AN EXPLORATORY DATA ANALYSIS FOR DRIVERS OF COST OF CARE

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Outline

- Dataset Overview
  - Demographic Data
  - Clinical Data
  - Bill Data
  - Master Data
- Univariate Analysis
  - Categorical Variables
  - Continuous Variables
- Multi-Variable Linear Regression

Section 1 – Dataset Overview

Demographic Data

- 3000 observations of 4 variables, each observation belonging to one unique patient (identified by patient ID)
- New variable generated: Age
- Total 5 demographic variables

Variable	Patient ID	Gender	Race	Resident Status	Date of Birth	Age
Type		Binary - Female - Male	Categorical - Chinese - Malay - Indian - Others	Categorical - Singaporean - PR - Foreigner	Date	Discrete (treated as continuous)

Clinical Data

- 3400 observations of 25 variables, each observation belonging to one unique admission (identified by patient ID and date of admission)
- Medical history 2 and 5 have missing values (7% and 9%):
  - Option 1: NA treated as another level
  - Option 2 (sensitivity analysis): Removing observations with missing values (2898 observations)
- New variables generated: Length of stay and BMI, total 27 variables
- Based on the number of unique patients (3000), a small portion of patients are admitted more than once
- Assumption: from Client's perspective, the expense of each unique admission is of greater interest than the overall expense of each patient

Variable	Patient ID	Date of Admission/Discharge	Medical History 1 -7	Preop Medication 1 - 6	Symptom 1 - 5	Lab Result 1 - 3	Weight	Height	Length of Stay	BMI
Type		Date	Categorical (1/0/NA)	Binary (1/0)		Continuous				

Bill Data

- Combined Bill ID with Bill Amount, 13600 observations of 2 variables
- Based on the number of unique admission record (3400), each admission record corresponds with multiple bills
- Sum the bill amount for each unique admission, generating 3400 observations with 2 variables

Variable	Patient ID	Date of Admission	Bill Amount
Type		Date	Continuous

Master Data

- Combined Demographic, Clinical and Bill data by patient ID and date of admission
- New variable generated: Readmitted Status
- 3400 observations with 31 variables
- Categorical variables:

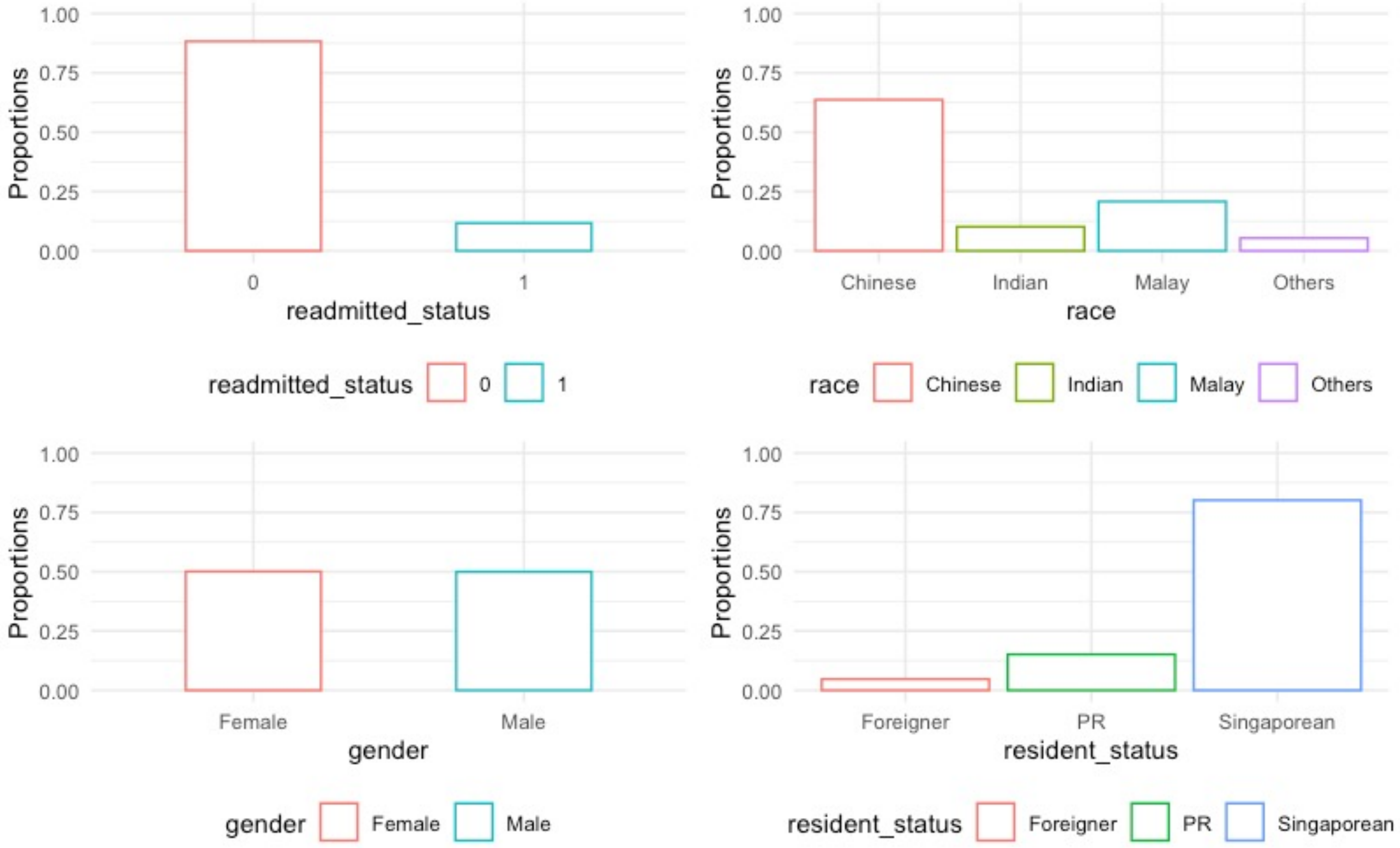
Variable	Readmitted Status	Gender	Race	Resident Status	Medical History 1 - 7	Preop Medication 1 - 6	Symptom 1 - 5
Levels	(1/0)	- Female - Male	- Chinese - Indian - Malay - Others	- Singaporean - PR - Foreigner	(1/0/NA)	(1/0)	(1/0)

- Continuous variables:

Variable	Amount	Lab Result 1 - 3	Weight	Height	BMI	Length of Stay	Age

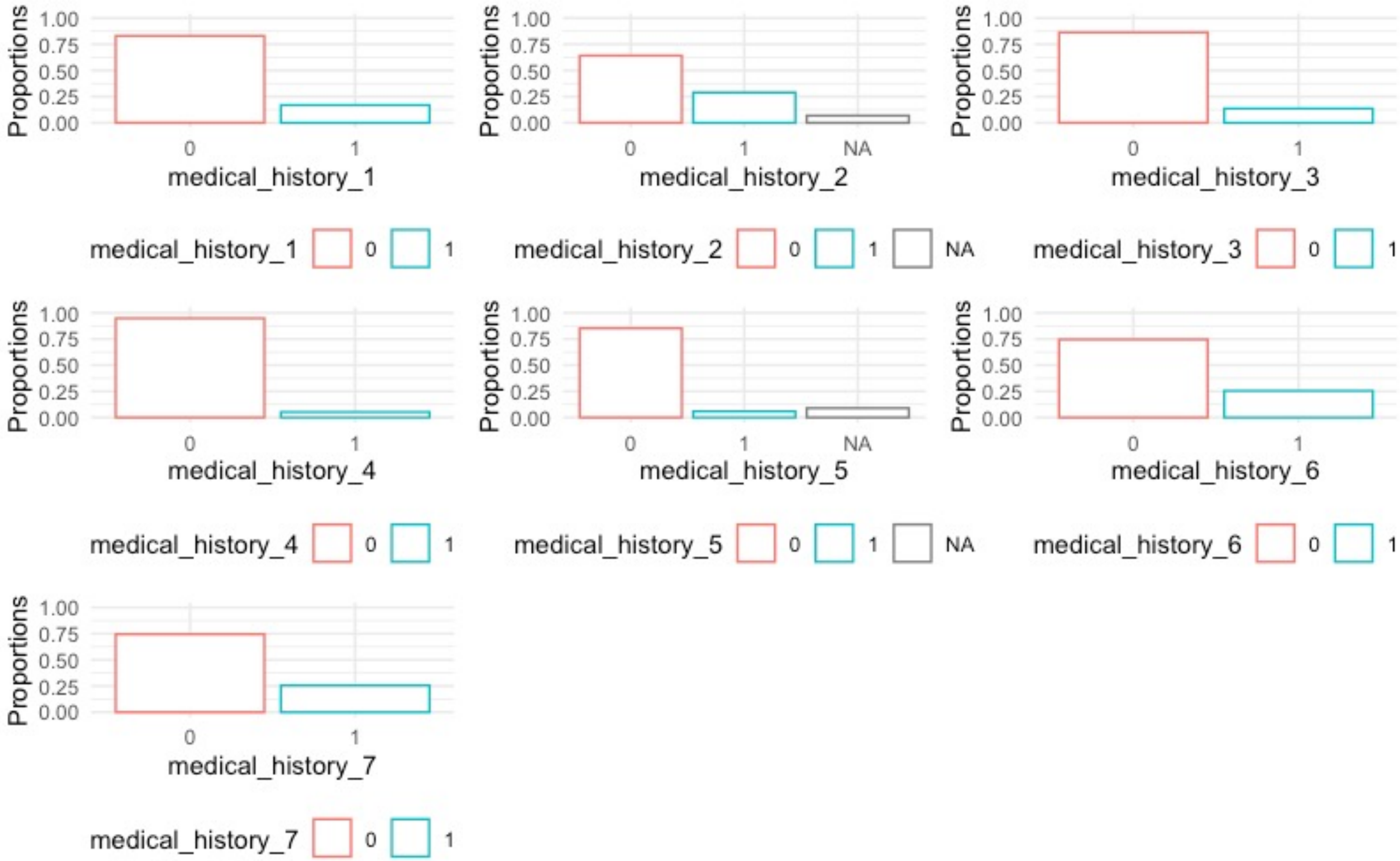
Section 2 – Univariate Analysis

Categorical Variables – Demographics



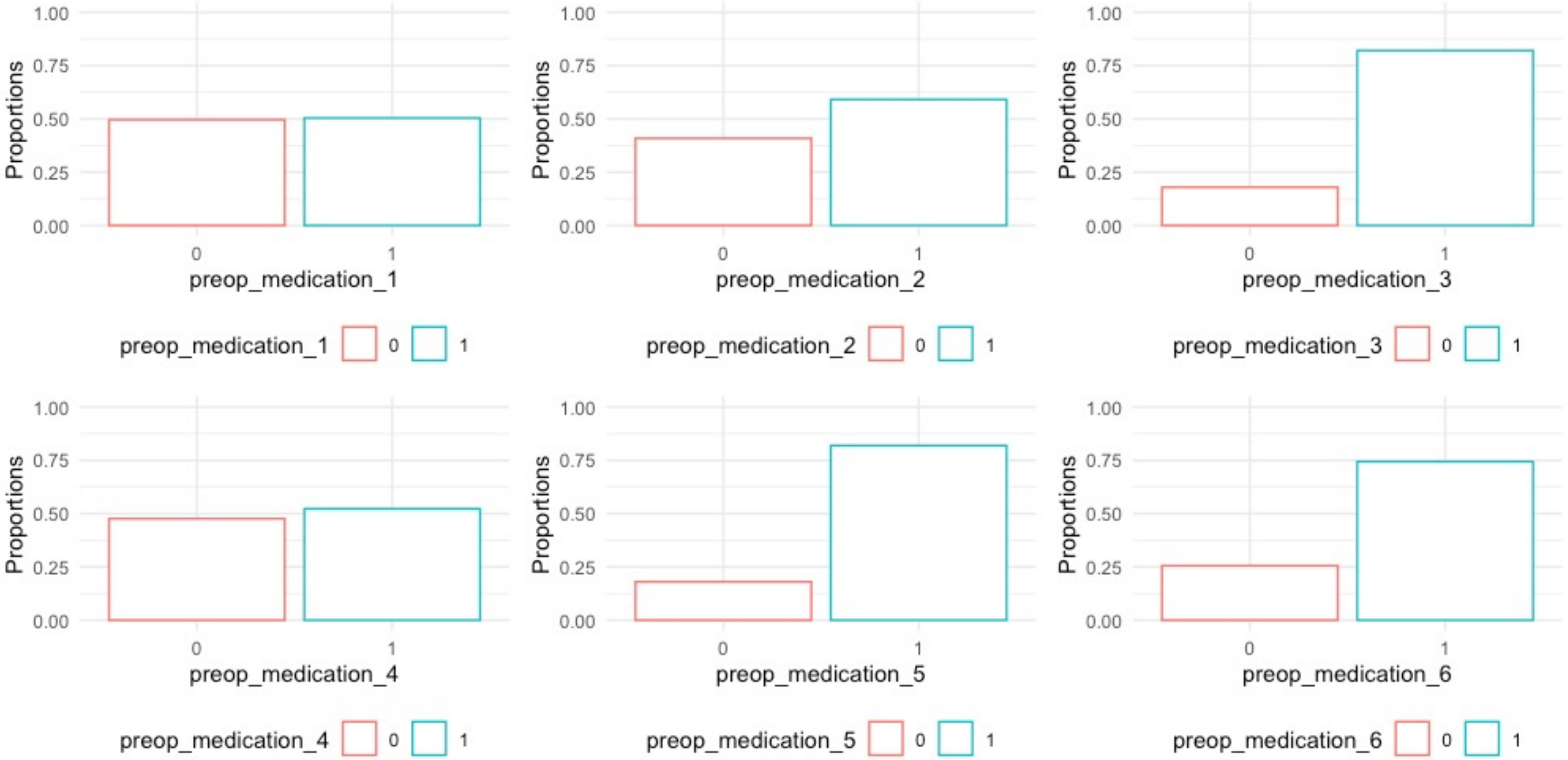
- Readmitted status: majority being first-time admission with 12% repeated admission
- Race: majority being Chinese and Malay, with 10% Indian and 5% Others
- Resident status: majority being Singaporean, with 15% PR and 5% Foreigner
- Gender: equal proportion of Female and Male

