Predicting Recovery Time of Patients with Covid-19

Data Science II Final Project

Yi Huang, Yuchen Zhang, Shun Xie

May 8, 2023

Abstract

This project applies varies regression and classfication methods to predict the recovery time of participants with Covid-19 to estimate the recovery time of these participants. The ultimate goal is to develop a prediction model for recovery time and identify important risk factors for long recovery time. The dataset is from a study that combines three existing cohort studies that have been tracking participants for several years.

1 Introduction

1.1 Background

To gain a better understanding of the factors that predict recovery time from COVID-19 illness, a study was designed to combine three existing cohort studies that have been tracking participants for several years. The study collects recovery information through questionnaires and medical records, and leverages existing data on personal characteristics prior to the pandemic. The ultimate goal is to develop a prediction model for recovery time and identify important risk factors for long recovery time.

1.2 Data Description

The dataset is a random sample of 3593 participants draw from `"recovery.RData` includes 16 variables and 3593 observations.

Description of each variable:

- Gender (gender): 1 = Male, 0 = Female;
- Race/ethnicity (race): 1 = White, 2 = Asian, 3 = Black, 4 = Hispanic;
- Smoking (smoking): Smoking status; 0 = Never smoked, 1 = Former smoker, 2 = Current smoker;
- Height (height): Height (in centimeters);
- Weight (weight): Weight (in kilograms);
- BMI (bmi): Body Mass Index; BMI = weight (in kilograms) / height (in meters) squared;
- Hypertension (hypertension): 0 = No, 1 = Yes;
- Diabetes (diabetes): 0 = No, 1 = Yes;
- Systolic blood pressure (SBP): Systolic blood pressure (in mm/Hg);
- (10)LDL cholesterol (LDL): LDL (low-density lipoprotein) cholesterol (in mg/dL);
- Vaccination status at the time of infection (vaccine): 0 = Not vaccinated, 1 = Vaccinated;
- Severity of COVID-19 infection (severity): 0 = Not severe, 1= Severe;
- Study (study): The study (A/B/C) that the participant belongs to;
- Age: age of participants;
- Time to recovery (tt_recovery_time): Time from COVID-19 infection to recovery in days;
- ID: unique id of each participant.

1.3 Data Cleaning

Table 1: **Summary of Dataset by Study Group**

Characteristic	**A**, N = 729	**B**, N = 2,179	**C**, N = 685
age	60.0 (57.0, 63.0)	60.0 (57.0, 63.0)	60.0 (57.0, 63.0)
height	170 (166, 174)	170 (166, 174)	170 (166, 174)
weight	79 (75, 84)	80 (75, 85)	80 (76, 85)
bmi	27.50 (25.80, 29.30)	27.60 (25.80, 29.50)	27.80 (25.90, 29.50)
SBP	130 (125, 136)	130 (125, 136)	129 (124, 135)
LDL	111 (98, 125)	110 (97, 124)	110 (97, 123)
recovery_time	40 (33, 47)	38 (24, 55)	39 (33, 45)
gender			

Characteristic	**A**, N = 729	**B**, N = 2,179	**C**, N = 685
0	383 (53%)	1,099 (50%)	358 (52%)
1	346 (47%)	1,080 (50%)	327 (48%)
race			
1	491 (67%)	1,408 (65%)	447 (65%)
2	35 (4.8%)	107 (4.9%)	33 (4.8%)
3	146 (20%)	454 (21%)	142 (21%)
4	57 (7.8%)	210 (9.6%)	63 (9.2%)
smoking			
0	445 (61%)	1,316 (60%)	424 (62%)
1	210 (29%)	632 (29%)	201 (29%)
2	74 (10%)	231 (11%)	60 (8.8%)
hypertension			
0	378 (52%)	1,112 (51%)	399 (58%)
1	351 (48%)	1,067 (49%)	286 (42%)
diabetes			
0	606 (83%)	1,833 (84%)	573 (84%)
1	123 (17%)	346 (16%)	112 (16%)
vaccine			
0	299 (41%)	854 (39%)	281 (41%)
1	430 (59%)	1,325 (61%)	404 (59%)
severity			
0	640 (88%)	1,951 (90%)	623 (91%)
1	89 (12%)	228 (10%)	62 (9.1%)

