Group_2_Analysis

Group 2

2022/3/20

```r
library(tidyverse)
library(moderndive)
library(gapminder)
library(sjPlot)
library(stats)
library(jtools)
library(MASS)
library(kableExtra)
library(olsrr)
library(skimr)
library(GGally)
library(car)
library(epiDisplay)
```

```r
#import data
data<-read.csv("dataset2.csv")

#processing discrete data
data[, 4] <- as.factor(data[, 4])
data[, 6] <- as.factor(data[, 6])
data[, 11] <- as.factor(data[, 11])

#delete "Region" column
data = data[, -2]
```

Introduction

The Family Income and Expenditure Survey (FIES) is a survey of every households in a country which is taken every three years. This gives information on the levels of living and disparities in income of each family and spending patterns.

In this project, we use the pre-downloaded FIES data of a single region of Philippines. It is Mimaropa, former designated as Region IV-B and formally known as the southwestern Tagalog region. There are 1249 recorded households. Each of them contains 11 following variables:
\newline \qquad · `Total.Household.Income` is the Annual household income (in Philippine peso)
\qquad · `Region` is the region of the Philippines which a household is in
\qquad · `Total.Food.Expenditure` is the annual expenditure by the household on food (in Philippine peso)
\qquad · `Household.Head.Sex` is the head of the households sex
\qquad · `Household.Head.Age` is the head of the households age (in years)
\qquad · `Type.of.Household` is the relationship between the group of people living in the house
\qquad · `Total.Number.of.Family.members` is the number of people living in the house
\qquad · `House.Floor.Area` is the floor area of the house (in square meter)
\qquad · `House.Age` is the age of the building (in years)
\qquad · `Number.of.bedrooms` is the number of bedrooms in the house
\qquad · `Electricity` is the electricity status of the house (1=Yes, 0=No)

where "head of the household" is the person who is in charge of that house.

The Generalised Linear Model (GLM) method will be used as an analysing tool. We are interested in the number of people living in a household (`Total.Number.of.Family.members`). The other variables having influences will be investigated.

Exploratory Data Analysis

Statistics Summary

In order to make it more clear, we devide all variables into continous and discrete variables.

```
#select continuous variables
con_var = c("Total.Number.of.Family.members","Total.Household.Income",
            "Total.Food.Expenditure","Household.Head.Age",
           "House.Floor.Area", "House.Age", "Number.of.bedrooms")


# data summary of continuous variables
data[con_var] %>%
  skim() %>%
  transmute(Variable=skim_variable,
            Mean=round(numeric.mean),
            SD=round(numeric.sd),
            Min=numeric.p0,
            Median=numeric.p50,
            Max=numeric.p100,
            IQR = numeric.p75-numeric.p50) %>%
  kable(caption = '\\label{tab:summaries_con}
        Summary statistics of continuous variables') %>%
  kable_styling(font_size = 10, latex_options = "hold_position")
```

Table 1: Summary statistics of continuous variables

Variable	Mean	SD	Min	Median	Max	IQR
Total.Number.of.Family.members	4	2	1	4	16	2
Total.Household.Income	216685	263207	18784	140483	2891788	89919
Total.Food.Expenditure	70760	41638	10488	62590	413844	24118
Household.Head.Age	51	14	15	51	87	10
House.Floor.Area	49	49	5	36	750	24
House.Age	16	13	0	14	105	8
Number.of.bedrooms	2	1	0	2	7	0

From Table 1, we can see that the median of "Total.Household.Income" is much less than its mean. It indicates that high income families have considerable impact on the samples. However, when we look at "Total.Food.Expenditure", the difference of mean and median is much smaller comparing with "Total.Household.Income".

The range of "Total.Number.of.Family.members" is from 1 to 16. The median and the mean are equal which is 4. The standard deviation is 2 so the variance is 4 which is equal to the mean. This means the distribution of "Total.Number.of.Family.members" may be similar to poisson distribution.

Regarding other continuous variables, we do not find something special.

```
#select discrete variables
dis_var = c("Household.Head.Sex", "Type.of.Household", "Electricity")

# data summary of discrete variables
data[dis_var] %>%
```

Table 2: Summary statistics of discrete variables

Variable	Counts
Household.Head.Sex	Mal: 983, Fem: 266
Type.of.Household	Sin: 900, Ext: 344, Two: 5
Electricity	1: 1069, 0: 180

```r
skim() %>%
 transmute(Variable=skim_variable,
          Counts=factor.top_counts) %>%
kable(caption = '\\label{tab:summaries_dis}
      Summary statistics of discrete variables')
```

Regarding Household.Head.Sex, Mal represents male, Fem represents female. Regarding Type.of.Household, Sin means Single Family, Ext means Extended Family and Two means Two or More Nonrelated Persons/Members. Regarding Electricity, 1 means the house has electricity, 0 means does not have.

Table 2 shows that most house heads are male, there are a few of families consist of unrelated persons and some houses still do not have electricity.

Data Visualization Analysis

```
#create a poisson distribution
n = dpois(1:16, 4) *1249
x = c(1:16)
poi = data.frame(cbind(x, n))

#plot the distribution of "Total.Number.of.Family.members"
ggplot(data, aes(x=Total.Number.of.Family.members)) +
  geom_histogram() +
  geom_line(data=poi, mapping=aes(x=x, y=n), size=1, color="#3399CC") +
  ylab("Count")
```

