Data collection and data wrangling

The ASTA team

Contents

1 Data

1.1 Data example

We use data about pengiuns from the R package palmerpenguins

```
pingviner <- palmerpenguins::penguins
pingviner
```

```
## # A tibble: 344 x 8
##    species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
##    <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
##  1 Adelie  Torgersen           39.1          18.7               181        3750
##  2 Adelie  Torgersen           39.5          17.4               186        3800
##  3 Adelie  Torgersen           40.3          18                 195        3250
##  4 Adelie  Torgersen           NA            NA                  NA          NA
##  5 Adelie  Torgersen           36.7          19.3               193        3450
##  6 Adelie  Torgersen           39.3          20.6               190        3650
##  7 Adelie  Torgersen           38.9          17.8               181        3625
##  8 Adelie  Torgersen           39.2          19.6               195        4675
##  9 Adelie  Torgersen           34.1          18.1               193        3475
## 10 Adelie  Torgersen           42            20.2               190        4250
## # i 334 more rows
```

```
## # i 2 more variables: sex <fct>, year <int>
```

2 Summaries and plots of qualitative variables

2.1 Tables of qualitative variables

- The main function to make tables from a data frame of observations is `tally()` which tallies (counts up) the number of observations within a given category. E.g:

```
tally(~species, data = pingviner)
```

```
## species
##    Adelie Chinstrap    Gentoo
##       152        68       124
```

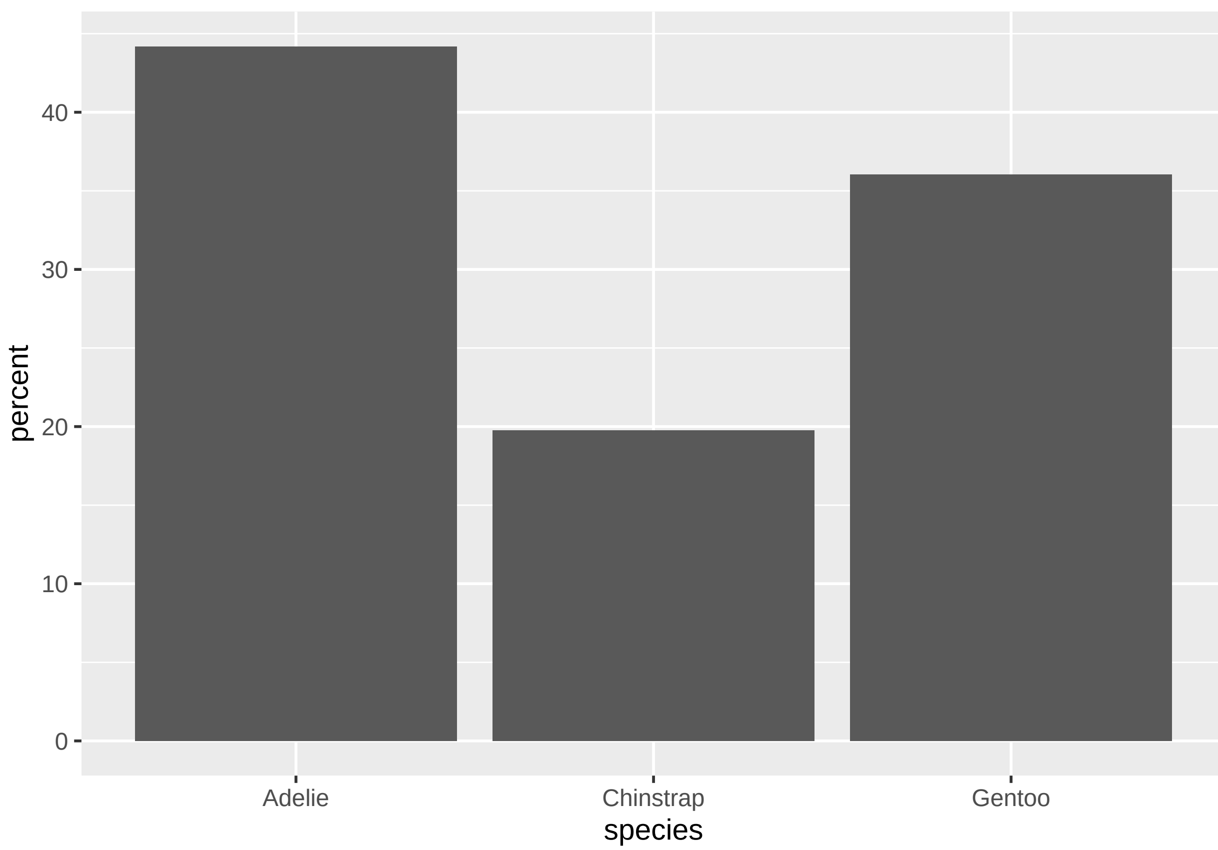
```
tally(species ~ island, data = pingviner)
```

```
##            island
## species     Biscoe Dream Torgersen
##   Adelie        44    56        52
##   Chinstrap      0    68         0
##   Gentoo       124     0         0
```

