# IS5 in R: Relationships Between Categorical Variables–Contingency Tables (Chapter 3)

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## Introduction and background

This document is intended to help describe how to undertake analyses introduced as examples in the Fifth Edition of *Intro Stats* (2018) by De Veaux, Velleman, and Bock. More information about the book can be found at http://wps.aw.com/aw_deveaux_stats_series. This file as well as the associated R Markdown reproducible analysis source file used to create it can be found at http://nhorton.people.amherst.edu/is5.

This work leverages initiatives undertaken by Project MOSAIC (http://www.mosaic-web.org), an NSF-funded effort to improve the teaching of statistics, calculus, science and computing in the undergraduate curriculum. In particular, we utilize the `mosaic` package, which was written to simplify the use of R for introductory statistics courses. A short summary of the R needed to teach introductory statistics can be found in the mosaic package vignettes (http://cran.r-project.org/web/packages/mosaic). A paper describing the mosaic approach was published in the *R Journal*: https://journal.r-project.org/archive/2017/RJ-2017-024.

## Chapter 3: Relationships Between Categorical Variables–Contingency Tables

### Section 3.1: Contingency Tables

```
library(mosaic)
library(readr)
library(janitor)
OKCupid <- read_csv("http://nhorton.people.amherst.edu/is5/data/OKCupid_CatsDogs.csv", skip = 1) %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   CatsDogsBoth = col_character(),
##   Gender = col_character(),
##   `drugsY/N` = col_character(),
##   `smokesY/N` = col_character()
## )
```

```
names(OKCupid)
```

```
## [1] "cats_dogs_both" "gender"         "drugs_y_n"      "smokes_y_n"
```

By default, `read_csv()` prints the variable names. These messages can be suppressed using the `message=FALSE` code chunk option to save space and improve readability.
Here we use the `clean_names()` function from the `janitor` package to sanitize the names of the columns (which would otherwise contain special characters or whitespace).

```
tally(~ cats_dogs_both + gender, margin = TRUE, data = OKCupid)
```

```
##               gender
## cats_dogs_both     F     M Total
##       Has Both   897   577  1474
```

```
##       Has cats  3412  2388  5800
##       Has dogs  3431  3587  7018
##       <NA>     16377 29274 45651
##       Total    24117 35826 59943
```

```
tally(~ cats_dogs_both + gender, format = "percent", margin = TRUE, data = OKCupid)
```

```
##               gender
## cats_dogs_both           F           M       Total
##       Has Both   1.4964216   0.9625811   2.4590027
##       Has cats   5.6920741   3.9837846   9.6758587
##       Has dogs   5.7237709   5.9840182  11.7077891
##       <NA>      27.3209549  48.8363946  76.1573495
##       Total     40.2332216  59.7667784 100.0000000
```

```
tally(~ cats_dogs_both | gender, format = "percent", margin = TRUE, data = OKCupid)
```

```
##               gender
## cats_dogs_both          F          M
##       Has Both   3.719368   1.610562
##       Has cats  14.147697   6.665550
##       Has dogs  14.226479  10.012282
##       <NA>      67.906456  81.711606
##       Total    100.000000 100.000000
```

```
tally(~ gender | cats_dogs_both, format = "percent", margin = TRUE, data = OKCupid)
```

```
##        cats_dogs_both
## gender   Has Both  Has cats  Has dogs      <NA>
##   F      60.85482  58.82759  48.88857  35.87435
##   M      39.14518  41.17241  51.11143  64.12565
##   Total 100.00000 100.00000 100.00000 100.00000
```

**Example 3.1: Exploring Marginal Distributions**

```
SuperBowl <- read_csv("http://nhorton.people.amherst.edu/is5/data/Watch_the_Super_bowl.csv", skip = 1)
```

```
## Parsed with column specification:
## cols(
##   Plan = col_character(),
##   Sex = col_character()
## )
```

```
tally(~ Plan + Sex, data = SuperBowl)
```

```
##              Sex
## Plan          Female Male
##   Commercials    156   81
##   Game           200  279
##   Wont Watch     160  132
```

