

DIABETES PREDICTION

Machine Learning
Side Project

BY HUANG LIN CHUN WALLY

🔗 link of the visualized interface (Streamlit):

<https://diabetesprediction-c9v4wbza6kodzyhpq7nxoj.streamlit.app/>

🔗 link of my git hub:

https://github.com/Wh4130/Diabetes_Prediction



CATALOG

[!\[\]\(99f58673407353e96a019fbca558fd72_img.jpg\) link of the visualized interface \(Streamlit\):](#)

<https://diabetesprediction-c9v4wbza6kodzyhpq7nxoj.streamlit.app/>

MOTIVATION

Taiwan is one of the few countries with the highest rate of Diabetes.

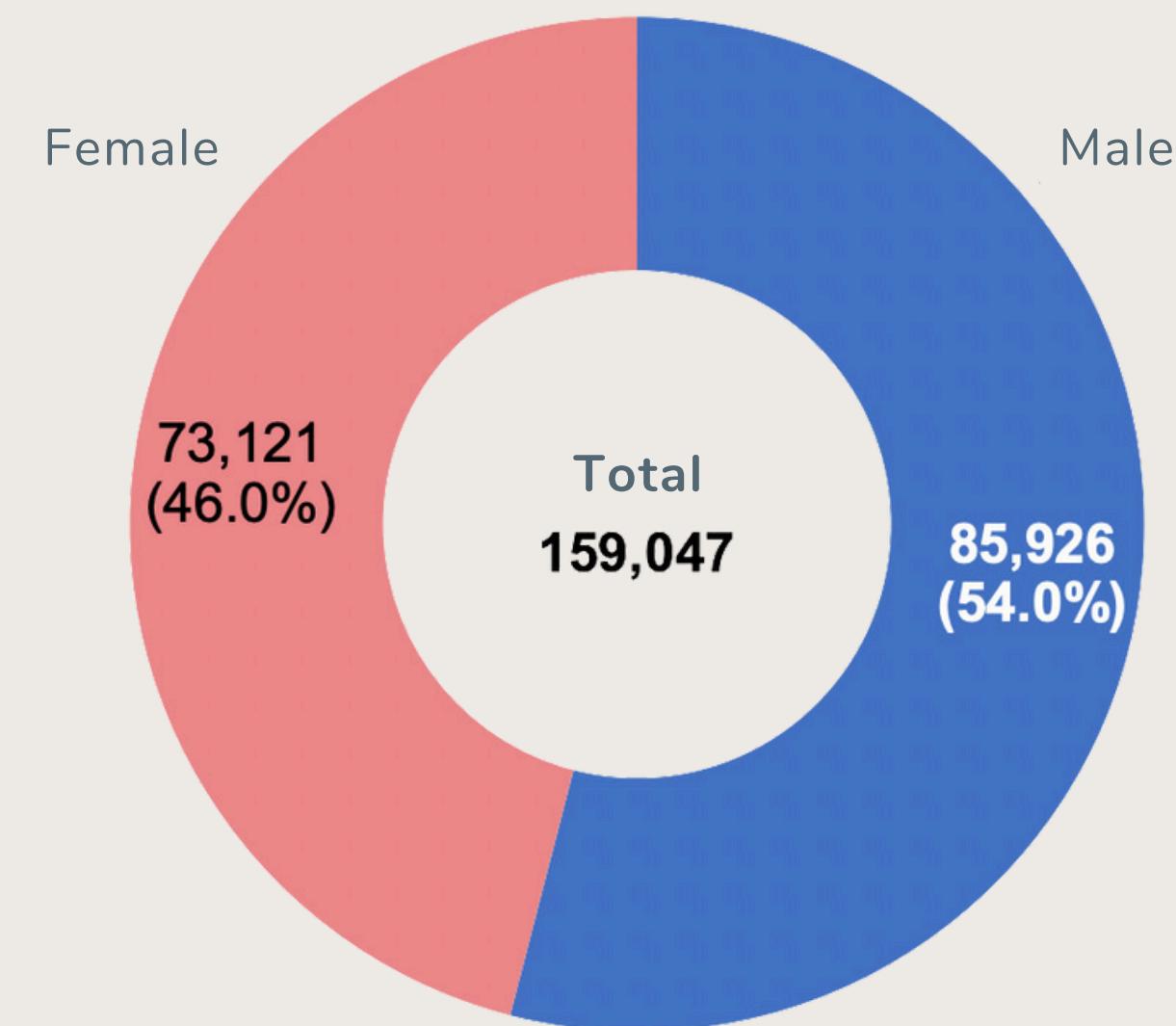
According to the government's report, diabetes patients account for 9% of total adults (18 - 64) in 2019, and this astonishingly high amount keeps increasing.

Data Source:

社團法人中華民國糖尿病衛教學會

Taiwanese Association of Diabetes Educators

第 2 型糖尿病患者數



Number of Patients of Type-2 Diabetes
in Taiwan, 2019

MOTIVATION

Taiwan is one of the few countries with the highest rate of Diabetes.

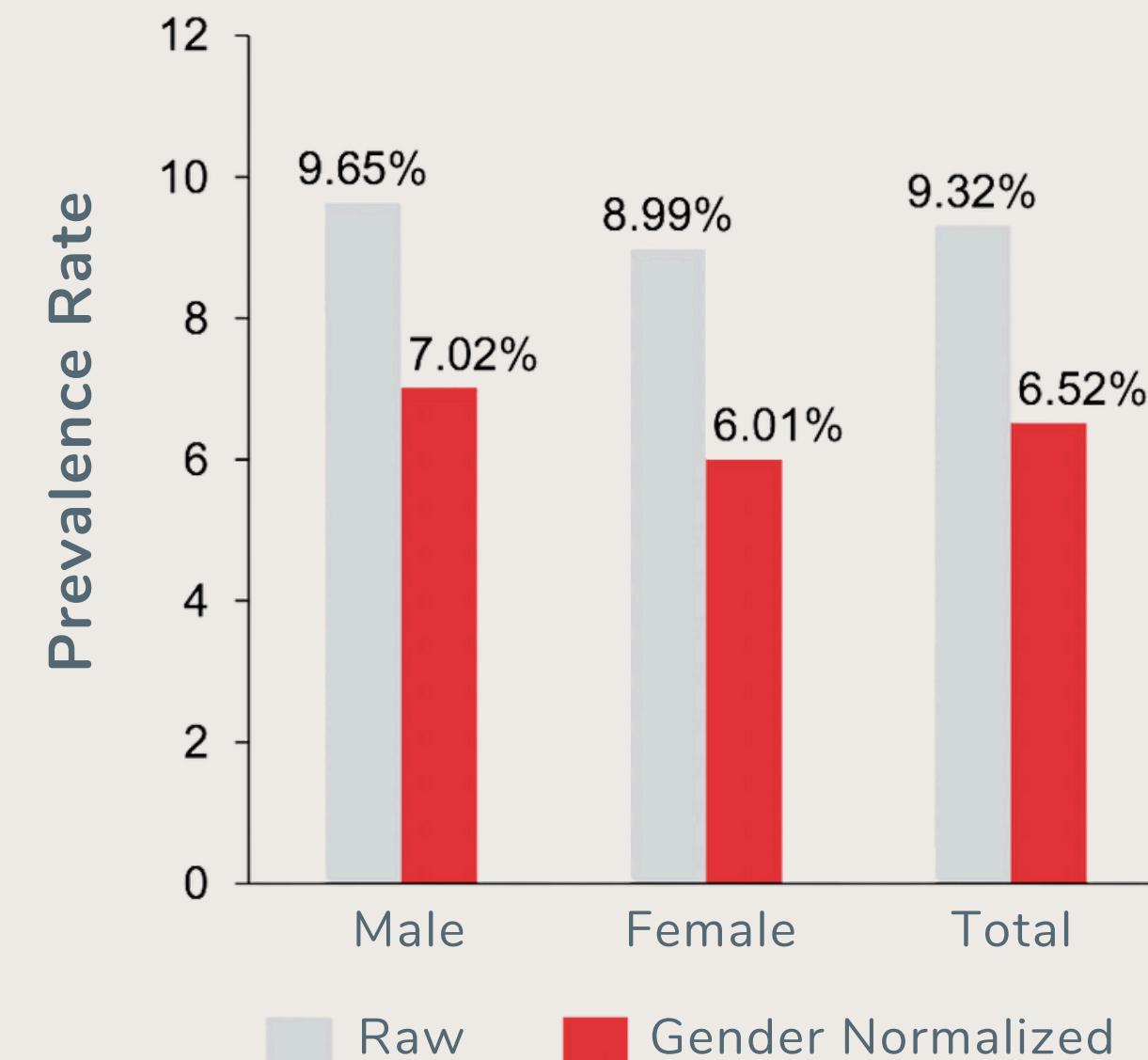
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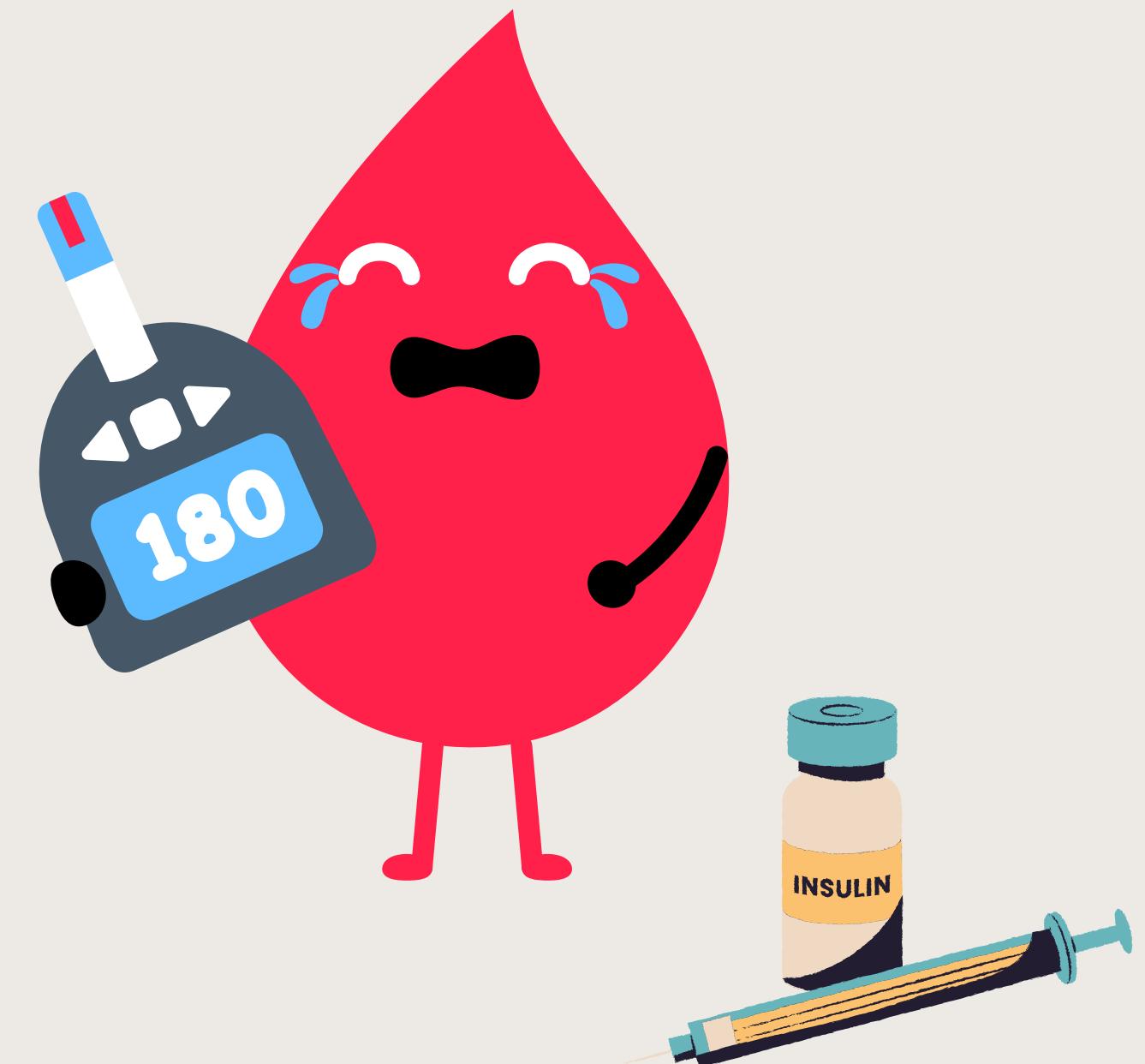
Proportion of Patients of Type-2 Diabetes in Taiwan, 2019



Proportion of Patients of Type-2 Diabetes among all adults in Taiwan, 2019

MOTIVATION

In light of this, I was inspired to establish a data analysis and machine learning project based on Diabetes survey data on Kaggle.com and build up an interactive user interface to make the public more aware of the risk and consequence of diabetes.



