# Predict Patients’ Revisit Tendency by Multiple Linear Regression, Stepwise Selection and Clustering

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# Data Description

- **1.1 Datasets**
- 1. bill_id (3 columns, 13600 entries)
- 2. bill_amount (2 columns, 13600 entries)
- 3. demographics (5 columns, 3000 entries)
- 4. clinical_data (26 columns, 3400 entries)

# Data Description

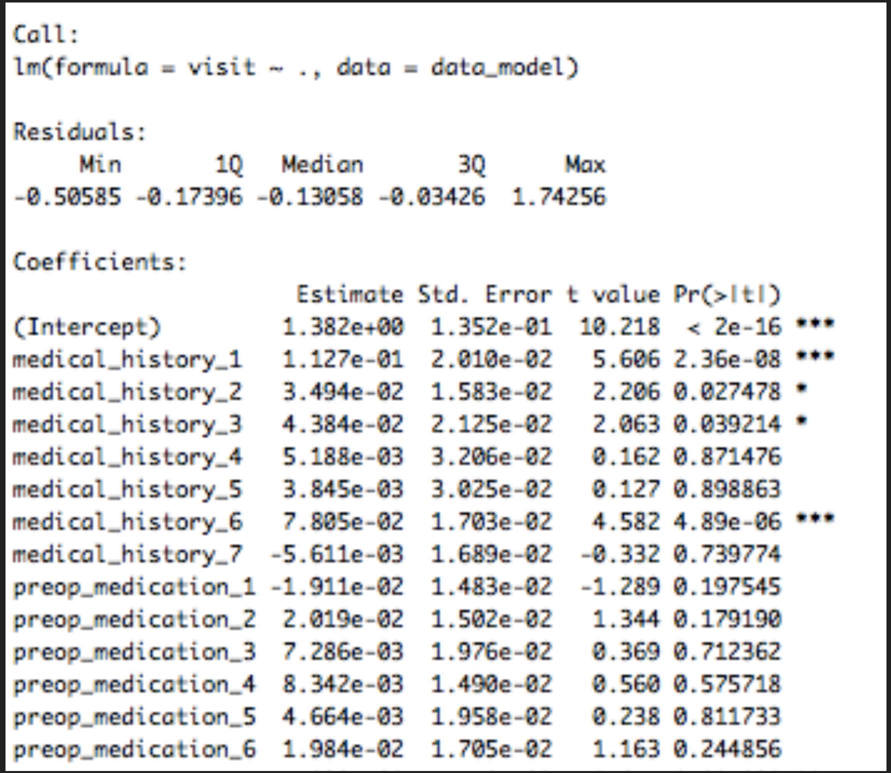
- **1.2 Data Pre-processing**
- Merge 4 datasets with patient_id being the key.
- Reserve latest entry of each patient in clinical_data
- Calculate total number of visits for each patient from 2012 to 2015
- Remove NAs
- **Final dataset contains 2555 complete data entries.**
- **2012-2014: training dataset (1979 entries)**
- **2015: testing dataset (576 entries).**

# Data Description

- **1.3 Variable Construction**
- 1. visit (dependent variable)
- 2. average_pay
- 3. age at the date_of_admission
- 4. bmi: weight/(height/100)^2
- 5. Dummies for gender, race, resident_status, bmi
- **The final dataset contains 43 variables, we selected 32 variables for model constructions.**

