Teladoc® HEALTH

For individuals

3

Expert Medical Opinions

Get connected or referred to leading medical specialists for consultations on specific health issues

2

Primary360 (For adults aged 18 and above)

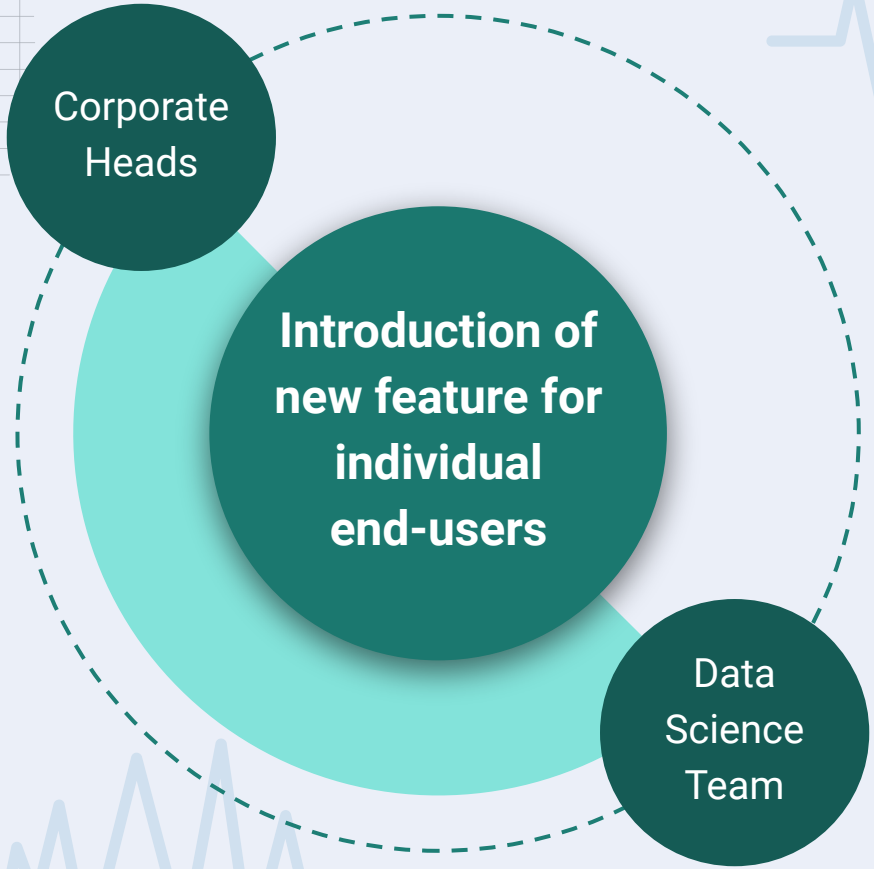
Subscription-based service with a primary care physician

1

General and Mental Health

Provides access to consultation with board-certified doctors via phone or video call for non-emergency concerns

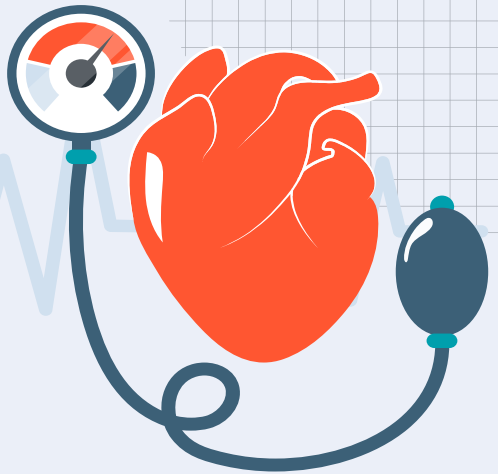
WHO ARE YOU?



WHO ARE WE?

In A Heartbeat

Prediction of Heart Disease Risk for Early Detection



DSI-SG-42 | Group 3
Amoz Kuang | Jayme Zhang | Timothy Chan

Agenda

01

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- Context
- Problem Statement

02

Data Findings

- Exploratory Data Analysis

03

Data Modeling

- Classifications models
- Model Comparison

04

Cost-Benefit Analysis

- Tangible/ Intangible
- Direct/ Indirect

05

Conclusion

- Limitations
- Recommendations

01 Introduction

Leading cause of death in US

Number of people who died from heart disease

695,547

Every 33 seconds, 1 person dies from heart disease

Every 40 seconds, 1 person will have a heart attack

Average age of first heart attack

65.6 years

72.0 years

Source:https://www.cdc.gov/heartdisease/facts.htm

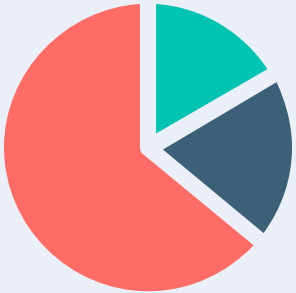
American Heart Association.

100 YEARS

Bold Hearts

Categories: Heart News, Stroke News & Brain Health | Published: January 24, 2024

More than half of U.S. adults don't know heart disease is leading cause of death, despite 100-year reign



Heart disease remains the leading cause of death in U.S., according to a new report from the American Heart Association; yet fewer than half of survey respondents knew that

Source: https://newsroom.heart.org/news/more-than-half-of-u-s-adults-dont-know-heart-disease-is-leading-cause-of-death-despite-100-year-reign

Get Healthy Sleep

Stop Smoking

Manage Blood Pressure

Manage Cholesterol

Eat Better

Get Active

Manage Blood Sugar

Maintain a Healthy Weight

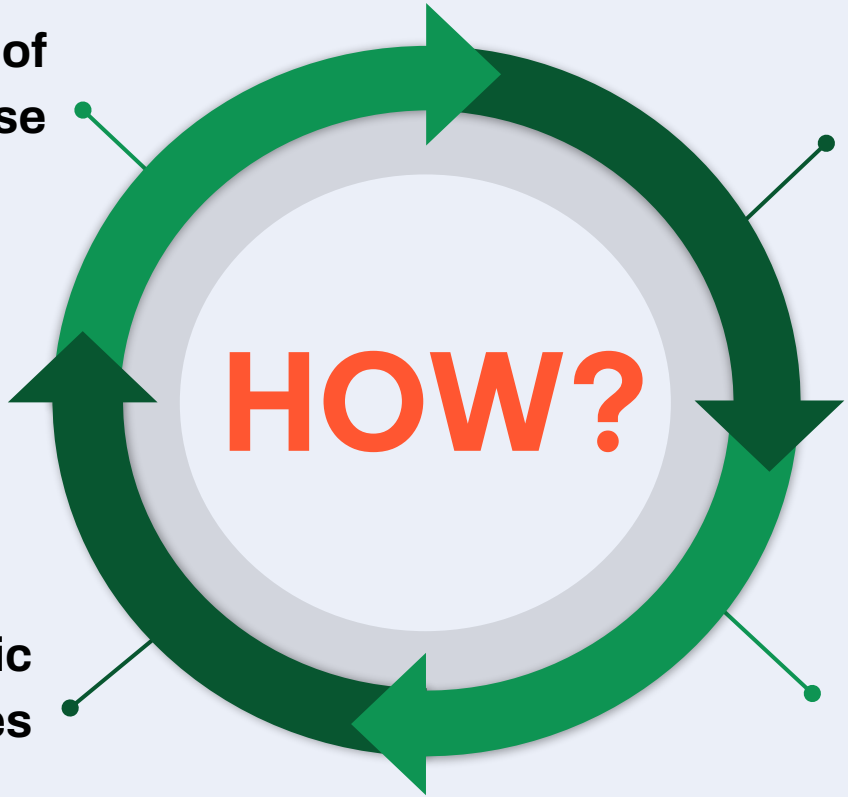
Source:https://www.heart.org/en/healthy-living/healthy-lifestyle/lifes-essential-8

The first step toward reducing any risk factor for cardiovascular disease is ***awareness***.

—Joseph C. Wu, M.D., Ph.D., FAHA,
volunteer president of the AHA,
Director and Professor at Stanford School of Medicine

Reduce risk of heart disease

Increase awareness amongst our end users and public



Make specific lifestyle changes

Manage health risk factors

John Patterson, 57, semi-retired

Attitudes & Behaviours

•Started using Teladoc since 2020, for the occasional flu and fever
•Enjoys fine dining and occasional drinking, leads a sedentary lifestyle
•On long-term medication for high cholesterol and high blood pressure

Pain points

•Fishing buddy, 51, had a 'silent' heart attack recently
•Got diagnosed when he visited the doctor for unrelated issues
•Long-term medication to lower risk of future heart attack

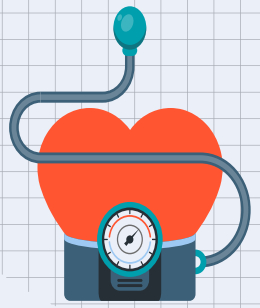
Scenario

•Started having chest pains on left side
•Felt better after resting
•Happened 3 times within the past 2 months

Motivation

•First grandchild arriving in 3 months
•To be independent and mobile
•Enjoying his golden years with family and friends

Problem Statement



Despite being the **leading cause of death** in the US for a century, many heart disease risk factors are **controllable**, and can be identified if we take a proactive approach to our health. **Early detection** is crucial, as it allows for intervention and risk reduction strategies to be implemented.

How can we develop and integrate a data-driven feature that provides Teladoc end-users with a rigorous prediction of their risk for heart disease to facilitate early detection?

02 Data Findings

Data Process

Data Acquisition	Data Cleaning	Exploratory Data Analysis	Data Modeling
• Data obtained from the Centers for Disease Control and Prevention 2022	• Imputation of missing values	• Distribution of the variables	• XGBoost • Logistic Regression • Random Forest • Decision Trees • Neural Networks

Data Acquisition

Sample size

~ 450,000 respondents

Demographics

Sex
Age
Income
Education
Race/ Ethnicity
Health Insurance

Body Measurements

Height
Weight
BMI

Lifestyle

Smoker status
No. of years smoked
No. of packs per day
E-cigarette
Binge drinking
Heavy drinking
No. of sleep hours
Exercise in past 30 days

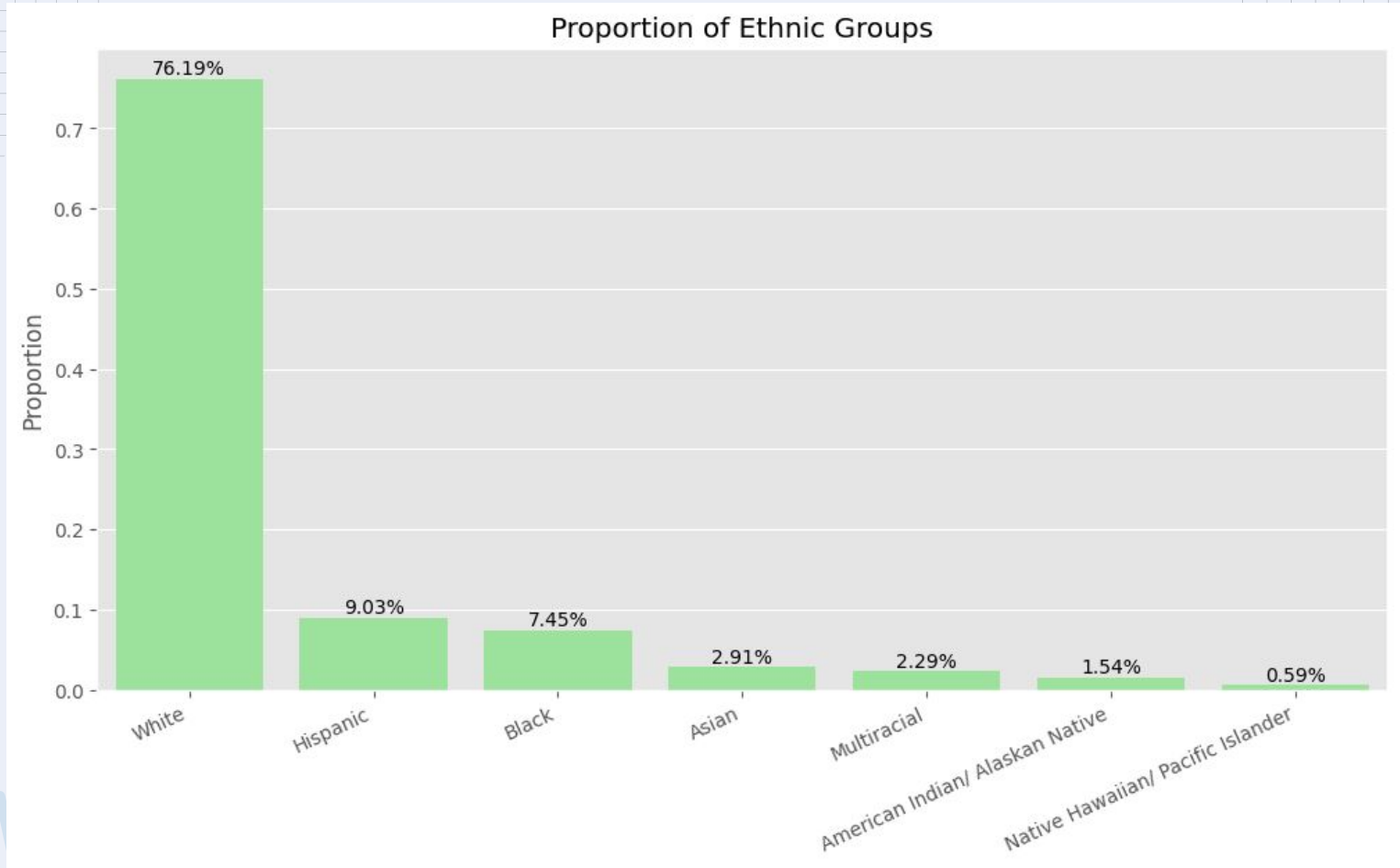
Medical History

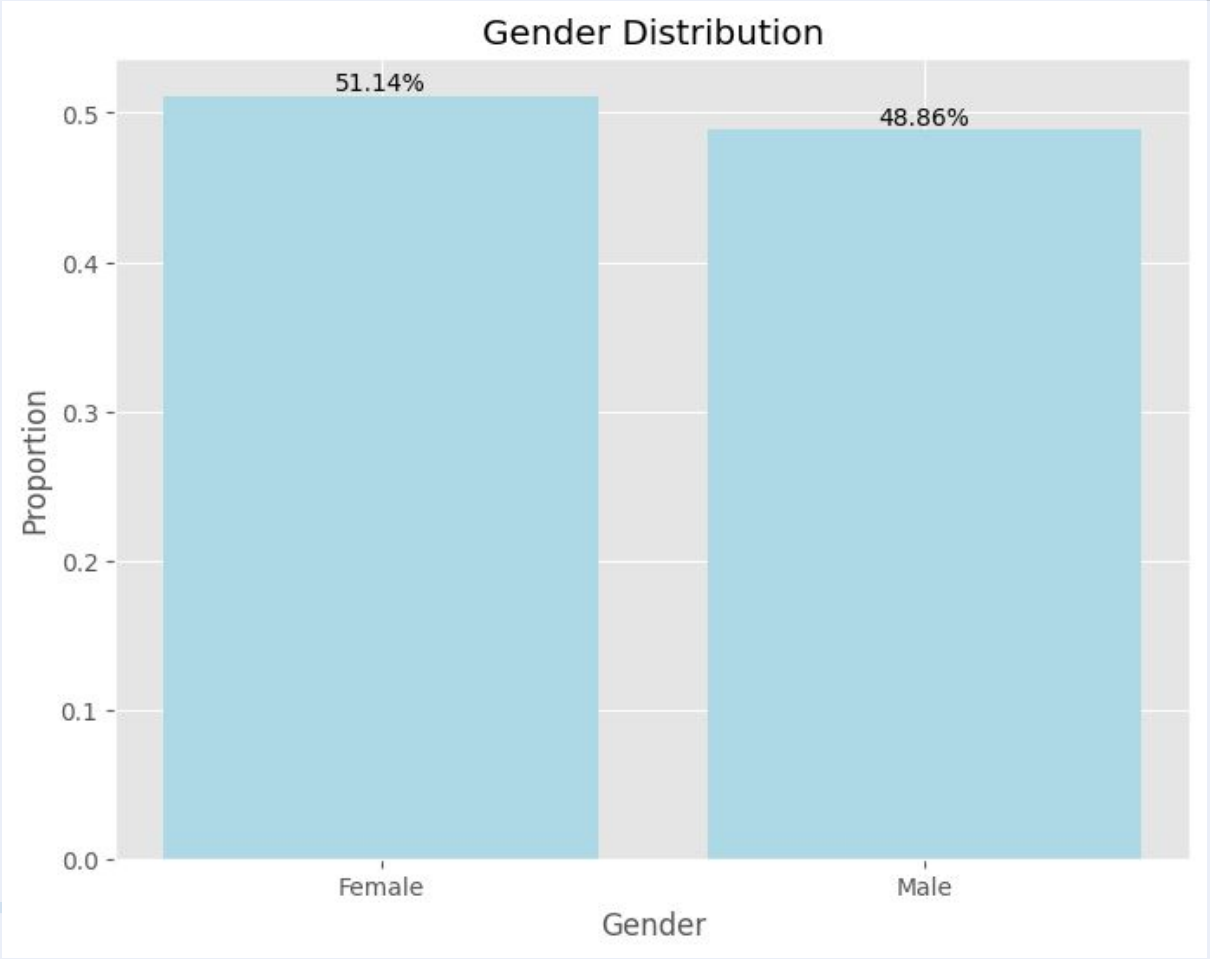
Heart disease
Stroke
Cancer
Kidney disease
Asthma