2 Exploratory analysis and data visualization:

We consider the EDA for the training data, which we will use later on to train our models. Recovery data contains 6 continuous predictors, namely age, height, weight, bmi, Systolic blood pressure (SBP) and LDL cholesterol (LDL), as well as 8 discrete/factor predictors, namely gender, race, smoking, hypertension, diabetes, vaccine status, Severity of COVID-19 infection and study which the data belongs to. The response value is the time for recovery. It is a continuous variable. \

Distribution of data is included in appendix 1. In accordance to distribution of continuous variables, only the recovery time, which is the response, has a right skewed shape. All predictors are normally distributed with symmetric density plot. \

The correlation plot (only considers continuous variable), calculated from Pearson Correlation in appendix 2, gives an insight of linear correlation between continuous predictors and transformed recovery time. It can be seen that bmi and weight have a relatively weak positive relation with log recovery time whereas height may have a weak negative linear correlation with log recovery time. While linear trend may be sufficient in some cases, some data may show a non-linear correlation with log recovery time. As shown in appendix 3, weight and bmi is likely to have a non-linear correlation with the response, suggesting a motivation to consider non-linear method. Box plot in appendix 4 illustrates that most data have a small difference in median. People with smoking is likely to have a higher recovery time as it has a higher median and people that are vaccinated has a lower median recovery time than the people without vaccination. Thus, we include these factors in our study of predicting recovery time.

3 Model training for regression

This section describes the models used for predicting time to recovery from COVID-19. State the assumptions made by using the models and detailed description of the model training procedure and how to obtained the final model.

4 Results for regression

In this section, report the final model that you built for predicting time to recovery from COVID-19. Interpret the results. Assess the model's training/test performance.

5 Model training for classification

This section describes the models used for predicting time to recovery from COVID-19. State the assumptions made by using the models and detailed description of the model training procedure and how to obtained the final model.

6 Results for classification

In this section, report the final model that you built for predicting time to recovery from COVID-19. Interpret the results. Assess the model's training/test performance.

7 Conclusions and discussion

References

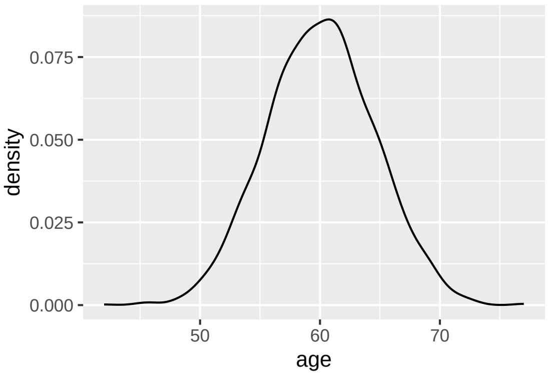
CDC Covid Data Tracker. (2021), Centers for Disease Control and Prevention.

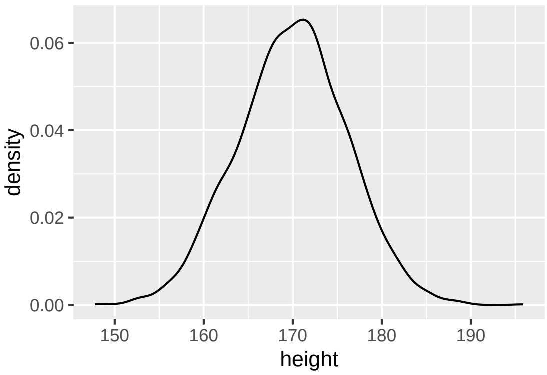
James, Gareth, e. a. (2021), An Introduction to Statistical Learning: With Applications in R., Springer.

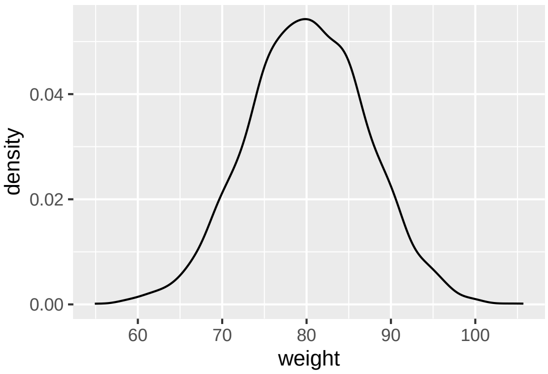
Pradhan, A. and Olsson., P.-E. (2021), 'Sex differences in severity and mortality from covid- 19: are males more vulnerable?', Biology of sex differences 11(1), 53.