# Model Specification

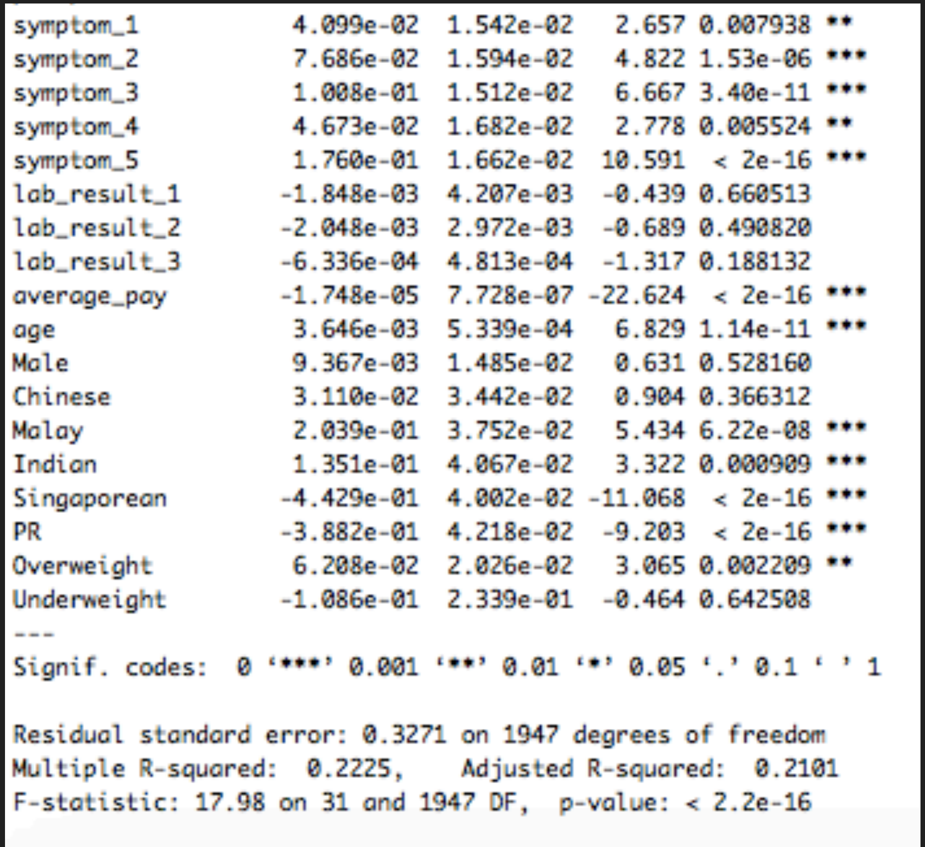
- 2.1 Multiple Linear Regression



```
Call:
lm(formula = visit ~ ., data = data_model)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.50585 -0.17396 -0.13058 -0.03426  1.74256 

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)    
(Intercept)          1.382e+00  1.352e-01  10.218  < 2e-16 ***
medical_history_1    1.127e-01  2.010e-02   5.606 2.36e-08 ***
medical_history_2    3.494e-02  1.583e-02   2.206 0.027478 *  
medical_history_3    4.384e-02  2.125e-02   2.063 0.039214 *  
medical_history_4    5.188e-03  3.206e-02   0.162 0.871476    
medical_history_5    3.845e-03  3.025e-02   0.127 0.898863    
medical_history_6    7.805e-02  1.703e-02   4.582 4.89e-06 ***
medical_history_7   -5.611e-03  1.689e-02  -0.332 0.739774    
preop_medication_1 -1.911e-02  1.483e-02  -1.289 0.197545    
preop_medication_2  2.019e-02  1.502e-02   1.344 0.179190    
preop_medication_3  7.286e-03  1.976e-02   0.369 0.712362    
preop_medication_4  8.342e-03  1.490e-02   0.560 0.575718    
preop_medication_5  4.664e-03  1.958e-02   0.238 0.811733    
preop_medication_6  1.984e-02  1.705e-02   1.163 0.244856    
```

