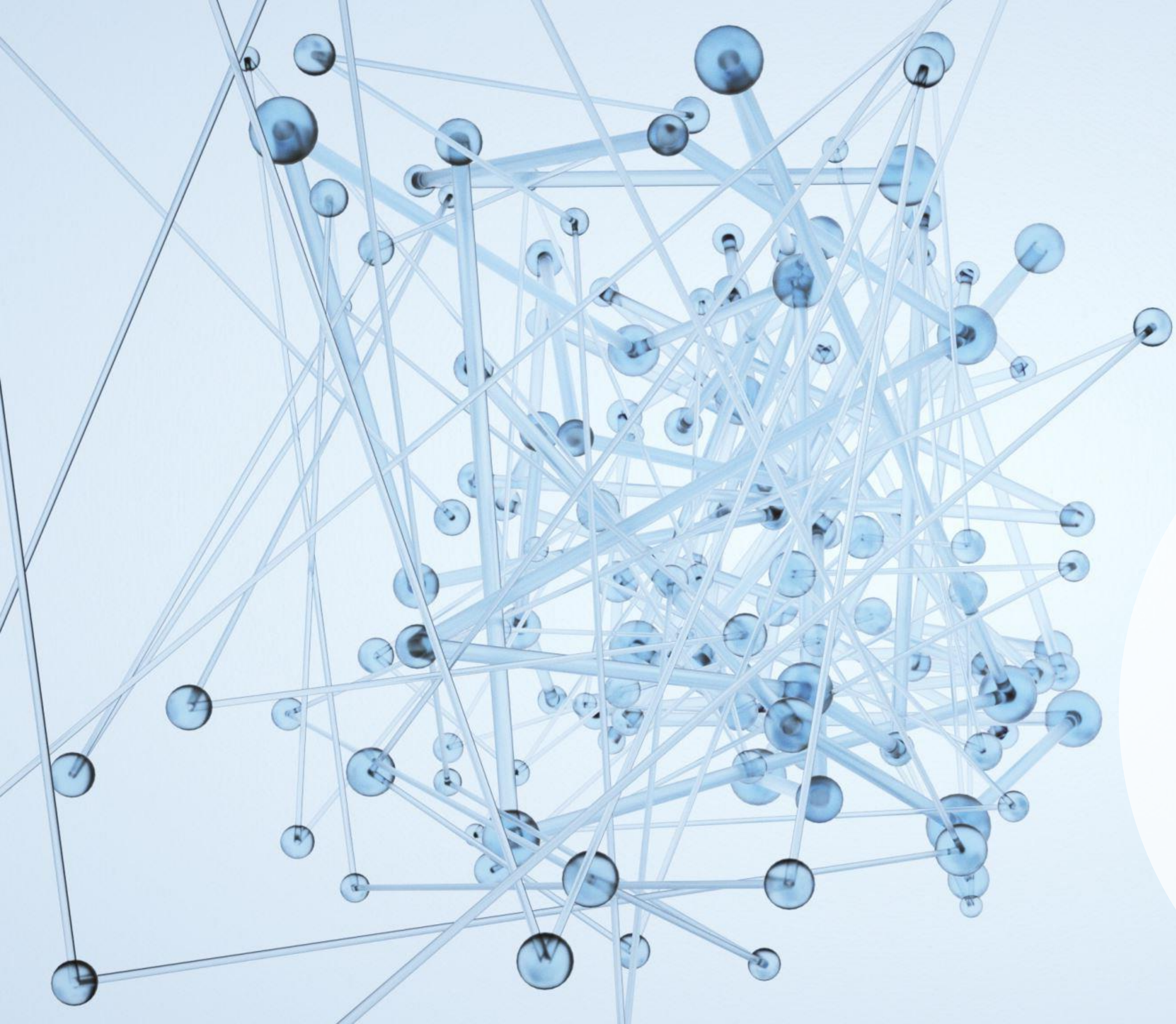

Statistical Learning Project

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Data analysis on stroke detection

- "Stroke" is the medical term for damage to brain tissue or the death of a portion of it, due to insufficient blood supply to an area of the brain
- It is responsible for approximately 11% of total deaths
- Normal values of glucose: 60-110 mg/dl
  - > 126 diabetes
- Normal BMI range: 18.5 - 24.9
  - > 30.0 obesity

