431 Class 04

thomaselove.github.io/431

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Today's Agenda

- Working with the "Simple" Survey data again
- Dealing with types of variables
  - Turning characters into factors
- Numerical summaries of quantities and categorical variables
- Visualizing distributions
  - of quantitative variables (histograms)
  - of quantities stratified by categories (violin plots, boxplots)
  - using faceting to stratify by categories
- Some Coding "Tricks" in the tidyverse
- Bonus Content: Reviewing the Photo Age Guesses from Class 01

R Packages loaded for today's class

```
library(patchwork)   # to combine plots
library(knitr)       # for the kable function
```

Main package for today's class

```
library(tidyverse)  # includes essential packages
```

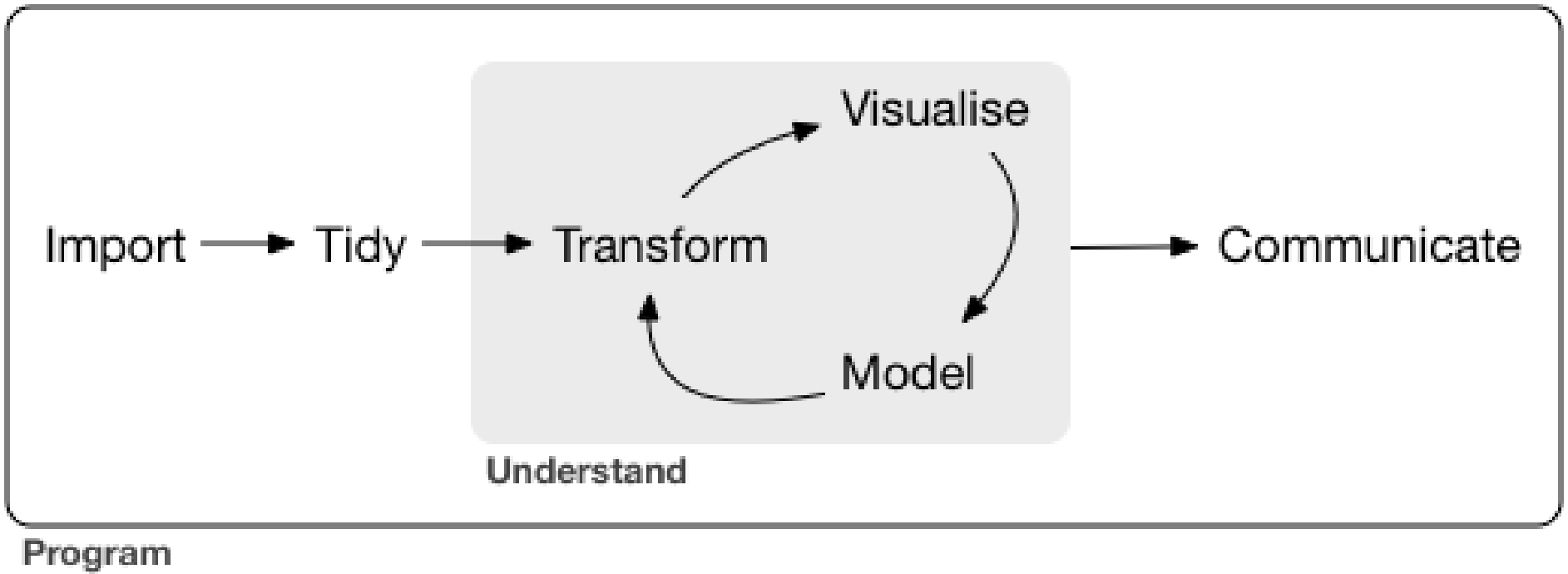
```
-- Attaching packages ---------------------------------------
v ggplot2 3.3.2     v purrr   0.3.4
v tibble  3.0.3     v dplyr   1.0.2
v tidyr   1.1.2     v stringr 1.4.0
v readr   1.3.1     v forcats 0.5.0

-- Conflicts ------------------------------------------------
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
```

We always load the tidyverse last

It helps resolve some (but not all) conflicts.

