Group Project 2

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Contents

1 Introduction

The total number of people living in a household can be influenced by multiple variables. In certain cases, a specific type of variable may have a significant impact, which can be determined by different actual situations. By studying the correlation between variables, we can examine the living characteristics of local people.

In this dataset, we notice that six numeric variables are displayed, so we initially consider all of them. We plan to apply a generalized linear model to fit the data and discover the relevance of the variables.

At the same time, we should take into account the interaction between variables. The interaction between variables can sometimes provide insights that may not be evident when considering each variable independently. By including interaction terms in our generalized linear model, we can better understand the combined effects of these variables on the total number of people living in a household. This can help us develop a more accurate and comprehensive understanding of the factors that influence household size in the area under study.

This project begins with an expalnatory analysis into the data including data graphics and summaries in **??**. The formal analysis has been procured in a GLM model at which will be seen in sections **??** and **??**.

2 Exploratory Data Analysis

2.1 Data Mining

```
spc_tbl_ [1,725 x 11] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
 $ Total.Household.Income        : num [1:1725] 480332 198235 82785 107589 189322 ...
 $ Region                        : chr [1:1725] "CAR" "CAR" "CAR" "CAR" ...
 $ Total.Food.Expenditure        : num [1:1725] 117848 67766 61609 78189 94625 ...
 $ Household.Head.Sex            : chr [1:1725] "Female" "Male" "Male" "Male" ...
 $ Household.Head.Age            : num [1:1725] 49 40 39 52 65 46 45 33 17 53 ...
 $ Type.of.Household             : chr [1:1725] "Extended Family" "Single Family" "Single Family" "Sing
 $ Total.Number.of.Family.members: num [1:1725] 4 3 6 3 4 4 5 5 2 6 ...
 $ House.Floor.Area              : num [1:1725] 80 42 35 30 54 40 35 35 35 70 ...
 $ House.Age                     : num [1:1725] 75 15 12 15 16 7 18 48 8 12 ...
 $ Number.of.bedrooms            : num [1:1725] 3 2 1 1 3 2 1 2 1 3 ...
 $ Electricity                   : num [1:1725] 1 1 0 1 1 1 1 1 1 1 ...
 - attr(*, "spec")=
  .. cols(
  ..   Total.Household.Income = col_double(),
  ..   Region = col_character(),
  ..   Total.Food.Expenditure = col_double(),
  ..   Household.Head.Sex = col_character(),
  ..   Household.Head.Age = col_double(),
  ..   Type.of.Household = col_character(),
  ..   Total.Number.of.Family.members = col_double(),
  ..   House.Floor.Area = col_double(),
  ..   House.Age = col_double(),
  ..   Number.of.bedrooms = col_double(),
  ..   Electricity = col_double()
  .. )
 - attr(*, "problems")=<externalptr>
```

```
 Total.Household.Income    Region          Total.Food.Expenditure
 Min.   :  11988       Length:1725        Min.   :  6781
 1st Qu.: 118565       Class :character   1st Qu.: 51922
 Median : 188580       Mode  :character   Median : 73578
 Mean   : 269540                          Mean   : 80353
 3rd Qu.: 328335                          3rd Qu.: 98493
 Max.   :6042860                          Max.   :327724
 Household.Head.Sex Household.Head.Age Type.of.Household
 Length:1725        Min.   :17.00      Length:1725
 Class :character   1st Qu.:41.00      Class :character
 Mode  :character   Median :52.00      Mode  :character
                    Mean   :52.23
                    3rd Qu.:63.00
                    Max.   :99.00
 Total.Number.of.Family.members House.Floor.Area   House.Age
 Min.   : 1.000                 Min.   :  5.00   Min.   :  0.00
 1st Qu.: 3.000                 1st Qu.: 32.00   1st Qu.: 12.00
 Median : 4.000                 Median : 54.00   Median : 20.00
 Mean   : 4.669                 Mean   : 90.92   Mean   : 22.98
 3rd Qu.: 6.000                 3rd Qu.:102.00   3rd Qu.: 31.00
 Max.   :15.000                 Max.   :900.00   Max.   :100.00
```

```
Number.of.bedrooms  Electricity
Min.   :0.000      Min.   :0.0000
1st Qu.:1.000      1st Qu.:1.0000
Median :2.000      Median :1.0000
Mean   :2.259      Mean   :0.9252
3rd Qu.:3.000      3rd Qu.:1.0000
Max.   :9.000      Max.   :1.0000

Total.Household.Income Total.Food.Expenditure Household.Head.Age
Min.   :  11988        Min.   :  6781         Min.   :17.00
1st Qu.: 118565        1st Qu.: 51922         1st Qu.:41.00
Median : 188580        Median : 73578         Median :52.00
Mean   : 269540        Mean   : 80353         Mean   :52.23
3rd Qu.: 328335        3rd Qu.: 98493         3rd Qu.:63.00
Max.   :6042860        Max.   :327724         Max.   :99.00
Total.Number.of.Family.members House.Floor.Area   House.Age
Min.   : 1.000                 Min.   :  5.00   Min.   :  0.00
1st Qu.: 3.000                 1st Qu.: 32.00   1st Qu.: 12.00
Median : 4.000                 Median : 54.00   Median : 20.00
Mean   : 4.669                 Mean   : 90.92   Mean   : 22.98
3rd Qu.: 6.000                 3rd Qu.:102.00   3rd Qu.: 31.00
Max.   :15.000                 Max.   :900.00   Max.   :100.00
Number.of.bedrooms
Min.   :0.000
1st Qu.:1.000
Median :2.000
Mean   :2.259
3rd Qu.:3.000
Max.   :9.000
```

Table 1: Asian Health Data Summary Statistics for 2015.

