R Project - Household

EDA, Summarization, Visualization

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Due: Friday, March 5, 2021

RStudio version 1.4.1103.

Project Scope

Data Source

- http://stat511.cwick.co.nz/homeworks/acs_or.csv

Industry Orient

- Real Estate / Agent
- Banking / Mortgage / Loan
- City Hall / CRA / Property Tax
- Household Utilities Providers

Analysis Tasks

- Identify the distribution of Income Group, i.e., Low Income, Middle Class, and High-Income families;
- Analysis of the relationship between Communication Mode and Income Group;
- Identify and handle outlier, if any;
- Analysis of the relationship between the number of bedrooms and internet accessibility;
- Identify the distribution of household ownership;
- Identify the distribution based on the built decade of houses;
- Analysis of the relationship between house owner's age and income;
- Analysis of the relationship between house owner's age and internet accessibility;
- Analysis of the relationship between ownership and income group.

R Learning Points and Skills

Data Set Cleaning

- Changing Working Directory
- Importing and Reading Data
- Understanding Data
- Cleaning Data
- Processing and Amending Data

- Outliers Handling

Data Set Summarization

- Distribution Analysis
- Segmentation
- Contingency Table (Two-way Table)

Data Set Visualization

- Pie Chart
- Simple Bar Chart
- Histogram Plots
- Stacked Bar Chart
- Grouped Bar Chart
- Mosaic Plots
- Association Plots

Data Set Relationship Analysis

- Bivariate Analysis
- Chi-square Test
- T-test

Question 1 – Data Cleaning

Add a new column of 'income_total' which is the sum of 'income_husband' and 'income_wife'. Then segment to 'income_group' by 'income_total'.

```
# 1.1: Add the 1st column - income_total
hh$income_total <- hh$income_husband + hh$income_wife
summary(hh$income_total)
```

```
## Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  -9000   42300   69700   88816  106000  979000
```

```
# 1.2: Add the 2nd column - income_group
hh$income_group = ifelse(hh$income_total < 50000, "Low Income",
                  ifelse(hh$income_total < 300000, "Middle Class",
                  ifelse(hh$income_total >= 300000, "High Income", "")))
str(hh)
```

```
## 'data.frame':       7811 obs. of  15 variables:
 $ household      : int  48 218 279 612 947 1373 1733 1858 1947 1962 ...
 $ age_husband    : int  64 63 56 71 37 86 67 70 33 41 ...
 $ age_wife       : int  62 64 51 68 33 91 67 74 31 47 ...
 $ income_husband : int  11000 100000 31000 51700 16600 77500 8400 73670...
 $ income_wife    : int  29200 3100 0 8800 26000 30000 4800 11000 600 ...
 $ bedrooms       : num  1 4 2 3 3 4 4 0 1 3 ...
 $ electricity    : int  90 230 200 170 260 20 70 180 20 80 ...
 $ gas            : int  3 30 40 3 3 30 150 80 30 200 ...
 $ number_children: int  0 0 0 0 2 0 0 0 0 2 ...
 $ internet       : chr  "Yes" "Yes" "No" "Yes" ...
 $ mode           : chr  "followup" "mail" "followup" "internet" ...
 $ own            : chr  "Owned with mortgage or loan" "Owned with mortgage o
r loan" "Rented" "Owned free and clear" ...
 $ decade_built   : int  1940 1990 1950 1950 1990 1980 1980 2000 1930 ...
 $ income_total   : int  40200 103100 31000 60500 42600 107500 13200 ...
 $ income_group   : chr  "Low Income" "Middle Class" "Low Income"...
```

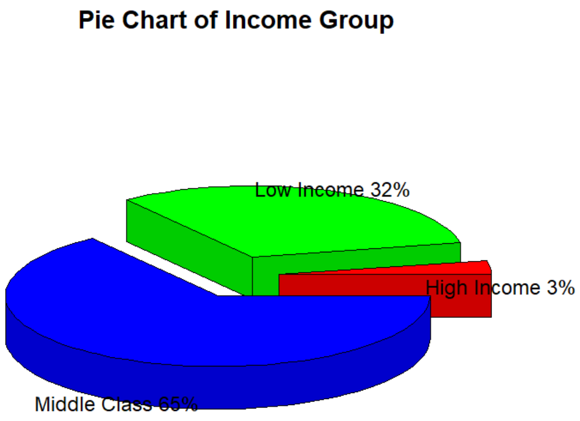
Question 2 – Distribution & Charts

What is the distribution of the variable 'income_group'?

```
# 2.1: list the distribution
tbl <- aggregate(hh$income_group,list(hh$income_group),length)
tbl
```

```
##        Group.1    x
1  High Income  250
2   Low Income 2489
3 Middle Class 5072
```

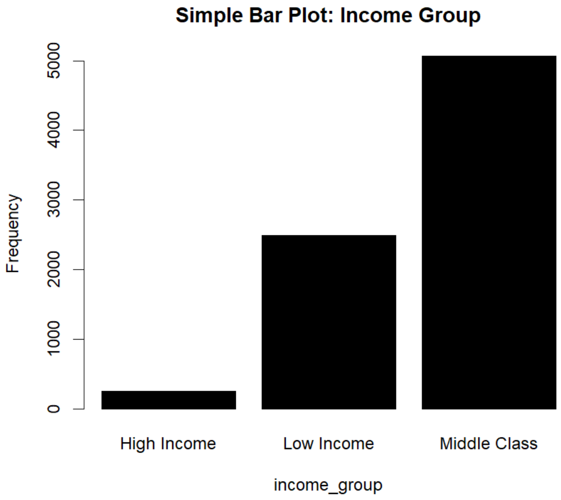
```
# 2.2: 3D Pie Chart
install.packages('plotrix')
library(plotrix)
count <- table(hh$income_group)
pct <- round(count/sum(count)*100)
lbls <- c("High Income", "Low Income", "Middle Class")
lbls <- paste(lbls, pct) # add pct to label
lbls <- paste(lbls, "%", sep = "") # add % to pct
pie <- pie3D(count,
             explode=0.2,
             main = "Pie Chart of Income Group")
pie3D.labels(pie, labels = lbls)
```