**Example 3.2: Exploring Percentages: Children and First-Class Ticket Holders First?**

```
Titanic <- read_csv("http://nhorton.people.amherst.edu/is5/data/Titanic.csv")
```

```
## Parsed with column specification:
## cols(
```

```
##   Name = col_character(),
##   Survived = col_character(),
##   Boarded = col_character(),
##   Class = col_character(),
##   MWC = col_character(),
##   Age = col_double(),
##   Adut_or_Chld = col_character(),
##   Sex = col_character(),
##   Paid = col_double(),
##   Ticket_No = col_character(),
##   Boat_or_Body = col_character(),
##   Job = col_character(),
##   Class_Dept = col_character(),
##   Class_Full = col_character()
## )
```

```
tally(~ Class + Survived, format = "percent", margin = TRUE, data = Titanic)
```

```
##        Survived
## Class        Alive       Dead      Total
##   1       9.103261   5.570652  14.673913
##   2       5.389493   7.518116  12.907609
##   3       8.152174  24.003623  32.155797
##   Crew    9.601449  30.661232  40.262681
##   Total  32.246377  67.753623 100.000000
```

```
tally(~ Survived | Class, format = "percent", margin = TRUE, data = Titanic)
```

```
##         Class
## Survived         1         2         3      Crew
##    Alive  62.03704  41.75439  25.35211  23.84702
##    Dead   37.96296  58.24561  74.64789  76.15298
##    Total 100.00000 100.00000 100.00000 100.00000
```

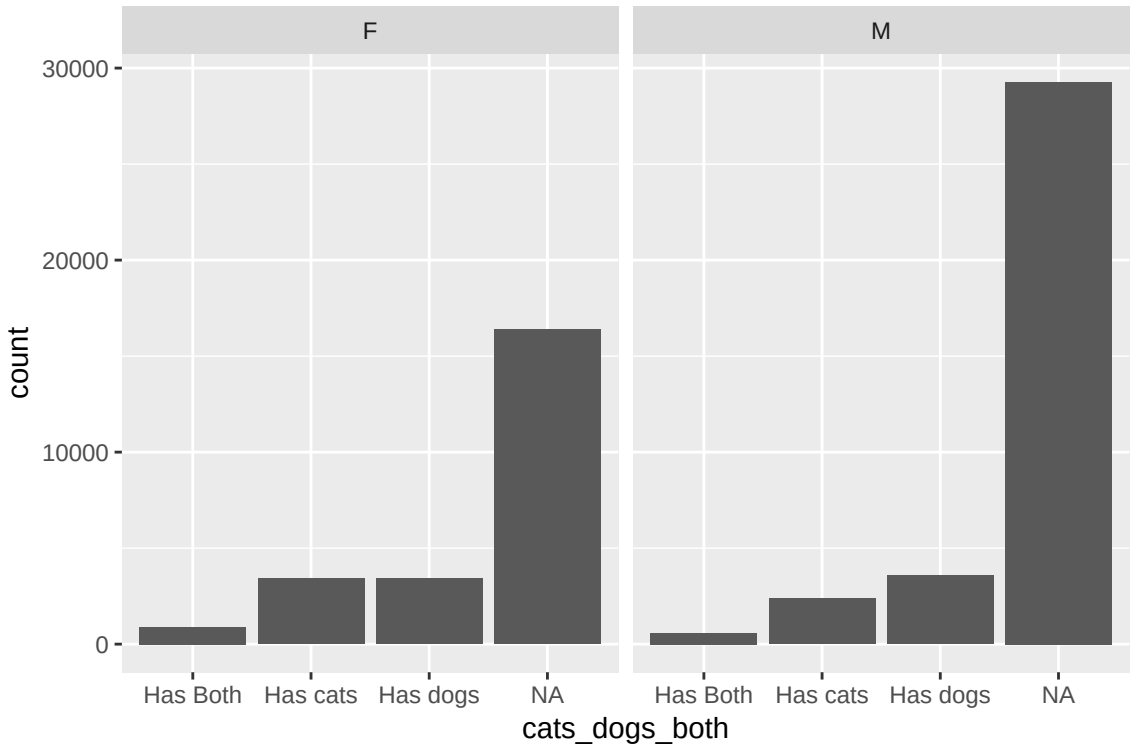
```
tally(~ Class | Survived, format = "percent", margin = TRUE, data = Titanic)
```

```
##        Survived
## Class        Alive       Dead
##   1      28.230337   8.221925
##   2      16.713483  11.096257
##   3      25.280899  35.427807
##   Crew   29.775281  45.254011
##   Total 100.000000 100.000000
```