Variable	n	Mean	SD	Min	Median	Max	IQR
Total.Household.Income	1725	269540.48	274564.17	11988	188580	6042860	139755
Total.Food.Expenditure	1725	80352.78	41194.36	6781	73578	327724	24915
Household.Head.Age	1725	52.23	14.52	17	52	99	11
Total.Number.of.Family.members	1725	4.67	2.33	1	4	15	2
House.Floor.Area	1725	90.92	99.20	5	54	900	48
House.Age	1725	22.98	15.32	0	20	100	11
Number.of.bedrooms	1725	2.26	1.44	0	2	9	1

To better understand the data at hand, various figures were created to provide visuals and illustrations. We begin with the scatterplots of each variable to understand the distribution of the data:

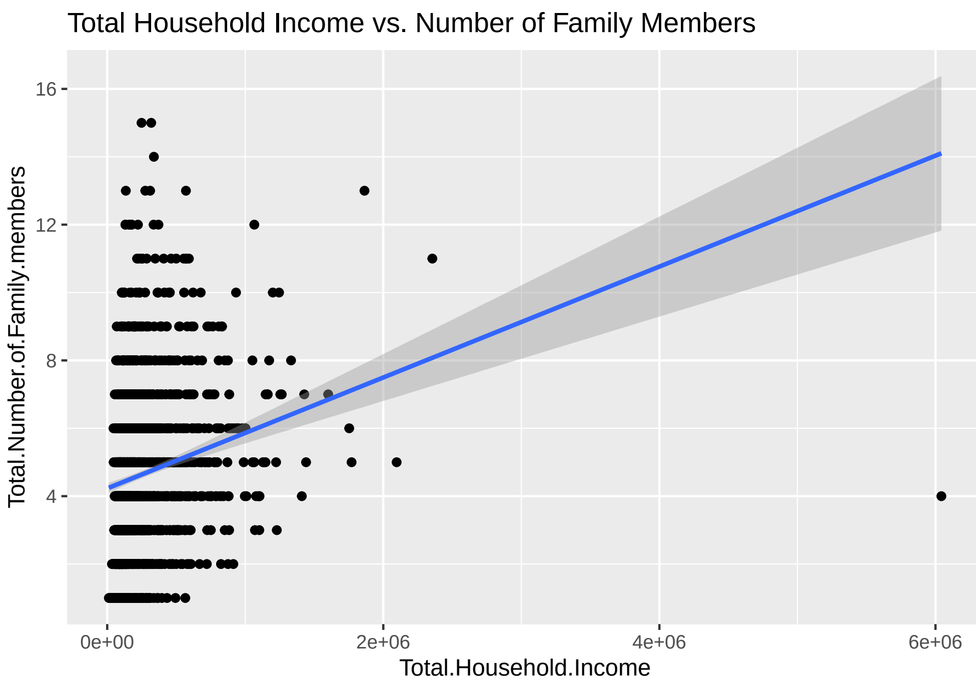


Figure 1: Scatterplots of Phillipine Family

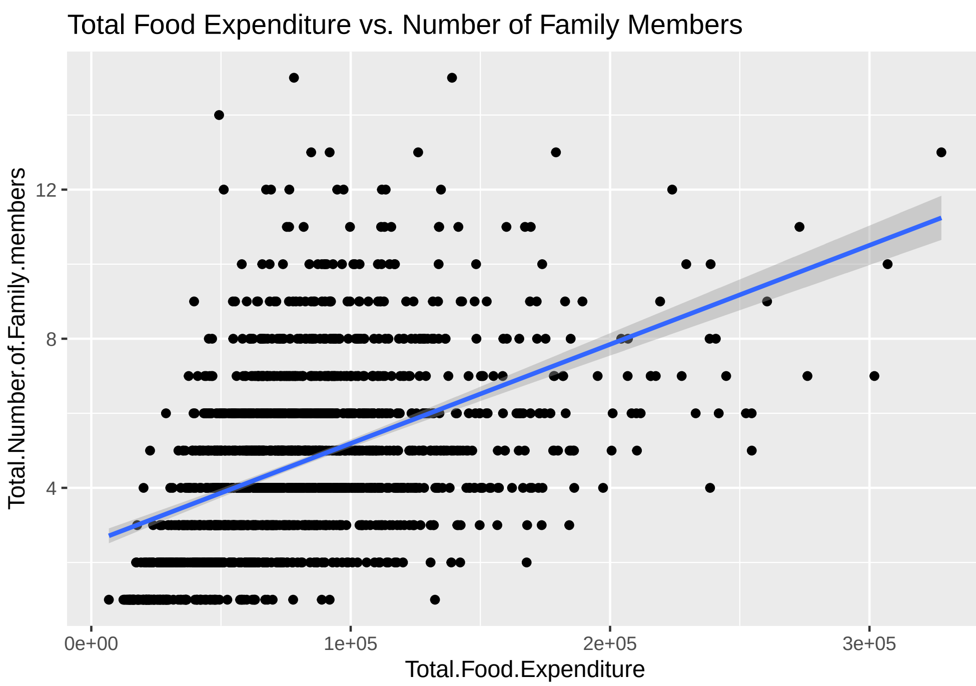


Figure 2: Scatterplots of Phillipine Family

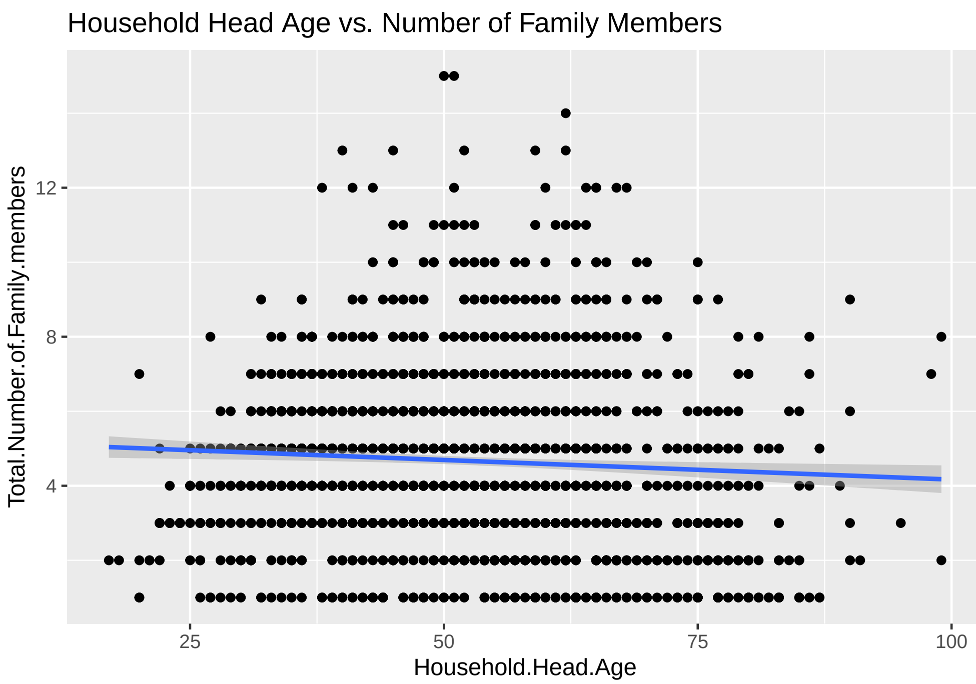