Categorical Variables – Medical History 1 - 7



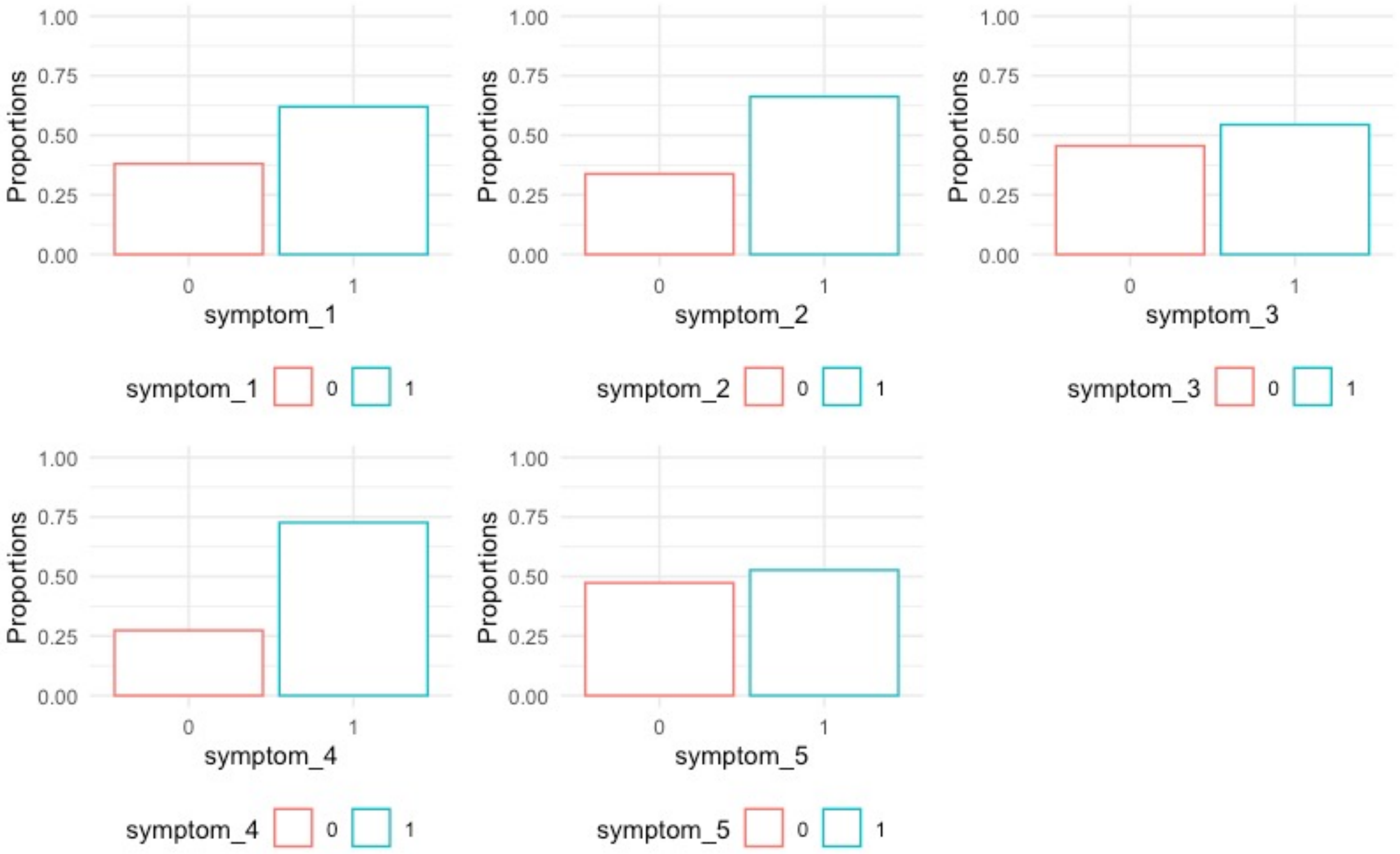
For all 7 Medical Histories, only a small proportion is YES, imbalanced data to be noted

Categorical Variables – Preop Medication 1 - 6



Most of the admission records show usage of Preop Medication 1, 2, 3, 4, 5, or 6

Categorical Variables – Symptom 1 - 5

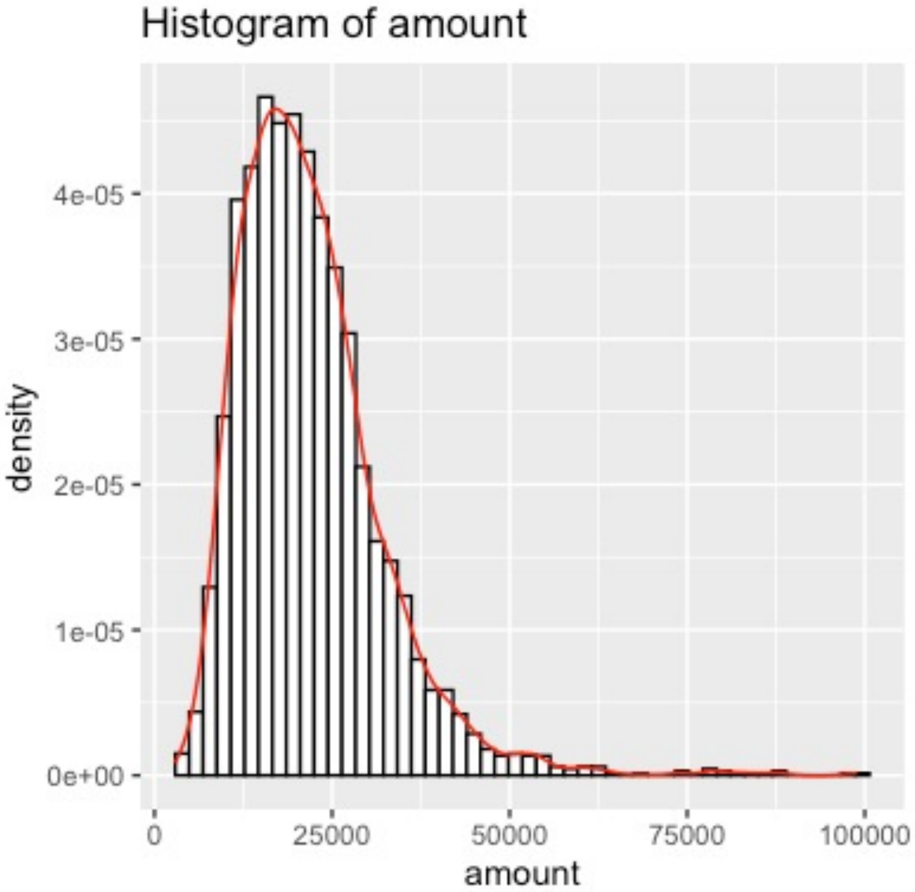


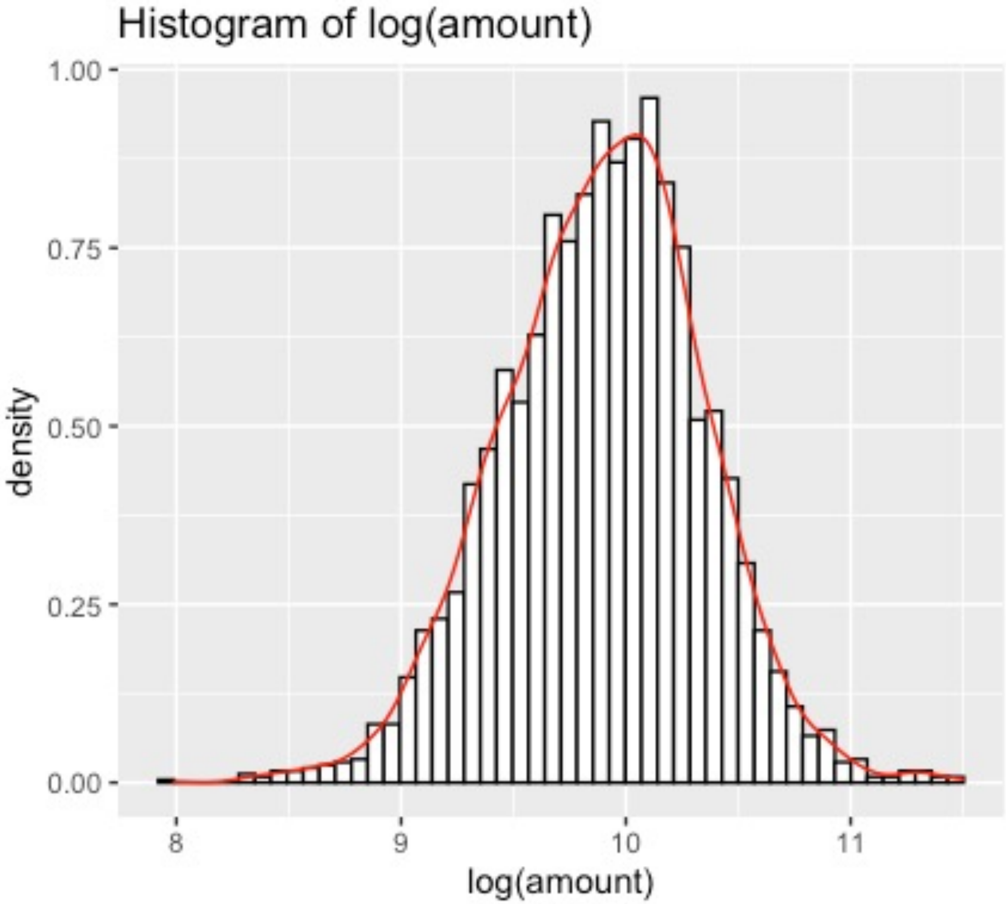
Most of the admission records present Symptom 1, 2, 3, 4 or 5

Association between Categorical Variables and Amount

- Applying one-way ANOVA, 13 categorical variables identified to be associated with bill amount
  - Gender
  - Race
  - Resident status
  - Medical history 1
  - Medical history 6
  - Medical history 7
  - Preop medication 2
  - Preop medication 6
  - Symptom 1
  - Symptom 2
  - Symptom 3
  - Symptom 4
  - Symptom 5