### Section 3.2: Conditional Distributions

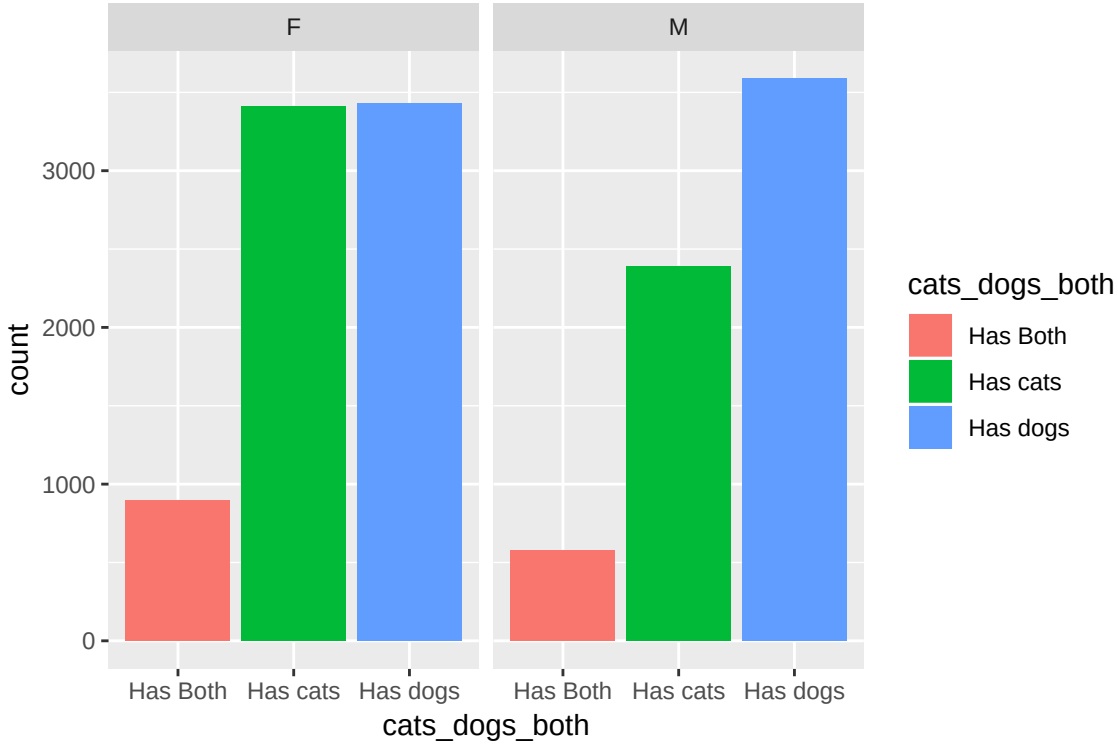
See displays on 68-69.

```
gf_bar(~ cats_dogs_both | gender, data = OKCupid)
```




```
# There are many who don't own either

# Figure 3.2, page 69
gf_bar(~ cats_dogs_both | gender, fill = ~ cats_dogs_both,
  data = filter(OKCupid, cats_dogs_both != "NA"))
```



**Example 3.3: Finding Conditional Distributions: Watching the Super Bowl**

```
tally(~ Plan + Sex, margin = TRUE, data = SuperBowl)
```