Figure 3: Scatterplots of Phillipine Family

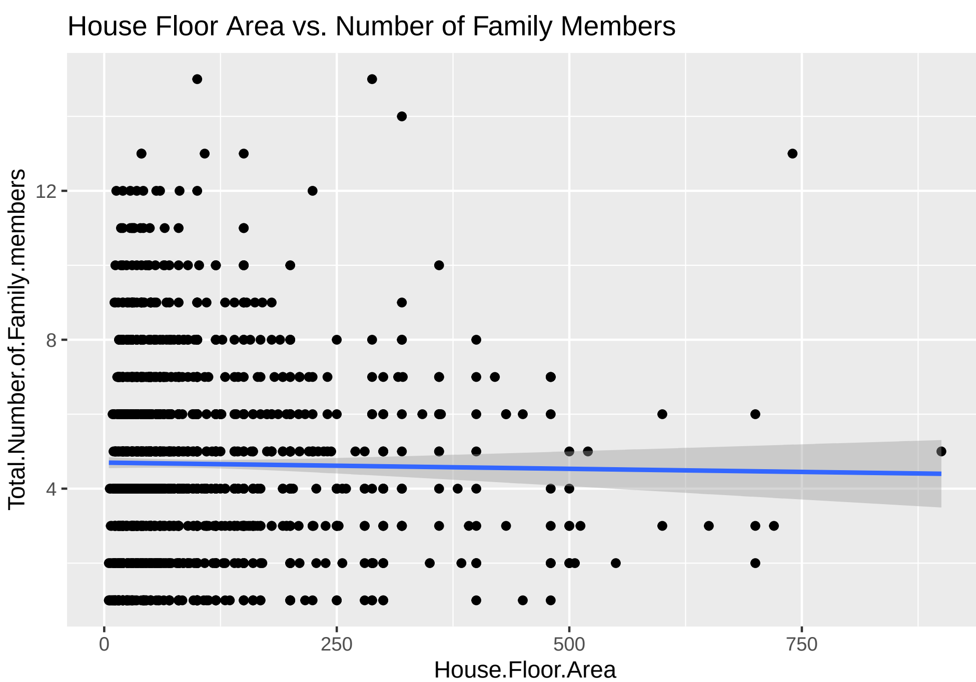


Figure 4: Scatterplots of Phillipine Family

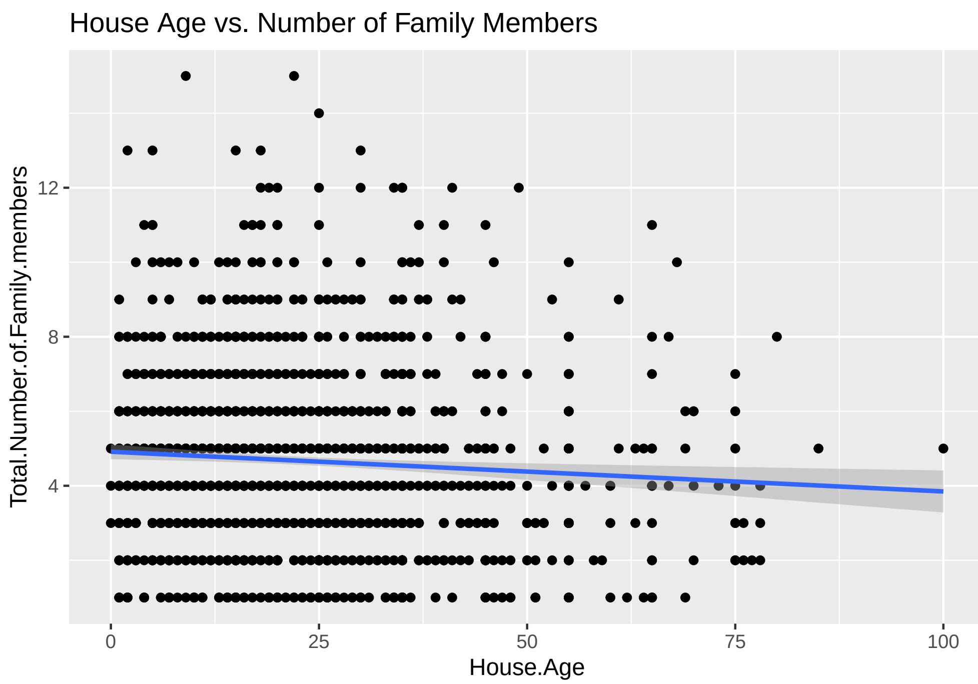


Figure 5: Scatterplots of Phillipine Family

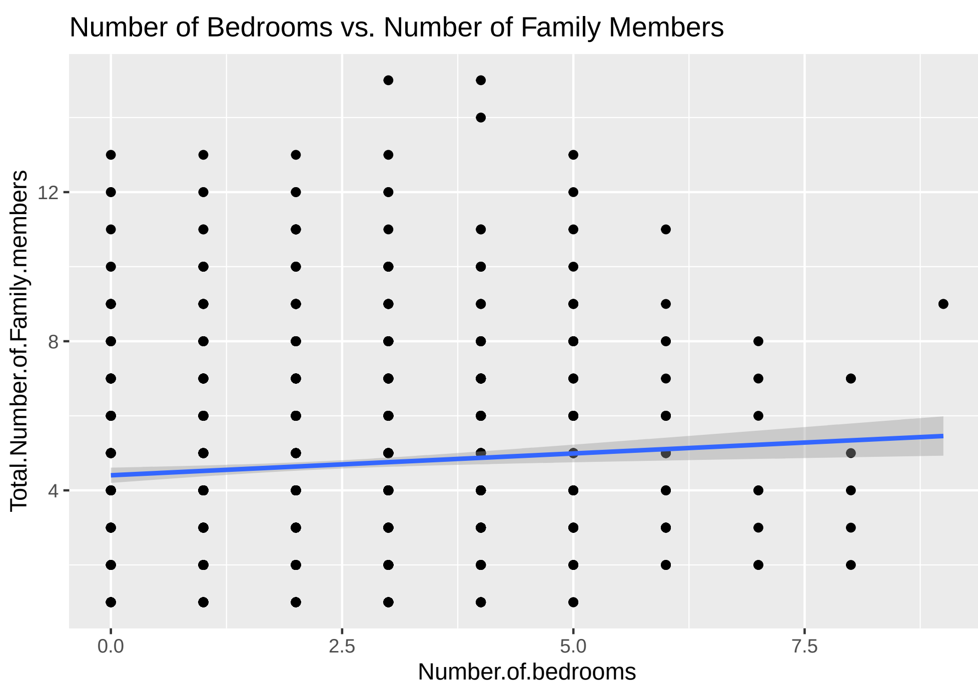


Figure 6: Scatterplots of Phillipine Family

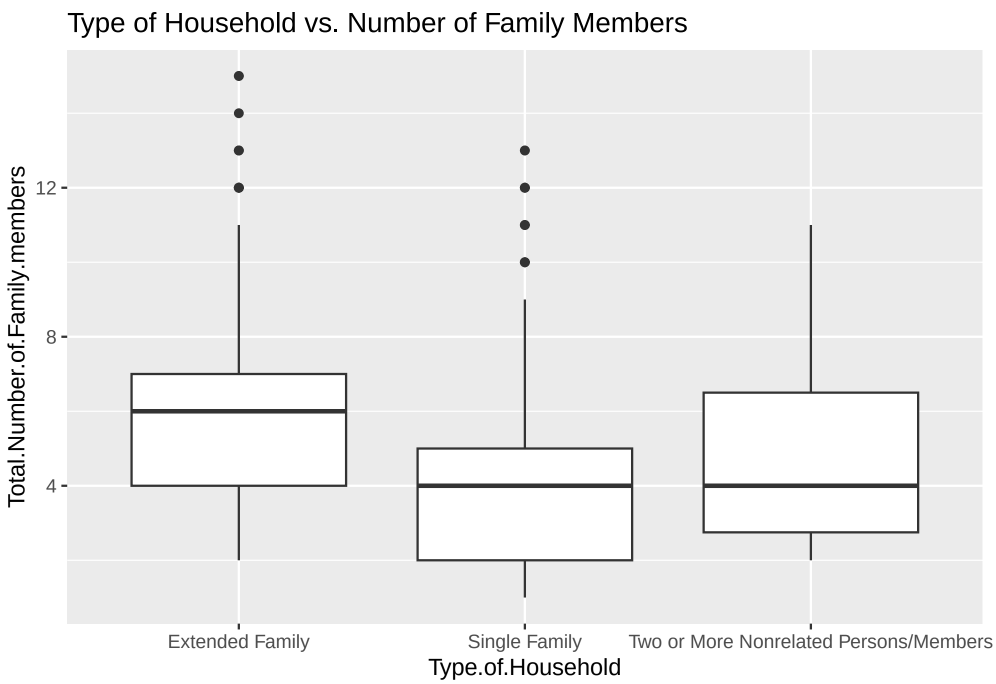


Figure 7: Scatterplots of Phillipine Family