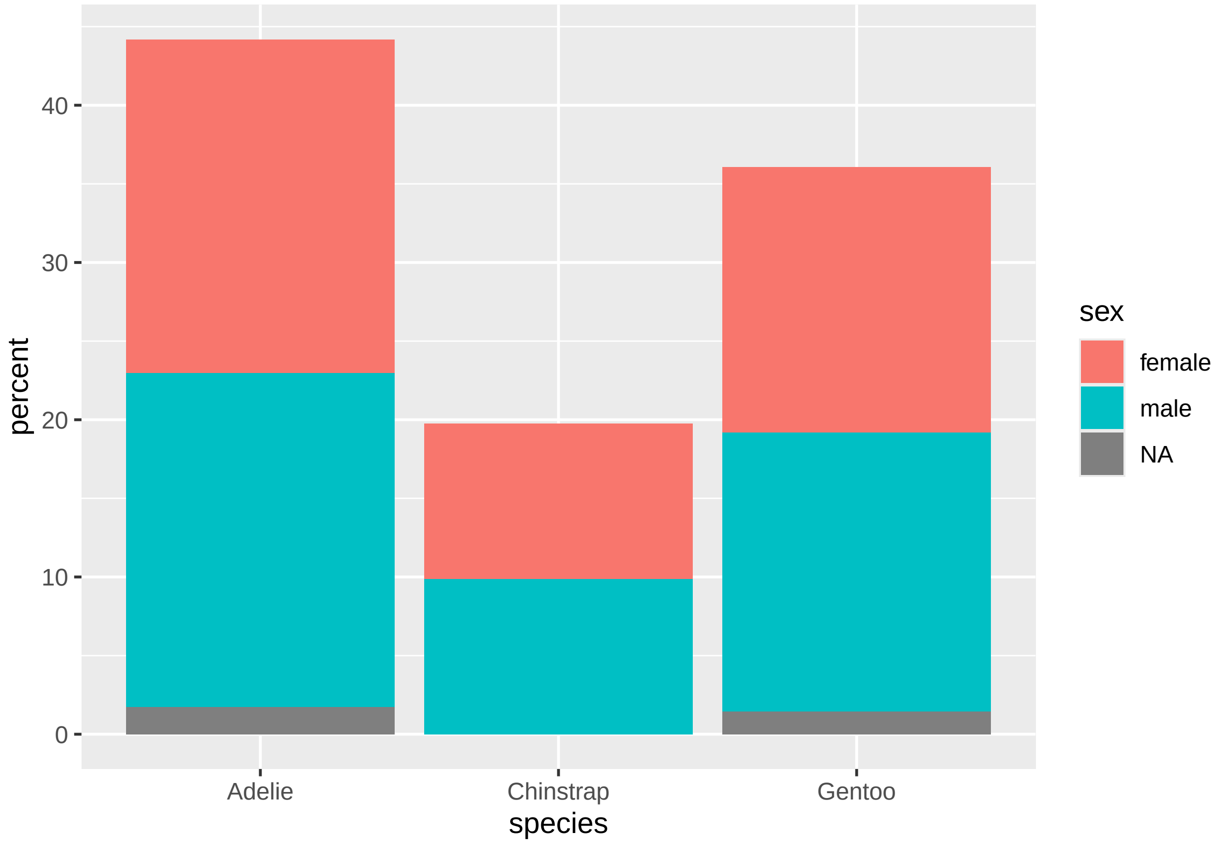
2.2 Plots of qualitative variables

- The main plotting functions for qualitative variables are `gf_percents()` and `gf_bar()`. E.g:

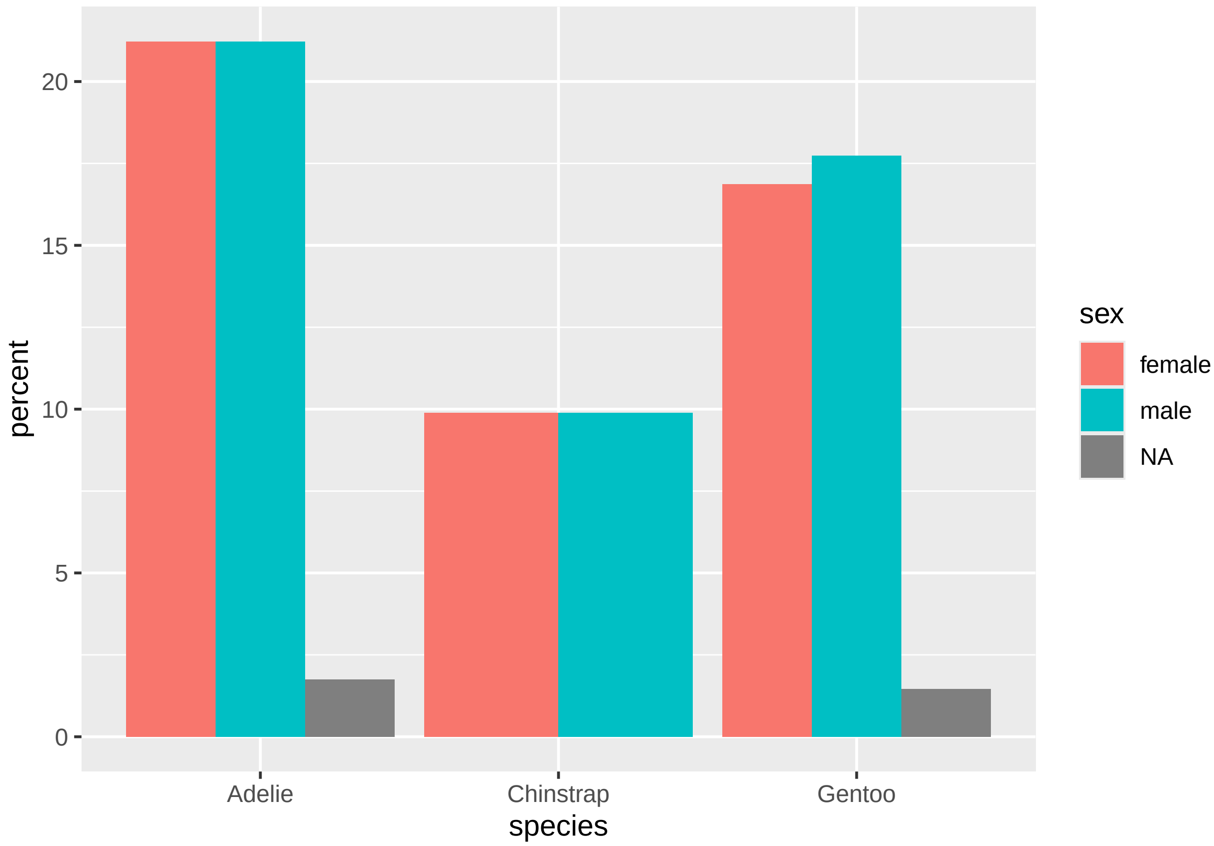
```
gf_percents(~species, data = pingviner)
```



```r
gf_percents(~species, fill = ~sex, data = pingviner)
```




```r
gf_percents(~species, fill = ~sex, data = pingviner, position = position_dodge())
```



3 Target population and random sampling

3.1 Population parameters

- When the sample size grows, then e.g. the mean of the sample, $\overline{y}$, will stabilize around a fixed value, μ, which is usually unknown. The value μ is called the **population mean**.
- Correspondingly, the standard deviation of the sample, s, will stabilize around a fixed value, σ, which is usually unknown. The value σ is called the **population standard deviation**.
- Notation:
  - μ (mu) denotes the population mean.
  - σ (sigma) denotes the population standard deviation.

Population	Sample
μ	$\overline{y}$
σ	s

3.1.1 A word about terminology

- **Standard deviation**: a measure of variability of a population or a sample.
- **Standard error**: a measure of variability of an estimate. For example, a measure of variability of the sample mean.

3.2 Aim of statistics

- Statistics is all about "saying something" about a population.

