Intro stats with `mosaic`

ggformula version

Loading packages

```
library(mosaic)
```

Essential R syntax

Names in R are case sensitive

Function and arguments
```
rflip(10)
```

Optional arguments
```
rflip(10, prob = 0.8)
```

Assignment
```
x <- rflip(10, prob = 0.8)
```

Getting help on any function
```
help(mean)
```

Arithmetic operations

`+  -  *  /`	basic operations
`^`	exponentiation
`( )`	grouping
`sqrt(x)`	square root
`abs(x)`	absolute value
`log10(x)`	logarithm, base 10
`log(x)`	natural logarithm, base e
`exp(x)`	exponential function e^x
`factorial(k)`	$k! = k(k-1)\ldots1$

Logical operators

`==`	is equal to (note double equal sign)
`!=`	is not equal to
`<`	is less than
`<=`	is less than or equal to
`>`	is greater than
`>=`	is greater than or equal to
`&`	`A & B` ("A and B") is `TRUE` if both `A` and `B` are `TRUE`
`|`	`A	B` ("A or B") is `TRUE` if one or both of `A` and `B` are `TRUE`
`%in%`	inclusion; for example `"C" %in% c("A", "B")` is `FALSE`

Formula interface

Use for graphics, statistics, inference, and modeling operations.
```
goal(y ~ x, data = mydata)
```
Read as "Calculate `goal` for `y` using `mydata` "broken down by" `x`, or "modeled by" `x`.
```
mean(age ~ sex, data = HELPrct)
```

For graphics:
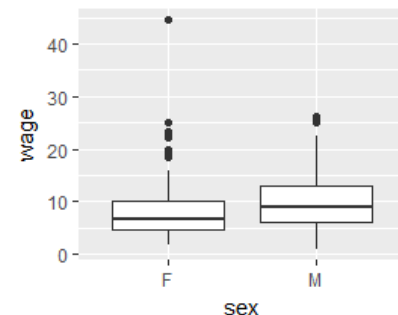```
goal(y ~ x | z, data = mydata,
   color = ~ w)
```
`y` : y-axis variable (*optional*)
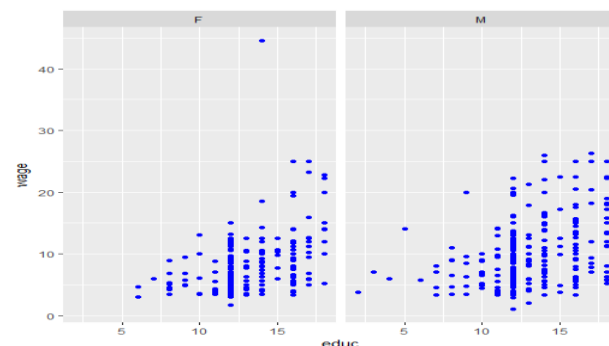`x` : x-axis variable (*required*)
`z` : panel-by variable (*optional*)
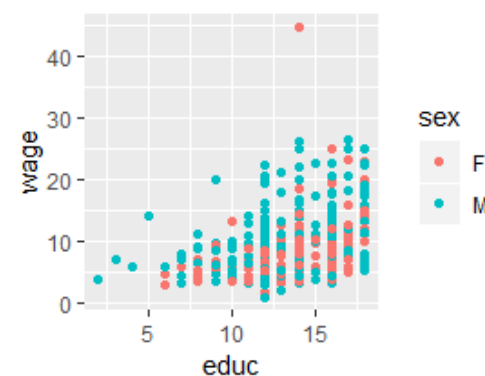`w` : color-by formula (*optional*)
```
gf_boxplot(wage ~ sex,
   data = CPS85)
```



