Cardiac Stroke Risk Stratification using Classification Model

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Cardiac Stroke Statistics: US in 2017

1 in 20 deaths

Accounts from cardiac stroke

Rank #5

Among all causes of death in US, killing 133K people a year

795K people

Experience a new or recurrent stroke

$52 Billion

Estimated indirect and direct costs for stroke

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Problem Statement

Why should you care?

- Stroke is a preventive condition (i.e., lifestyle and dietary)
- ↑ in projected stroke prevalence US
- ↑ in cost for stroke treatment ($)

Stakeholders:

- Chain of hospitals: cardiac care unit managers and clinicians

Goal:

- Predict patients with high risks of developing a stroke

Objective:

- Help physicians to take proactive cardiac health monitoring
- Target prevention on patients with high risk of stroke

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Dataset Overview

Dataset contains **11** input features for predicting an "**stroke**" label:

- 8 categorical & 3 numerical features
- Lifestyle and health demographic indicators
- Sample size = 43,000 rows

Observations (rows)

ID	Gender	Age	Hypertension	Heart_Disease	Ever_Married	Work_Type	Residential_Type	Avg_Glucose_Level	BMI	Smoking_Status	Stroke
30669	Male	3	No	No	No	Children	Rural	95.1	18	NULL	0
16523	Male	58	Yes	No	Yes	Private	Urban	110.9	39.2	Never Smoked	0
56543	Female	8	No	No	No	Private	Urban	69	17.6	NULL	0
46136	Female	70	No	No	Yes	Private	Rural	161.3	35.9	Formerly Smoked	0
32257	Male	47	No	No	Yes	Private	Rural	210.1	50.1	NULL	0

Features (attributes)

Classes (label)

Challenges:

- Class imbalance (98% healthy vs. 2% stroke)
- Outliers & duplicates
- Missing values

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Data Wrangling

Raw Data Loading

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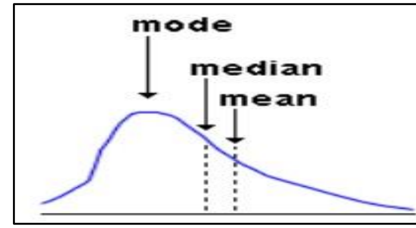
Feature Drop

Feature Imputation

Missing Value Replacement



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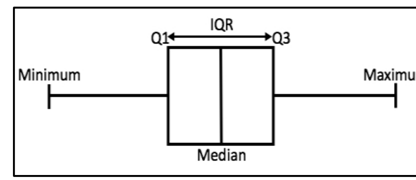
Interquartile Range:
LB = Q1 – 1.5*IQR
UB = Q3 + 1.5*IQR

Handling Outliers



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Down-sampling

Resampling

Non-stroke (50%)	Stroke (50%)