- Typically, this is done by taking a random sample from the population.
- The sample is then analysed and a statement about the population can be made.
- The process of making conclusions about a population from analysing a sample is called **statistical inference**.

3.3 Random sampling schemes

Possible strategies for obtaining a random sample from the target population are explained in Agresti section 2.4:

- **Simple sampling: each possible sample of equal size equally probable**
- Systematic sampling
- Stratified sampling
- Cluster sampling
- Multistage sampling
- ...

4 Biases

4.1 Types of biases

Agresti section 2.3:

- Sampling/selection bias
  - Probability sampling: each sample of size n has same probability of being sampled
    - Still problems: undercoverage, groups not represented (inmates, homeless, hospitalized, ...)
  - Non-probability sampling: probability of sample not possible to determine
    - E.g. volunteer sampling
- Response bias
  - E.g. poorly worded, confusing or even order of questions
  - Lying if think socially unacceptable
- Non-response bias
  - Non-response rate high; systematic in non-responses (age, health, believes)

4.2 Example of sample bias: United States presidential election, 1936

(Based on Agresti, this and this.)

- Current president: Franklin D. Roosevelt
- Election: Franklin D. Roosevelt vs Alfred Landon (Republican governor of Kansas)
- Literary Digest: magazine with history of accurately predicting winner of past 5 presidential elections

---

4.2.1 Results

- Literary Digest poll: Landon: 57%; Roosevelt: 43%
- Actual results: Landon: 38%; Roosevelt: 62%
- Sampling error: 57%-38% = 19%
  - Practically all of the sampling error was the result of **sample bias**
  - Poll size of $>$ 2 mio. individuals participated – extremely large poll

---

4.2.2 Problems (biases)

- Mailing list of about 10 mio. names was created

- Based on every telephone directory, lists of magasine subscribers, rosters of clubs and associations, and other sources
    - Each one of 10 mio. received a mock ballot and asked to return the marked ballot to the magazine
- "respondents who returned their questionnaires represented only that subset of the population with a relatively intense interest in the subject at hand, and as such constitute in no sense a random sample ... it seems clear that the minority of anti-Roosevelt voters felt more strongly about the election than did the pro-Roosevelt majority" (*The American Statistician*, 1976)
- Biases:
    - Sample bias
        * List generated towards middle- and upper-class voters (e.g. 1936 and telephones)
        * Many unemployed (club memberships and magazine subscribers)
    - Non-response bias
        * Only responses from 2.3/2.4 mio out of 10 million people

4.3 Example of response bias: Wording matters

New York Times/CBS News poll on attitude to increased fuel taxes

- "Are you in favour of a new gasoline tax?" - 12% said yes.
- "Are you in favour of a new gasoline tax to decrease US dependency on foreign oil?" - 55% said yes.
- "Do you think a new gas tax would help to reduce global warming?" - 59% said yes.

4.4 Example of response bias: Order of questions matter

US study during cold war asked two questions:

1 "Do you think that US should let Russian newspaper reporters come here and sent back whatever they want?"

2 "Do you think that Russia should let American newspaper reporters come in and sent back whatever they want?"

The percentage of yes to question 1 was 36%, if it was asked first and 73%, when it was asked last.

4.5 Example of survivior bias: Bullet holes of honor

(Based on this.)

- World War II
- Royal Air Force (RAF), UK
    - Lost many planes to German anti-aircraft fire
- Armor up!
    - Where?
    - Count up all the bullet holes in planes that returned from missions
        * Put extra armor in the areas that attracted the most fire

---

- Hungarian-born mathematician Abraham Wald:
    - If a plane makes it back safely with a bunch of bullet holes in its wings: holes in the wings aren't very dangerous
        * **Survivorship bias**
    - Armor up the areas that (on average) don't have any bullet holes
        * They never make it back, apparently dangerous