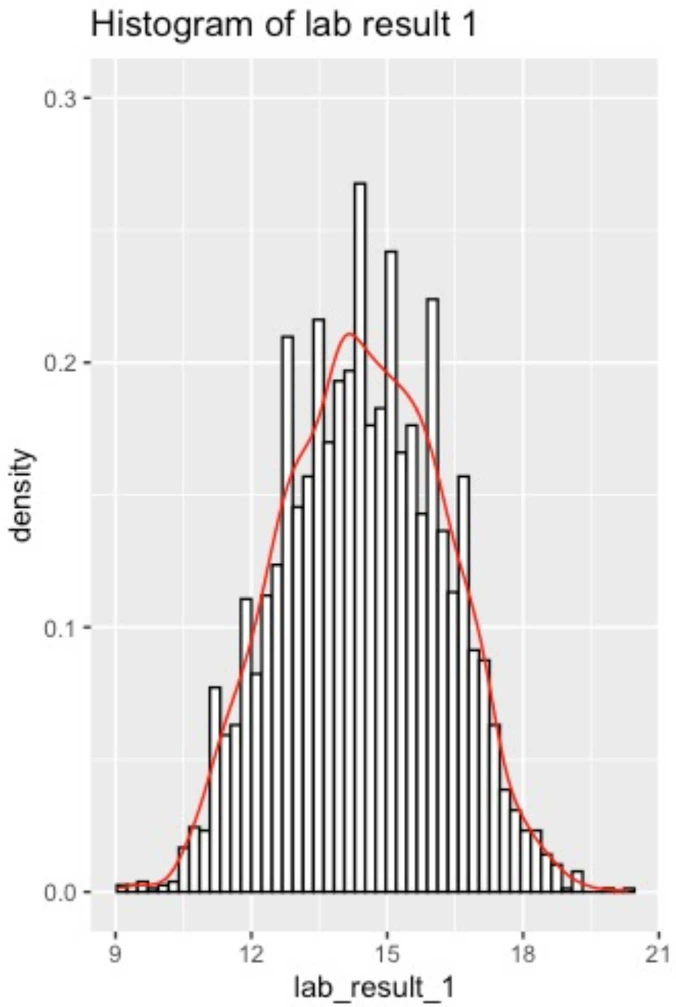
Continuous Variables - Amount



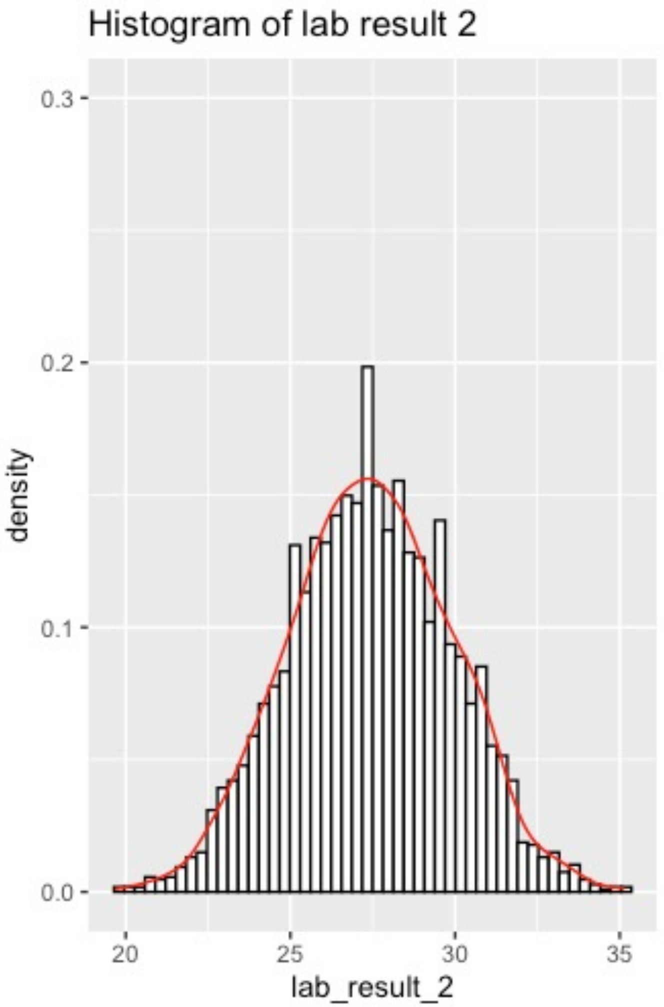


Due to the right skewedness of bill amount, log(amount) is taken to approximate normal distribution

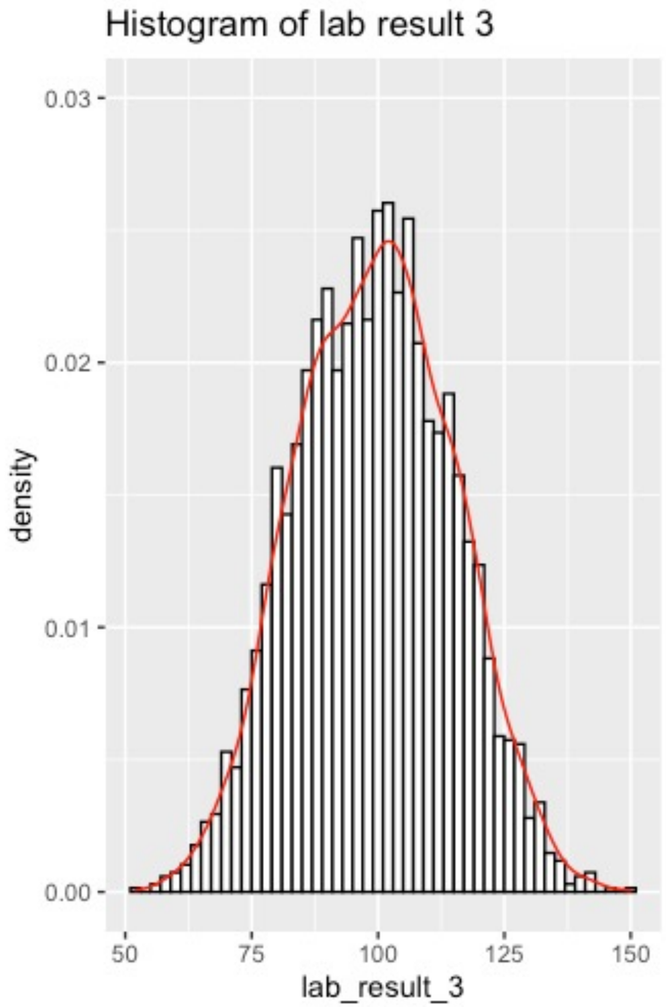
Continuous Variables – Lab Results 1 - 3