🔗 link of the visualized interface (Streamlit):

<https://diabetesprediction-c9v4wbza6kodzyhpq7nxoj.streamlit.app/>

DATA & MODULE IMPORT

DATA DESCRIPTION

- Data Source: Kaggle.com → [Diabetes Health Indicators Dataset \(Survey Data\)](#)
- Features



21 Features

High Blood Pressure	High Cholesterol	Cholesterol Check
BMI	Smoker	Stroke
Physical Activity past 30d	Sex	Heart Disease or Attack
Heavy Alcohol Consumption	Fruits	Age
Not See Doctor due to costs	Any Healthcare Coverage	Vegetables
Physical Health	General Health	Mental Health
Difficulty Walking	Income	Education

DATA & MODULE IMPORT

REQUIRED MODULE & SELECTED ML MODELS

MODULES

Pandas	Numpy
Matplotlib	pyplot
Seaborn	Sklearn
Pickle	Streamlit
Gzip	

4 Candidate Models

Logistic Regression

Random Forest

Gradient Boosting DT

Neural Network

Because:

1. Many binary features
→ Data Scaling Not Proper
2. All these four models
are versatile and prominent



DATA PREPROCESSING

CHECK IF THE DATA IS CLEAN

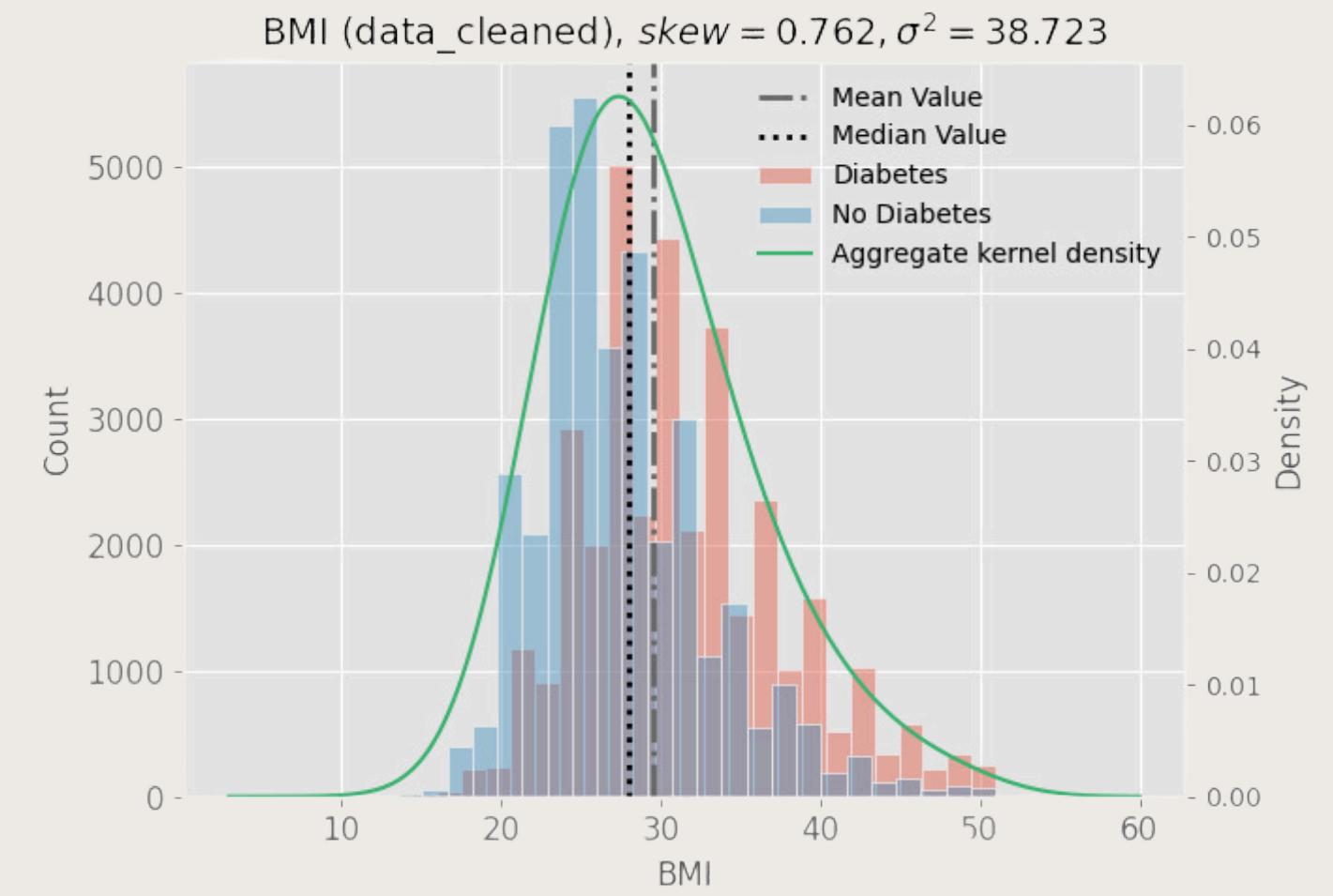
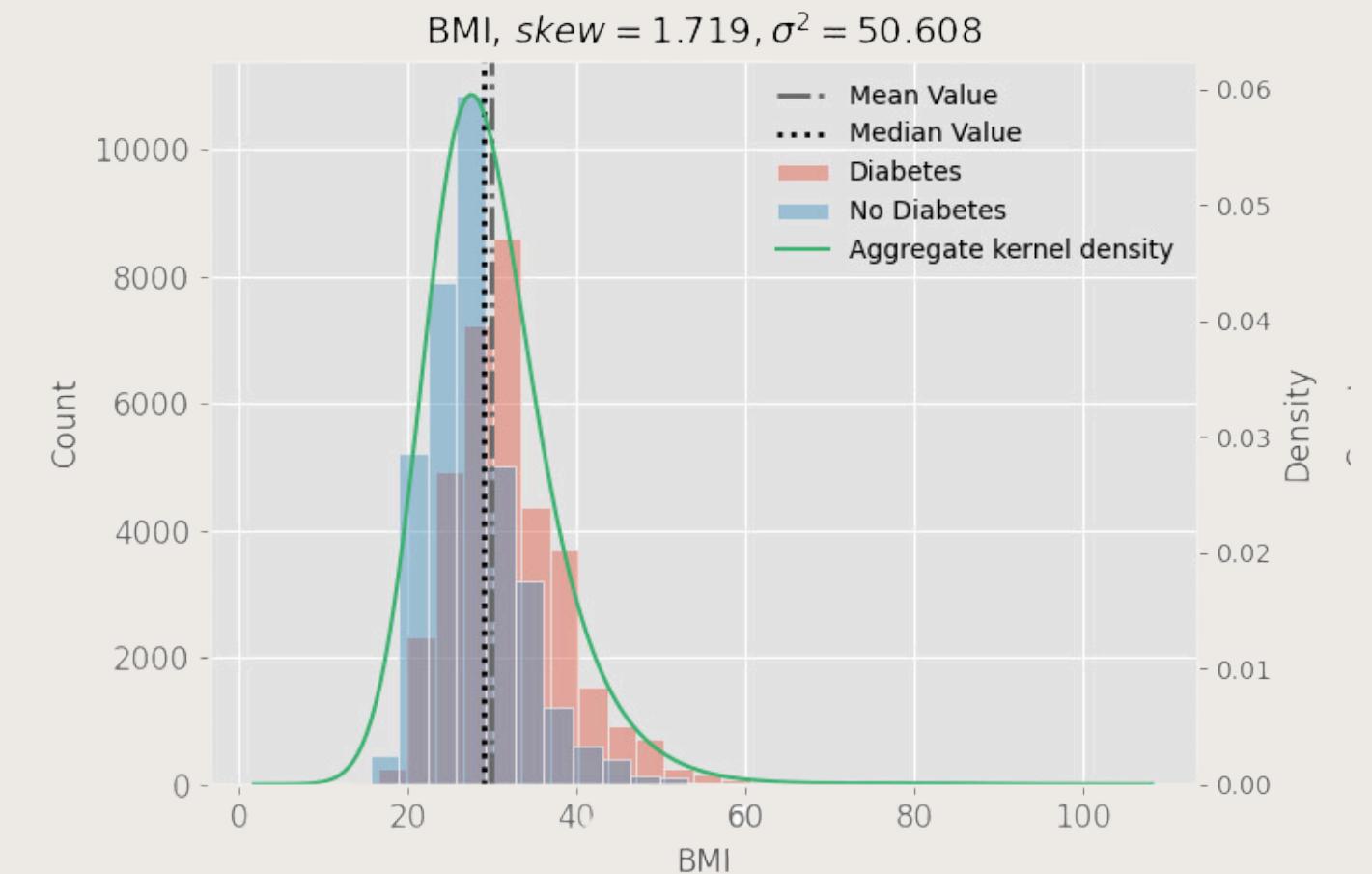
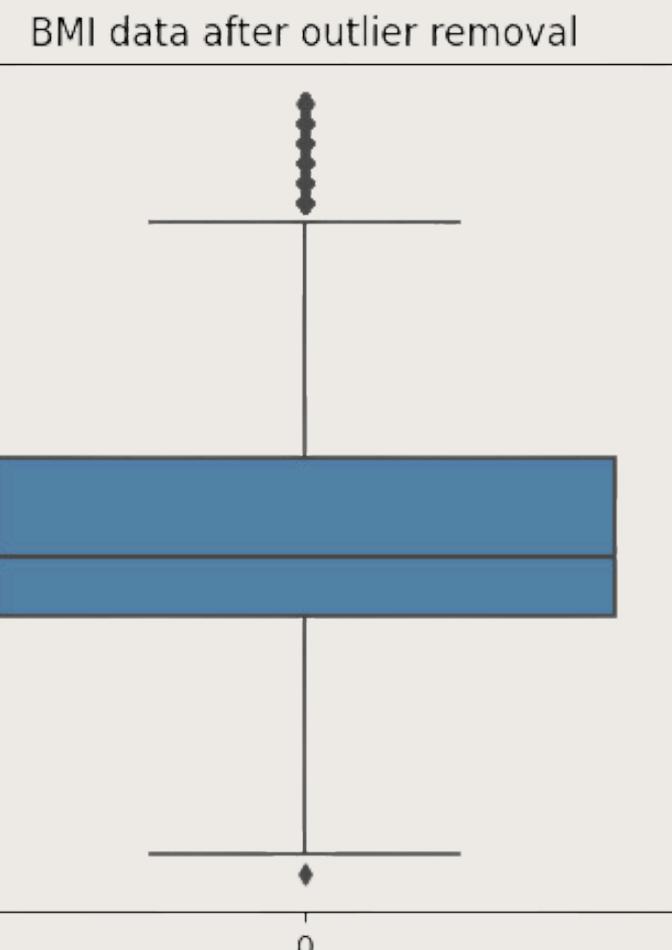
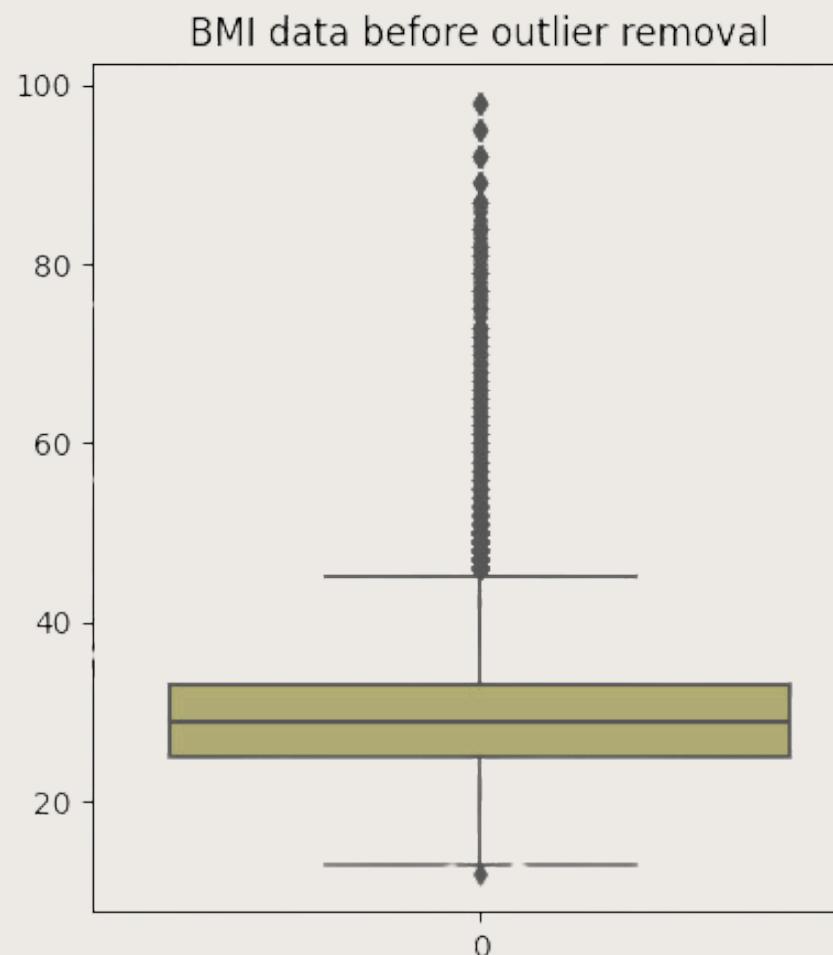
data.isnull().sum()			
Diabetes_binary	0	HvyAlcoholConsump	0
HighBP	0	AnyHealthcare	0
HighChol	0	NoDocbcCost	0
CholCheck	0	GenHlth	0
BMI	0	MentHlth	0
Smoker	0	PhysHlth	0
Stroke	0	DiffWalk	0
HeartDiseaseorAttack	0	Sex	0
PhysActivity	0	Age	0
Fruits	0	Education	0
Veggies	0	Income	0