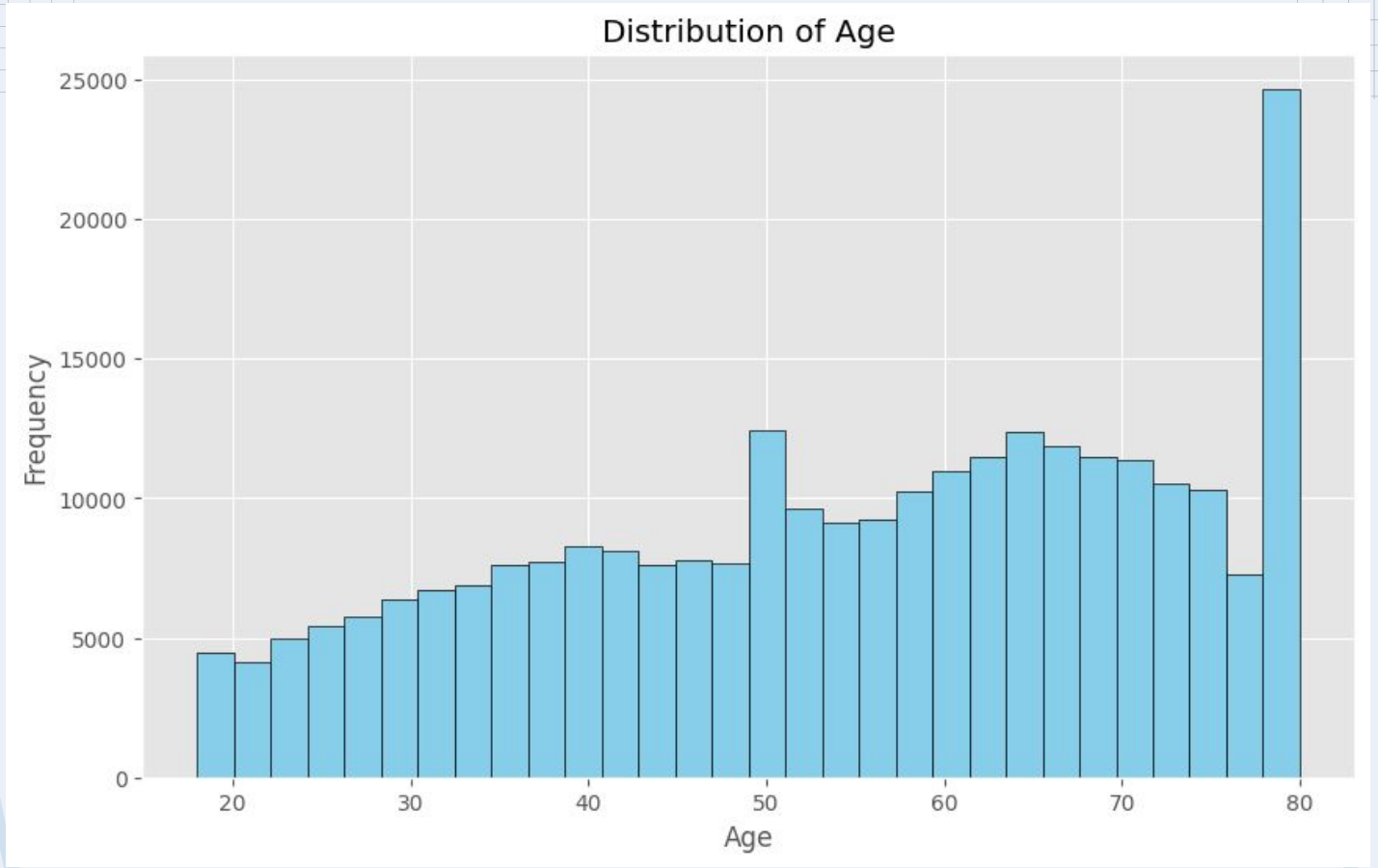
Frequency of Check-ups

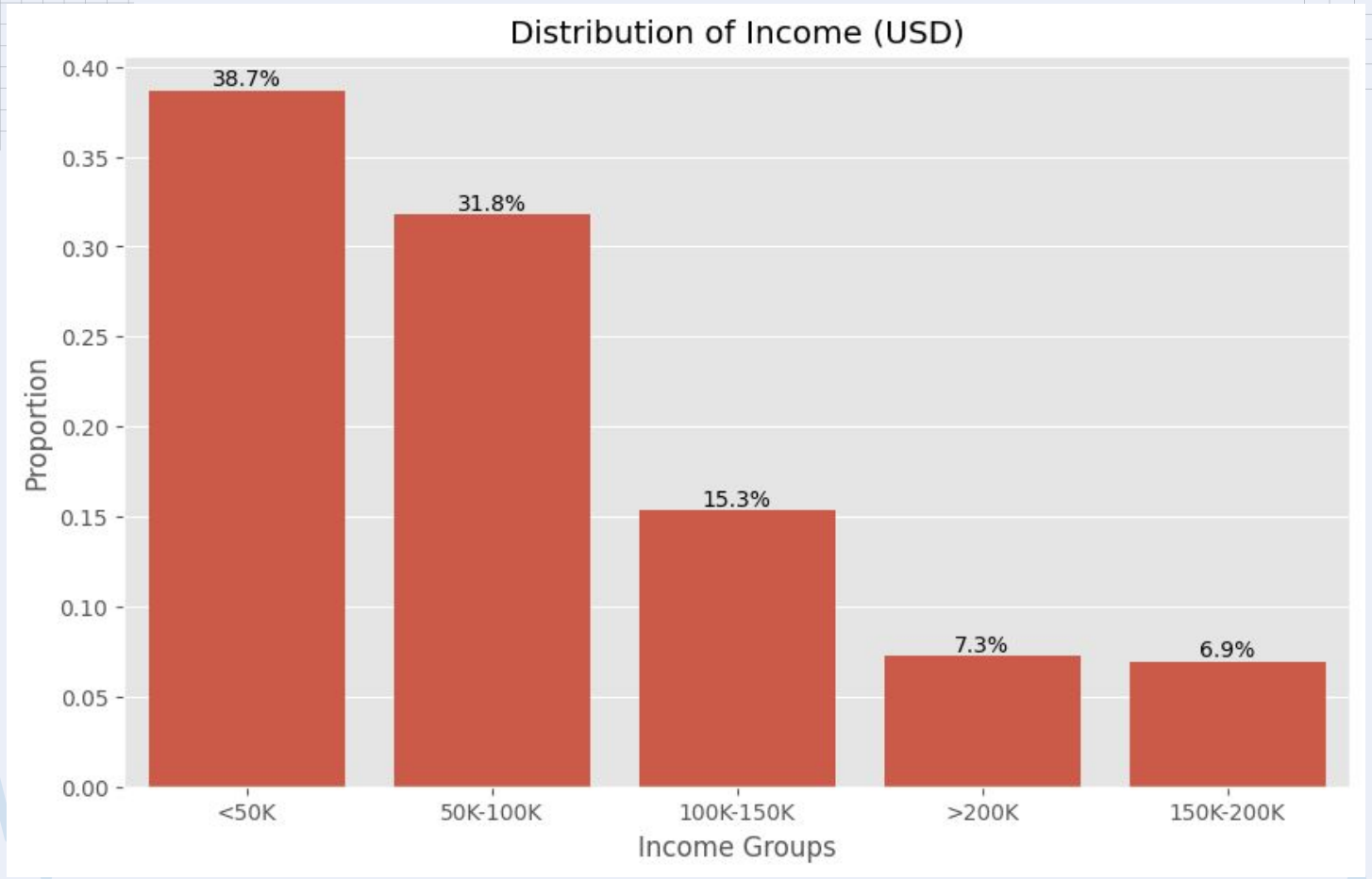
Last visit to doctor
Last visit to dentist
Colonoscopy/ Sigmoidoscopy

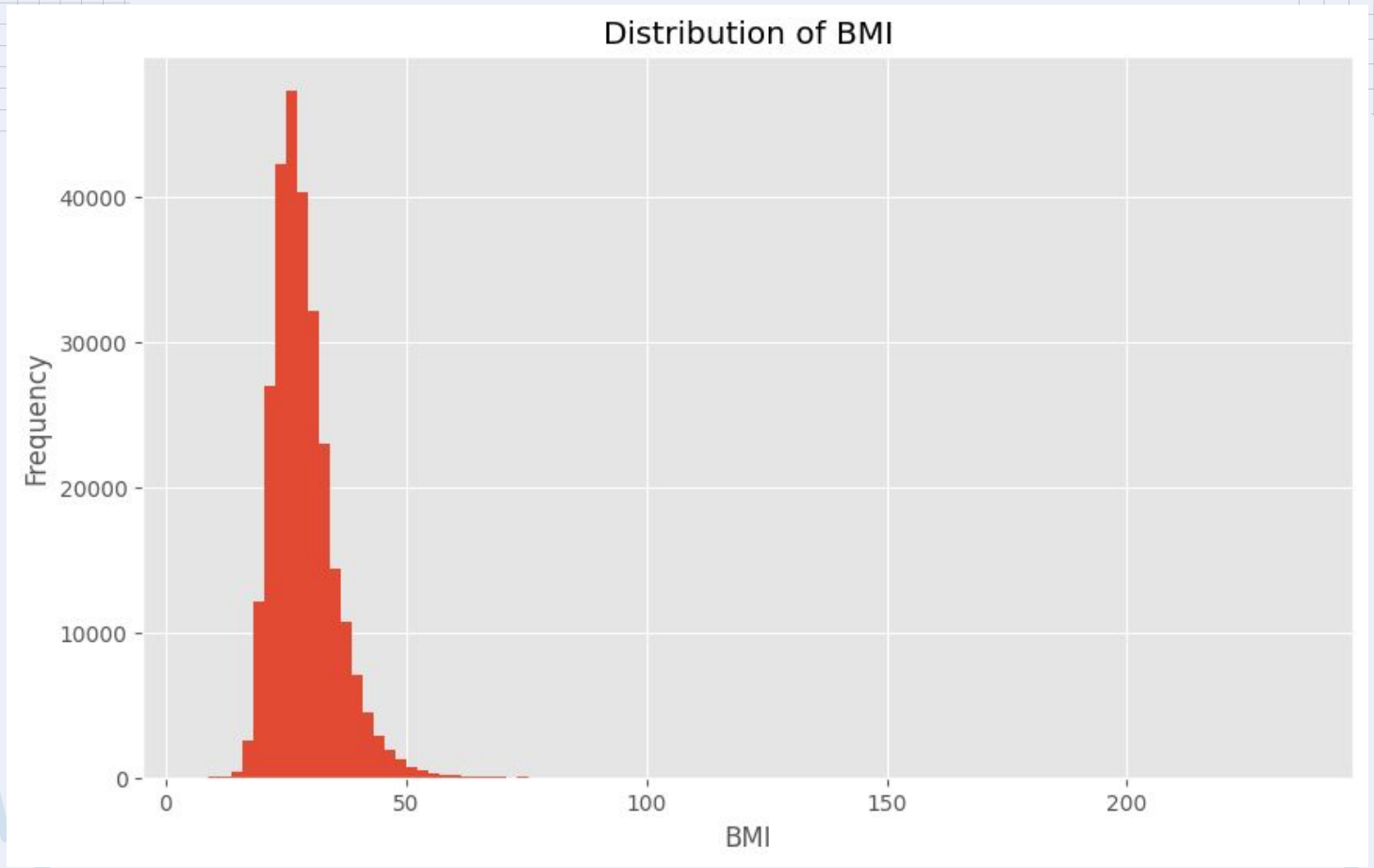
Demographics of Respondents

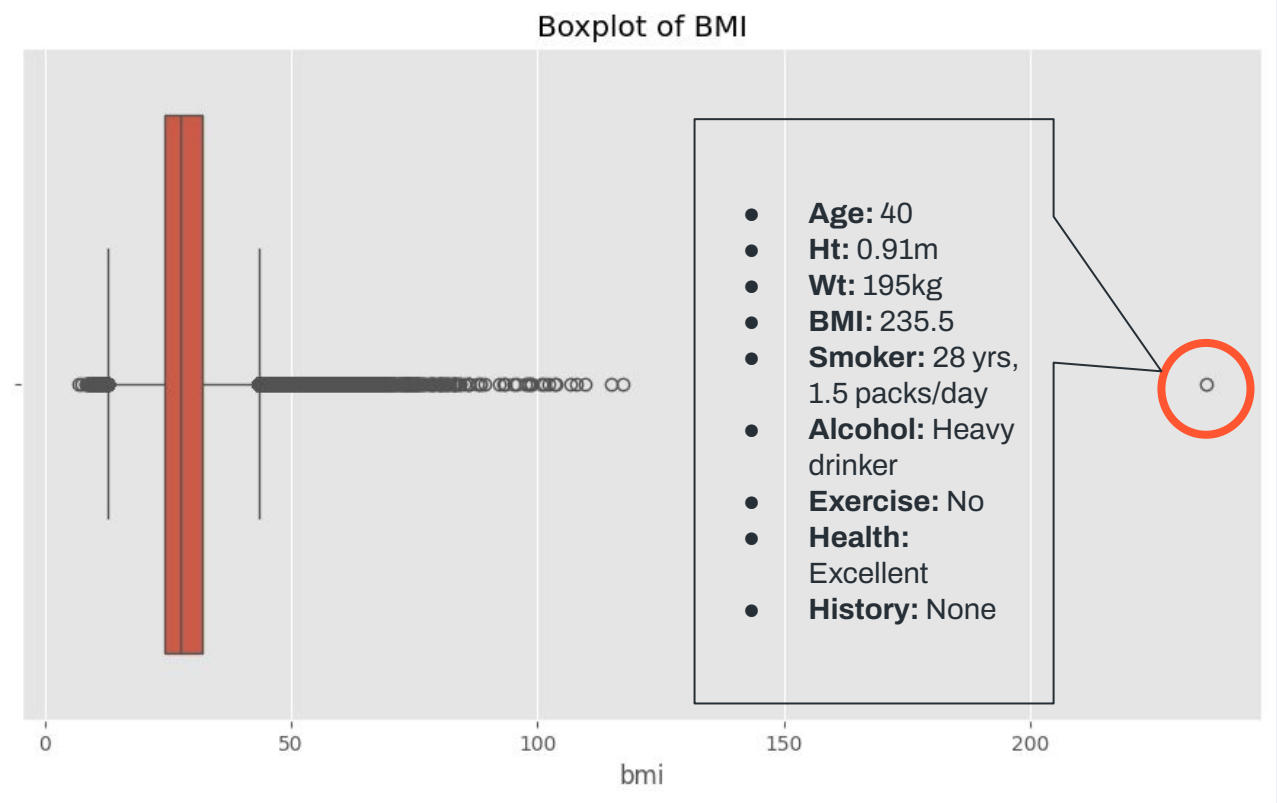

Proportion of Ethnic Groups
Proportion
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
76.19%
9.03%
7.45%
2.91%
2.29%
1.54%
0.59%
White
Hispanic
Black
Asian
Multiracial
American Indian/ Alaskan Native
Native Hawaiian/ Pacific Islander


Gender Distribution
51.14%
48.86%
0.5
0.4
0.3
0.2
0.1
0.0
Proportion
Female
Male
Gender