Dataset

id	gender	age	hypert.	hd	ev_ marr	work_ type	res_ type	glucose	bmi	smoking	stroke
9046	Male	67	0	1	Yes	Private	Urban	228.69	36.6	formerly smoked	1
51676	Female	61	0	0	Yes	Self-employed	Rural	202.21	N/A	never smoked	1
31112	Male	80	0	1	Yes	Private	Rural	105.92	32.5	never smoked	1
60182	Female	49	0	0	Yes	Private	Urban	171.23	34.4	smokes	1
1665	Female	79	1	0	Yes	Self-employed	Rural	174.12	24	never smoked	1

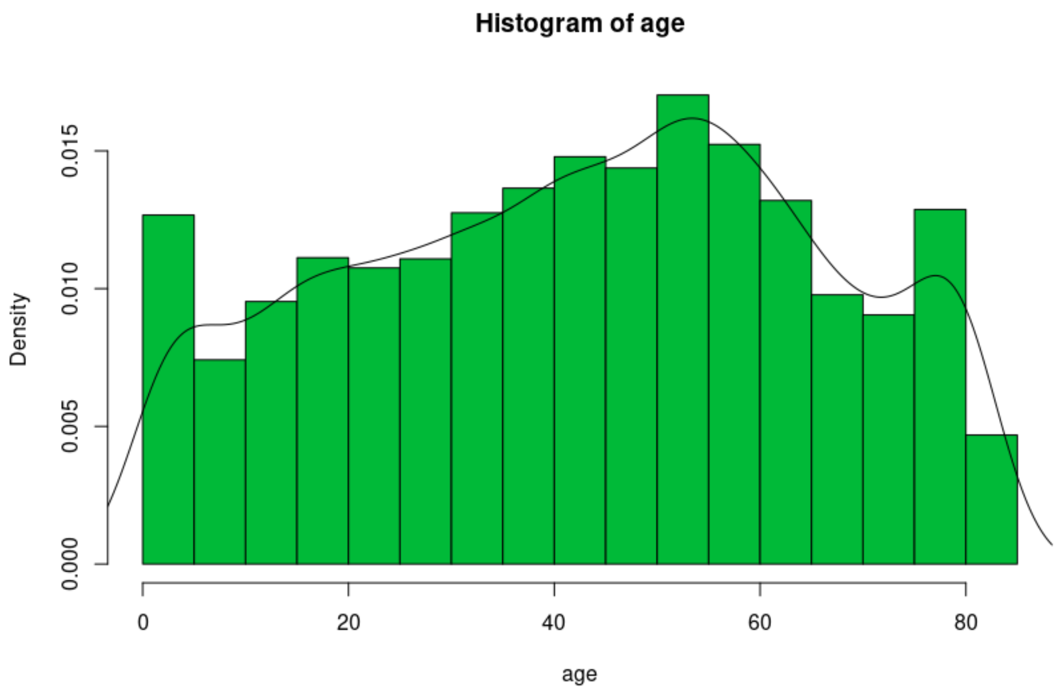
Dataset

- **Data variables**: id, gender, age, hypertension, heart_disease, ever_married, work_type, Residence_type, avg_glucose_level, bmi, smoking_status, stroke