Data Science



Load in some data...

```
day1 <- read_csv("data/surveyday1_2020.csv")
```

```
Parsed with column specification:
cols(
  .default = col_double(),
  sex = col_character(),
  glasses = col_character(),
  english = col_character(),
  favcolor = col_character()
)

See spec(...) for full column specifications.
```

- `col_double()` means a double-precision (number)
- `col_character()` means a string (non-numeric)

day1

```
# A tibble: 382 x 21
   student sex   glasses english statsofar ageguess
     <dbl> <chr> <chr>   <chr>       <dbl>    <dbl>
 1  202001 <NA>  y       n              NA       NA
 2  202002 <NA>  y       y              NA       NA
 3  202003 <NA>  y       y              NA       NA
 4  202004 <NA>  y       n              NA       NA
 5  202005 <NA>  y       y              NA       NA
 6  202006 <NA>  n       y              NA       NA
 7  202007 <NA>  y       y              NA       NA
 8  202008 <NA>  n       y              NA       NA
 9  202009 <NA>  y       n              NA       NA
10  202010 <NA>  y       n              NA       NA
# ... with 372 more rows, and 15 more variables:
#   smoke <dbl>, h.left <dbl>, h.right <dbl>,
#   handedness <dbl>, statfuture <dbl>, haircut <dbl>,
#   lecture <dbl>, alone <dbl>, height.in <dbl>,
```

Summary of some day1 variables

```
day1 %>% select(english, lastsleep, year) %>% summary()
```

```
   english             lastsleep          year     
 Length:382         Min.   : 2.000   Min.   :2014  
 Class :character   1st Qu.: 6.000   1st Qu.:2016  
 Mode  :character   Median : 7.000   Median :2017  
                    Mean   : 6.907   Mean   :2017  
                    3rd Qu.: 8.000   3rd Qu.:2019  
                    Max.   :12.000   Max.   :2020  
                    NA's   :3                      
```

Working with Factors

Convert a "character" variable to a "factor"

```
day1 <- day1 %>% mutate(english_fac = as.factor(english))

day1 %>% select(english, english_fac) %>% summary()
```

```
   english           english_fac
 Length:382          n   : 73
 Class :character    y   :306
 Mode  :character    NA's:  3
```

Convert to a factor and recode the levels

```
day1 <- day1 %>%
  mutate(english_fac = as.factor(english)) %>%
  mutate(english_det = fct_recode(english_fac,
                                  "Not English" = "n",
                                  "English" = "y"))

day1 %>% select(english, english_fac, english_det) %>%
  summary()
```

```
   english           english_fac      english_det
 Length:382         n   : 73    Not English: 73
 Class :character   y   :306    English    :306
 Mode  :character   NA's:  3    NA's       :  3
```

Convert a numeric code to a "factor"

```
day1 <- day1 %>%
  mutate(smoke_fac = as.factor(smoke)) %>%
  mutate(smoke_det = fct_recode(smoke_fac,
           Never = "1", Quit = "2", Current = "3"))

day1 %>% select(smoke, smoke_fac, smoke_det) %>% summary()
```

```
     smoke        smoke_fac     smoke_det
 Min.   :1.000   1   :358   Never  :358
 1st Qu.:1.000   2   : 18   Quit   : 18
 Median :1.000   3   :  4   Current:  4
 Mean   :1.068   NA's:  2   NA's   :  2
 3rd Qu.:1.000
 Max.   :3.000
 NA's   :2
```

Numerical Summaries of Quantities

Summarizing the Sleep Times

```
mosaic::favstats(~ lastsleep, data = day1)
```

```
Registered S3 method overwritten by 'mosaic':
  method                           from
  fortify.SpatialPolygonsDataFrame ggplot2
```

min	Q1	median	Q3	max	mean	sd	n	missing
2	6	7	8	12	6.907045	1.314816	379	3

Stop the messages about this. . .

