Cardiovascular Diseases Risk Prediction

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Presentation Roadmap

1. Introduction and Problem
2. Overview of EDA
3. Models and Results
4. Conclusion

Introduction

- Cardiovascular diseases (CVDs) are a significant health issue for millions around the world.
- Existing health conditions and lifestyle factors play a crucial role in determining an individual's vulnerability to CVDs.
- Objective:
    - Develop an understanding of the risk factors associated with CVDs
    - Create predictive models that can assess an individual's vulnerability to CVDs
- Our project highlights the significance of the application of AI in medicine
    - Support understanding, knowledge, & new findings
    - Inform data driven decisions

Our Dataset

- The Behavioral Risk Factor Surveillance System (BRFSS) collects comprehensive health-related data from U.S. residents through telephone surveys conducted by various state health departments in collaboration with the Centers for Disease Control and Prevention (CDC).
- Our dataset contains 308854 rows (records) and 19 columns (features)
  - Of the 19 features, 7 are numerical, 9 are categorical, and 3 are ordinal
- Features in the dataset are related to lifestyle factors that have commonly been associated with an increased risk of various CVDs

```
Index(['General_Health', 'Checkup', 'Exercise', 'Heart_Disease', 'Skin_Cancer',
       'Other_Cancer', 'Depression', 'Diabetes', 'Arthritis', 'Sex',
       'Age_Category', 'Height_(cm)', 'Weight_(kg)', 'BMI', 'Smoking_History',
       'Alcohol_Consumption', 'Fruit_Consumption',
       'Green_Vegetables_Consumption', 'FriedPotato_Consumption'],
      dtype='object')
```

Details of Our Methodology

Task:

Predict CVD from a few select risk factors and identify which risk factors are the most significant

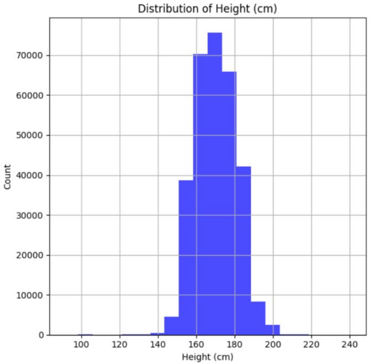
Solution:

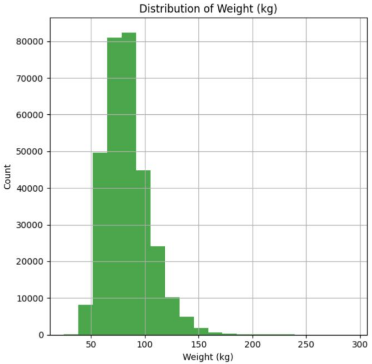
Data Analysis and Machine Learning

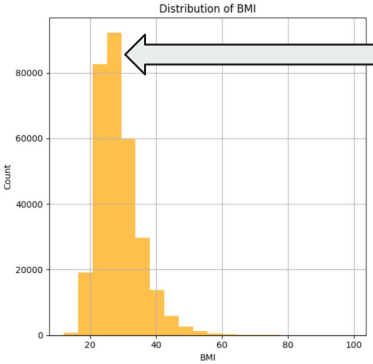
Tools:
Python, sklearn, pandas, matplotlib, Google colab

