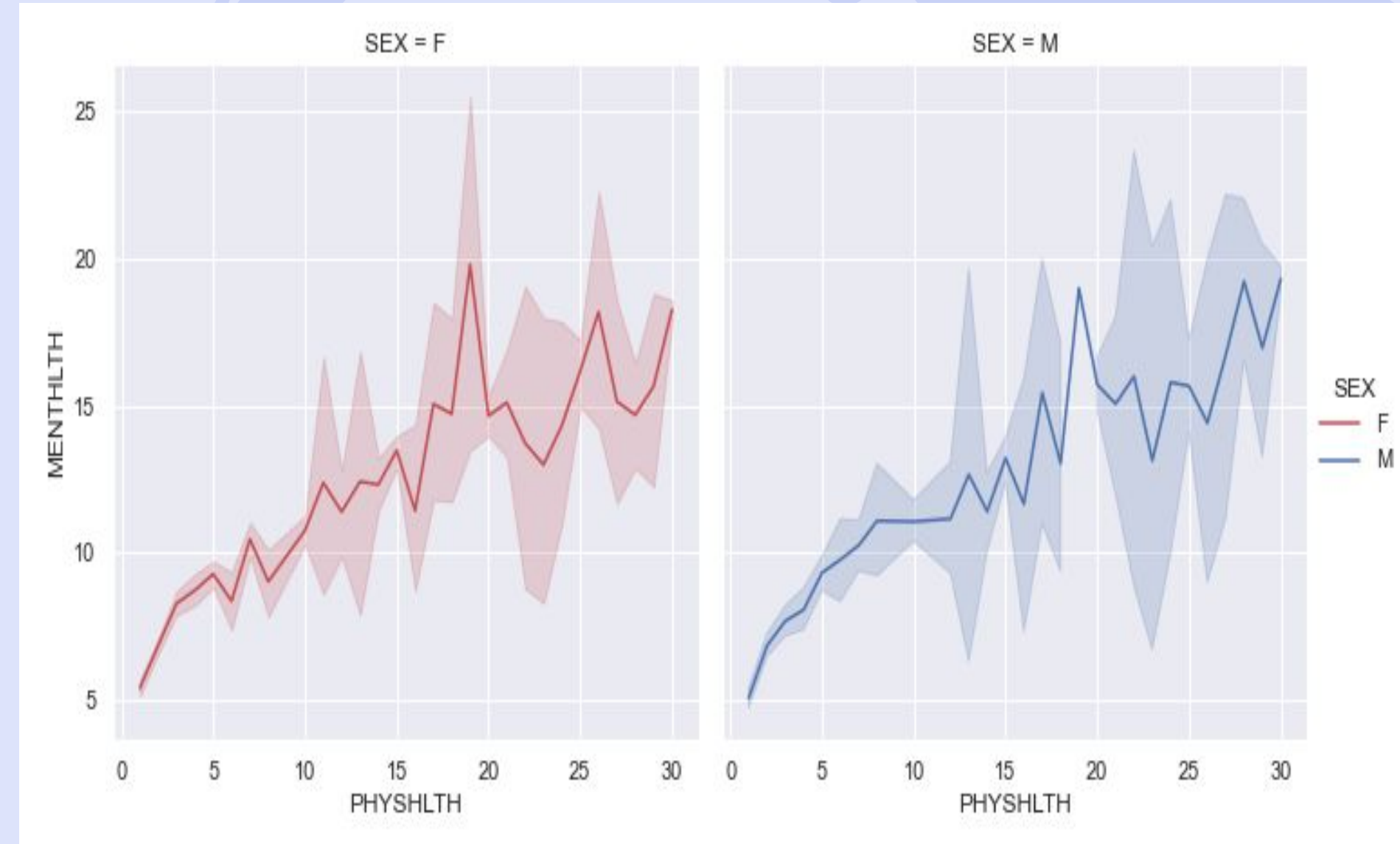