Histogram of lab result 1



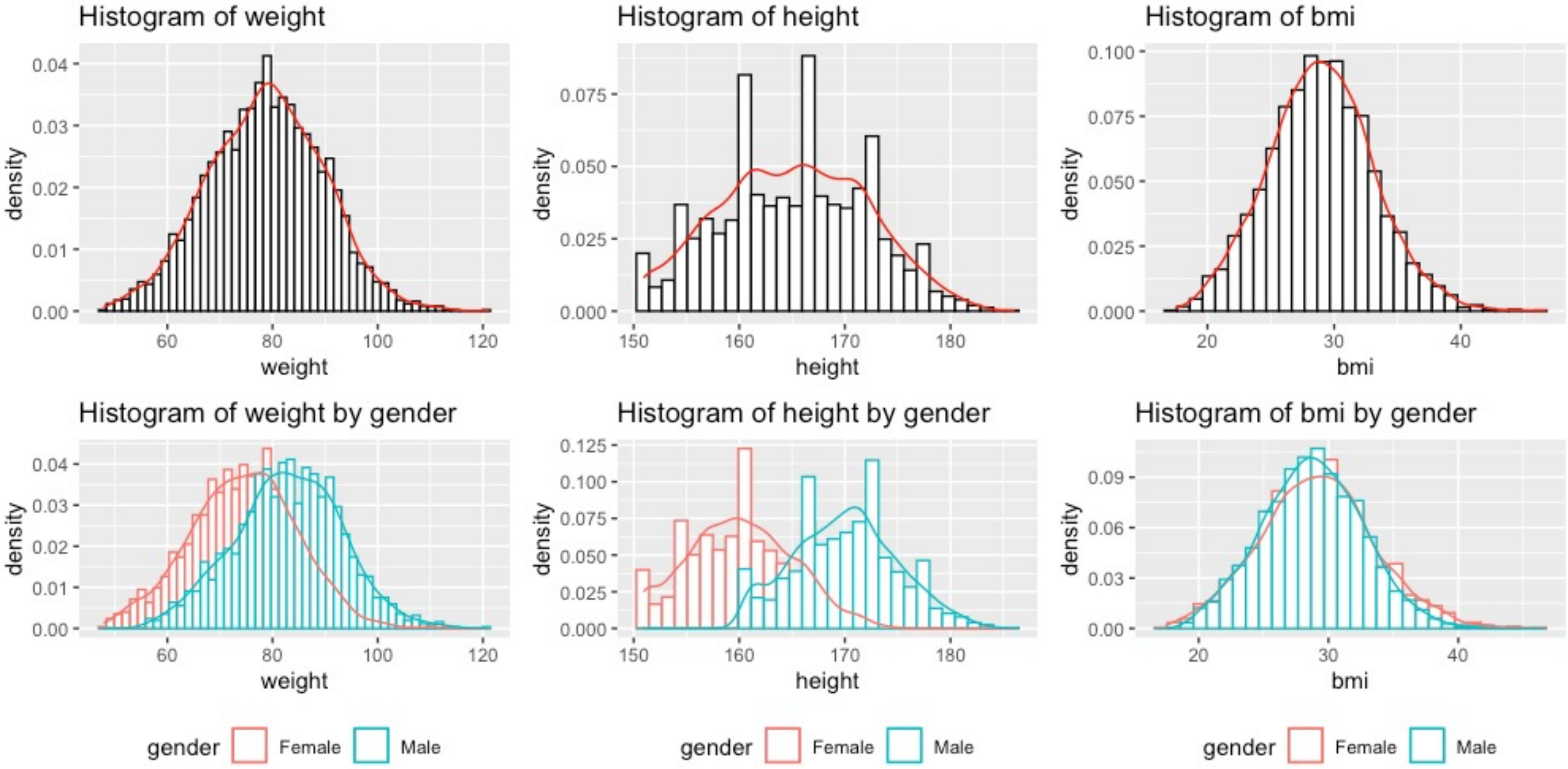
Histogram of lab result 2



Histogram of lab result 3

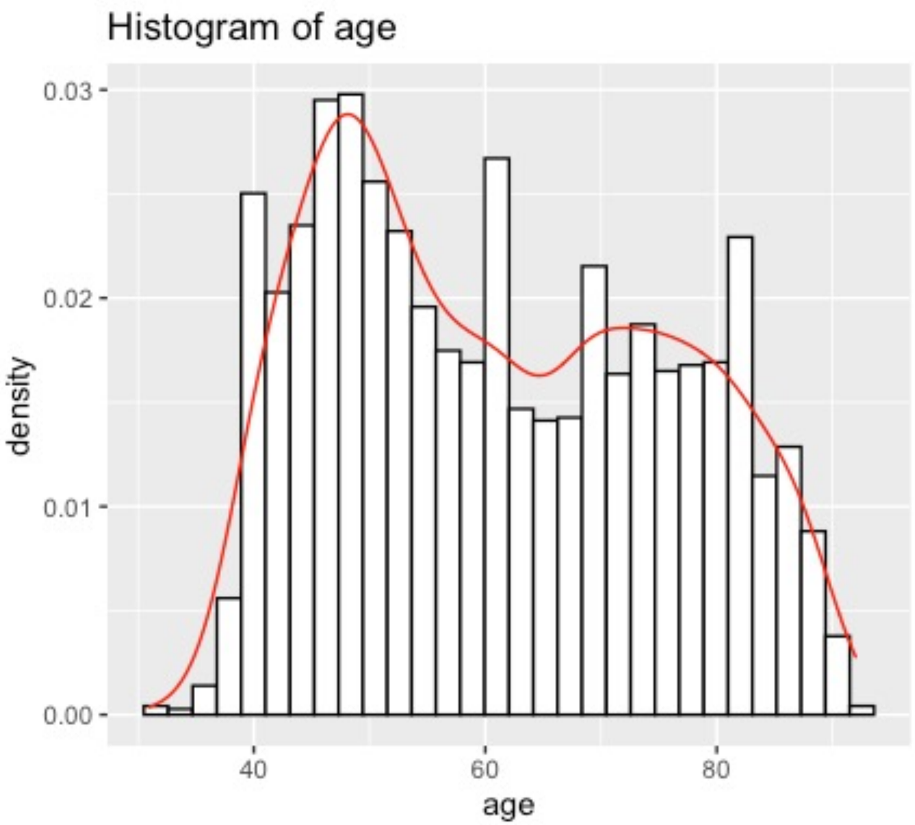
Lab results 1 to 3 all approximate normal distribution

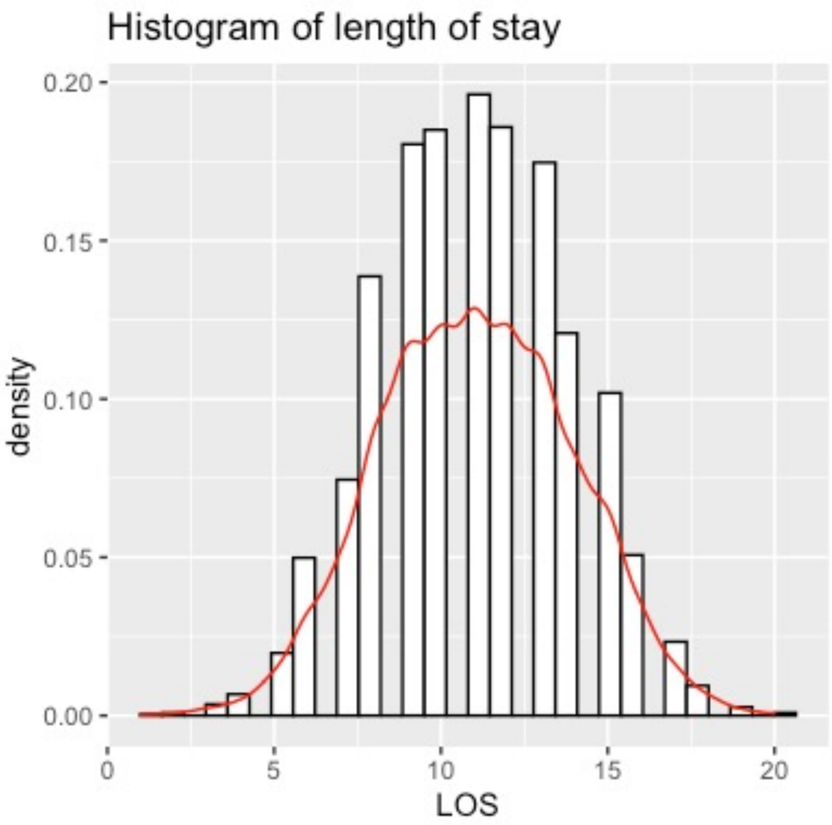
Continuous Variables – Weight, Height & BMI



- Weight and Height are both significantly associated with gender, whereas BMI between Female and Male shows no significant difference
- In the following analysis, BMI will be used instead of Weight and Height