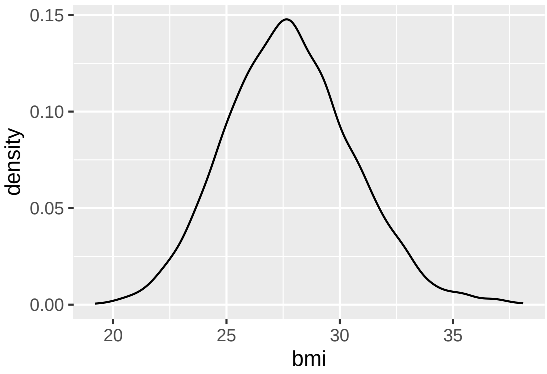
Appendix

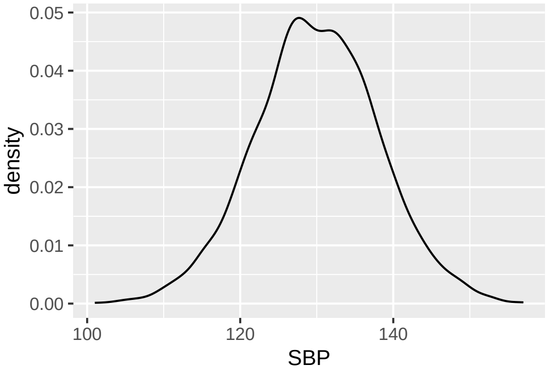
Appendix 1

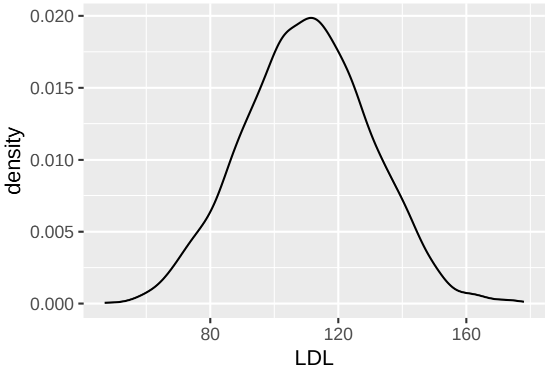

Distribution for age

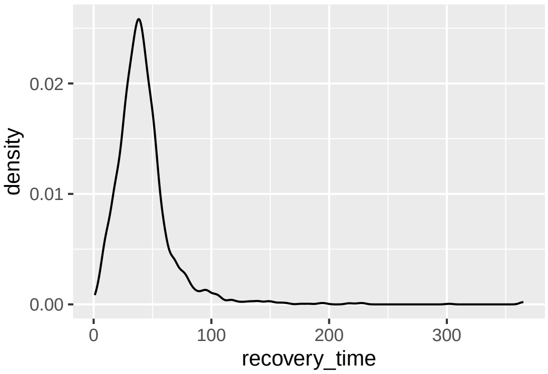

Distribution for height


Distribution for weight

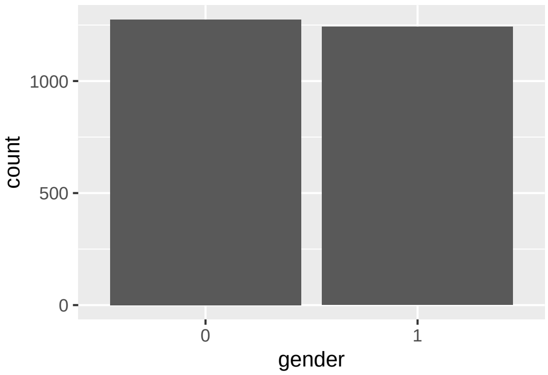

Distribution for bmi


Distribution for SBP

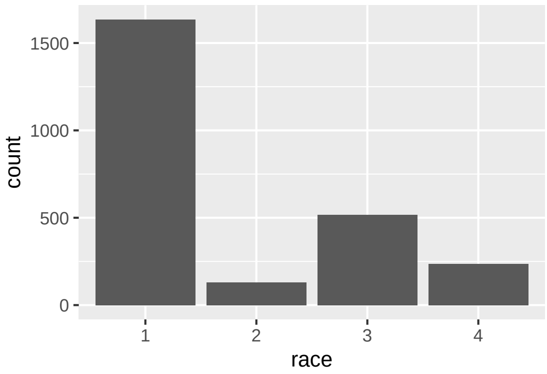