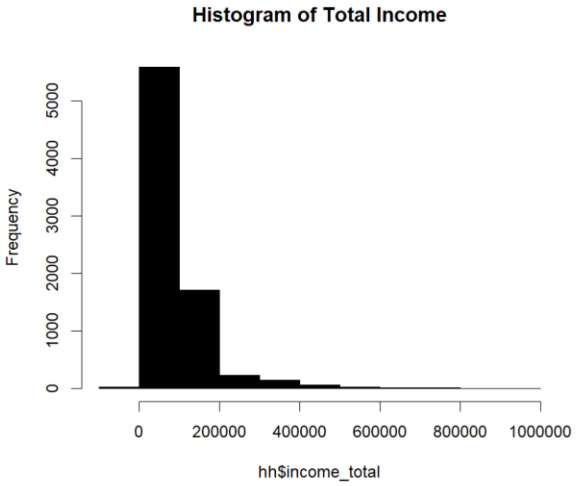
```
# 2.3: Simple Bar Plot
counts <- table(hh$income_group)
counts
```

```
barplot(counts,
        main = "Simple Bar Plot: Income Group",
        xlab = "income_group",
        ylab = "Frequency",
        col = 'black',
        horiz = FALSE)
```

```
##
   High Income    Low Income Middle Class
         250          2489         5072
```



```
# 2.4: Histogram of income_total
hist(hh$income_total,
     main = "Histogram of Total Income",
     col = "black")
```



Question 3 - Bivariate Analysis

Is there any relation between communication mode and target(income_group)?

Bivariate analysis for categorical vs. categorical

For visualization:

- Stacked bar chart or grouped bar chart

For summarization:

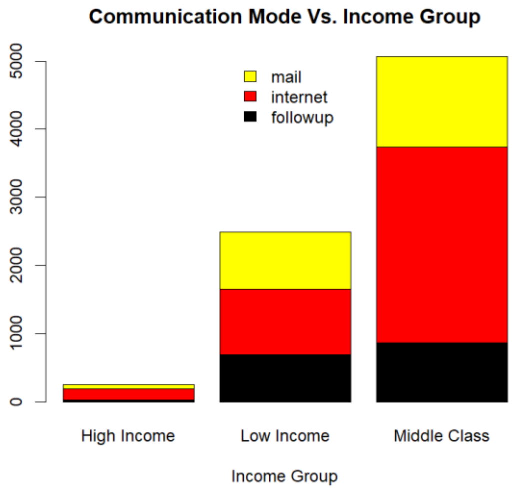
- Contingency table(two-way table)

For the test of independence:

- chi-square test

```r
# 3.1 - Visualization: Stacked Bar Plot
tbl <- table(hh$mode,hh$income_group)
tbl
counts <- tbl[1:3,1:3]
counts
barplot(counts,
        main = "Communication Mode Vs. Income Group",
        xlab = "Income Group",
        col = c("black","red", "yellow"),
        legend = rownames(counts),
        args.legend = list(x ='top', bty='n', inset=c(0,0)))
# Legend position: https://stackoverflow.com/questions/27688754/bar-chart-legend-position-avoiding-operlap-in-r
```

```
##                High Income Low Income Middle Class
  followup          27        694          865
  internet         166        960         2878
  mail              57        835         1329
```



```
# 3.2 - Summarization: Contingency Table

add <- addmargins(xtabs(~ mode + income_group,data=hh))

add[1:4,1:4]

proportions(xtabs(~ mode + income_group,data=hh))[1:3,1:3]
```

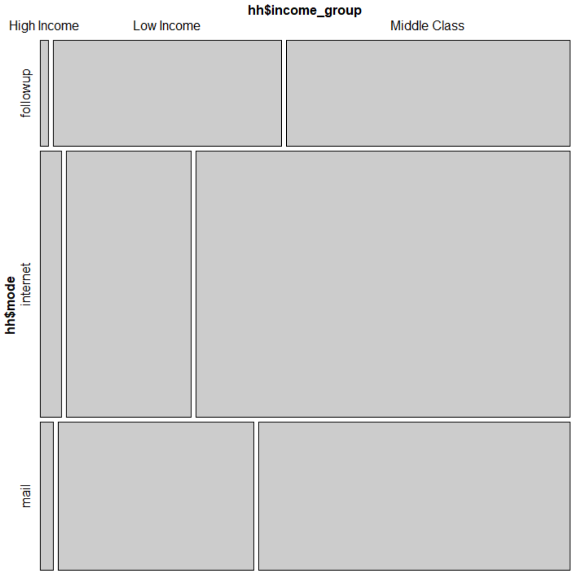
```
          income_group
mode        High Income  Low Income Middle Class
  followup 0.003456664 0.088849059  0.110741262
  internet 0.021252080 0.122903597  0.368454743
  mail     0.007297401 0.106900525  0.170144668
```

```
# 3.3 - Indipendency: Chi-square Test

# 3.3.1 Problem:

# Test whether the communication mode is independent of the income group at a
 0.05 significance level.

# Null hypothesis:  Communication Mode is independent of Income Group

# 3.3.2 Solution:

# p-value

library(MASS)

tbl <- table(hh$mode,hh$income_group)

tbl

chisq.test(tbl) # the p-value < 2.2e-16
```

