CMDA-3654

Homework 8

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Due as a .pdf upload

Problem 1: [35] Tests of association

Load the CoalMiners data from the vcd library in R.

a. Convert the 3-way table into a data frame with 36 rows and 4 columns.

```
#Loading libraries
library(tidyverse)
library(vcd)

#Creating dataframe
coalminerdf<-as.data.frame(CoalMiners)
coalminerdf
```

```
   Breathlessness Wheeze   Age Freq
1               B      W 20-24    9
2             NoB      W 20-24   95
3               B    NoW 20-24    7
4             NoB    NoW 20-24 1841
5               B      W 25-29   23
6             NoB      W 25-29  105
7               B    NoW 25-29    9
8             NoB    NoW 25-29 1654
9               B      W 30-34   54
10            NoB      W 30-34  177
11              B    NoW 30-34   19
12            NoB    NoW 30-34 1863
13              B      W 35-39  121
14            NoB      W 35-39  257
15              B    NoW 35-39   48
16            NoB    NoW 35-39 2357
17              B      W 40-44  169
18            NoB      W 40-44  273
19              B    NoW 40-44   54
20            NoB    NoW 40-44 1778
21              B      W 45-49  269
22            NoB      W 45-49  324
23              B    NoW 45-49   88
24            NoB    NoW 45-49 1712
25              B      W 50-54  404
26            NoB      W 50-54  245
27              B    NoW 50-54  117
28            NoB    NoW 50-54 1324
29              B      W 55-59  406
30            NoB      W 55-59  225
31              B    NoW 55-59  152
32            NoB    NoW 55-59  967
33              B      W 60-64  372
34            NoB      W 60-64  132
35              B    NoW 60-64  106
36            NoB    NoW 60-64  526
```

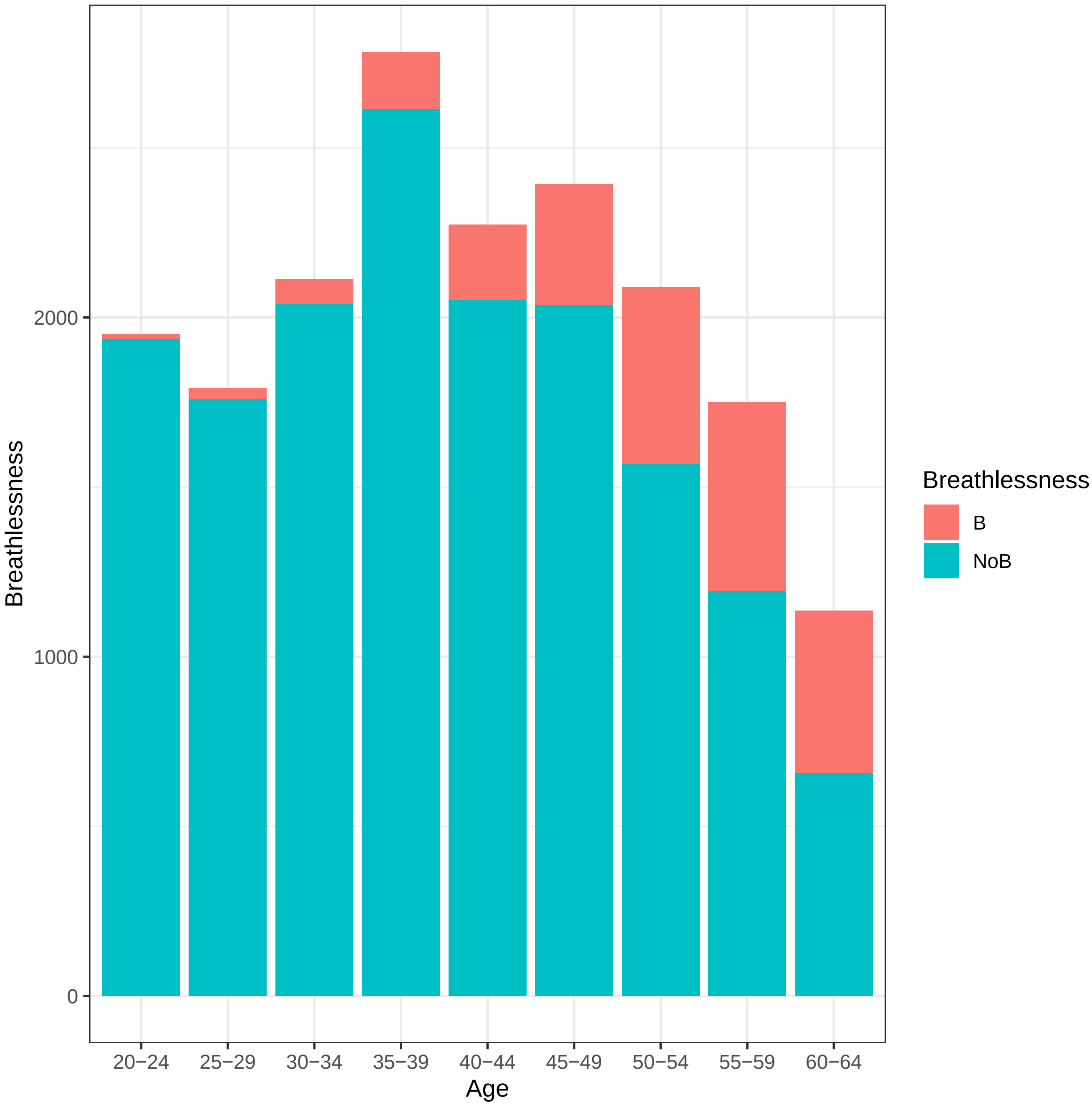
b. Flatten the 3-way table so that we can see everything in a single large table.

```r
#flattening table to see everything in a single large table with ftable
ftable(coalminerdf)
```

```
                               Freq 7 9 19 23 48 54 88 95 105 106 117 121 132 152 169 177 225 245 257 269 273 324
Breathlessness Wheeze Age                                                                                         
B              W      20-24         0 1  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      25-29         0 0  0  1  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      30-34         0 0  0  0  0  1  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      35-39         0 0  0  0  0  0  0  0   0   0   0   1   0   0   0   0   0   0   0   0   0   0
                      40-44         0 0  0  0  0  0  0  0   0   0   0   0   0   0   1   0   0   0   0   0   0   0
                      45-49         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   1   0   0
                      50-54         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      55-59         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      60-64         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
               NoW    20-24         1 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      25-29         0 1  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      30-34         0 0  1  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      35-39         0 0  0  0  1  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      40-44         0 0  0  0  0  1  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      45-49         0 0  0  0  0  0  1  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      50-54         0 0  0  0  0  0  0  0   0   0   1   0   0   0   0   0   0   0   0   0   0   0
                      55-59         0 0  0  0  0  0  0  0   0   0   0   0   0   1   0   0   0   0   0   0   0   0
                      60-64         0 0  0  0  0  0  0  0   0   1   0   0   0   0   0   0   0   0   0   0   0   0
NoB            W      20-24         0 0  0  0  0  0  0  1   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      25-29         0 0  0  0  0  0  0  0   1   0   0   0   0   0   0   0   0   0   0   0   0   0
                      30-34         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   1   0   0   0   0   0   0
                      35-39         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   1   0   0   0
                      40-44         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   1   0
                      45-49         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   1
                      50-54         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
                      55-59         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   1   0   0   0   0   0
                      60-64         0 0  0  0  0  0  0  0   0   0   0   0   1   0   0   0   0   0   0   0   0   0
               NoW    20-24         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      25-29         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      30-34         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      35-39         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      40-44         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      45-49         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      50-54         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      55-59         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                      60-64         0 0  0  0  0  0  0  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
```