↓

Feature Encoding

Feature Engineering

Feature Scaling

Feature Transform

$$X_{norm} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

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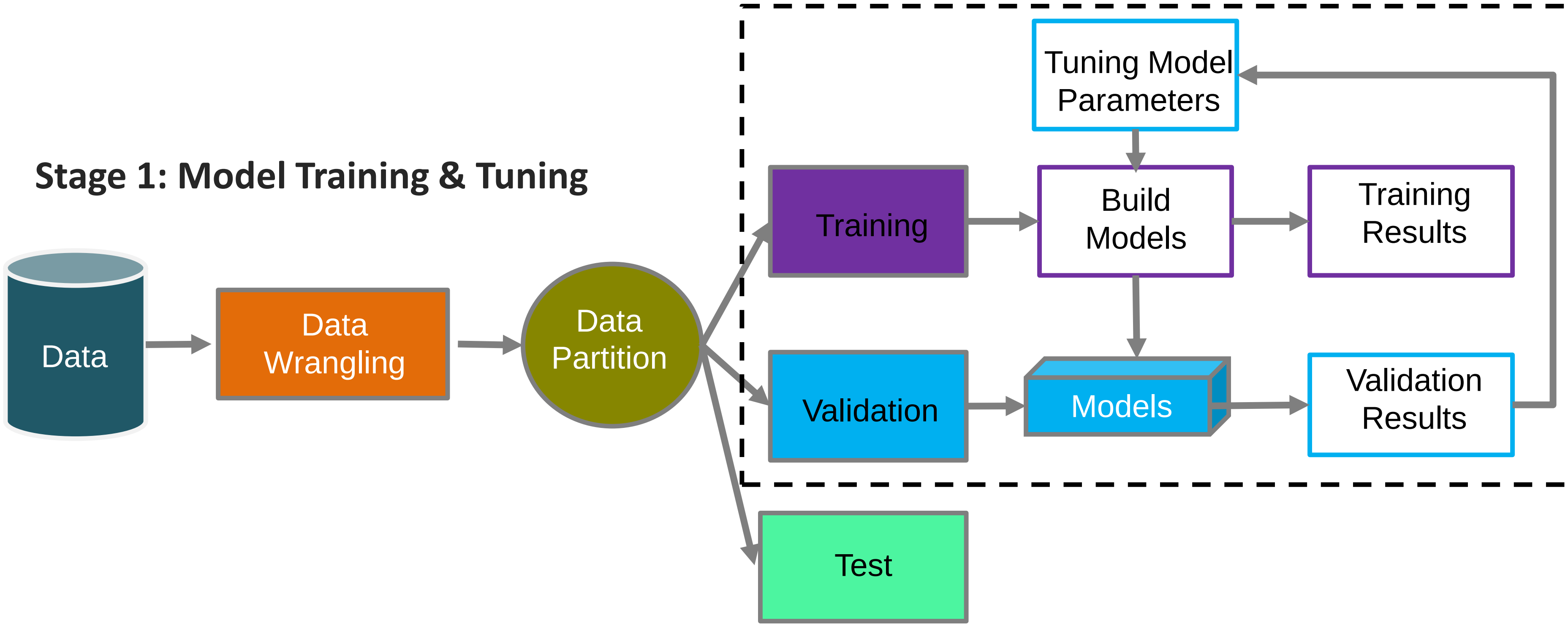
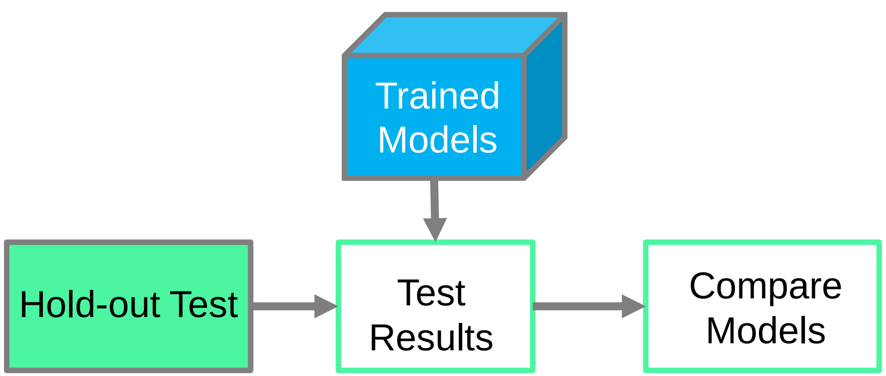
Classification Model Workflows