```
gf_point(wage ~ educ | sex,
   data = CPS85, color = "blue")
```



```
gf_point(wage ~ educ,
   data = CPS85, color = ~ sex)
```


Examining data

Print short summary of all variables
```
inspect(HELPrct)
```

Number of rows and columns
```
dim(HELPrct)
nrow(HELPrct)
ncol(HELPrct)
```

Print first rows or last rows
```
head(KidsFeet)
tail(KidsFeet, 10)
```

Names of variables
```
names(HELPrct)
```
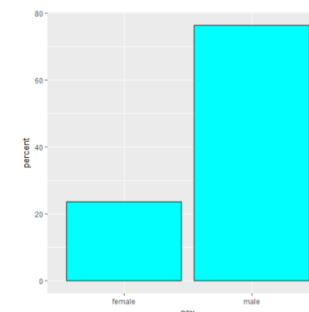
One categorical variable

Counts by category
```
tally(~ sex, data = HELPrct)
```
Percentages by category
```
tally(~ sex, data = HELPrct,
   format = "percent")
```

Bar graph of percentages
```
gf_percents(~ sex,
   data = HELPrct, fill = "cyan",
   color = "black")
```


Tests and confidence intervals

Exact test
```
result1 <-
   binom.test(~ (homeless ==
   "homeless"), data = HELPrct)
```
Approximate test (large samples)
```
result2 <-
   prop.test(~ (homeless ==
   "homeless"), data = HELPrct,
   alternative = "less",
   p = 0.4)
```
Extract confidence intervals and *p*-values
```
confint(result1)
pval(result2)
```

One quantitative variable

Make output more readable
```
options(digits = 3)
```

Compute summary statistics
```
mean(~ cesd, data = HELPrct)
```

Other summary statistics work similarly
```
median()  iqr() max()  min()
fivenum() sd()  var()  sum()
```

Table of summary statistics
```
favstats(~ cesd, data = HELPrct)
```
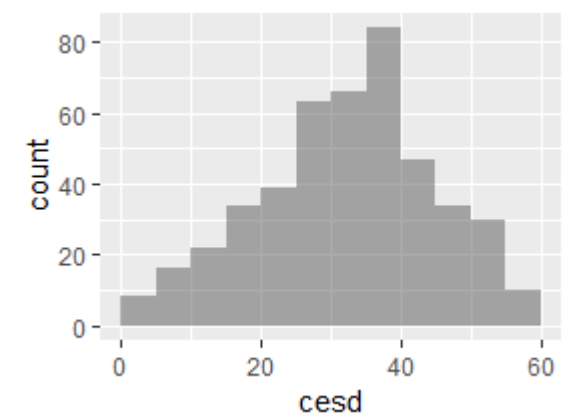
Summary statistics by group
```
favstats(cesd ~ sex,
   data = HELPrct)
```

Quantiles
```
quantile(~ cesd, data = HELPrct,
   prob = c(0.25, 0.5, 0.8))
```

Histogram
```
gf_histogram(~ cesd,
   data = HELPrct, binwidth = 5,
   center = 2.5)
```


Normal probability plot
```
gf_qq(~ cesd, data = HELPrct)
```

Density plot
```
gf_dens(~ cesd, data = HELPrct,
   color = "blue", size = 1.25)
```

One-sample *t*-test
```
result <- t_test(~ cesd,
   data = HELPrct, mu = 34)
```

Extract confidence intervals and *p*-values
```
confint(result)
pval(result)
```

Paired *t*-test
```
t_test(extra ~ group,
   data = sleep, paired = TRUE)
```

Data wrangling

Drop, rename, or reorder variables
```
df <- select(HELPrct,
  c(id, age, gender = sex))
```

Create new variables from existing ones
```
KidsFeet <- mutate(KidsFeet,
  width_in = 0.394 * width)
```

Retain specific rows from data
```
girls_feet <- filter(KidsFeet,
  sex == "G")
```

Sort data rows by value in column
```
df <- arrange(KidsFeet, length)
```

Compute summary statistics by group
```
group_by(KidsFeet, sex) %>%
  summarize(mean_width =
    mean(width))
```

For more, see **Tidyverse cheatsheet**

Importing data

Import data from file or URL
```
MustangPrice <-
  read.file("C:/MustangPrice.csv")
```
Note: R uses *forward* slashes
```
kidsfeet <-
  read.file("http://www.mosaic-
  web.org/go/datasets/kidsfeet.csv")
```

Randomization and simulation

Fix random number sequence
```
set.seed(42)
```

Toss coins
```
rflip(10) # default prob is 0.5
```

Do something repeatedly
```
do(5) * rflip(10, prob = 0.75)
```

Draw a simple random sample
```
sample(LETTERS, 10)
deal(Cards, 5) # poker hand
```

Resample with replacement
```
Small <- sample(KidsFeet, 10)
resample(Small)