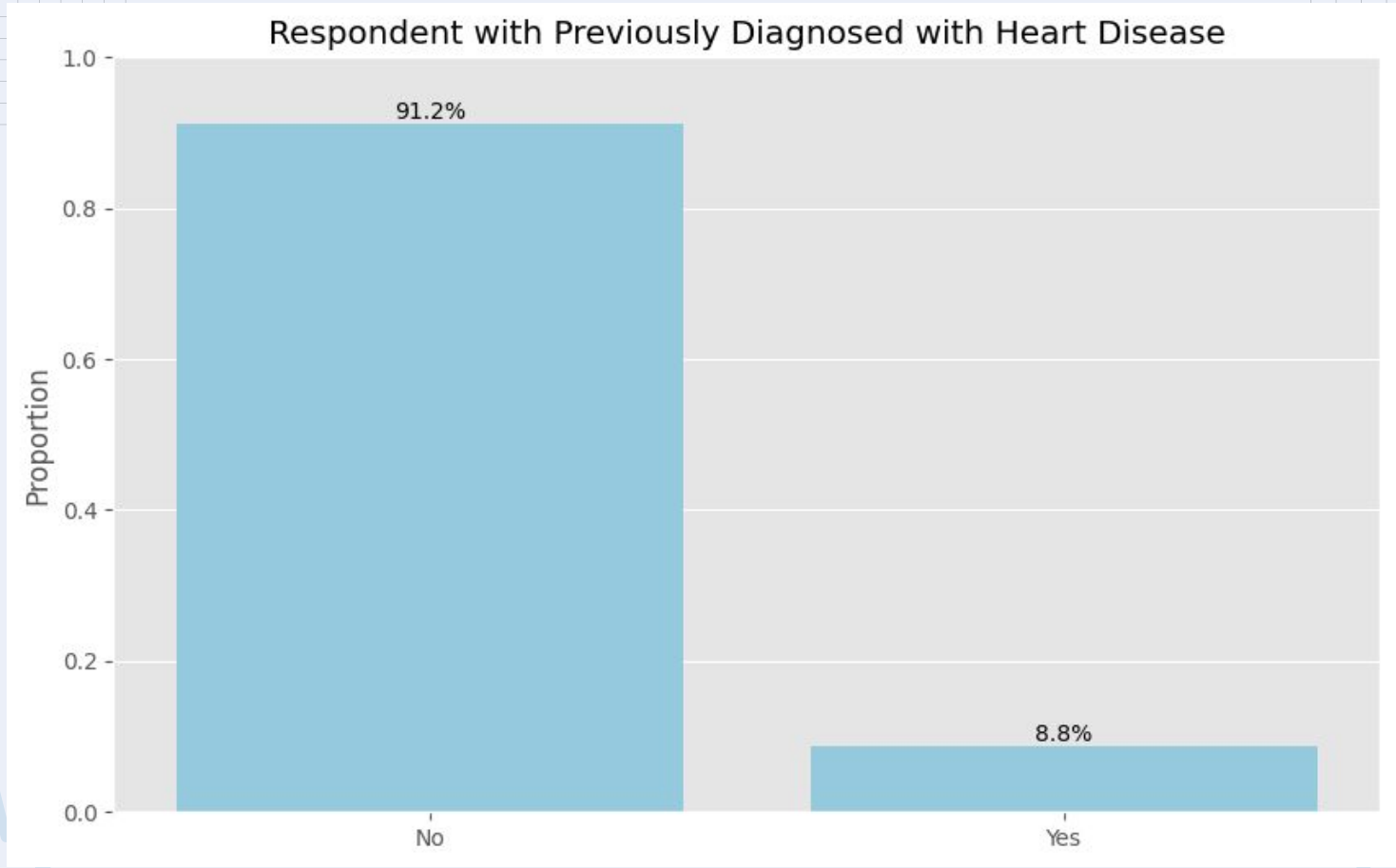

Distribution of Age
Frequency
25000
20000
15000
10000
5000
0
20
30
40
50
60
70
80
Age

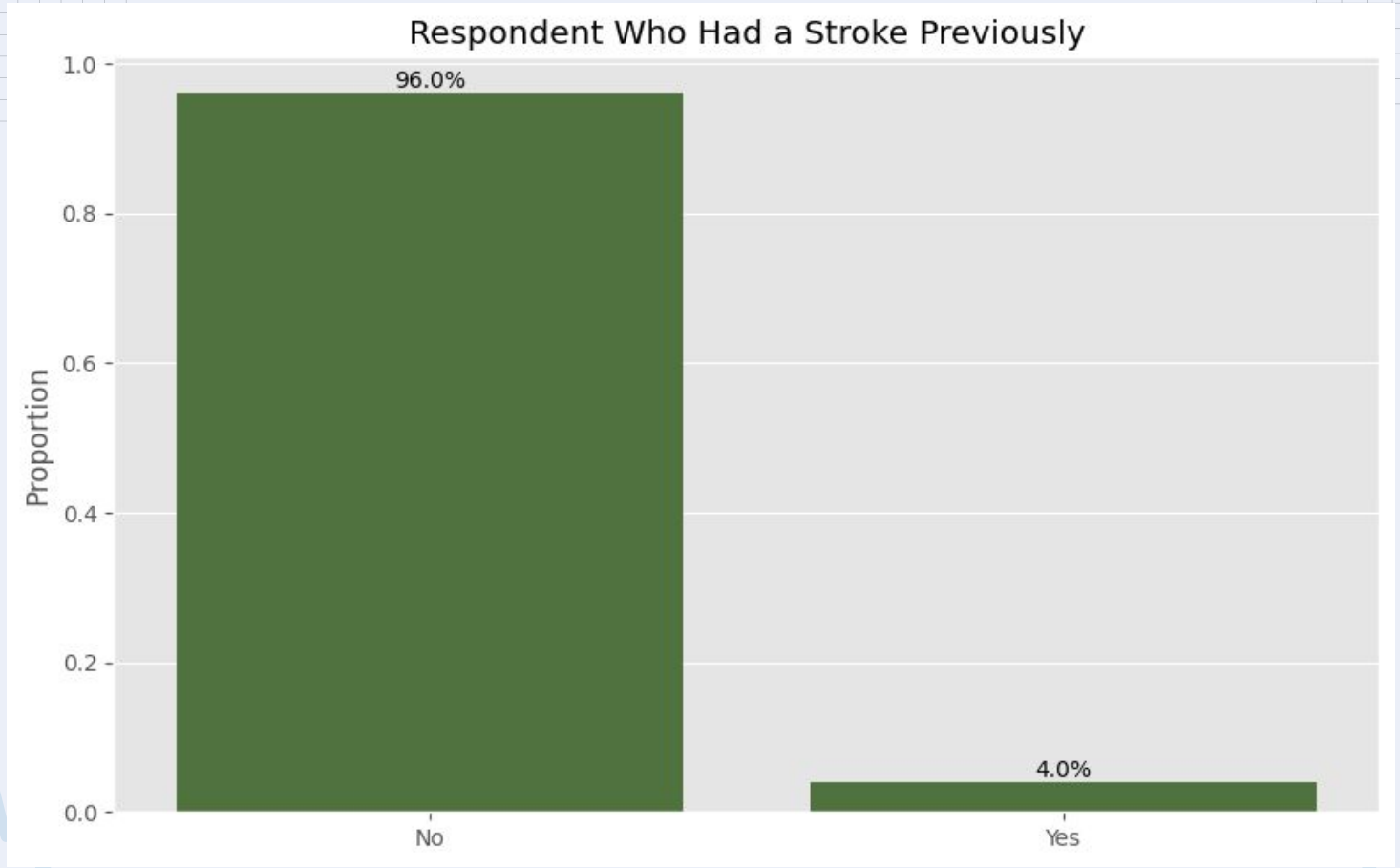

Distribution of Income (USD)
Proportion
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
38.7%
31.8%
15.3%
7.3%
6.9%
<50K
50K-100K
100K-150K
>200K
150K-200K
Income Groups

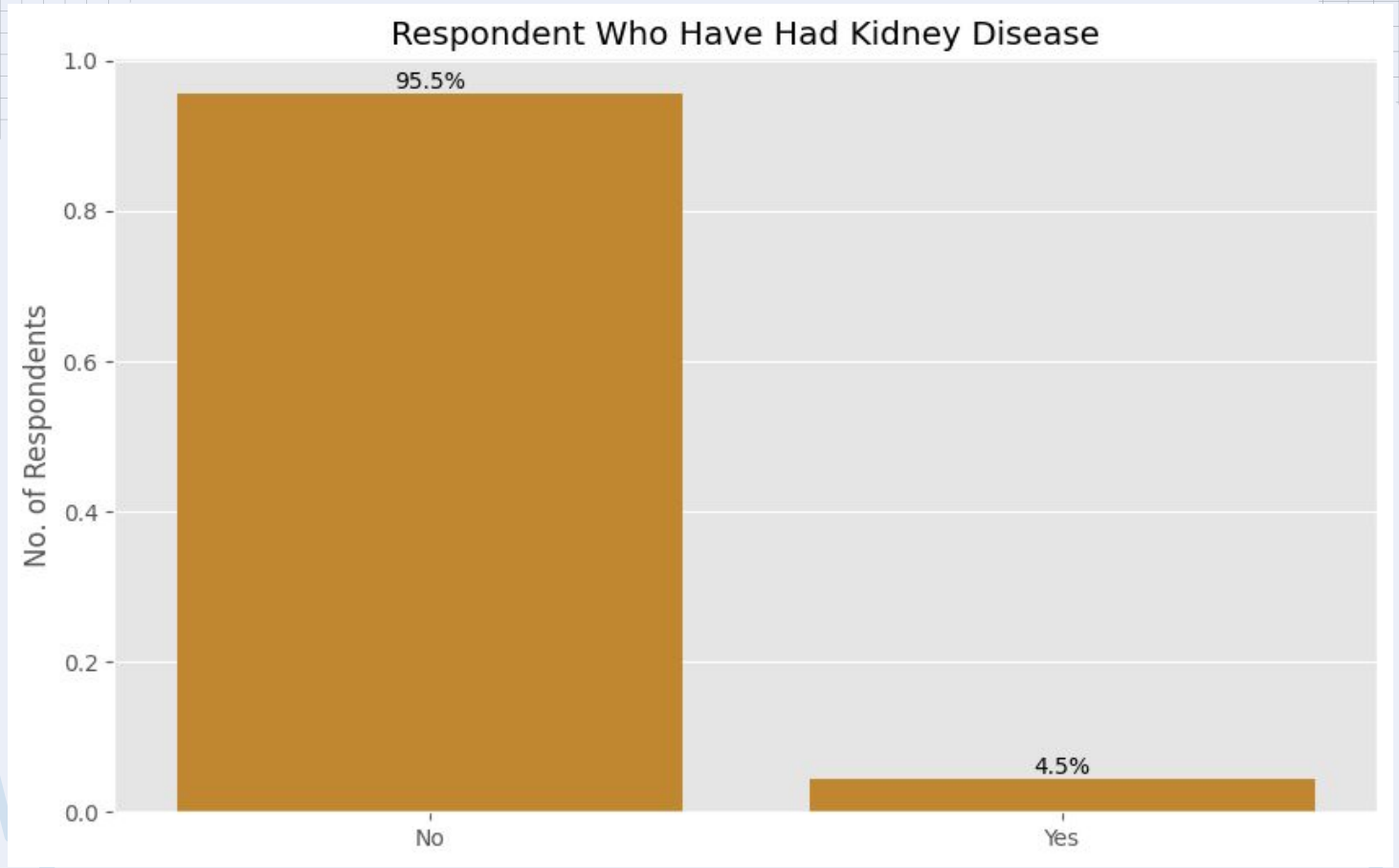

Distribution of BMI
Frequency
40000
30000
20000
10000
0
0
50
100
150
200
BMI

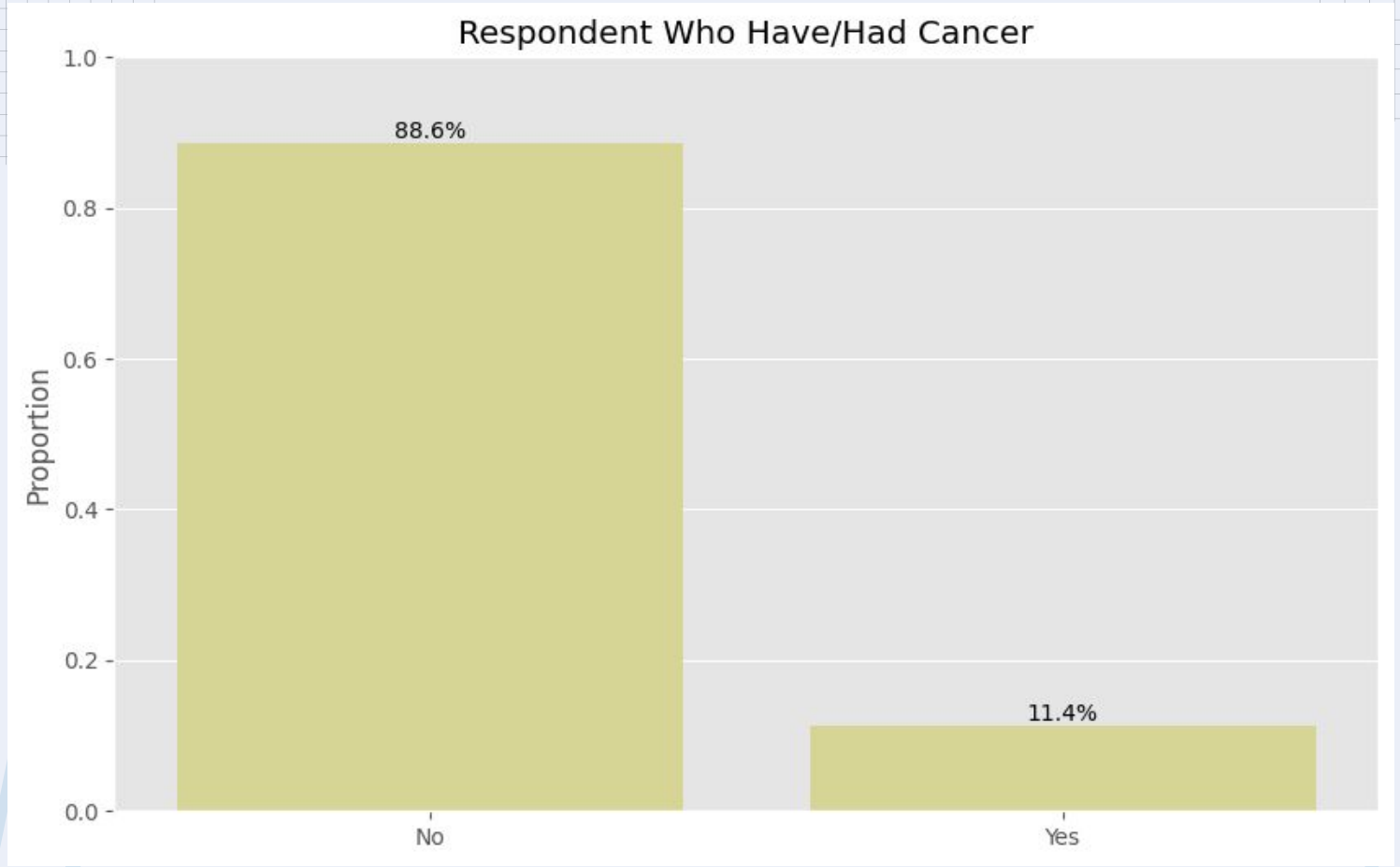

Boxplot of BMI
0
50
100
150
200
bmi
Age: 40
Ht: 0.91m
Wt: 195kg
BMI: 235.5
Smoker: 28 yrs, 1.5 packs/day
Alcohol: Heavy drinker
Exercise: No
Health: Excellent
History: None

Distribution of Medical Information

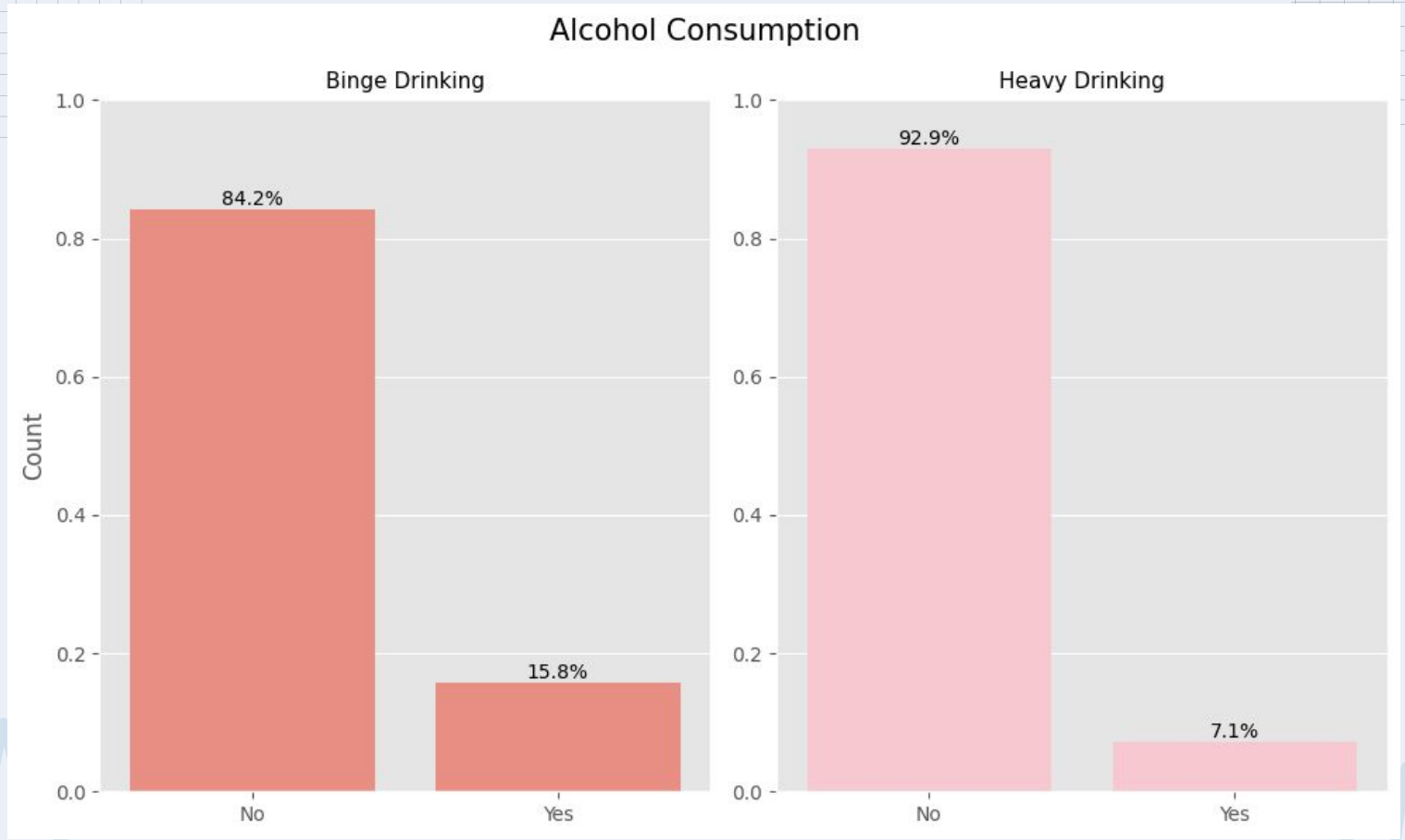

Respondent with Previously Diagnosed with Heart Disease
1.0
0.8
0.6
0.4
0.2
0.0
Proportion
91.2%
8.8%
No
Yes