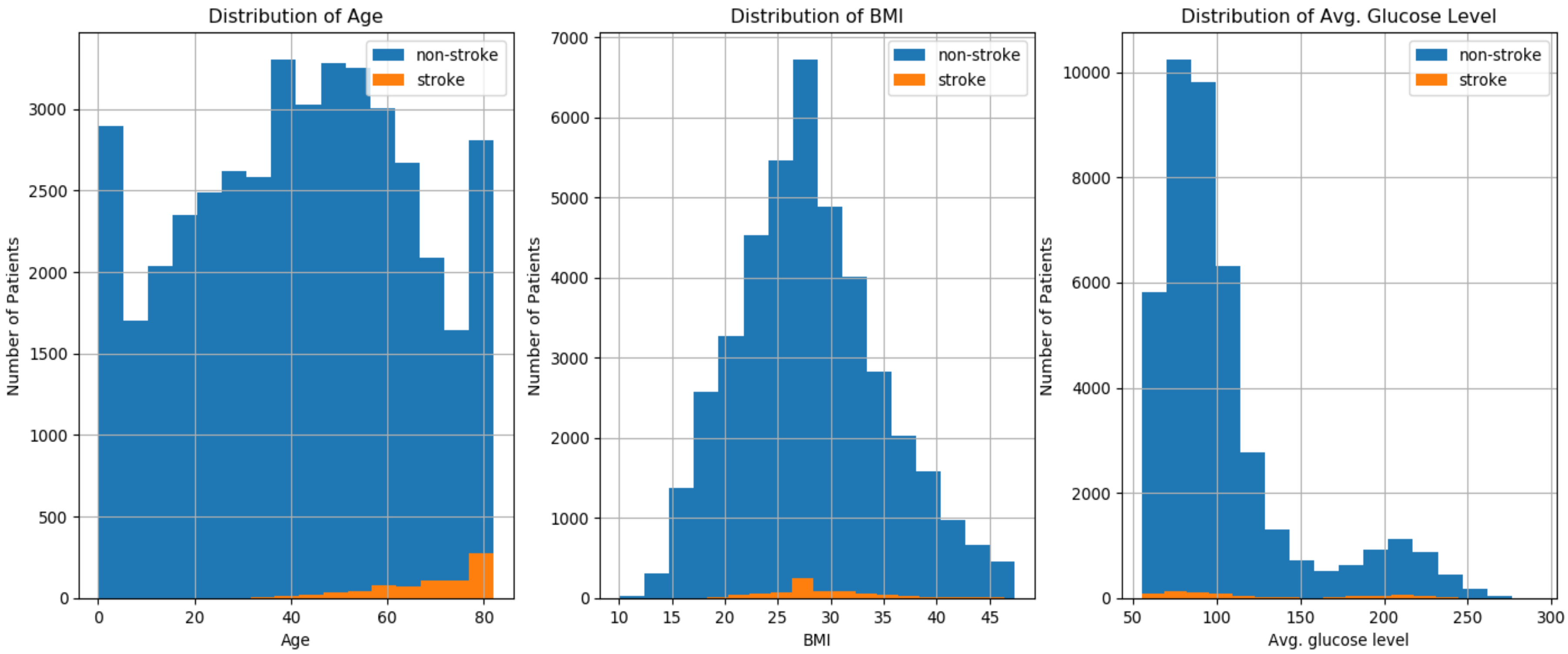
Stage 1: Model Training & Tuning



Stage 2: Model Performance Estimate



Distributions: Healthy vs. Stroke Population

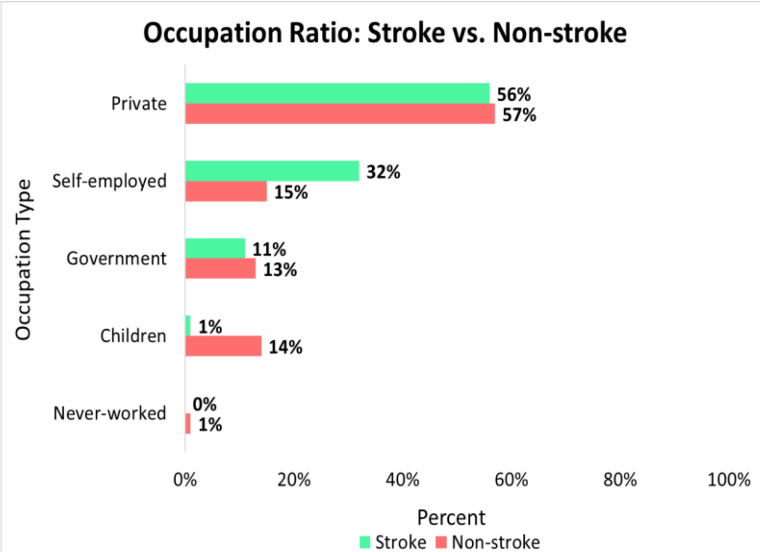


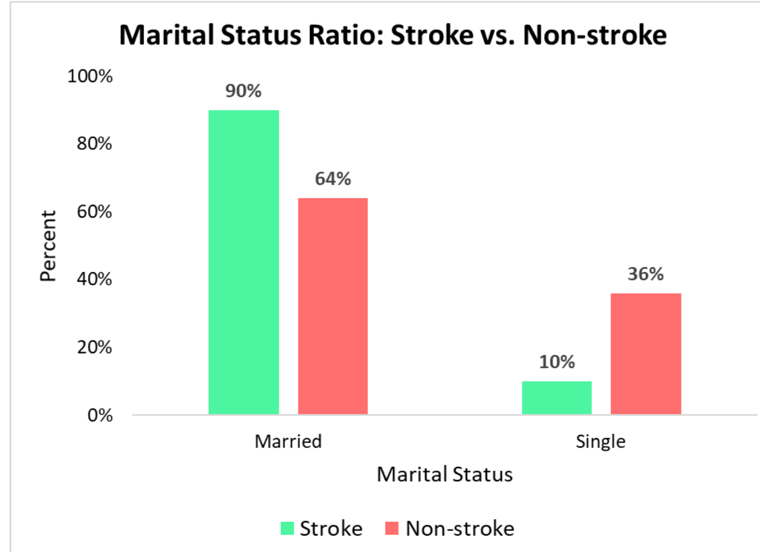
Age: majority of senior stroke patients (skewed to left)