EDA: CVD by Height, Weight, & BMI

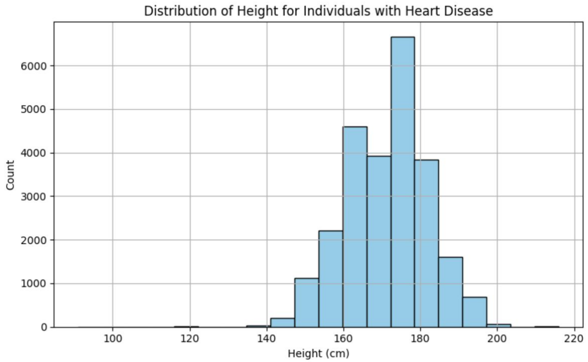
Median BMI: 20-30

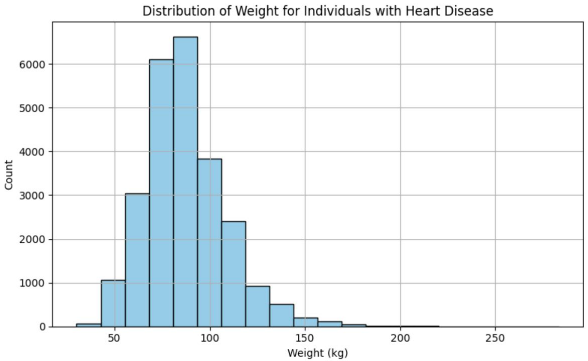


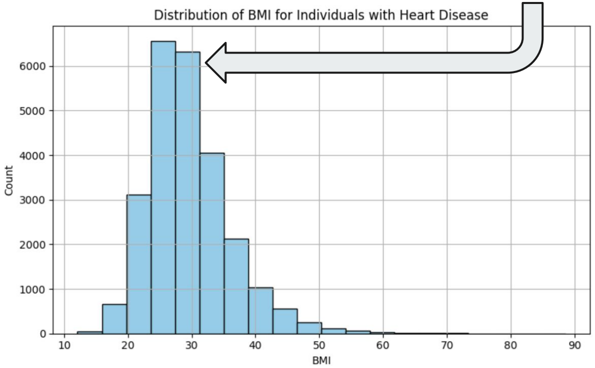




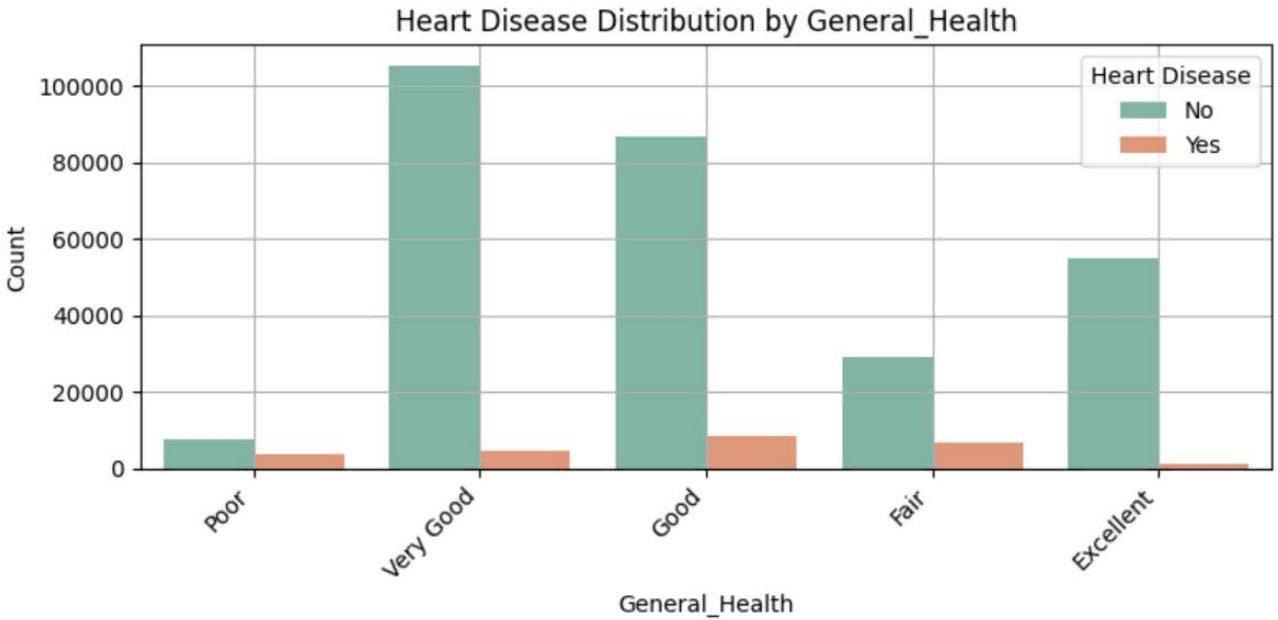
Median BMI: 25-30



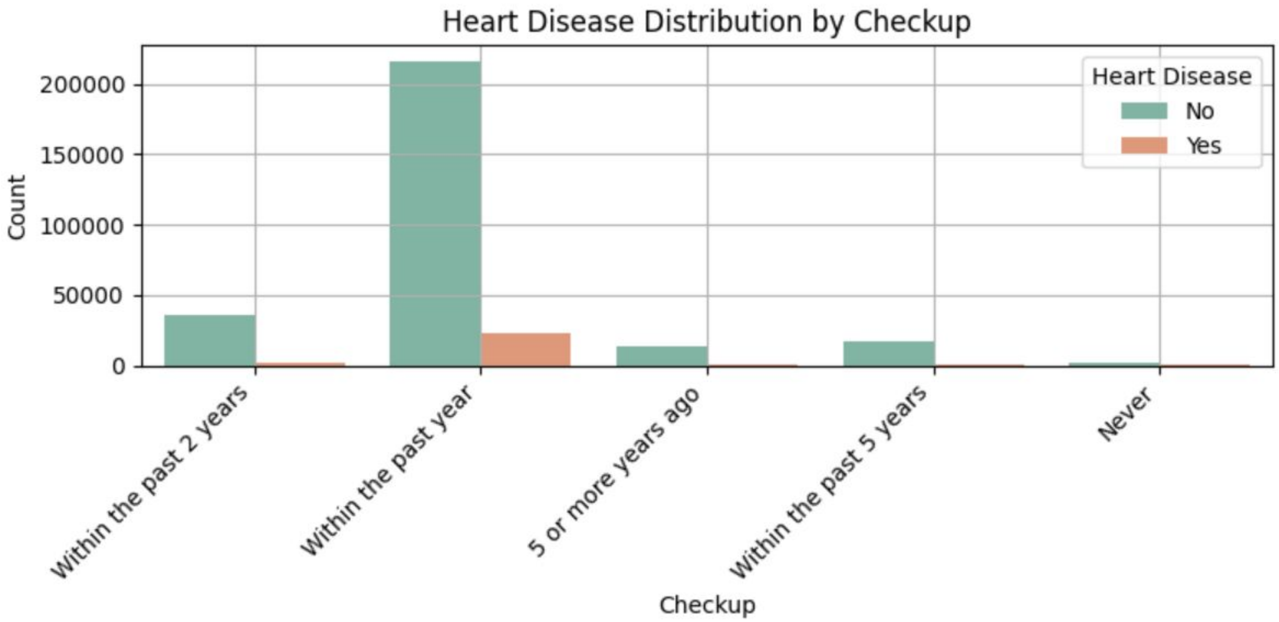




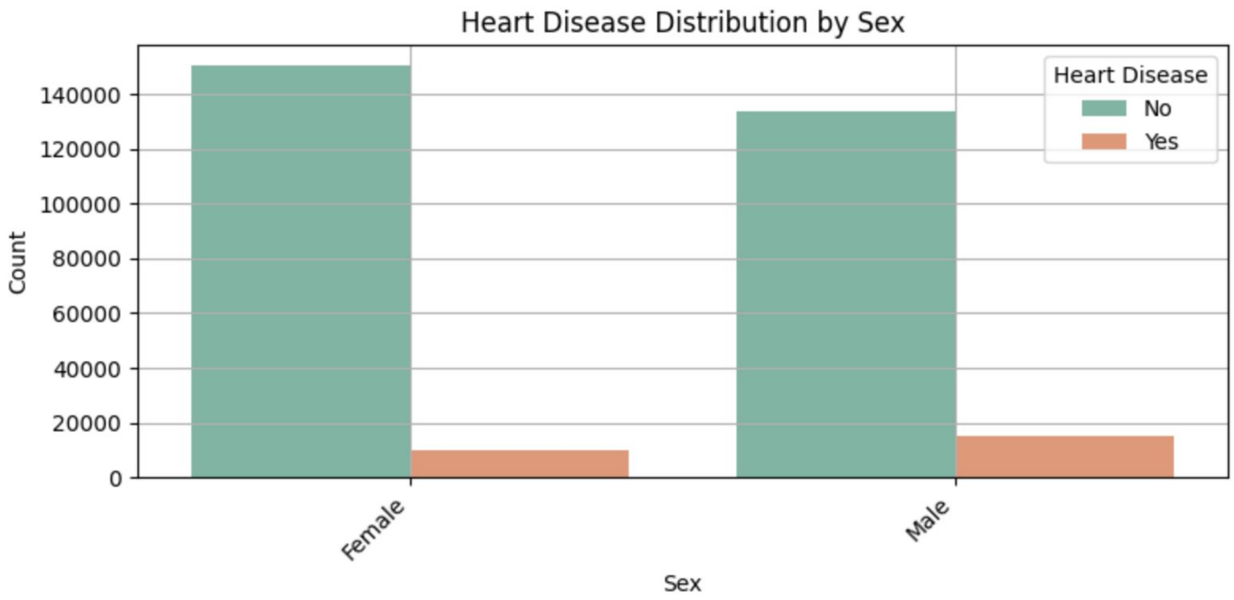
EDA: CVD by General Health



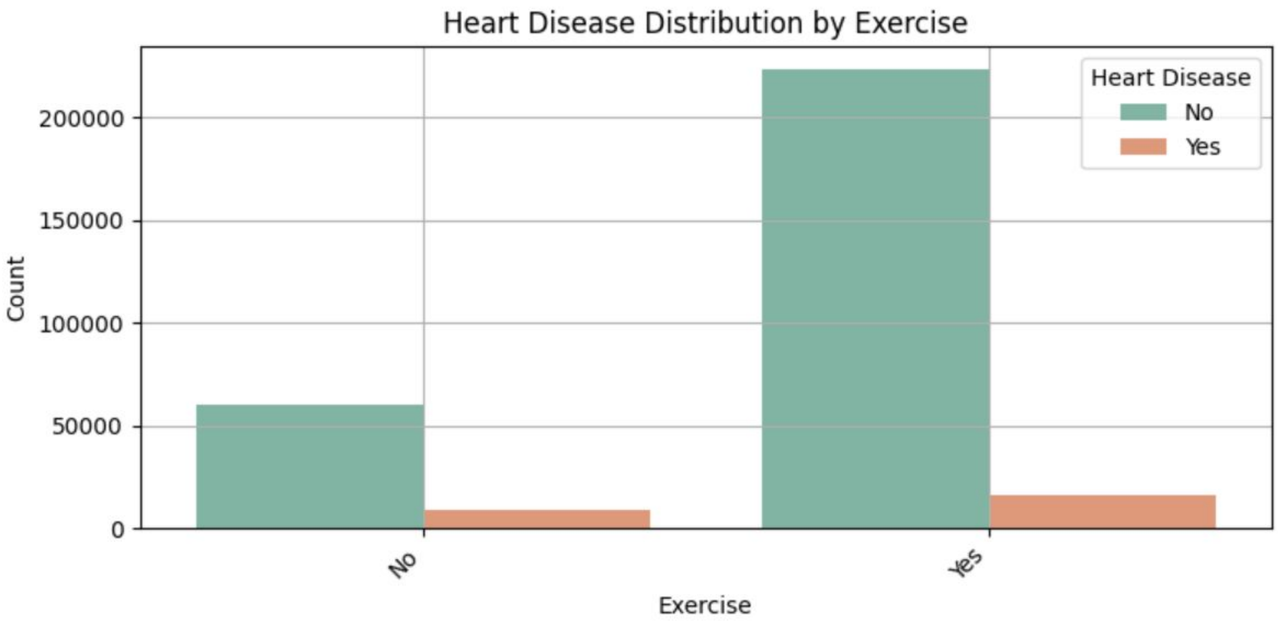
EDA: CVD by Checkup Frequency



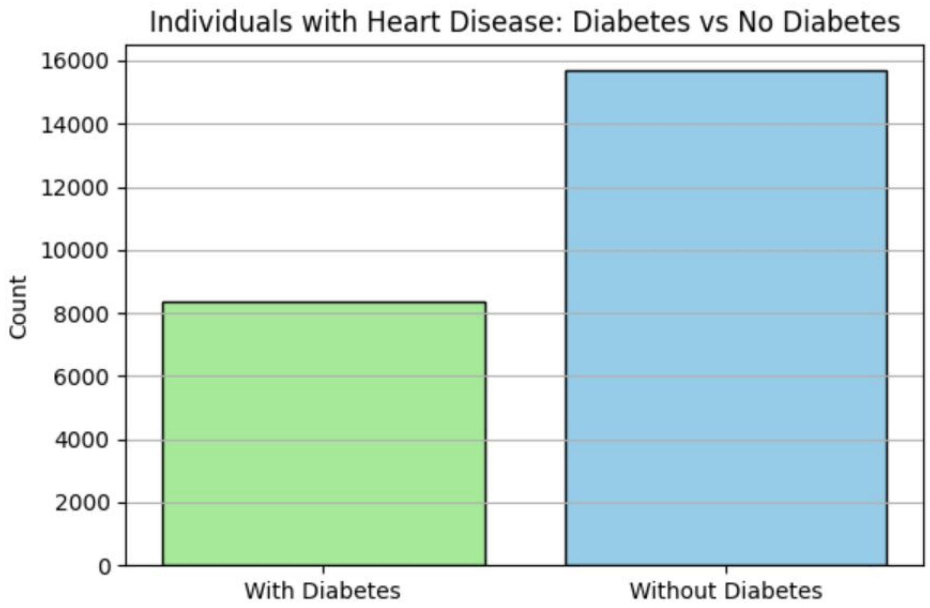
EDA: CVD by Sex



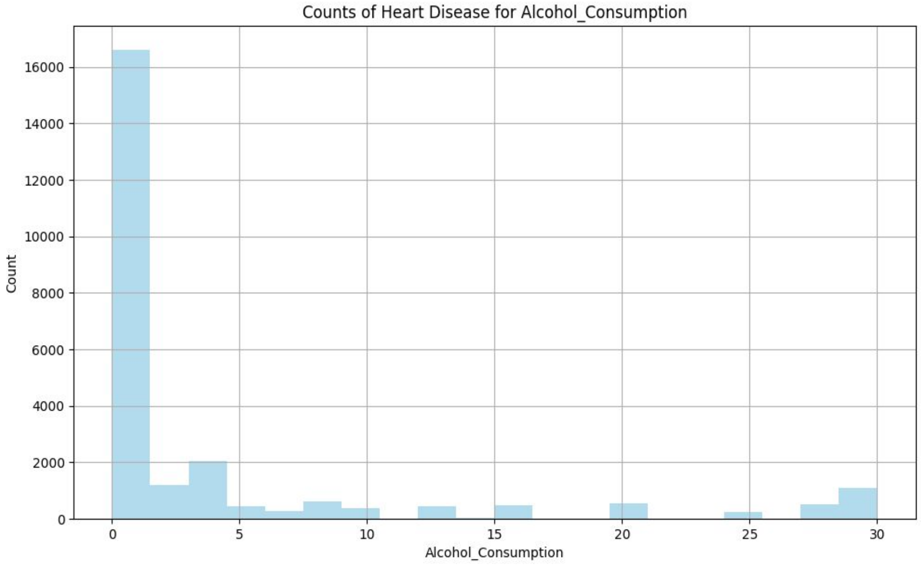
