

Analysis of Factors Influencing Philippine Family Population Based on GLM

Group_03

Introduction

In Philippine, **FIES**(Family Income and Expenditure Survey), which is undertaken every three years, is aimed at providing data on family income and expenditure. This dataset, comes from the FIES recorded in the Philippines, is analysed in this report.

In particular, this report presents numerical and graphical summaries of FIES and fits a **Generalized Linear Model(GLM)** to analyze which household related variables influence the number of people living in a household.

Research Question

Which household related variables influence the number of people living in a household?

Data Cleaning

First read the data and tidy the data using tidyverse:

```
# Read the data set
Data_FIES <- read.csv("dataset03.csv")
# Tidy the data
FIES <- Data_FIES %>%
  # Place the dependent variable in the first column and delete the unique value
  select(Total.Number.of.Family.members, everything(), -Region) %>%
  # Convert categorical variables into factors
```

```
mutate(
  Household.Head.Sex = as.factor(Household.Head.Sex),
  Type.of.Household = as.factor(Type.of.Household),
  Electricity = as.factor(Electricity)) %>%
# Remove Missing Values
drop_na()
FIES_saved <- FIES # Used for model fitting
```

We moved the implicit variable to the first row and deleted the region which has no difference in the data. ‘Household.Head.Sex’, ‘Type.of.Household’, and ‘Electricity’ were converted to factors to ensure that the statistical model correctly handled the categorical variables. Also we removed missing values to ensure data integrity.

The dependent variable and independent variables are shown as below:

Dependent Variable:

- **Total.Number.of.Family.members:** Number of people living in the house.

Independent Variables:

- **Total.Household.Income:** Annual household income (in Philippine peso)
- **Total.Food.Expenditure:** Annual expenditure by the household on food (in Philippine peso)
- **Household.Head.Sex:** Head of the households sex
- **Household.Head.Age:** Head of the households age (in years)
- **Type.of.Household:** Relationship between the group of people living in the house
- **House.Floor.Area:** Floor area of the house (in m^2)
- **House.Age:** Age of the building (in years)
- **Number.of.bedrooms:** Number of bedrooms in the house
- **Electricity:** Does the house have electricity? (1=Yes, 0=No)

Exploratory Data Analysis

Then we can check the data structure and get summary statistics of all variables:

```
str(FIES) # Check data structure
```

```
'data.frame':  1887 obs. of  10 variables:
 $ Total.Number.of.Family.members: int  10 8 5 6 6 5 5 5 8 2 ...
 $ Total.Household.Income       : int  89359 108400 51982 76623 135232 73522 60369 60146 1
 $ Total.Food.Expenditure       : int  54537 56611 30827 43639 59614 47563 48962 47482 556
 $ Household.Head.Sex           : Factor w/ 2 levels "Female","Male": 1 2 2 2 2 2 1 2 2 2
 $ Household.Head.Age           : int   34 55 26 53 55 38 50 32 49 60 ...
 $ Type.of.Household            : Factor w/ 3 levels "Extended Family",...: 2 2 2 2 2 2 2 2 2
 $ House.Floor.Area             : int   64 60 48 42 56 56 48 42 48 20 ...
 $ House.Age                   : int   11 13 13 5 5 8 5 13 3 19 ...
 $ Number.of.bedrooms           : int    1 3 1 2 2 1 1 1 2 1 ...
 $ Electricity                  : Factor w/ 2 levels "0","1": 1 2 1 1 2 2 1 1 1 2 ...
```

```
summary(FIES) # Get summary statistics of all variables
```

Total.Number.of.Family.members	Total.Household.Income	Total.Food.Expenditure
Min. : 1.000	Min. : 16238	Min. : 3704
1st Qu.: 3.000	1st Qu.: 85545	1st Qu.: 38311
Median : 4.000	Median : 131806	Median : 54594
Mean : 4.677	Mean : 214058	Mean : 64113
3rd Qu.: 6.000	3rd Qu.: 249176	3rd Qu.: 77068
Max. :16.000	Max. :2598050	Max. :363572

Household.Head.Sex	Household.Head.Age
Female: 400	Min. :15.00
Male :1487	1st Qu.:41.00
	Median :51.00
	Mean :51.52
	3rd Qu.:61.00
	Max. :95.00

Type.of.Household	House.Floor.Area	House.Age
Extended Family	: 567	Min. : 10.00
Single Family	:1311	1st Qu.: 30.00
Two or More Nonrelated Persons/Members:	9	Median : 50.00
		Mean : 59.81
		Mean :19.5

```

3rd Qu.: 80.00 3rd Qu.:26.0
Max.      :600.00 Max.      :95.0

Number.of.bedrooms Electricity
Min.      :0.000      0: 257
1st Qu.:1.000      1:1630
Median   :2.000
Mean     :1.945
3rd Qu.:2.000
Max.     :8.000

```

```
dim(FIES) # Check dataset dimensions (number of rows and columns)
```

```
[1] 1887  10
```

Numerical summaries and Data visualization

Now we can take a look at the numerical summaries and data visualization of **dependent variable** shown in the following tables and plots:

Table 1: Summary statistics for ‘Total.Number.of.Family.members’