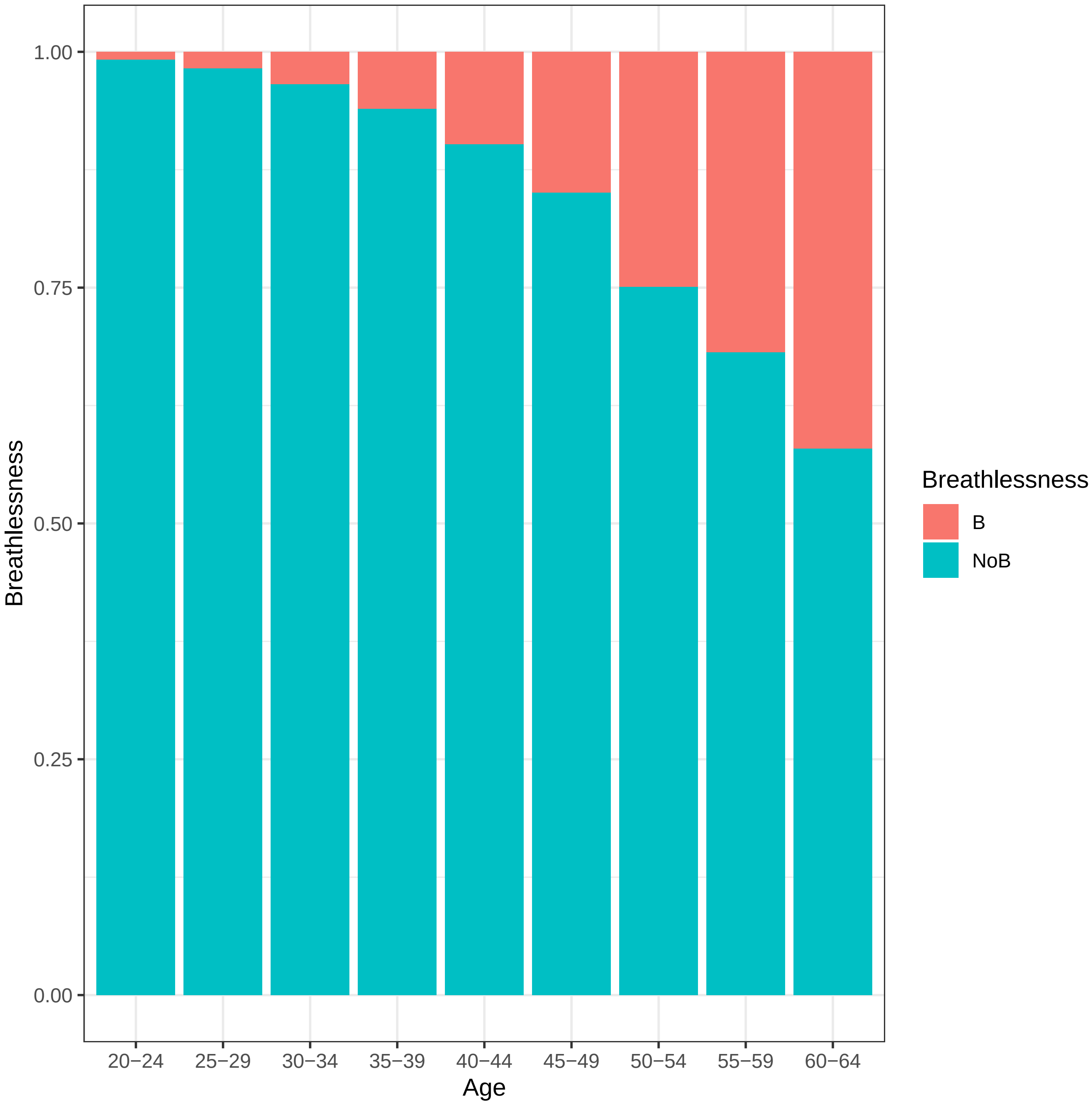
c. Construct a stacked barplot with `Age` group on the x-axis and `Breathlessness` on the y-axis with the different outcomes of `Breathlessness` having different colors.

```r
#Barplot using ggplot
ggplot(data=coalminerdf, aes(x=Age,y=Freq,fill=Breathlessness))+labs(x="Age",y="Breathlessness",tittle="Breath
```