EDA: CVD by Exercise

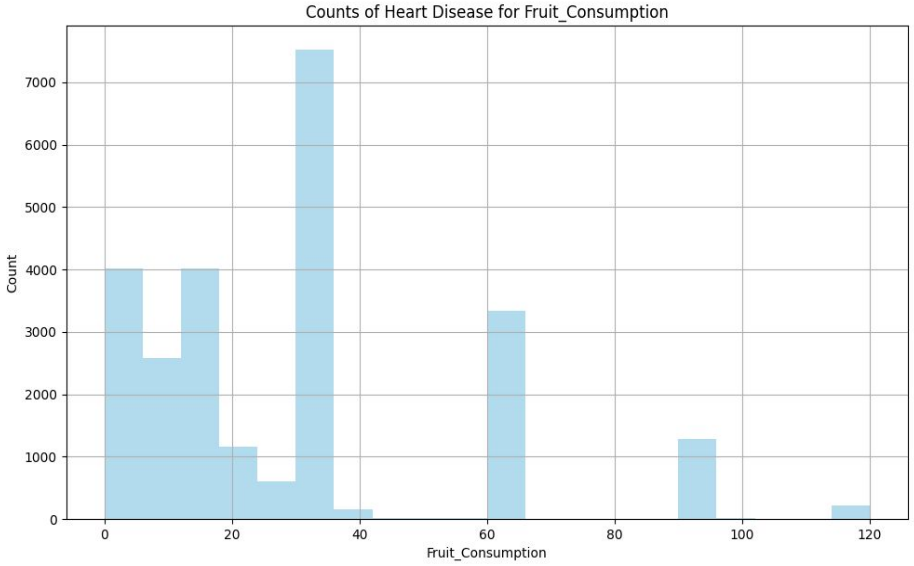


EDA: CVD by Diabetes

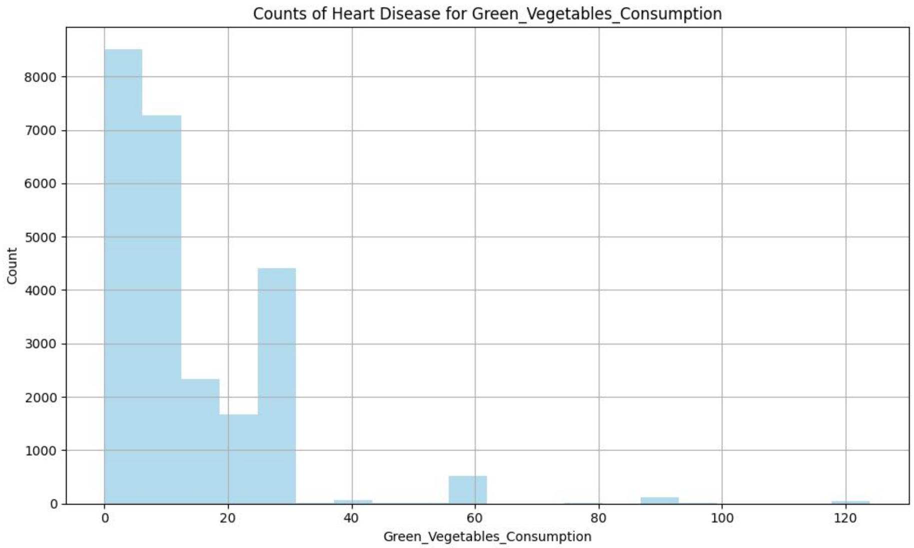


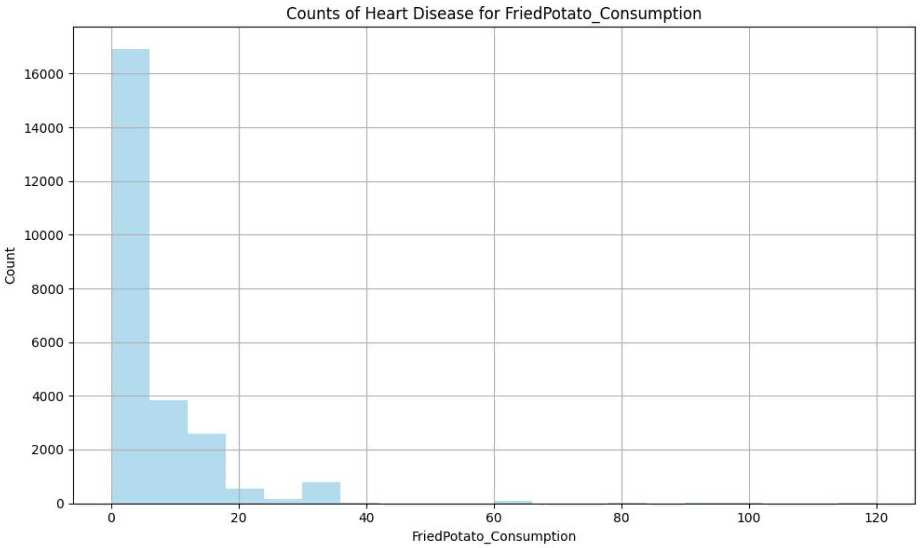
EDA: CVD by Alcohol & Fruit Consumption





EDA: CVD by Vegetable & Fried Potato Consumption





Preprocessing for Modeling

```
ohedf.columns
```

```
Index(['Exercise', 'Heart_Disease', 'Skin_Cancer', 'Other_Cancer',
       'Depression', 'Diabetes', 'Arthritis', 'Sex', 'Height_(cm)',
       'Weight_(kg)', 'BMI', 'Smoking_History', 'Alcohol_Consumption',
       'Fruit_Consumption', 'Green_Vegetables_Consumption',
       'FriedPotato_Consumption', 'General_Health_Excellent',
       'General_Health_Fair', 'General_Health_Good', 'General_Health_Poor',
       'General_Health_Very Good', 'Checkup_5 or more years ago',
       'Checkup_Never', 'Checkup_Within the past 2 years',
       'Checkup_Within the past 5 years', 'Checkup_Within the past year',
       'Age_Category_18-24', 'Age_Category_25-29', 'Age_Category_30-34',
       'Age_Category_35-39', 'Age_Category_40-44', 'Age_Category_45-49',
       'Age_Category_50-54', 'Age_Category_55-59', 'Age_Category_60-64',
       'Age_Category_65-69', 'Age_Category_70-74', 'Age_Category_75-79',
       'Age_Category_80+'],
      dtype='object')
```

Models

- KNN
  - 10-Fold Cross Validation
  - Tested with 5, 10, 15, 20, 25, and 30 Neighbors
- Random Forest
  - Tested with 5-Fold, 10-Fold, 15-Fold, and 20-Fold Cross Validation
- Naive Bayes
  - Tested with 5-Fold, 10-Fold, 15-Fold, and 20-Fold Cross Validation