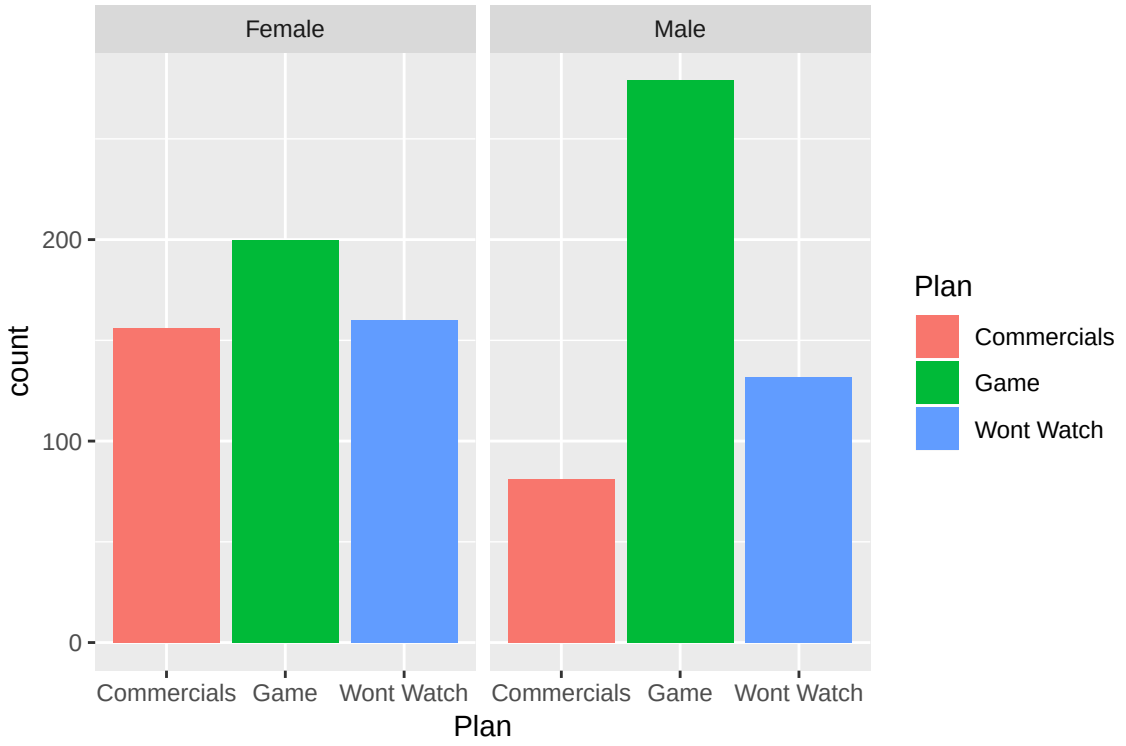
```
##              Sex
## Plan          Female Male Total
##   Commercials    156   81   237
##   Game           200  279   479
##   Wont Watch     160  132   292
##   Total          516  492  1008
```

```
tally(~ Plan | Sex, format = "percent", data = SuperBowl)
```

```
##              Sex
## Plan            Female     Male
##   Commercials 30.23256 16.46341
##   Game        38.75969 56.70732
##   Wont Watch  31.00775 26.82927
```

**Example 3.4: Looking for Associations Between Variables: Still Watching the Super Bowl**

```
gf_bar(~ Plan | Sex, fill = ~ Plan, format = "percent", data = SuperBowl)
```




### Examining Contingency Tables

See displays on page 72.

```
FishDiet <- read_csv("http://nhorton.people.amherst.edu/is5/data/Fish_diet.csv", skip = 1) %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
```

```
##   `Diet:Counts` = col_character(),
##   `Cancer:Counts` = col_character()
## )
```

```
tally(~ diet_counts + cancer_counts, data = FishDiet)
```

```
##            cancer_counts
## diet_counts   No  Yes
##    Large     507   42
##    Moderate 2769  209
##    Never     110   14
##    Small    2420  201
```

### Random Matters

See display on page 74.

```
Nightmares <- read_csv("http://nhorton.people.amherst.edu/is5/data/Nightmares.csv", skip = 1)
```

```
## Parsed with column specification:
## cols(
##   Side = col_character(),
##   Dream = col_character()
## )
```

```
Nightmares <- Nightmares %>%
  mutate(Dream = ifelse(Dream == "N", "Nightmare", "SweetDreams"))
tally(~ Side + Dream, data = Nightmares)
```

```
##     Dream
## Side Nightmare SweetDreams
##    L         9          13
##    R         6          35
```