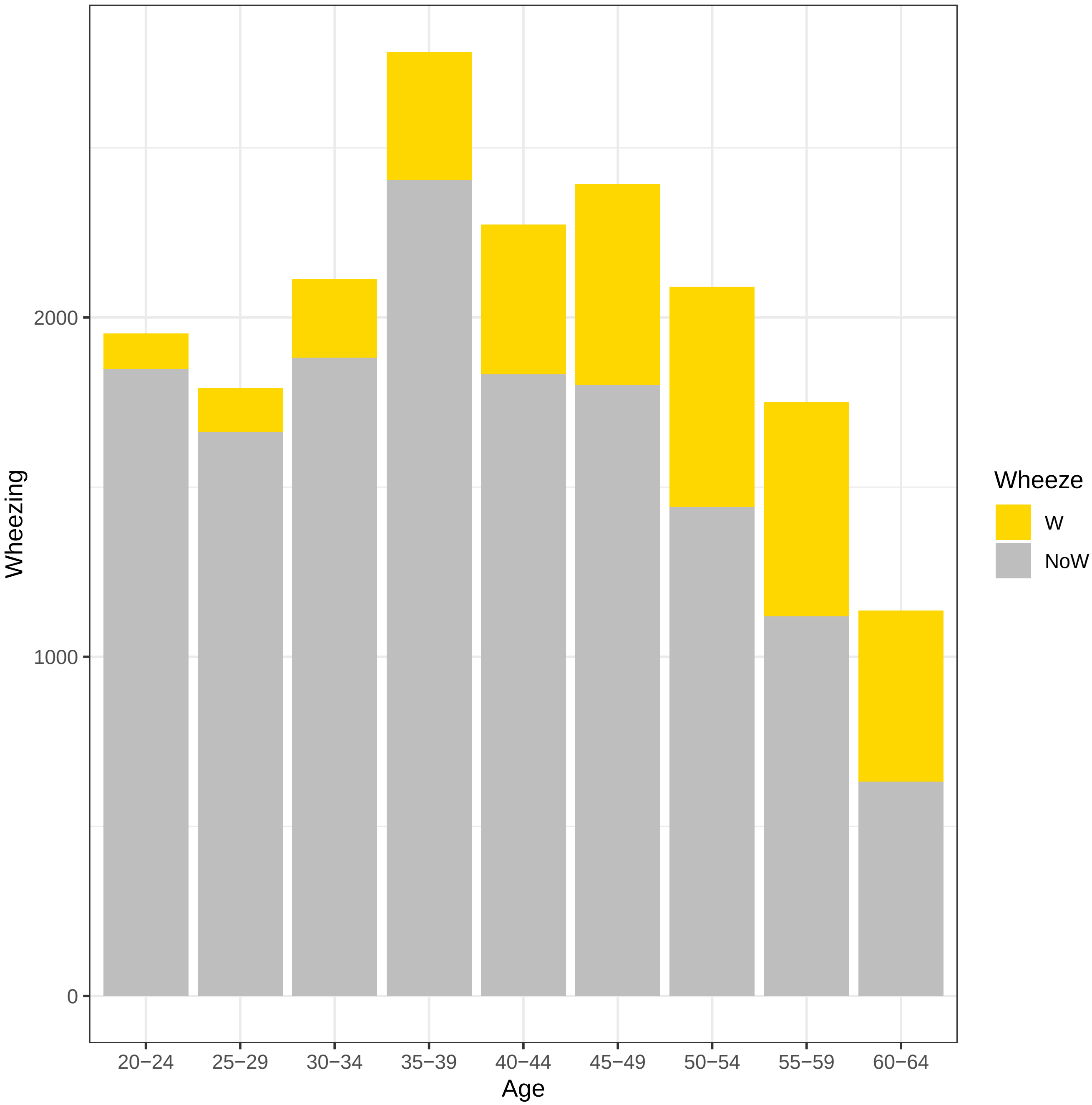
- The above plot is clearly an absolute frequency barplot. Remake the plot, this time using the relative frequencies (there are many ways to do this, do whatever seems easiest).

```
#Creating relative frequency plot using ggplot
ggplot(data=coalminerdf, aes(x=Age,y=Freq,fill=Breathlessness))+labs(x="Age",y="Breathlessness",tittle="Relati
```