```

Random permutation (shuffling)
```
shuffle(Cards)
```

Random values from distributions
```
rbinom(5, size = 10, prob = 0.7)
rnorm(5, mean = 10, sd = 2)
```

Two categorical variables

Contingency table with margins
```
tally(~ substance + sex,
  data = HELPrct, margins = TRUE)
```

Percentages by column
```
tally(~ sex | substance,
  data = HELPrct,
  format = "percent")
```

Mosaic plot
```
my_tbl <- tally(substance ~ sex,
  data = HELPrct)
mosaicplot(my_tbl, color = TRUE)
```


Test for proportions (approximate)
```
prop.test(homeless ~ sex,
  success = "homeless",
  data = HELPrct)
```

Distributions

Normal distribution function
```
pnorm(13, mean = 10, sd = 2)
```

Normal distribution function with graph
```
xpnorm(1.645, mean = 0, sd = 1)
```

Normal distribution quantiles
```
qnorm(0.95) # mean = 0, sd = 1
```

Normal distribution quantiles with graph
```
xqnorm(0.85, mean = 10, sd = 2)
```

Binomial density function ("size" means n)
```
dbinom(5, size = 8, prob = 0.65)
```

Binomial distribution function
```
pbinom(5, size = 8, prob = 0.65)
```

Central portion of distribution
```
cdist("norm", 0.95)
cdist("t", c(0.90, 0.99), df = 5)
```

Plotting distributions
```
plotDist("binom", size = 8,
  prob = 0.65, xlim = c(-1, 9))
plotDist("norm", mean = 10,
  sd = 2)
```

Two quantitative variables

Correlation coefficient
```
cor(cesd ~ mcs, data = HELPrct)
```

Scatterplot with regression line and smooth
```
gf_point(cesd ~ mcs,
        data = HELPrct) %>%
  gf_lm(size = 1.5, linetype =
    "dashed") %>%
  gf_smooth(color = "red")
```
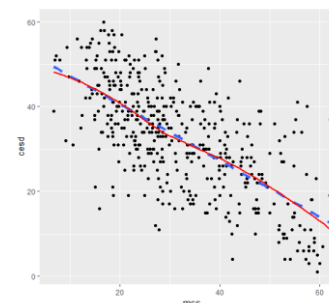

Simple linear regression
```
cesdmodel <- lm(cesd ~ mcs,
  data = HELPrct)
msummary(cesdmodel)
```

Prediction
```
lm_fun <- makeFun(cesdmodel)
lm_fun(mcs = 35)
```

Extract useful quantities
```
anova(cesdmodel)
coef(cesdmodel)
confint(cesdmodel)
rsquared(cesdmodel)
```

Diagnostics; plot residuals
```
gf_dhistogram(~resid(cesdmodel))
gf_qq(~resid(cesdmodel))
```

Diagnostics; plot residuals vs. fitted
```
gf_point(resid(cesdmodel) ~
    fitted(cesdmodel)) %>%
  gf_lm(size = 2)
```

## Categorical response, quantitative predictor

Logistic regression
```
logit_mod <- glm(homeless ~ age,
  data = HELPrct,
  family = binomial)
msummary(logit_mod)
```

Odds ratios and confidence intervals
```
exp(coef(logit_mod))
exp(confint(logit_mod))
```

Quantitative response, categorical predictor

Two-level predictor: two-sample t test
Numeric summaries
```
favstats(~length | sex,
  data = KidsFeet)
```
Graphic summaries
```
gf_qq(~ length | sex,
      data = KidsFeet) %>%
  gf_qqline() %>%
  gf_labs(x = "Normal quantile",
          y = "Length (cm)")
```
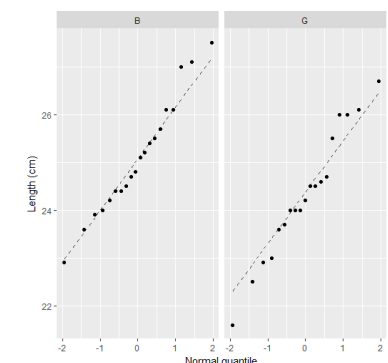

Two-sample t-test and confidence interval
```
result <- t_test(cesd ~ sex,
  data = HELPrct)
result # view results
confint(result)
pval(result)
```

More than two levels (Analysis of variance)
Numeric and graphic summaries
```
favstats(cesd ~ substance,
  data = HELPrct)
gf_boxplot(cesd ~ substance,
  data = HELPrct)
```
Fit and summarize model
```
mod <- lm(age ~ substance,
  data = HELPrct)
anova(mod)
```

Which differences are significant?
```
mplot(TukeyHSD(mod))
```