With messages permitted...

```
```{r}
mosaic::favstats(~ lastsleep, data = day1)
```
```

Messages not shown...

```
```{r, message = FALSE}
mosaic::favstats(~ lastsleep, data = day1)
```
```

Breaking down Sleep Hours, by Year

```
mosaic::favstats(lastsleep ~ year, data = day1)
```

```
  year min  Q1 median   Q3  max     mean       sd  n
1 2014   4 6.0   7.00 8.00  9.0 6.902439 1.179086 41
2 2015   4 6.5   7.50 8.00  9.0 7.316327 1.184509 49
3 2016   4 6.0   7.00 8.00  9.5 7.002698 1.197164 63
4 2017   2 6.0   6.75 8.00  9.0 6.708333 1.406041 48
5 2018   4 6.0   7.00 7.50  8.5 6.784314 1.030800 51
6 2019   4 6.5   7.00 8.00 12.0 7.113333 1.260679 60
7 2020   2 6.0   7.00 7.75 11.0 6.571642 1.652803 67
  missing
1       1
2       0
3       1
4       0
5       0
6       1
```

Using `kable` to specify decimal places

```
mosaic::favstats(lastsleep ~ year, data = day1) %>%
  kable(digits = 2)
```

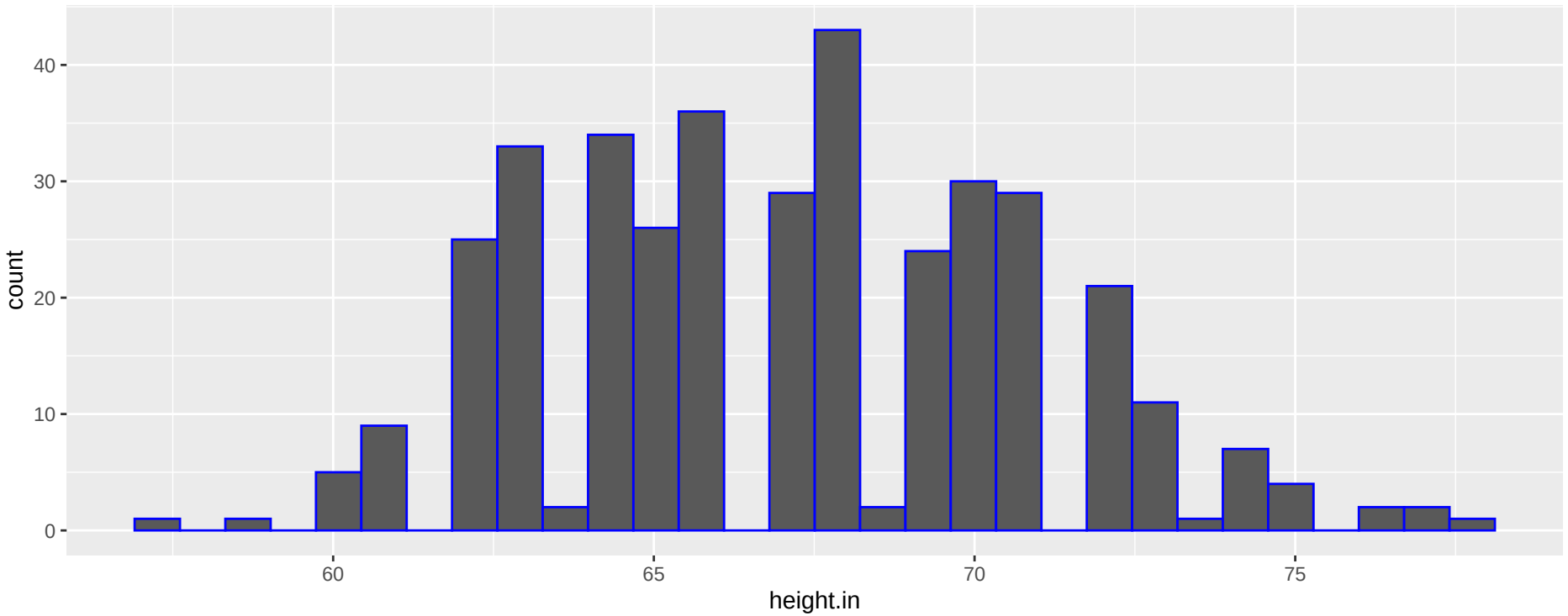
year	min	Q1	median	Q3	max	mean	sd	n	missing
2014	4	6.0	7.00	8.00	9.0	6.90	1.18	41	1
2015	4	6.5	7.50	8.00	9.0	7.32	1.18	49	0
2016	4	6.0	7.00	8.00	9.5	7.00	1.20	63	1
2017	2	6.0	6.75	8.00	9.0	6.71	1.41	48	0
2018	4	6.0	7.00	7.50	8.5	6.78	1.03	51	0
2019	4	6.5	7.00	8.00	12.0	7.11	1.26	60	1
2020	2	6.0	7.00	7.75	11.0	6.57	1.65	67	0