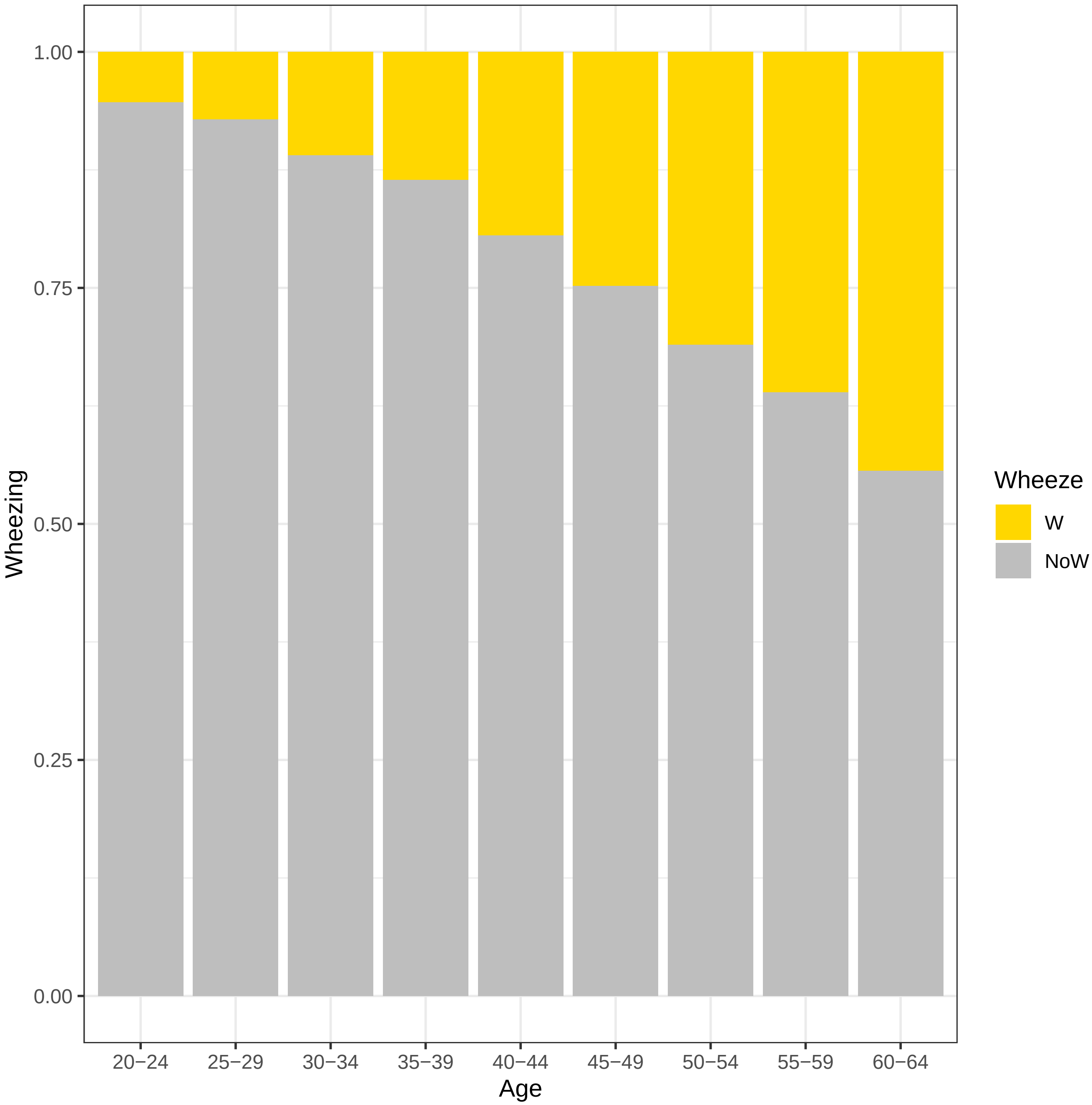


d. Repeat the above steps but this time with `Age` group on the x-axis and `Wheezing` on the y-axis with the different outcomes of `Wheezing` having different colors.

```
#Barplot using ggplot
ggplot(data=coalminerdf, aes(x=Age,y=Freq,fill=Wheeze))+labs(x="Age",y="Wheezing",tittle="Wheezing by Age")+ t
```




```
#Creating relative frequency plot using ggplot
ggplot(data=coalminerdf, aes(x=Age,y=Freq,fill=Wheeze))+labs(x="Age",y="Wheezing",tittle="Relative Frequency Wh
```



e. Add a new column with the feature named "`Career`" to your data frame where you will recode the ages into the following three groups: "`Early`" = 20-34, "`Middle`" = 35-49, and "`Late`" = 50 - 64. These groups will reflect where people tend to be if they started their career at the age of 20 and stayed employed, i.e. Early Career, Middle Career, Late Career.

- Construct a 3-way table for `Wheezing` Symptoms and `Breathlessness` Symptoms for the three `Career` levels. Each two-way table slice should be `Wheezing` versus `Breathlessness.`

```
??????
#Creating 3 groups by age
coalminerdf$Career[coalminerdf$Age=="20-24"]<-"Early"

Contacting Delphi...the oracle is unavailable.
We apologize for any inconvenience.

coalminerdf$Career[coalminerdf$Age=="25-29"]<-"Early"
coalminerdf$Career[coalminerdf$Age=="30-34"]<-"Early"
```

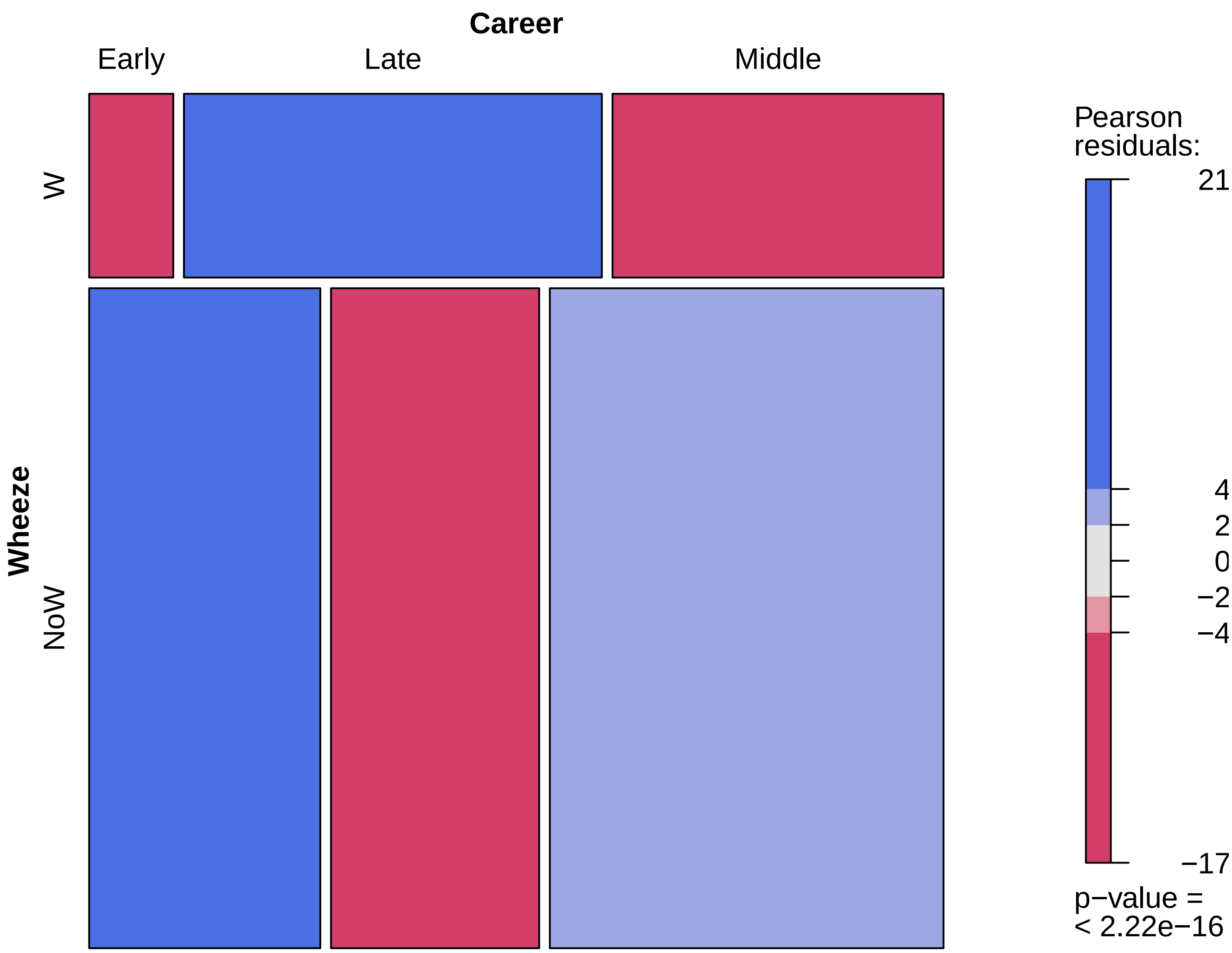
```r
coalminerdf$Career[coalminerdf$Age=="35-39"]<-"Middle"
coalminerdf$Career[coalminerdf$Age=="40-44"]<-"Middle"
coalminerdf$Career[coalminerdf$Age=="45-49"]<-"Middle"

coalminerdf$Career[coalminerdf$Age=="50-54"]<-"Late"
coalminerdf$Career[coalminerdf$Age=="55-59"]<-"Late"
coalminerdf$Career[coalminerdf$Age=="60-64"]<-"Late"

#Creating 3 tables
xtabs(Freq~Wheeze+Breathlessness+Career,data=coalminerdf)
```

```
, , Career = Early

      Breathlessness
Wheeze    B  NoB
   W     77  282
   NoW   28 3517

, , Career = Late

      Breathlessness
Wheeze    B  NoB
   W   1182  602
   NoW  375 2817

, , Career = Middle

      Breathlessness
Wheeze    B  NoB
   W    559  854
   NoW  190 5847
```

f. Make a mosaic plot (use `shade = T` and the `mosaic()` function from the `vcd` library) for each of the following pair of features:

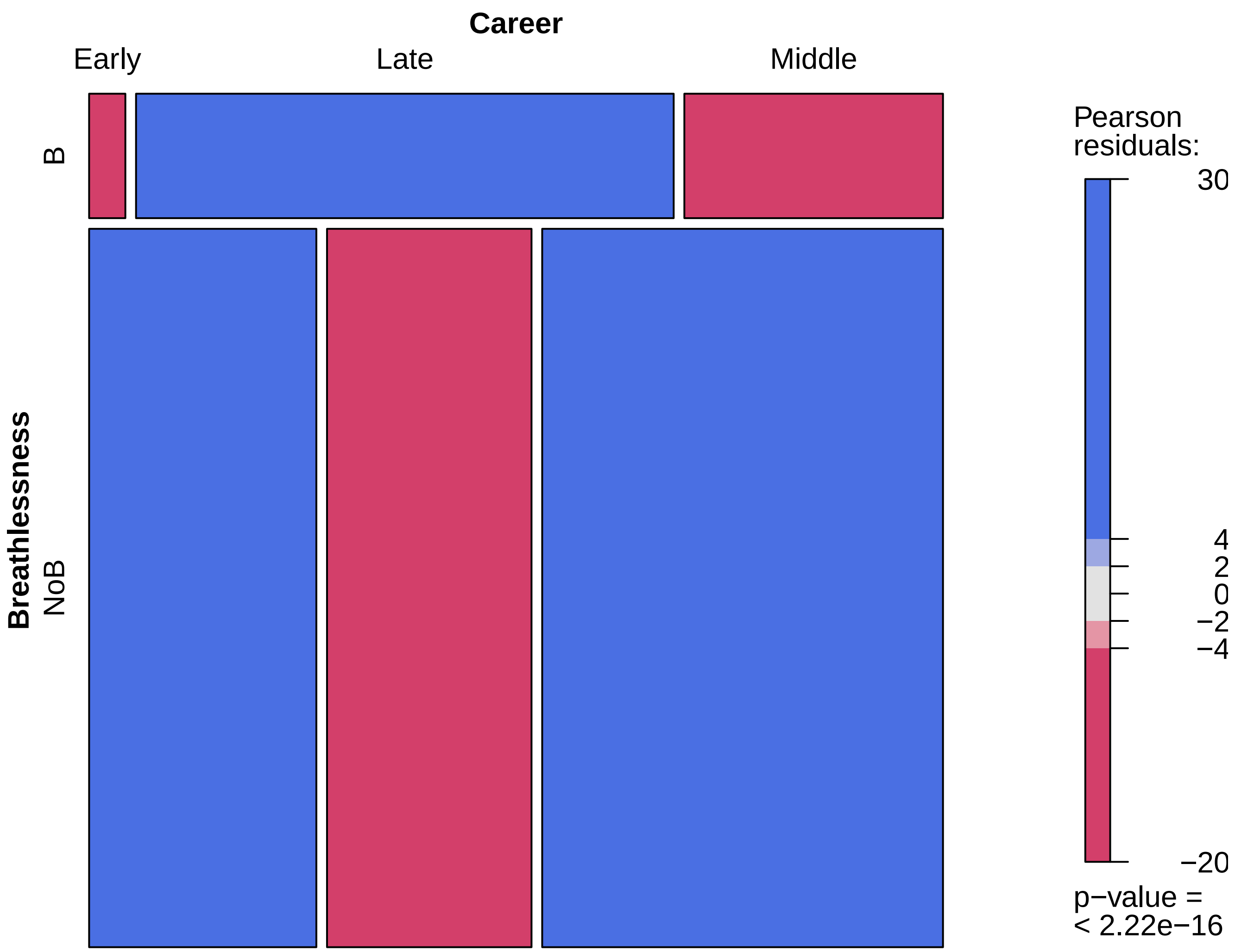
   i. `Wheeze` versus `Career`

```r
#Creating variable for Wheeze vs Carrear
wc<-xtabs(Freq~Wheeze+Career,data=coalminerdf)
#Mosaic Plot
mosaic(wc,shade = T)
```



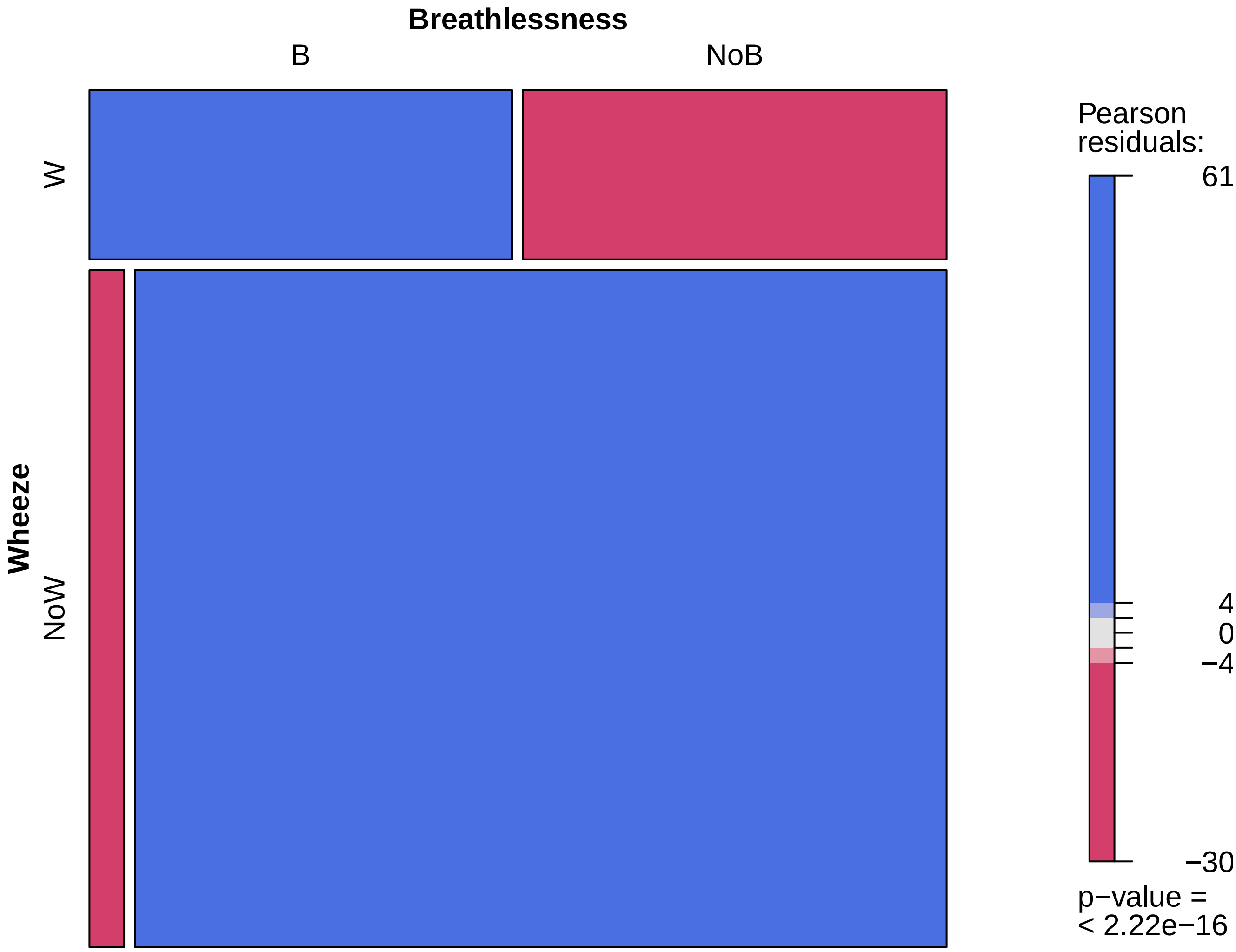
ii. ‘Breathlessness‘ versus ‘Career‘

```
#Creating variable for Breathlessness vs Carrear
bc<-xtabs(Freq~Breathlessness+Career,data=coalminerdf)
#Mosaic Plot
mosaic(bc,shade = T)
```