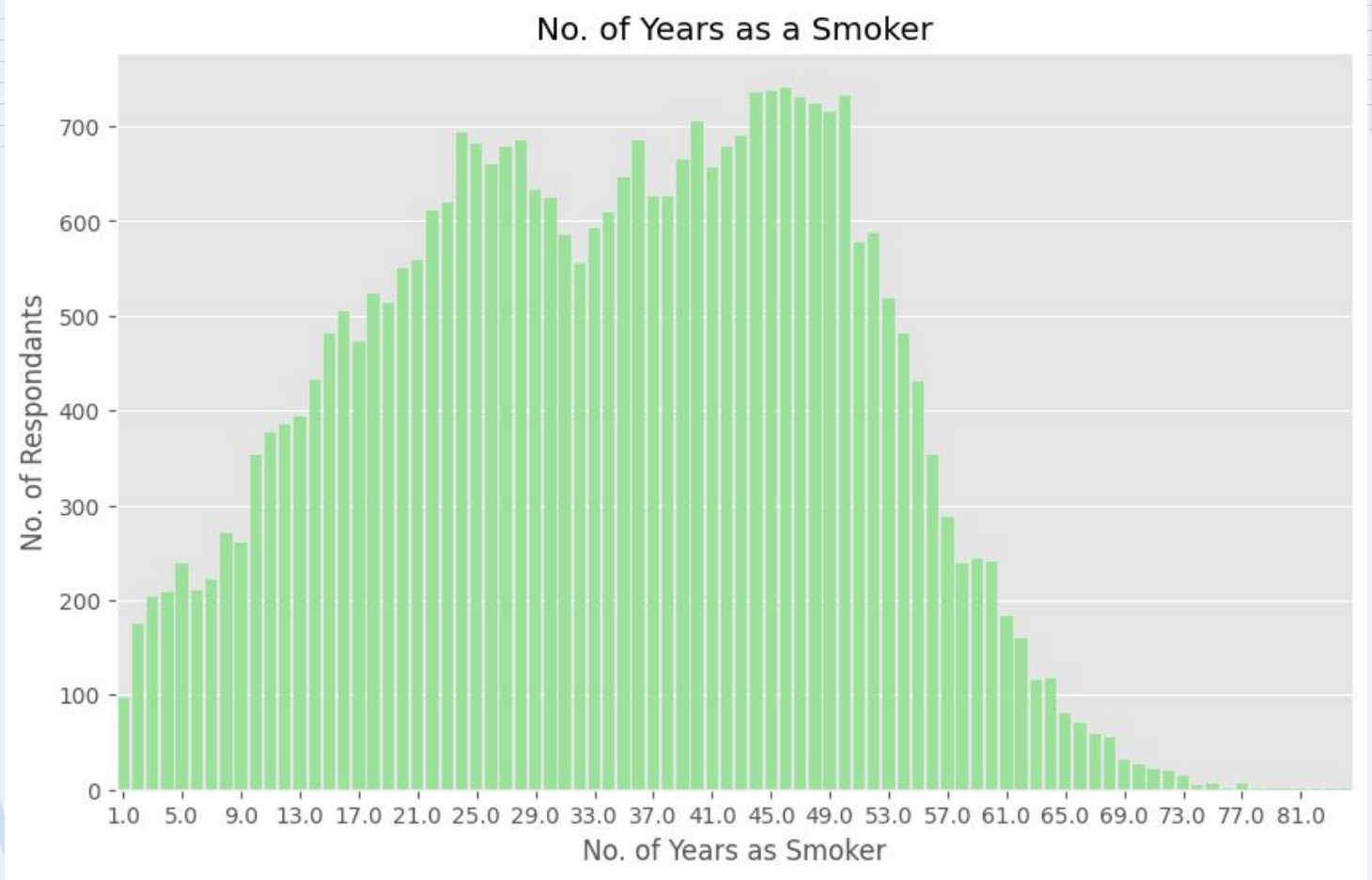

Respondent Who Had a Stroke Previously
1.0
0.8
0.6
0.4
0.2
0.0
Proportion
96.0%
4.0%
No
Yes

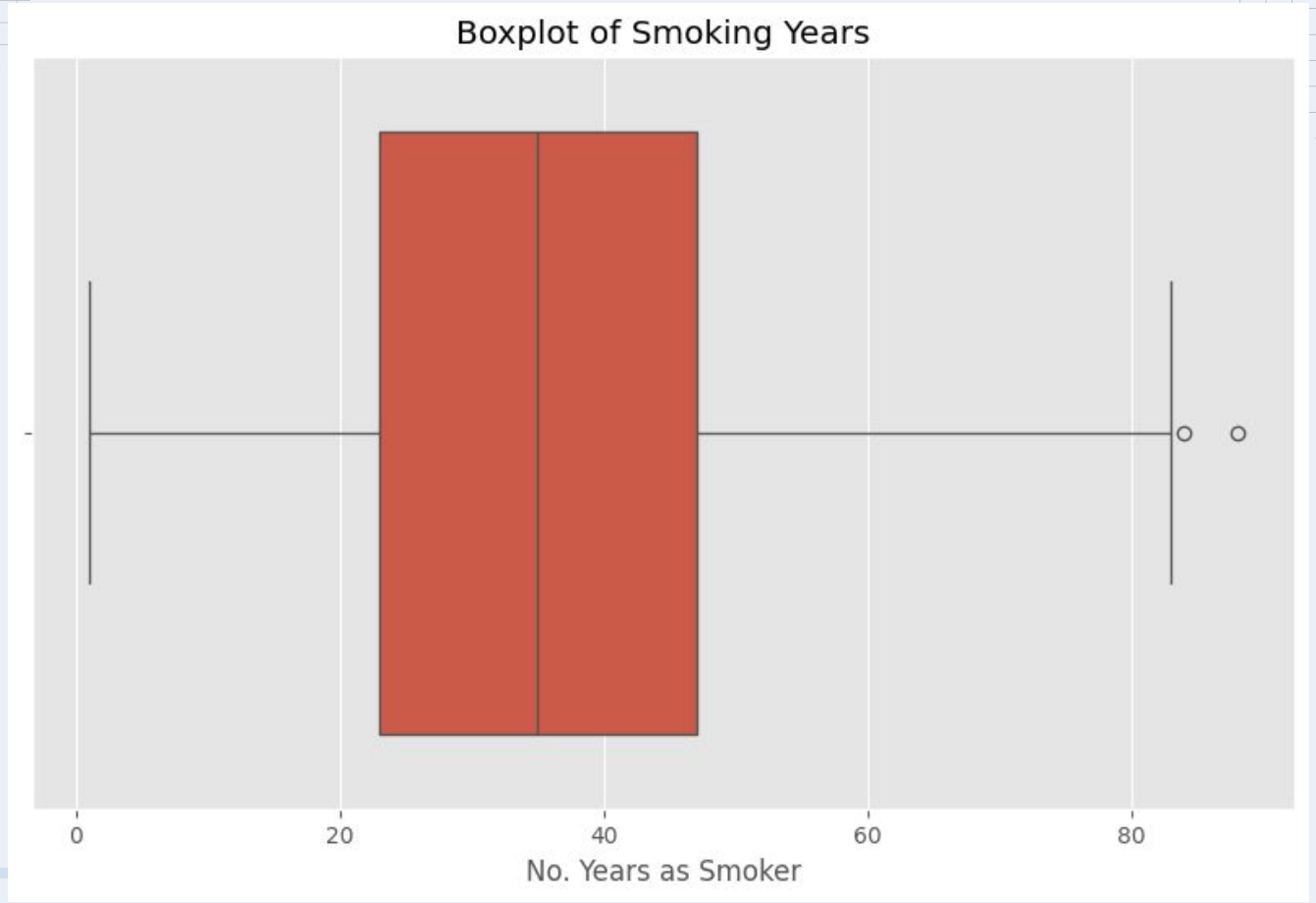

Respondent Who Have Had Kidney Disease
No. of Respondents
1.0
0.8
0.6
0.4
0.2
0.0
95.5%
4.5%
No
Yes

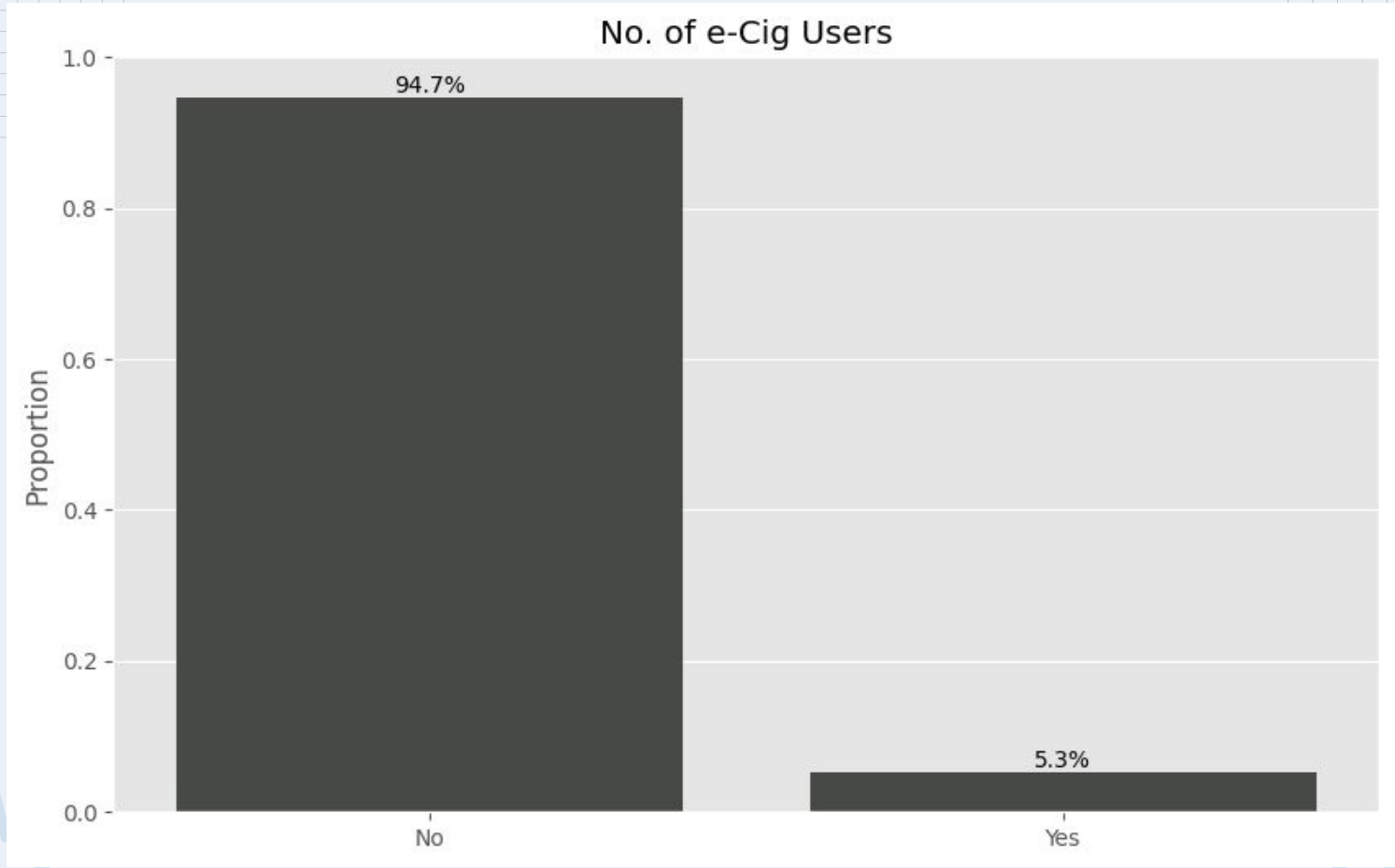

Respondent Who Have/Had Cancer
1.0
0.8
0.6
0.4
0.2
0.0
Proportion
88.6%
11.4%
No
Yes

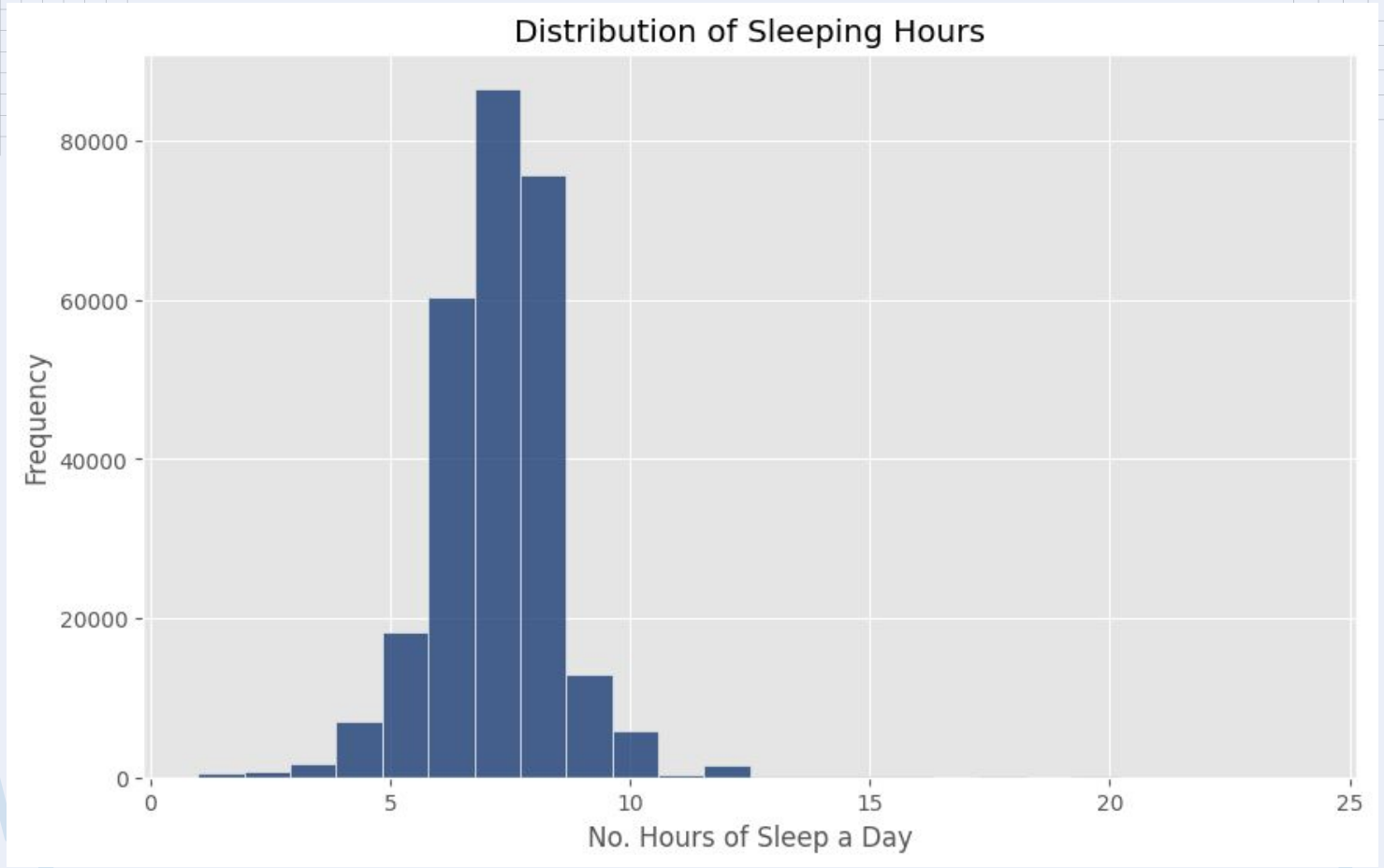
Lifestyle Choices


Alcohol Consumption
Binge Drinking
Heavy Drinking
Count
1.0
0.8
0.6
0.4
0.2
0.0
84.2%
15.8%
92.9%
7.1%
No
Yes
No
Yes