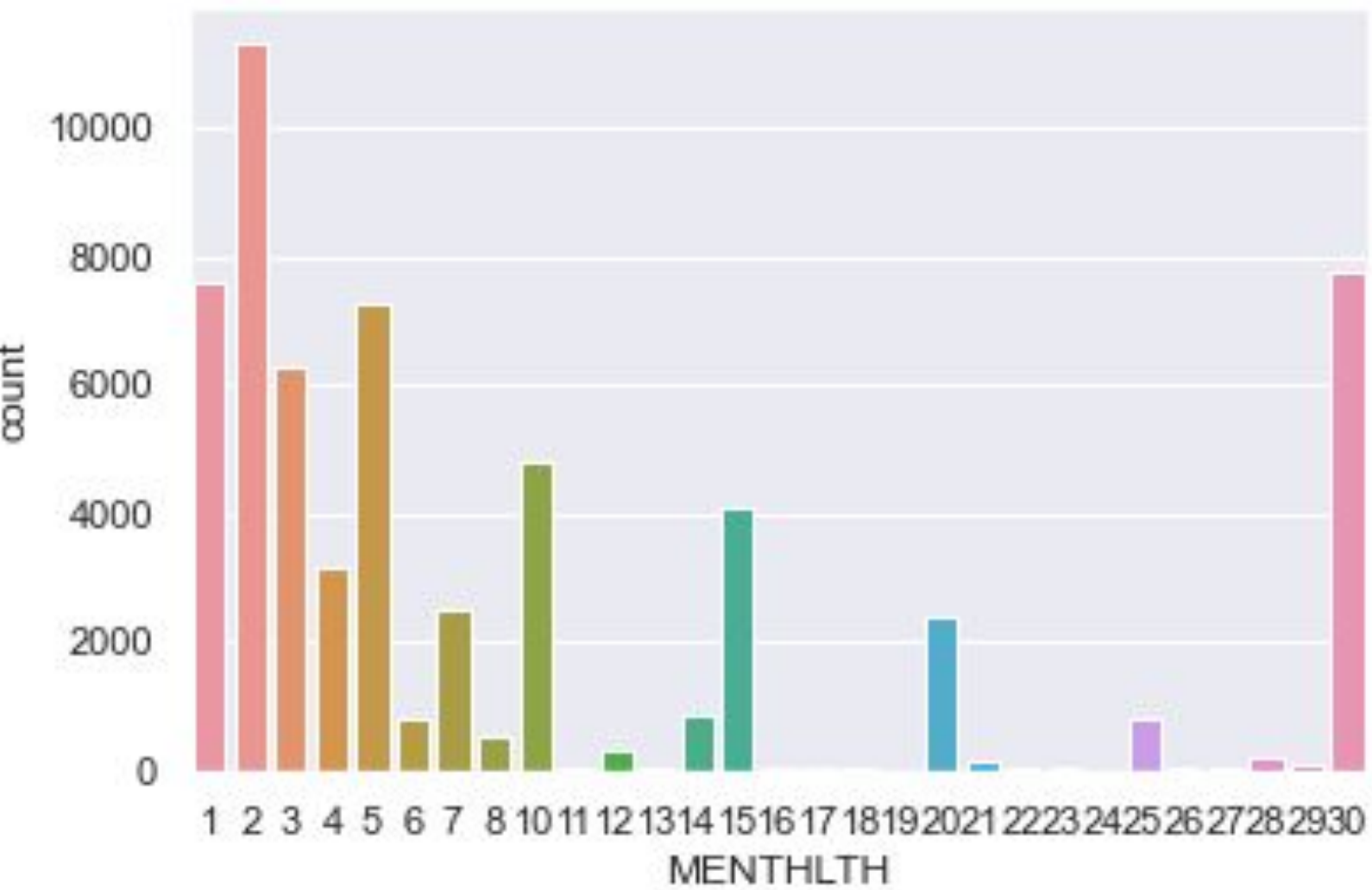