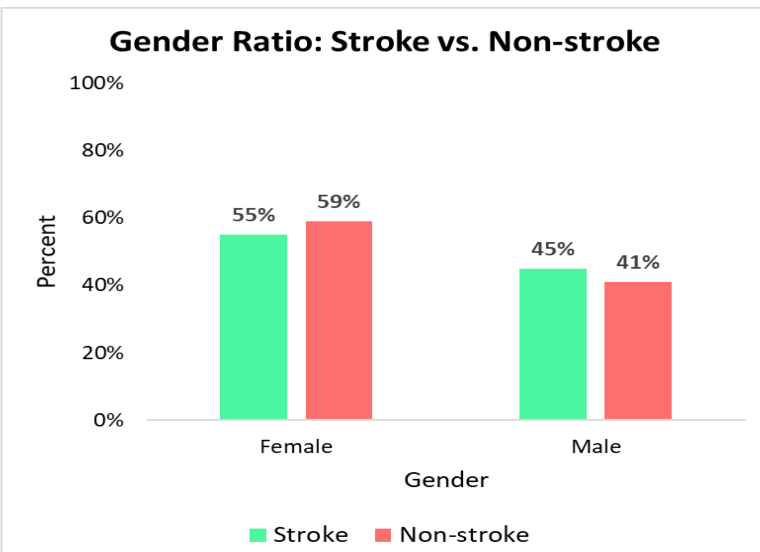
BMI: normal distribution (centralized from 25 to 30)

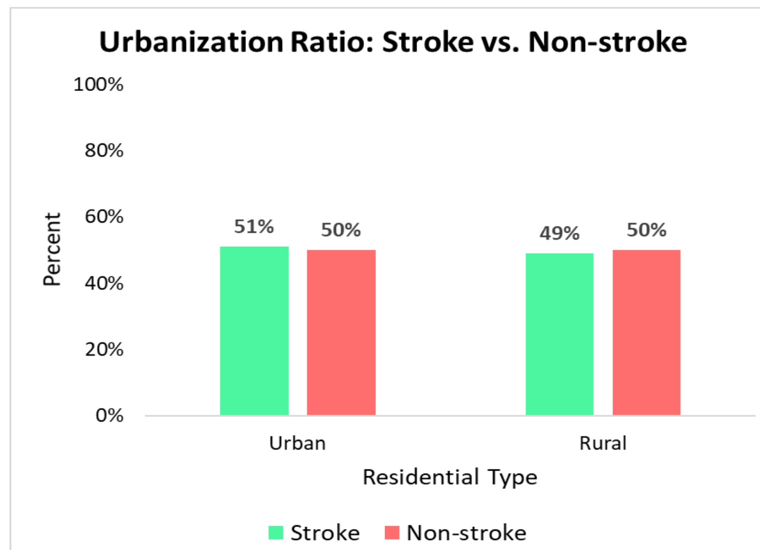
Avg. glucose level: non-normal distribution (bi-modal peaks)

Lifestyle Factors: Healthy vs. Stroke Population









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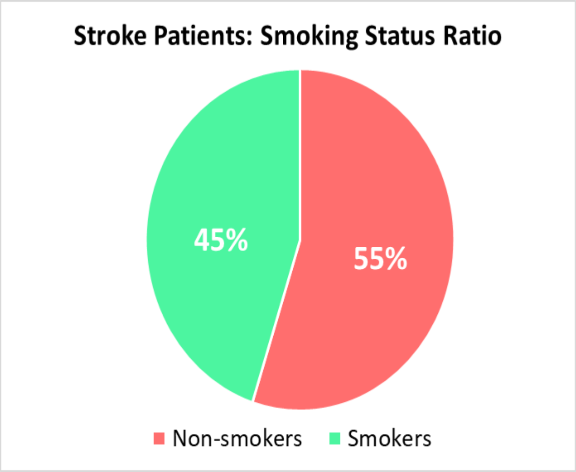
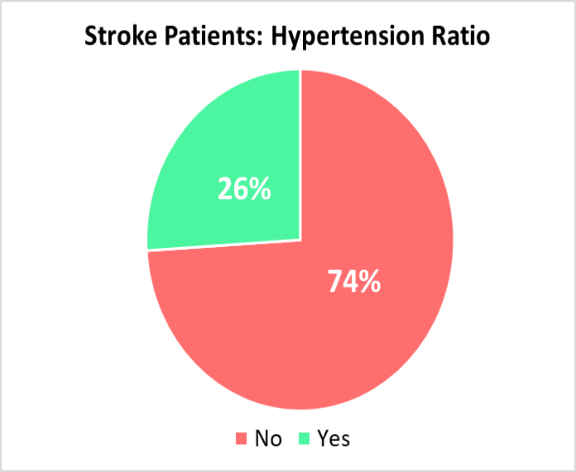
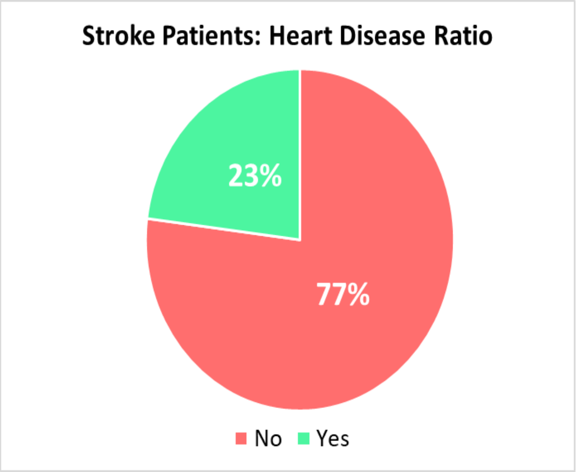
Health Indicators: Healthy vs. Stroke Population