- **Missing values**

- **Unbalanced data**:
4,26% of the people get a stroke

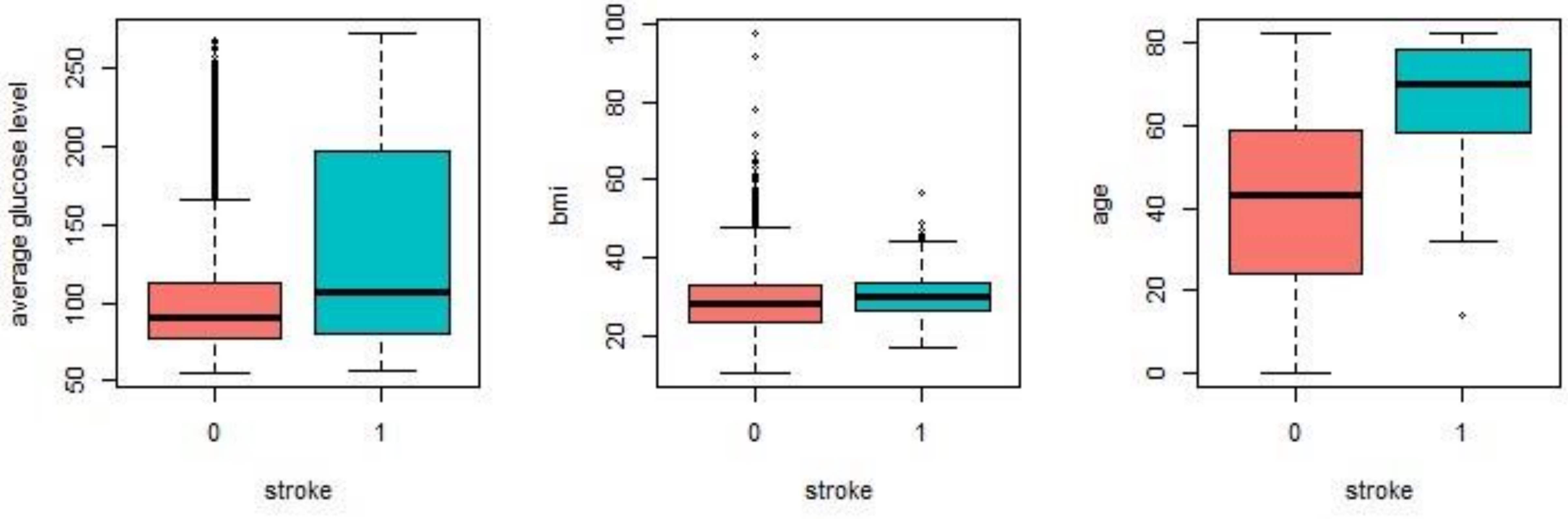
Age distribution



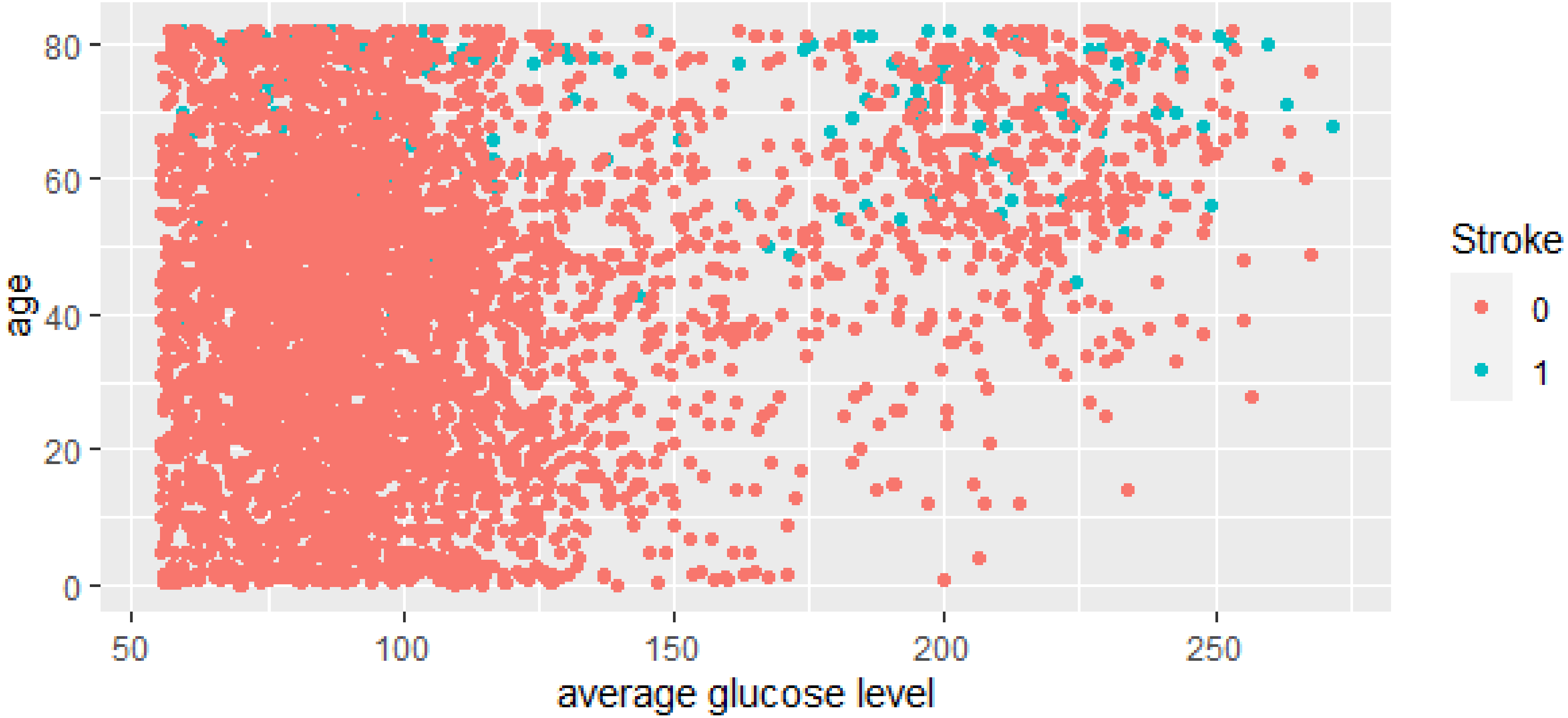
Data cover people of all ages from babies of 8 days to seniors of 82 years old