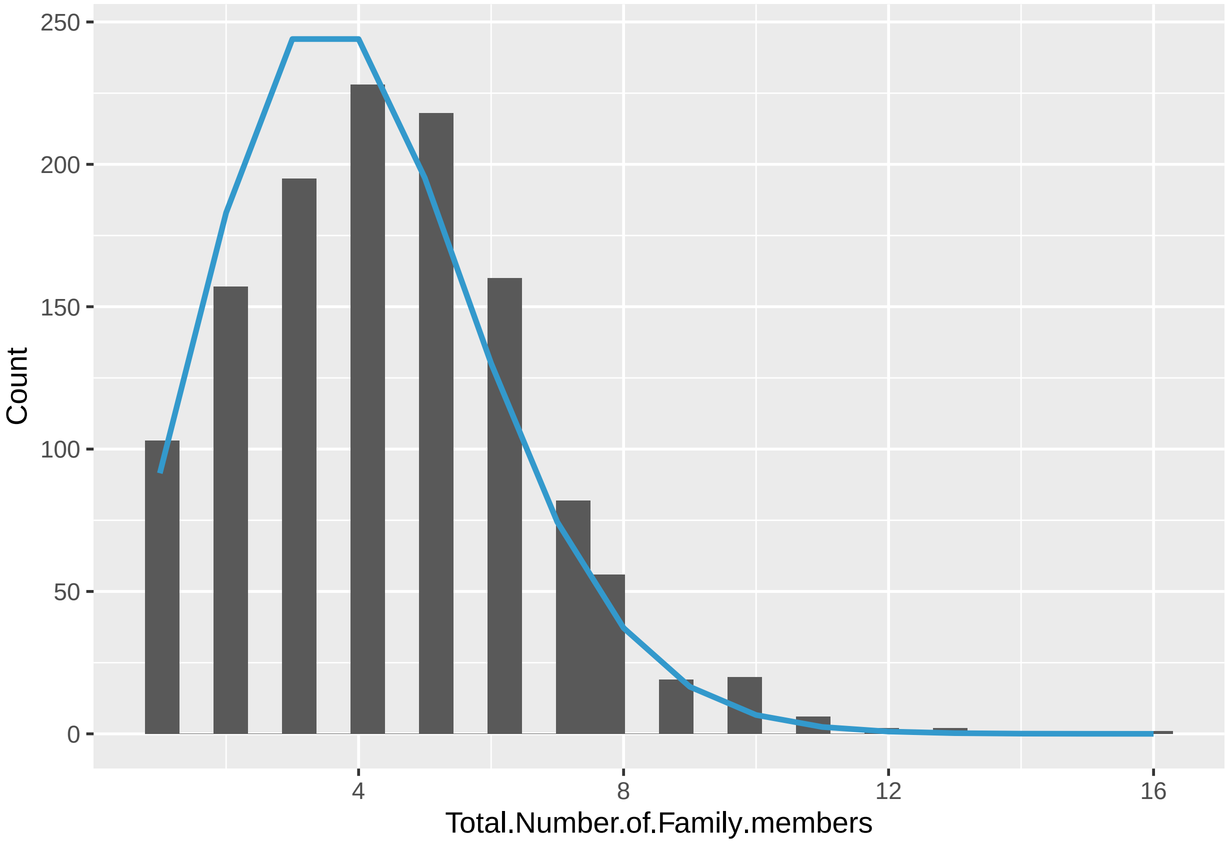


Figure 1: Distribution of Total.Number.of.Family.members

As Figure 1 shows that the variance of “Total.Number.of.Family.members” is equal to its mean. In addition, Figure 1 shows that the distribution of “Total.Number.of.Family.members” is symmetry from 1 to 9 which is similar to poisson distribution. In general, we can infer that except some families with people numbers higher than 9, the distribution of “Total.Number.of.Family.members” is likely to be poisson distribution and poisson logistic regression may be applied to solve our problem.

```
#boxplot of "household.Head.Sex" vs "Total.Number.of.Family.members"
ggplot(data, aes(x=Household.Head.Sex, y=Total.Number.of.Family.members)) +
  geom_boxplot()
```

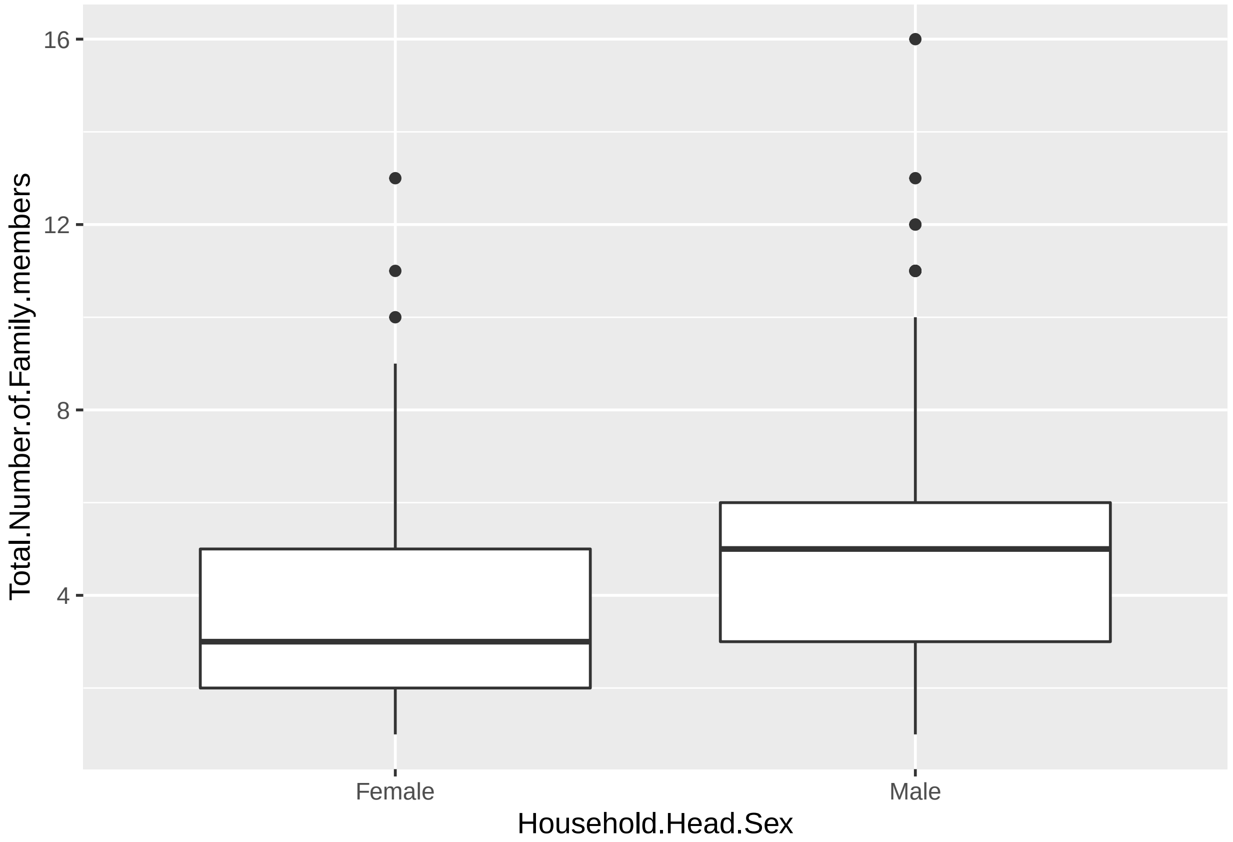


Figure 2: Boxplot of Household.Head.Sex and Total.Number.of.Family.members

From Figure 2, we can see that on average, male head families have more members than female. However, we also can see there is overlap in the IQR's.

```
#boxplot of "Type.of.Household" vs "Total.Number.of.Family.members"
ggplot(data, aes(x=Type.of.Household, y=Total.Number.of.Family.members)) +
  geom_boxplot()
```