Mean	Median	Std	Min	Max	IQ Range	Sample
4.68	4.00	2.30	1.00	16.00	3.00	1,887.00

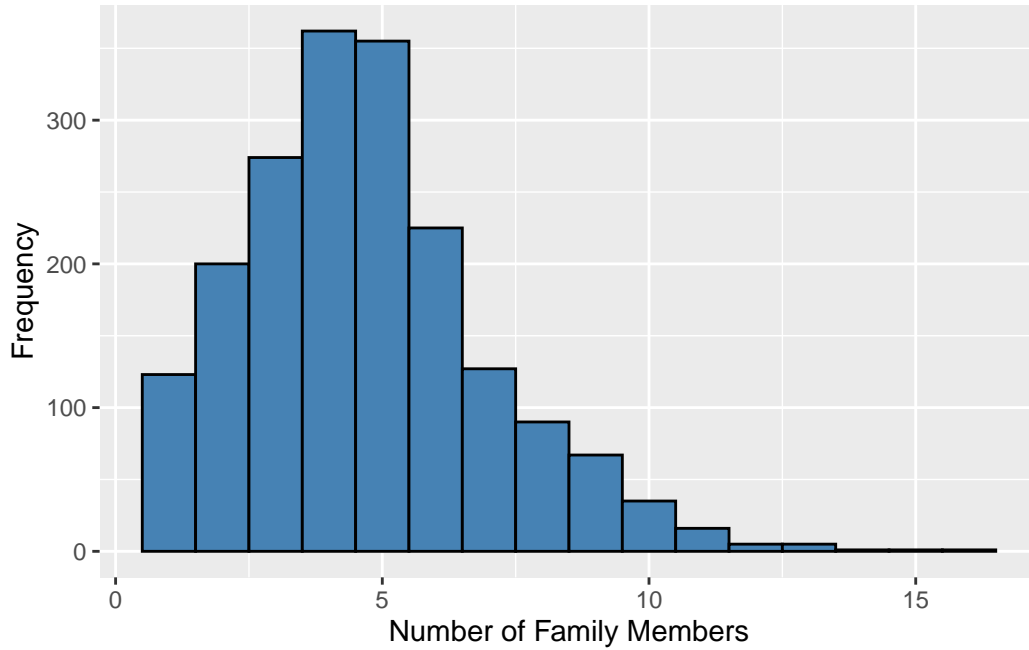


Figure 1: Histogram of ‘Total.Number.of.Family.members’

From Table 1, we can see our dataset includes 1887 samples, which is a sufficiently large sample size to ensure reliability. The mean value (4.68) and median (4.00) are very close, suggesting a roughly symmetric distribution. However, the median is slightly lower than the mean hints at a mild right skew in the data. The standard deviation (2.30) indicates moderate variability around the mean.

Figure 1 shows a strong right-skewed distribution of frequency data. The highest bar (around 300) is concentrated on the left side of the x-axis, indicating that most values are in the lower ranges. The frequency sharply decreased toward the right, with the far-right bars approaching 0, shows that rare occurrences in higher-value intervals.

Then check the variance of the dependent variable and compare with the mean:

```
mean = 4.677266
```

```
var = 5.28232
```

```
var_ratio = 1.129361
```

$\text{var}/\text{mean}=5.28/4.68=1.13$ 1 indicates that there is no overdispersion problem, so Poisson regression model may be appropriate.

Then we separate independent variables into categorical variables and numerical variables for analysis.

1. Categorical Variables

Table 2: Summary statistics on ‘Total.Number.of.Family.members’ by ‘Household.Head.Sex’

Household.Head.Sex	Family Size Summary						
	Mean	Median	Std. Dev	Min	Max	IQR	Sample
Female	3.83	3.00	2.33	1.00	15.00	3.00	400.00
Male	4.91	5.00	2.23	1.00	16.00	3.00	1,487.00

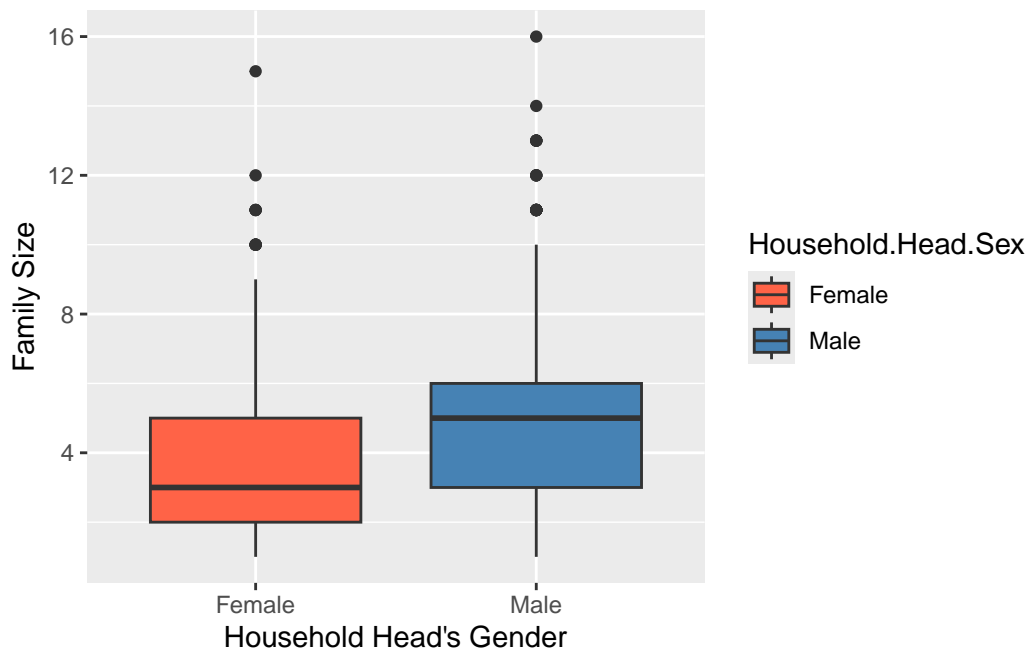


Figure 2: Boxplot of ‘Total.Number.of.Family.members’ by ‘Household.Head.Sex’

Table 2 compares family size statistics between female-headed and male-headed households. Female-headed households exhibit smaller family size, with a mean of 3.83 and a median of 3.00, while male-headed households show significantly larger families (mean = 4.91, median

= 5.00). Despite similar variability in both groups (standard deviations of nearly 2.3), the male-headed households display a broader range. Notably, the dataset is heavily skewed toward male-headed households (1487 samples vs. 400 female samples), which could influence the result. Both groups share identical interquartile ranges (IQR = 3.00), suggesting comparable central clustering of data.

Figure 2 shows that male-headed households exhibit a higher median family size of 5 members, compared to female-headed households with a median of 4 members. Both groups shows moderate variability in their distribution, but male-headed families display a wider range, with extreme outliers reaching up to 16 members which higher than the maximum of 15 members observed in female-headed households. This visualizes the tendency for male-led families to hold a larger household size.