Explanatory Data Analysis (EDA)

- High glucose level and bmi do not imply directly a stroke
- Rare/interesting cases of stroke
- Strong relation between age and stroke

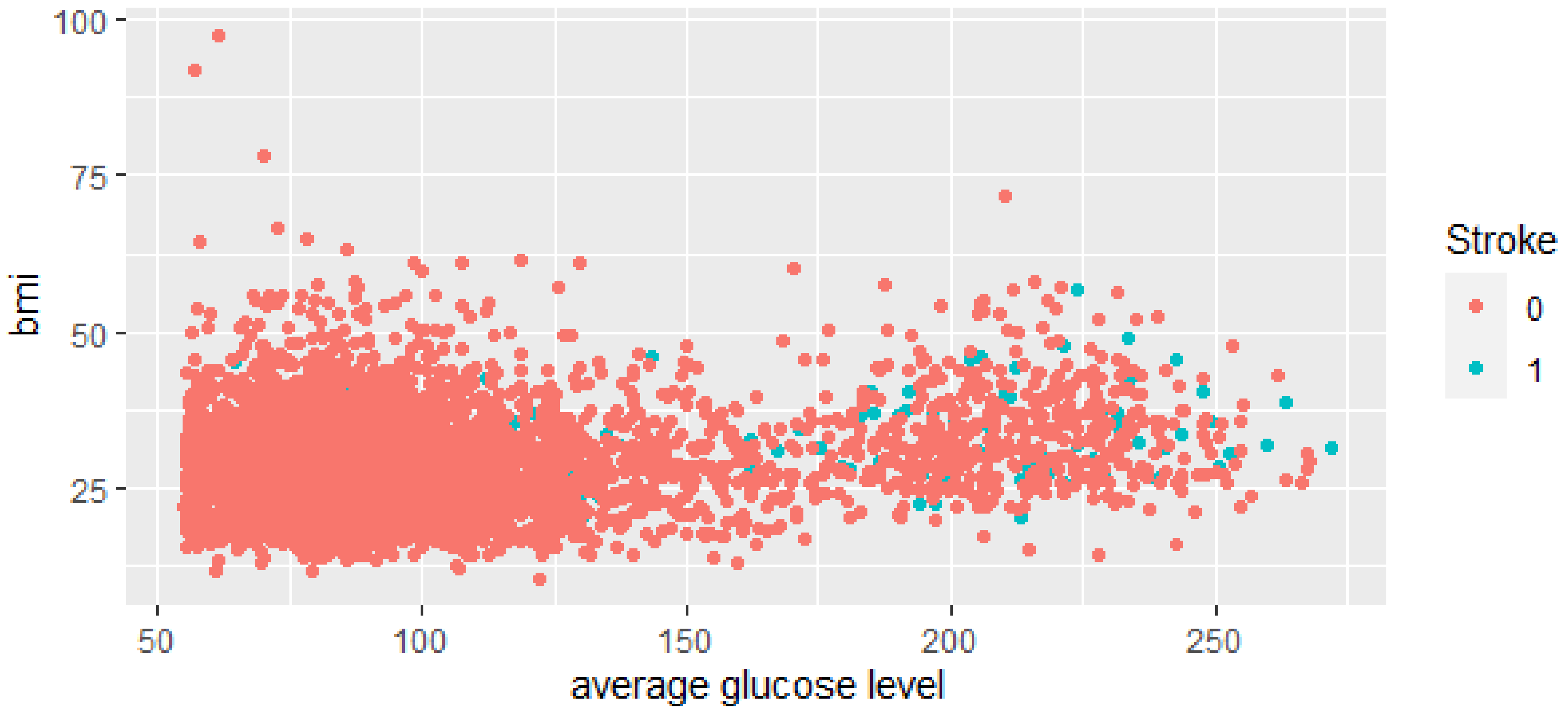


Not an easy problem



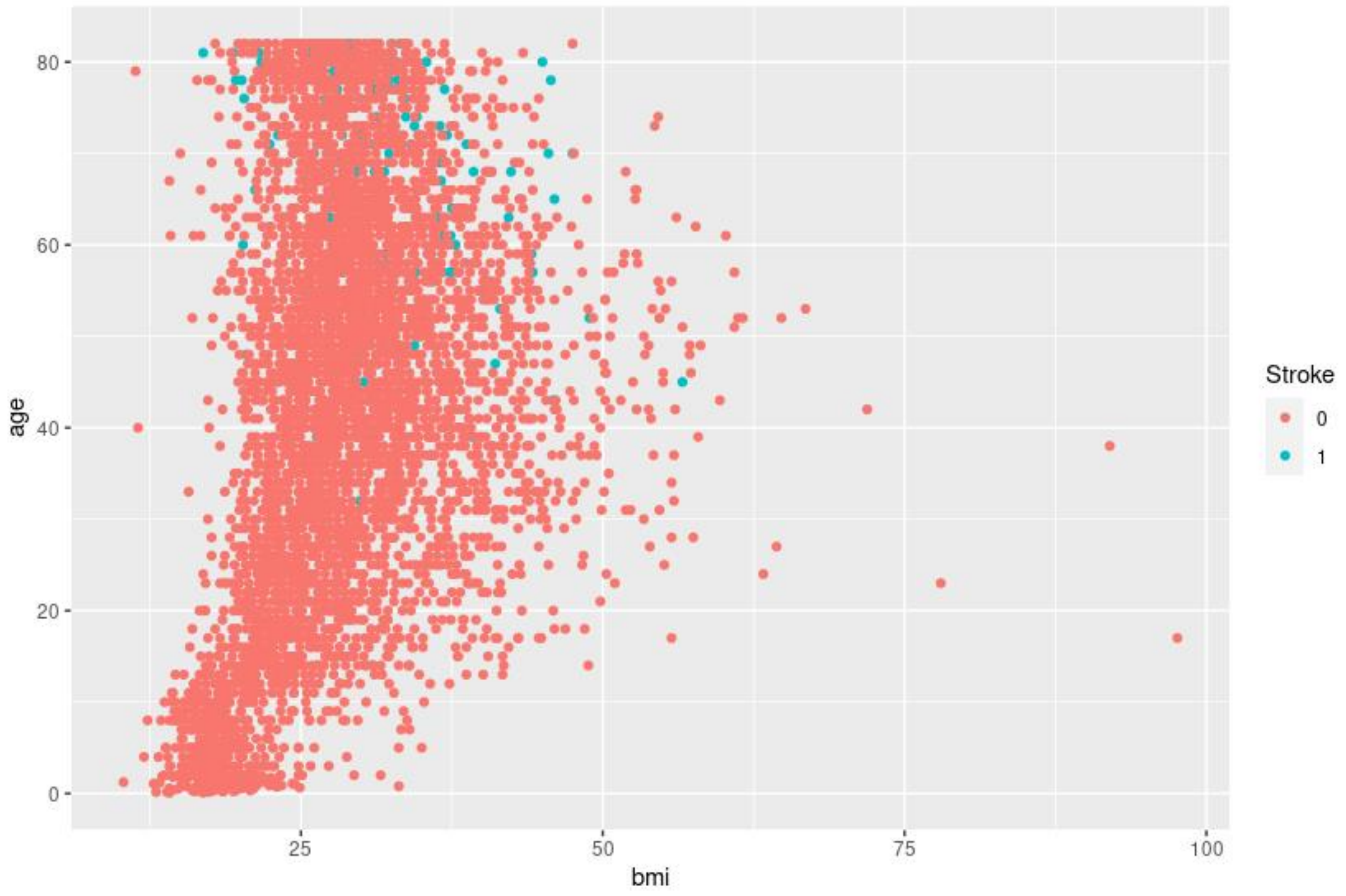
- Non-linear separable
- Not easy to identify a direct relationship with stroke diseases