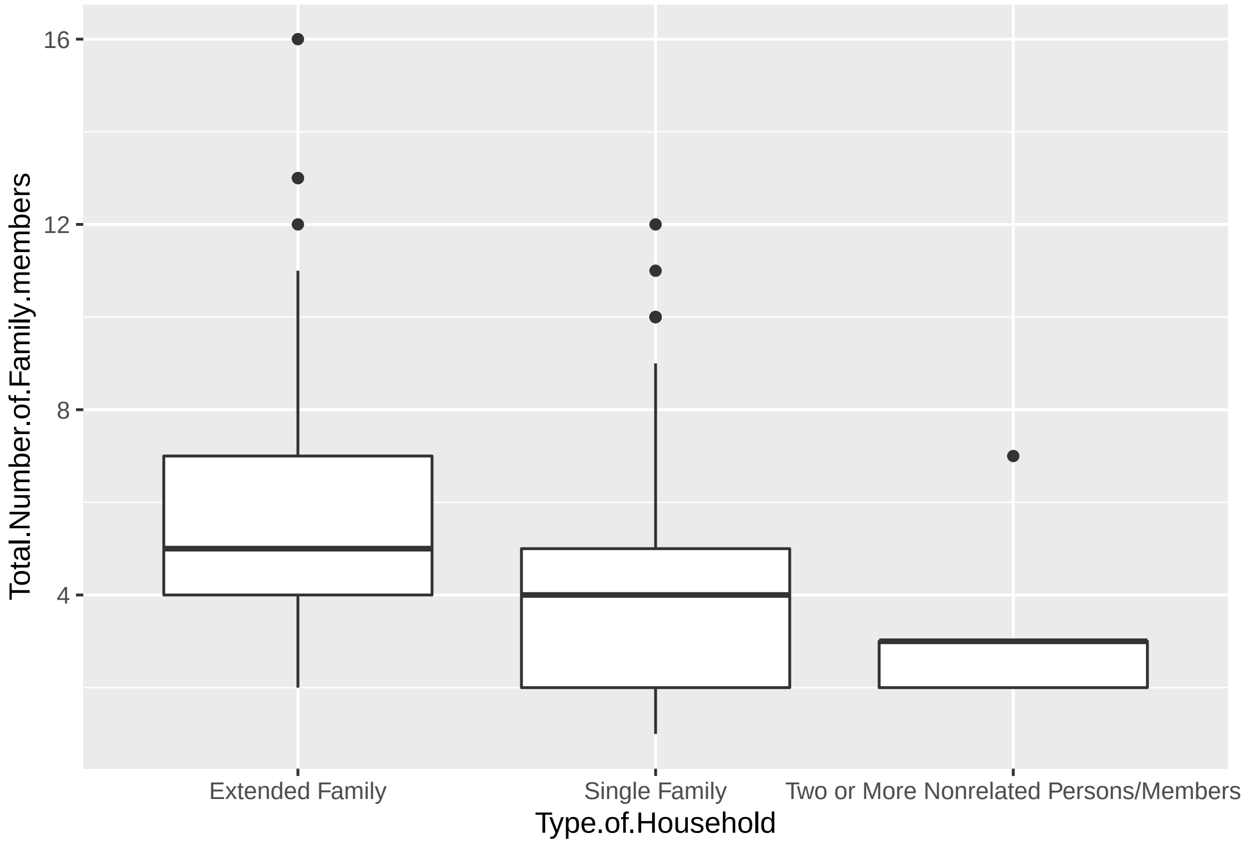


Figure 3: Boxplot of Type.of.Household and Total.Number.of.Family.members

From Figure 3, we can see that on average, different types of household, on average, have different numbers of members as well. Extended Families have more members than single families and single families have more members than nonrelated persons families. There are overlaps between them as well.

```
#boxplot of "Electricity" vs "Total.Number.of.Family.members"
ggplot(data, aes(x=as.factor(Electricity), y=Total.Number.of.Family.members)) +
  geom_boxplot()
```