Distribution for LDL


Distribution for recovery_time

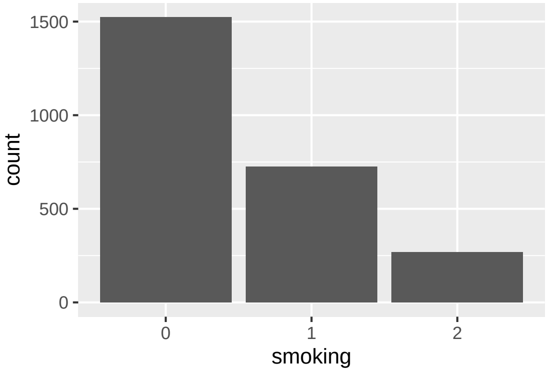
Bar plot for different gender



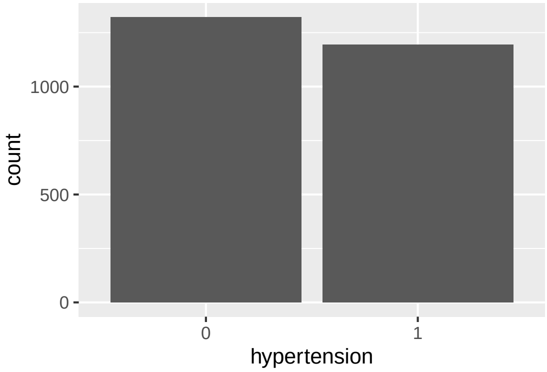
Bar plot for different race



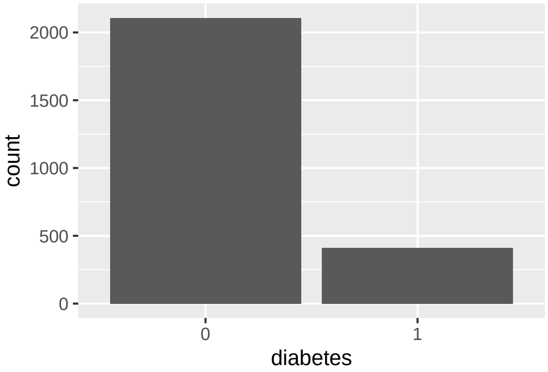
Bar plot for different smoking



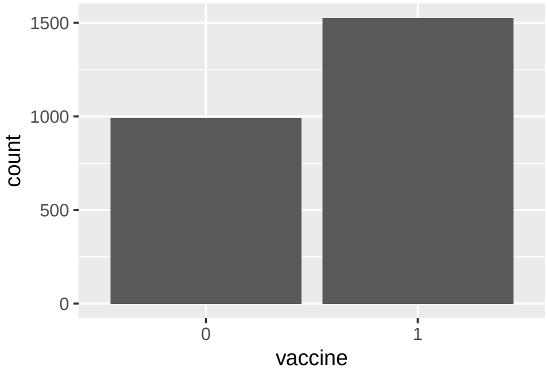
Bar plot for different hypertension



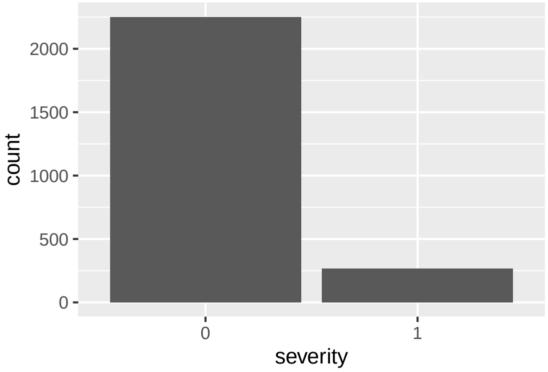