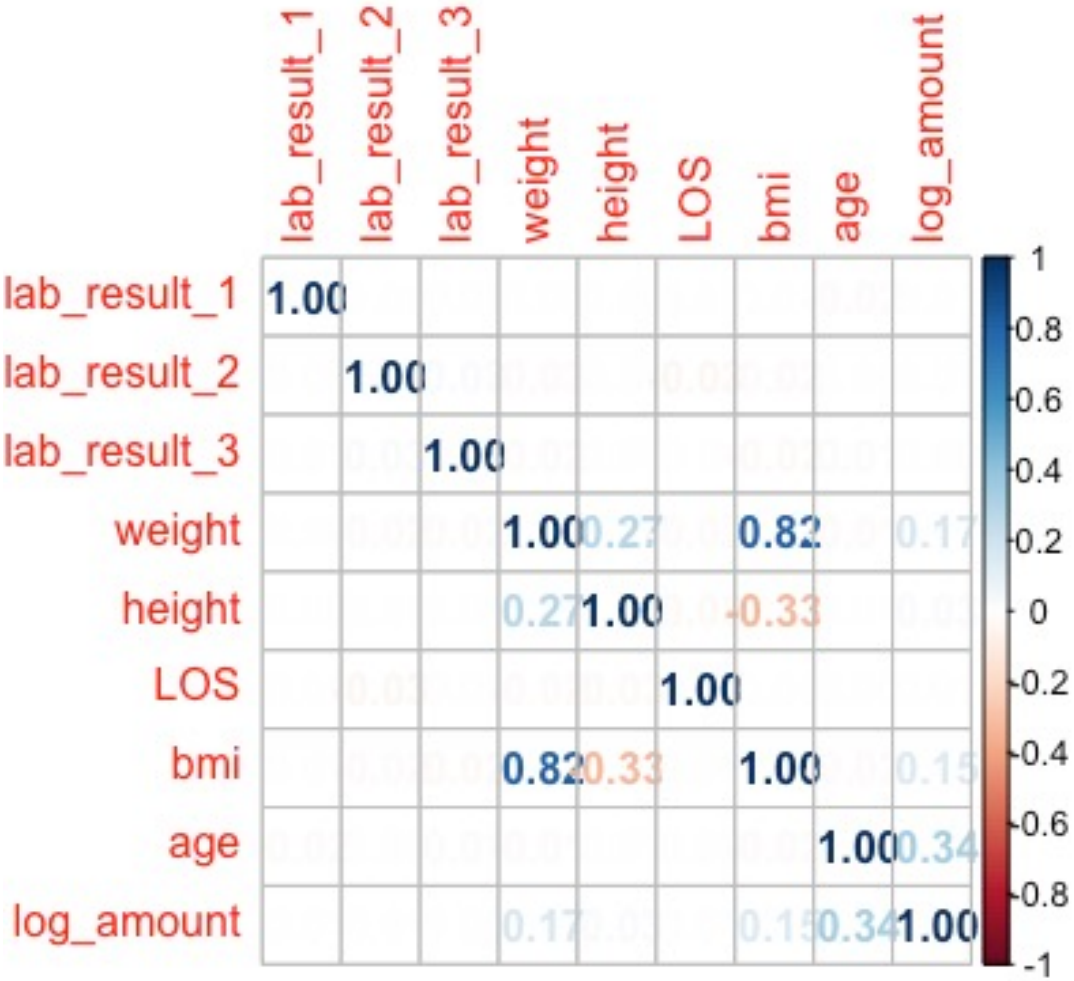
Continuous Variables – Age & Length of Stay





- Age approximates bi-modal normal distribution
- Length of stay approximates normal distribution when treated as continuous

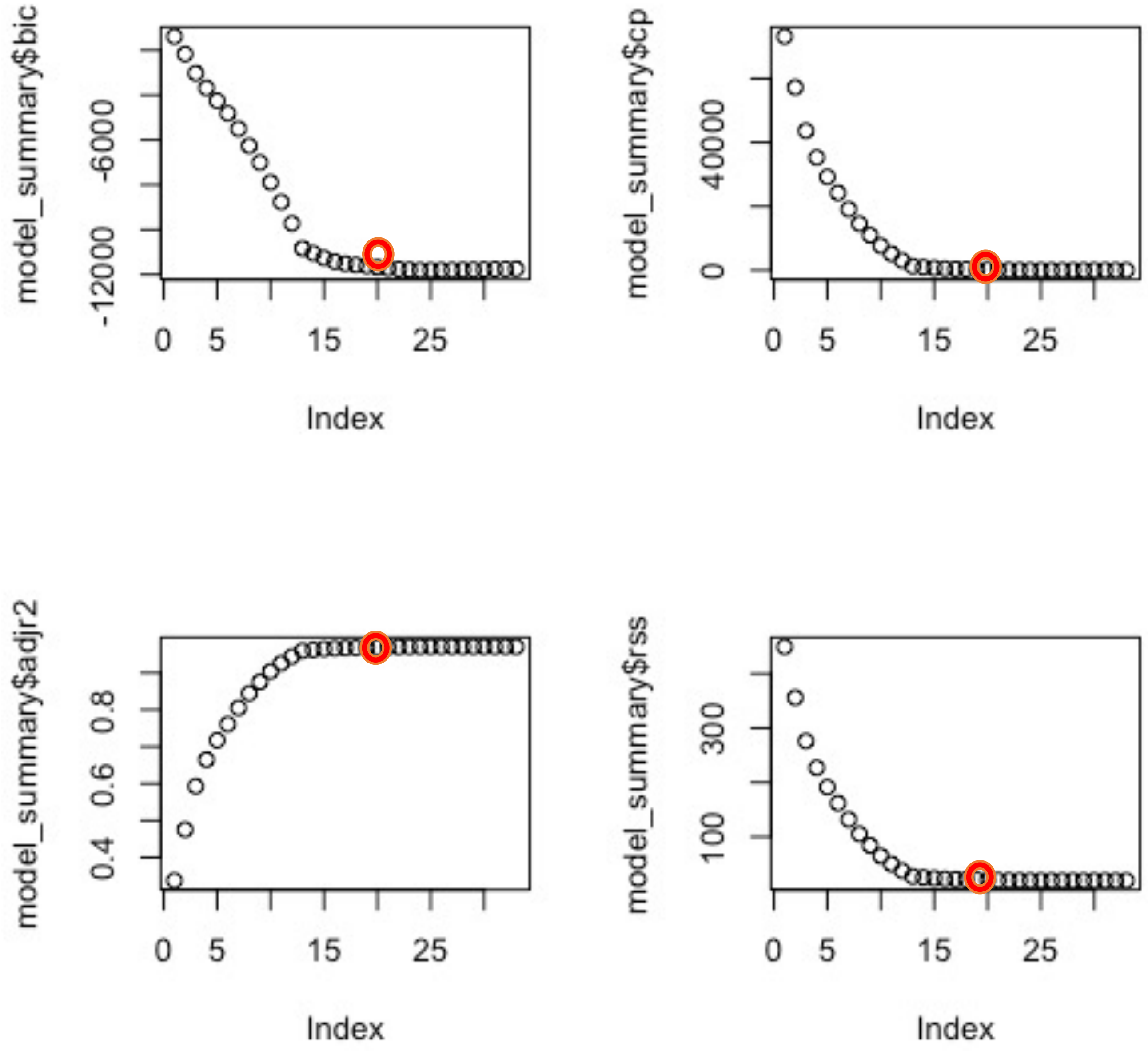
Correlation Among Continuous Variables



- Age is moderately associated with amount
- The other continuous variables do not show significant correlation with amount

Section 3 – Multi-Variable Linear Regression

Optimal Linear Regression Model



- Using regsubsets() function to identify the best linear models with different number of independent variables
- The 14th model with 12 variables is chosen due to a good balance of low BIC, low Cp, high Adjusted R square and low RSS