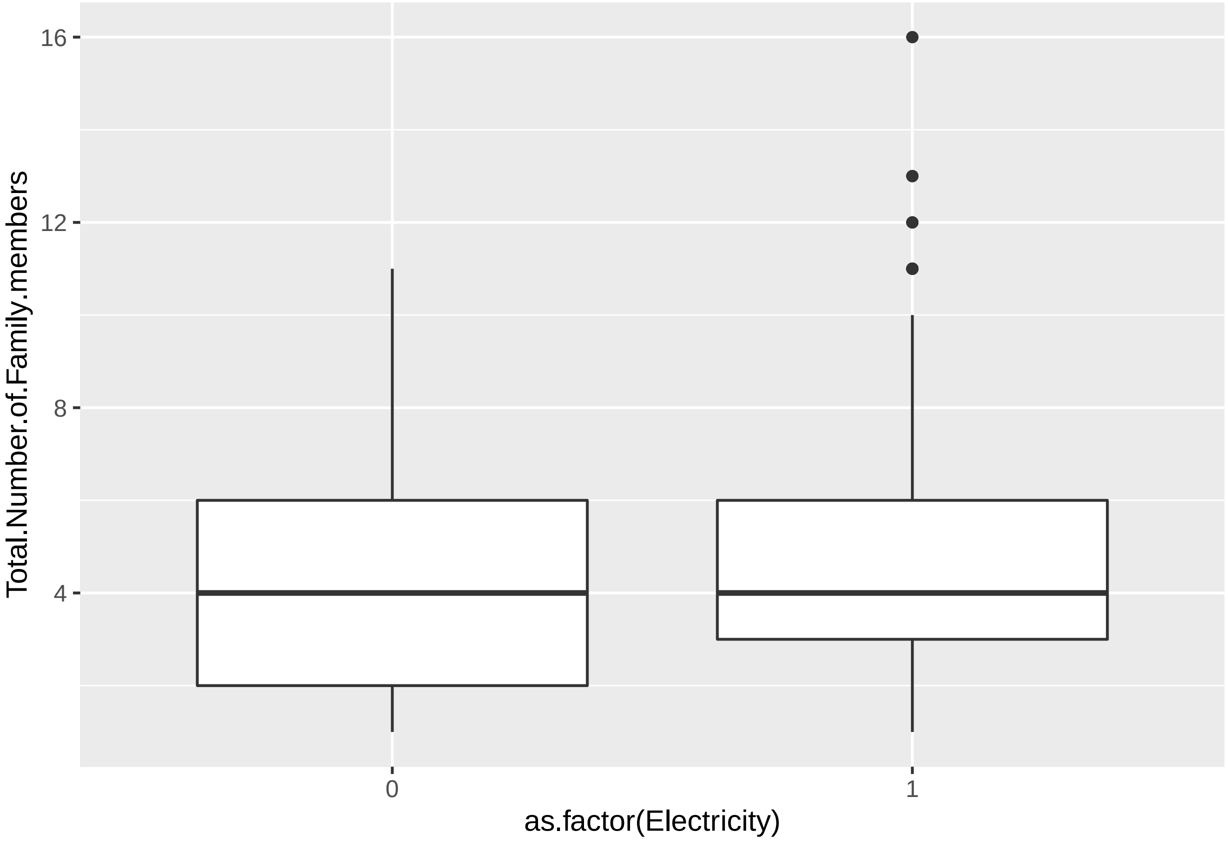


Figure 4: Boxplot of Electricity and Total.Number.of.Family.members

Figure 4 shows that on average, electricity has no impact on the numbers of members in each family.

```r
#plot matrix of continuous variables
ggpairs(data[, con_var], aes(alpha = 0.1))
```

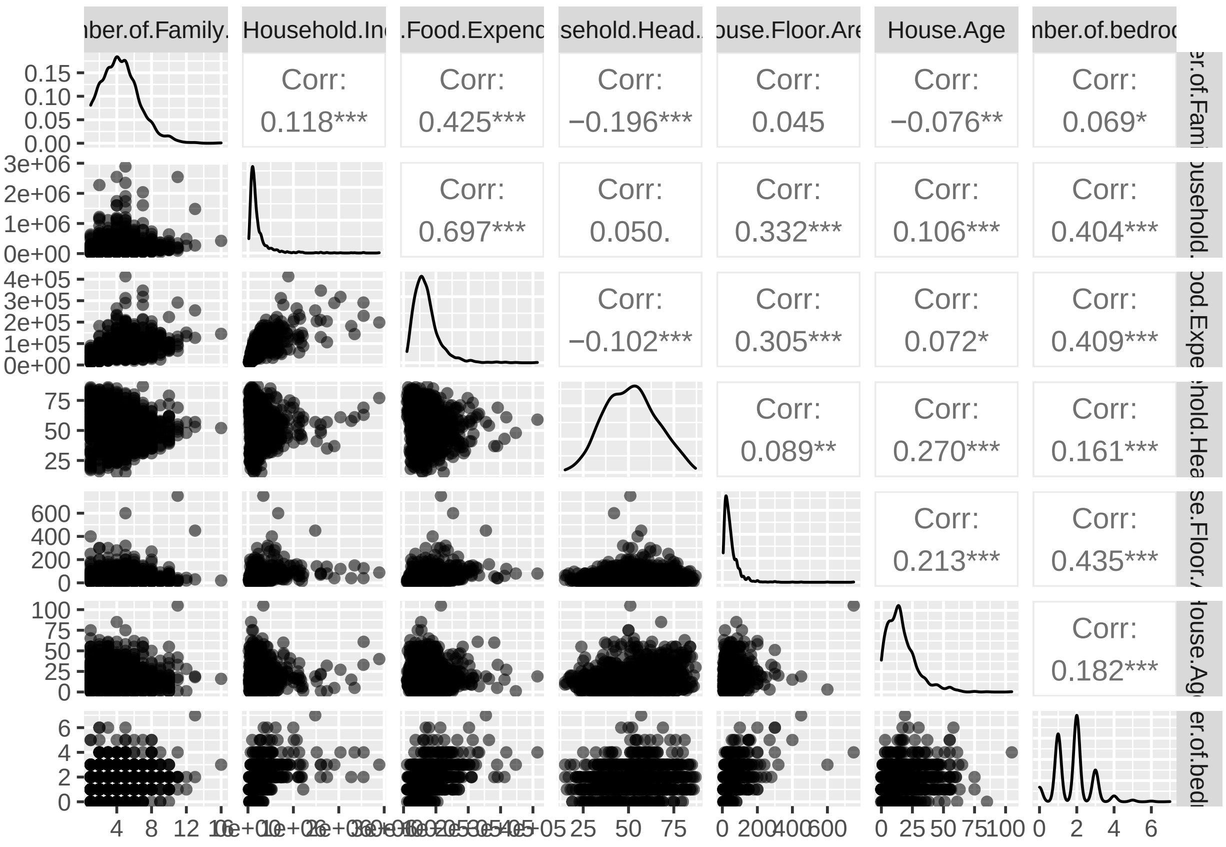


Figure 5: Matrix of plots of continuous variables

From Figure 5, we can see that the correlation between "Total.Number.of.Family.members" and other continuous variables weak and very weak. When we look at the first column of this matrix, we can find that although "Total.Number.of.Family.members" and other continuous variables only have weak linear relationship, there may be non-linear relationship between them.

We we look at the correlation of other variables except "Total.Number.of.Family.members", we can find that only "Total.Household.Income" and "Total.Food.Expenditure" have moderate positive correlation and others only have weak and very weak correlation.

Modelling and Results

Because the dependent variable of the data of this fitting model is the counting variable (the total number of families), and the independent variable is the continuity or category variable. In addition, the variable data are measured every three years, and the length of the whole observation concentration is unchanged. This study decided to use Poisson regression to fit the model. Poisson regression mainly has two assumptions. Firstly, the human time risk of different objects with the same characteristics and at the same time is homogeneous. Secondly, when the sample size is larger and larger, the mean of frequency tends to variance.