Visualizing the distribution of a variable with a Histogram

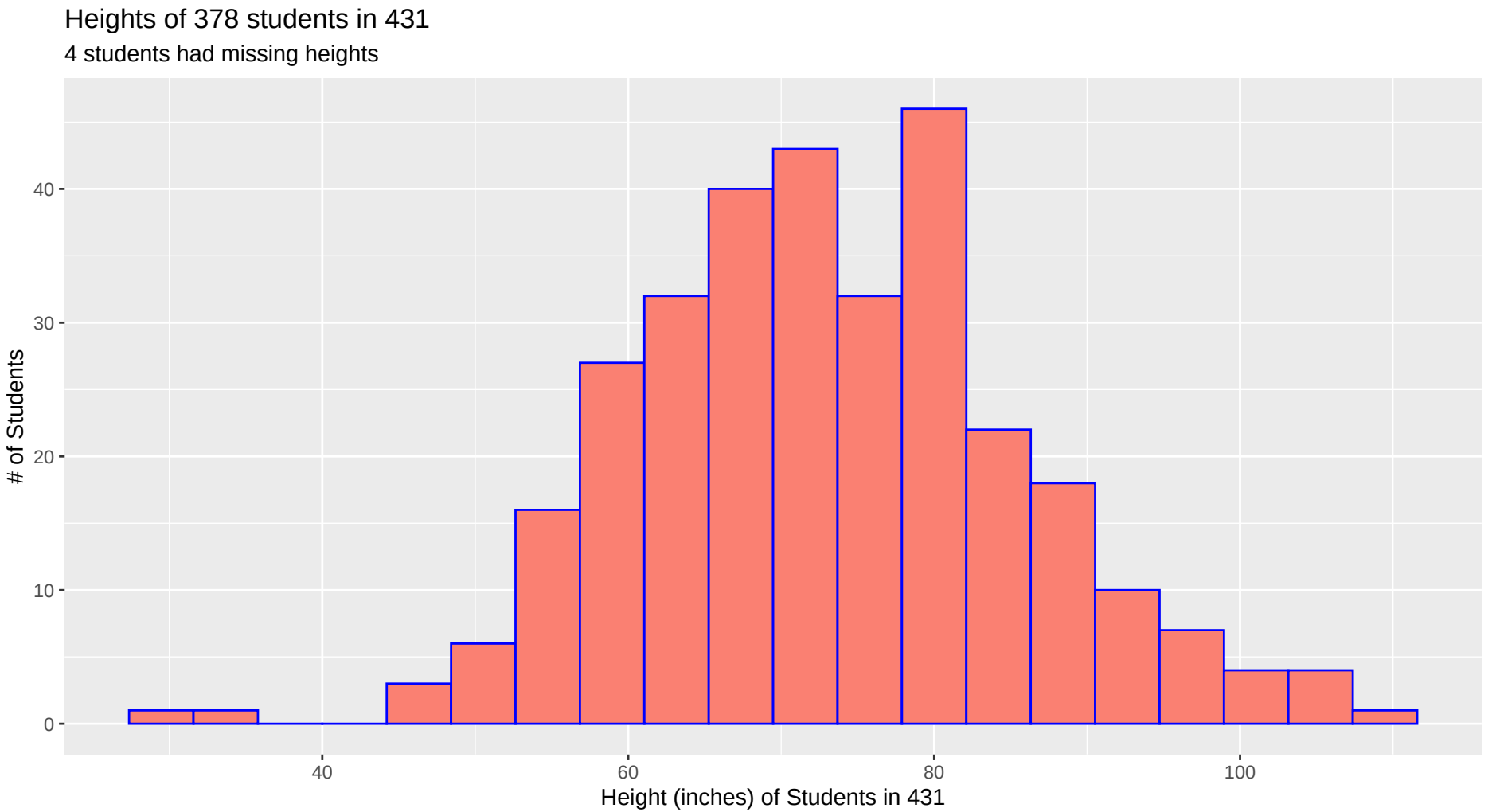
Plot 1. Initial Attempt

```
day1 %>% filter(complete.cases(height.in)) %>%
  ggplot(data = ., aes(x = height.in)) +
  geom_histogram(col = "blue")
```

```
`stat_bin()` using `bins = 30`. Pick better value
with `binwidth`.
```