Bar plot for different diabetes



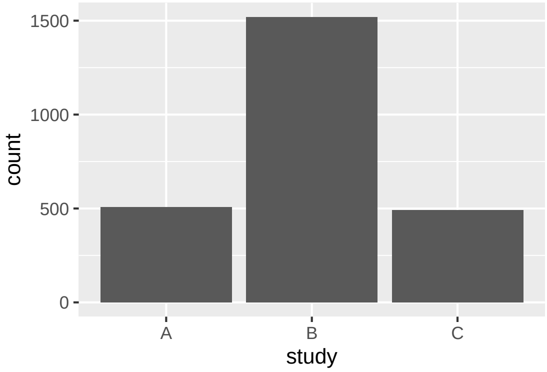
Bar plot for different vaccine



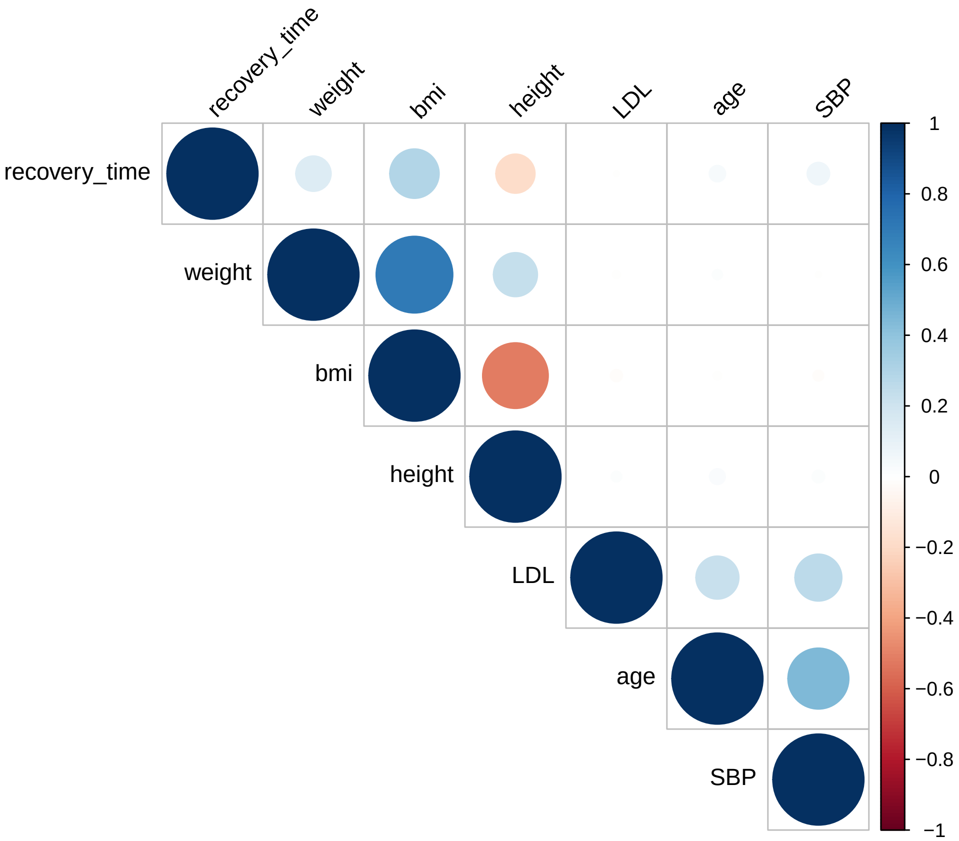
Bar plot for different severity



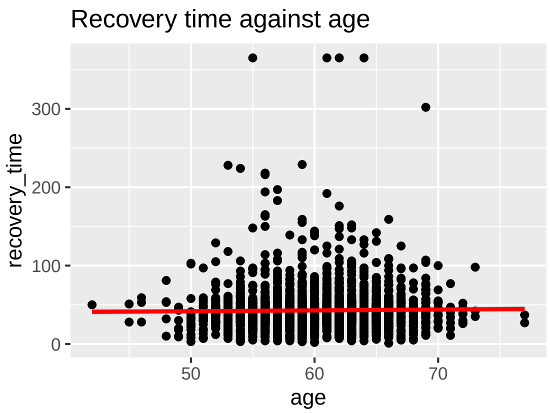
Bar plot for different study

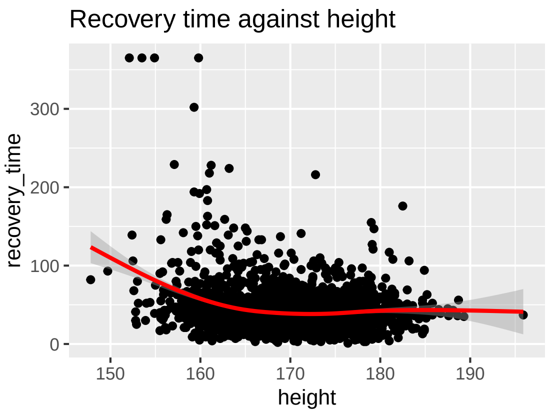


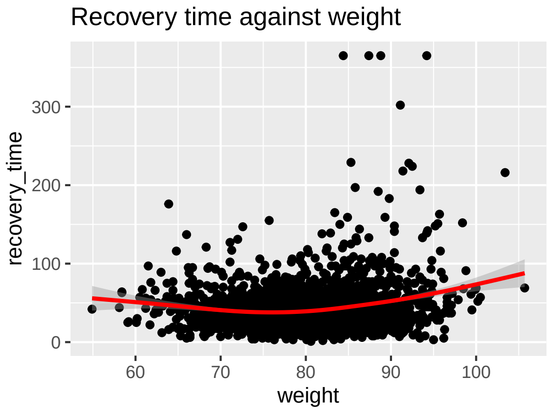
Appendix 2

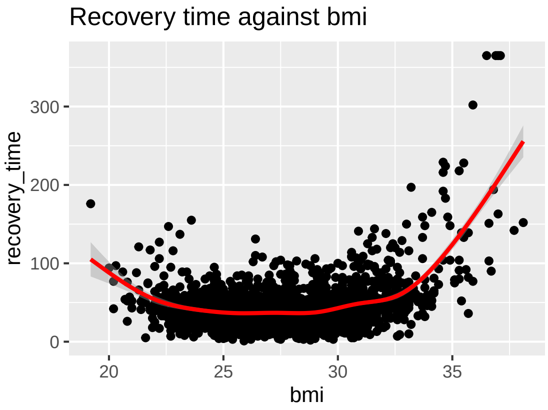