iii. ‘Wheeze‘ versus ‘Breathlessness‘

```
#Creating variable for Wheeze vs Breathlessness
wb<-xtabs(Freq~Wheeze+Breathlessness,data=coalminerdf)
#Mosaic Plot
mosaic(wb,shade = T)
```




```
iv. Comment on the results.

#There is no correlation between breathlessness and wheeze late in career.
```

g. Consider the 3-way table you constructed in part (e). There are three features: `Breathlessness`, `Wheezing`, and `Career`. **For each pair of features**, carry out a chi-square test of independence and report whether there is association between features.

```
#Chi-square using chiq-test function
chisq.test(wc)

    Pearson's Chi-squared test

data:  wc
X-squared = 976.05, df = 2, p-value < 2.2e-16
```

```
chisq.test(bc)

    Pearson's Chi-squared test

data:  bc
X-squared = 1663.6, df = 2, p-value < 2.2e-16

chisq.test(wb,correct=F)

    Pearson's Chi-squared test

data:  wb
X-squared = 5336.8, df = 1, p-value < 2.2e-16

#Because the p-value is less than 0.05 we can say there is correlation between features
```

Problem 2 [35 pts] Tests of association.

A random sample of 5,000 high school students who have applied for vocational training has been collected which contains their `Gender` and `Acceptance` into the program. The data is contained in `acceptance.csv`.

a. After reading in the data, summarize the data into a 3D array of the counts (name this `byVoc` table) where the 3rd dimension corresponds to the `Vocation`. Display this output in the 3D format. Additionally display the data using a flat contingency table.

```
#Reading csv file
dfacceptance<-read.csv("/Users/eduardosalvador/Desktop/FINAL\ Spring\ Semester\ 2021/CMDA\ /Assignments/HW8/ac
#Reading first 5 rows
head(dfacceptance)

     Vocation Gender Accepted
1 Cosmetology Female       No
2    Plumbing   Male      Yes
3     Welding   Male       No
4     Nursing Female       No
5     Welding   Male       No
6    Plumbing   Male      Yes

#Summerizing into 3d array
byVoc<-table(dfacceptance$Gender,dfacceptance$Accepted,dfacceptance$Vocation)
byVoc

, ,  = Cosmetology


          No Yes
  Female 515  40
  Male   582  36

, ,  = Nursing
```

```
         No Yes
  Female 404 217
  Male   462 229

, ,  = Plumbing


         No Yes
  Female  31 148
  Male   519 848

, ,  = Welding


         No Yes
  Female  13  28
  Male   343 585

#Displaing data using contigency table
Cosmetology<-byVoc[,,"Cosmetology"]
Cosmetology


         No Yes
  Female 515  40
  Male   582  36

Nursing<-byVoc[,,"Nursing"]
Nursing


         No Yes
  Female 404 217
  Male   462 229

Plumbing<-byVoc[,,"Plumbing"]
Plumbing


         No Yes
  Female  31 148
  Male   519 848

Welding<-byVoc[,,"Welding"]
Welding


         No Yes
  Female  13  28
  Male   343 585

#Flatting tables
ftable(Cosmetology)

        No Yes

Female  515  40
Male    582  36
```

```
ftable(Nursing)
```

```
         No Yes

Female  404 217
Male    462 229
```

```
ftable(Plumbing)
```