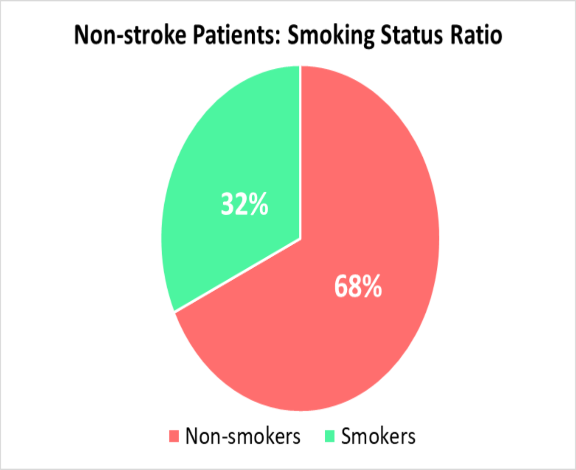
Stroke

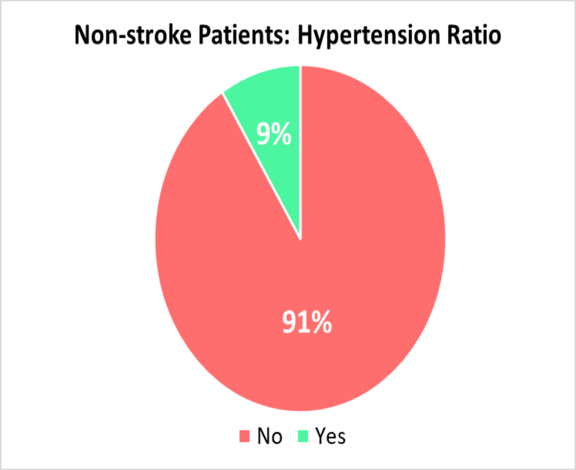


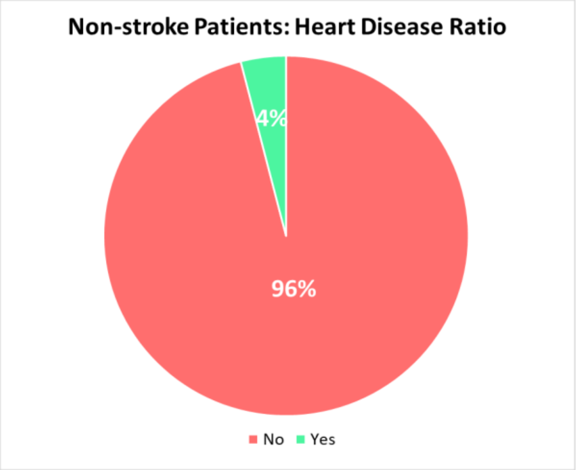




Non-stroke







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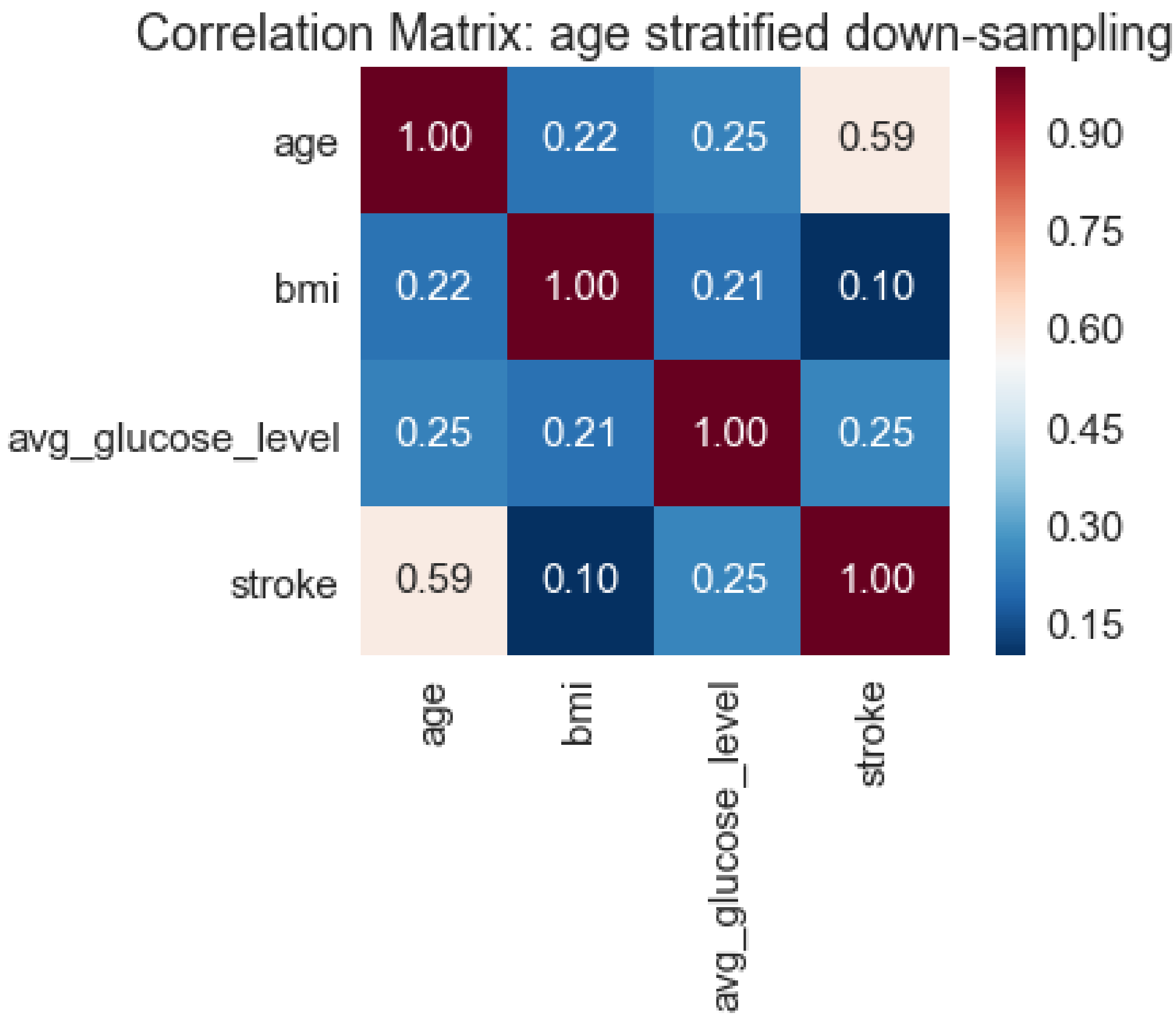
Correlation Matrix



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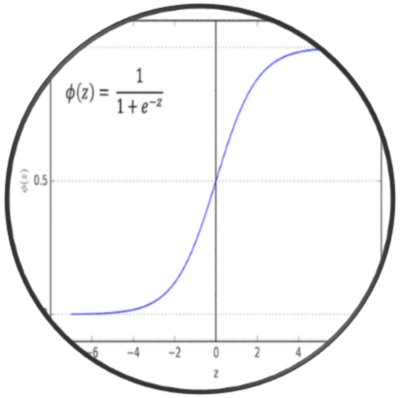
Model Selections

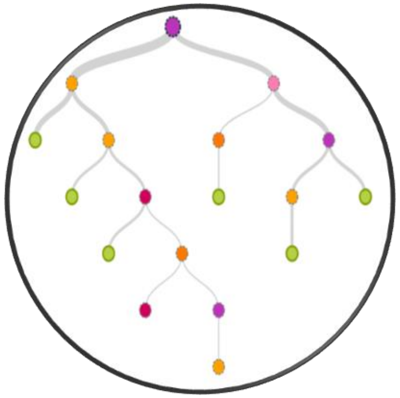