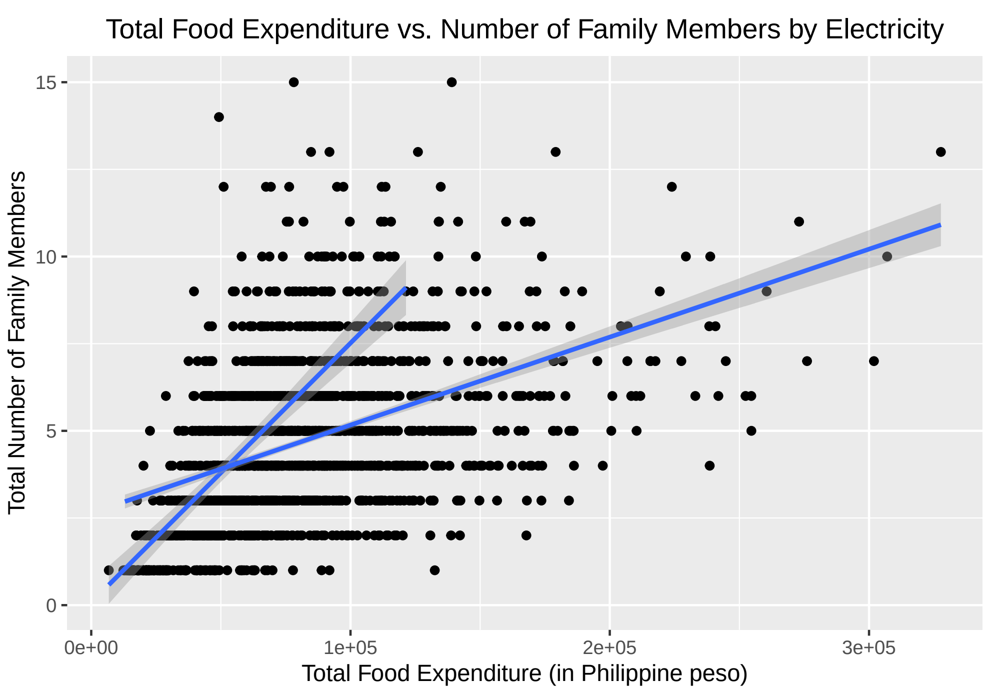


Figure 8: Scatterplots of Phillipine Family

We proceed with the correlation matrix the highlight relationships, below:

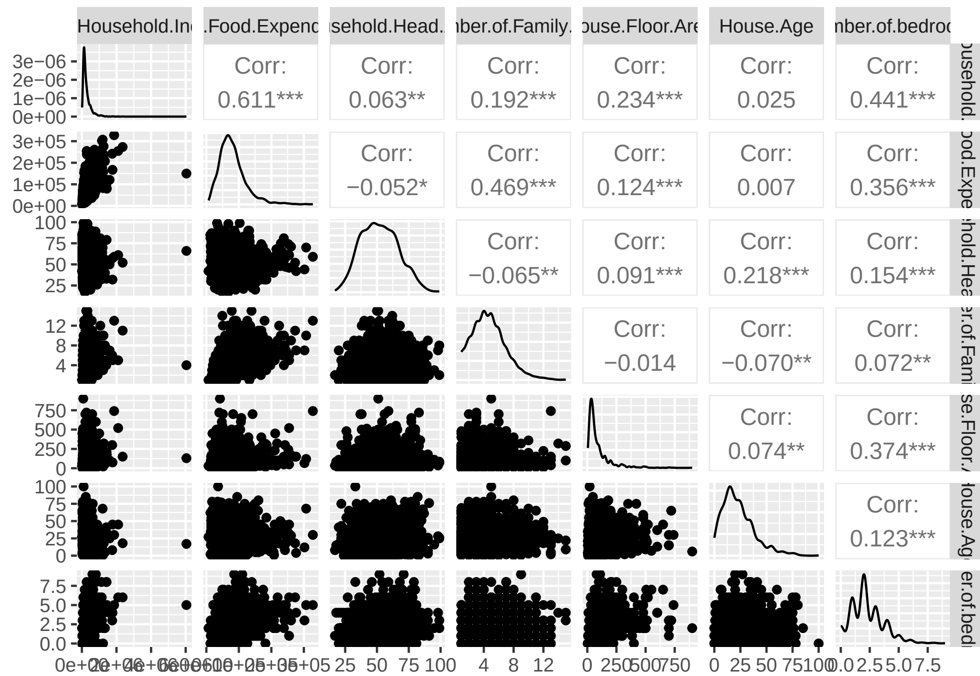


Figure 9: Correlation Matrix of Phillipine Households

It is evident from the corrmatrix plot correlation matrix that the greatest positive correlation exists between family members and food expenditure.