Preliminary fitting model

fitting model

```r
#build preliminary model
model<-glm(Total.Number.of.Family.members~Total.Household.Income+
             Total.Food.Expenditure+Household.Head.Sex+Household.Head.Age+
             Type.of.Household+House.Floor.Area+House.Age+
             Number.of.bedrooms+Electricity,
           data=data, family = "poisson")
summary(model)
```

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

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-4.6392  -0.6578  -0.1209   0.5018   2.7098

Coefficients:
                                                          Estimate Std. Error
(Intercept)                                              1.671e+00  8.230e-02
Total.Household.Income                                  -4.266e-07  7.596e-08
Total.Food.Expenditure                                   5.239e-06  4.066e-07
Household.Head.SexMale                                   2.418e-01  3.739e-02
Household.Head.Age                                      -5.818e-03  1.080e-03
Type.of.HouseholdSingle Family                          -3.732e-01  3.047e-02
Type.of.HouseholdTwo or More Nonrelated Persons/Members -5.036e-01  2.447e-01
House.Floor.Area                                        -9.056e-05  3.033e-04
House.Age                                               -2.451e-03  1.177e-03
Number.of.bedrooms                                      -2.366e-02  1.680e-02
Electricity1                                            -5.232e-02  4.048e-02
                                                        z value Pr(>|z|)
(Intercept)                                              20.299  < 2e-16 ***
Total.Household.Income                                   -5.616 1.96e-08 ***
Total.Food.Expenditure                                   12.886  < 2e-16 ***
Household.Head.SexMale                                    6.467 1.00e-10 ***
Household.Head.Age                                       -5.386 7.21e-08 ***
Type.of.HouseholdSingle Family                          -12.250  < 2e-16 ***
Type.of.HouseholdTwo or More Nonrelated Persons/Members  -2.058   0.0396 *
House.Floor.Area                                         -0.299   0.7653
House.Age                                                -2.082   0.0374 *
Number.of.bedrooms                                       -1.409   0.1589
Electricity1                                             -1.293   0.1961
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 1373.63  on 1248  degrees of freedom
Residual deviance:  881.01  on 1238  degrees of freedom
AIC: 4931.9

Number of Fisher Scoring iterations: 4
```

The stepwise method was used to complete the screening of independent variables

```
#use step wise to select features
step(model)
```

```
Start:  AIC=4931.87
Total.Number.of.Family.members ~ Total.Household.Income + Total.Food.Expenditure +
    Household.Head.Sex + Household.Head.Age + Type.of.Household +
    House.Floor.Area + House.Age + Number.of.bedrooms + Electricity

                         Df Deviance    AIC
- House.Floor.Area        1   881.10 4930.0
- Electricity             1   882.67 4931.5
- Number.of.bedrooms      1   883.00 4931.9
<none>                        881.01 4931.9
- House.Age               1   885.41 4934.3
- Household.Head.Age      1   910.02 4958.9
- Total.Household.Income  1   916.63 4965.5
- Household.Head.Sex      1   924.80 4973.7
- Type.of.Household       2  1028.11 5075.0
- Total.Food.Expenditure  1  1033.71 5082.6

Step:  AIC=4929.96
Total.Number.of.Family.members ~ Total.Household.Income + Total.Food.Expenditure +
    Household.Head.Sex + Household.Head.Age + Type.of.Household +
    House.Age + Number.of.bedrooms + Electricity

                         Df Deviance    AIC
- Electricity             1   882.78 4929.6
<none>                        881.10 4930.0
- Number.of.bedrooms      1   883.59 4930.4
- House.Age               1   885.80 4932.7
- Household.Head.Age      1   910.07 4956.9
- Total.Household.Income  1   917.76 4964.6
- Household.Head.Sex      1   924.93 4971.8
- Type.of.Household       2  1028.11 5073.0
- Total.Food.Expenditure  1  1033.71 5080.6
```

```
Step:  AIC=4929.64
Total.Number.of.Family.members ~ Total.Household.Income + Total.Food.Expenditure +
    Household.Head.Sex + Household.Head.Age + Type.of.Household +
    House.Age + Number.of.bedrooms

                         Df Deviance    AIC
<none>                        882.78 4929.6
- Number.of.bedrooms      1   886.06 4930.9
- House.Age               1   888.38 4933.2
- Household.Head.Age      1   911.64 4956.5
- Total.Household.Income  1   919.96 4964.8
- Household.Head.Sex      1   927.56 4972.4
- Type.of.Household       2  1030.52 5073.4
- Total.Food.Expenditure  1  1033.99 5078.8

Call:  glm(formula = Total.Number.of.Family.members ~ Total.Household.Income +
    Total.Food.Expenditure + Household.Head.Sex + Household.Head.Age +
    Type.of.Household + House.Age + Number.of.bedrooms, family = "poisson",
    data = data)

Coefficients:
                                            (Intercept)
                                              1.636e+00
                                 Total.Household.Income
                                             -4.333e-07
                                 Total.Food.Expenditure
                                              5.211e-06
                                 Household.Head.SexMale
                                              2.441e-01
                                     Household.Head.Age
                                             -5.808e-03
                         Type.of.HouseholdSingle Family
                                             -3.739e-01
Type.of.HouseholdTwo or More Nonrelated Persons/Members
                                             -5.039e-01
                                              House.Age
                                             -2.707e-03
                                     Number.of.bedrooms
                                             -2.859e-02

Degrees of Freedom: 1248 Total (i.e. Null);  1240 Residual
Null Deviance:      1374
Residual Deviance: 882.8    AIC: 4930
```

Use a better model

```
#build new model after selecting features
model.better<-glm(Total.Number.of.Family.members~Total.Household.Income+
                    Total.Food.Expenditure +Household.Head.Sex+
                    Household.Head.Age+Type.of.Household+House.Age+
                    Number.of.bedrooms,
                  data=data, family = "poisson")
```

Look for outliers in the model

```
#find outlier
outlierTest(model.better)
```

```
     rstudent unadjusted p-value Bonferroni p
944 -5.065151         4.0808e-07   0.00050969
```

Remove the row of outliers

```
#delete outlier in the dataset
data<-data[-944,]

#build new model after dropping out outlier
model.better<-glm(Total.Number.of.Family.members~Total.Household.Income+
                    Total.Food.Expenditure +Household.Head.Sex+
                    Household.Head.Age+Type.of.Household+House.Age+
                    Number.of.bedrooms,
                  data=data, family = "poisson")


outlierTest(model.better)
```

```
No Studentized residuals with Bonferroni p < 0.05
Largest |rstudent|:
    rstudent unadjusted p-value Bonferroni p
709 -2.89874          0.0037467           NA
```

Without outliers, the best model is obtained