Experimental Results

Naive Bayes

	Precision	Recall	f1	Accuracy	num_folds
0	0.197206	0.471347	0.277879	0.801757	5
1	0.197510	0.472109	0.278205	0.801991	10
2	0.198835	0.471428	0.278534	0.801900	15
3	0.198219	0.471789	0.278480	0.802000	20

KNN

	Precision	Recall	f1	Accuracy	num_neighbors
0	0.174976	0.013135	0.024428	0.915206	5
1	0.375000	0.000761	0.001518	0.919111	10
2	0.486667	0.000561	0.001120	0.919162	15
3	0.000000	0.000000	0.000000	0.919146	20
4	0.000000	0.000000	0.000000	0.919146	25
5	0.000000	0.000000	0.000000	0.919150	30

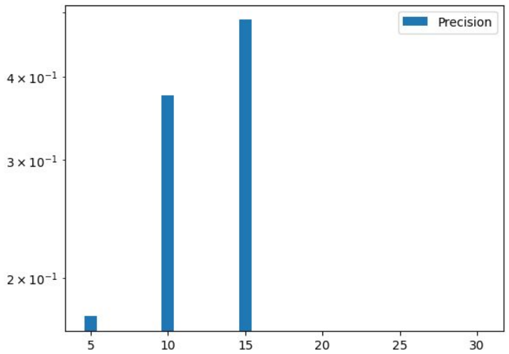
Random Forest

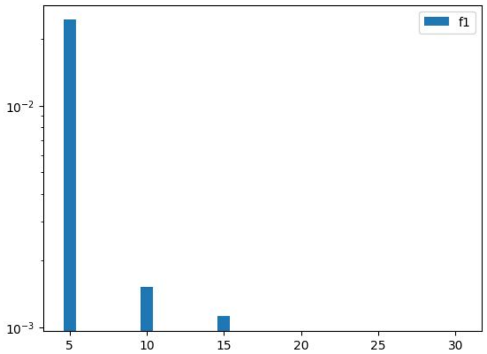
	Precision	Recall	f1	Accuracy	num_folds
0	0.441357	0.044211	0.080358	0.918194	5
1	0.443334	0.045613	0.082675	0.918188	10
2	0.439369	0.044972	0.081411	0.918104	15
3	0.444500	0.045173	0.081898	0.918211	20

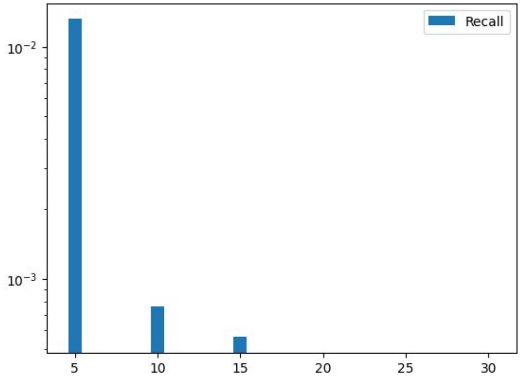
	Model	F1
1	Logistic Regression	0.32564
2	Naive Bayes	0.26982
3	Decision Tree Classifier	0.22237
4	K Neighbors Classifier	0.27350
5	Random Forest Classifier	0.17830

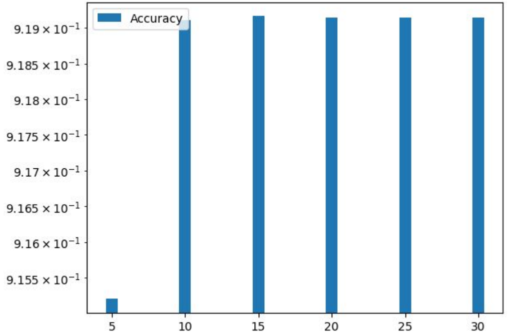
Lupague R.M.J.M., Mabborang R.C., Bansil A.G., Lupague M.M. (2023) Integrated Machine Learning Model for Comprehensive Heart Disease Risk Assessment Based on Multi-Dimensional Health Factors