Section of plane	Bullet holes per square foot
Engine	1.11

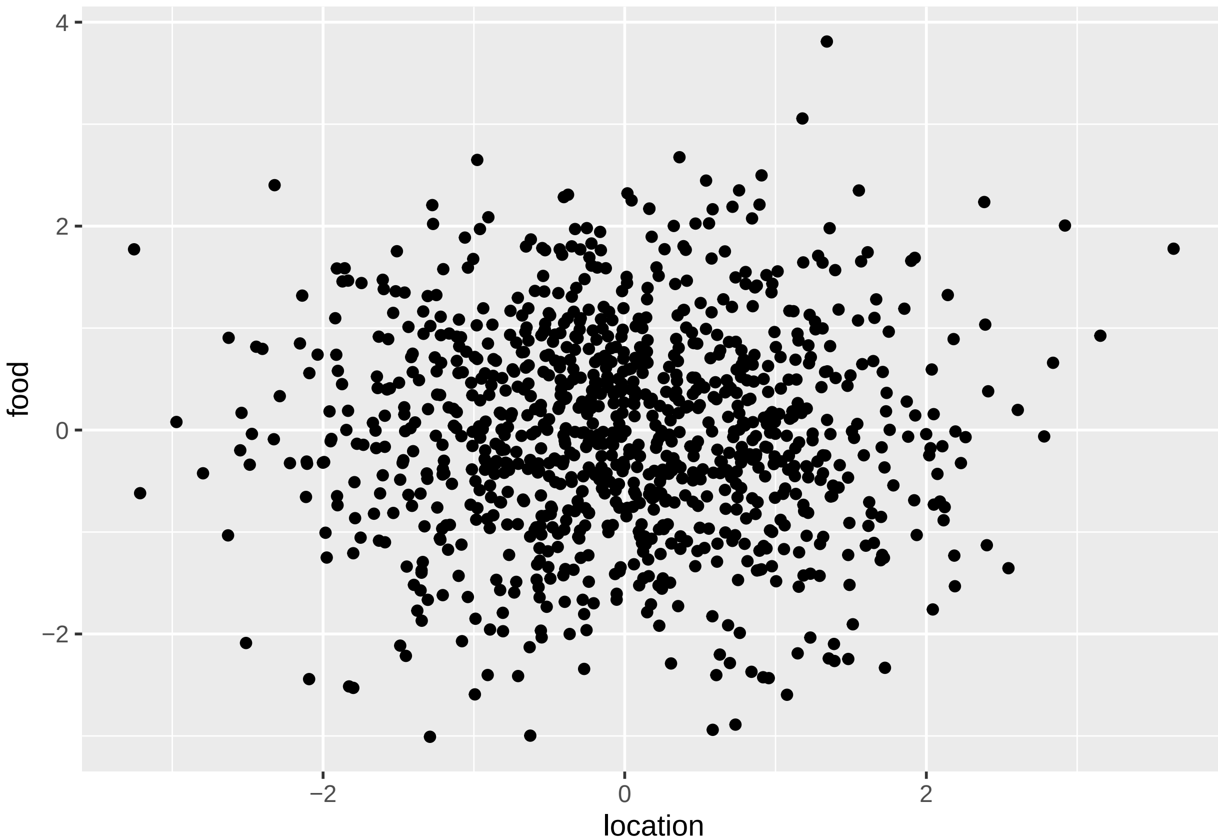
Section of plane	Bullet holes per square foot
Fuselage	1.73
Fuel system	1.55
Rest of the plane	1.80

(See also this xkcd)