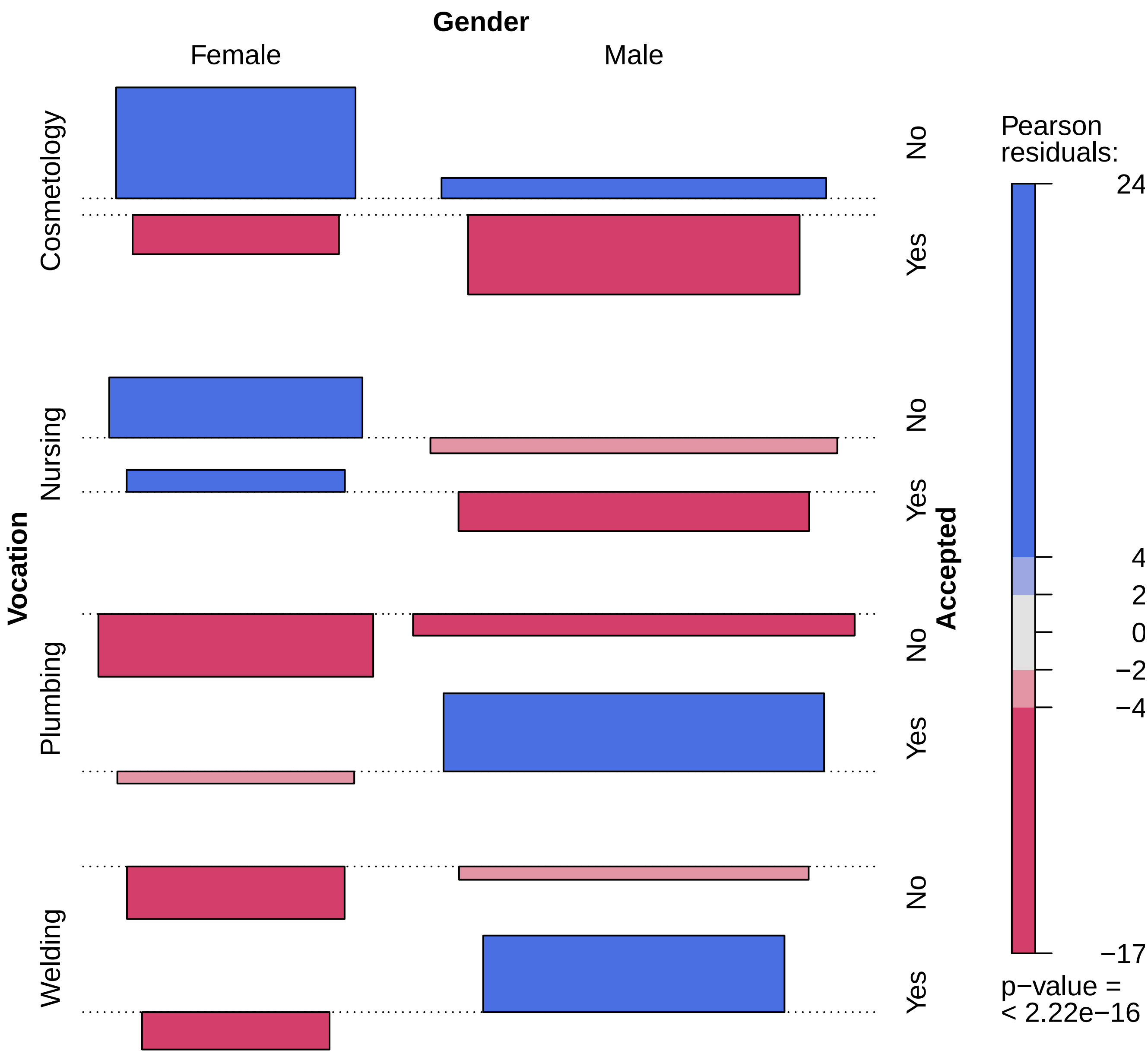
```
         No Yes

Female   31 148
Male    519 848
```

```
ftable(Welding)
```

```
         No Yes

Female   13  28
Male    343 585
```

b. Construct an association plot using `assoc()` from the `vcd` library, use `shade = T` for the three features: `Accepted`, `Vocation`, and `Gender`. Comment on any patterns that you see.

```
#Association plot
assoc(dfacceptance,shade=T)
```



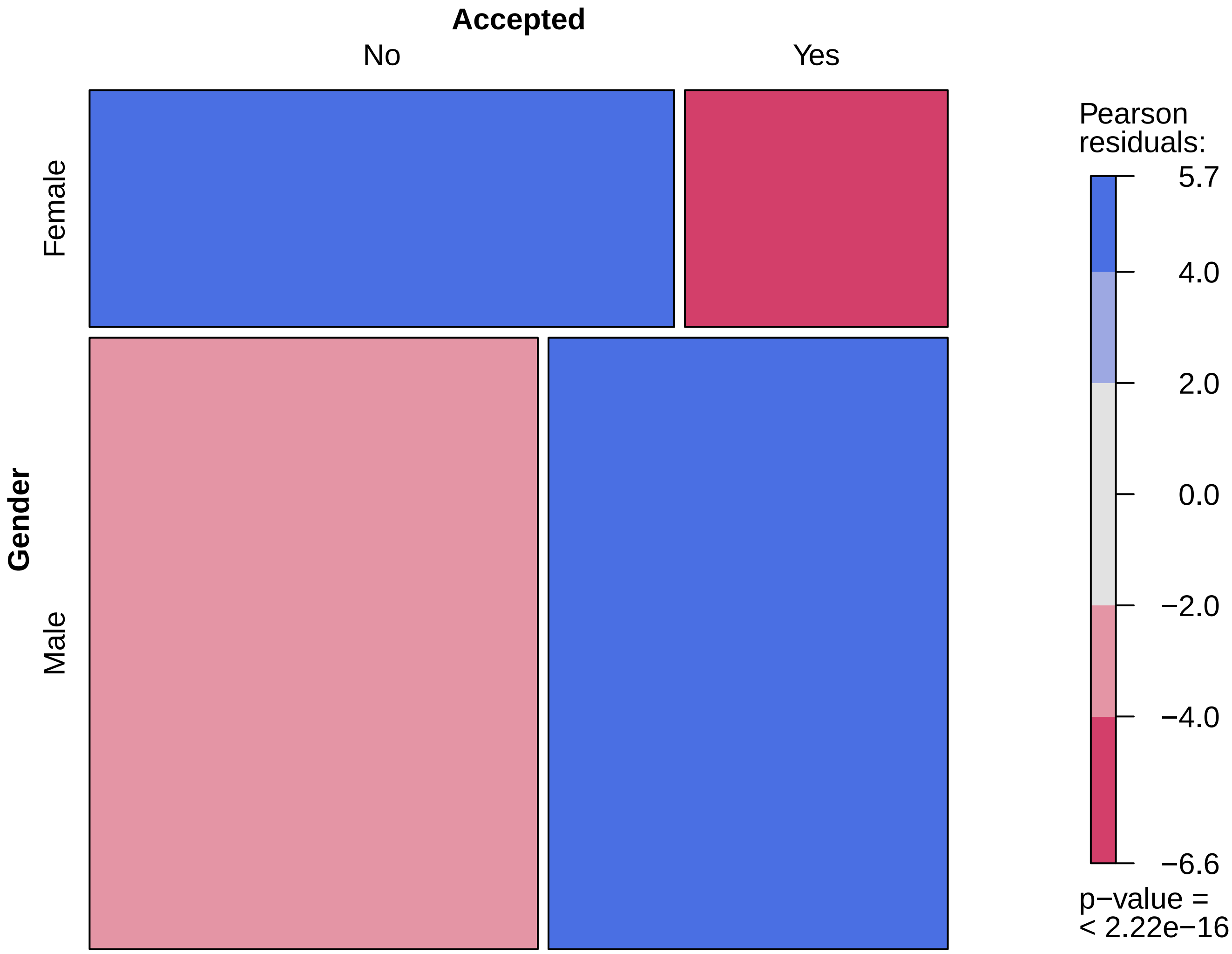
c. For each Vocation, carry out a chi-square test of independence and report whether there is association between Gender and Acceptance.

```
#Using chisq.test function to carry out chi-square test of independance for every Vocation
chisq.test(Cosmetology)

    Pearson's Chi-squared test with Yates' continuity correction

data:  Cosmetology
X-squared = 0.70766, df = 1, p-value = 0.4002

chisq.test(Nursing)

    Pearson's Chi-squared test with Yates' continuity correction

data:  Nursing
X-squared = 0.39703, df = 1, p-value = 0.5286
```

```
chisq.test(Plumbing)

    Pearson's Chi-squared test with Yates' continuity correction

data:  Plumbing
X-squared = 28.548, df = 1, p-value = 9.142e-08

chisq.test(Welding)

    Pearson's Chi-squared test with Yates' continuity correction

data:  Welding
X-squared = 0.26768, df = 1, p-value = 0.6049

#Because the p-value is greater than 0.05 this means that there could be a lack
#of association between Gender and Acceptance in Cosmetology, Nursing and Welding but,
#for Plumbing since the p-value is less than 0.05, there is association.
```