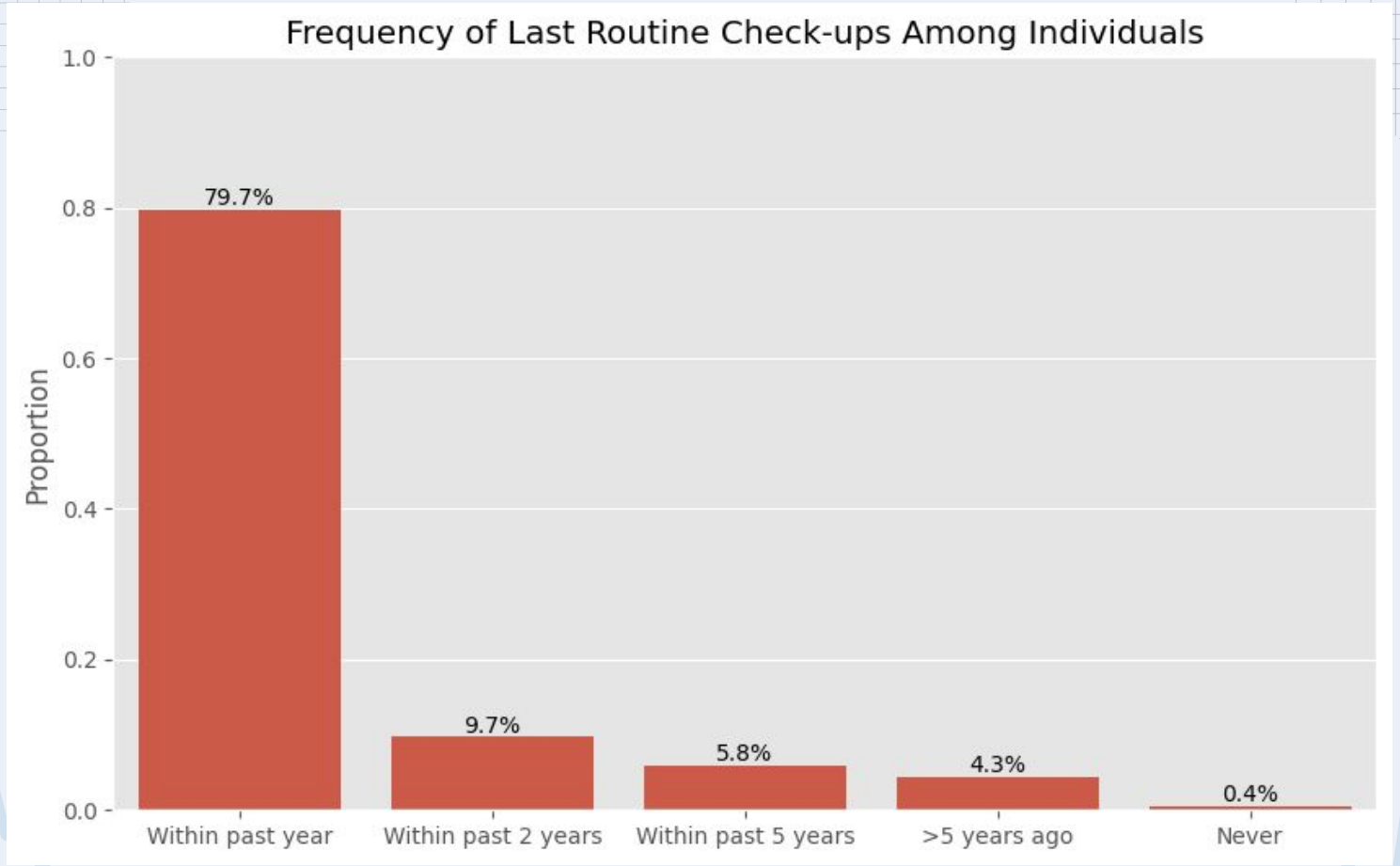

No. of Years as a Smoker
No. of Respondants
0
100
200
300
400
500
600
700
1.0
5.0
9.0
13.0
17.0
21.0
25.0
29.0
33.0
37.0
41.0
45.0
49.0
53.0
57.0
61.0
65.0
69.0
73.0
77.0
81.0
No. of Years as Smoker

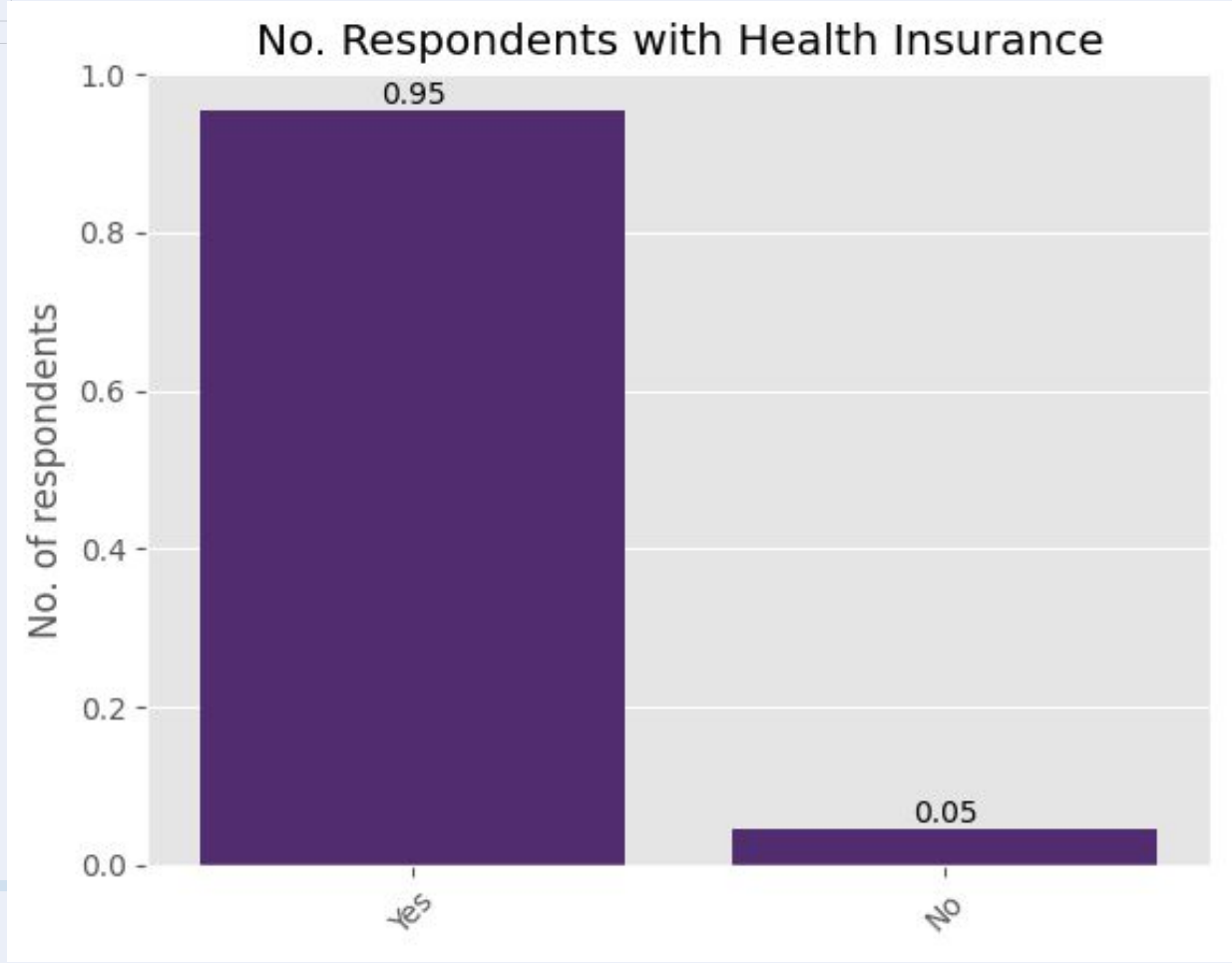

Boxplot of Smoking Years
0
20
40
60
80
No. Years as Smoker


No. of e-Cig Users
1.0
0.8
0.6
0.4
0.2
0.0
Proportion
94.7%
5.3%
No
Yes


Distribution of Sleeping Hours
Frequency
80000
60000
40000
20000
0
0
5
10
15
20
25
No. Hours of Sleep a Day

Personal Health Status


Frequency of Last Routine Check-ups Among Individuals
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
79.7%
9.7%
5.8%
4.3%
0.4%
Within past year
Within past 2 years
Within past 5 years
>5 years ago
Never


No. Respondents with Health Insurance
No. of respondents
1.0
0.8
0.6
0.4
0.2
0.0
0.95
0.05
Yes
No

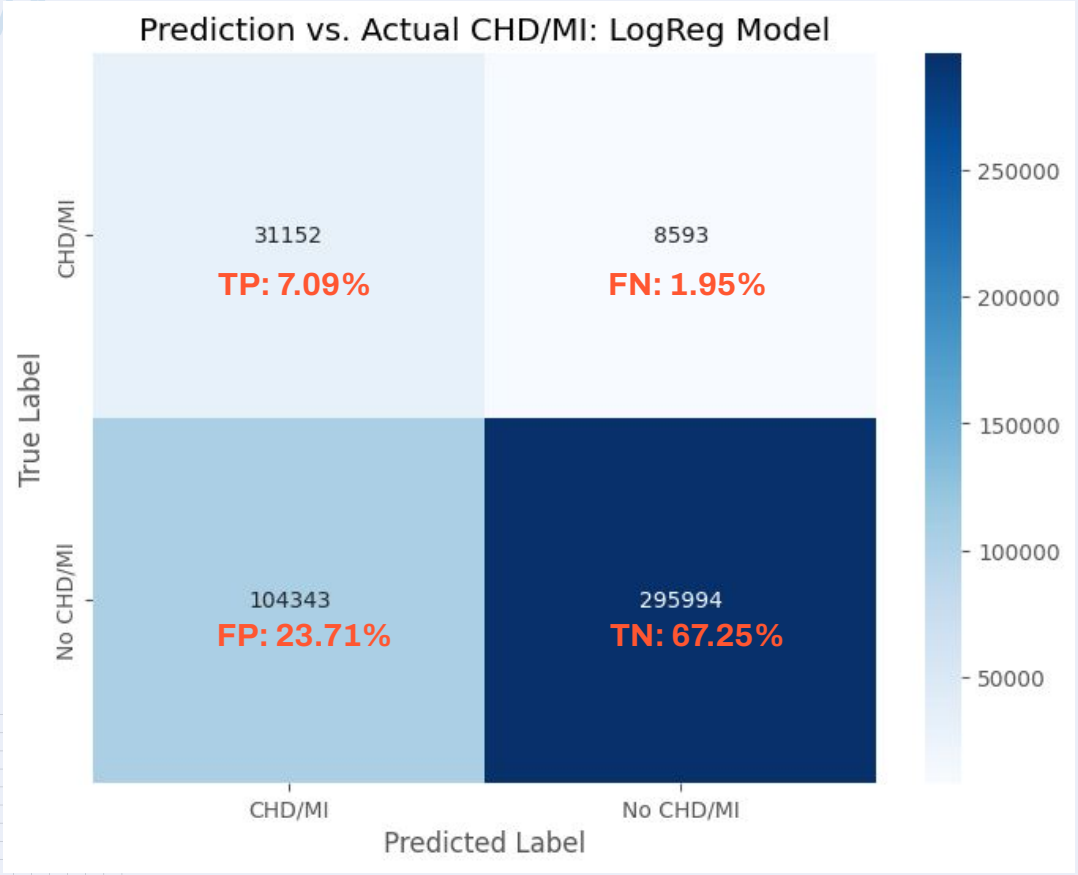
03 Data Modeling

Base Model Comparison

Model	Train	Test	Cross-Validation	Processing Time (sec)
XGBoost	0.9136	0.9112	0.9122	12
Logistic Regression	0.9112	0.9117	0.9112	10
Random Forest	0.9998	0.9109	0.9101	48
Decision Trees	0.9999	0.8553	0.8543	40

Model Comparison

Model	Train	Test	ROC AUC	Sensitivity	Processing Time (sec)
Logistic Regression (Base)	0.9112	0.9117	NA	NA	10
Logistic Regression (Hypertuned)	0.7434	0.7434	0.8395	0.7874	662
Keras FNN (Deep Learning)	0.6907	0.6903	0.8424	0.8526	163



ROC AUC: **0.8379**

Sensitivity: **0.7874**

To the layman...

- The model has close to 84% chance of distinguishing the group of people with and without heart diseases

- Out of 100 people with heart disease, the model will identify 79 of them

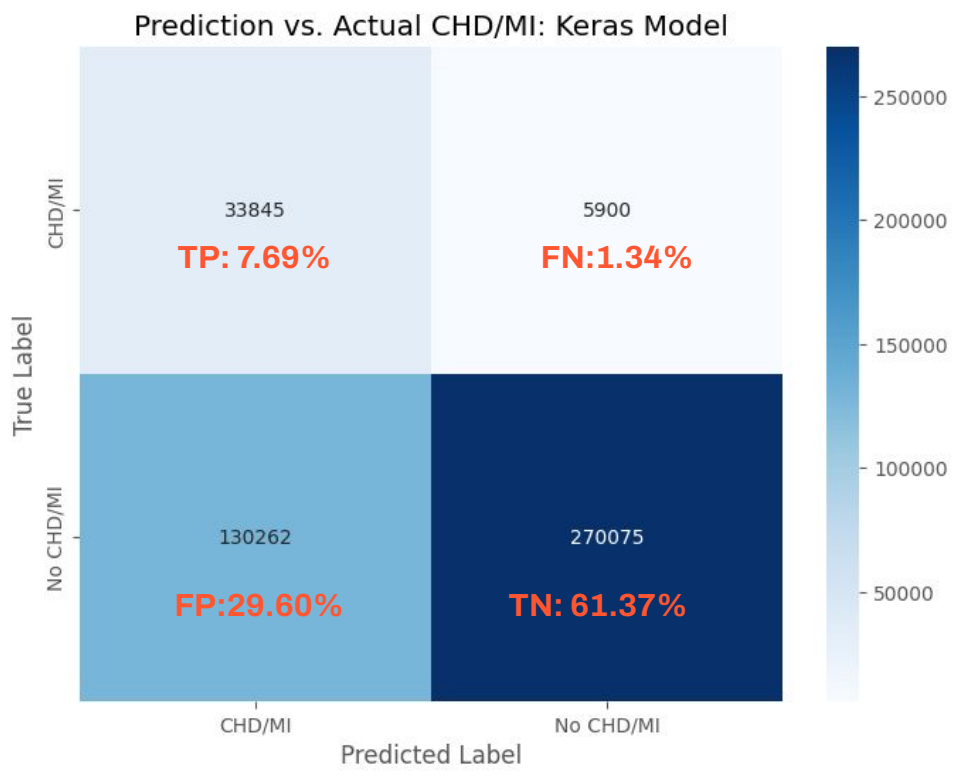
ROC AUC: **0.8424**

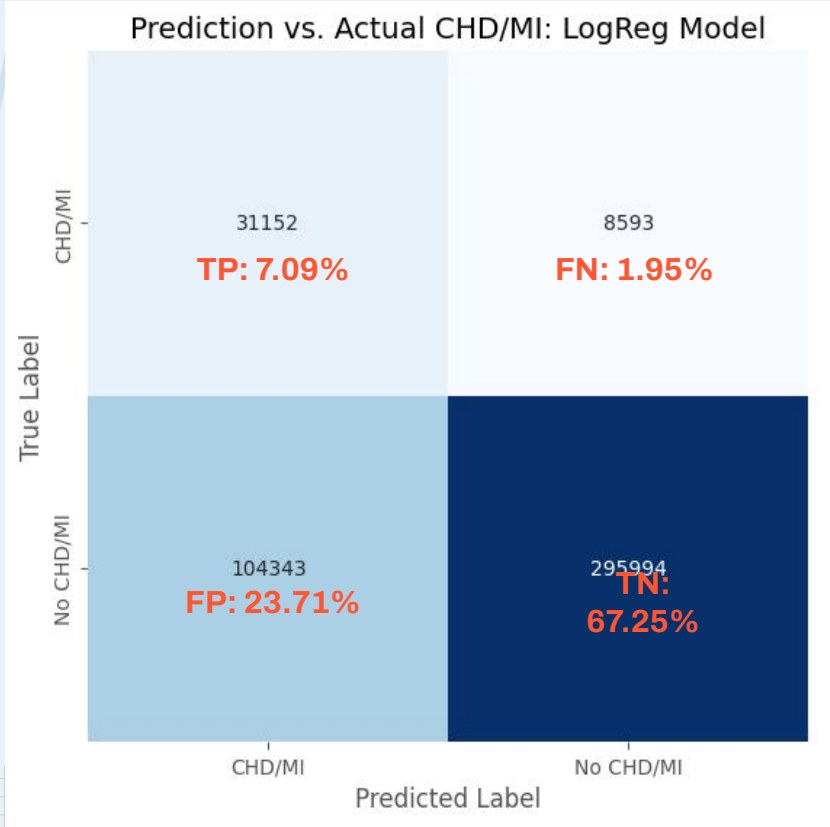
Sensitivity: **0.8526**

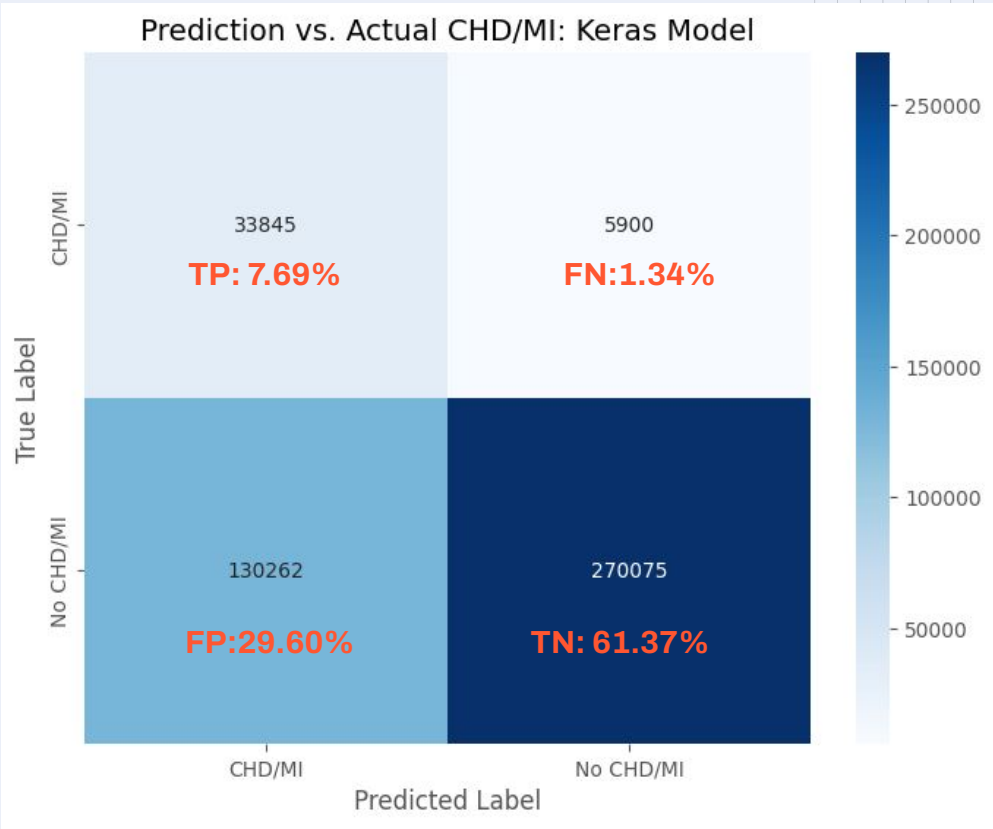
To the layman...