CHEK IF THE DATA IS BALANCED



DATA PREPROCESSING

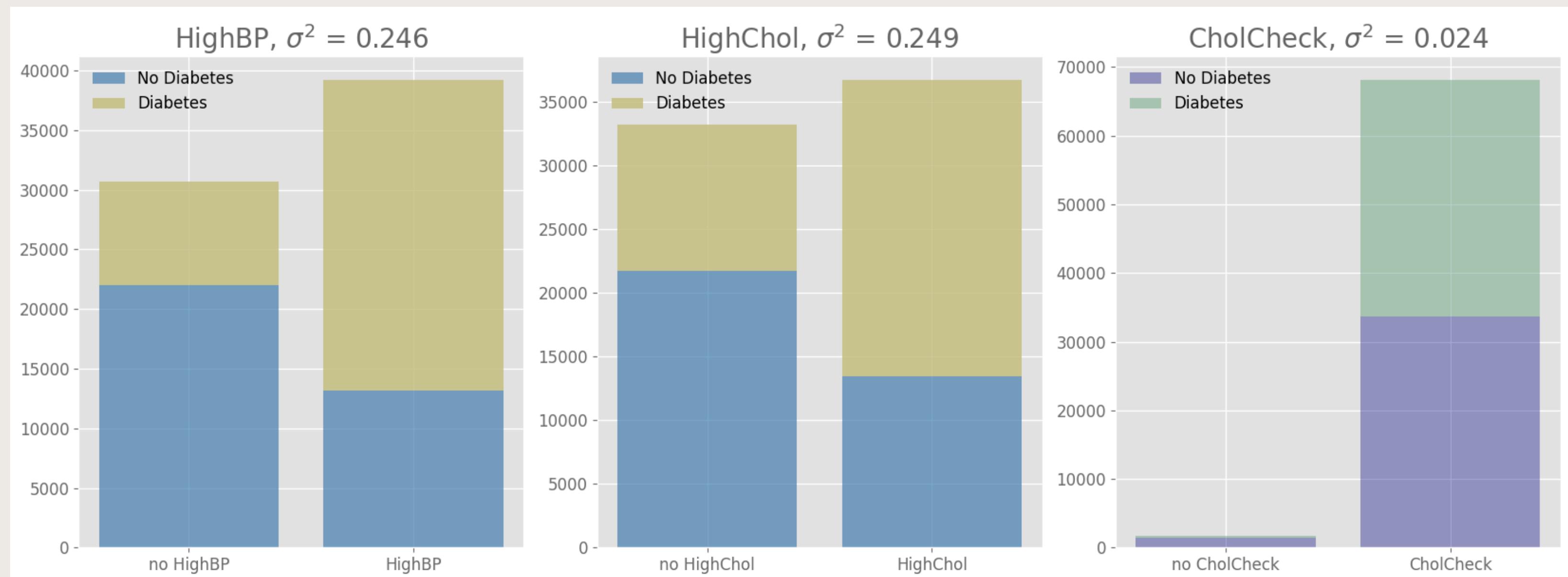
REMOVE OUTLIERS FOR BMI



EXPLORATORY DATA ANALYSIS

BINARY FEATURES

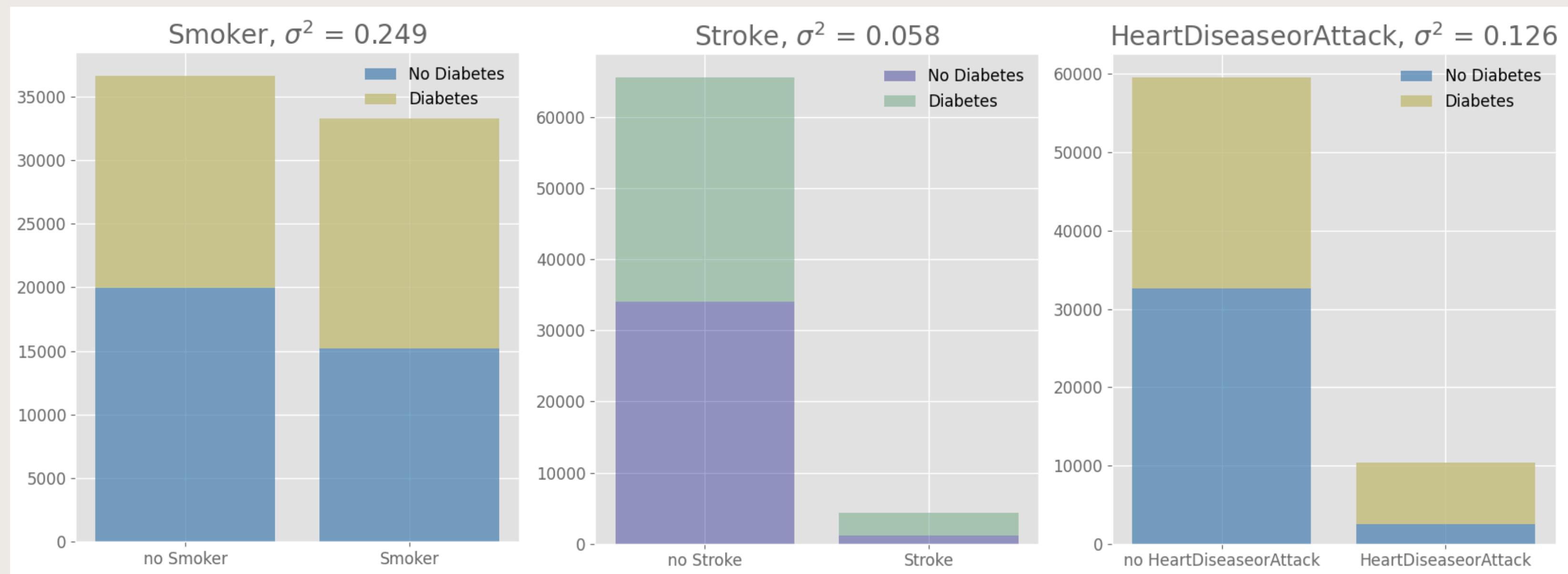
Features with variance < 0.09 were highlighted by green



EXPLORATORY DATA ANALYSIS

BINARY FEATURES

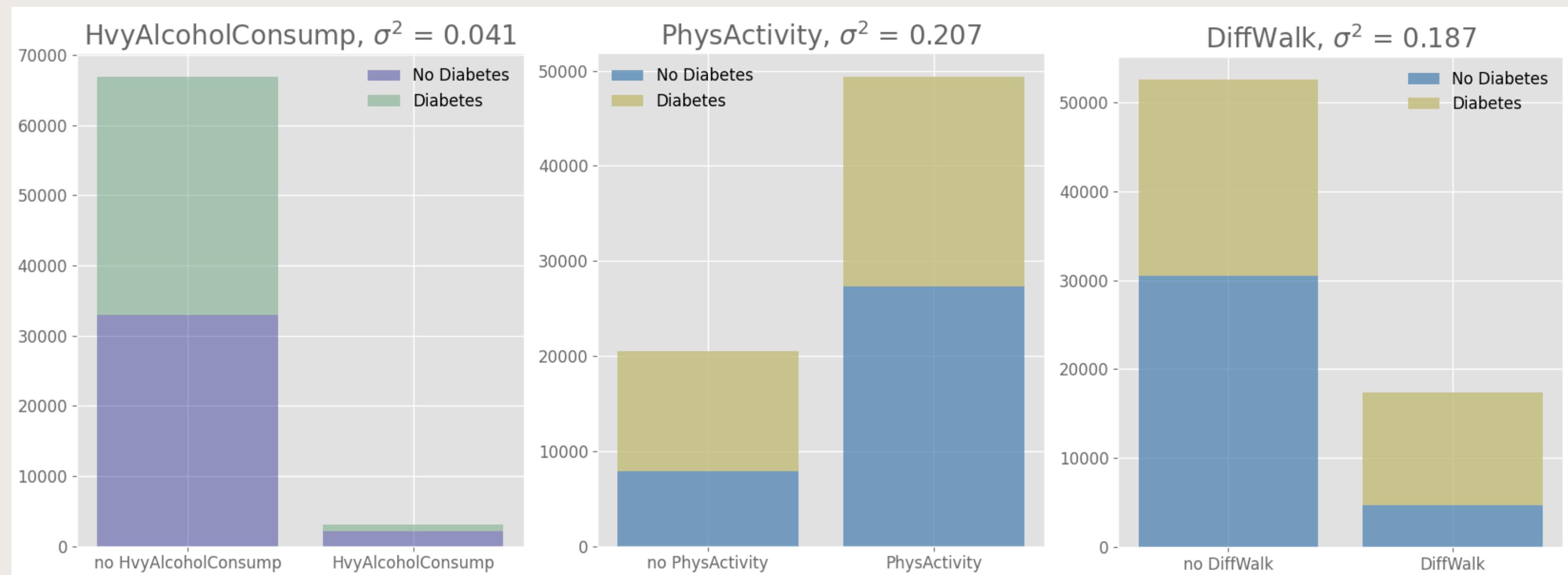
Features with variance < 0.09 were highlighted by green



EXPLORATORY DATA ANALYSIS

BINARY FEATURES

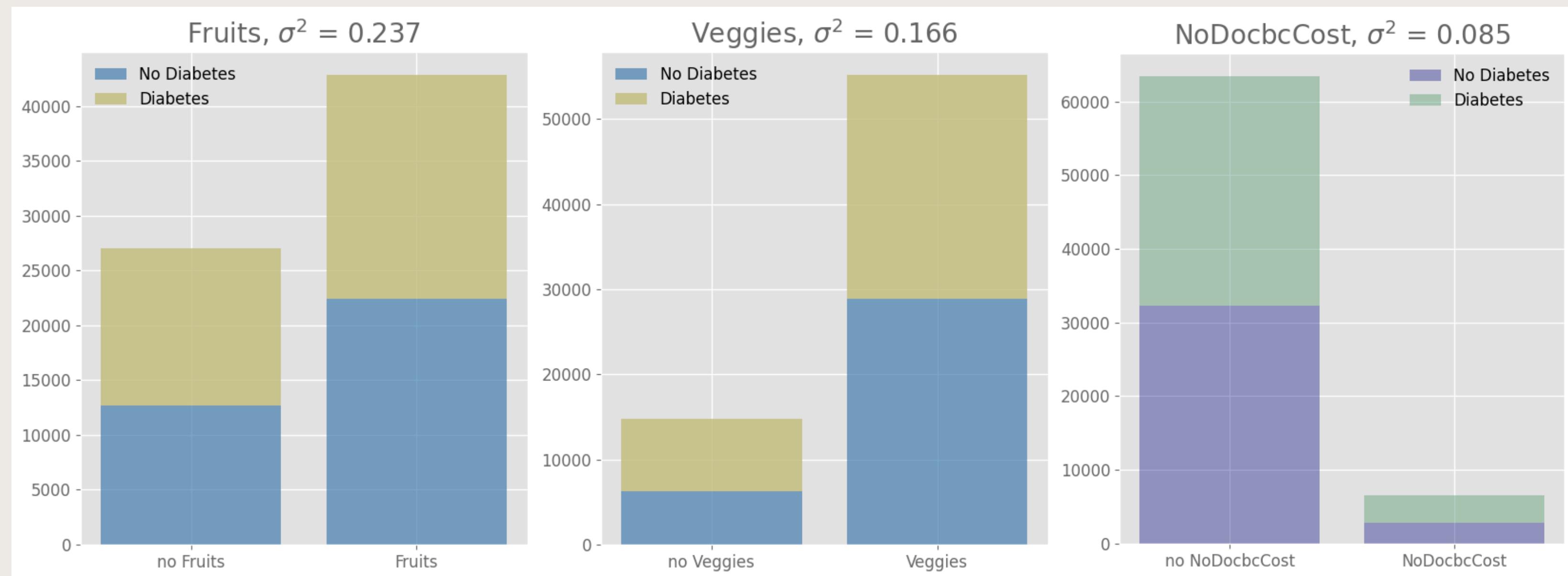
Features with variance < 0.09 were highlighted by green