Table 3: Summary statistics on ‘Total.Number.of.Family.members’ by ‘Type.of.Household’

Type.of.Household	Household Summary						Sample Size
	Mean	Median	Std. Dev	Min	Max	IQR	
Single Family	4.14	4.00	2.03	1.00	13.00	2.00	1,311.00
Extended Family	5.88	5.00	2.40	2.00	16.00	3.00	567.00
Two or More Nonrelated Persons/Members	6.89	6.00	2.80	4.00	12.00	2.00	9.00

Table 3 summarizes family size statistics across three household types. Single-family households have the smallest average family size (mean = 4.14, median = 4.00) with a large sample size (1311). Extended families show significantly larger family sizes (mean=5.88, median = 5.00) and a broader spread (max = 16). Households with two or more unrelated members report the highest average (mean = 6.89, median - 6.00), but with a extremely small sample size (9) weakens reliability.

Figure 3 shows that extended families exhibit the highest median family size (5) with a broader range which is up to 16 members, indicating potential outliers. Single families shows a lower median (4) and tighter clustering of data. It reflects a more consistent household size. Households with two or more unrelated members have a median of 6 members. However it only have a sample size of 9 which weakens the reliability of this category.

Table 4: Summary statistics on Family.members by Electricity

Electricity	Mean	Median	Std	Min	Max	IQ	Sample
0	4.70	5.00	2.47	1.00	12.00	3.00	257.00
1	4.67	4.00	2.27	1.00	16.00	3.00	1,630.00

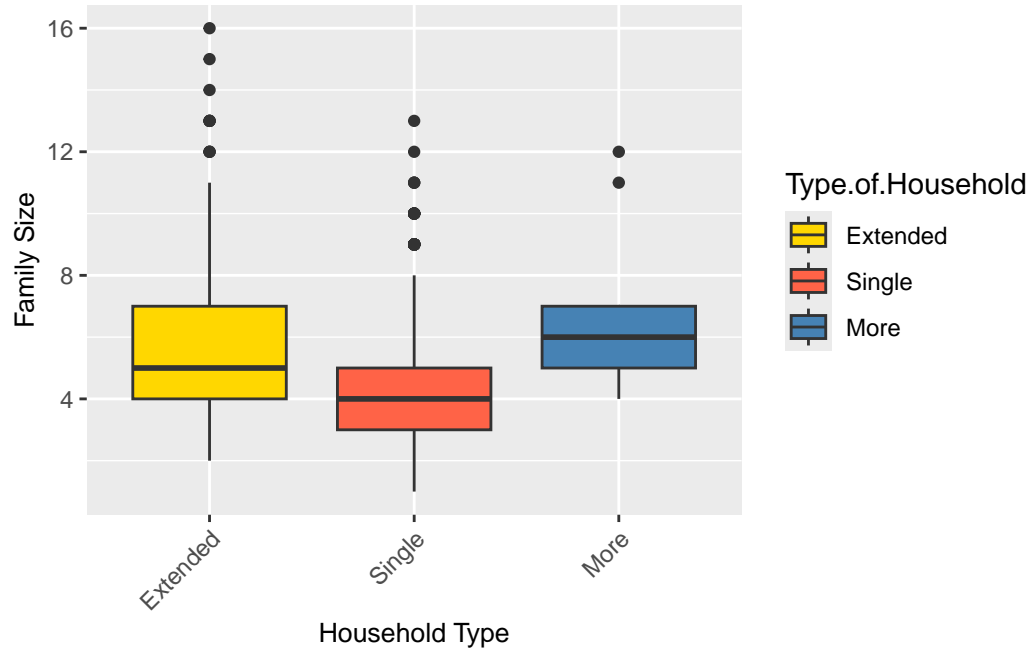


Figure 3: Boxplot of 'Total.Number.of.Family.members' by 'Type.of.Household'

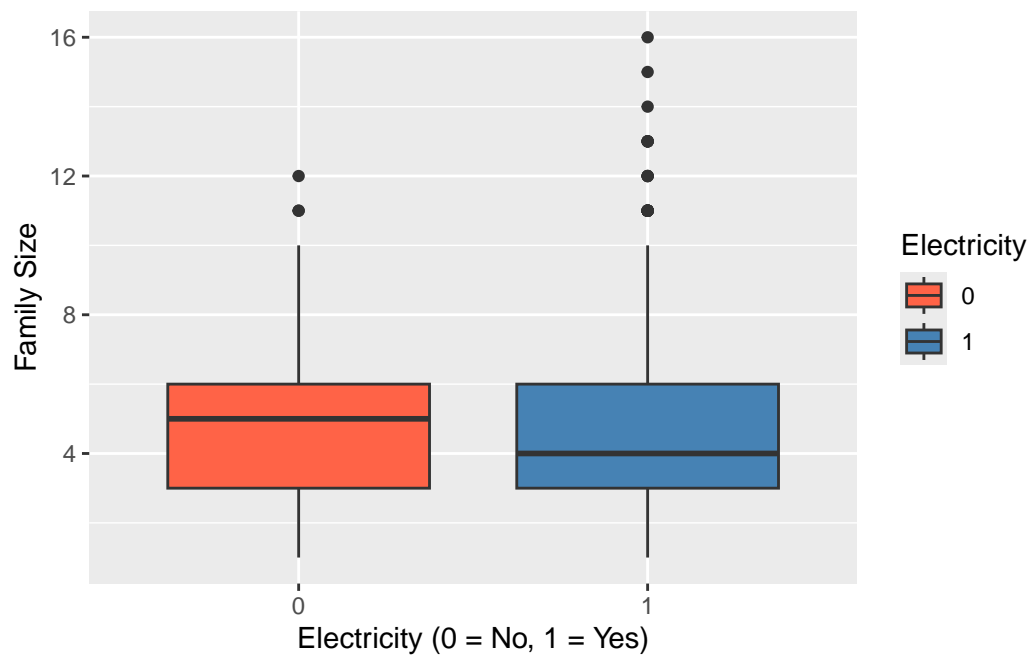


Figure 4: Boxplot of 'Total.Number.of.Family.members' by 'Electricity'

From Table 4, we can see households with electricity (1,630) are about six times more than those without (257). The mean values are nearly identical (4.70 vs. 4.67), but the median is slightly higher for households without electricity (5.00 vs. 4.00). The standard deviation is also slightly larger in the non-electric group (2.47 vs. 2.27), indicating a bit more variability. The maximum value is higher in the electricity group (16.00 vs. 12.00), suggesting a wider range. Both groups have the same interquartile range (3.00), meaning their middle 50% distributions are similar. These differences can be visualized more clearly with boxplots.