Logistic Regression

Sigmoid logit function:
log(p/(1-p))

Transforms:
Linear reg. → Logistic reg.
into a range (0, 1)

Works well on linearly separable classes.

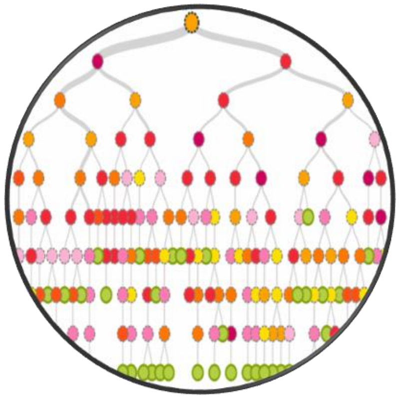


Decision Tree

Split data on features.

Repetitive splitting procedure.

Continue splitting until each node left with same class label.

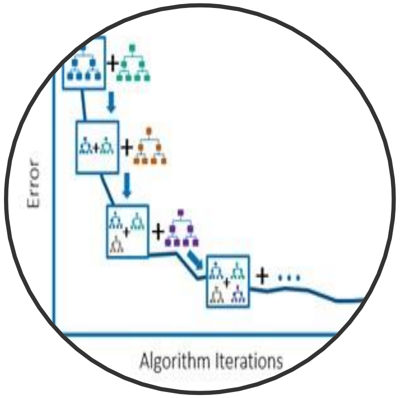


Random Forest

Ensemble learning.