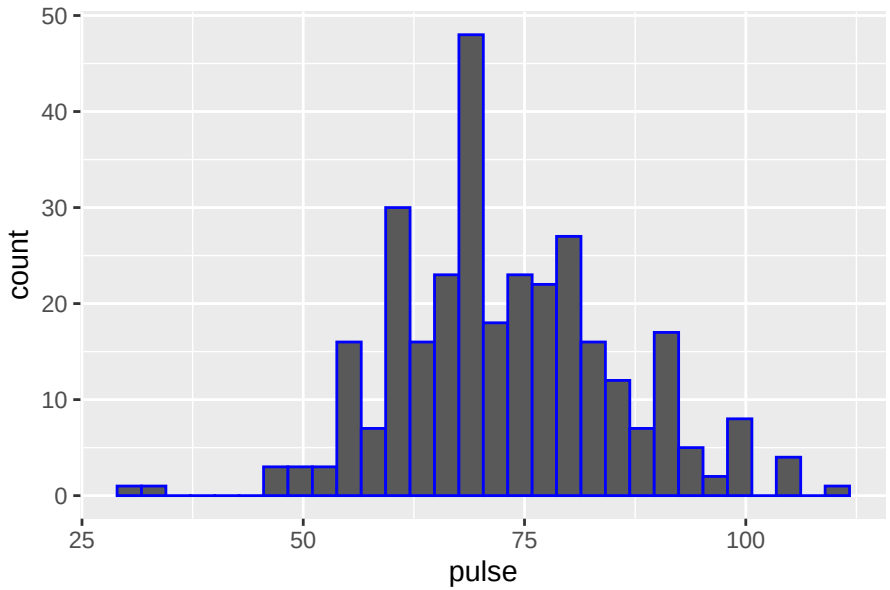


Plot 2. New Version: fill is *salmon*, using 20 bins.

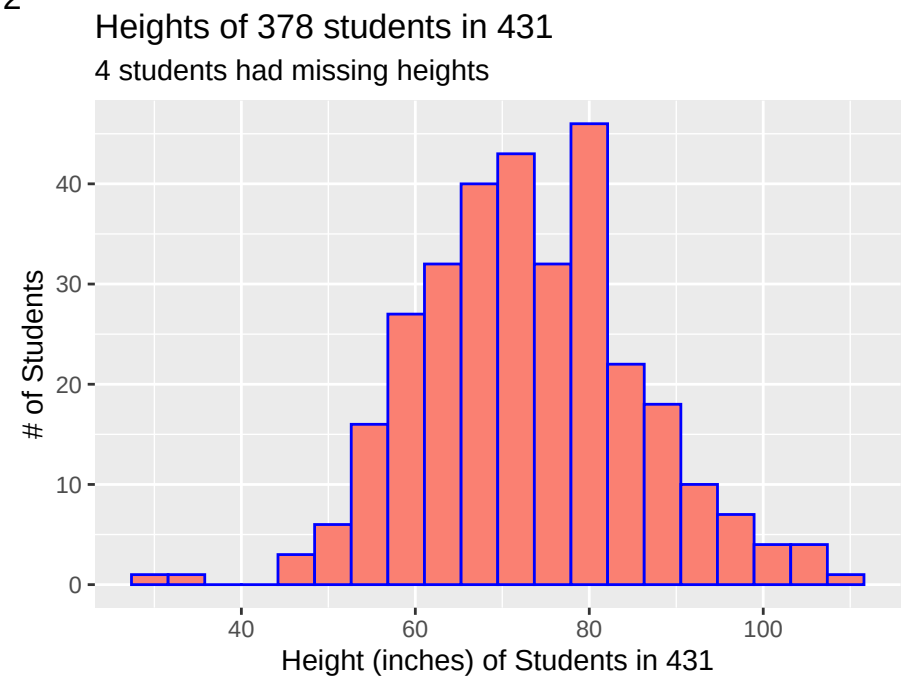


How do we get from plot 1 to plot 2?