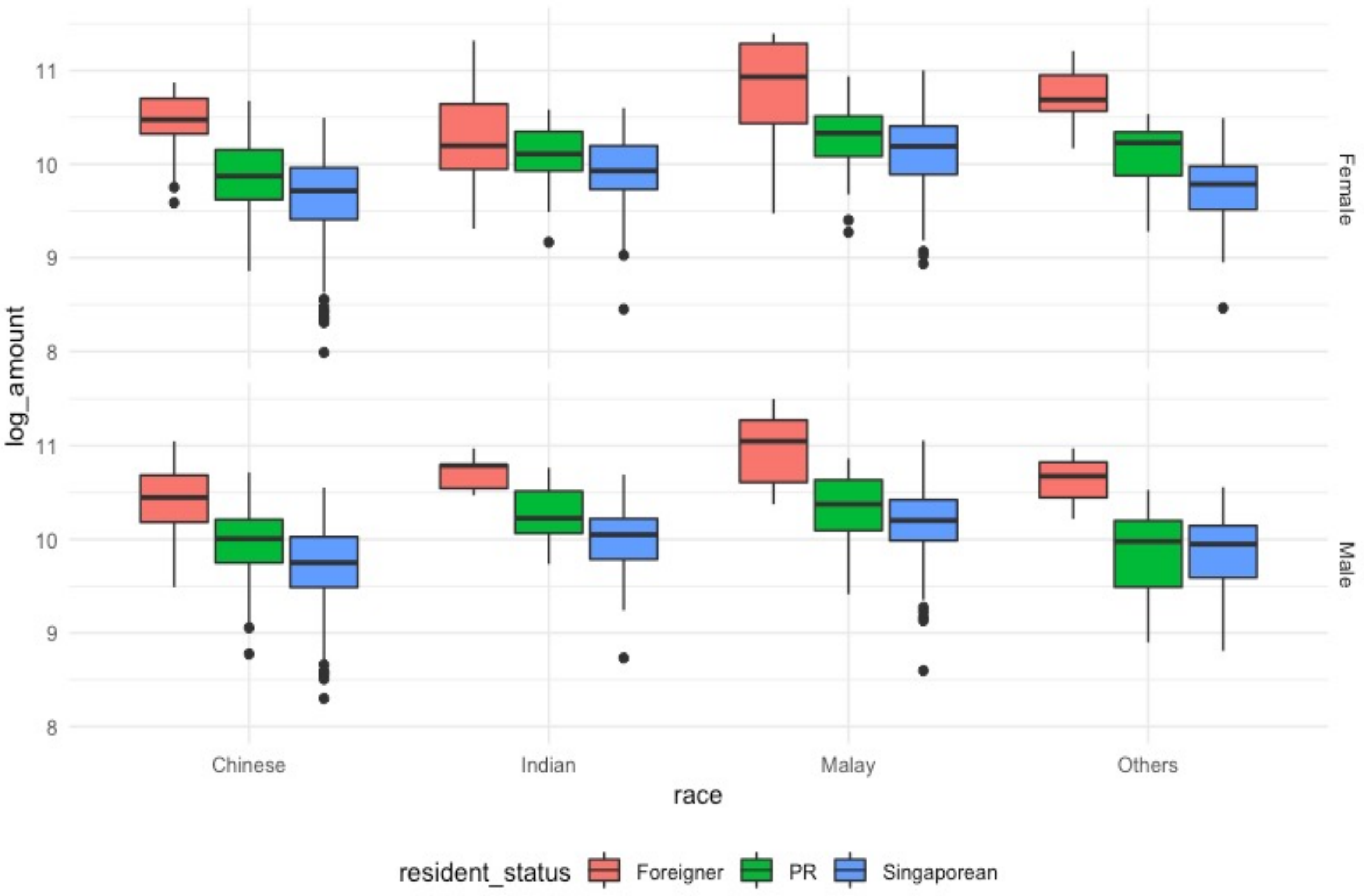
❑ Gender
❑ Race
❑ Resident status

❑ BMI
❑ Age

❑ Medical history 1
❑ Medical history 6

❑ Symptom 1
❑ Symptom 2
❑ Symptom 3
❑ Symptom 4
❑ Symptom 5

Amount versus Race grouped by Gender and Resident Status



- The median bill amount of Malays is the highest among all races
- Male has slightly higher median bill amount than female
- Foreigner has the highest median bill amount, followed by PR. Singaporean has the lowest median bill amount regardless of gender or race

Amount versus Race grouped by Gender and Resident Status

Resident Status:

- If government subsidy for Singaporean and PR is taken into consideration, the higher bill amount of Foreigners could potentially be explained by inaccessibility of subsidy scheme.
- If datasets originate from different hospitals including private and public hospitals, the sampled Foreigners might have a higher tendency to visit a private hospital than a public one, compared with Singaporean and PR.

Race:

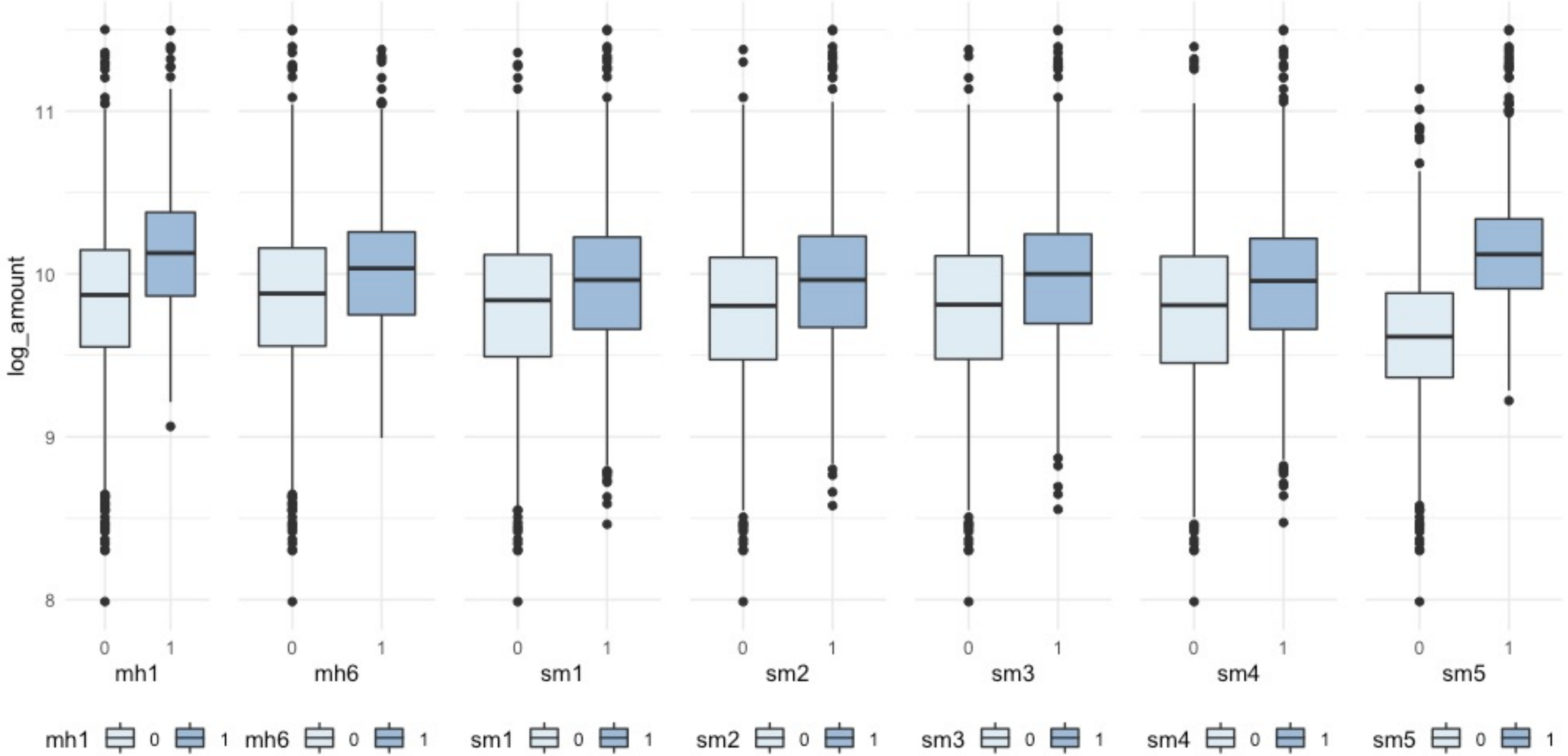
- Among all patients admitted for this particular condition, Malays might have a worse underlying health condition compared with the other races, which is not captured by any of the variable reported. As a result, more intensive care is needed for Malays and bill amount is increased.

Gender:

- Among all patients admitted by this particular condition, Male might have an overall worse health condition compared with Female.