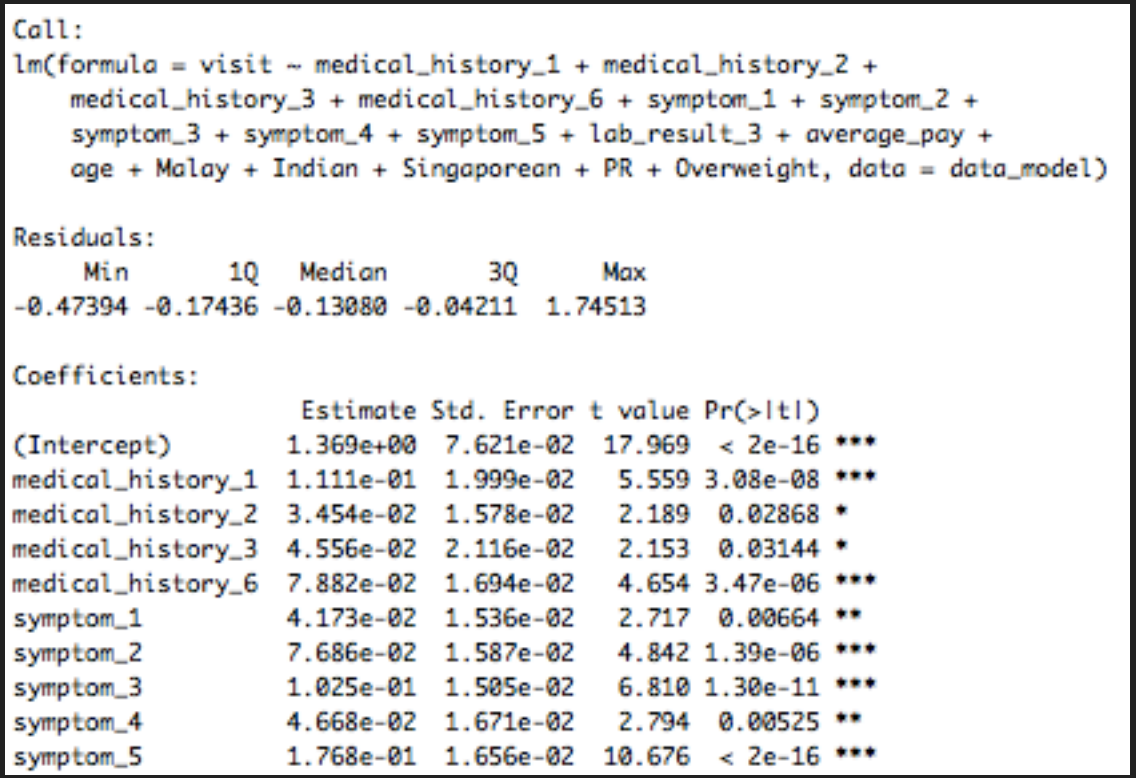


```
symptom_1           4.099e-02  1.542e-02   2.657 0.007938 ** 
symptom_2           7.686e-02  1.594e-02   4.822 1.53e-06 ***
symptom_3           1.008e-01  1.512e-02   6.667 3.40e-11 ***
symptom_4           4.673e-02  1.682e-02   2.778 0.005524 ** 
symptom_5           1.760e-01  1.662e-02  10.591  < 2e-16 ***
lab_result_1       -1.848e-03  4.207e-03  -0.439 0.660513    
lab_result_2       -2.048e-03  2.972e-03  -0.689 0.490820    
lab_result_3       -6.336e-04  4.813e-04  -1.317 0.188132    
average_pay        -1.748e-05  7.728e-07 -22.624  < 2e-16 ***
age                 3.646e-03  5.339e-04   6.829 1.14e-11 ***
Male                9.367e-03  1.485e-02   0.631 0.528160    
Chinese             3.110e-02  3.442e-02   0.904 0.366312    
Malay               2.039e-01  3.752e-02   5.434 6.22e-08 ***
Indian              1.351e-01  4.067e-02   3.322 0.000909 ***
Singaporean        -4.429e-01  4.002e-02 -11.068  < 2e-16 ***
PR                 -3.882e-01  4.218e-02  -9.203  < 2e-16 ***
Overweight          6.208e-02  2.026e-02   3.065 0.002209 ** 
Underweight        -1.086e-01  2.339e-01  -0.464 0.642508    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3271 on 1947 degrees of freedom
Multiple R-squared:  0.2225,	Adjusted R-squared:  0.2101 
F-statistic: 17.98 on 31 and 1947 DF,  p-value: < 2.2e-16
```