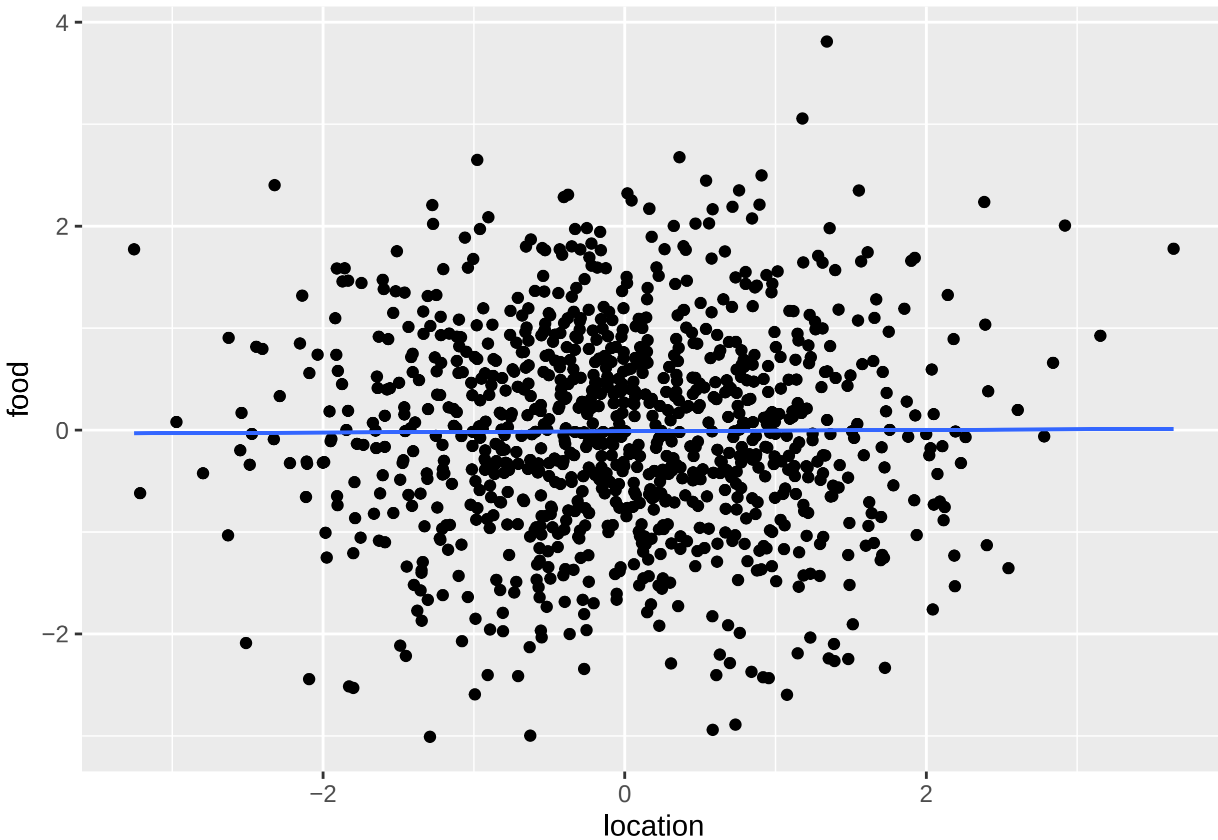
4.6 Example of selection bias

All restaurants:

```r
set.seed(1)
n <- 1000
food <- rnorm(n, mean = 0, sd = 1)
location <- rnorm(n, mean = 0, sd = 1)
gf_point(food ~ location)
```




```r
gf_point(food ~ location) %>% gf_lm()
```



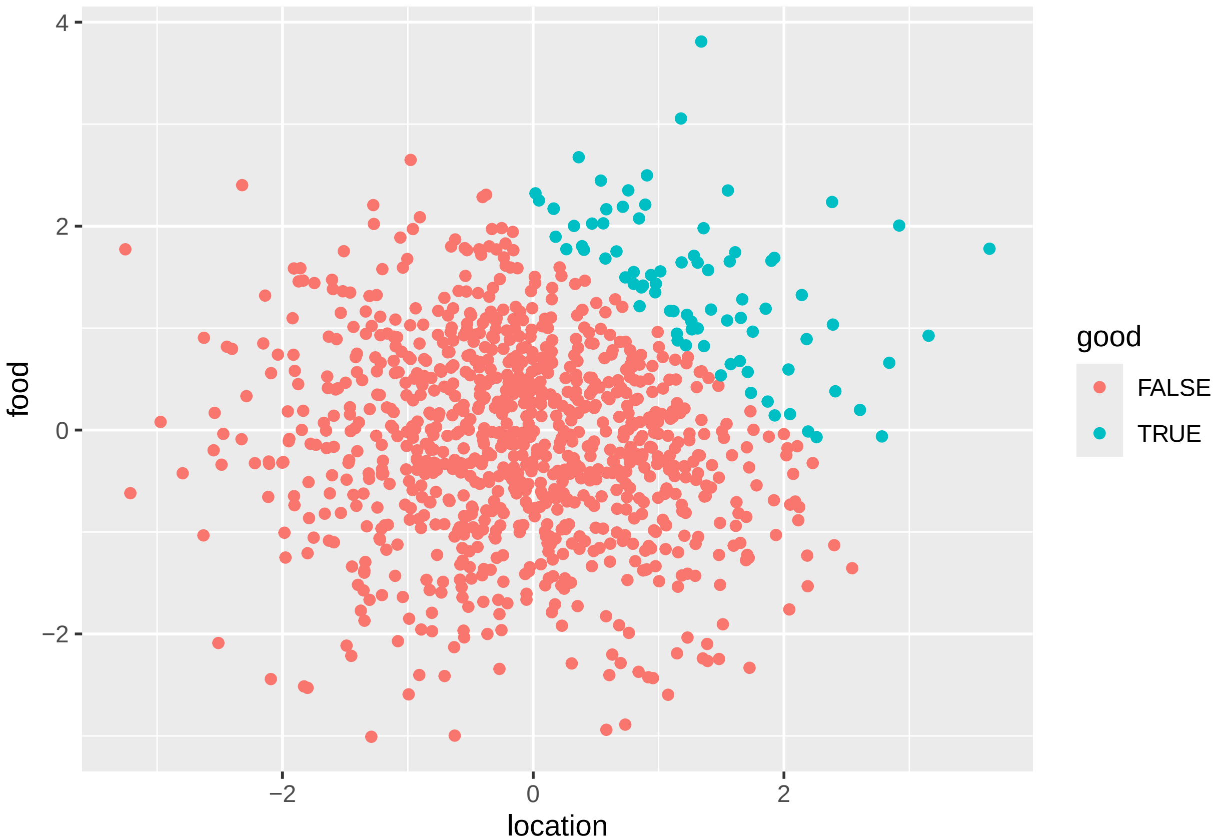

```
cor.test(food, location)
```

```
##
##  Pearson's product-moment correlation
##
## data:  x and y
## t = 0.2, df = 998, p-value = 0.8
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.056  0.068
## sample estimates:
##    cor
## 0.0064
```