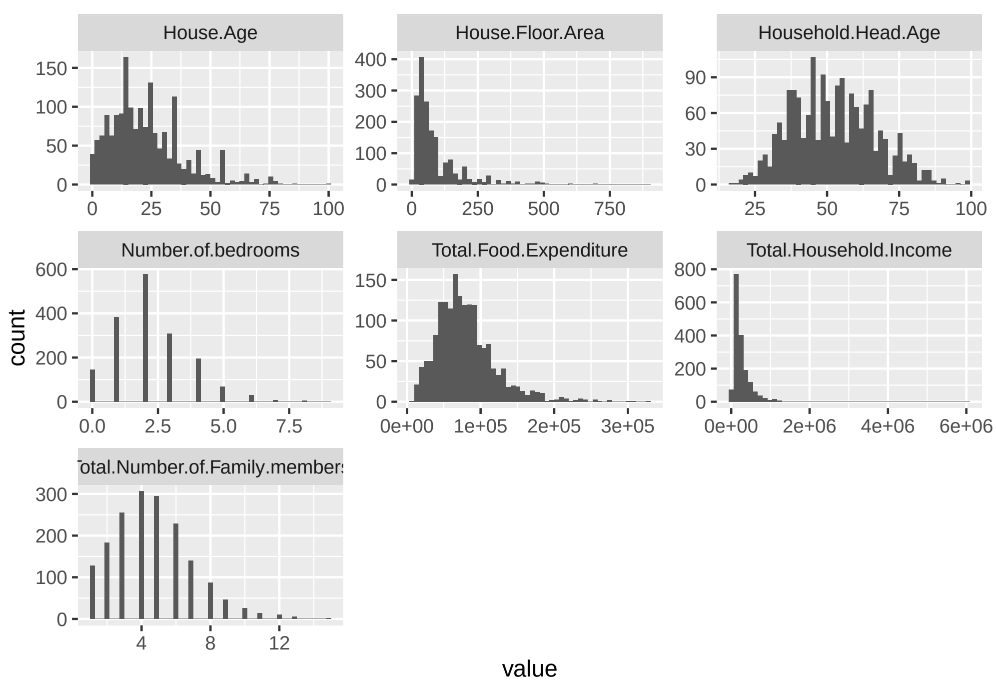


Figure 10: Plot histograms of the variables

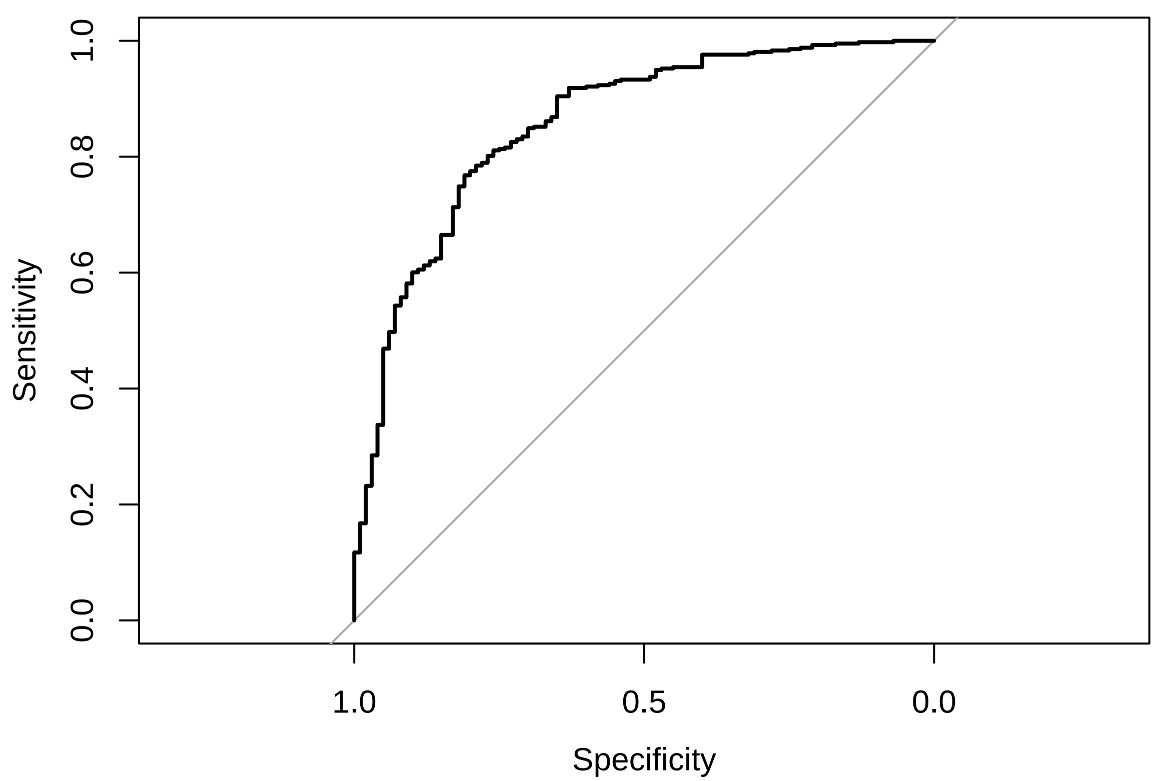
Using the trends seen in the data exploration, our group has taken this further to examine causal relationships through generalized linear models in the Logistic regression.

3 Logistic regression

3.1 Data logistic regression {sec;sub}

After drawing the scatter plot and data correlation, we trying to do a logistic regression from data. we dividing the dataset into training and testing sets, logistic regression models are fitted for each predictor variable and a full model using the glm function in R. The response variable in all the models is Total.Number.of.Family.members, and the predictor variables are Total.Household.Income, Total.Food.Expenditure, Household.Head.Age, House.Floor.Area, House.Age, and Number.of.bedrooms. Multiple logistic regression models are also fitted for each predictor variable separately.

The predict function is then used to generate predicted probabilities for the test data using the full model and the type = "response" argument. And the table function is used to compare the predicted probabilities with the actual values in the test data. And a binary response variable is created by collapsing some levels of the original response variable, and the pROC package is used to calculate the ROC curve using the binary response variable and predicted probabilities. Finally, a Poisson GLM model is fit using all the predictor variables in the dataset with the glm function and family = poisson() argument, which specifies that the response variable has a Poisson distribution. The resulting model is stored in the Our_glm_model object for further examination




```
Call:  glm(formula = Total.Number.of.Family.members ~ Total.Household.Income +
    Total.Food.Expenditure + Household.Head.Age + House.Floor.Area +
```

```
    House.Age + Number.of.bedrooms, family = poisson(), data = dataset)

Coefficients:
           (Intercept)  Total.Household.Income  Total.Food.Expenditure
             1.224e+00               -2.294e-07               6.099e-06
    Household.Head.Age        House.Floor.Area               House.Age
            -6.002e-04               -1.948e-04              -2.282e-03
    Number.of.bedrooms
            -1.552e-02

Degrees of Freedom: 1724 Total (i.e. Null);  1718 Residual
Null Deviance:      2024
Residual Deviance: 1574     AIC: 7251
```

3.2 Show Logistic

We get results listed below:

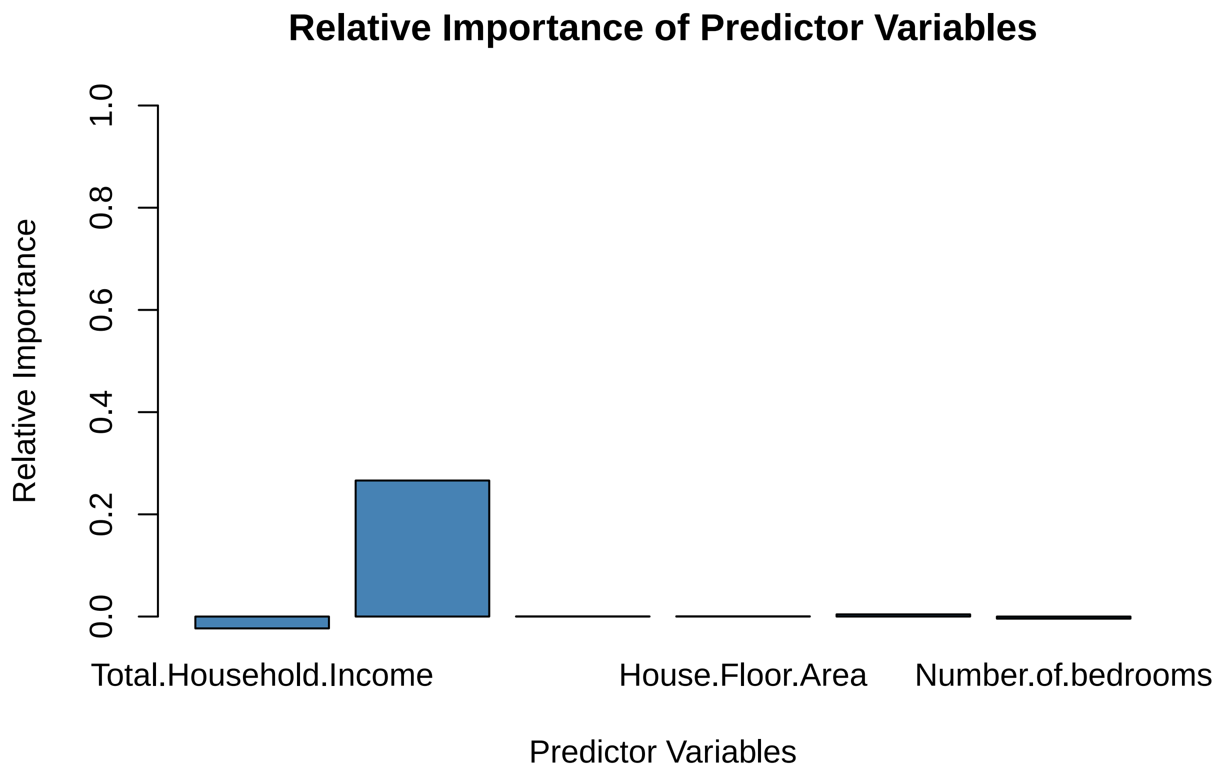
```
Call:
glm(formula = Total.Number.of.Family.members ~ Total.Household.Income +
    Total.Food.Expenditure + Household.Head.Age + House.Floor.Area +
    House.Age + Number.of.bedrooms, data = train_data)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-5.4258  -1.4417  -0.3176   1.1365   8.6724

Coefficients:
                         Estimate Std. Error t value Pr(>|t|)
(Intercept)             3.090e+00  2.554e-01  12.097  < 2e-16 ***
Total.Household.Income -8.688e-07  2.651e-07  -3.277  0.00108 **
Total.Food.Expenditure  3.114e-05  1.757e-06  17.731  < 2e-16 ***
Household.Head.Age     -1.640e-03  4.218e-03  -0.389  0.69748
House.Floor.Area       -7.071e-04  6.095e-04  -1.160  0.24628
House.Age              -9.000e-03  3.849e-03  -2.338  0.01953 *
Number.of.bedrooms     -1.552e-01  5.040e-02  -3.079  0.00212 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 4.150948)

    Null deviance: 6609.6  on 1206  degrees of freedom
Residual deviance: 4981.1  on 1200  degrees of freedom
AIC: 5152.3

Number of Fisher Scoring iterations: 2
```

The deviance residuals measure how much probabilities estimated from our model differ from the observed proportions of successes. Bigger values indicate a bigger difference. Smaller values mean a smaller difference. The summary of the logistic regression model shows the coefficient estimates, standard errors, z-values, and p-values for each predictor variable in the model. The deviance residuals measure the difference between the observed and predicted values, with larger values indicating a larger difference. Although the deviance residuals suggest a generally good fit of the model, the presence of a large maximum value suggests that there may be non-relevant variables included in the model. Hence, it is advisable to rank the importance of variables and remove any irrelevant variables from the model.

4 Importance ranking of variables {sec:IRV}

```
Call:
glm(formula = Total.Number.of.Family.members ~ Total.Household.Income +
    Total.Food.Expenditure + Household.Head.Age + House.Floor.Area +
    House.Age + Number.of.bedrooms, data = dataset)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-5.5814  -1.4710  -0.3067   1.1883  10.7487

Coefficients:
                         Estimate Std. Error t value Pr(>|t|)
(Intercept)             2.882e+00  2.177e-01  13.236  < 2e-16 ***
Total.Household.Income -1.024e-06  2.383e-07  -4.298 1.82e-05 ***
Total.Food.Expenditure  3.213e-05  1.529e-06  21.007  < 2e-16 ***
Household.Head.Age     -5.947e-04  3.516e-03  -0.169  0.86569
House.Floor.Area       -7.110e-04  5.354e-04  -1.328  0.18437
House.Age              -9.258e-03  3.292e-03  -2.813  0.00497 **
Number.of.bedrooms     -9.277e-02  4.085e-02  -2.271  0.02326 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 4.130421)

    Null deviance: 9384.0  on 1724  degrees of freedom
Residual deviance: 7096.1  on 1718  degrees of freedom
AIC: 7351

Number of Fisher Scoring iterations: 2


Response variable: Total.Number.of.Family.members
Total response variance: 5.44315
Analysis based on 1725 observations

6 Regressors:
Total.Household.Income Total.Food.Expenditure Household.Head.Age House.Floor.Area House.Age Number.of.be
Proportion of variance explained by model: 24.38%
Metrics are not normalized (rela=FALSE).

Relative importance metrics:

                               pratt
Total.Household.Income -0.0231816731
Total.Food.Expenditure  0.2661854246
Household.Head.Age      0.0002421048
House.Floor.Area        0.0004279960
```

```
House.Age               0.0042567456
Number.of.bedrooms     -0.0041188170

Total.Household.Income Total.Food.Expenditure     Household.Head.Age
         -0.0231816731           0.2661854246           0.0002421048
      House.Floor.Area              House.Age     Number.of.bedrooms
          0.0004279960           0.0042567456          -0.0041188170

Response variable: Total.Number.of.Family.members
Total response variance: 5.480614
Analysis based on 1207 observations

6 Regressors:
Total.Household.Income Total.Food.Expenditure Household.Head.Age House.Floor.Area House.Age Number.of.be
Proportion of variance explained by model: 24.64%
Metrics are not normalized (rela=FALSE).

Relative importance metrics:

                               lmg
Total.Household.Income 0.022266237
Total.Food.Expenditure 0.209189297
Household.Head.Age     0.003118050
House.Floor.Area       0.001823189
House.Age              0.003948434
Number.of.bedrooms     0.006035561

Average coefficients for different model sizes:

                                  1X           2Xs           3Xs           4Xs
Total.Household.Income  1.519865e-06  1.035593e-06  5.498247e-07  6.859011e-08
Total.Food.Expenditure  2.532814e-05  2.701121e-05  2.833981e-05  2.942677e-05
Household.Head.Age     -1.177284e-02 -1.163472e-02 -9.956241e-03 -7.493635e-03
House.Floor.Area       -4.499505e-04 -9.887290e-04 -1.190092e-03 -1.153884e-03
House.Age              -9.746825e-03 -1.009141e-02 -9.640261e-03 -9.110728e-03
Number.of.bedrooms      9.995607e-02  1.674951e-02 -4.967261e-02 -1.000670e-01
                                 5Xs           6Xs
Total.Household.Income -4.047109e-07 -8.687803e-07
Total.Food.Expenditure  3.034396e-05  3.114479e-05
Household.Head.Age     -4.658000e-03 -1.640169e-03
House.Floor.Area       -9.657748e-04 -7.070664e-04
House.Age              -8.845777e-03 -8.999935e-03
Number.of.bedrooms     -1.350426e-01 -1.551883e-01
```