1



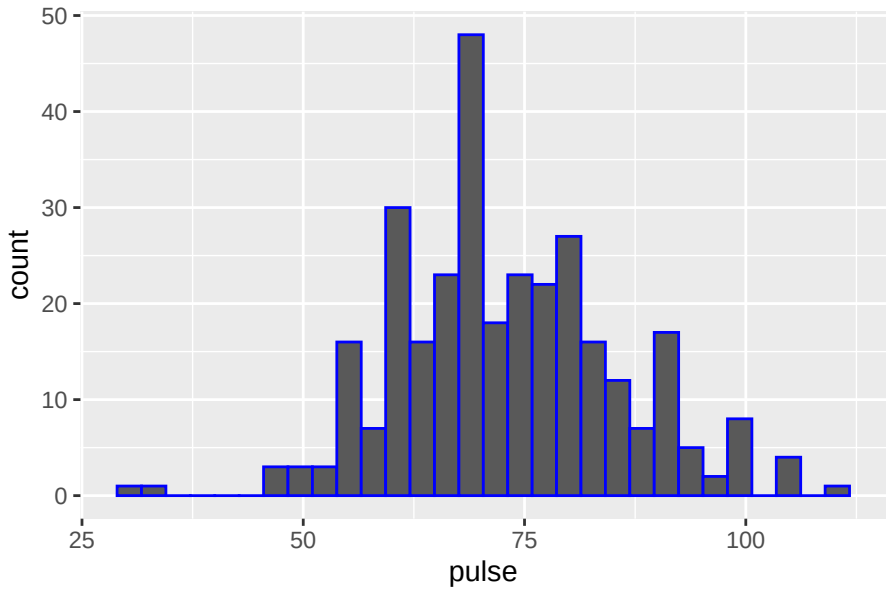
2



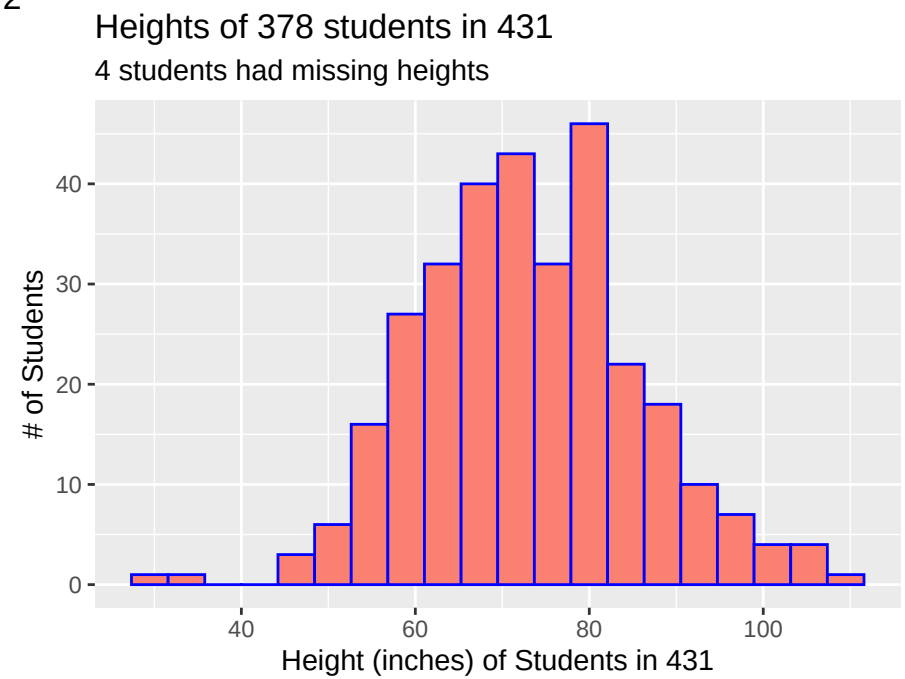
- What do we need to change?