d. Ignoring Vocation, carry out a single chi-square test of independence for the whole data and report whether there is association between `Gender` and `Acceptance`. Additionally provide a mosaic plot with `shade = T`.

```
#Creating xtabs variable to ignore Vocation
IgVoc<-xtabs(~Gender+Accepted,data=dfacceptance)
IgVoc

        Accepted
Gender     No  Yes
  Female  963  433
  Male   1906 1698

#Doing the chi-square test while ignoring Vocation
chisq.test(IgVoc,correct = F )

    Pearson's Chi-squared test

data:  IgVoc
X-squared = 106.62, df = 1, p-value < 2.2e-16

#Creating mosaic plot using mosaic function
mosaic(IgVoc,shade = T)
```




```
#Because the p-value is less than 0.05, there is association between Gender and Acceptance ignoring Vocation.
```

e. Carry out a **CMH chi-square test** and report whether there is association between Gender and Acceptance taking into account the different vocations.

```
#Producing a common(weighted) odds ratio using mantelhaen.test() from the stats package
library(stats)
mantelhaen.test(byVoc)

    Mantel-Haenszel chi-squared test with continuity correction

data:  byVoc
Mantel-Haenszel X-squared = 14.289, df = 1, p-value = 0.0001568
alternative hypothesis: true common odds ratio is not equal to 1
95 percent confidence interval:
 0.6003882 0.8474693
```

```
sample estimates:
common odds ratio
        0.7133096

#Because the p=value is less than 0.05 we can say that there is indeed association between gender and
#acceptance doing the cmh chi-square test
```

f. Is there any conflict between the results obtained in parts (b-e), and c? What is your final conclusion regarding association between `Gender` and `Acceptance`?

```
#It is hard to say because for b-e there is association in all of the results but, for c there is
#no assosiation so my conclusion would be that there is a high chance of association between acceptance and ge
```

g. Construct a summary matrix with success rates for male and female applicants in each `Vocation.` Also calculate the overall success rate (i.e., ignoring department) of male and female candidates. From these numbers (without referring to statistical tests) what is your empirical conclusion—do you think there is gender bias in admissions? Why or why not?

```
#Creating variables based on success rate
male<-c(prop.table(Cosmetology,2)[4],prop.table(Nursing,2)[4],prop.table(Plumbing,2)[4],prop.table(Welding,2)[
female<-c(prop.table(Cosmetology,2)[2],prop.table(Nursing,2)[2],prop.table(Plumbing,2)[2],prop.table(Welding,2

#Cbinding male and female success rates
combination<-cbind(male,female)
rownames(combination)<-c("Cosmetology","Nursing","Plumbing","Welding")
combination

                 male    female
Cosmetology 0.4736842 0.5305378
Nursing     0.5134529 0.5334873
Plumbing    0.8514056 0.9436364
Welding     0.9543230 0.9634831

#My empirical conclusion lookin g at the success rate for male and female applicants in each Vocation is that
#there is no gender bias whastoever since the percentages for male and female are not to far apart.
```

Problem 3 [30 pts] Market Basket Analysis.

Load the `Groceries` transactions database from the `arules` package in R (you will need to do `data("Groceries", package = "arules")` this time around). Answer the following questions:

a. How many transactions and items are there in this database? What is the most frequent item and how many times was it bought?

```
#Loading and summarizing data to find the amount of transactions and most frequent item
library(arules)
data("Groceries",package = "arules")
summary(Groceries)
```

```
transactions as itemMatrix in sparse format with
 9835 rows (elements/itemsets/transactions) and
 169 columns (items) and a density of 0.02609146

most frequent items:
      whole milk other vegetables       rolls/buns             soda
            2513             1903             1809             1715
          yogurt          (Other)
            1372            34055

element (itemset/transaction) length distribution:
sizes
   1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16
2159 1643 1299 1005  855  645  545  438  350  246  182  117   78   77   55   46
  17   18   19   20   21   22   23   24   26   27   28   29   32
  29   14   14    9   11    4    6    1    1    1    1    3    1

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   2.000   3.000   4.409   6.000  32.000

includes extended item information - examples:
       labels  level2           level1
1 frankfurter sausage meat and sausage
2     sausage sausage meat and sausage
3  liver loaf sausage meat and sausage

#There are 9835 rows of transactions and the whole milk is the most frequent item with 2513 times appearance.
```

b. What percentage of transactions involved 20 or more items? On average, how many items were involved per transaction?

```
#Looking at the summary table the percentage of transactions involving 20 or mkore items
# are 12/29 which is around 41%.
#On average there were 339.13793103448 items involved per transaction by summing all the items
#divided by the number of transactions from summary
```

c. Find all rules with support > 1% and confidence > 50%. How many such rules are there? Which of these rules has the highest confidence and highest support? Report the support, confidence, and lift of this rule. What are the interpretations of these numbers?

```
#Finding all rules with rule function
#rules(Groceries,parameter=list(supp=0.01,conf=0.5))
```

Problem 4 [10 pts Extra Credit]

Continue working with the data in problem 3.

a. Which items do "whole milk" lead to? Find all rules with support > 1%, confidence > 20%, and "whole milk" on the left hand side. Report these rules.

b. Which items lead to "whole milk"? Find all rules with support > 1%, confidence > 20%, and "whole milk" on the right hand side. Report these rules.