recovery_time
weight
bmi
height
LDL
age
SBP
recovery_time
weight
bmi
height
LDL
age
SBP
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1

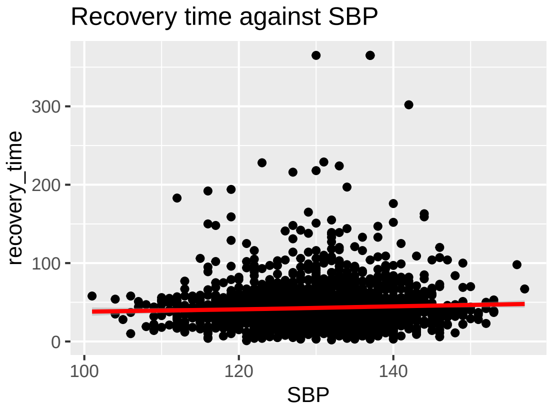
Appendix 3

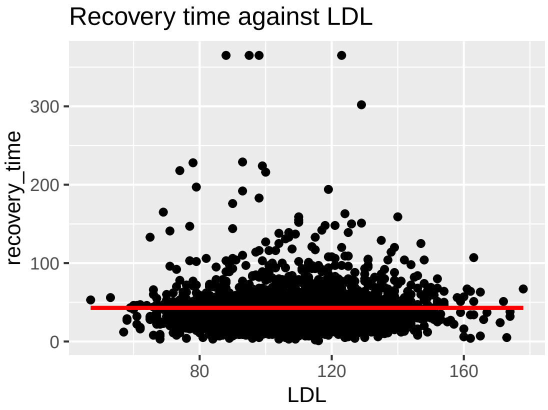

Recovery time against age
recovery_time
0
100
200
300
50
60
70
age


Recovery time against height
recovery_time
0
100
200
300
150
160
170
180
190
height