Creates many decision trees.

Average performance of tree.



Gradient Boost

Sequential training.

Learn from residuals.

Iterative classifiers.

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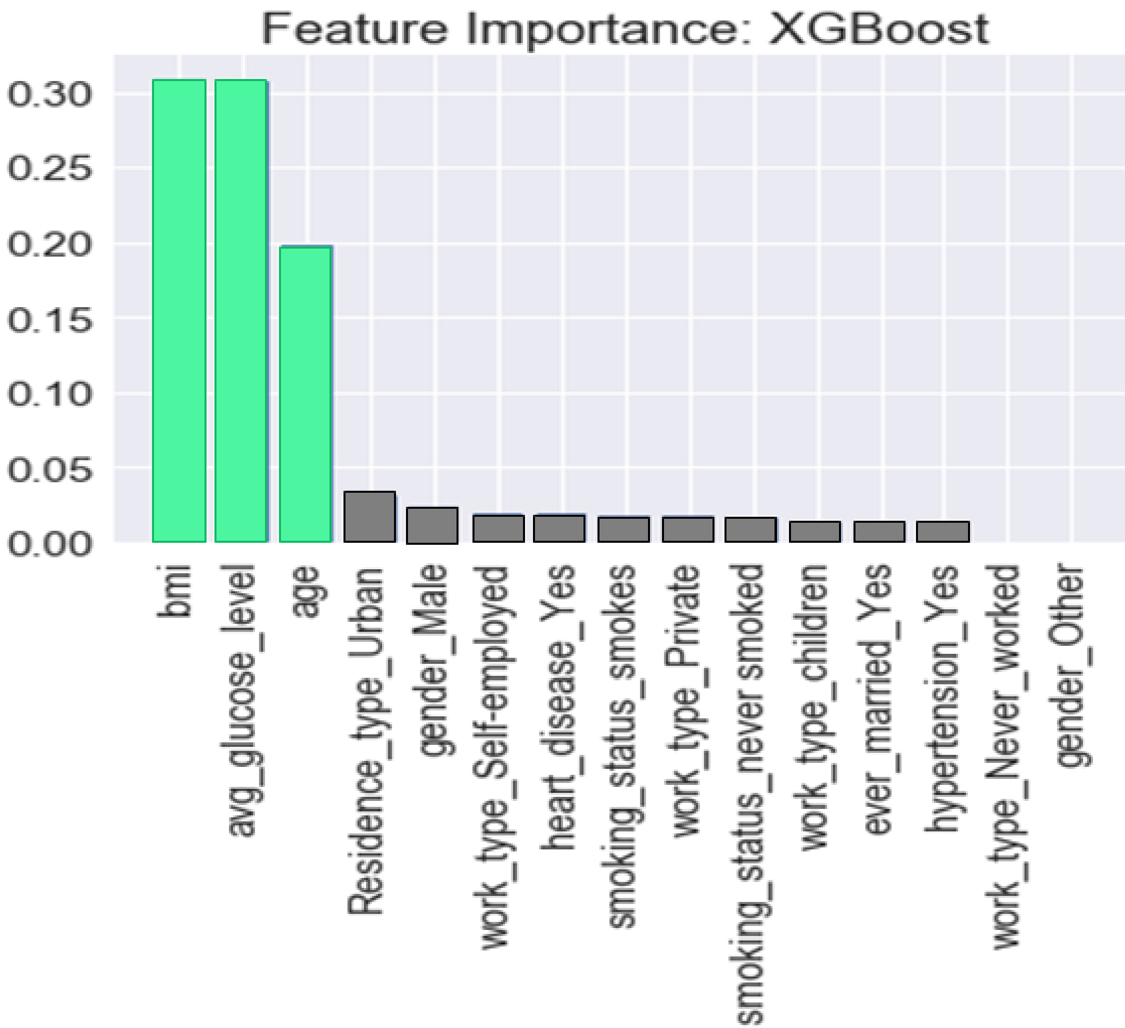
Feature Selections



Model Comparison

	Logistic Regression	Decision Tree	Random Forest	XGBoost
Accuracy	77%	75%	77%	**77%**
Precision	**75%**	68%	73%	73%
Recall	81%	**93%**	84%	86%
ROC Score	77%	75%	77%	**77%**

Overall, in terms of evaluation metrics:

- Best performing model was “XGBoost classifier”

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Confusion Matrix

XGBoost Classifier		
	Predicted Class	
Actual Class	**Stroke**	**Non-stroke**
Stroke	**43%**	**7%**
Non-stroke	**16%**	**34%**

Outcome Interpretation:
- 77% of correct predictions
- 23% of mis-classification errors

Balance between ML model and human intervention is required especially on **7% error** (*Type II error*).