Not an easy problem



Glucose levels and *Bmi* could not be so strictly related to the disease but maybe correlated to other illnesses linked to it.

Not an easy problem



- Strong correlation with *age*
- Weak correlation with *Bmi*

Correlation between features

- Presence of collinearity:
  - Age ~ Ever married : 0.68
  - Age ~ Work type : 0.54
  - Age ~ Smoking status : 0.39
  - Ever married ~ Bmi: 0.34

- Correlated variables:
  - Stroke ~ Age: 0.23
  - Stroke ~ Hypertension: 0.14
  - Stroke ~ Avg. glucose level: 0.14

Relevant Questions:

• Which factors are the most related to the stroke disease?

• How strong are the relations between the features?

• Are the given variables enough to predict a good accuracy of some possible person affected by stroke?

• Is it possible to prevent the stroke?

Tested Models

- **Logistic Regression**
  - Full and Reduced Models
  - Interaction Models
  - Polynomial Models

- **Bayesian Models**
  - LDA Model
  - QDA Model

LOGISTIC REGRESSION

- A type of Generalized linear model (GLM)
- The dependent variable is binary

0 NO STROKE

1 STROKE

Model selection:

- Hypothesis
- p-value
- AIC

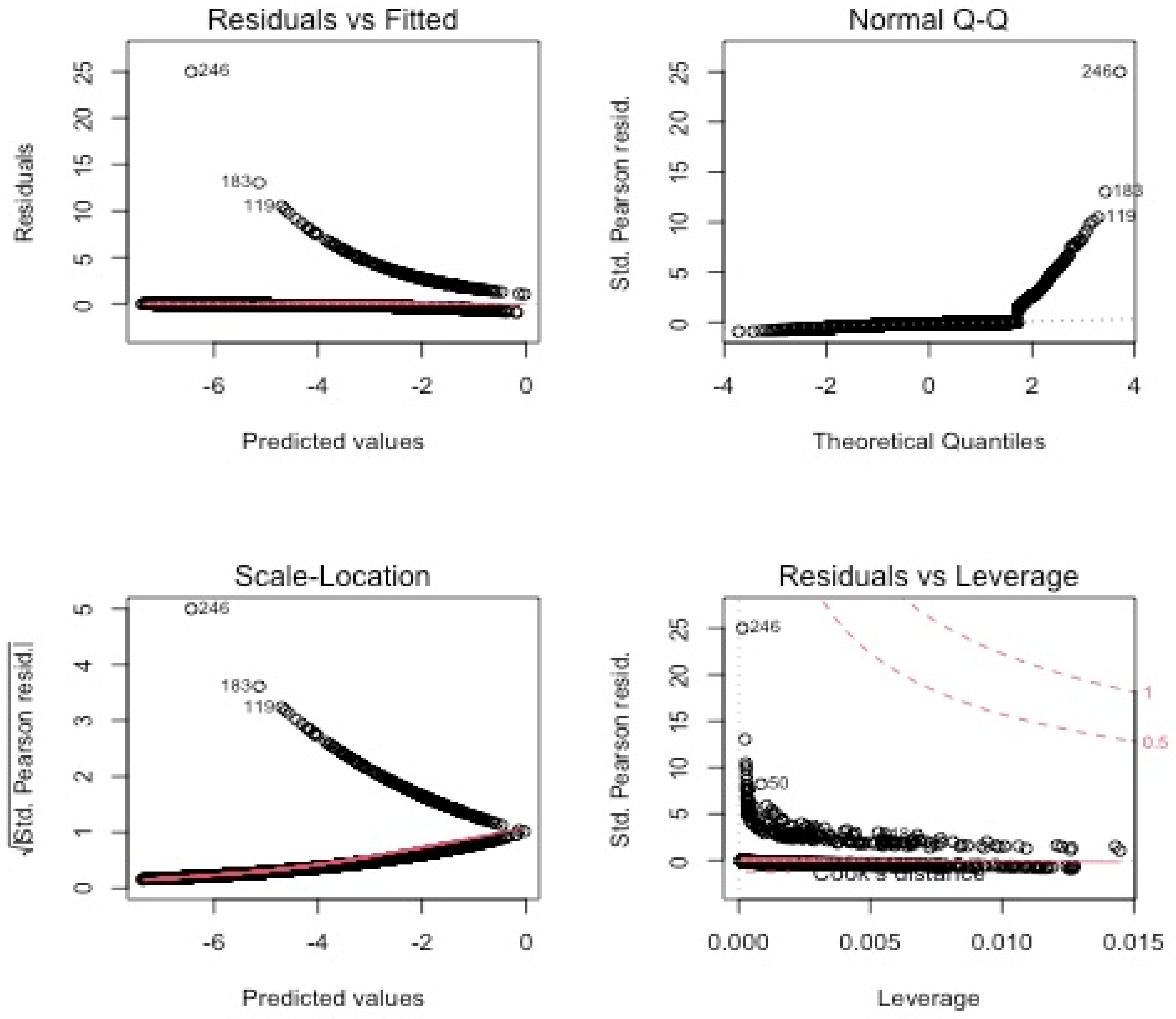
Reduced Model

Feature	Coef.	Level of significance