# Machine Learning Optimization

- SMOTE oversampling to balance the uneven target variable (0: 70%, 1: 30%)
- Used PyCaret's `tune_model()` function to automatically tune hyperparameters
- Final accuracy: 75.46% Final F1: 74.00%

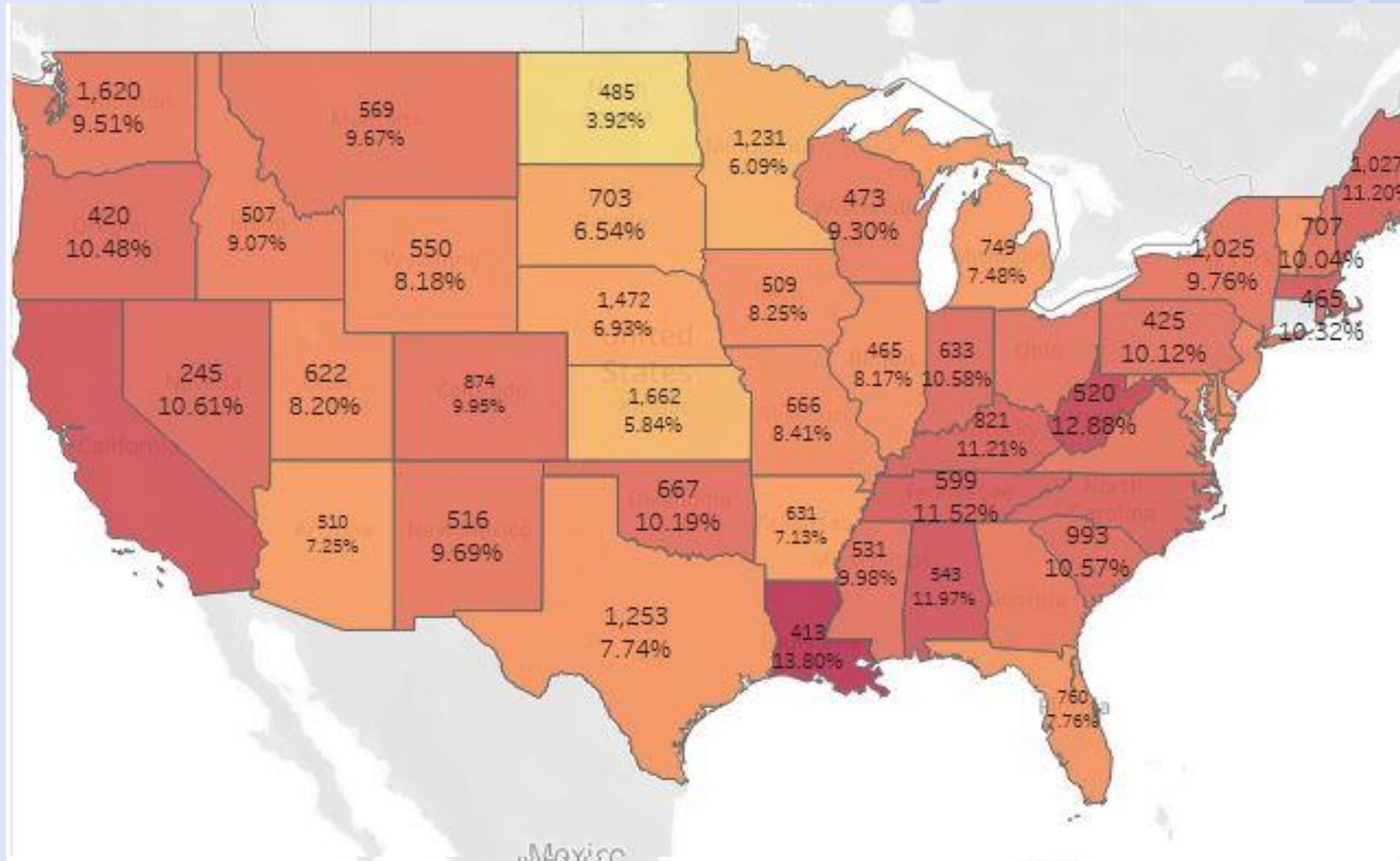


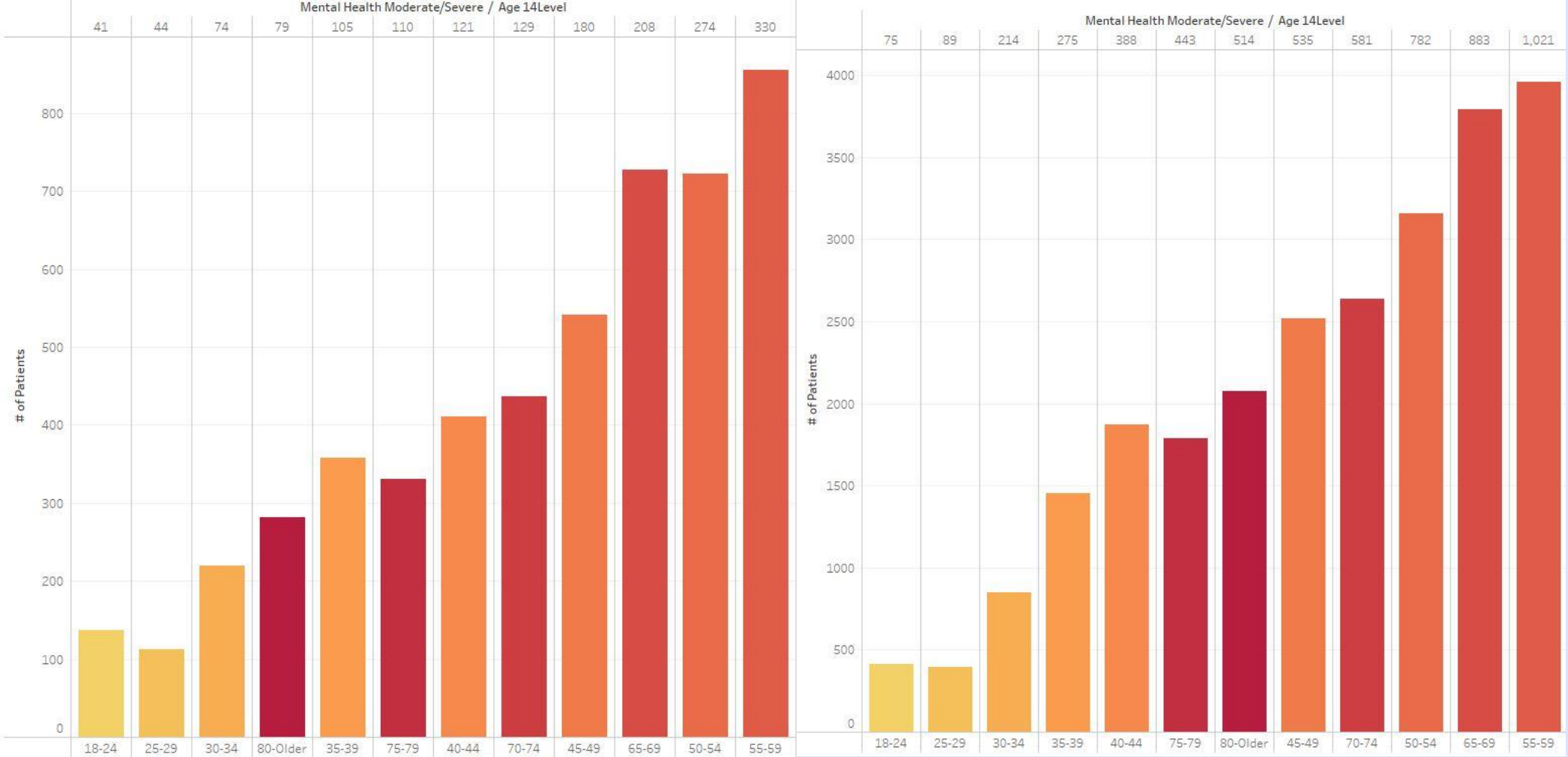
# Results





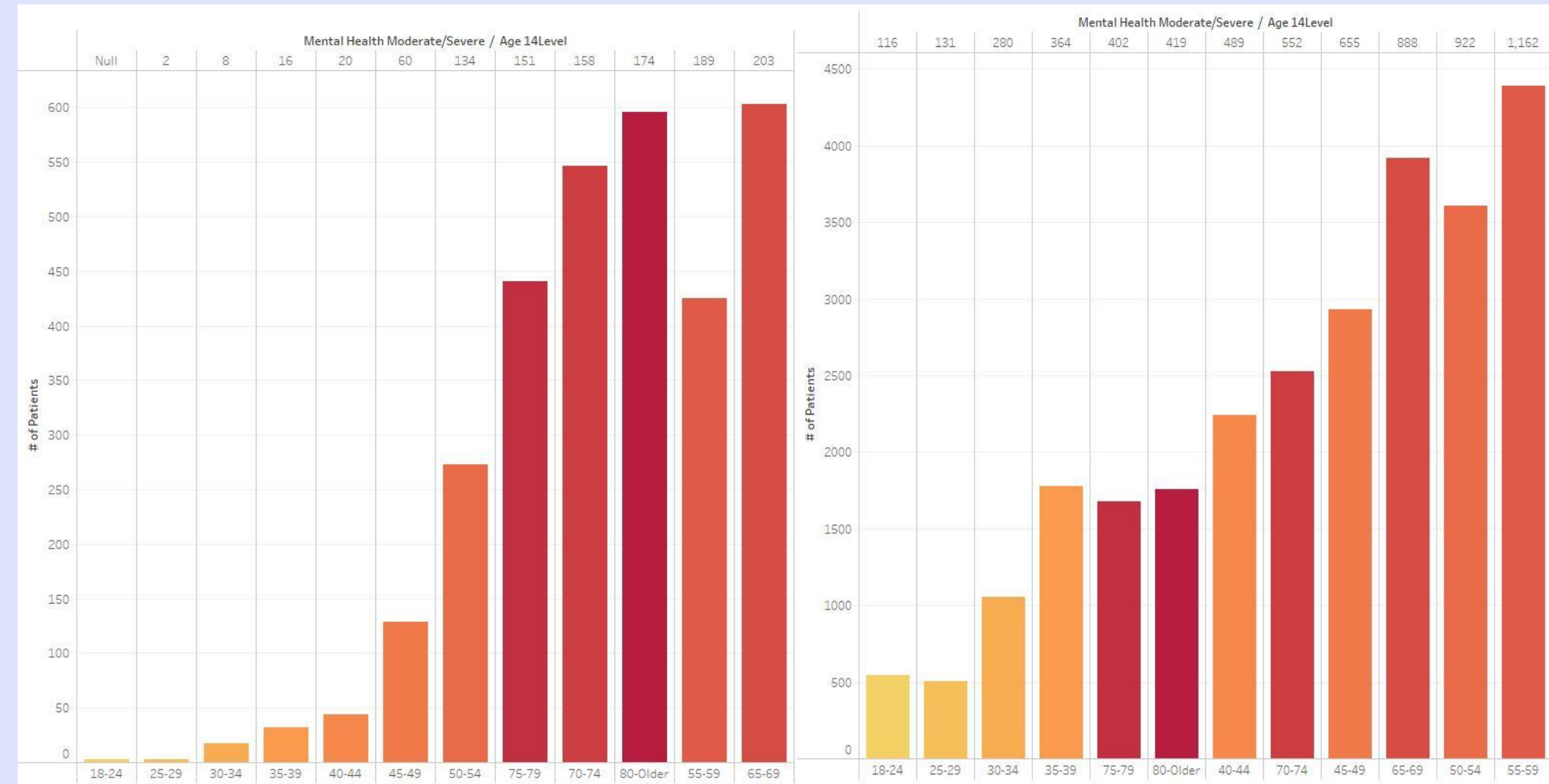
# Results





# Coronary Disease

5x more likely



# Results





# Future Analysis Recommendations



## Additional Datasets




Our data was limited to 2015.

For future analysis loading additional years would allow for more trend analysis and high relevant-low data columns to play a bigger role.

## More Feature Cleaning Before Machine Learning



Machine learning was performed on 42 columns. Some codes for features included a very small percentage of the responses. The accuracy of the model may be improved if we devoted time to manually go through all 42 columns, removing or recategorizing these very small response categories (such as “refused to answer” or “didn’t know”)



# Future Analysis Recommendations

## Clear & Complete Data

Some fields that were deemed of higher importance had odd calculations leading to unclear results with visualization. Refusal to answer certain important questions caused problems in visualizations.