KNN


Precision
4×10^{-1}
3×10^{-1}
2×10^{-1}
5
10
15
20
25
30

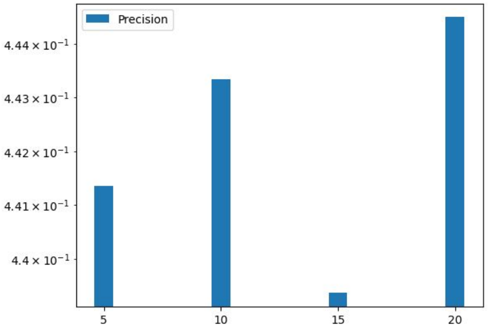

f1
10^{-2}
10^{-3}
5
10
15
20
25
30

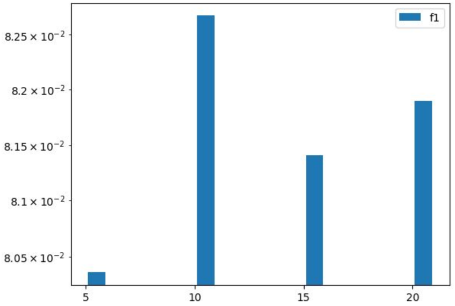

Recall
10^{-2}
10^{-3}
5
10
15
20
25
30

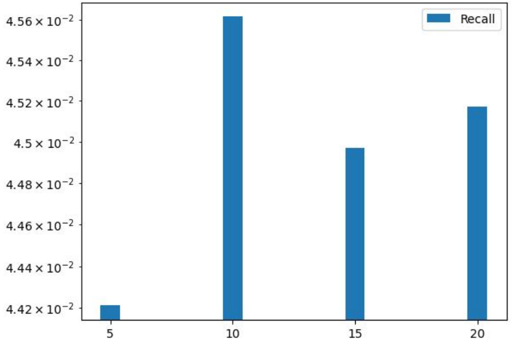

Accuracy
9.19×10^{-1}
9.185×10^{-1}
9.18×10^{-1}
9.175×10^{-1}
9.17×10^{-1}
9.165×10^{-1}
9.16×10^{-1}
9.155×10^{-1}
5
10
15
20
25
30

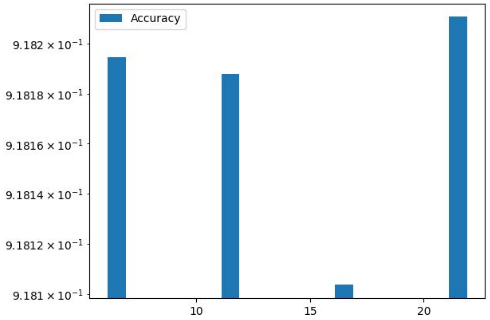
Random Forest

```
array([0.01960809, 0.01427426, 0.01579944, 0.0187046 , 0.02144972,
       0.01837596, 0.01548138, 0.09530568, 0.1258011 , 0.14161415,
       0.01630808, 0.06008439, 0.09162513, 0.09413556, 0.08859432,
       0.00640482, 0.01449094, 0.00771149, 0.02193178, 0.0079308 ,
       0.00238815, 0.00068243, 0.00562183, 0.00299067, 0.00818475,
       0.00140625, 0.0014288 , 0.00206393, 0.00270284, 0.00331855,
       0.00410394, 0.00517215, 0.00681821, 0.00837412, 0.00927102,
       0.01075815, 0.01135102, 0.01773149])
```









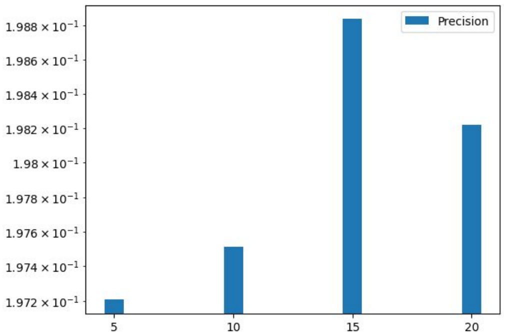
Random Forest Feature Importance

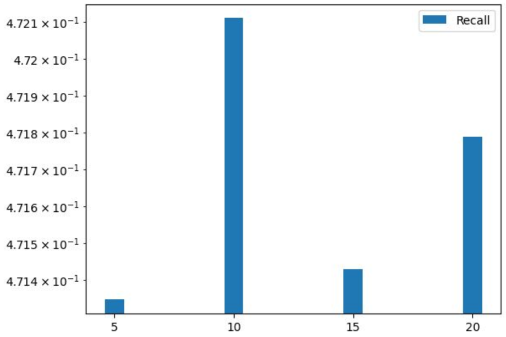
index	feature	importance
9	BMI	0.1416141488530385
8	Weight_(kg)	0.12580110206974682
7	Height_(cm)	0.095305677169544
13	Green_Vegetables_Consumption	0.09413555643070755
12	Fruit_Consumption	0.09162513491299387
14	FriedPotato_Consumption	0.08859432127399156
11	Alcohol_Consumption	0.060084390002987556
18	General_Health_Poor	0.02193178433355509
4	Diabetes	0.021449720928456668
0	Exercise	0.019608088628981078