- The model has more than 84% chance of distinguishing the group of people with and without heart diseases

- Out of 100 people with heart disease, the model will identify 85 of them





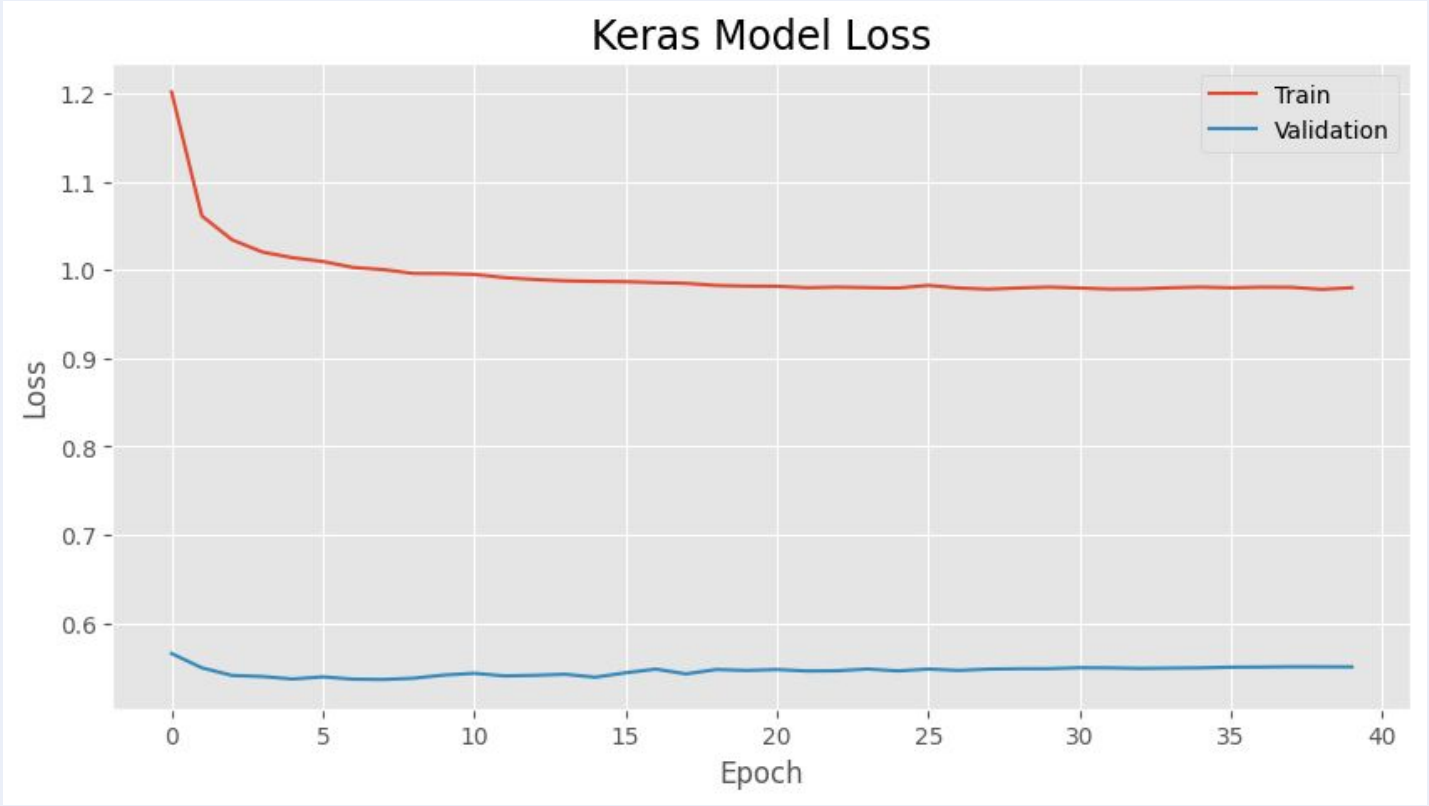


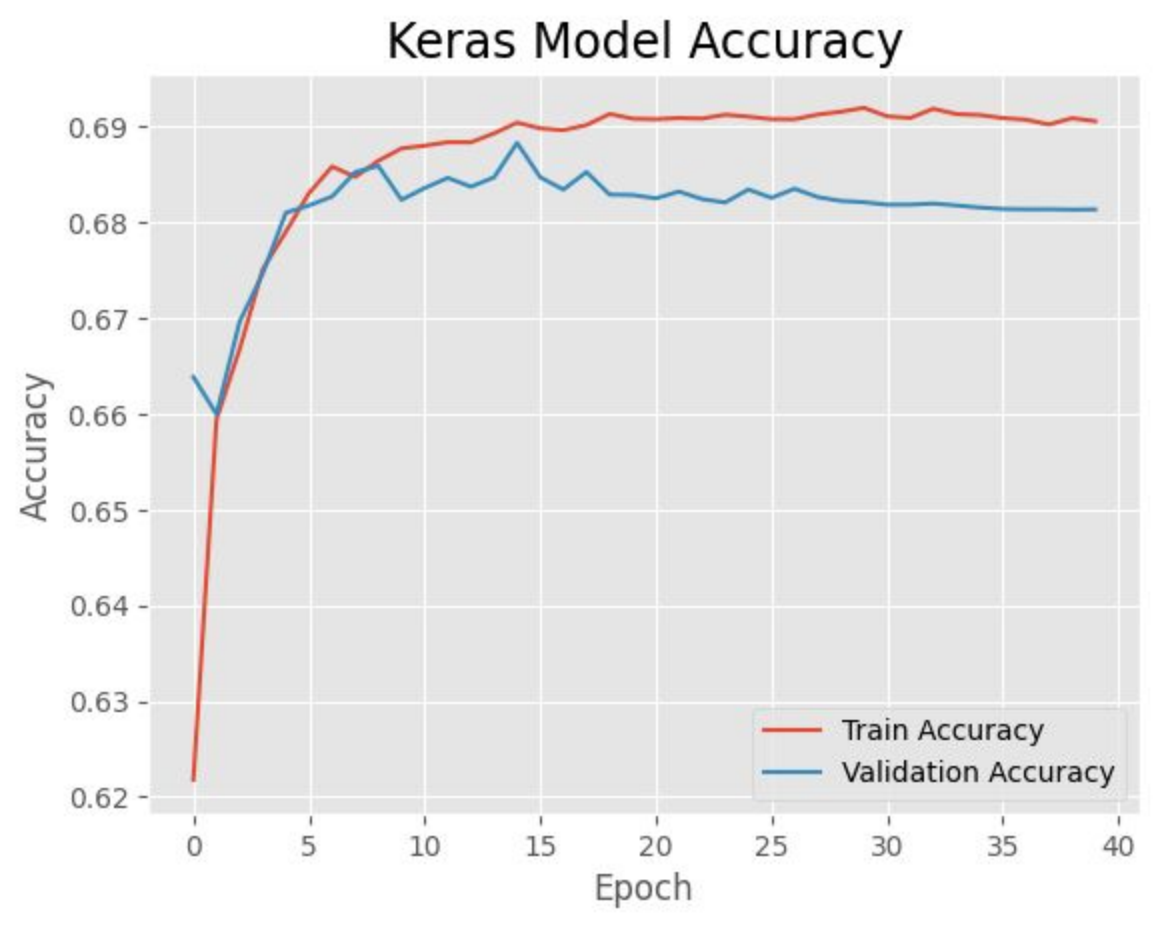
ROC AUC: **0.8379**

Sensitivity: **0.7874**

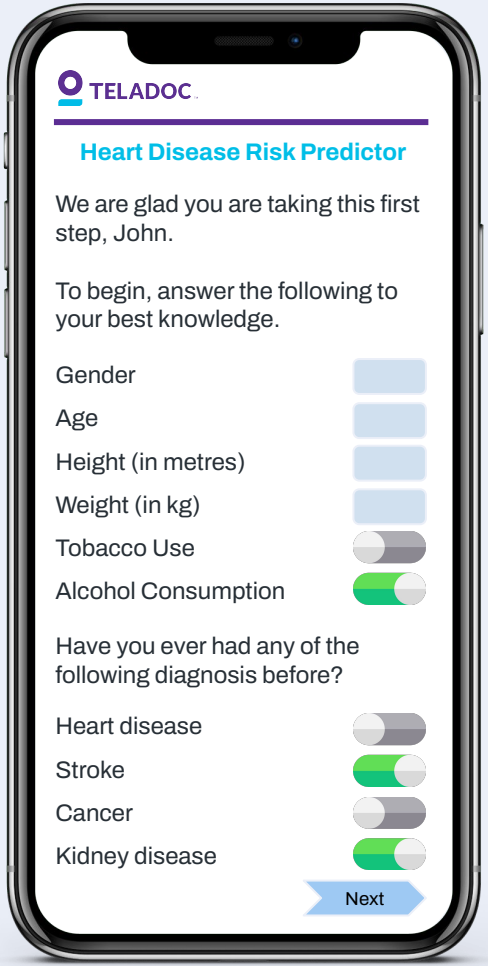
ROC AUC: **0.8424**

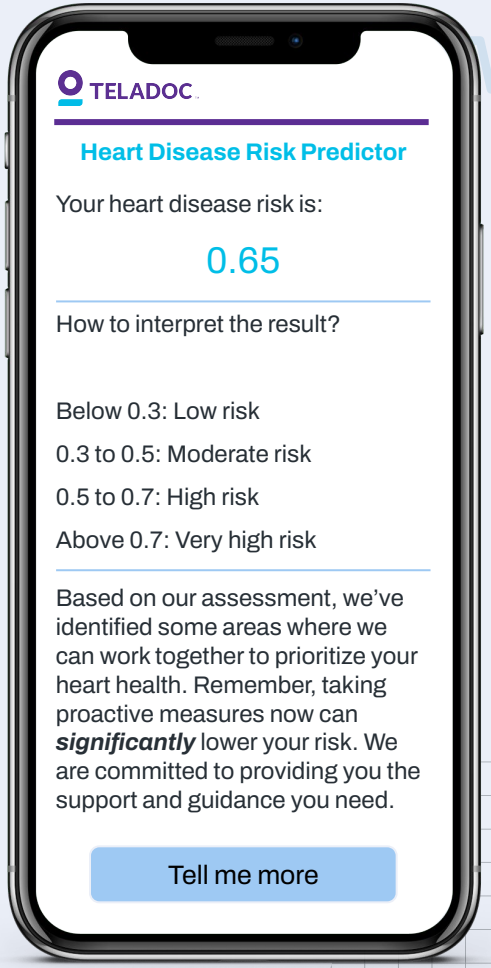
Sensitivity: **0.8526**


Keras Model Loss
Train
Validation
Loss
Epoch
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0
5
10
15
20
25
30
35
40

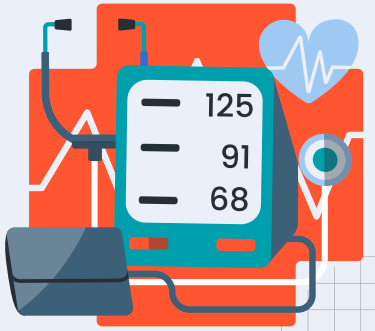

Keras Model Accuracy
Accuracy
Epoch
0.69
0.68
0.67
0.66
0.65
0.64
0.63
0.62
0
5
10
15
20
25
30
35
40
Train Accuracy
Validation Accuracy

John Patterson, 57, semi-retired





04 Cost and Benefit Analysis



What does this mean for John?

Cost

- With insurance, General Medical visits can be as low as $0 per visit
- Without insurance, General Medical is $89 per visit
- Purchase of household medical equipment (eg. blood pressure machine) for regular self-monitoring

Benefits

- Medical costs averted
- Improved quality of life

Source:https://www.teladoc.com/how-it-works/

Costs of Heart Disease

Annual healthcare premiums and out-of-pocket

- Without heart diseases and other chronic conditions: $2,558
- With heart diseases: $4,124

Hospitalisation and surgery

- ~5.3 days of stay in hospital: $21,500
- Cardiac bypass: $56,000
- Open-heart surgery: $137,000

Medication

- From less than $10 to more than $500 per month

Others

- Physical rehabilitation
- Loss of income and career opportunities
- Mental health costs

Source:https://www.pdcenterlv.com/blog/the-cost-of-a-heart-attack/, https://www.goodrx.com/health-topic/heart/manage-costs-of-heart-disease

What does this mean for the country?

Direct Medical Costs

- Hospitalizations and procedures
- Drugs and medical supplies
- Physician visits
- Diagnostics tests

Indirect Costs

- Loss of productivity from patients and caregivers
- Increased dependence on social security benefits or disability insurance
- Increase in caregiving needs
- Long-term societal impacts

2035:
$1.1 trillion

2016:
$555 billion

Source: https://www.heart.org/-/media/Files/About-Us/Policy-Research/Fact-Sheets/Public-Health-Advocacy-and-Research/CVD-A-Costly-Burden-for-America-Projections-Through-2035.pdf

05 Conclusion

Limitations

Limited resources

- Require better resources to shorten computation runtime and improve efficiency in modeling process

Completeness of Data

- Sizeable proportion of missing data from survey respondents

Heart-Related Variables

- Dietary consumption
- Family medical history
- Health statistics (blood pressure, cholesterol level, heart rate etc.)