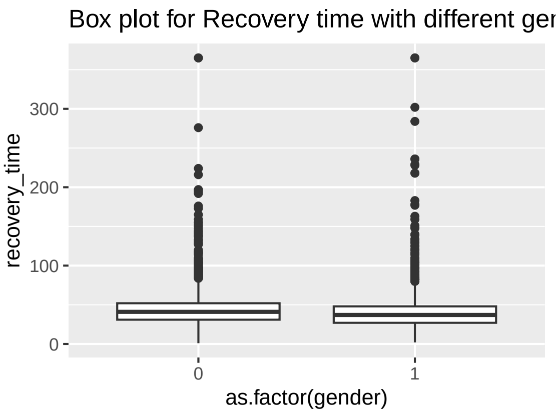

Recovery time against weight
recovery_time
0
100
200
300
60
70
80
90
100
weight

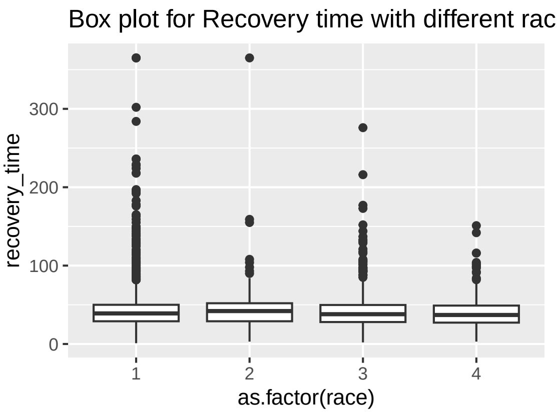

Recovery time against bmi
recovery_time
0
100
200
300
20
25
30
35
bmi

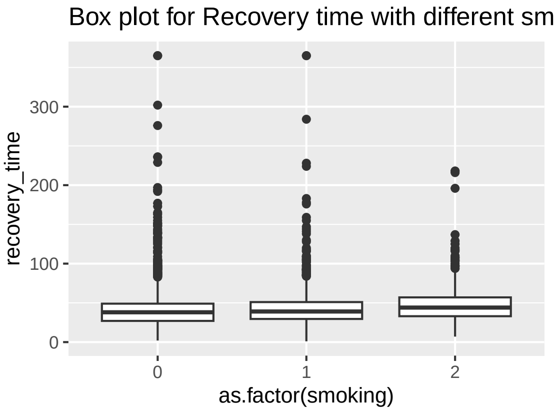

Recovery time against SBP
recovery_time
0
100
200
300
100
120
140
SBP

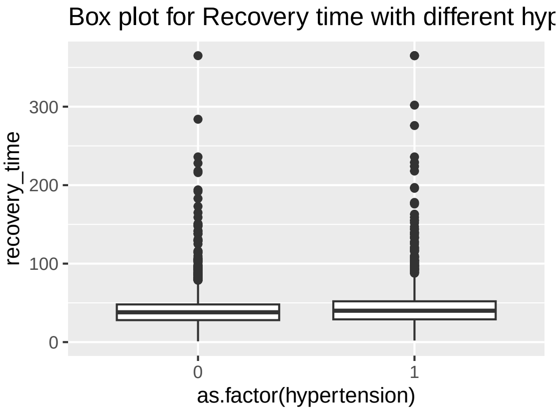

Recovery time against LDL
recovery_time
0
100
200
300
80
120
160
LDL

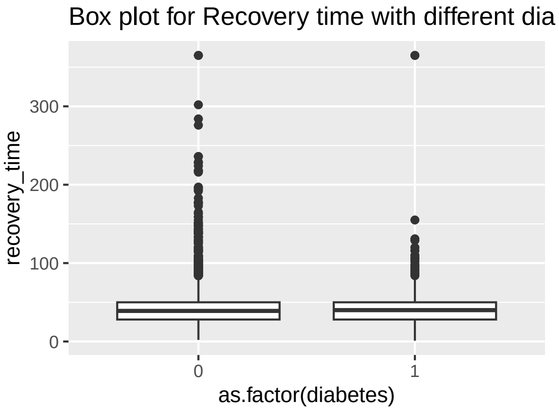
Appendix4

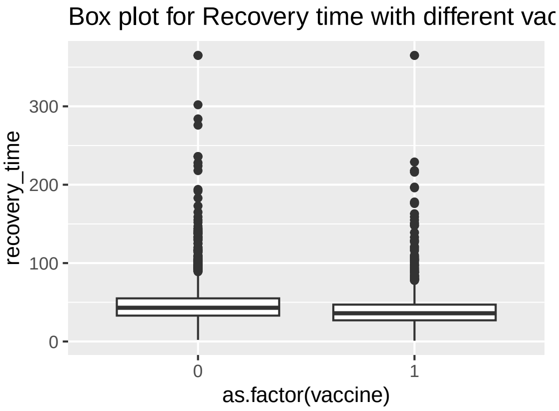

Box plot for Recovery time with different ger
recovery_time
0
100
200
300
0
1
as.factor(gender)