EXPLORATORY DATA ANALYSIS

BINARY FEATURES

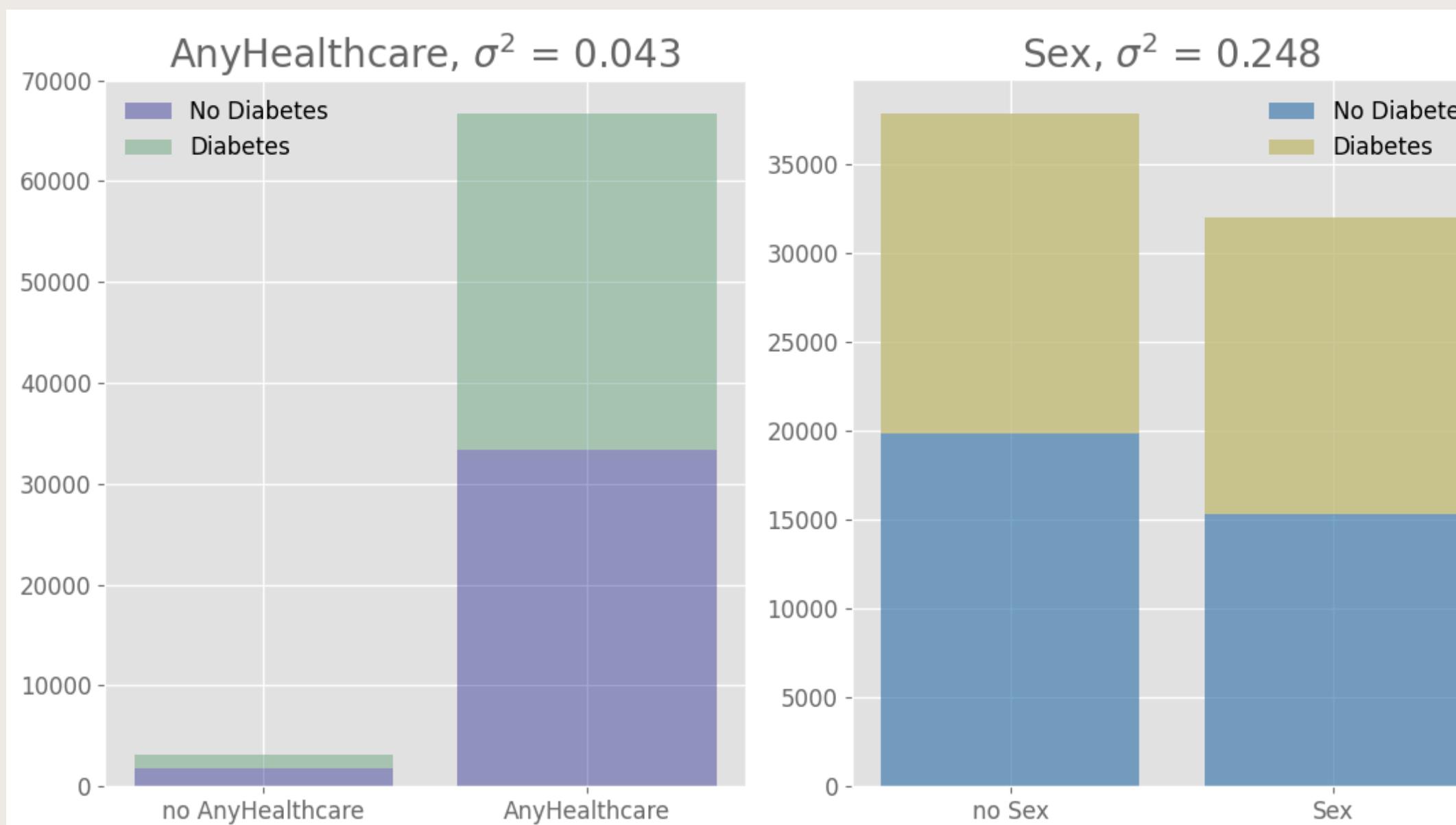
Features with variance < 0.09 were highlighted by green



EXPLORATORY DATA ANALYSIS

BINARY FEATURES

Features with variance < 0.09 were highlighted by green



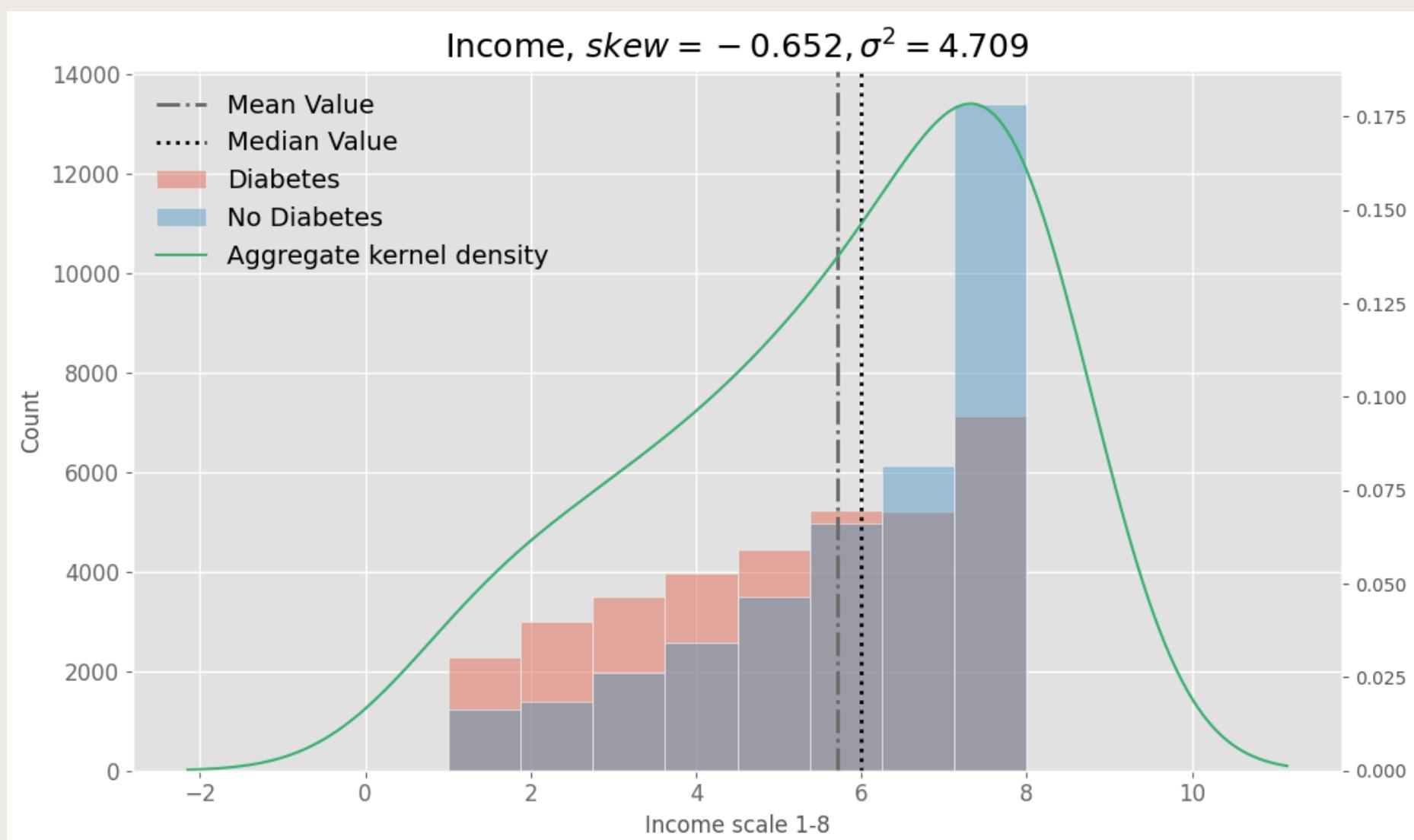
Features “Cholesterol Check”, “Stroke”, “Heavy Alcohol Consumption”, “Not See Doctor due to costs”, and “Any Healthcare coverage” have too low variance, which means that they might not be good features.

→ We conduct further analysis to determine whether to eliminate these features from our model.

- Correlation Analysis
- Feature Importance Analysis

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES

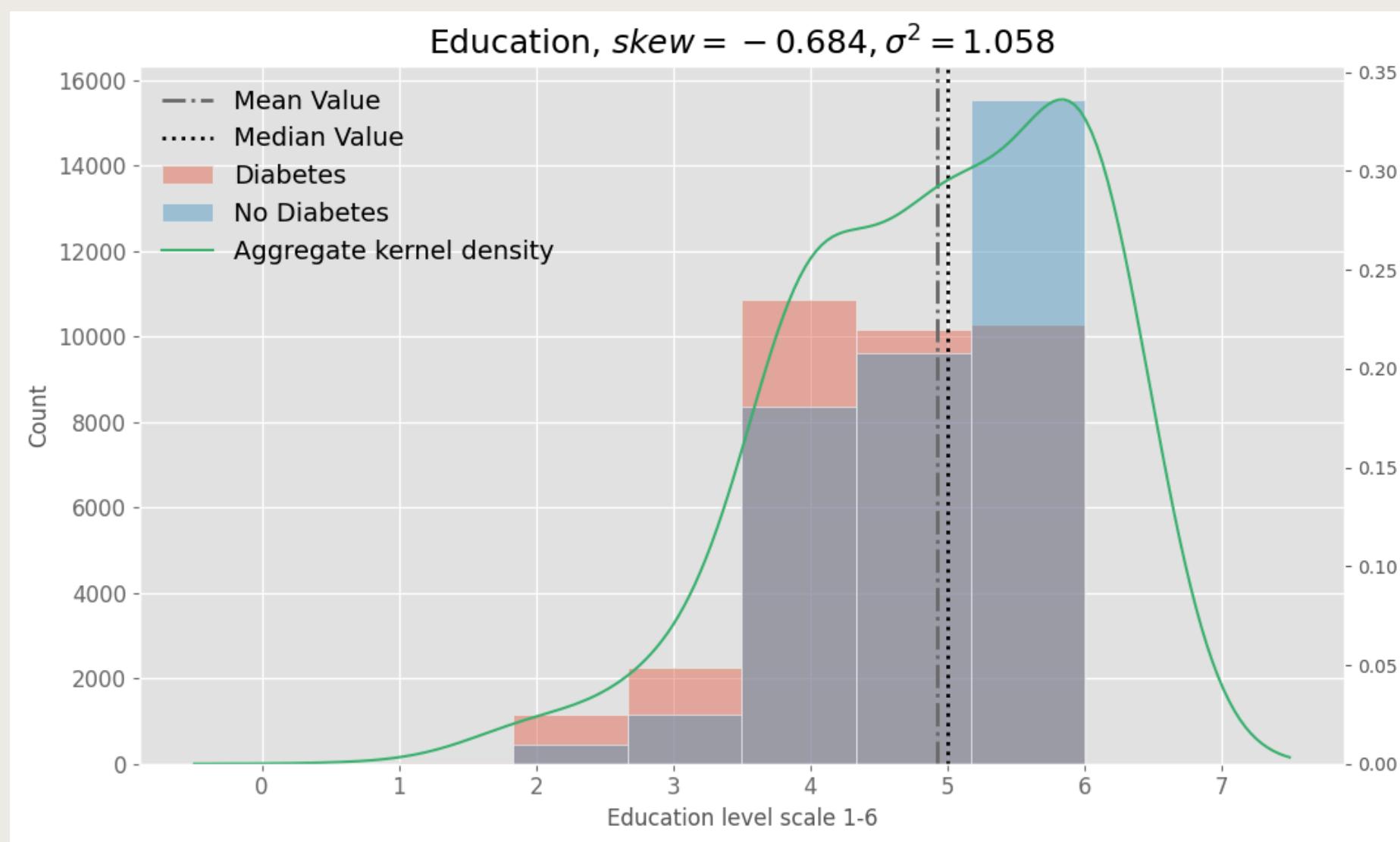


INCOME

- 8 scales income level → Not scalable
 - Most of the respondents are in the highest-level group (left-skewed) → biased feature
 - It does not have direct predictability on target (more like a confounder)
- We eliminate Income from our model

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES

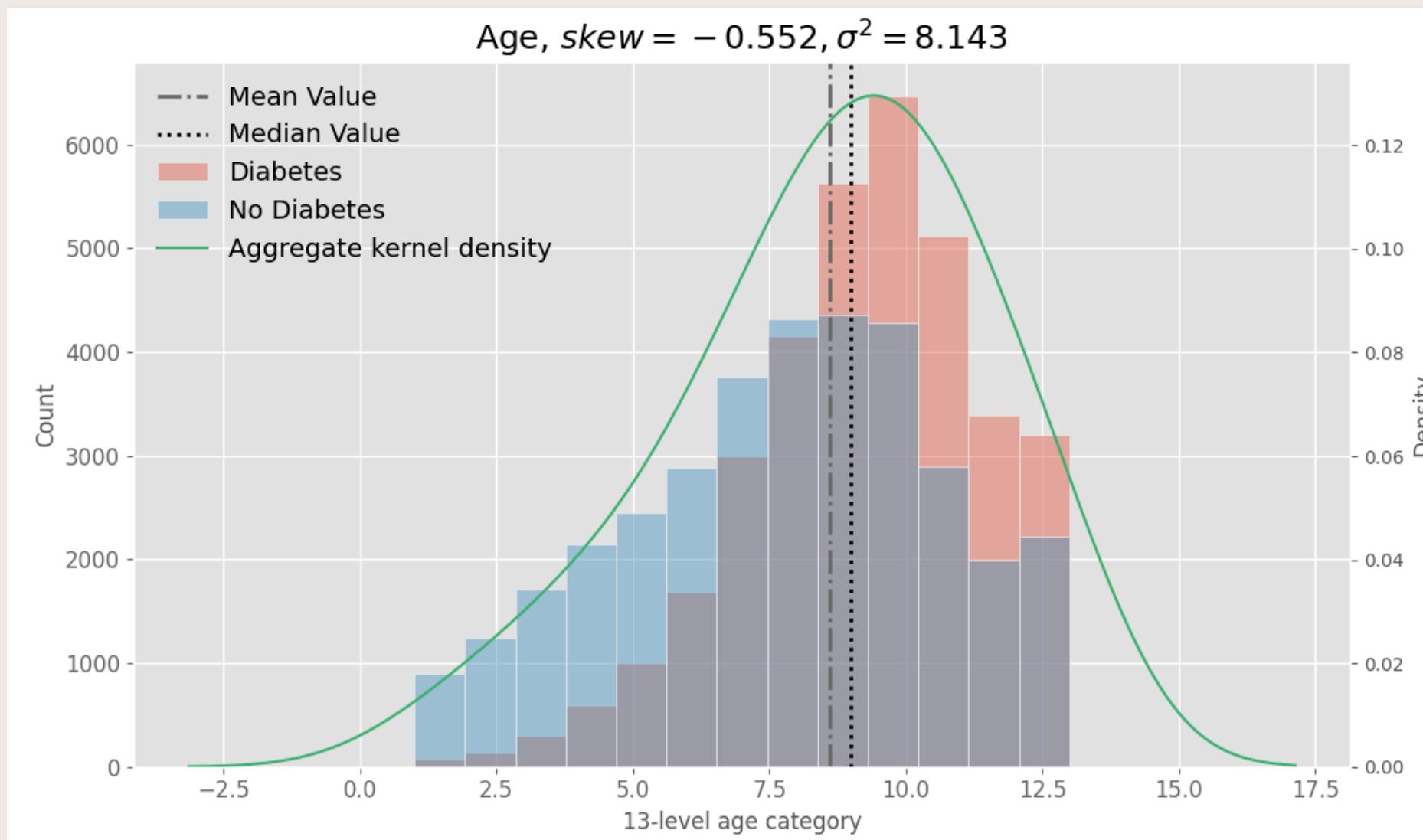


EDUCATION

- 6 scales education level → Not scalable
 - Most of the respondents are in the highest-educated group (left-skewed) → biased feature
 - It does not have direct predictability on target (more like a confounder)
- We eliminate Education from our model