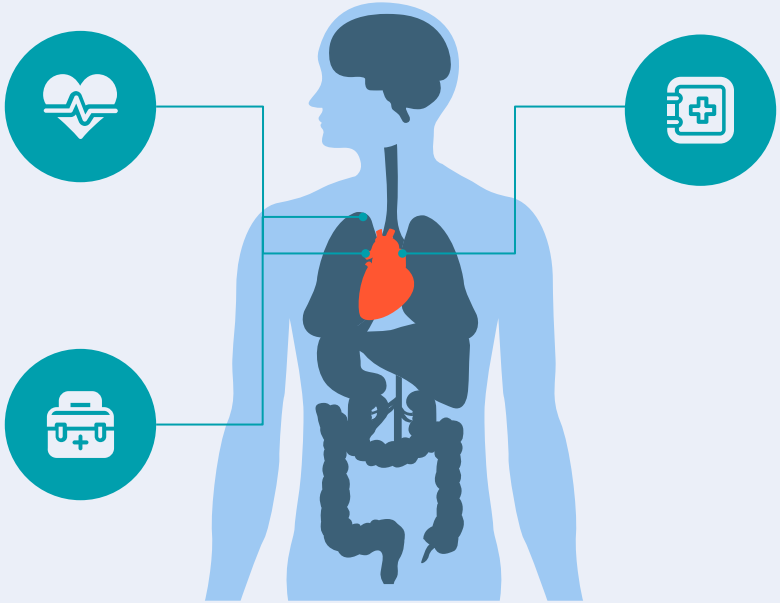
Recommendations

Follow-up with at-risk users

Integrate easy access measures for users to reach out to reduce their risk

Frequent Training & Monitoring

Update once a month to improve the model's prediction



User Interface

- Outline the caveat use of the risk predictor to end user
- Easy use of inputting user data

Conclusion

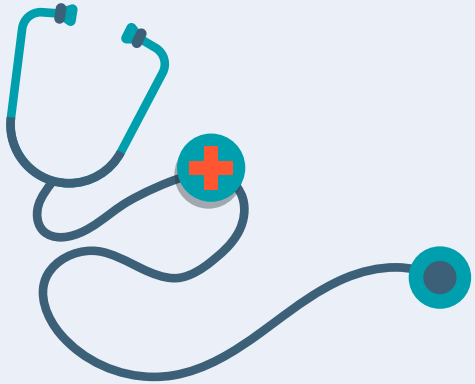
Benefits far outweigh the costs for early detection