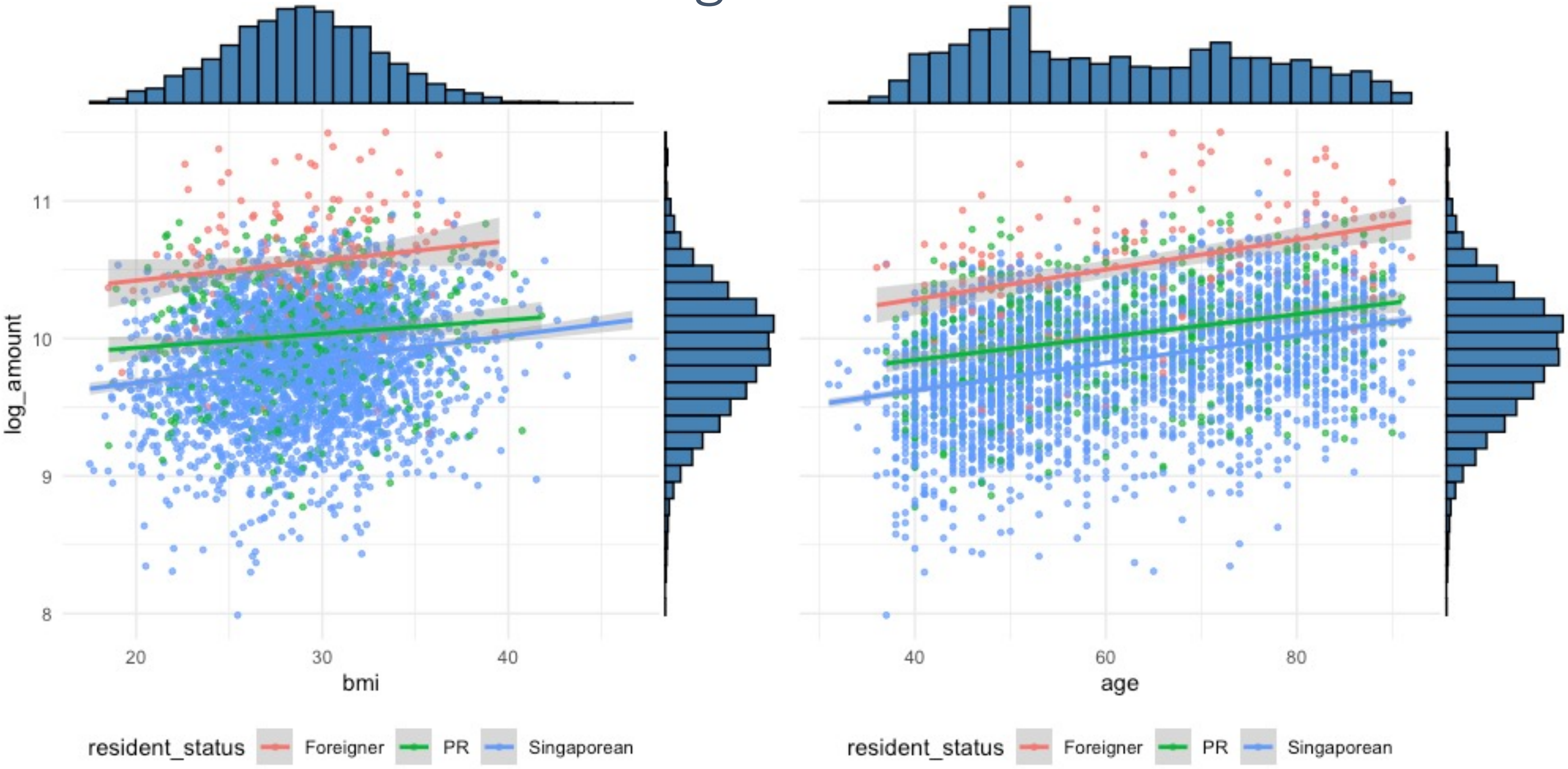
Relatively small sample size of Foreigners and Malays should be noted.

Amount versus Medical Histories and Symptoms



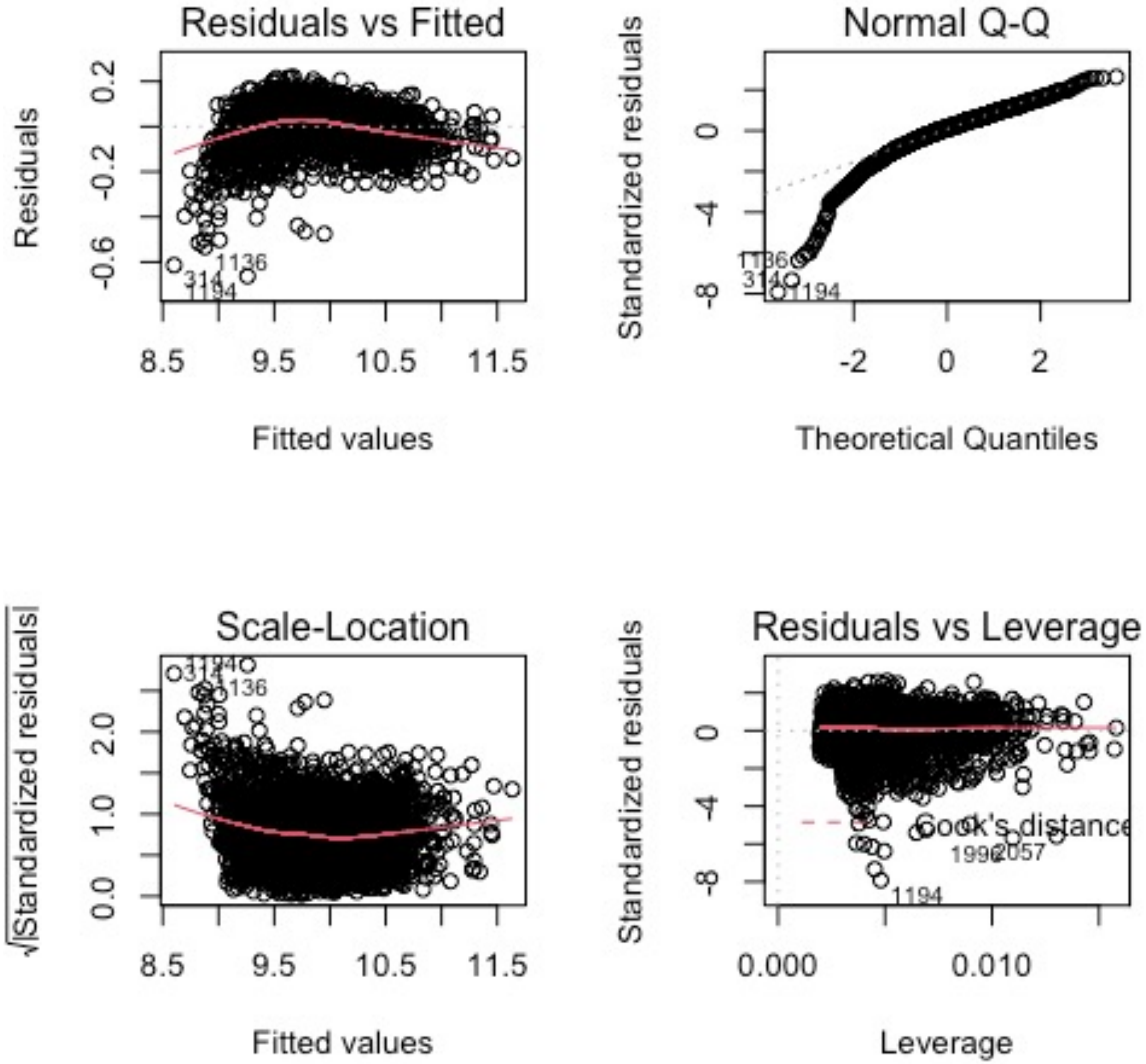
Presence of Medical History 1, Medical History 6 or any symptom from 1 to 5 would lead to a higher median bill amount

Amount versus BMI and Age



- BMI and Age are both positively correlated with bill amount.
- No significant difference observed in the magnitude of association for different Resident Status. Similar trend observed when grouped by Race and Gender.

Optimal Linear Regression Model - Limitation



- Diagnostic graphs indicating that data do not fit well into a multi-variable linear model.
- Nevertheless, linear model is a good starting point to identify the significant variables.