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES

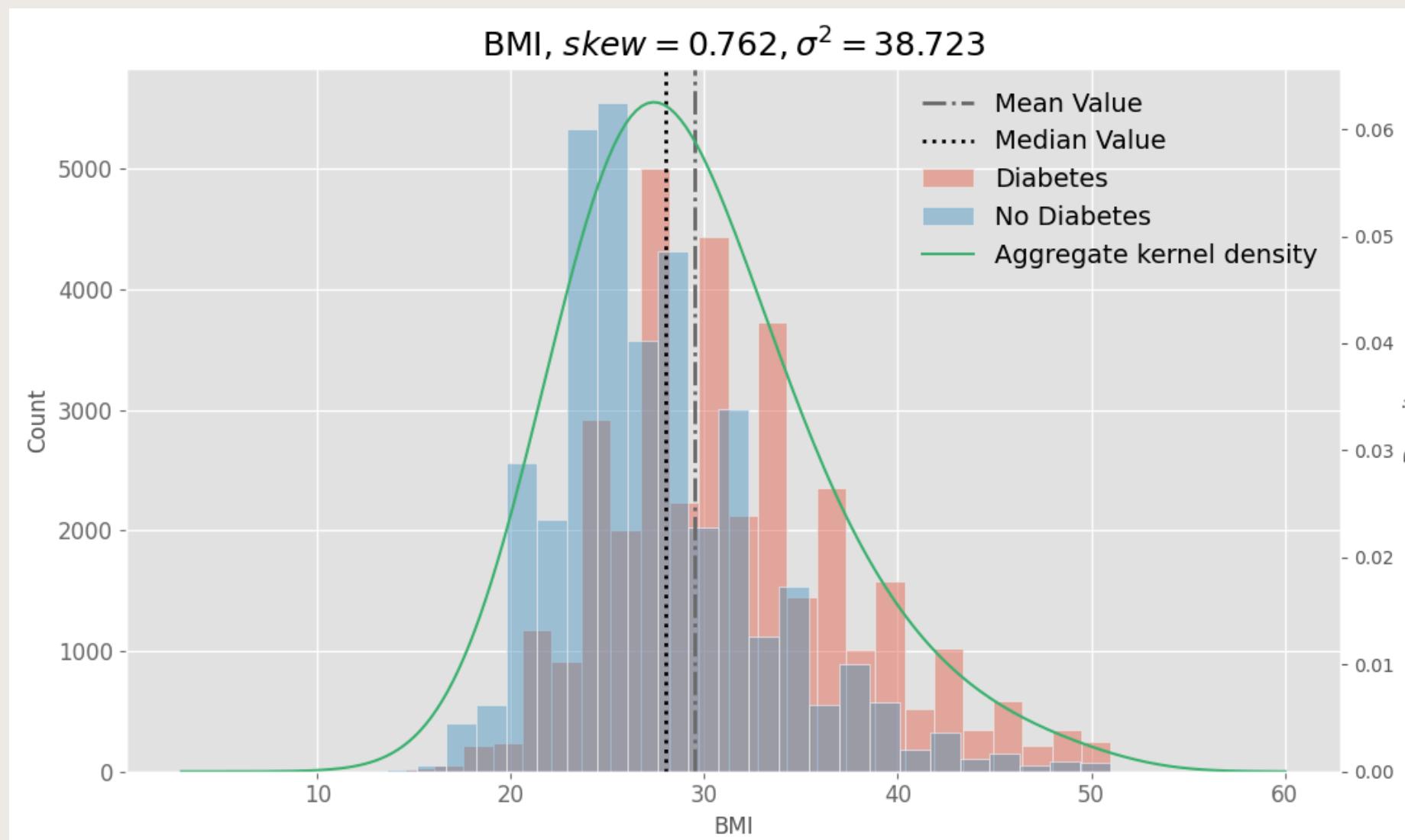


AGE

- 13 scales age level → Not scalable
 - Skewness is not severely high
 - Variance is large enough
 - It separates diabetic and non-diabetic targets well
- We include Age in our model

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES



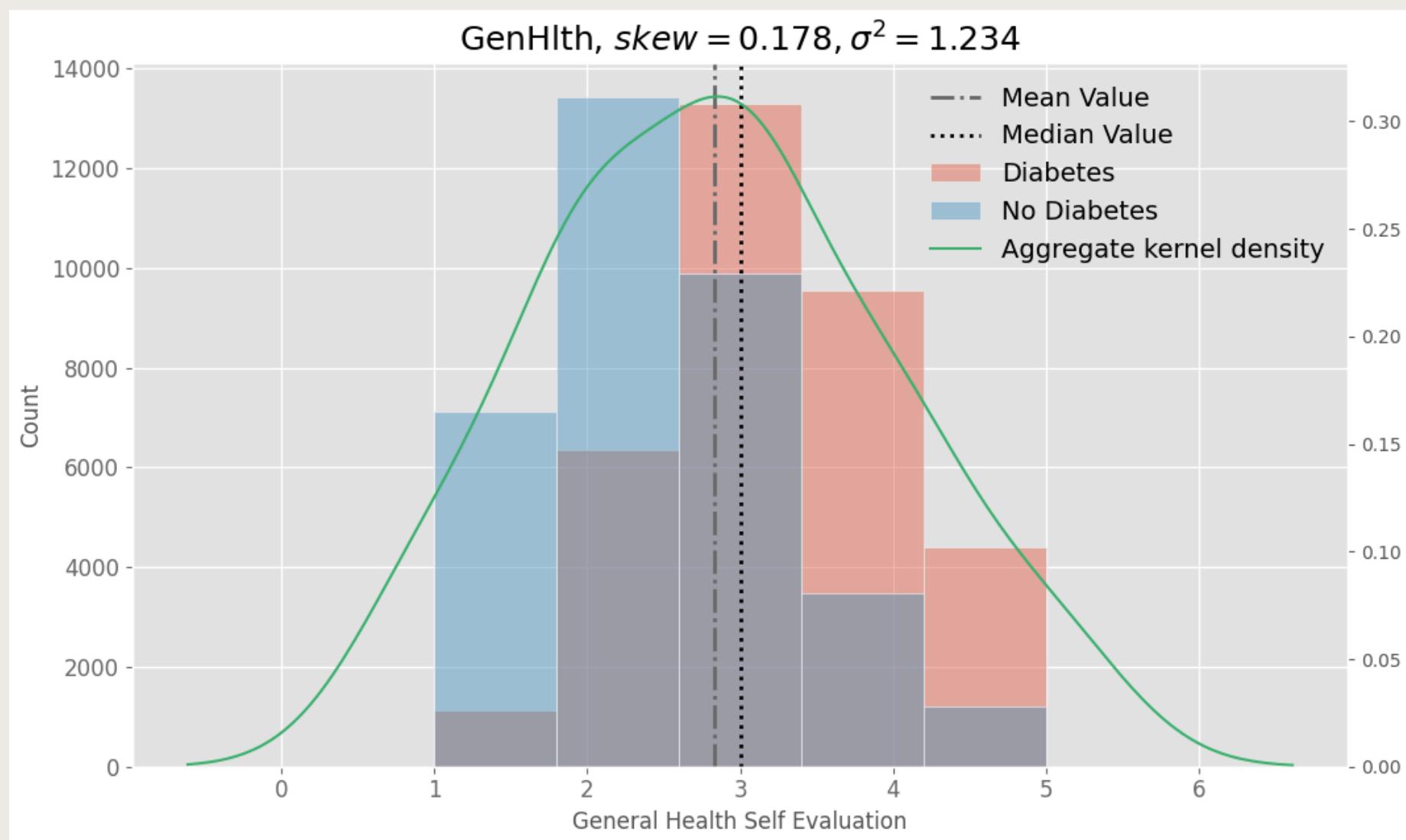
BMI

- Not scaled origin BMI data
- Skewness is not severely high after the removal of outliers
- Variance is large enough
- It separates diabetic and non-diabetic targets well

→ We include BMI in our model

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES

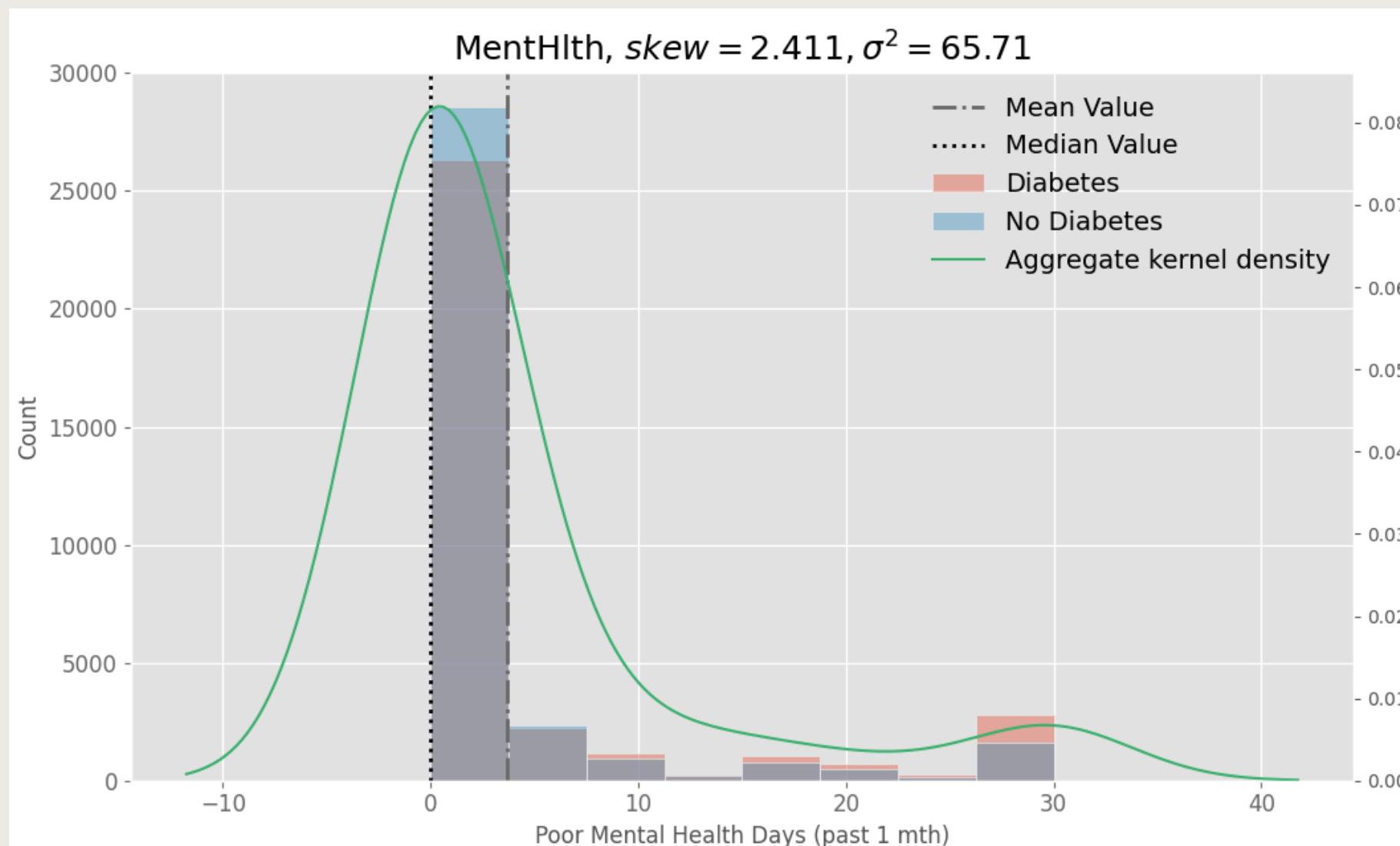


GENERAL HEALTH

- Subjective and abstract self-evaluation
→ likely to be biased (hmm...)
1 = excellent ; 5 = poor
 - Skewness is low
 - It separates diabetic and non-diabetic targets well
- We include GenHlth in our model