```
#model summary
summary(model.better)
```

```

Call:
glm(formula = Total.Number.of.Family.members ~ Total.Household.Income +
    Total.Food.Expenditure + Household.Head.Sex + Household.Head.Age +
    Type.of.Household + House.Age + Number.of.bedrooms, family = "poisson",
    data = data)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.7839  -0.6516  -0.1001   0.4892   2.7201

Coefficients:
                                                          Estimate Std. Error
(Intercept)                                              1.565e+00  7.977e-02
Total.Household.Income                                  -5.150e-07  7.839e-08
Total.Food.Expenditure                                   6.114e-06  4.521e-07
Household.Head.SexMale                                   2.415e-01  3.733e-02
Household.Head.Age                                      -5.273e-03  1.089e-03
Type.of.HouseholdSingle Family                          -3.694e-01  3.038e-02
Type.of.HouseholdTwo or More Nonrelated Persons/Members -5.151e-01  2.449e-01
House.Age                                               -2.896e-03  1.152e-03
Number.of.bedrooms                                      -2.997e-02  1.575e-02
                                                        z value Pr(>|z|)    
(Intercept)                                              19.622  < 2e-16 ***
Total.Household.Income                                   -6.570 5.03e-11 ***
Total.Food.Expenditure                                   13.524  < 2e-16 ***
Household.Head.SexMale                                    6.470 9.82e-11 ***
Household.Head.Age                                       -4.842 1.29e-06 ***
Type.of.HouseholdSingle Family                          -12.159  < 2e-16 ***
Type.of.HouseholdTwo or More Nonrelated Persons/Members  -2.104   0.0354 *  
House.Age                                                -2.515   0.0119 *  
Number.of.bedrooms                                       -1.902   0.0571 .  
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 1373.6  on 1247  degrees of freedom
Residual deviance:  857.2  on 1239  degrees of freedom
AIC: 4900.6

Number of Fisher Scoring iterations: 4
```

Test the goodness of fit of Poisson model

```
#test the goodness of fit of model
poisgof(model.better)
```

```
$results
[1] "Goodness-of-fit test for Poisson assumption"

$chisq
[1] 857.1986

$df
[1] 1239

$p.value
[1] 1
```

The p value is 1, which indicates that the goodness of fit of the model is good.

Coefficient and interpretation of model

```
#transform coefficients into exponential form
exp(coef(model.better))
```

```
                                            (Intercept)
```

```
                                              4.7835932
                                 Total.Household.Income
                                              0.9999995
                                 Total.Food.Expenditure
                                              1.0000061
                                 Household.Head.SexMale
                                              1.2731562
                                     Household.Head.Age
                                              0.9947412
                         Type.of.HouseholdSingle Family
                                              0.6911276
Type.of.HouseholdTwo or More Nonrelated Persons/Members
                                              0.5974600
                                              House.Age
                                              0.9971080
                                     Number.of.bedrooms
                                              0.9704752
```

Because the sample data of Total.Household.Income and Total.Food.Expenditure is too large, their coefficient is too close to 1. It is impossible to know whether the interval contains 1, that is, whether the variable is significant. Therefore, we try to use the logarithm of these two variables to repeat the above steps to fit the model.

Change variable fitting model

```r
#transform "Total.Household.Income" and "Total.Food.Expenditure"
#into  logarithm form and build new model
model<-glm(Total.Number.of.Family.members~log(Total.Household.Income)+
             log(Total.Food.Expenditure)+Household.Head.Sex+
             Household.Head.Age+Type.of.Household+House.Floor.Area+
             House.Age+Number.of.bedrooms+Electricity,
           data=data, family = "poisson")
summary(model)
```

```

Call:
glm(formula = Total.Number.of.Family.members ~ log(Total.Household.Income) + 
    log(Total.Food.Expenditure) + Household.Head.Sex + Household.Head.Age + 
    Type.of.Household + House.Floor.Area + House.Age + Number.of.bedrooms + 
    Electricity, family = "poisson", data = data)

Deviance Residuals: 
     Min        1Q    Median        3Q       Max  
-2.19376  -0.58252  -0.09119   0.41915   2.65231  

Coefficients:
                                                          Estimate Std. Error
                                                                             
(Intercept)                                             -3.156e+00  3.498e-01
log(Total.Household.Income)                             -2.523e-01  3.382e-02
log(Total.Food.Expenditure)                              7.270e-01  4.658e-02
Household.Head.SexMale                                   1.921e-01  3.756e-02
Household.Head.Age                                      -3.411e-03  1.114e-03
```

```
Type.of.HouseholdSingle Family                          -3.251e-01  3.074e-02
Type.of.HouseholdTwo or More Nonrelated Persons/Members -4.589e-01  2.440e-01
House.Floor.Area                                        -8.945e-05  3.042e-04
House.Age                                               -2.296e-03  1.174e-03
Number.of.bedrooms                                      -2.993e-02  1.704e-02
Electricity1                                            -7.605e-02  4.138e-02
                                                        z value Pr(>|z|)
(Intercept)                                              -9.024  < 2e-16 ***
log(Total.Household.Income)                              -7.461 8.59e-14 ***
log(Total.Food.Expenditure)                              15.607  < 2e-16 ***
Household.Head.SexMale                                    5.114 3.16e-07 ***
Household.Head.Age                                       -3.062   0.0022 **
Type.of.HouseholdSingle Family                          -10.576  < 2e-16 ***
Type.of.HouseholdTwo or More Nonrelated Persons/Members  -1.880   0.0601 .
House.Floor.Area                                         -0.294   0.7687
House.Age                                                -1.957   0.0504 .
Number.of.bedrooms                                       -1.756   0.0790 .
Electricity1                                             -1.838   0.0661 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 1373.55  on 1247  degrees of freedom
Residual deviance:  749.66  on 1237  degrees of freedom
AIC: 4797

Number of Fisher Scoring iterations: 4
```

The stepwise method was used to complete the screening of independent variables.