Figure 4 shows that households without electricity tend to have a slightly larger median family size compared to those with electricity. However, the distributions of family sizes in both groups are quite similar. The spread of family sizes in both groups is also comparable, as indicated by the interquartile range. Additionally, both groups exhibit several outliers, representing families with unusually large sizes, as shown by the points beyond the “whiskers” of the boxplots.

2. Numerical Variables

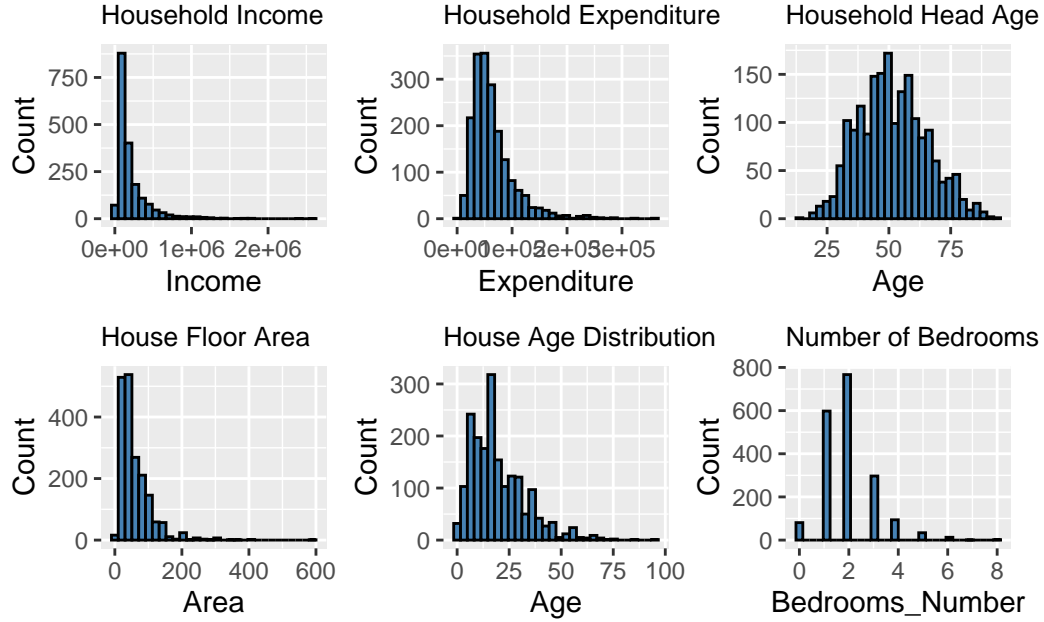


Figure 5: Histograms for Numerical Variables

From Figure 5, we can see the distributions of ‘Total.Household.Income’, ‘Total.Food.Expenditure’, and ‘House.Floor.Area’ are right-skewed, so applying a log

transformation would be beneficial when fitting a Poisson model.

“Household.Head.Age” follows an approximately normal distribution, with most household heads falling within the 30-60 age range. This suggests that middle-aged individuals are the primary decision-makers in households.

The distribution of ‘House.Floor.Area’ is strongly right-skewed, with most houses having relatively small areas, while a few have significantly larger ones. The scarcity of large houses may be due to their higher costs.

The distribution of ‘House.Age’ exhibits a slight bimodal pattern, indicating the presence of two types of houses: newly houses and older houses.

The ‘Number.of.bedrooms’ is a discrete variable, with most houses having 2 or 3 bedrooms, while houses with 4 or more bedrooms are less common. So we can covert the ‘Number.of.bedrooms’ into categorical variable:

```
# Convert 'Number.of.bedrooms' to categorical variable
FIES$Bedroom.Category <- cut(FIES$Number.of.bedrooms,
                             c(-1, 1, 3, Inf),
                             labels = c("Small", "Medium", "Large"),right = TRUE)
# Convert categorical variable into factor
FIES$Bedroom.Category <- factor(FIES$Bedroom.Category)
```

Then we can use the heat map to check the correlation between numerical variables and dependent variable:

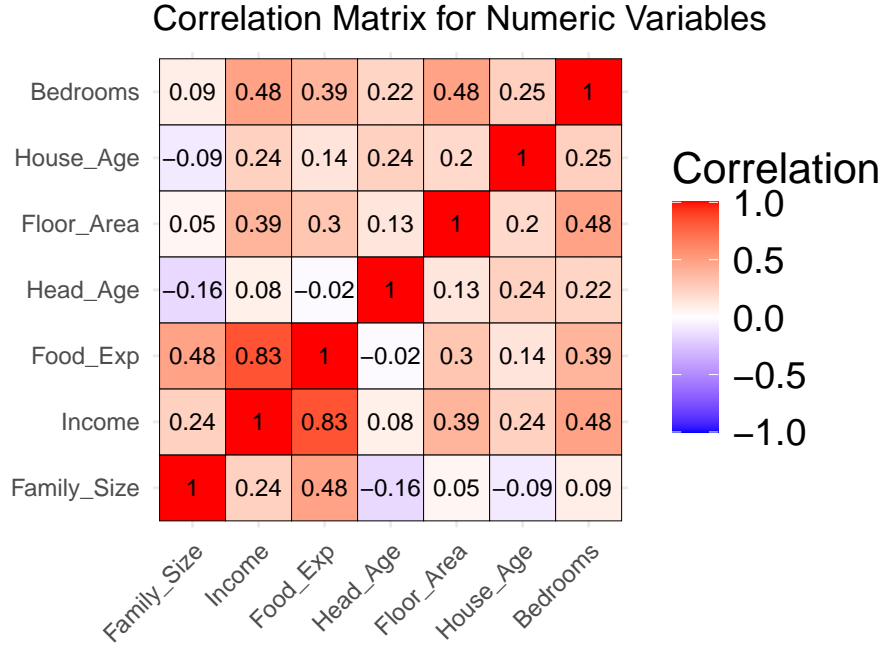


Figure 6: Heat map for numerical variables by ‘Total.Number.of.Family.members’

Form Figure 6, we can see ‘Total.Household.Income’ and ‘Total.Food.Expenditure’ are strongly correlated, reinforcing the expected relationship that higher-income households tend to spend more. ‘Total.Number.of.Family.members’ influences ‘Total.Food.expenditure’, but its impact on ‘Total.Household.Income’ is weaker. ‘Household.head.age’ has a minor effect on most other variables, with a slight negative correlation with family size. ‘House.Floor.Area’ shows some correlation with income, but not significantly with ‘Household.head.age’.