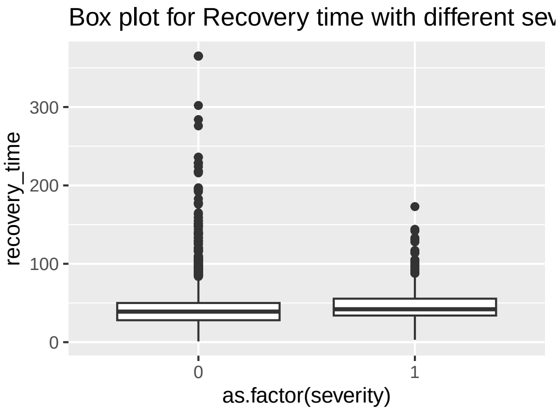

Box plot for Recovery time with different rac
recovery_time
0
100
200
300
1
2
3
4
as.factor(race)

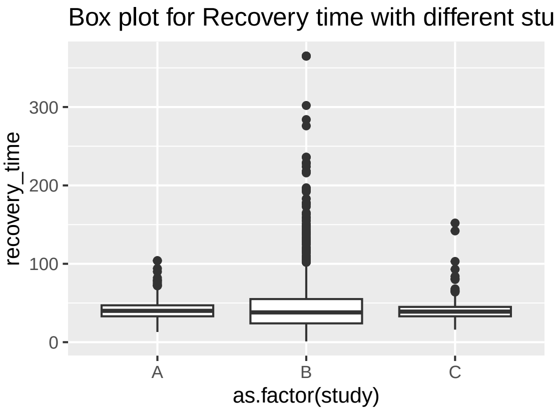

Box plot for Recovery time with different sm
recovery_time
0
100
200
300
0
1
2
as.factor(smoking)


Box plot for Recovery time with different hyp
recovery_time
0
100
200
300
0
1
as.factor(hypertension)


Box plot for Recovery time with different dia
recovery_time
0
100
200
300
0
1
as.factor(diabetes)


Box plot for Recovery time with different vac
recovery_time
0
100
200
300
0
1
as.factor(vaccine)


Box plot for Recovery time with different sev
recovery_time
0
100
200
300
0
1
as.factor(severity)


Box plot for Recovery time with different stu
recovery_time
0
100
200
300
A
B
C
as.factor(study)

A Appendix: Figure

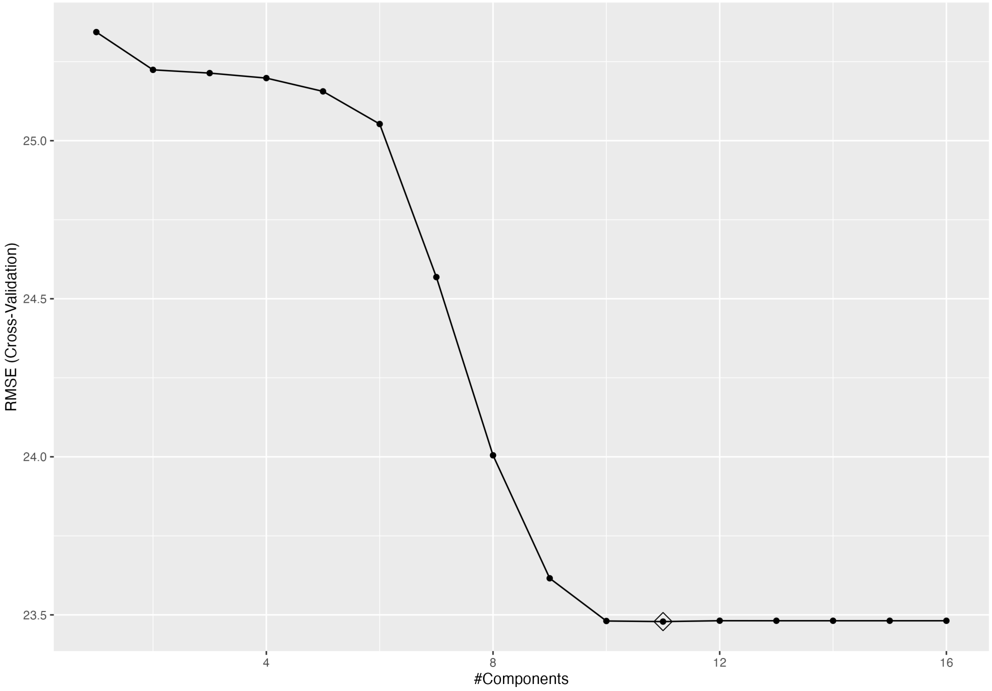


Figure 1: example

B Appendix: Code