Total score = food + location

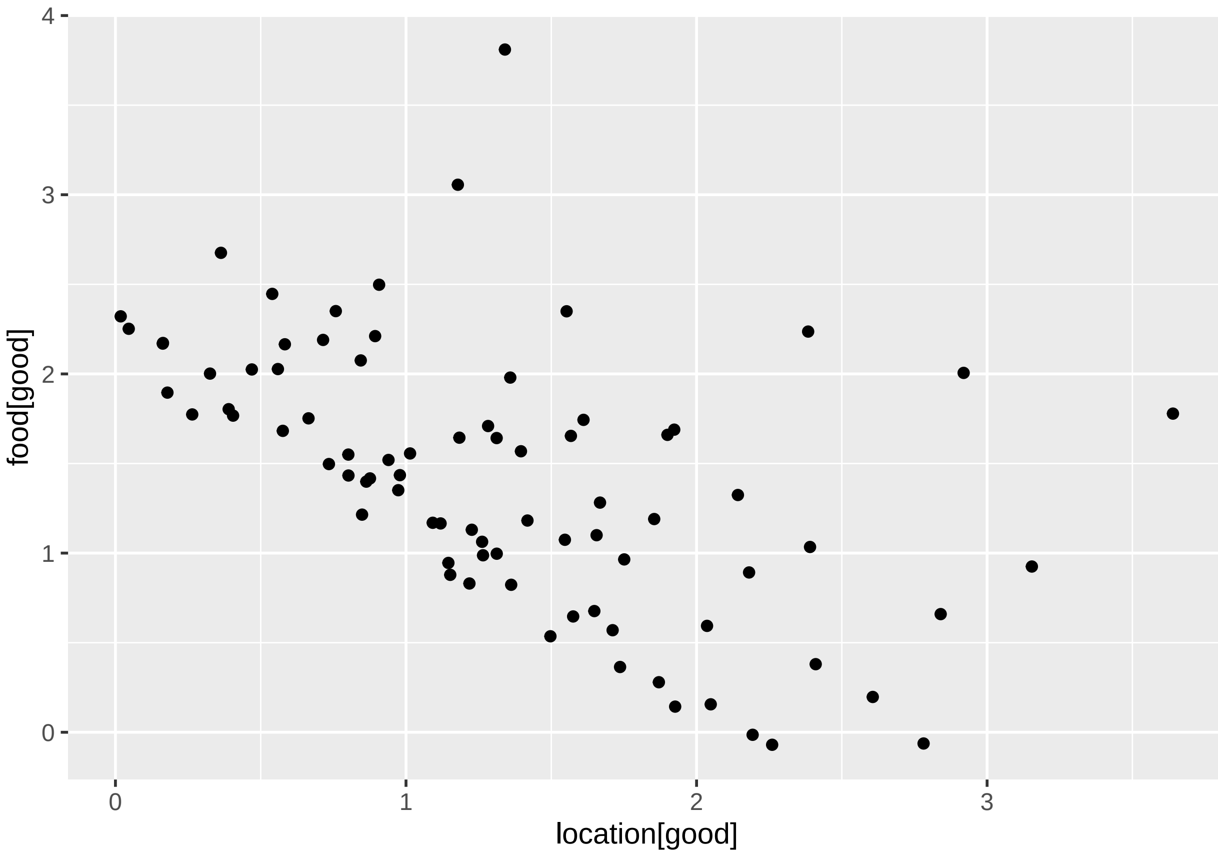
Good review if score > 2

```
score <- food + location
good <- score > 2
gf_point(food ~ location, color = ~ good)
```