```
#use step wise to select features
step(model)
```

```
Start:  AIC=4797.04
Total.Number.of.Family.members ~ log(Total.Household.Income) +
    log(Total.Food.Expenditure) + Household.Head.Sex + Household.Head.Age +
    Type.of.Household + House.Floor.Area + House.Age + Number.of.bedrooms +
    Electricity

                              Df Deviance    AIC
- House.Floor.Area             1   749.75 4795.1
<none>                             749.66 4797.0
- Number.of.bedrooms           1   752.75 4798.1
- Electricity                  1   753.00 4798.4
- House.Age                    1   753.54 4798.9
- Household.Head.Age           1   759.03 4804.4
- Household.Head.Sex           1   776.78 4822.2
- log(Total.Household.Income)  1   807.08 4852.5
- Type.of.Household            2   860.16 4903.5
- log(Total.Food.Expenditure)  1  1000.58 5046.0

Step:  AIC=4795.13
```

```
Total.Number.of.Family.members ~ log(Total.Household.Income) +
    log(Total.Food.Expenditure) + Household.Head.Sex + Household.Head.Age +
    Type.of.Household + House.Age + Number.of.bedrooms + Electricity

                              Df Deviance    AIC
<none>                              749.75 4795.1
- Electricity                  1   753.08 4796.5
- Number.of.bedrooms           1   753.45 4796.8
- House.Age                    1   753.90 4797.3
- Household.Head.Age           1   759.11 4802.5
- Household.Head.Sex           1   776.89 4820.3
- log(Total.Household.Income)  1   809.51 4852.9
- Type.of.Household            2   860.16 4901.5
- log(Total.Food.Expenditure)  1  1001.24 5044.6

Call:  glm(formula = Total.Number.of.Family.members ~ log(Total.Household.Income) +
    log(Total.Food.Expenditure) + Household.Head.Sex + Household.Head.Age +
    Type.of.Household + House.Age + Number.of.bedrooms + Electricity,
    family = "poisson", data = data)

Coefficients:
                                            (Intercept)
                                              -3.144768
                            log(Total.Household.Income)
                                              -0.253972
                            log(Total.Food.Expenditure)
                                               0.727582
                                  Household.Head.SexMale
                                               0.192173
                                      Household.Head.Age
                                              -0.003409
                         Type.of.HouseholdSingle Family
                                              -0.324931
Type.of.HouseholdTwo or More Nonrelated Persons/Members
                                              -0.460081
                                              House.Age
                                              -0.002346
                                     Number.of.bedrooms
                                              -0.031361
                                           Electricity1
                                              -0.076011

Degrees of Freedom: 1247 Total (i.e. Null);  1238 Residual
Null Deviance:      1374
Residual Deviance: 749.8    AIC: 4795
```

Use a better model.

```r
#build new model after selecting features
model.best<-glm(Total.Number.of.Family.members~log(Total.Household.Income)+
                  log(Total.Food.Expenditure) +Household.Head.Sex+
                  Household.Head.Age+Type.of.Household+House.Age+
                  Number.of.bedrooms+Electricity,
                data=data, family = "poisson")
```

```
outlierTest(model.best)
```

```
No Studentized residuals with Bonferroni p < 0.05
Largest |rstudent|:
    rstudent unadjusted p-value Bonferroni p
977 2.681894          0.0073207           NA
```

```
#model summary
summary(model.best)
```

```

Call:
glm(formula = Total.Number.of.Family.members ~ log(Total.Household.Income) + 
    log(Total.Food.Expenditure) + Household.Head.Sex + Household.Head.Age + 
    Type.of.Household + House.Age + Number.of.bedrooms + Electricity, 
    family = "poisson", data = data)

Deviance Residuals: 
     Min        1Q    Median        3Q       Max  
-2.19539  -0.58469  -0.09141   0.42019   2.66999  

Coefficients:
                                                         Estimate Std. Error
(Intercept)                                             -3.144768   0.347530
log(Total.Household.Income)                             -0.253972   0.033361
log(Total.Food.Expenditure)                              0.727582   0.046545
Household.Head.SexMale                                   0.192173   0.037564
Household.Head.Age                                      -0.003409   0.001114
Type.of.HouseholdSingle Family                          -0.324931   0.030739
Type.of.HouseholdTwo or More Nonrelated Persons/Members -0.460081   0.244011
House.Age                                               -0.002346   0.001161
Number.of.bedrooms                                      -0.031361   0.016328
Electricity1                                            -0.076011   0.041378
                                                        z value Pr(>|z|)    
(Intercept)                                              -9.049  < 2e-16 ***
log(Total.Household.Income)                              -7.613 2.68e-14 ***
log(Total.Food.Expenditure)                              15.632  < 2e-16 ***
Household.Head.SexMale                                    5.116 3.12e-07 ***
Household.Head.Age                                       -3.061  0.00221 ** 
Type.of.HouseholdSingle Family                          -10.571  < 2e-16 ***
Type.of.HouseholdTwo or More Nonrelated Persons/Members  -1.885  0.05936 .  
House.Age                                                -2.021  0.04325 *  
Number.of.bedrooms                                       -1.921  0.05478 .  
Electricity1                                             -1.837  0.06621 .  
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 1373.55  on 1247  degrees of freedom
Residual deviance:  749.75  on 1238  degrees of freedom
AIC: 4795.1

Number of Fisher Scoring iterations: 4
```

Without outliers, the best model is obtained.

Test the goodness of fit of Poisson model

```
#test the goodness of fit of model
poisgof(model.best)
```

```
$results
[1] "Goodness-of-fit test for Poisson assumption"

$chisq
[1] 749.7502

$df
[1] 1238

$p.value
[1] 1
```

The p value is 1, which indicates that the goodness of fit of the model is good.

Coefficient and interpretation of model

```
#transform coefficients into exponential form
exp(coef(model.best))
```

```
                                            (Intercept) 
                                             0.04307693 
                            log(Total.Household.Income) 
                                             0.77571384 
                            log(Total.Food.Expenditure) 
                                             2.07006853 
                                 Household.Head.SexMale 
                                             1.21188068 
                                     Household.Head.Age 
                                             0.99659634 
                         Type.of.HouseholdSingle Family 
                                             0.72257687 
Type.of.HouseholdTwo or More Nonrelated Persons/Members 
                                             0.63123227 
                                              House.Age 
                                             0.99765704 
                                     Number.of.bedrooms 
                                             0.96912536 
                                           Electricity1 
                                             0.92680617 
```