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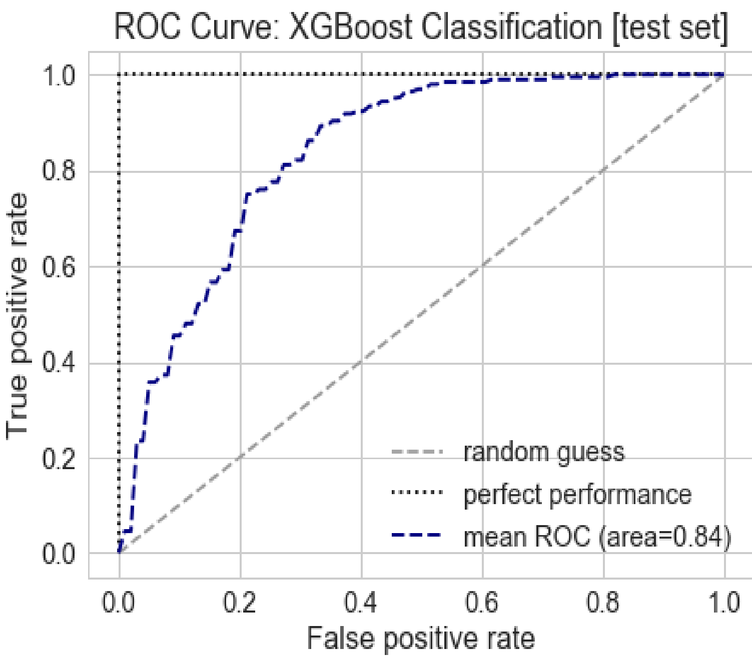
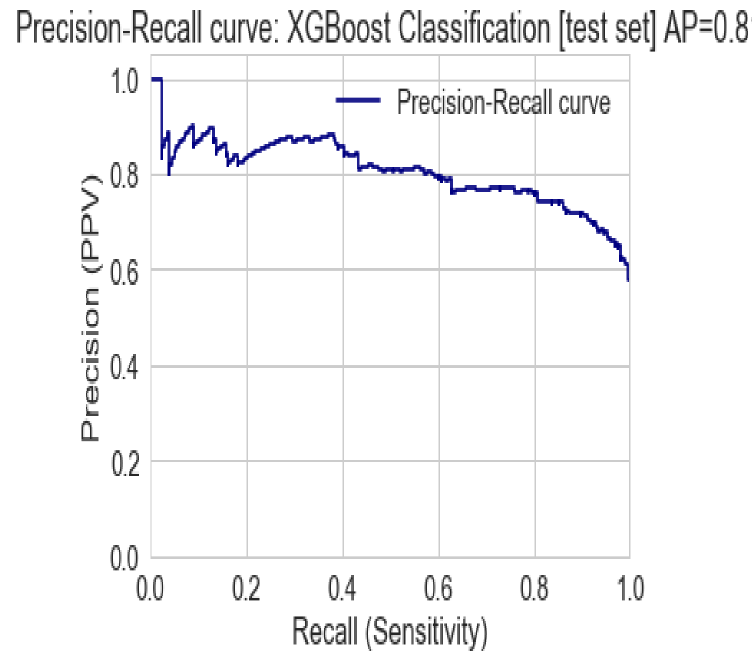
ROC and Precision-Recall Curves



ROC Curve



Precision-Recall Curve

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Summary: Stroke Classification

Goal

Predict cases at high risks of developing a stroke by classification model

Results

- Model was able to predict whether or not patients were at risk of stroke
- 77% of accurate predictions were made on test set of stroke data

Risks & Mitigation

Risks:
Model incorrectly classified with 7% error as likely patients are healthy but in fact had strokes

Mitigation:
Review identified cases with a group of clinicians before decision making

Next Steps

- Collection of meaningful features
- Model improvement: algorithms, resampling and designs

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Limitations & Future Work

Limitation:

- Absence of useful features/attributes
- Weak feature interaction (i.e., smoking, hypertension)

Future Work:

- Collection of features (i.e., genetic pre-disposition, physical activity, etc.)

- Model improvement: combine multiple classifiers
  - Majority Vote
  - Stacking

- Resampling strategies:
  - SMOTE
  - Oversampling (i.e., minority class: stroke cases)

- Age stratified classifiers:
  - Younger patients cohort (age < 30)
  - Senior patients cohort (age > 50)

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Recommendations

Add stroke screening test
At a recommended age (before 65)

Collect meaningful features
Stress level, physical activity,
blood pressure, genetic factors.

Conduct cohort studies
Using feature engineering, further stratify patient cohorts into diabetic and obese groups.

Thank You!

Questions?