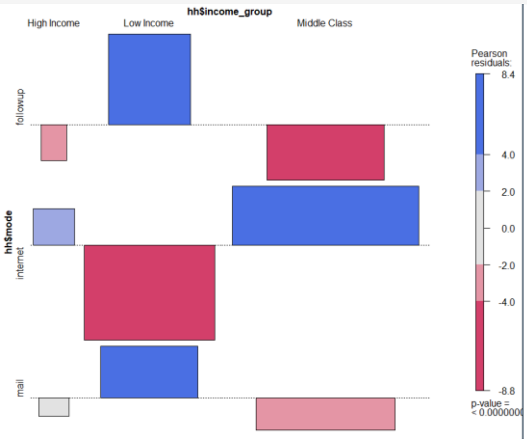
```
##

Pearson's Chi-squared test

data:  tbl

X-squared = 261.59, df = 4, p-value < 0.00000000000000022
```

```
# Mosaic Plots
```

```
library(vcd)

library(grid)

mosaic(structable(hh$income_group ~ hh$mode))

# structable: https://stackoverflow.com/questions/14547162/missing-value-where-true-false-needed-error-vcdmosaic
```



```
# Association Plots

assoc(hh$income_group ~ hh$mode, shade=TRUE)
```



# 3.3.3 Conclusion:

As the p-value 2.2e-16 is less than the 0.05 significance level, we **reject** the null hypothesis that Communication Mode is independent of the Income_Group and conclude that in our data, the 'mode' and the 'income_group' are statistically significantly associated (p-value = 0).

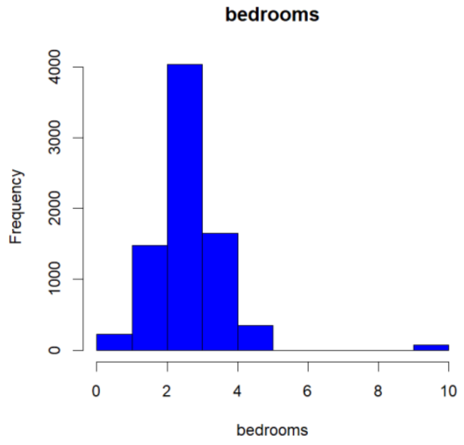
Question 4

What is Bedrooms distribution, how to handle the outlier, if any?

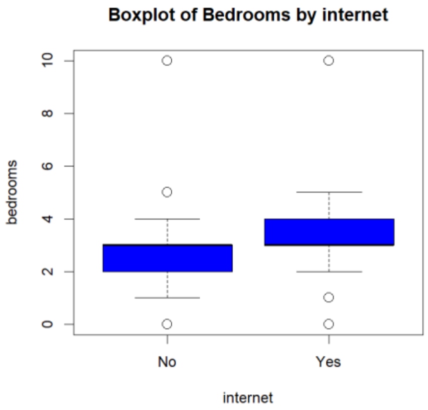
```
# 4.1 summary
summary(hh$bedrooms) # 10 rooms seems too much
```

```
##
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  0.000   3.000   3.000   3.117   4.000  10.000
```

```
# 4.2 histogram
hist(hh$bedrooms,
     breaks = 8,
     main = "bedrooms",
     col = "blue",
     xlab = "bedrooms",
     ylab = "Frequency")
```



```
# 4.3 Boxplot of Bedrooms by internet
boxplot(bedrooms ~ internet,
        data = hh,
        main = "Boxplot of Bedrooms by internet",
        xlab = "internet",
        ylab = "bedrooms",
        col = "blue")
```



```
# 4.4 pattern of outlier
bed_out <- hh[which(hh["bedrooms"]==10),]
bed_out$bedrooms # total 72 obs cross all types of ownership, income_group, b
uilt years...
summary(bed_out["bedrooms"])
nrow(bed_out)
```

```
    bedrooms
 Min.   :10
 1st Qu.:10
 Median :10
 Mean   :10
 3rd Qu.:10
 Max.   :10
> nrow(bed_out)
[1] 72
```

```
# 4.5 prove the bedroom numbers = 10 are just scaled up by 10.
count <- 0
for (val in bed_out$bedrooms){
  if (val%%10 !=0) {count = count+1}
}
count # count = 0 means all the bedrooms equal to 10 are scaled up by 10
# 4.6 amend outlier by deviding by 10
hh$bedrooms <- ifelse(hh$bedrooms == 10, hh$bedrooms/10, hh$bedrooms)
summary(hh["bedrooms"]) # Max reduced to 5.
```

```
##
   bedrooms
```

```
Min.   :0.000
1st Qu.:3.000
Median :3.000
Mean   :3.034
3rd Qu.:4.000
Max.   :5.000
```

Question 5 – T-test

Is there any relationship between Bedrooms and Internet(Yes/No)?

Continuous Vs. Categorical

For summarization:

group by categorical column an aggregate for numerical column

For visualization:

Grouped box plot

For the test of independence :

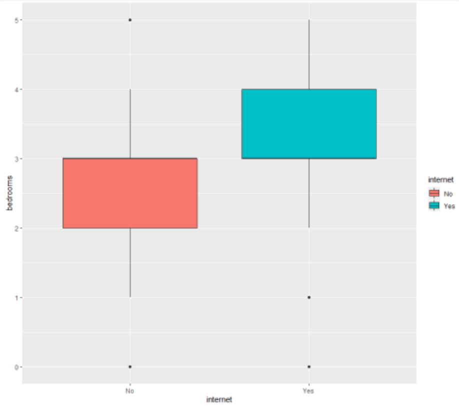
1) if the categorical column has only two levels: t-test

2) if the categorical column has more than two levels: ANOVA

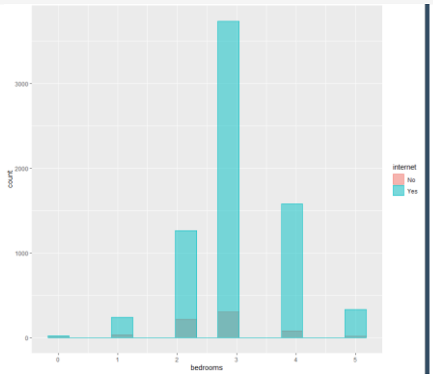
```
# 5.1: Summary grouped by Internet(Yes/No)
agg1 <- aggregate(bedrooms ~ internet, hh , mean)
agg1
```

```
##
internet bedrooms
1        No 2.732087
2       Yes 3.060957
```

```
# 5.2: Visualization by qplot
library(ggplot2)
qplot(internet,
      bedrooms,
      data = hh,
      geom="boxplot",
      fill = internet)
```