Age	0.067547	< 2e-16
Avg. Glucose level	0.004802	0.000129
Heart disease	0.404298	0.046895
Hypertension	0.539613	0.001820

AIC: 1384.6

Reduced Model Plots

- Non-linearity in dataset
- Residuals do not follow normal distribution
- Heteroscedasticity
- Leverage points
- Outliers



"Outliers"

Able to infer some particular stroke cases, *anomaly detection*.

	gender	age	hypert.	hd	ev_marr	work_type	res_type	glucose	bmi	smoking	stroke
119	Female	38	0	0	No	Self-employed	Urban	82.28	24.0	formerly smoked	1
183	Female	32	0	0	Yes	Private	Rural	76.13	29.9	smokes	1
246	Female	14	0	0	No	children	Rural	57.93	30.9	Unknown	1

Interaction between features

- age * heart_disease, avg_glucose_level, bmi, hypertension
- avg_glucose_level * heart_disease, bmi, hypertension
- heart_disease * hypertension
- bmi * hypertension

Best Interaction Model

Feature	Coef.	Level of significance
Age	0.070133	< 2e-16
Avg. Glucose level	0.004702	0.000176
Heart disease	2.765299	0.047694
Hypertension	0.536550	0.001880
Age:heart disease	-0.032872	0.091604

AIC: 1384

Best Model Selection

To choose the best model among the electives ones we used Training and Validation testing method.

Data splits should be done carefully cause of unbalanced issue.