### Section 3.3: Displaying Contingency Tables

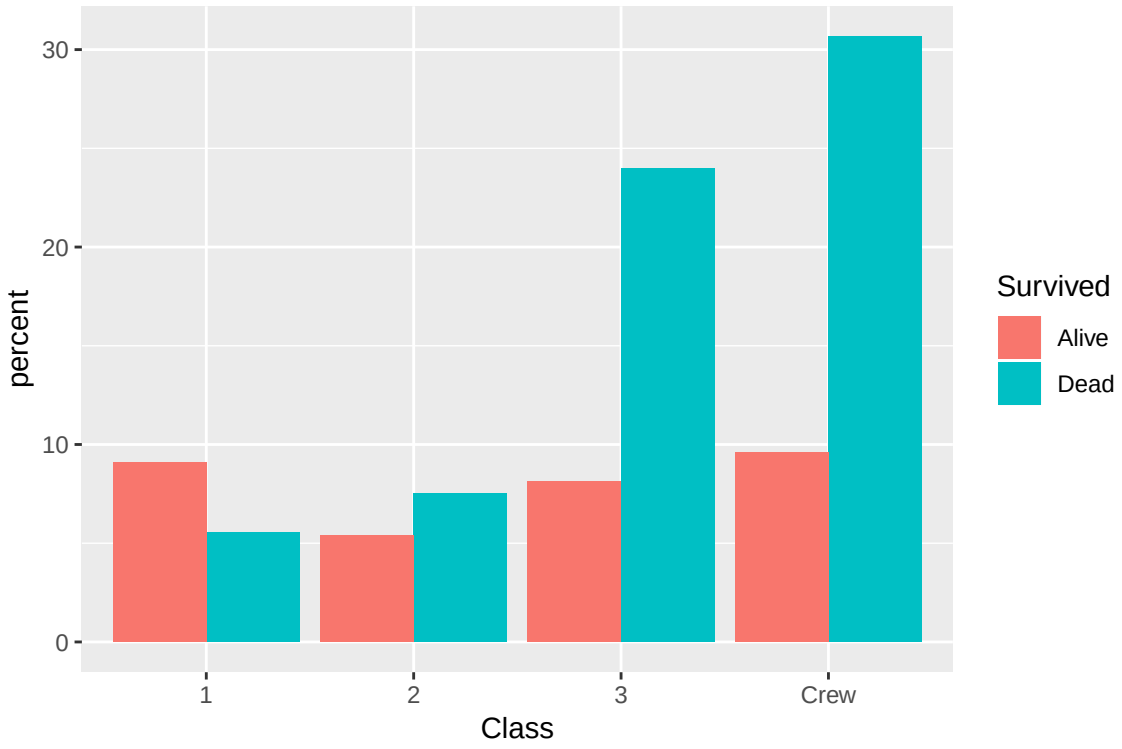
```
tally(~ Class + Survived, format = "count", data = Titanic)
```

```
##       Survived
## Class  Alive Dead
##   1      201  123
##   2      119  166
##   3      180  530
##   Crew   212  677
```