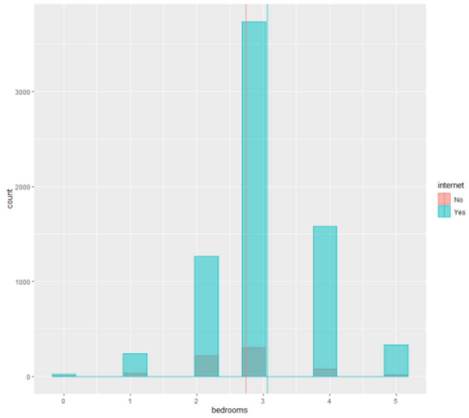


```
# 5.3: Changing histogram plot fill colors by internet and usinging semi-transparent fill

p <- ggplot(hh,aes(x=bedrooms, fill=internet, color=internet)) +

      geom_histogram(position="identity", bins=15, alpha=0.5)

# bins: https://stackoverflow.com/questions/34774120/set-number-of-bins-for-histogram-directly-in-ggplot

p
```

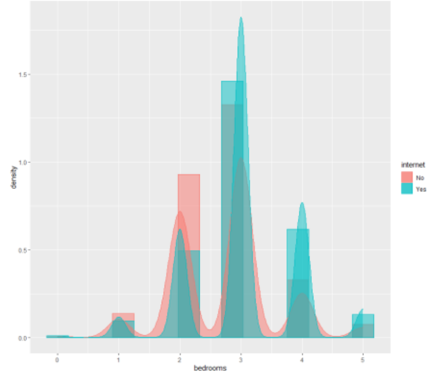


```
# 5.4: Add mean lines

library(plyr)

mu <- ddply(hh, "internet", summarise, grp.mean=mean(bedrooms,na.rm=T))

head(mu)

p <- p + geom_vline(data=mu, aes(xintercept=grp.mean, color=internet),linetype="solid")

p
```

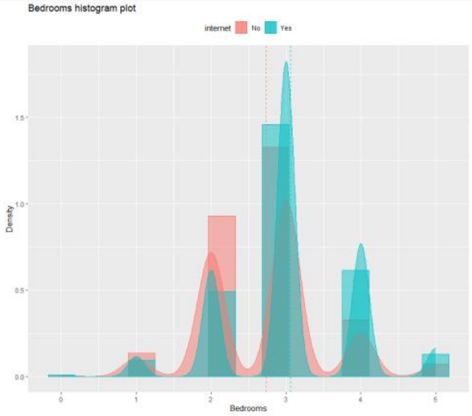
```
  internet grp.mean

1       No 2.732087

2      Yes 3.060957
```



```
# 5.5: Add density

p <- ggplot(hh, aes(x=bedrooms, fill=internet, color=internet)) +
      geom_histogram(aes(y=..density..),bins=15, position="identity", alpha=0.5)+

      geom_density(alpha=0.5)

p
```



```
# 5.6: Add mean lines and Change the legend position

p + geom_vline(data=mu, aes(xintercept=grp.mean, color=internet),linetype="dashed")+

     theme(legend.position="top")+

     labs(title="Bedrooms histogram plot", x="Bedrooms", y = "Density")
```



```
# 5.7 t-test

# Yes: House has internet, No: House has no internet

# Null Hypothesis: µYes = µNo (the means of both populations are equal)

# Alternate Hypothesis: µYes <> µNo (the means of both populations are not equal)

t.test(bedrooms ~ internet, data=hh )
```

```
Welch Two Sample t-test


data:  bedrooms by internet

t = -9.4886, df = 766.41, p-value < 0.00000000000000022
```

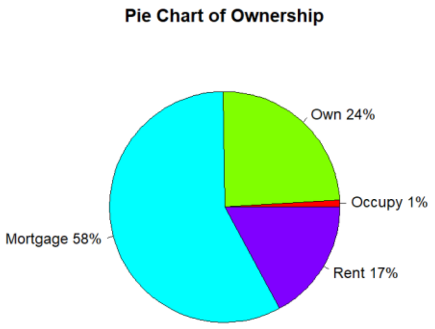
```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.3969082 -0.2608311
sample estimates:
 mean in group No mean in group Yes
         2.732087          3.060957
# Conclusion: p-value is less than 0.05, so the mean values between uYes and
uNo are not equal.
```

Question 6

What is the distribution of ownership?

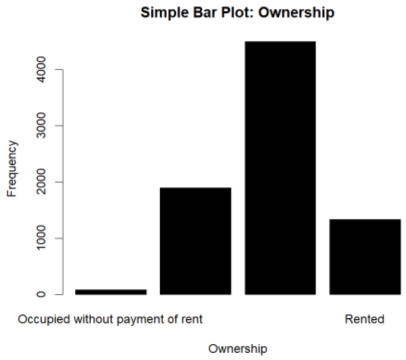
```
# 6.2: Pie Chart
count <- table(hh$own)
count
freq1 <- c(count[1], count[2], count[3], count[4])
lbls <- c("Occupy", "Own", "Mortgage", "Rent")
pct <- round(freq1/sum(freq1)*100)
lbls <- paste(lbls, pct) # add percents to labels
lbls <- paste(lbls,"%",sep="") # ad % to labels
pie(freq1,
    labels = lbls,
    col = rainbow(length(lbls)),
    main = "Pie Chart of Ownership")
```

```
                          Group.1    x
1 Occupied without payment of rent   76
2             Owned free and clear 1896
3      Owned with mortgage or loan 4505
4                           Rented 1334
```



```
# 6.3: Simple Bar Plot

counts <- table(hh$own)
counts
barplot(counts,
        main = "Simple Bar Plot: Ownership",
        xlab = "Ownership",
        ylab = "Frequency",
        col = 'black',
        horiz = FALSE)
```

```
                         Group.1    x
1 Occupied without payment of rent   76
2             Owned free and clear 1896
3      Owned with mortgage or loan 4505
4                           Rented 1334
```