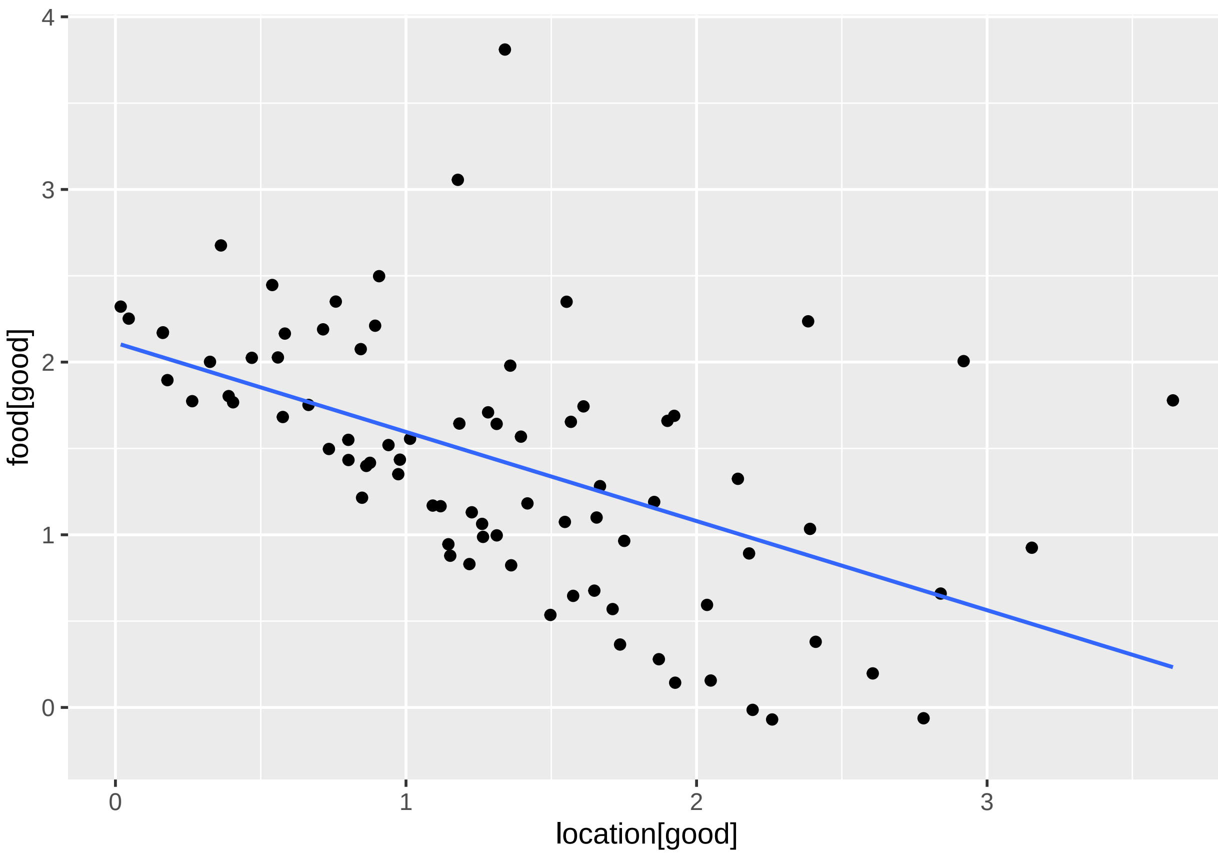


4.6.1 Focusing on "good" restaurants

```
gf_point(food[good] ~ location[good])
```



```r
gf_point(food[good] ~ location[good]) %>%
  gf_lm()
```




```
cor.test(food[good], location[good])
```

```
##
##  Pearson's product-moment correlation
##
## data:  x and y
## t = -6, df = 79, p-value = 4e-07
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.67 -0.35
## sample estimates:
##   cor
## -0.53
```