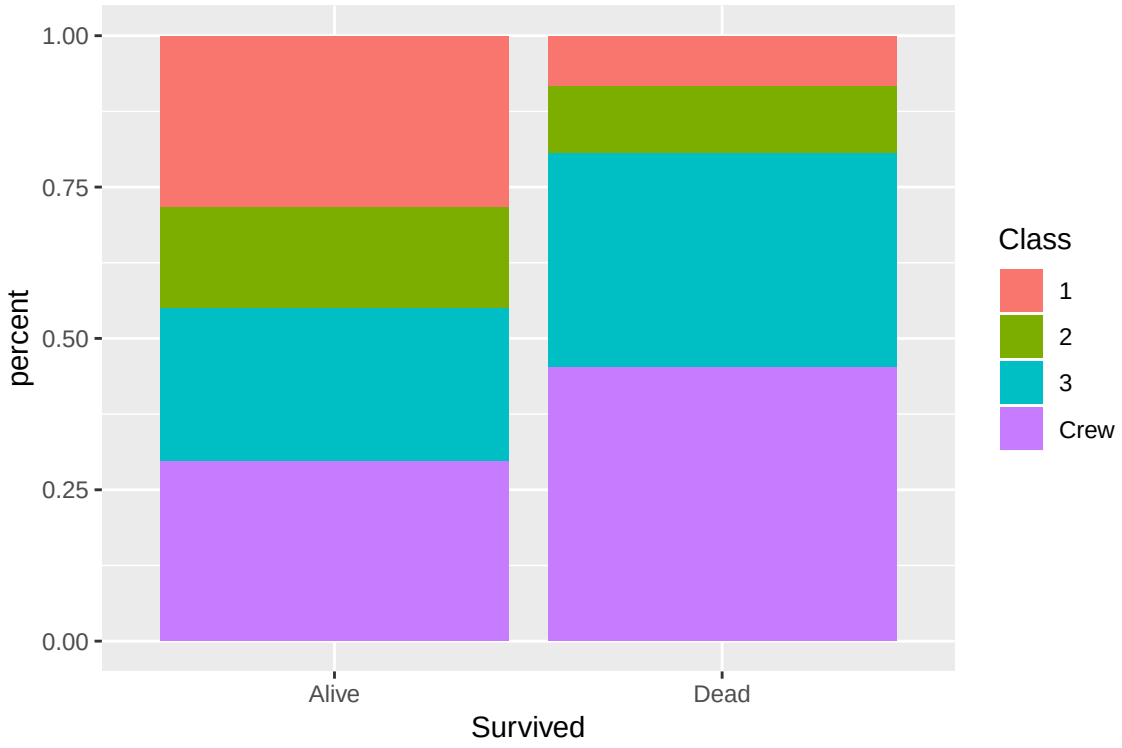
```
tally(~ Class + Survived, format = "percent", data = Titanic)
```

```
##       Survived
## Class      Alive      Dead
##   1     9.103261  5.570652
##   2     5.389493  7.518116
##   3     8.152174 24.003623
##   Crew  9.601449 30.661232
```

```
# Figure 3.4, page 75
gf_percents(~ Class, fill = ~ Survived, position = position_dodge(), data = Titanic)
```

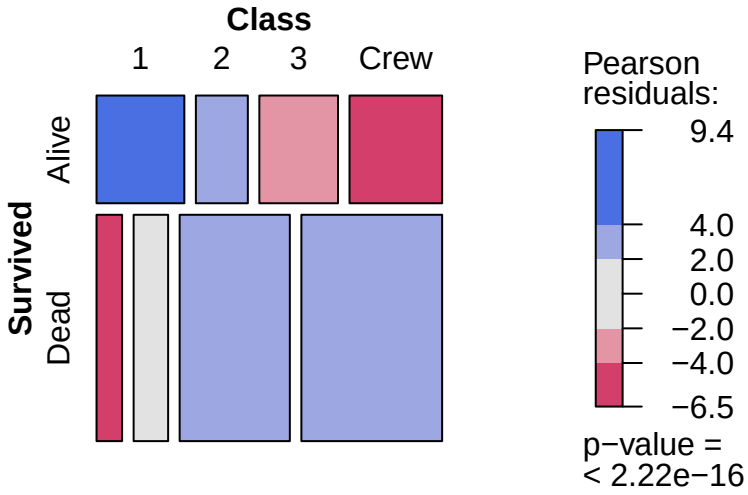



```
# Figure 3.5
gf_percents(~ Survived, fill = ~ Class, position = "fill", data = Titanic)
```




```
# Figure 3.6, page 76
vcd::mosaic(tally(~ Survived + Class, data = Titanic),
            main = "Mosaic plot of Class by Survival",
            shade = TRUE)
```

# Mosaic plot of Class by Survival




See the mosaic plots on page 77.