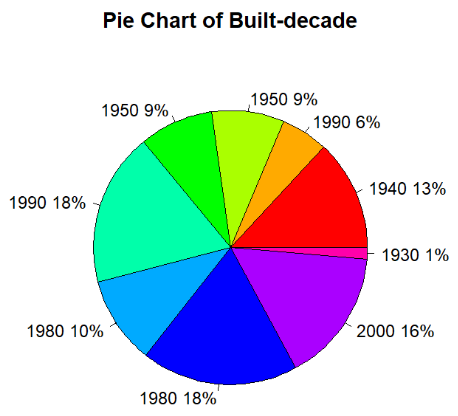
Question 7

What is the distribution of built year?

```
tbl <- aggregate(hh$decade_built,list(hh$decade_built),length)
tbl
```

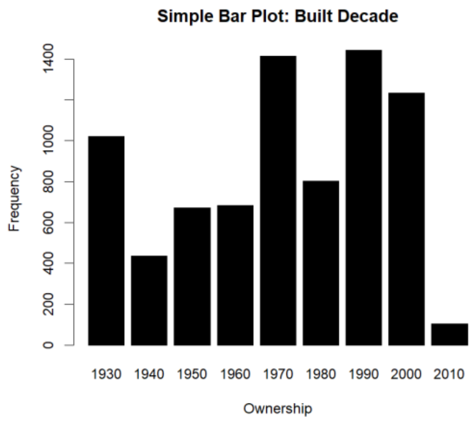
```
Group.1    x
1    1930 1021
2    1940  435
3    1950  671
4    1960  684
5    1970 1415
6    1980  803
7    1990 1444
8    2000 1234
9    2010  104
```

```
# 7.2: Pie Chart

count <- table(hh$decade_built)
pct <- round(count/sum(count)*100)
lbls <- hh$decade_built
lbls <- paste(lbls, pct) # add pct to label
lbls <- paste(lbls, "%", sep = "") # add % to pct
pie(count,
    labels = lbls,
    col = rainbow(length(pct)),
    main = "Pie Chart of Built-decade")
```

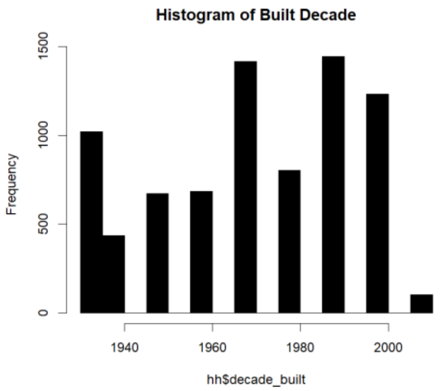


```
# 7.3: Simple Bar Plot


counts <- table(hh$decade_built)

counts

barplot(counts,

        main = "Simple Bar Plot: Built Decade",

        xlab = "Ownership",

        ylab = "Frequency",

        col = 'black',

        horiz = FALSE)
```

```
1930 1940 1950 1960 1970 1980 1990 2000 2010

1021  435  671  684 1415  803 1444 1234  104
```



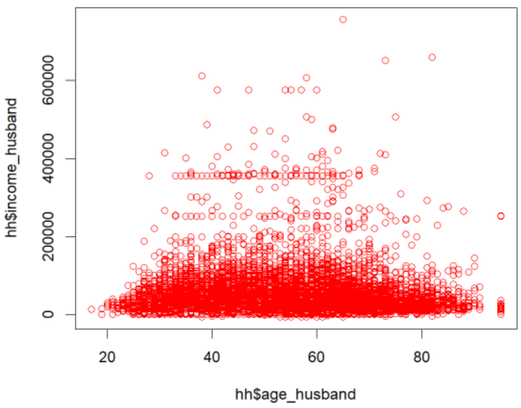
```
# 7.4: Histogram


hist(hh$decade_built,

     main = "Histogram of Built Decade",

     col = "black")
```


Histogram of Built Decade
Frequency
0
500
1000
1500
1940
1960
1980
2000
hh$decade_built

Question 8

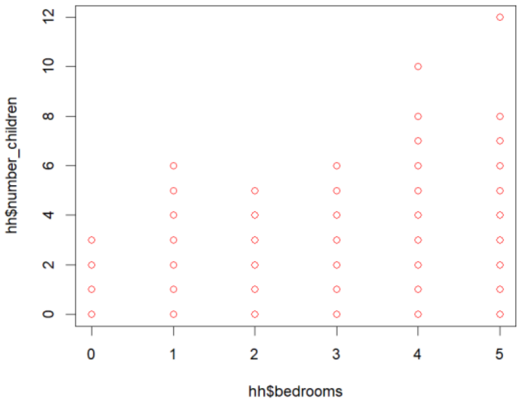
Are there any relationships between the husband's age and his income?

```
# create a scatter plot of a data set
plot(x = hh$age_husband , y = hh$income_husband, type = 'p', col="red")
```