# Model Specification

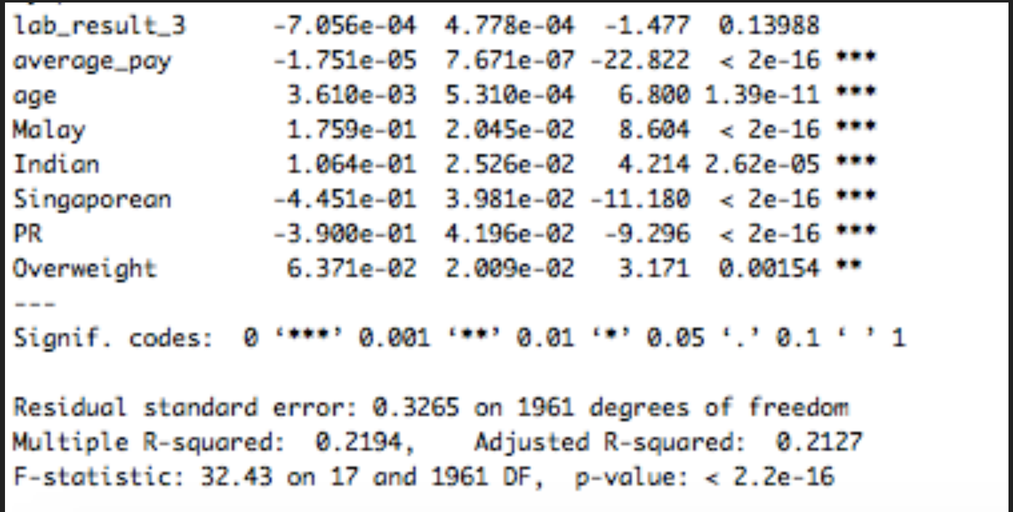
- 2.2 Stepwise Selection



```
Call:
lm(formula = visit ~ medical_history_1 + medical_history_2 + 
    medical_history_3 + medical_history_6 + symptom_1 + symptom_2 + 
    symptom_3 + symptom_4 + symptom_5 + lab_result_3 + average_pay + 
    age + Malay + Indian + Singaporean + PR + Overweight, data = data_model)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.47394 -0.17436 -0.13080 -0.04211  1.74513 

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)    
(Intercept)       1.369e+00  7.621e-02  17.969  < 2e-16 ***
medical_history_1 1.111e-01  1.999e-02   5.559 3.08e-08 ***
medical_history_2 3.454e-02  1.578e-02   2.189  0.02868 *  
medical_history_3 4.556e-02  2.116e-02   2.153  0.03144 *  
medical_history_6 7.882e-02  1.694e-02   4.654 3.47e-06 ***
symptom_1         4.173e-02  1.536e-02   2.717  0.00664 ** 
symptom_2         7.686e-02  1.587e-02   4.842 1.39e-06 ***
symptom_3         1.025e-01  1.505e-02   6.810 1.30e-11 ***
symptom_4         4.668e-02  1.671e-02   2.794  0.00525 ** 
symptom_5         1.768e-01  1.656e-02  10.676  < 2e-16 ***
```



```
lab_result_3     -7.056e-04  4.778e-04  -1.477  0.13988    
average_pay      -1.751e-05  7.671e-07 -22.822  < 2e-16 ***
age               3.610e-03  5.310e-04   6.800 1.39e-11 ***
Malay             1.759e-01  2.045e-02   8.604  < 2e-16 ***
Indian            1.064e-01  2.526e-02   4.214 2.62e-05 ***
Singaporean      -4.451e-01  3.981e-02 -11.180  < 2e-16 ***
PR               -3.900e-01  4.196e-02  -9.296  < 2e-16 ***
Overweight        6.371e-02  2.009e-02   3.171  0.00154 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3265 on 1961 degrees of freedom
Multiple R-squared:  0.2194,	Adjusted R-squared:  0.2127 
F-statistic: 32.43 on 17 and 1961 DF,  p-value: < 2.2e-16
```