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES

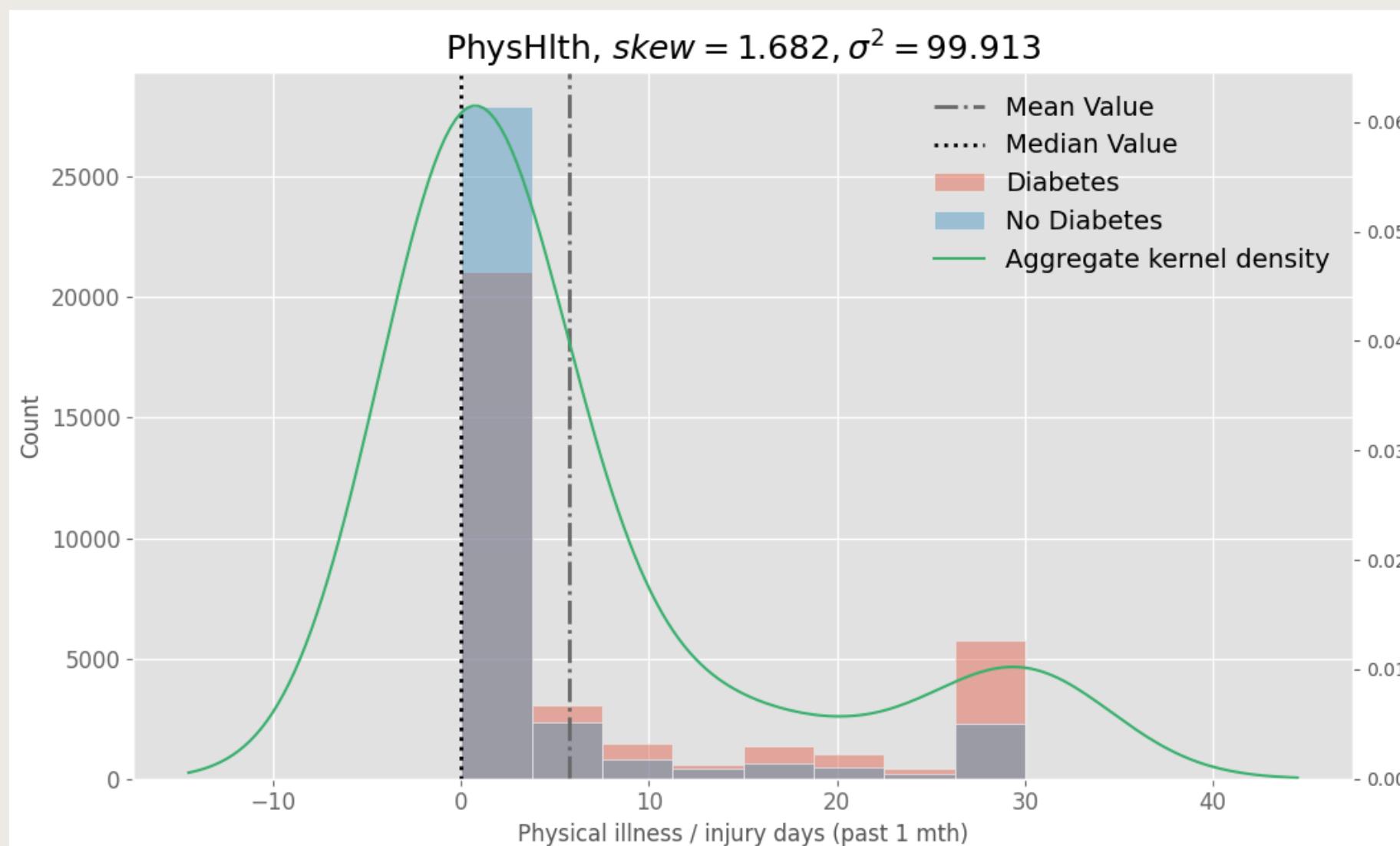


MENTAL HEALTH

- Quantitative self-evaluation
How many days during the past 30 days was your mental health not good?
 - Severely right skewed
 - It does not separate diabetic and non-diabetic targets well
- We consider if including it to our model

EXPLORATORY DATA ANALYSIS

NON BINARY FEATURES



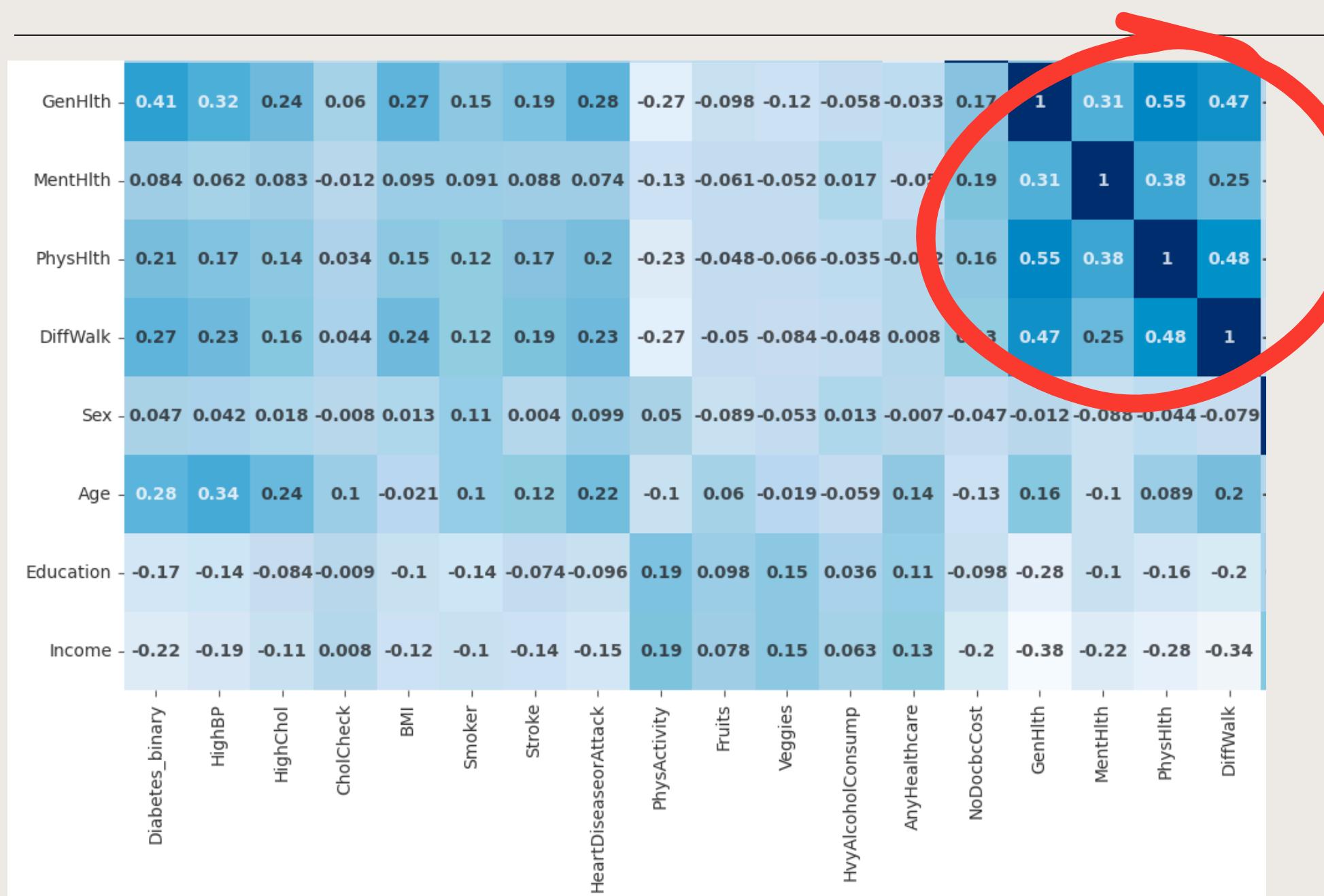
PHYSICAL HEALTH

- Quantitative self-evaluation
How many days during the past 30 days was your physical health not good?
 - Severely right skewed
 - It separates diabetic and non-diabetic targets well, but might be highly correlated with General Health
- We consider if including it to our model

EXPLORATORY DATA ANALYSIS

CORREALTION ANALYSIS

Check if there exists multicollinearity issue



HEATMAP

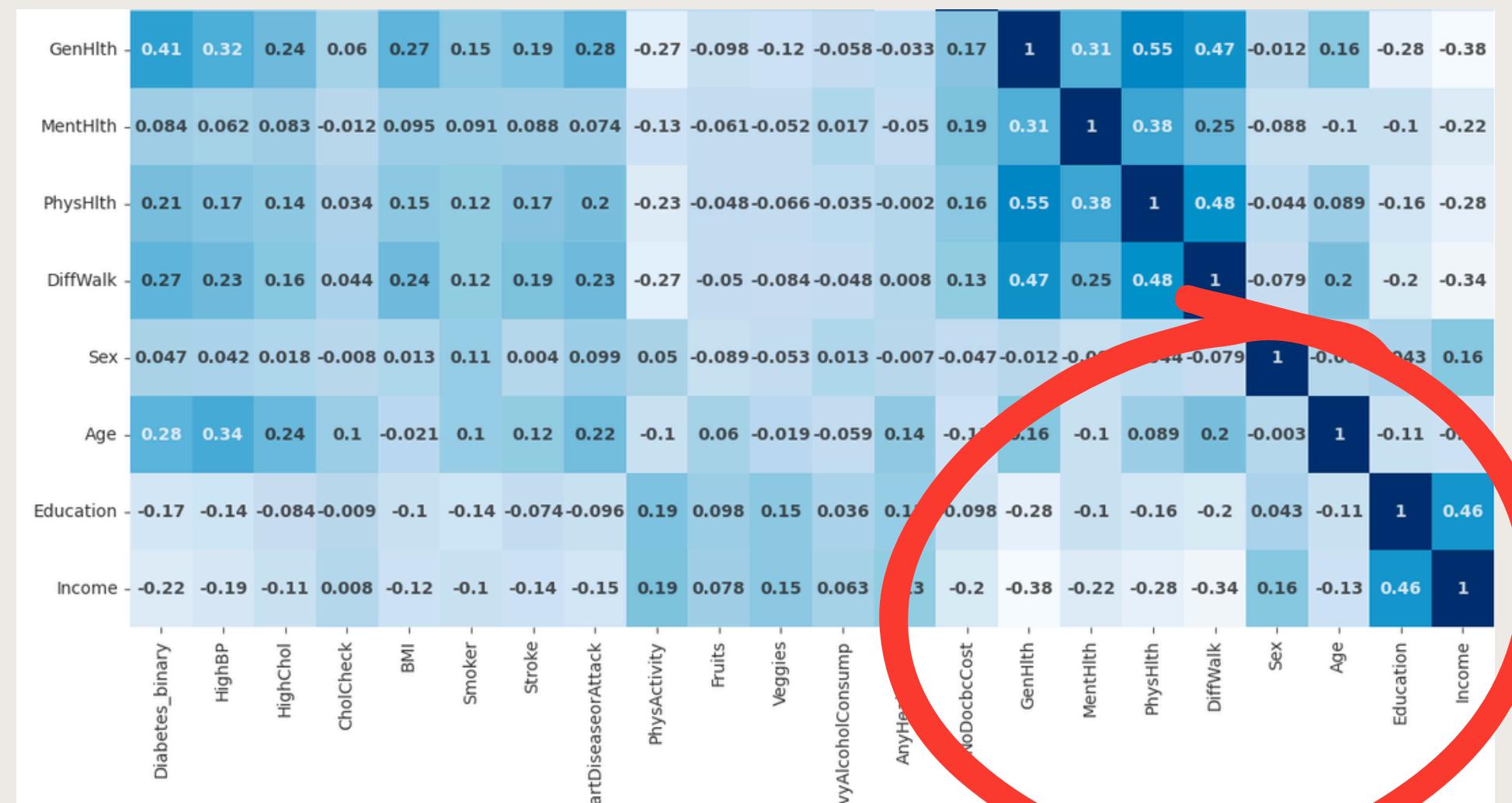
- General Health is highly correlated with
 - Mental Health
 - Physical Health
 - Difficulty Walking
- But the coefficients of correlation are lower or not too larger than 0.5