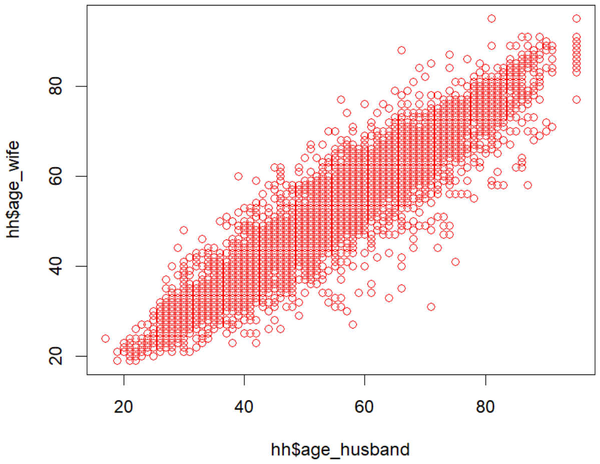
```
# Answer: In this data set, there's NO evidence to prove there's a relation between the husband's age and his income.
```

```
plot(x = hh$bedrooms , y = hh$number_children, type = 'p', col="red")
```



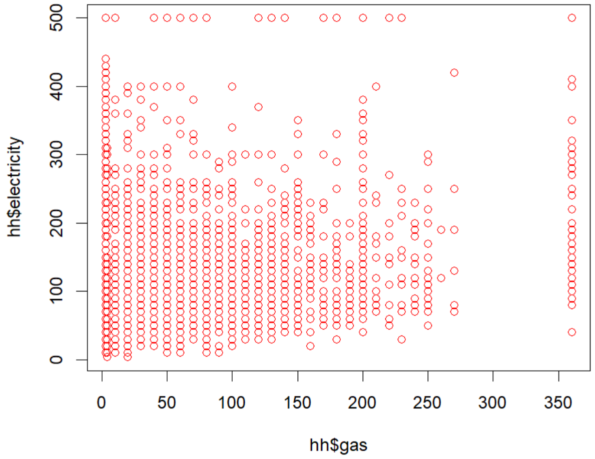
```
# Answer: In this data set, there's evidence to prove there's a relation between the bedrooms and number of children.
```

```
plot(x = hh$age_husband , y = hh$age_wife, type = 'p', col="red")
```



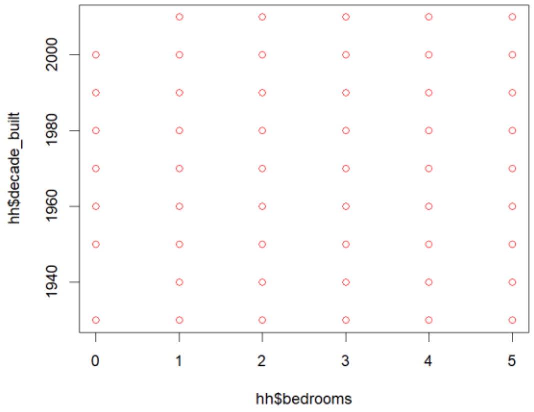
```
# Answer: In this data set, there's evidence to prove there's a relation betw
een the husband’s age and wife’s age.
```

```
plot(x = hh$gas , y = hh$electricity, type = 'p', col="red")
```



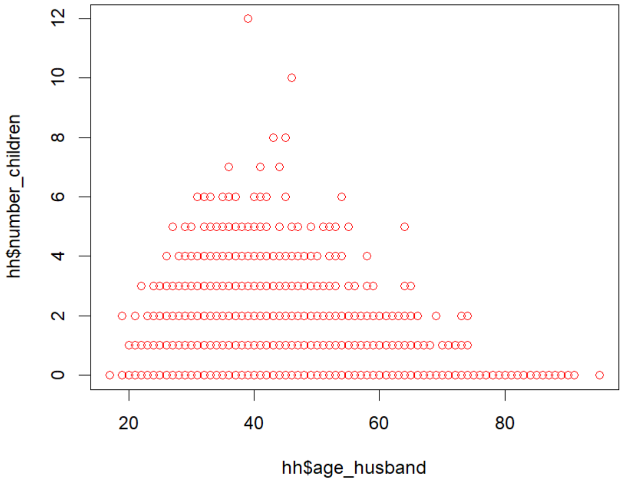
```
# Answer: In this data set, there's NO evidence to prove there's a relation b
etween the gas expense and electricity expense.
```

```
plot(x = hh$bedrooms , y = hh$decade_built, type = 'p', col="red")
```



```
# Answer: In this data set, there's evidence to prove there's a relation between the bedrooms and decade of built year.
```

```
plot(x = hh$age_husband , y = hh$number_children, type = 'p', col="red")
```



```
# Answer: In this data set, there's evidence to prove there's a relation between the husband's age and the number of children.
```

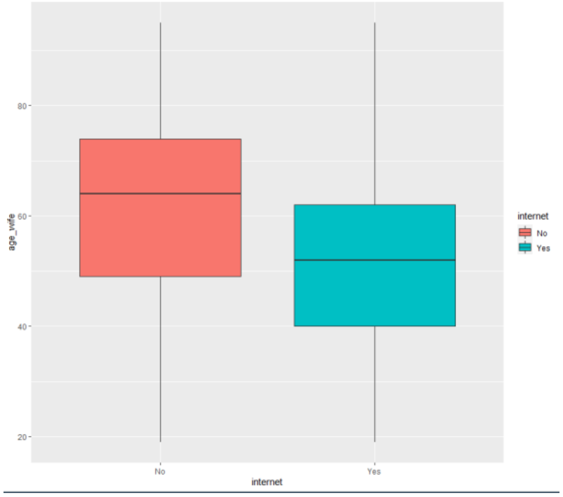
Question 9

Is there any relationship between wife's age and Internet availability(Yes/No)?

```
# 9.1: Summary grouped by Internet(Yes/No)
agg1 <- aggregate(age_wife ~ internet, hh , mean)
agg1
```