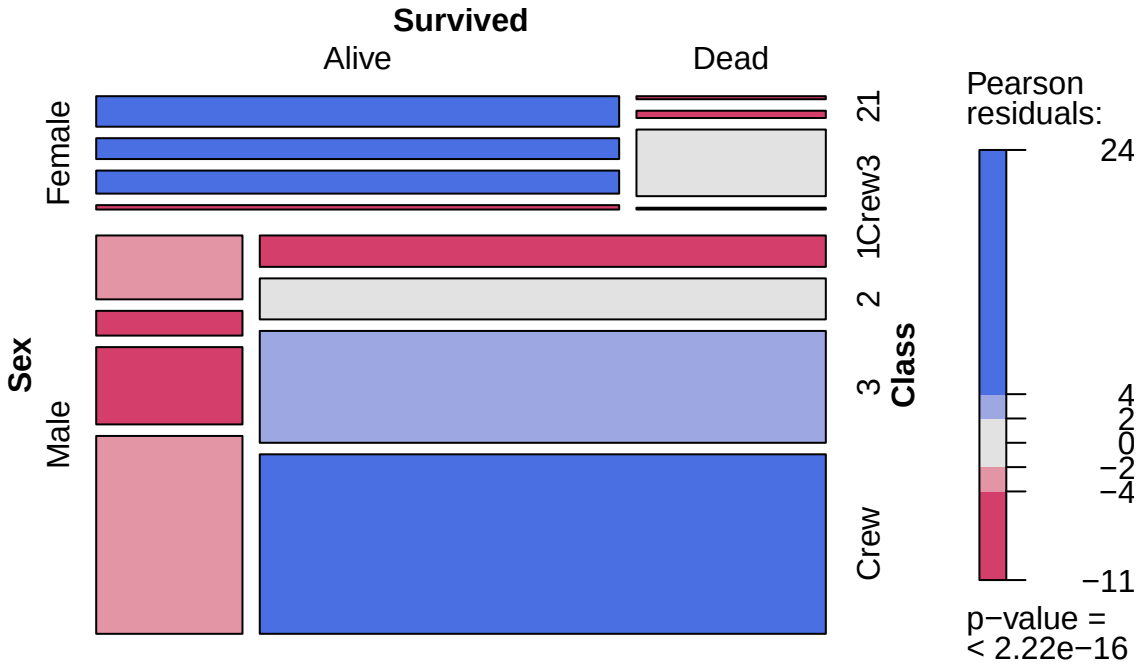
**Section 3.4: Three Categorical Variables**

```
tally(~ gender + cats_dogs_both + drugs_y_n, format = "percent", data = OKCupid)
```

```
## , , drugs_y_n = No
##
##       cats_dogs_both
## gender   Has Both   Has cats   Has dogs       <NA>
##      F  1.0243064  3.4199156  3.9437466 18.0187845
##      M  0.5922293  2.0819779  3.7769214 30.0719016
##
## , , drugs_y_n = Yes
##
##       cats_dogs_both
## gender   Has Both   Has cats   Has dogs       <NA>
##      F  0.2085314  0.8941828  0.6272626  2.9794972
##      M  0.1901807  0.8658225  0.9041923  6.9132342
##
## , , drugs_y_n = NA
##
##       cats_dogs_both
## gender   Has Both   Has cats   Has dogs       <NA>
##      F  0.2635837  1.3779757  1.1527618  6.3226732
##      M  0.1801712  1.0359842  1.3029044 11.8512587
```

**Example 3.7: Looking for Associations Among Three Variables at Once**

```
vcd::mosaic(tally(~ Sex + Survived + Class, data = Titanic), shade = TRUE)
```




**Example 3.8: Simpson's Paradox: Gender Discrimination?**

Here we demonstrate how to generate one of the tables on page 80.

```
# Create a dataframe from the counts
# http://mathematicalthinking.blogspot.com/2012/06/simpsons-paradox.html
Berk <- rbind(
  do(512) *       data.frame(admit = TRUE,  sex = "M", school = "A"),
  do(825 - 512) * data.frame(admit = FALSE, sex = "M", school = "A"),
  do(89) *        data.frame(admit = TRUE,  sex = "F", school = "A"),
  do(19) *        data.frame(admit = FALSE, sex = "F", school = "A")
)
class(Berk)
```

```
## [1] "do.data.frame" "data.frame"
```

```
tally(~ sex + admit, data = Berk)
```

```
##    admit
## sex TRUE FALSE
##   M  512   313
##   F   89    19
```

```
tally(~ admit | sex, format = "percent", data = Berk)
```

```
##        sex
## admit          M        F
##   TRUE  62.06061 82.40741
##   FALSE 37.93939 17.59259
```

In this case, `do(n)` creates `n` number of observations with the properties in `data.frame()`. We use `data.frame()` to make `Berk` a data frame. This can be checked with the `class()` function. `rbind()` is used to combine the data frames into one.