→ Acceptable

EXPLORATORY DATA ANALYSIS

CORREALTION ANALYSIS

Check if there exists multicollinearity issue



HEATMAP

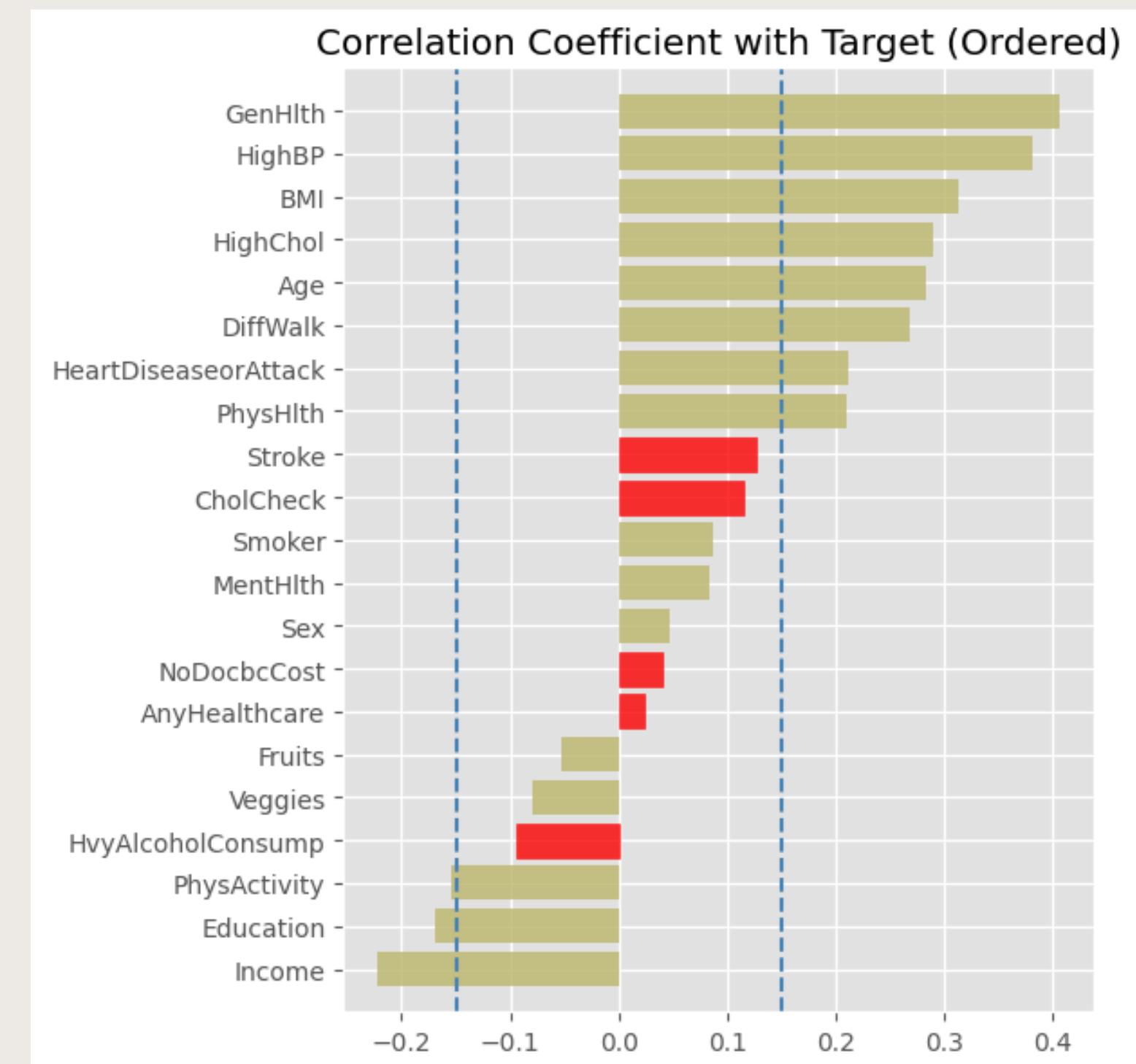
- Income and Education are highly correlated with each other, as expected
- Income and Education are also correlated with General Health
- Correlation through other feathers that are not observable here
- Not a good idea to include confounders

EXPLORATORY DATA ANALYSIS

CORREALTION ANALYSIS

CORRELATION WITH TARGET

- General Health, BMI, and other main health indicators have high correlation with the target
 - Five binary features which have low variances are subtly correlated with the target
 - Cholesterol Check | Stroke | Heavy Alcohol Consumption
 - Not See Doctor due to costs | Any Healthcare coverage
 - Among which, stroke has the highest correlation
 - And stroke is intuitively correlated with the target
- We include stroke

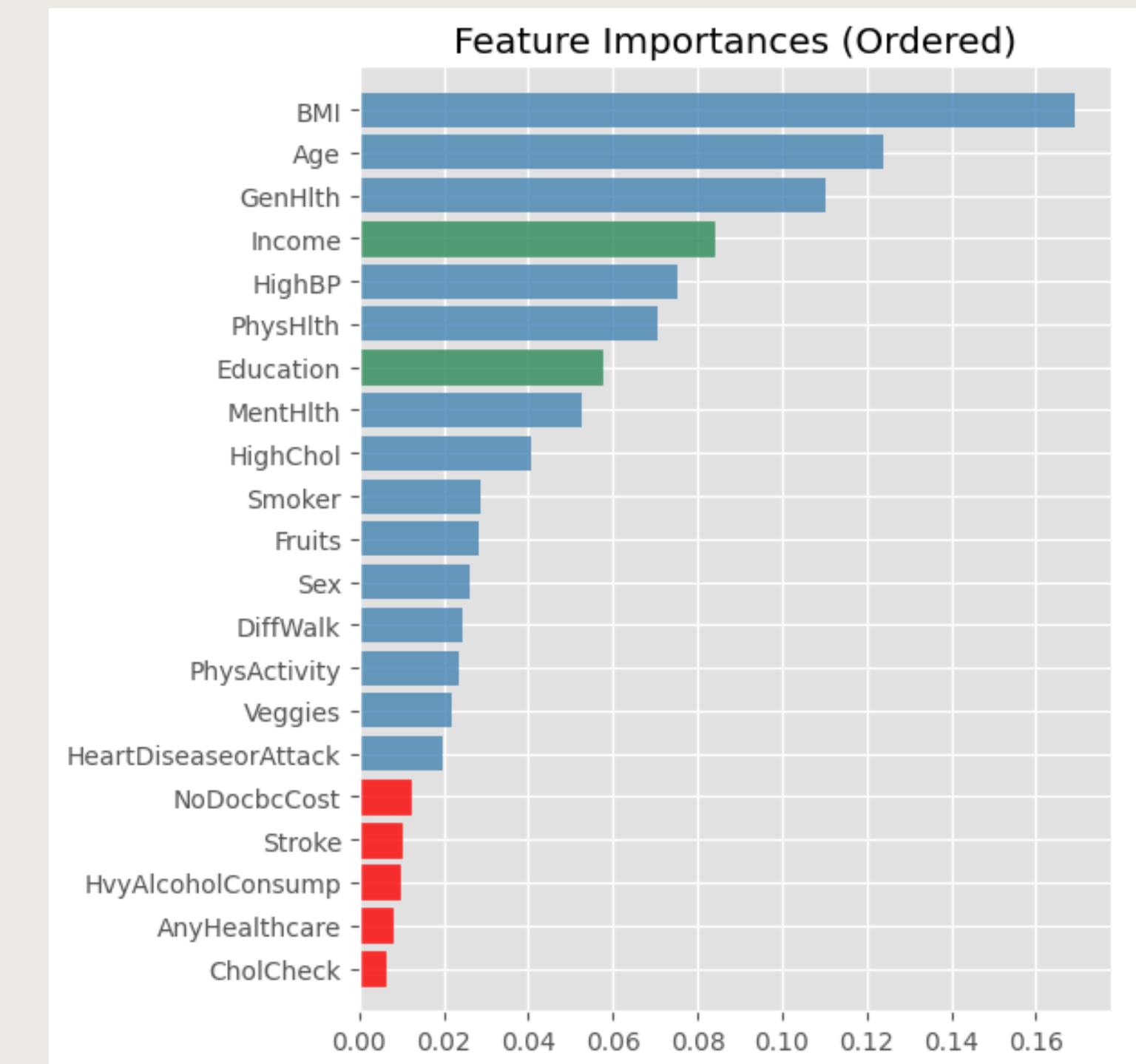


EXPLORATORY DATA ANALYSIS

FEATURE IMPORTANCE

RANDOM FOREST FEATURE IMPORTANCES

- Even Income and Education (green bars) have high importances, we exclude them based on the reasons stated before
 - The five binary features (red bars) that have low variances and subtly correlated with the target also have the lowest feature importances
- Eliminate these 7 features



EXPLORATORY DATA ANALYSIS

FEATURE SELECTION

Based on :

- Variance analysis
 - Correlation Analysis
 - Feature Importances Analysis
 - Other Causal Inference Rationality
- 6 features are ruled out

15 Features Selected

High Blood Pressure	High Cholesterol	Cholesterol Check
BMI	Smoker	Stroke
Physical Activity past 30d	Sex	Heart Disease or Attack
Heavy Alcohol Consumption	Fruits	Age
Not See Doctor due to costs	Vegetables	Any Healthcare Coverage
Physical Health	General Health	Mental Health
Difficulty Walking	Income	Education

MODEL SELECTION

CROSS VALIDATION

- We evaluated four metrics through cross validation across four models
- Among four metrics, we focus on recall (health issue → minimize false negative rate)

Metrics
Precision
F1_macro
● Recall
ROC_AUC

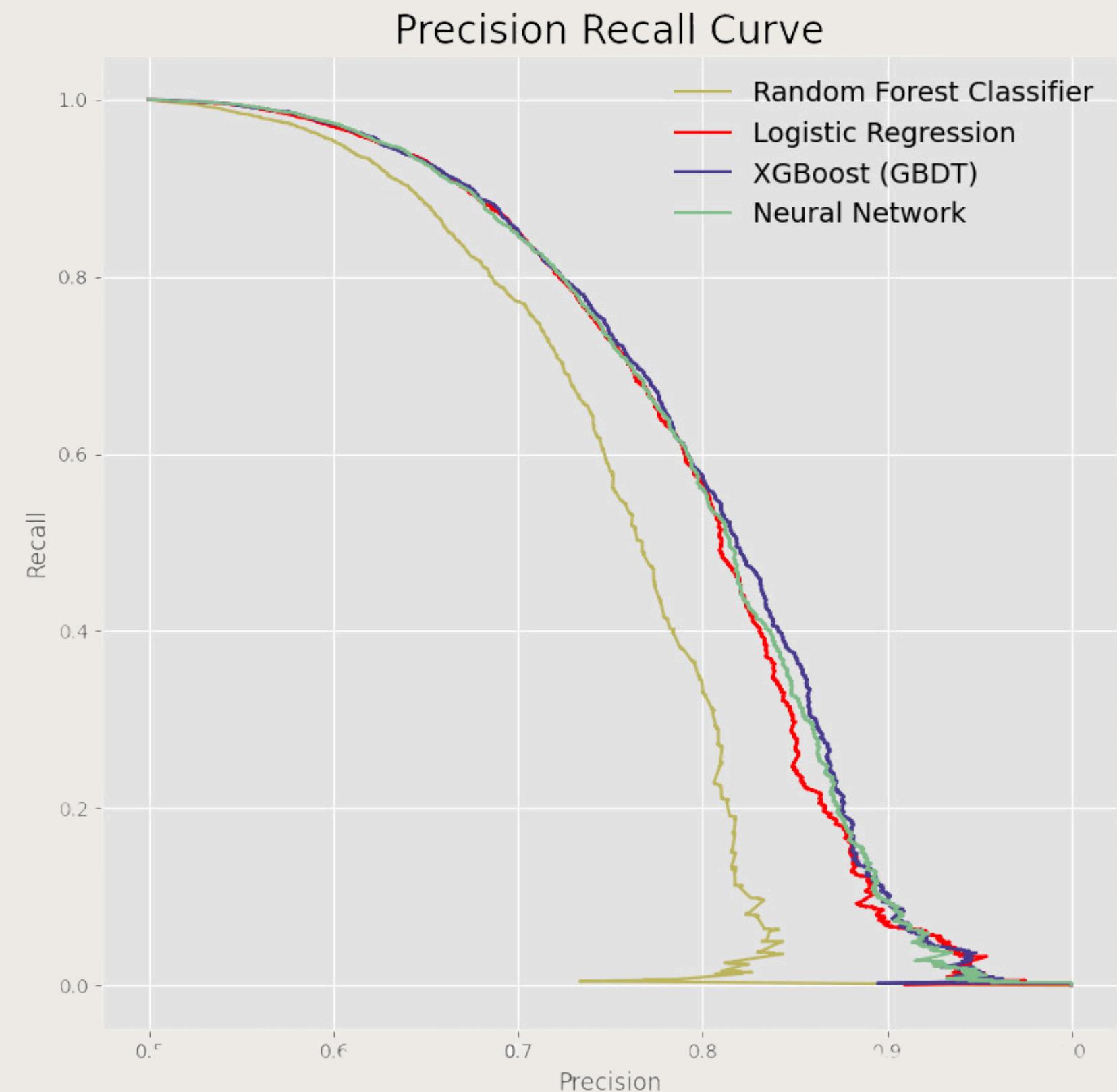
Model Comparisons based on 5 fold Cross Validation Scoring					
		precision	recall	f1_macro	roc_auc
	Random Forest Classifier	0.707228	0.754944	0.722935	0.790553
	Logistic Regression	0.733449	0.761428	0.744071	0.821454
	XGBoost (GBDT)	0.727366	0.788696	0.747969	0.826001
	Neural Network	0.732284	0.769098	0.743483	0.824334