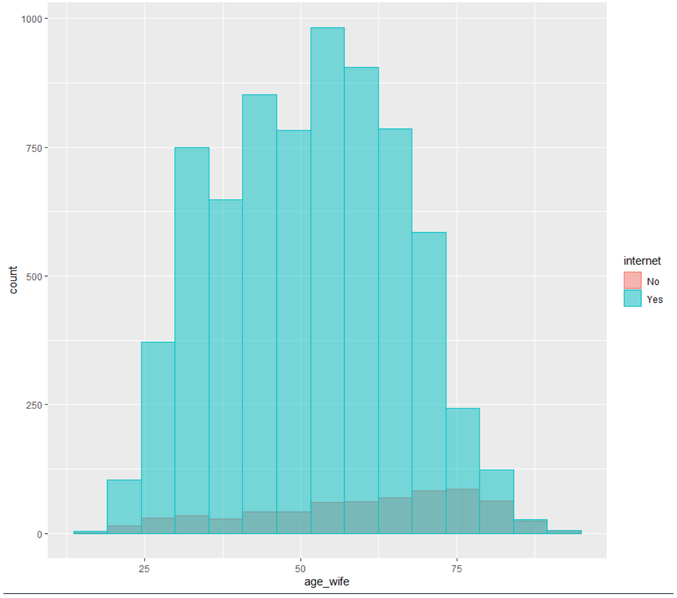
```
##
  internet age_wife
1       No 60.27103
2      Yes 51.34565
```

```
# 9.2: Visualization by qplot
library(ggplot2)
qplot(internet,
      age_wife,
      data = hh,
      geom="boxplot",
      fill = internet)
library(ggplot2)
# Conclusion: the younger the age, the more internet access
```



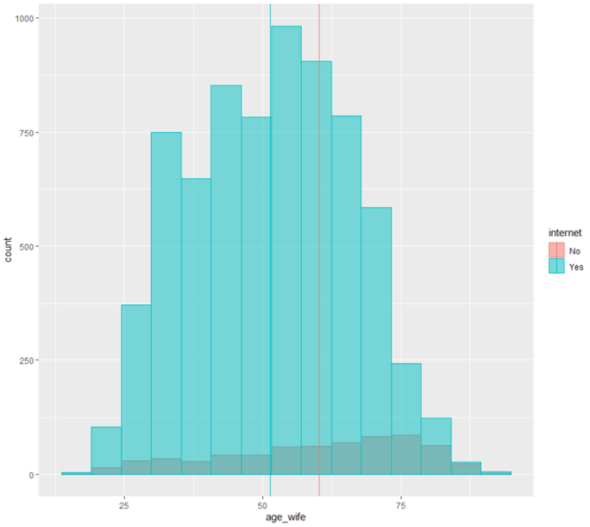
```
# 9.3: Changing histogram plot fill colors by internet and usinging semi-tran
sparent fill
p <- ggplot(hh,aes(x=age_wife, fill=internet, color=internet)) +
  geom_histogram(position="identity", bins=15, alpha=0.5)
# bins: https://stackoverflow.com/questions/34774120/set-number-of-bins-for-h
istogram-directly-in-ggplot
```

```
p
```



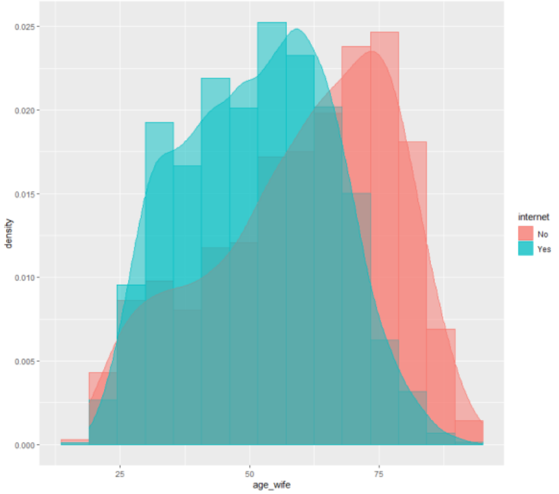
```
# 9.4: Add mean lines
library(plyr)
mu <- ddply(hh, "internet", summarise, grp.mean=mean(age_wife,na.rm=T))
head(mu)
p <- p + geom_vline(data=mu, aes(xintercept=grp.mean, color=internet),linetyp
e="solid")
p
```

```
  internet grp.mean
1       No 60.27103
2      Yes 51.34565
```

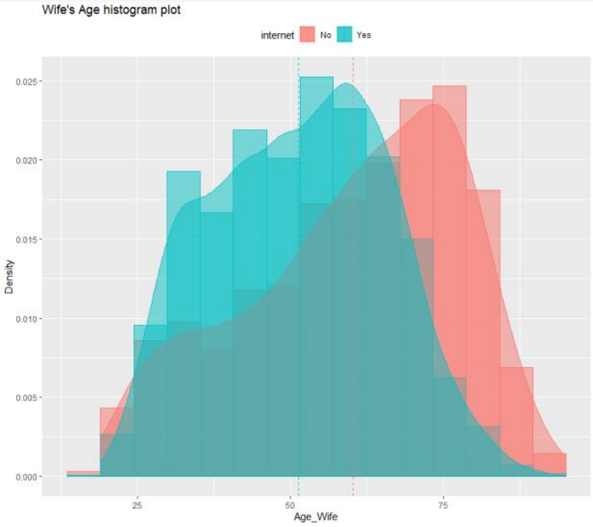


```
# 9.5: Add density
```

```
p <- ggplot(hh, aes(x=age_wife, fill=internet, color=internet)) +
  geom_histogram(aes(y=..density..),bins=15, position="identity", alpha=0.5)+
  geom_density(alpha=0.5)
p
```



```
# 9.6: Add mean lines and Change the legend position
p + geom_vline(data=mu, aes(xintercept=grp.mean, color=internet),linetype="da
shed")+
  theme(legend.position="top")+
  labs(title="Wife's Age histogram plot", x="Age_Wife", y = "Density")
```



```
# 9.7 t-test
# Yes: House has internet, No: House has no internet
# Null Hypothesis: μYes = μNo (the means of both populations are equal)
# Alternate Hypothesis: μYes <> μNo (the means of both populations are not eq
ual)
```

```
t.test(age_wife ~ internet, data=hh )

# Conclusion: p-value is less than 0.05, so there is association between wife
's age and internet at 5% significant level
```

```
Welch Two Sample t-test


data:  age_wife by internet

t = 12.603, df = 721.29, p-value < 0.00000000000000022

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

  7.534967 10.315779

sample estimates:

 mean in group No mean in group Yes

         60.27103          51.34565
```