Immense impact to end-users and population

Increased usage of Teladoc services and user base

Positive branding through CSR initiatives

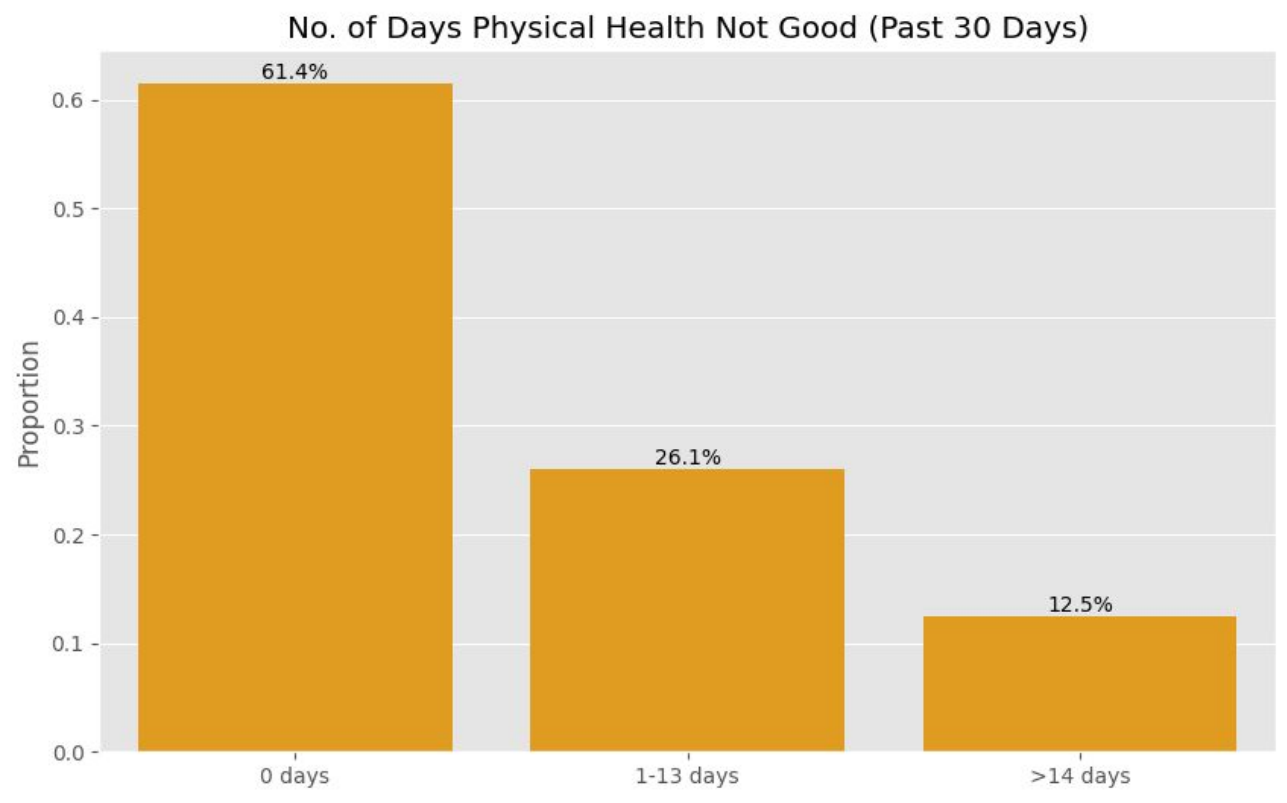
Thank You



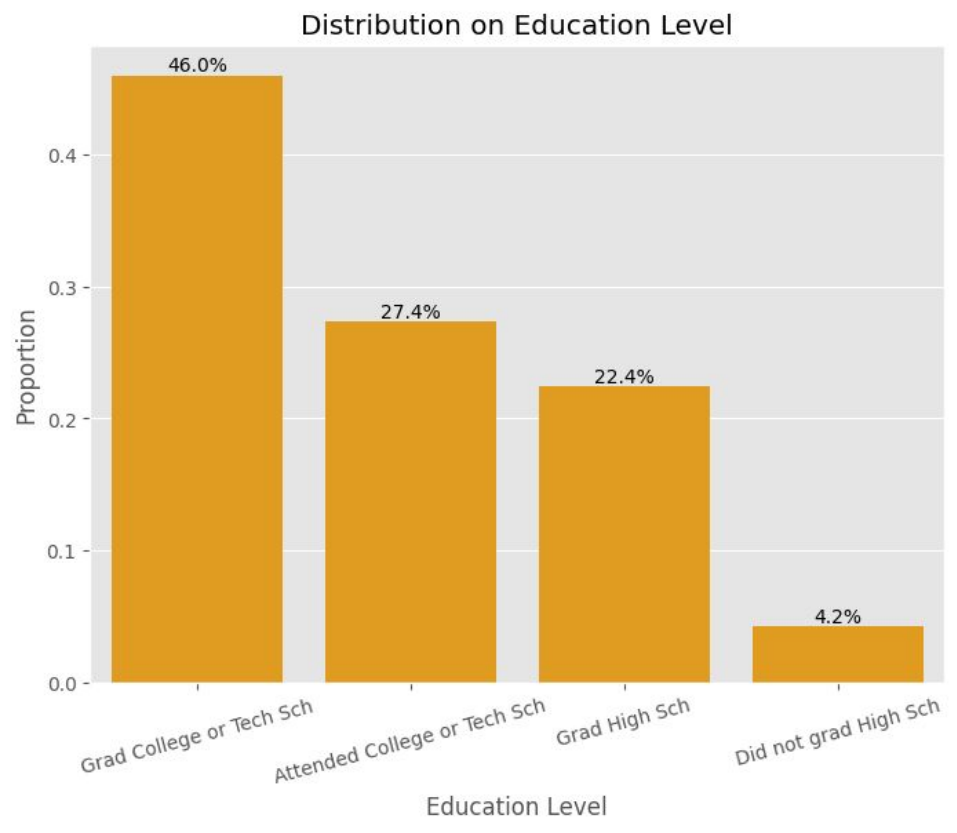
Q&A

Appendix

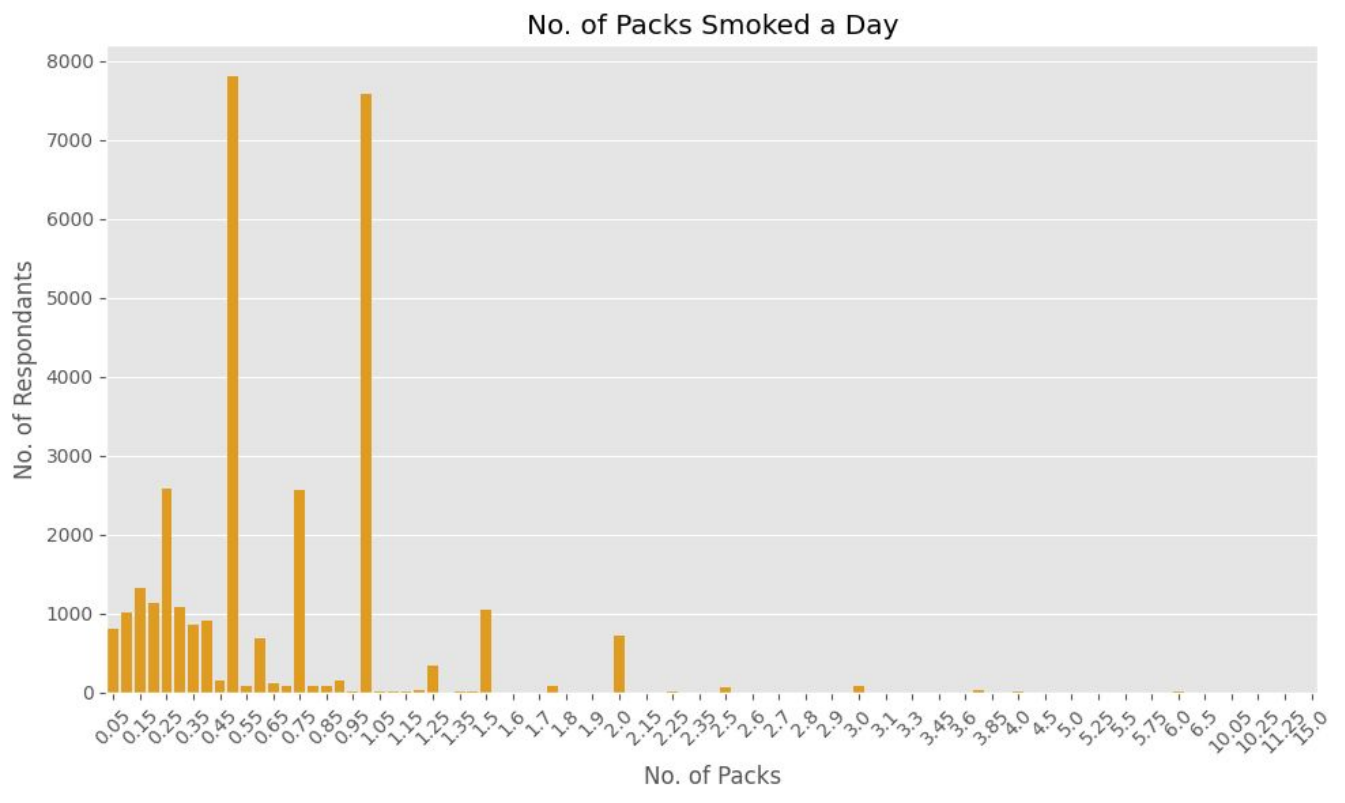
Personal Health Status



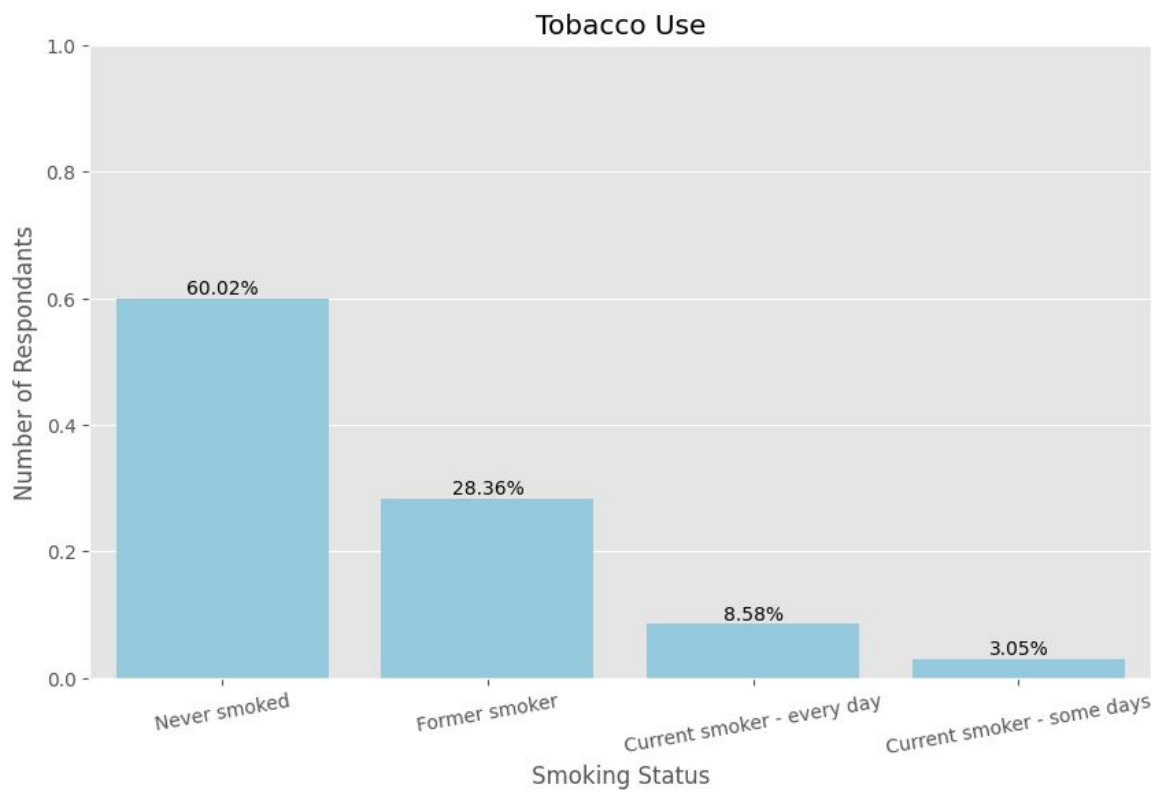
Demographics of Respondents



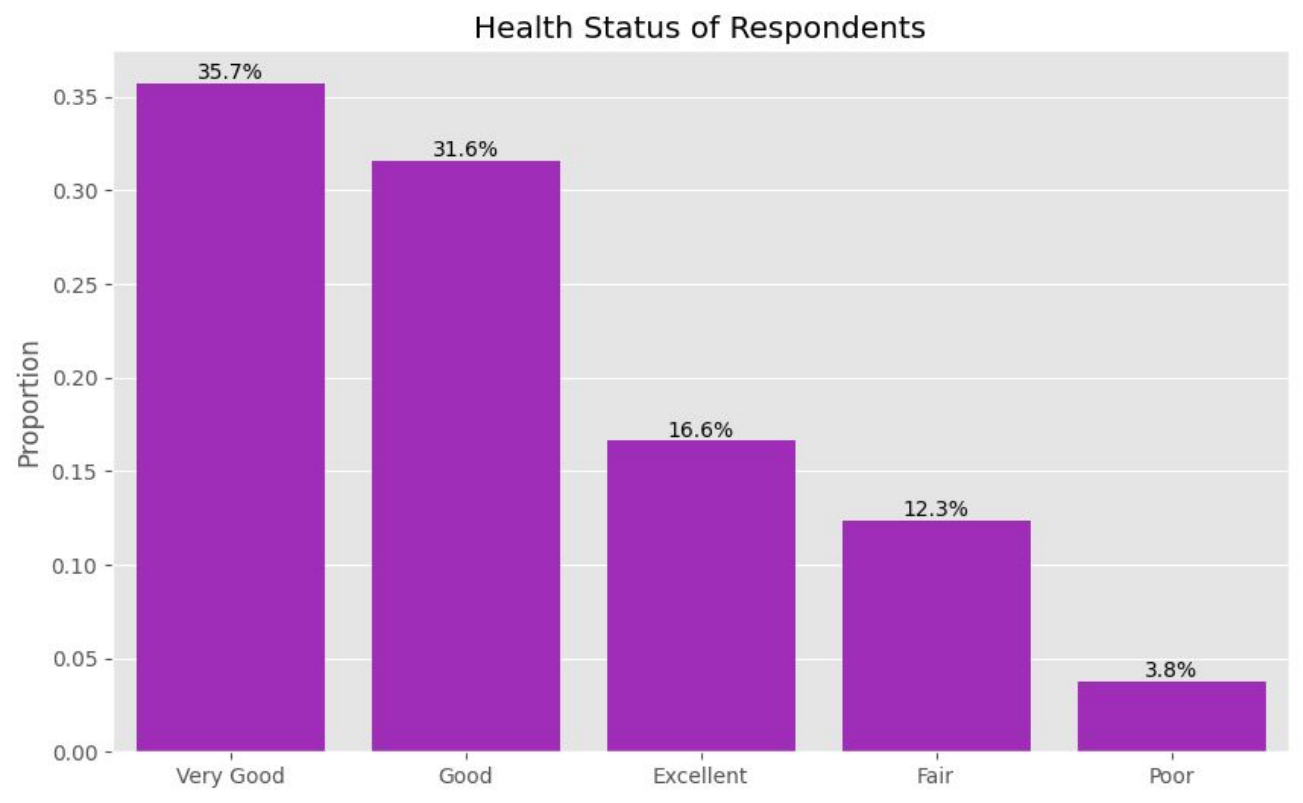
Lifestyle Choices



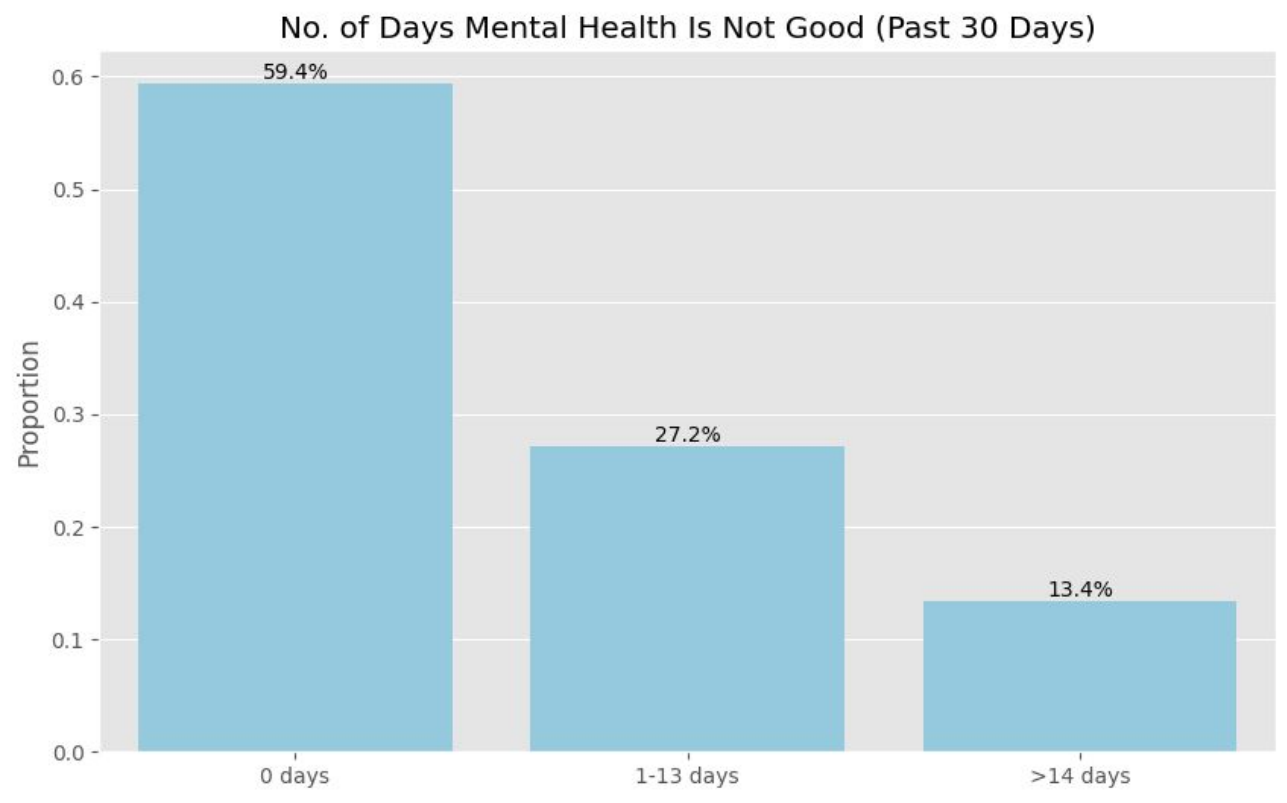
Lifestyle Choices



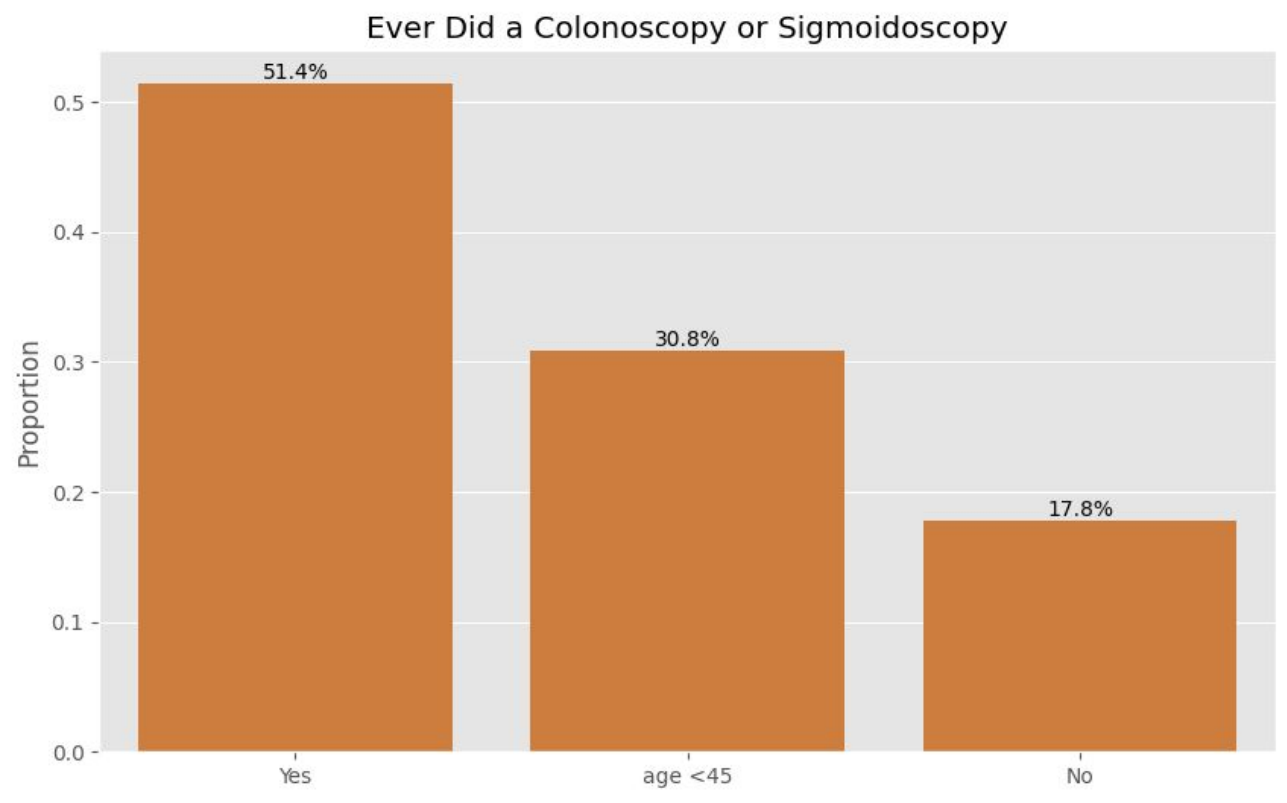
Personal Health Status



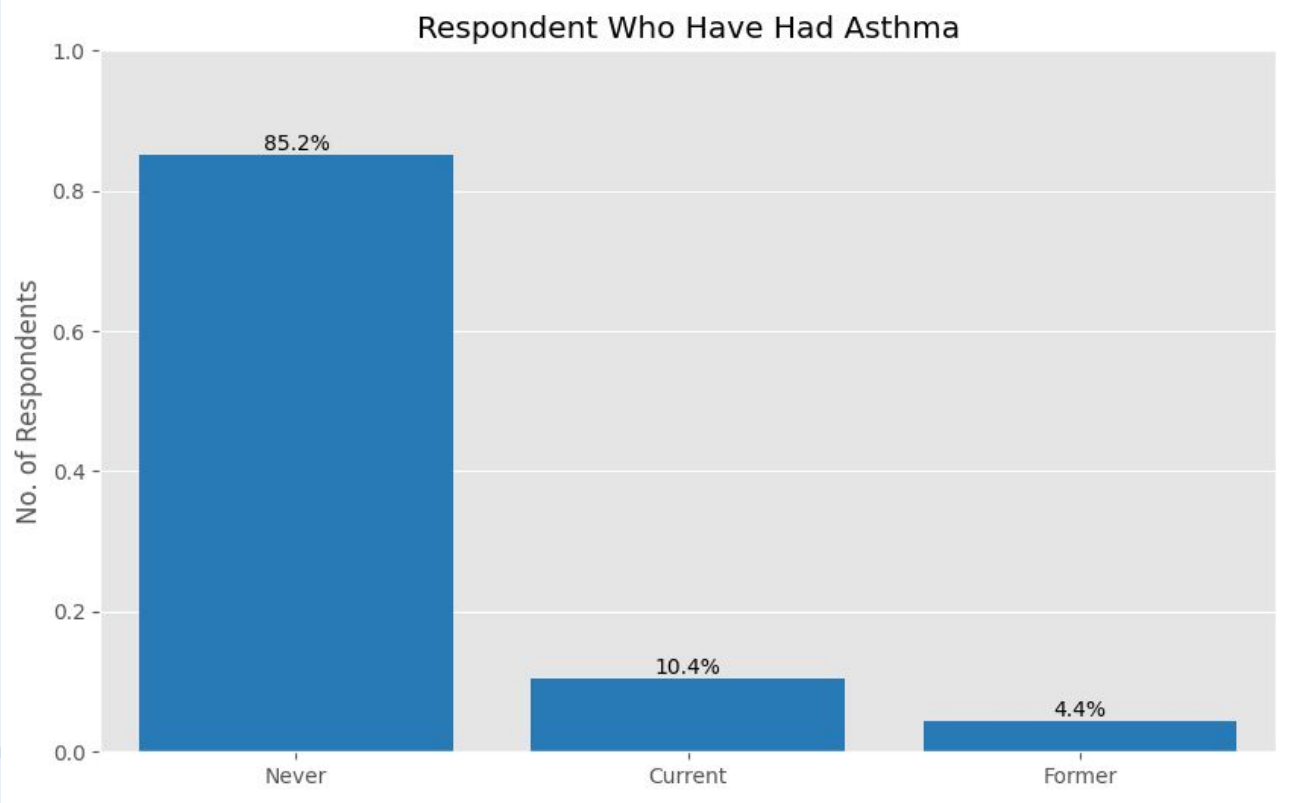
Personal Health Status

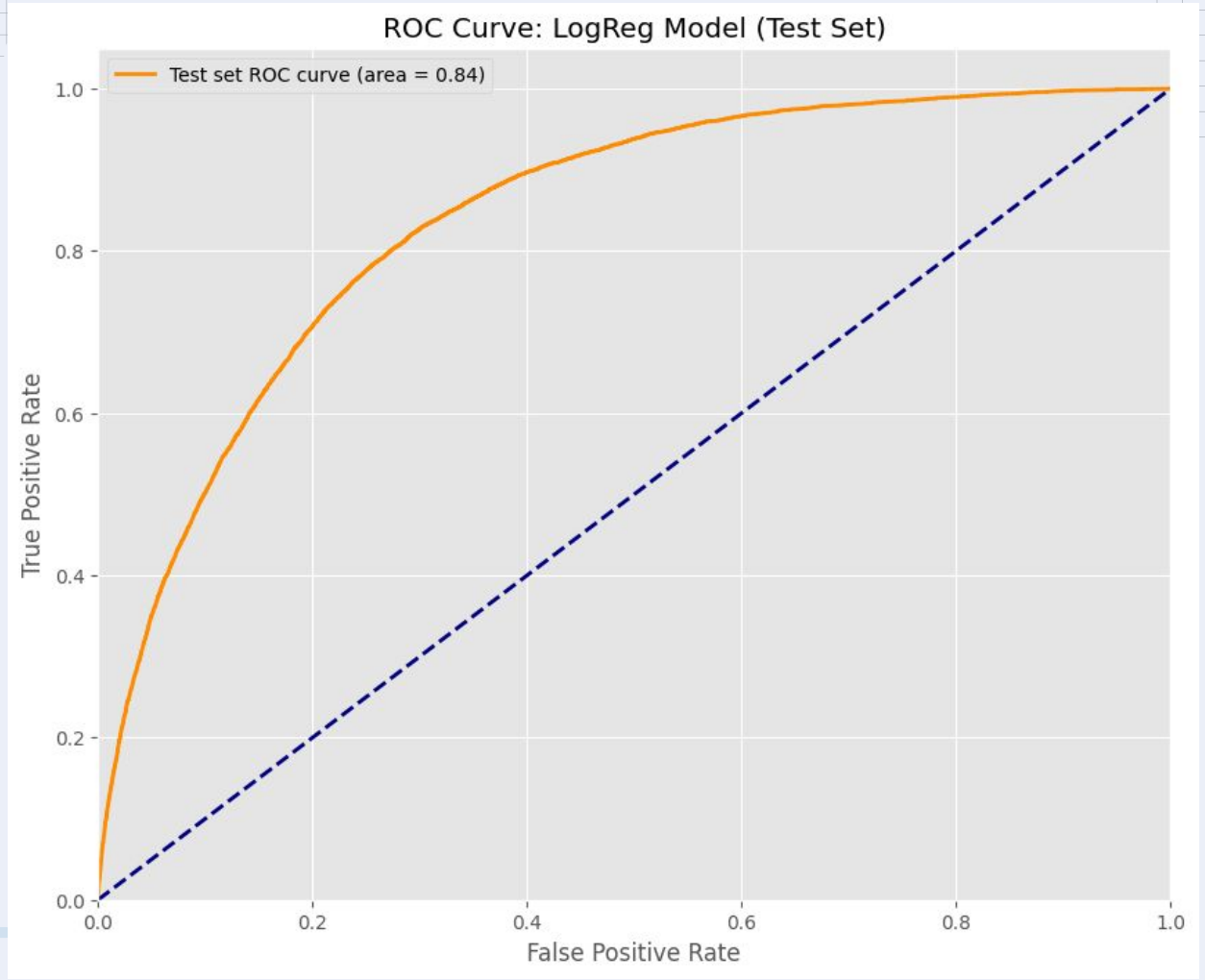


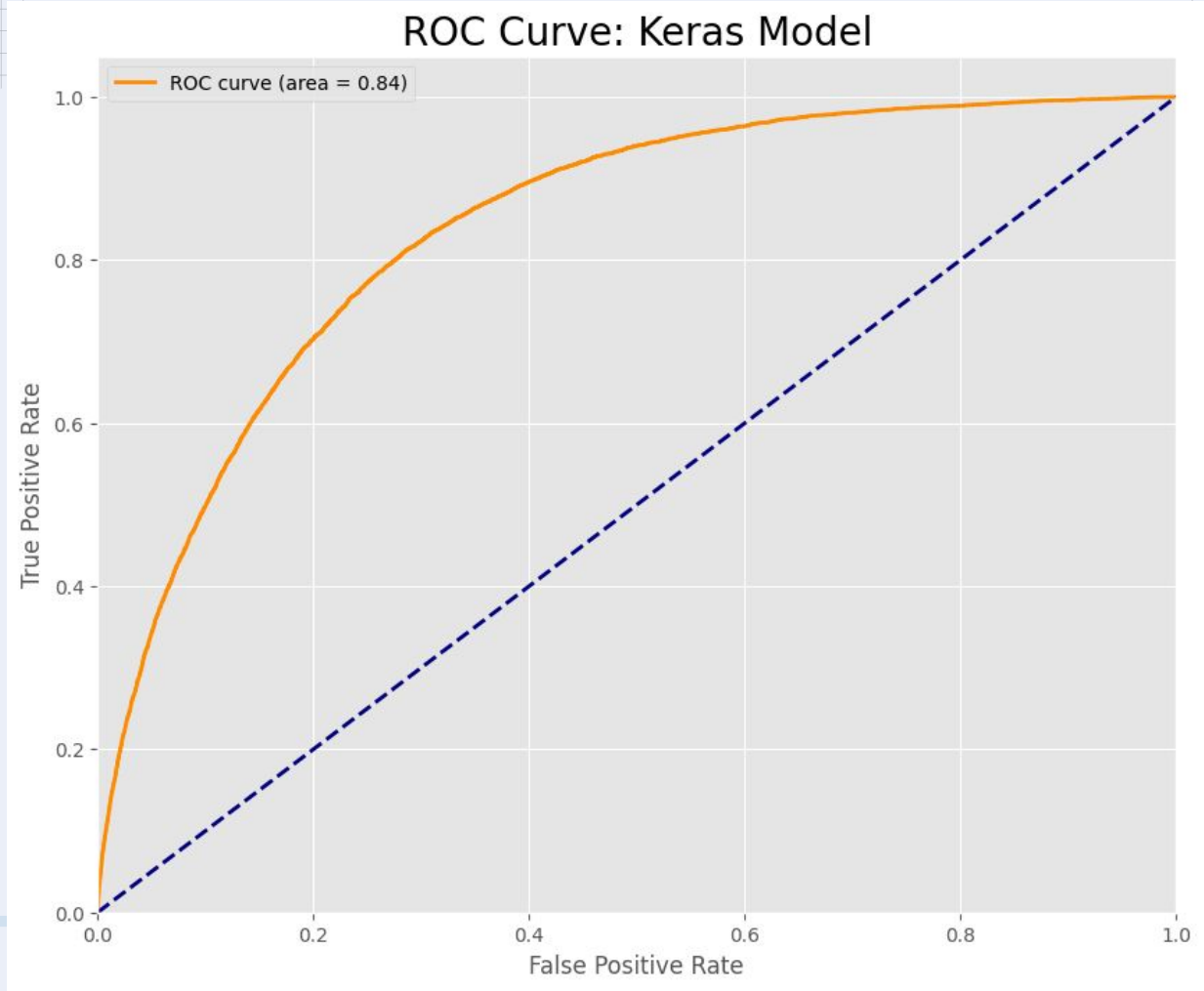
Personal Health Status



Distribution of Medical Info




ROC Curve: LogReg Model (Test Set)
Test set ROC curve (area = 0.84)
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0


ROC Curve: Keras Model
ROC curve (area = 0.84)
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0