# Model Specification

- 2.3 Clustering

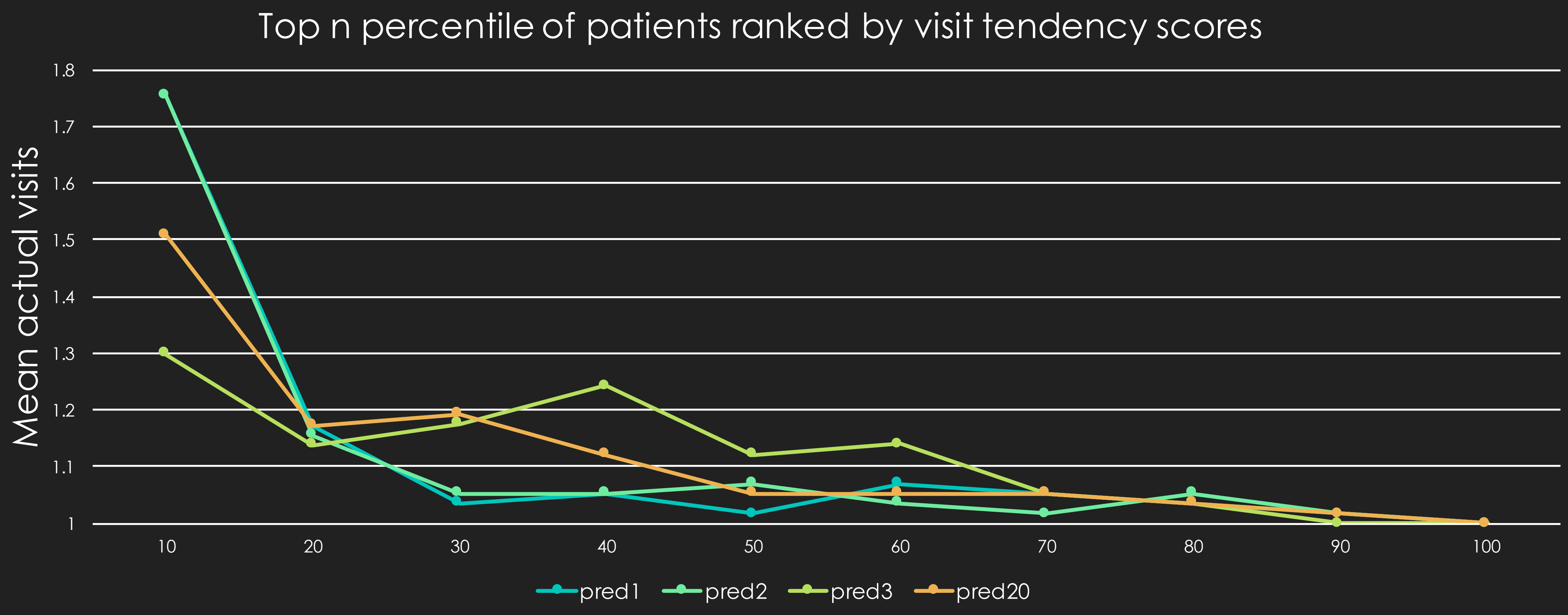
| | patient_id | X3 | X4 | … | X20 |
|---|---|---|---|---|---|
| 1 | 00225710a878eff524a1d13be817e8e2 | 3 | 3 | … | 8 |
| 2 | 0029d90eb654699c18001c17efb0f129 | 2 | 2 | … | 19 |
| 3 | 0040333abd68527ecb53e1db9073f52e | 3 | 3 | … | 14 |

# Model Specification

- 2.3 Clustering

| Number of clusters/ Cluster number | Tendency Score computed for each cluster | | | |
|---|---|---|---|---|
| | 3 | 4 | … | 20 |
| **1** | 1 | 1 | … | 1 |
| **2** | 1.020028612 | 1.040207523 | … | 1.117241379 |
| **3** | 1.222896791 | 1.280046674 | … | 1.030487805 |
| **4** | NA | 1 | … | 1 |
| **…** | … | … | … | … |
| **20** | NA | NA | … | 1.024193548 |

# Model Evaluation



# Conclusion

- By identifying groups of customers with higher tendency to be re-admitted to hospital, the hospital could provide consultancy services for the targeted group in advance to
- **Suggest the target patients to do health checks regularly**
- **Supervise on patients' health condition to arrest the growth of disease**