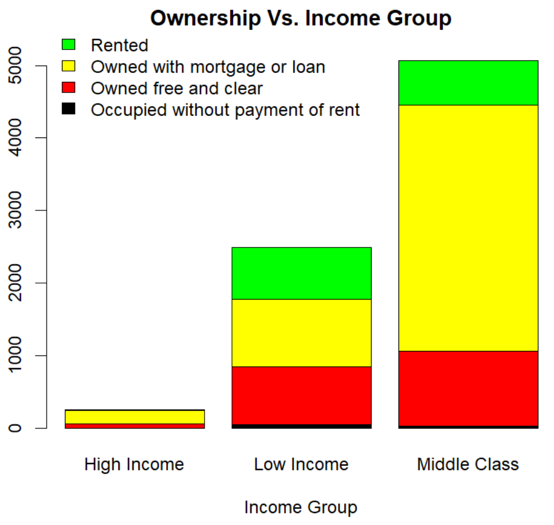
```
# Conclusion: p-value is less than 0.05, so the mean values between uYes and
uNo are not equal.
```

Question 10

Is there any relation between ownership and target(income_group)?

```
# 10.1 - Visualization: Stacked Bar Plot


tbl <- table(hh$own,hh$income_group)

tbl

counts <- tbl[1:4,1:3]

counts

barplot(counts,

        main = "Ownership Vs. Income Group",

        xlab = "Income Group",

        col = c("black","red", "yellow", "green"),

        legend = rownames(counts),

        args.legend = list(x ='topleft', bty='n', inset=c(0,-0.1)))

# Legend position: https://stackoverflow.com/questions/27688754/bar-chart-legend-position-avoiding-operlap-in-r
```

```
                                  High Income Low Income Middle Class

  Occupied without payment of rent           0         49           27

  Owned free and clear                      61        799         1036

  Owned with mortgage or loan              180        932         3393

  Rented                                     9        709          616
```



```
# 10.2 - Summarization: Contingency Table

add <- addmargins(xtabs(~ own + income_group,data=hh))
add
add[1:5,1:4]
proportions(xtabs(~ own + income_group,data=hh))[1:4,1:3]
```

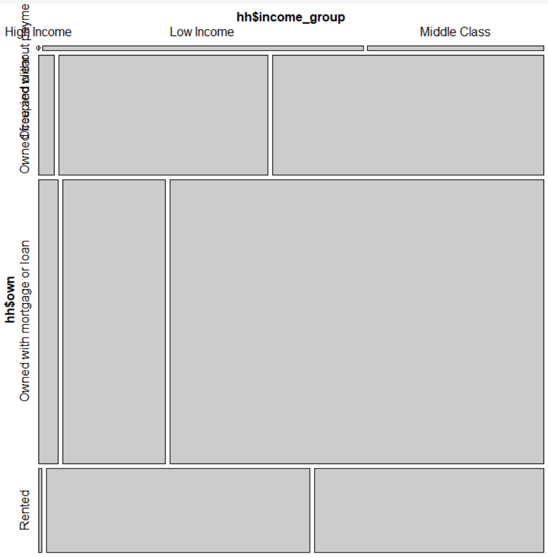
```
                                  income_group
own                                 High Income  Low Income Middle Class
  Occupied without payment of rent 0.000000000 0.006273204  0.003456664
  Owned free and clear             0.007809499 0.102291640  0.132633466
  Owned with mortgage or loan      0.023044425 0.119318909  0.434387402
  Rented                           0.001152221 0.090769428  0.078863142
```

```
# 10.3 - Indipendency: Chi-square Test

# 10.3.1 Problem:

# Test the hypothesis whether the ownership is independent of the income group  at .05 significance level.
# Null hypothesis:  Ownership is independent of Income Group

# 10.3.2 Solution:

# p-value
library(MASS)
tbl <- table(hh$own,hh$income_group)
tbl
chisq.test(tbl) # the p-value < 2.2e-16
```

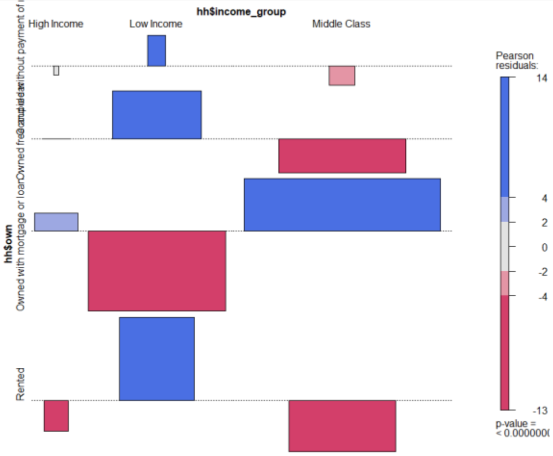
```
data:  tbl
X-squared = 680.48, df = 6, p-value < 0.00000000000000022

Warning message:
In chisq.test(tbl) : Chi-squared approximation may be incorrect
```

```
# Mosaic Plots
library(vcd)
library(grid)
```

```
mosaic(structable(hh$income_group ~ hh$own))

# structable: https://stackoverflow.com/questions/14547162/missing-value-where-true-false-needed-error-vcdmosaic
```



```
# Association Plots

assoc(hh$income_group ~ hh$own, shade=TRUE)
```



# 10.3.3 Conclusion:

As the p-value 2.2e-16 is less than the 0.05 significance level, we **reject** the null hypothesis that Communication Mode is independent of the Income_Group and conclude that in our data, the 'own' and the 'income_group' are statistically significantly associated (p-value = 0).