Gradient Boosting Decision Tree has the highest score on three metrics

MODEL SELECTION

PRECISION-RECALL CURVE

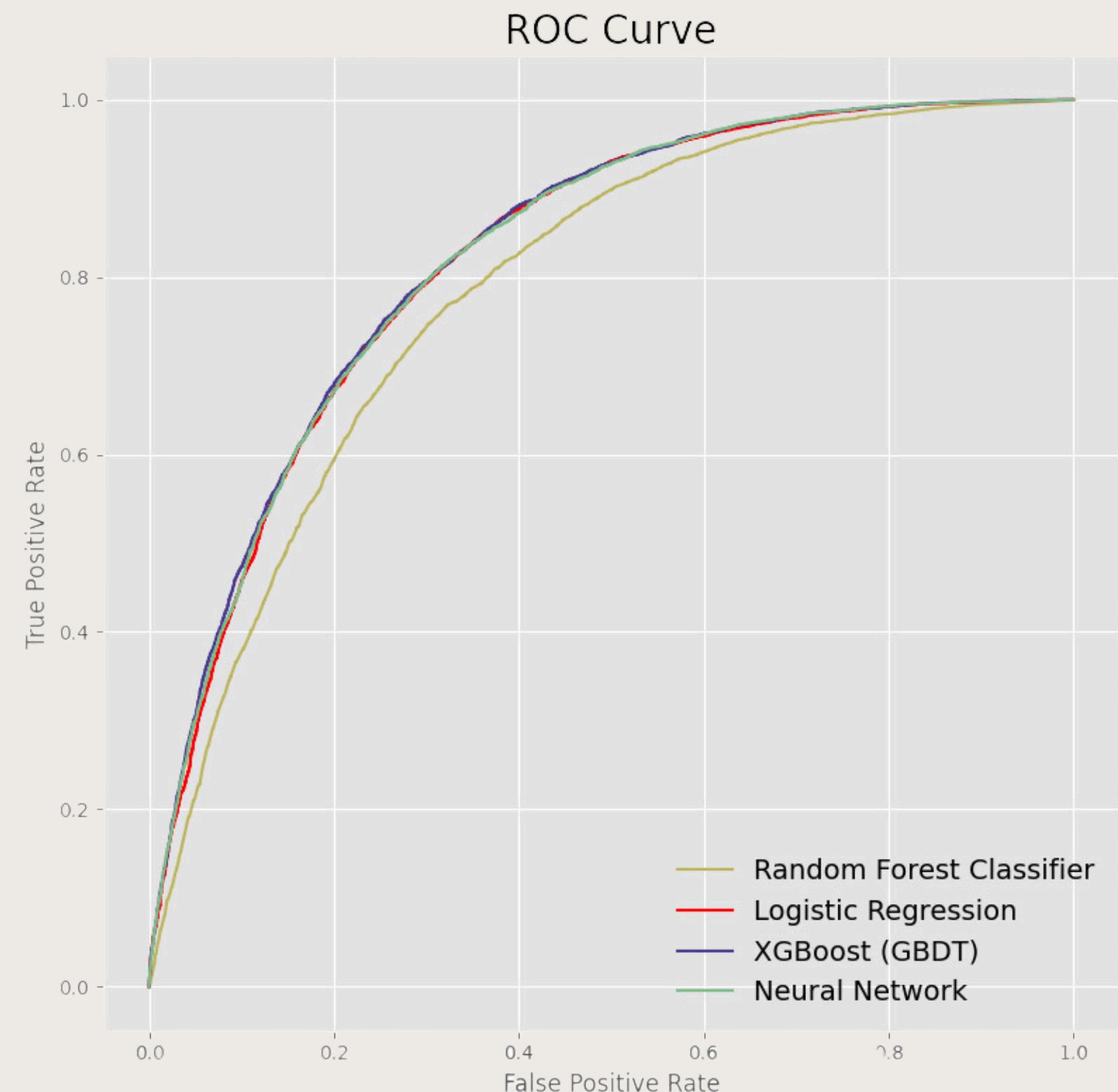
- Precision-recall curve evaluates models' trade-off between precision and recall
- The closer to the point (1, 1), the better the performance
- According to the plot, GBDT also has the best performance



MODEL SELECTION

ROC CURVE

- ROC curve evaluates models' trade-off between true positive rate (recall) and false positive rate
- The closer to the point (0, 1), the better the performance (the higher the `roc_auc`)
- According to the plot, GBDT also has the best performance



MODEL EVALUATION

HYPER PARAMETERS TUNING

- We exploited Grid Search to find the best combination of hyper parameters
- We chose n_estimators and learning_rate as the objective hyper parameters

```
clf = GradientBoostingClassifier()
grid_params = {'n_estimators': [10, 50, 100, 250, 500],
               'learning_rate': [0.0001, 0.001, 0.01, 0.1]}
grid_search = GridSearchCV(estimator = clf, param_grid = grid_params, scoring = 'recall', cv = 5).fit
(X_train, y_train)
```

Python

```
scores_params_dict = grid_search.cv_results_['params']
for i, score in enumerate(grid_search.cv_results_['mean_test_score']):
    scores_params_dict[i]['recall'] = score
scores_params_dict = pd.DataFrame(scores_params_dict).sort_values('recall', ascending = False)
scores_params_dict.iloc[0,:]
```

Python

MODEL EVALUATION

HYPER PARAMETERS TUNING

- The best combination of the hyper parameters is:
 - `learning_rate = 0.1`
 - `n_estimators = 500`
- The average cross-validated recall is 0.791686

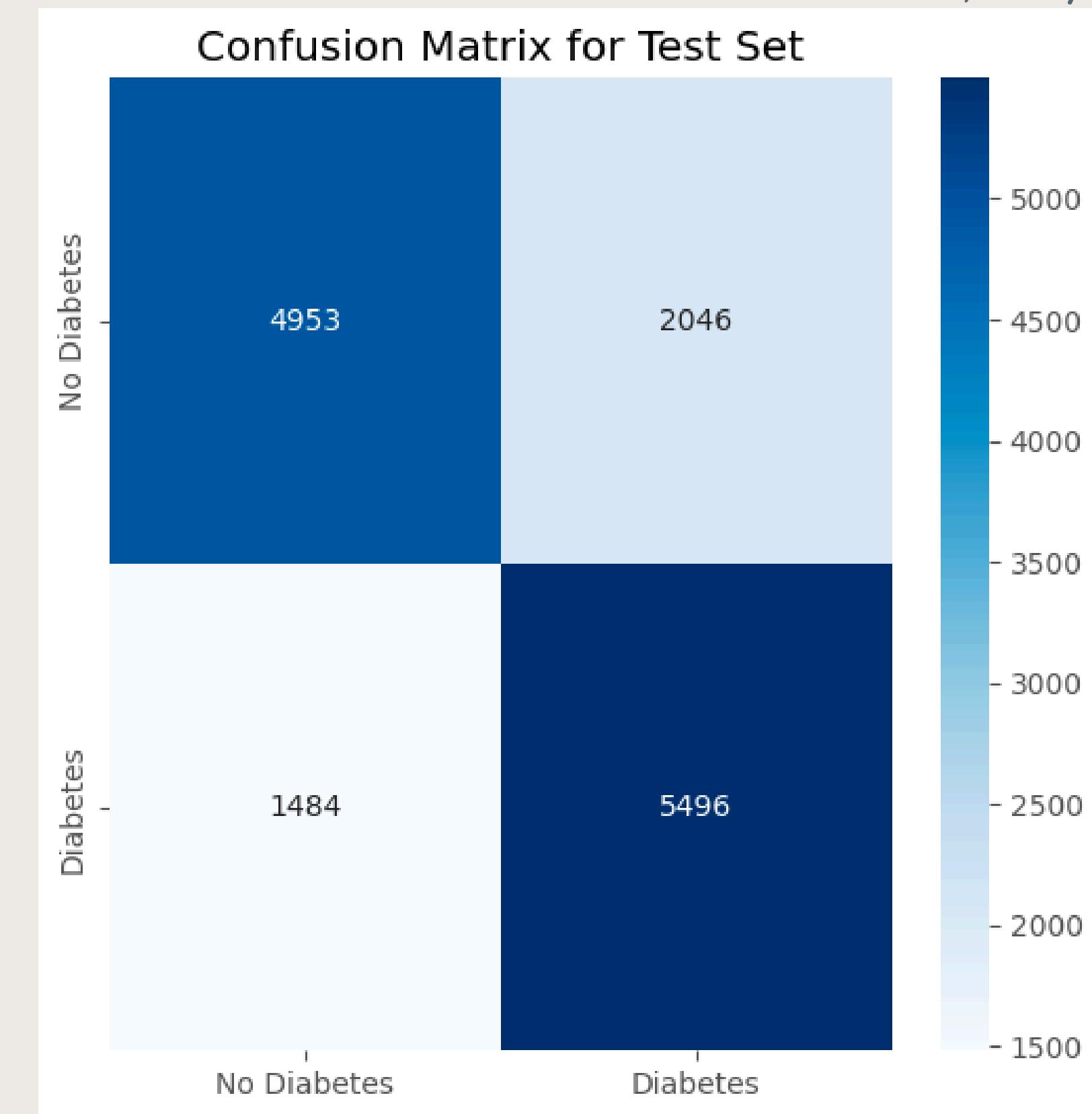
```
learning_rate          0.100000
n_estimators          500.000000
recall                0.791686
Name: 19, dtype: float64
```

→ We use this combination of hyper parameters as the final model

MODEL EVALUATION

FINAL MODEL EVALUATION

- We set:
 - `learning_rate = 0.1`
 - `n_estimators = 500`
- And trained the GBDT model, and then used the predicted values to establish the confusion matrix and classification report



MODEL EVALUATION

FINAL MODEL EVALUATION

- As shown in the two graphs on the RHS, the final model predicted diabetes with the macro-averaged recall = 0.75
 - Recall for diabetes = 0.79
 - Recall for no-diabetes = 0.71
- However, it is still hard to say that the result is precise and well-performing

Classification Report				
	precision	recall	f1-score	support
0.0	0.77	0.71	0.74	6999
1.0	0.73	0.79	0.76	6980
accuracy			0.75	13979
macro avg	0.75	0.75	0.75	13979
weighted avg	0.75	0.75	0.75	13979

MODEL EVALUATION

FINAL MODEL EVALUATION

- Possible reasons of the low performance:
 - a.features are represented as “level” → less precise (eg: age level instead of real age)
 - b.there are many skewed features → might exist selection bias
 - c.many features are based on subjective evaluation rather than objective clinical evidence (eg: General Health is based on subjective opinions of health condition)

Classification Report				
	precision	recall	f1-score	support
0.0	0.77	0.71	0.74	6999
1.0	0.73	0.79	0.76	6980
accuracy			0.75	13979
macro avg	0.75	0.75	0.75	13979
weighted avg	0.75	0.75	0.75	13979

FINAL MODEL OUTPUT

PICKLE

- We trained the model again based on all available data
- ⚠ Because ensemble model from scikit-learn seems not compatible with any web-deployment system, I had no choice but to choose Logistic Regression as the final output model
- We saved the model by pickle and gzip modules

```
X = pd.read_csv("./cleaned_features.csv")
y = pd.read_csv("./cleaned_target.csv")

X.drop(['Unnamed: 0', 'index'], axis = 1, inplace = True)
y.drop(['Unnamed: 0', 'index'], axis = 1, inplace = True)
y = y.values.ravel()

model = LogisticRegression(max_iter=2000).fit(X, y);

with gzip.GzipFile('model.pgz', 'w') as f:
    pickle.dump(model, f)
```

VISUALIZATION & UI

STREAMLIT

🔗 link of the visualized interface (Streamlit):

<https://diabetesprediction-c9v4wbza6kodzyhpq7nxoj.streamlit.app/>

Diabetes Prediction Machine Learning Project

Please input your information to obtain the probability of having diabetes.

Do you have High Blood Pressure?

Do you have High Cholesterol?

Do you smoke?

Do you have heart disease or attack?

Did you conduct any physical activity these past 30 days?

Have you ever got stroke?

Do you have fruits per day?

Do you have vegetable per day?

Check if you are biological male

Do you have serious difficulty walking or climbing stairs?

How many days during the past 30 days was your physical health not good?

0

0

30



0

How many days during the past 30 days was your mental health not good?

0

0

30



0

Rate your General Health for the past 30 days (The higher the better)

3

1

30

5



VISUALIZATION & UI

STREAMLIT

🔗 link of the visualized interface (Streamlit):

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The screenshot shows a Streamlit application with a dark theme. At the top, it says "Select your age" with a slider set to 22. Below that, there are two input fields: "Please input your height in cm" with a value of 170, and "Please input your weight in kg" with a value of 50. A message below the inputs states "Your BMI is 17.3". A red "Submit" button is visible. The main result is a large white text area that says "You don't have diabetes. Please keep your healthy life style" followed by a clapping hands emoji. Below this, it says "Probability of having Diabetes = 0.04638". A "Clear" button is at the bottom left.

Select your age

22

1 100

Please input your height in cm

170

Please input your weight in kg

50

Your BMI is 17.3

Submit

You don't have diabetes. Please keep your healthy life style 🙌

Probability of having Diabetes = 0.04638

Clear