- 75% Training
- 25% Validation
- Both splits have 4% of stroke cases

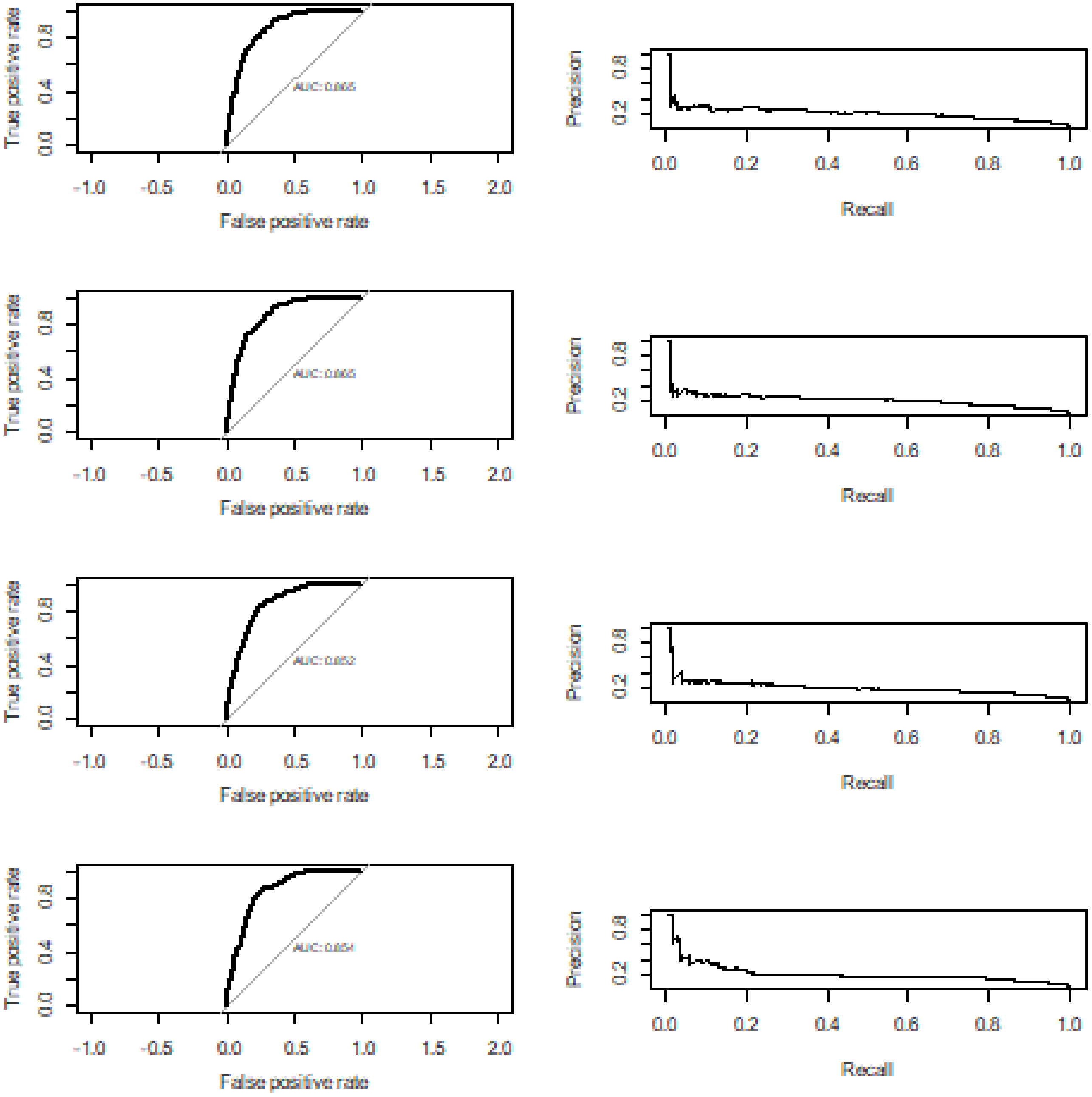
Training set

Validation set

Best Model Selection

- False Rates?
    - False negatives in medical cases
    - ROC or Precision-Recall curves?
    - Threshold

ROC
vs
Prec-Recall
Curves



Best Model Selection

REDUCED MODEL			
		Predicted	
		0	1
Ground thruth	0	497	681
	1	1	48

INTERACTION MODEL			
		Predicted	
		0	1
Ground thruth	0	499	679
	1	1	48

LDA MODEL			
		Predicted	
		0	1
Ground thruth	0	490	688
	1	1	48

QDA MODEL			
		Predicted	
		0	1
Ground thruth	0	599	579
	1	4	45

Best Model Selection
- Error Rates -

REDUCED MODEL:

- Positive rates: 0.0658
- Negative rates: 2.01 e-3

INTERACTION MODEL:

- Positive rates: 0.0660
- Negative rates: 2.0 e-3

LDA MODEL:

- Positive rates: 0.0652
- Negative rates: 2.04 e-3

QDA MODEL:

- Positive rates: 0.0721
- Negative rates: 6.633 e-3

Conclusions

- Interaction model is the best
- Older people have higher probability to get a stroke
- Not easy to make secure predictions
- Increase the number of data
- Find more features related with stroke
- Find out the appropriate false rate