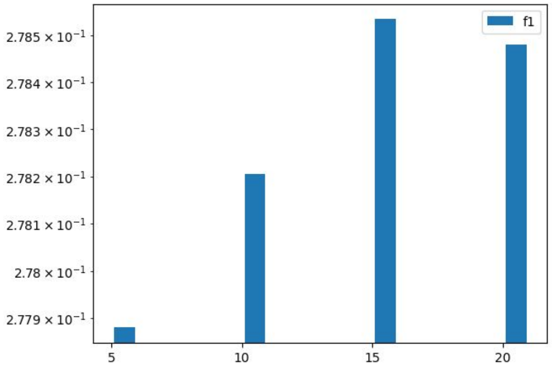
Naive Bayes

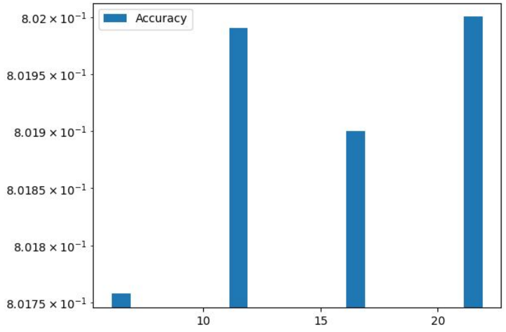
```
nb.feature_log_prob_

array([[ -6.08105346,  -8.26327604,  -8.25710757,  -7.46889393,
         -7.79044706,  -7.02852677,  -6.59639476,  -0.7033811 ,
         -1.41998473,  -2.49091597,  -6.78556852,  -4.19645163,
         -2.44098568,  -3.11874165,  -3.999295  ,  -7.48790398,
         -8.12422024,  -7.02536255,  -9.45128236,  -6.83266903,
         -8.93068506, -11.18605692,  -7.91817557,  -8.65699069,
         -6.11133183,  -8.56378528,  -8.76798576,  -8.59306486,
         -8.47787562,  -8.43051283,  -8.48194761,  -8.3249523 ,
         -8.22672143,  -8.10991895,  -8.10656749,  -8.20688181,
         -8.65276599,  -8.63781085],
       [ -6.29246387,  -7.5243825 ,  -7.5212606 ,  -7.25970316,
         -6.838367  ,  -6.41156422,  -6.34918824,  -0.70440368,
         -1.3818661 ,  -2.4600255 ,  -6.38747557,  -4.43902832,
         -2.51125458,  -3.21842546,  -4.03897913,  -8.9625987 ,
         -7.1495114 ,  -6.91247497,  -7.77358756,  -7.48864447,
        -10.09531904, -11.83988282,  -8.67881643,  -9.80115246,
         -5.94659426, -11.39957098, -11.27118981, -10.6595925 ,
        -10.36702044,  -9.89701681,  -9.46944025,  -8.88652516,
         -8.36224988,  -7.95328674,  -7.73110393,  -7.53898548,
         -7.75337027,  -7.48727404]])
```









Naive Bayes Probabilities

index	feature	0	1
7	Height_(cm)	-0.7033811003828951	-0.7044036810446599
8	Weight_(kg)	-1.4199847296416799	-1.3818661026698766
9	BMI	-2.4909159741193534	-2.460025500146795
12	Fruit_Consumption	-2.440985680117972	-2.511254575254359
13	Green_Vegetables_Consumption	-3.1187416486812864	-3.218425458348131
14	FriedPotato_Consumption	-3.999294997234893	-4.038979134662814
11	Alcohol_Consumption	-4.196451627305674	-4.439028318393484
24	Checkup_Within the past year	-6.111331828951377	-5.9465942572964
0	Exercise	-6.081053458858651	-6.29246387358071
6	Sex	-6.59639476163049	-6.349188241643962

Bonus: Neural Network

```
Epoch 1/10
7239/7239 [==============================] - 19s 2ms/step - loss: 0.2456 - accuracy: 0.9156 - precision_3: 0.3977 - recall_3: 0.0749
Epoch 2/10
7239/7239 [==============================] - 23s 3ms/step - loss: 0.2327 - accuracy: 0.9174 - precision_3: 0.4513 - recall_3: 0.0783
Epoch 3/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2296 - accuracy: 0.9180 - precision_3: 0.4696 - recall_3: 0.0693
Epoch 4/10
7239/7239 [==============================] - 15s 2ms/step - loss: 0.2282 - accuracy: 0.9183 - precision_3: 0.4782 - recall_3: 0.0653
Epoch 5/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2272 - accuracy: 0.9184 - precision_3: 0.4846 - recall_3: 0.0593
Epoch 6/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2263 - accuracy: 0.9185 - precision_3: 0.4899 - recall_3: 0.0616
Epoch 7/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2256 - accuracy: 0.9188 - precision_3: 0.5019 - recall_3: 0.0566
Epoch 8/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2253 - accuracy: 0.9187 - precision_3: 0.5003 - recall_3: 0.0486
Epoch 9/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2249 - accuracy: 0.9189 - precision_3: 0.5136 - recall_3: 0.0431
Epoch 10/10
7239/7239 [==============================] - 14s 2ms/step - loss: 0.2245 - accuracy: 0.9191 - precision_3: 0.5238 - recall_3: 0.0438
<keras.callbacks.History at 0x7e99774aeda0>
```

```
2413/2413 [==============================] - 8s 3ms/step - loss: 0.2252 - accuracy: 0.9172 - precision_3: 0.4319 - recall_3: 0.1264
[0.22517704963684082,
 0.9172041416168213,
 0.4319066107273102,
 0.12638255953788757]
```

Conclusion Main Idea - Contributing Factors to CVDs

- Our Feature Importance
  - Height, weight, BMI
  - Fruit, Green Vegetable, Fried Potato, Alcohol Consumption
  - General health
  - Checkup Frequency
  - Diabetes
  - Sex
  - Exercise
- Research Paper’s Feature Importance
  - Sex
  - Diabetes
  - General Health

Summary

- We have achieved high accuracy with a variety of different models
- Contrary to one of our initial hypotheses, the neural network proved surprisingly effective for this simple task
- Challenges we faced:
    - Training the models on large volumes of data
    - Learning the tensorflow APi
- Moving forward:
    - Create a more specialized neural network
    - Tune more hyperparameters
    - Address the severe overfitting issues (possibly with data augmentation)

References

Lupague R.M.J.M., Mabborang R.C., Bansil A.G., Lupague M.M. (2023) Integrated Machine Learning Model for Comprehensive Heart Disease Risk Assessment Based on Multi-Dimensional Health Factors, European Journal of Computer Science and Information Technology, 11 (3), 44-58