Formal Data Analysis

Since the dependent variable ‘Total.Number.of.Family.members’ is a typical count variable with a mean and variance that are approximately equal, Poisson regression was chosen for modeling. Based on the results of EDA, some variables were log-transformed to improve linear relationships and reduce heteroscedasticity. All selected variables were then included in the model, and stepwise regression using `drop1(poisson_model, test = “F”)` was performed to assess variable significance, gradually eliminating insignificant variables to ensure the final model’s robustness and explanatory power.

Fit the first Poisson regression model:

$$\begin{aligned}\log(\text{Family_Size}) = & \beta_0 + \beta_1 \log(\text{Income}) + \beta_2 \log(\text{Food_Exp}) + \beta_3 \text{Head_Sex} \\ & + \beta_4 \text{Head_Age} + \beta_5 \text{Household_Type} + \beta_6 \log(\text{Floor_Area}) \\ & + \beta_7 \log(\text{House_Age}) + \beta_8 \text{Bedrooms} + \beta_9 \text{Electricity}\end{aligned}$$

Family_Size: The expected value of family size (dependent variable). log(Income): The logarithm of household income, measuring the economic level of the family. log(Food_Exp): The logarithm of food expenditure, representing the household's spending on food. Head_Sex: The gender of the household head (categorical variable, usually 0 for female and 1 for male). Head_Age: The age of the household head (continuous variable), indicating the effect of the household head's age on family size. Household_Type: The type of household (categorical variable), indicating different family structures such as single-parent or nuclear families. log(House_Age): The logarithm of house age (with +1 to avoid taking the logarithm of 0), measuring the age of the dwelling. Electricity: Whether the household has access to electricity (0 = no, 1 = yes), reflecting the household's infrastructure. Bedrooms: The number of bedrooms in the household (continuous variable), reflecting the size of the dwelling. log(Floor_Area): The logarithm of the floor area of the household (continuous variable), measuring the size of the living space.

```
poisson_model1 <- glm(Family_Size ~
  log(Income) +
  log(Food_Exp) +
  Head_Sex +
  Head_Age +
  Household_Type +
  log(Floor_Area) +
  log(House_Age+0.1) +
  Bedrooms +
  Electricity,
  family = poisson(link = "log"),
  data = FIES)

summary(poisson_model1)
```

Single term deletions

Model:

```
Family_Size ~ log(Income) + log(Food_Exp) + Head_Sex + Head_Age +
  Household_Type + log(Floor_Area) + log(House_Age + 0.1) +
  Bedrooms + Electricity
```

	Df	Deviance	AIC	F value	Pr(>F)
<none>		1218.5	7450.3		
log(Income)	1	1315.2	7545.0	148.8405	< 2.2e-16 ***
log(Food_Exp)	1	1588.8	7818.6	570.1446	< 2.2e-16 ***
Head_Sex	1	1244.6	7474.4	40.1738	2.903e-10 ***
Head_Age	1	1241.2	7471.0	34.9168	4.077e-09 ***
Household_Type	2	1362.3	7590.1	110.6954	< 2.2e-16 ***
log(Floor_Area)	1	1218.7	7448.4	0.2034	0.6520
log(House_Age + 0.1)	1	1228.7	7458.5	15.6560	7.880e-05 ***
Bedrooms	1	1218.5	7448.3	0.0287	0.8654
Electricity	1	1229.0	7458.7	16.1106	6.210e-05 ***

```
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

For Floor_Area, since it is a continuous variable, a log transformation was applied during the EDA process to improve linearity and reduce heteroscedasticity. However, it remained insignificant in the Poisson regression model even after transformation, so it is considered for removal. As for Bedrooms, it is a discrete integer variable with a large number of zero values. Given the potential categorical effect, converting it into a categorical variable may be more appropriate to better capture its impact on family size.

```
FIES$Bedroom.Category <- cut(FIES$Bedrooms,
                             breaks = c(-1, 1, 3, Inf),
                             labels = c("Small", "Medium", "Large"),
                             right = TRUE)
FIES$Bedroom.Category <- factor(FIES$Bedroom.Category)
```

Fit a linear regression model with 'Bedroom.Category' and observe that the results show the category has a certain significance.

```
model_cat <- lm(Family_Size ~ Bedroom.Category, data = FIES)
```

Table 5: Model Coefficients and Significance

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	4.3961708	0.0878516	50.040880	0.0000000
Bedroom.CategoryMedium	0.4139795	0.1124417	3.681725	0.0002382
Bedroom.CategoryLarge	0.6246625	0.2100237	2.974248	0.0029744

Then we can Fit a poisson regression model with 'Bedroom.Category' the same as above:

```
poisson_model_cat <- glm(Family_Size ~
  log(Income) +
  log(Food_Exp) +
  Head_Sex +
  Head_Age +
  Household_Type +
  log(House_Age+1) +
  Bedroom.Category +
  Electricity,
  family = poisson(link = "log"),
  data = FIES)

summary(poisson_model_cat)
```

Single term deletions

Model:

```
Family_Size ~ log(Income) + log(Food_Exp) + Head_Sex + Head_Age +
  Household_Type + log(House_Age + 1) + Bedroom.Category +
  Electricity
```

	Df	Deviance	AIC	F value	Pr(>F)
<none>		1216.0	7447.8		
log(Income)	1	1314.7	7544.4	152.1694	< 2.2e-16 ***
log(Food_Exp)	1	1584.2	7814.0	567.9627	< 2.2e-16 ***
Head_Sex	1	1241.2	7471.0	38.8521	5.632e-10 ***
Head_Age	1	1239.4	7469.1	35.9972	2.366e-09 ***
Household_Type	2	1359.7	7587.5	110.8329	< 2.2e-16 ***
log(House_Age + 1)	1	1226.6	7456.3	16.2519	5.767e-05 ***
Bedroom.Category	2	1218.5	7446.2	1.8675	0.1548
Electricity	1	1227.7	7457.4	17.9213	2.414e-05 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

After converting Bedrooms into a categorical variable and refitting the model, it remained insignificant, so it was ultimately removed.

Then Fit the second Poisson regression model

$$\begin{aligned}\log(\text{Family_Size}) = & \beta_0 + \beta_1 \log(\text{Income}) + \beta_2 \log(\text{Food_Exp}) \\ & + \beta_3 \text{Head_Sex} + \beta_4 \text{Head_Age} + \beta_5 \text{Household_Type} \\ & + \beta_6 \log(\text{House_Age}) + \beta_7 \text{Electricity}\end{aligned}$$

```
poisson_model2 <- glm(Family_Size ~
  log(Income) +
  log(Food_Exp) +
  Head_Sex +
  Head_Age +
  Household_Type +
  log(House_Age+1) +
  Electricity,
  family = poisson(link = "log"),
  data = FIES)
```

Although the classification of Household_Type is not significant statistically, it is retained based on the theoretical justification from the original data classification. This ensures that its impact is still considered during model interpretation.

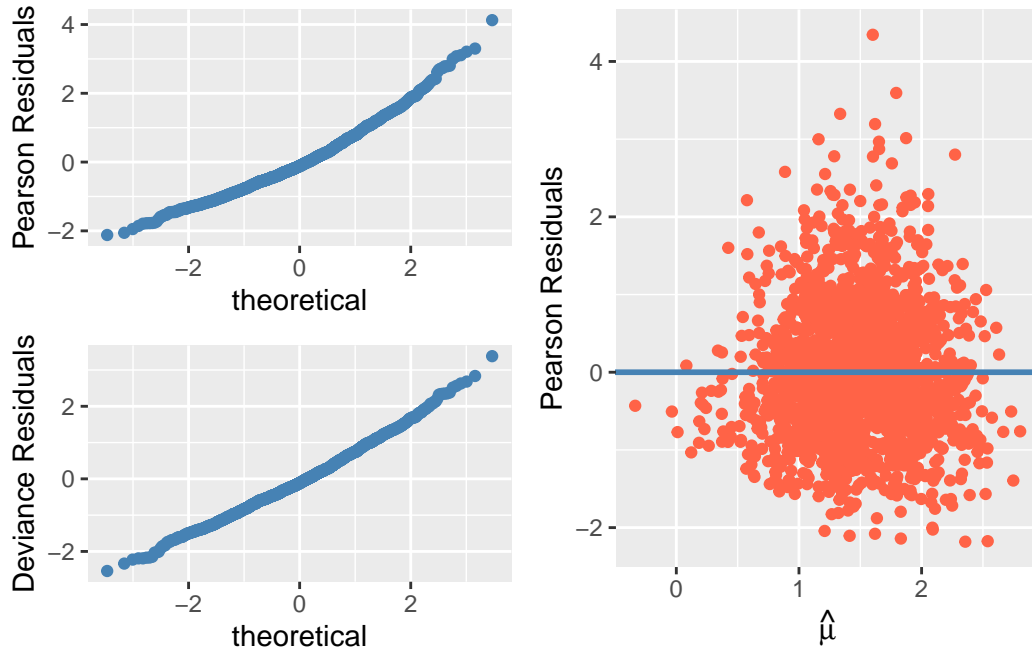


Figure 7: The Pearson and deviance residuals against the linear predictor

By plotting the QQ plots of Pearson and Deviance, we found that the data conform to the normality assumption. To further assess whether there is significant overdispersion in the Deviance distribution, we compared the performance of the original Poisson model and the Quasi-Poisson model in handling overdispersion. By comparing the standardized Pearson residuals of both models, we found that the original Poisson model performed better, indicating no significant overdispersion. Therefore, no adjustment was made to the standard errors of the parameters, as overdispersion was not evident.

Call:

```
glm(formula = Family_Size ~ log(Income) + log(Food_Exp) + Head_Sex +
     Head_Age + Household_Type + log(House_Age + 1) + Electricity,
     family = poisson(link = "log"), data = FIES)
```

Coefficients:

	Estimate	Std. Error
(Intercept)	-2.7453484	0.1956354
log(Income)	-0.2731779	0.0218092
log(Food_Exp)	0.7355788	0.0313499
Head_SexMale	0.1454000	0.0235193
Head_Age	-0.0041994	0.0007119
Household_TypeSingle Family	-0.2847395	0.0193537
Household_TypeTwo or More Nonrelated Persons/Members	0.0961818	0.1043781
log(House_Age + 1)	-0.0512741	0.0128593
Electricity1	-0.1092392	0.0271865

	z value	Pr(> z)
(Intercept)	-14.033	< 2e-16 ***
log(Income)	-12.526	< 2e-16 ***
log(Food_Exp)	23.464	< 2e-16 ***
Head_SexMale	6.182	6.32e-10 ***
Head_Age	-5.899	3.66e-09 ***
Household_TypeSingle Family	-14.712	< 2e-16 ***
Household_TypeTwo or More Nonrelated Persons/Members	0.921	0.357
log(House_Age + 1)	-3.987	6.68e-05 ***
Electricity1	-4.018	5.87e-05 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 0.6580882)

Null deviance: 2130.1 on 1886 degrees of freedom

Residual deviance: 1218.5 on 1878 degrees of freedom
AIC: 7446.2

Number of Fisher Scoring iterations: 4

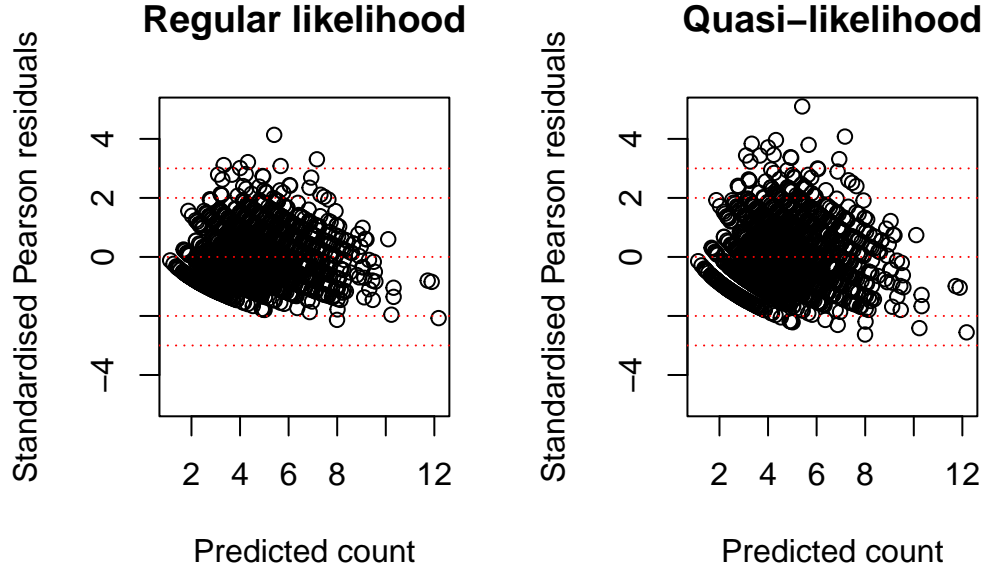


Figure 8: Regular likelihood and Quasi-likelihood

Based on the model comparison and LRT test results, and considering the high correlation observed in the EDA heatmap, an interaction term between Income and Food_Exp was introduced. After comparing the original model with the model including the interaction term, it was found that the Deviance decreased by 47.118 after adding the interaction term, indicating that the inclusion of the interaction term significantly improved the model's fit. Therefore, the conclusion can be made that introducing the interaction term effectively enhanced the model's explanatory power and fit:

$$\begin{aligned} \log(\text{Family_Size}) = & \beta_0 + \beta_1 \log(\text{Income}) + \beta_2 \log(\text{Food_Exp}) \\ & + \beta_3 \log(\text{Income}) \times \log(\text{Food_Exp}) + \beta_4 \text{Head_Sex} \\ & + \beta_5 \text{Head_Age} + \beta_6 \text{Household_Type} + \beta_7 \log(\text{House_Age}) \\ & + \beta_8 \text{Electricity} \end{aligned}$$

The explanation for each variable shows below: Family_size: The expected value of family size (dependent variable). log(Income): The logarithm of household income, measuring the economic level of the family. log(Food_Exp): The logarithm of food expenditure, representing the household's spending on food. log(Income) * log(Food_Exp): The interaction term between income and food expenditure, measuring their joint effect on family size. Head_Sex: The gender of the household head (categorical variable, usually 0 for female and 1 for male). Head_Age: The age of the household head (continuous variable), indicating the effect of the household head's age on family size. Household_Type: The type of household (categorical variable), indicating different family structures such as single-parent or nuclear families. log(House_Age: The logarithm of house age (with +1 to avoid taking the logarithm of 0), measuring the age of the dwelling. Electricity: Whether the household has access to electricity (0 = no, 1 = yes), reflecting the household's infrastructure.

```
poisson_model4 <- glm(Family_Size ~
  log(Income) * log(Food_Exp) +
  Head_Sex +
  Head_Age +
  Household_Type +
  log(House_Age + 1) +
  Electricity,
  family = poisson(link = "log"),
  data = FIES)
```

Analysis of Deviance Table

Model 1: Family_Size ~ log(Income) + log(Food_Exp) + Head_Sex + Head_Age + Household_Type + log(House_Age + 1) + Electricity

Model 2: Family_Size ~ log(Income) * log(Food_Exp) + Head_Sex + Head_Age + Household_Type + log(House_Age + 1) + Electricity

	Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
1	1878	1218.5			
2	1877	1171.3	1	47.118	6.685e-12 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

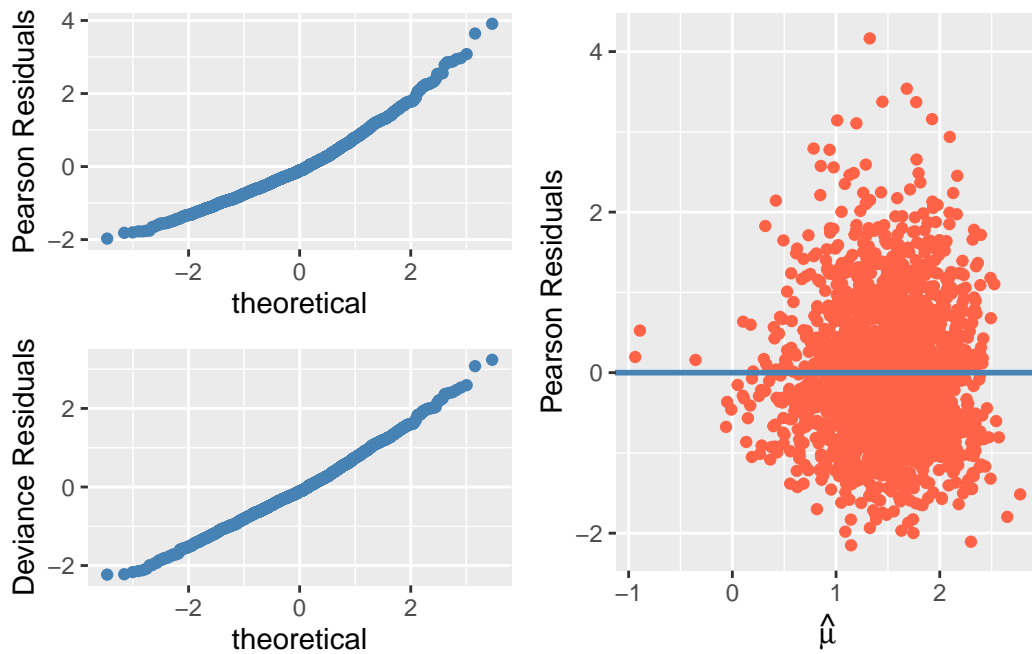


Figure 9: The Pearson and deviance residuals against the linear predictor

Call:

```
glm(formula = Family_Size ~ log(Income) * log(Food_Exp) + Head_Sex +
     Head_Age + Household_Type + log(House_Age + 1) + Electricity,
     family = poisson(link = "log"), data = FIES)
```

Coefficients:

	Estimate	Std. Error
(Intercept)	-2.177e+01	2.284e+00
log(Income)	1.332e+00	1.929e-01
log(Food_Exp)	2.420e+00	2.042e-01
Head_SexMale	1.378e-01	2.312e-02
Head_Age	-3.713e-03	7.043e-04
Household_TypeSingle Family	-2.827e-01	1.896e-02
Household_TypeTwo or More Nonrelated Persons/Members	8.186e-02	1.025e-01
log(House_Age + 1)	-5.536e-02	1.262e-02
Electricity1	-1.499e-01	2.703e-02
log(Income):log(Food_Exp)	-1.416e-01	1.694e-02
	z value	Pr(> z)

(Intercept)	-9.533	< 2e-16	***
log(Income)	6.909	4.88e-12	***
log(Food_Exp)	11.855	< 2e-16	***
Head_SexMale	5.959	2.53e-09	***
Head_Age	-5.273	1.34e-07	***
Household_TypeSingle Family	-14.911	< 2e-16	***
Household_TypeTwo or More Nonrelated Persons/Members	0.798	0.425	
log(House_Age + 1)	-4.385	1.16e-05	***
Electricity1	-5.545	2.94e-08	***
log(Income):log(Food_Exp)	-8.361	< 2e-16	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 0.635141)

Null deviance: 2130.1 on 1886 degrees of freedom
 Residual deviance: 1171.3 on 1877 degrees of freedom
 AIC: 7401.1

Number of Fisher Scoring iterations: 4

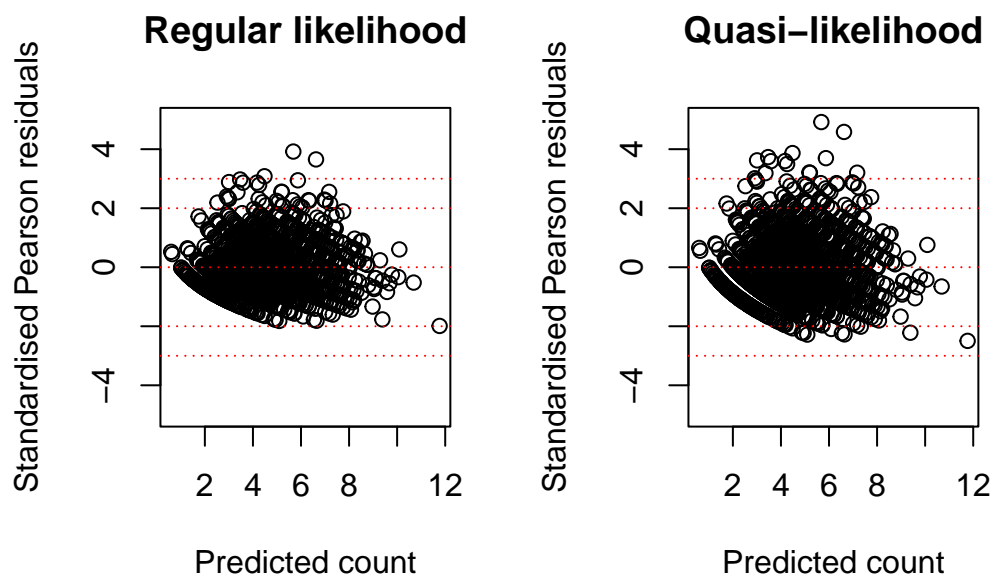


Figure 10: Regular likelihood and Quasi-likelihood

The QQ plots of the Pearson and Deviance both conform to the normality assumption and there is no obvious overdispersion in the Residuals plot.

Conclusion

Based on the results of Relative Risk from the model, the following key conclusions can be summarized:

Table 6: Poisson Model Coefficients and Relative Risks

term	estimate	RR
(Intercept)	-21.7708565	0.0000000
log(Income)	1.3324561	3.7903412
log(Food_Exp)	2.4203371	11.2496508
Head_SexMale	0.1377819	1.1477252
Head_Age	-0.0037134	0.9962935
Household_TypeSingle Family	-0.2826811	0.7537601
Household_TypeTwo or More Nonrelated Persons/Members	0.0818574	1.0853010
log(House_Age + 1)	-0.0553559	0.9461484
Electricity1	-0.1498882	0.8608042
log(Income):log(Food_Exp)	-0.1416451	0.8679292

Income's Impact on Family Size: When income increases by 1%, the average family size increases by approximately 3.79 times. This indicates a positive correlation between income and family size, suggesting that higher income may be associated with larger families.

Food Expenditure's Impact on Family Size: When food expenditure increases by 1%, the average family size increases by approximately 11.25 times. This suggests that higher food spending is closely related to an increase in family size.

House Age's Impact on Family Size: When house age increases by 1%, the average family size decreases by approximately 5.39%. This implies that older houses may be associated with smaller family sizes, possibly due to living conditions or other factors.

Interaction Between Income and Food Expenditure: When both income and food expenditure increase by 1%, the average family size decreases by approximately 13.21%. This suggests that while both variables have a positive individual effect, their interaction shows a negative association, possibly indicating that higher income combined with higher food expenditure may not lead to a larger family size.

Head Sex's Impact on Family Size: Families with male heads tend to have approximately 15% more members than those with female heads. This indicates that families with male heads may be larger than those with female heads.

Head Age's Impact on Family Size: For each additional year in the head's age, the average family size decreases by approximately 0.4%. This suggests that older heads of households may have smaller families.

Household Type's Impact on Family Size: If the household type is a single-parent family, the average family size is about 25% smaller compared to other household types. Single-parent families generally have smaller family sizes.

In conclusion, these results show that family size is closely related to various factors, particularly income, food expenditure, head sex, and household type. Changes in family size are influenced not only by individual variables but also by the interactions between them.