function calc.relimp() calculates several relative importance metrics for the linear model. From the results displayed above, we witness two sets of important index. Consistent to the logistic above, Total.Household.Income and Total.Food.Expenditure show greater vitality than other four indexes.House age and number of bedroom have a slightly impact. Now we first drop2 variables and then drop 2 slightly influenced variables and re-run de logistic and importance ranking to see the best we can do.

4.1 Re-run the analysis for 4 variables {sec:sub}

```
Response variable: Total.Number.of.Family.members
Total response variance: 5.480614
Analysis based on 1207 observations

4 Regressors:
Total.Household.Income Total.Food.Expenditure House.Age Number.of.bedrooms
Proportion of variance explained by model: 24.54%
Metrics are not normalized (rela=FALSE).

Relative importance metrics:

                               lmg
Total.Household.Income 0.022171568
Total.Food.Expenditure 0.211587337
House.Age              0.004677291
Number.of.bedrooms     0.006981862

Average coefficients for different model sizes:
```

```
                                 1X           2Xs           3Xs          4Xs
Total.Household.Income  1.519865e-06  6.580874e-07 -1.537458e-07 -9.04751e-07
Total.Food.Expenditure  2.532814e-05  2.797764e-05  2.995075e-05  3.13454e-05
House.Age              -9.746825e-03 -1.108776e-02 -1.022598e-02 -9.55285e-03
Number.of.bedrooms      9.995607e-02 -5.581408e-02 -1.479014e-01 -1.74897e-01
```

Based on the output of the calc.relimp function, we can see that the total response variance for this variable is 5.363603, and the proportion of variance explained by this model is 22.68%.

4.2 Re-run the analysis for only 2 variables {sec:sub}

```
Response variable: Total.Number.of.Family.members
Total response variance: 5.480614
Analysis based on 1207 observations

2 Regressors:
Total.Household.Income Total.Food.Expenditure
Proportion of variance explained by model: 23.09%
Metrics are not normalized (rela=FALSE).

Relative importance metrics:

                              lmg
Total.Household.Income 0.02483629
Total.Food.Expenditure 0.20610141

Average coefficients for different model sizes:

                                 1X           2Xs
Total.Household.Income 1.519865e-06 -1.179834e-06
Total.Food.Expenditure 2.532814e-05  3.018128e-05
```

Based on the output of the calc.relimp function, we can see that the total response variance for this variable is 5.363603, and the proportion of variance explained by this model is 22.02%. Total.Food.Expenditure appears to be more important in explaining the variance in the Total.Number.of.Family.members, as its relative importance (lmg) is higher than that of Total.Household.Income.And the coefficients indicate the relationship between each predictor and the response variable (Total.Number.of.Family.members). In the 1X model, a unit increase in Total.Household.Income is associated with a 2.276022e-06 increase in Total.Number.of.Family.members, whereas a unit increase in Total.Food.Expenditure is associated with a 2.539690e-05 increase in Total.Number.of.Family.members. In the 2Xs model, the relationships are -1.510802e-06 and 3.125984e-05, respectively.

5 Conclusion {sec:Conc}

From the results we get above, we have concluded that Total.Household.Income and Total.Food.Expenditure are the two most important variables. However, the average coefficients are still relatively small. This can be attributed to several reasons. The most significant reason is that Income and Expenditure are not on the same scale as the number of family members. Consequently, a sharp increase or decrease in Income and Expenditure may not necessarily cause any change in the number of family members.

5.1 Appendix {sec:sub}

Here, we discover the correlations between variables, in other words the columns of the dataset.

The results from above conducted on the dataset show that both p-values are extremely small, leading to the rejection of the null hypothesis (data is normally distributed). Consequently, neither Total.Household.Income nor Total.Food.Expenditure is normally distributed.The extremely small p-value in Pearson's product-moment correlation test reveals a statistically significant correlation between Total.Household.Income and Total.Food.Expenditure. The 95% confidence interval for this correlation is [0.5810680, 0.6402141], suggesting that the true correlation between these two variables lies within this range. And the sample estimate for the correlation (cor) is 0.6114945, indicating a positive and moderately strong relationship between Total.Household.Income and Total.Food.Expenditure.