```
Coefs<-exp(coef(model.best))
```

Fitted Poisson regression model

$$\begin{aligned}\log(\hat{Y_i}) = \log(\hat{\mu_i}) &= 0.0430769 + 0.7757138 \cdot \log(Total.Household.Income) + 2.0700685 \cdot \log(Total.Food.Expenditure) \\ &+ 1.2118807 \cdot \mathbb{I}_{\text{Male}}(x) + 0.9965963 \cdot Household.Head.Age \\ &+ 0.7225769 \cdot \mathbb{I}_{\text{Single Family}}(x) + 0.997657 \cdot HouseAge\end{aligned}$$

where

- `Total.Household.Income` is the Annual household income (in Philippine peso);
- `Total.Food.Expenditure` is the annual expenditure by the household on food (in Philippine peso);
- `Household.Head.Age` is the head of the households age (in years);
- `House.Age` is the age of the building (in years)
- $\mathbb{I}_{\text{Male}}(x)$ is an indicator function such that

$$\mathbb{I}_{\text{Male}}(x) = \begin{cases} 1 & \text{if Sex of } x\text{th observation is Male,} \\ 0 & \text{Otherwise.} \end{cases}$$

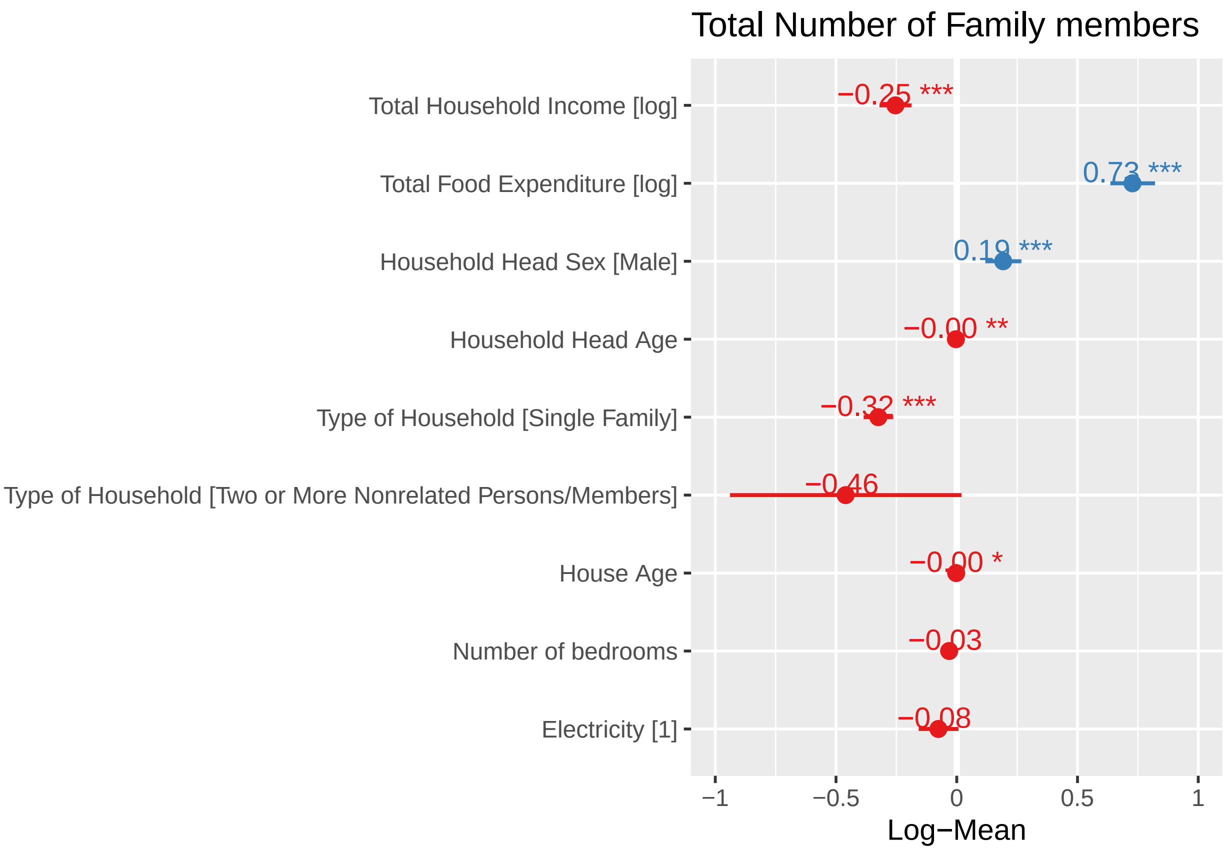
- $\mathbb{I}_{\text{Single Family}}(x)$ is an indicator function such that

$$\mathbb{I}_{\text{Single Family}}(x) = \begin{cases} 1 & \text{if type of family of } x\text{th observation is Single Family,} \\ 0 & \text{Otherwise.} \end{cases}$$

In the MIMAROPA region, all variables except Number.of.bedrooms and Electricity show significance. While keeping other variables unchanged, the number of people living in the house will be multiplied by 0.7757 for every 1 unit increase in the logarithm of the family's annual income (Philippine Peso).the number of people living in the house will be multiplied by 2.0701 for every 1 unit increase in the logarithm of Annual expenditure by the household on food (inmPhilippine peso).If the gender of head of the houses sex is male, the number of people living in the house will be multiplied by 1.2119, indicating that the owner is male, which has a positive impact on the increase of the number of people living in the room. The number of people living in the house will be multiplied by 0.9966 for each additional year of head of the houses age. In the relationship between the group of people living in the house,two or more nonrelated persons / members have no significant effect on the number of residents and single family will have a negative impact on the increase of the number of people living in the room. The number of people living in the house will be multiplied by 0.9977 for each year of age of the building.

Poisson regression predicting Total.Number.of.Family.members

```
#plot coefficients and their confidence interval
plot_model(model.best, transform = NULL, show.p = T, show.values = T)
```



It can be seen from the above figure that Total.Household.Income,Total.Food.Expenditure,Household.Head.Sex ,Household.Head.Age,Single Family in Type.of.Household and House.Age all have a significant impact on Total.Number.of.Family.That is, the increase of annual household food expenditure (Philippine Peso), the gender of the head of household is male, which has a positive impact on the number of people living in this house, and the increase of annual household income (in Philippine Peso), the age of the head of household (in), single families and construction age (in) have a negative impact on the number of people living in this house

Conclusions and Future Work

After selecting models, we have found that the influential variables of the number of people living in a household are : the Annual household income, the annual expenditure by the household on food, the head of the households sex, the head of the households age, the relationship between the group of people living in the house, and the age of the building. The model is built on poisson regression on these variables, where the first two variables are log-transformed. In contrast, non-influential variables are the number of bedrooms in the house and the electricity status of the house.

The goodness of fit test of poisson model shows that what we have observed fits well.

For the future work, we may select more regions of Philippines to compare these variables, or select year as one of the explanatory variables since this data is collected every three years.