How do we get from plot 1 to plot 2?

1



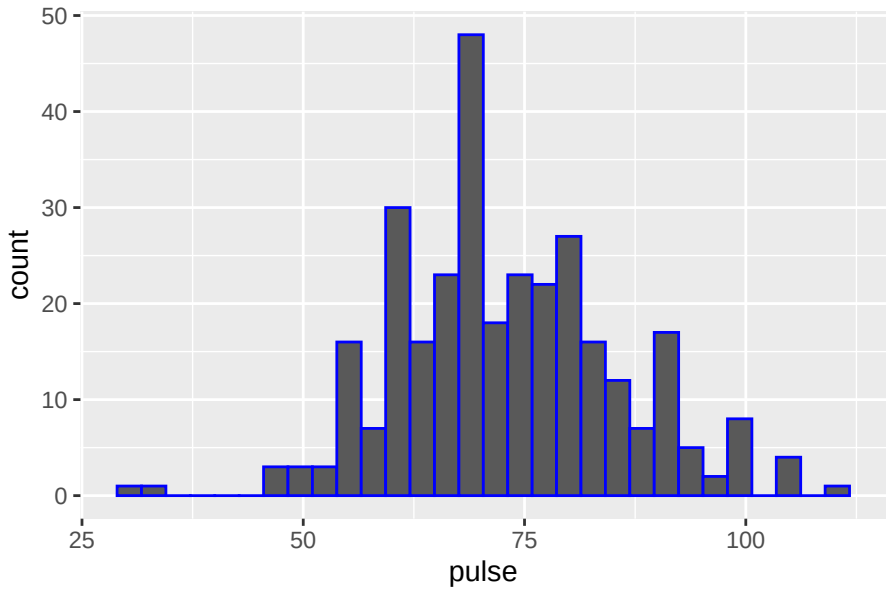
2



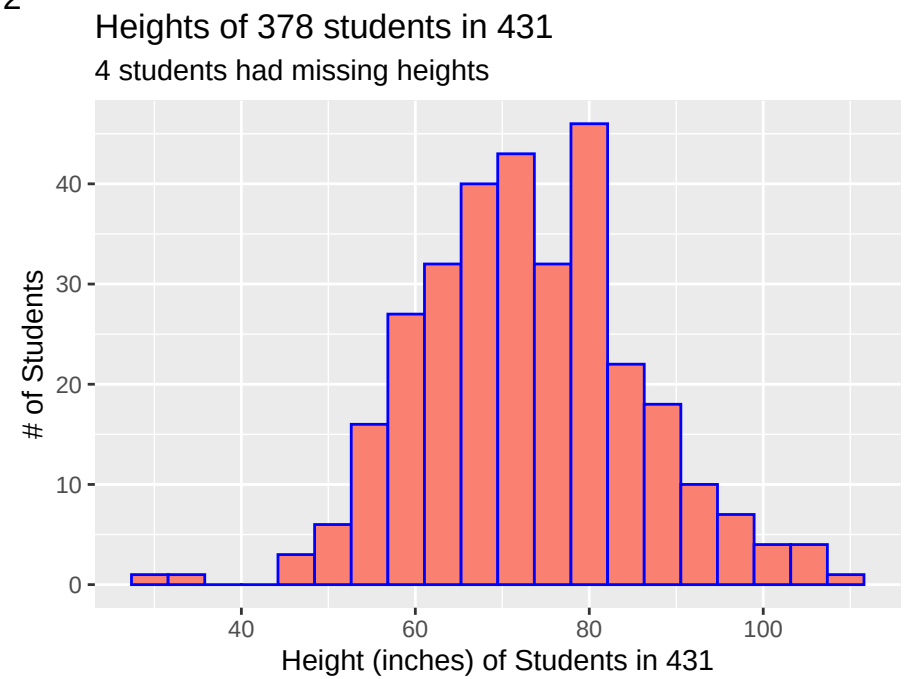
- What do we need to change?
- salmon color for the "fill" of the histogram's bars

How do we get from plot 1 to plot 2?

1



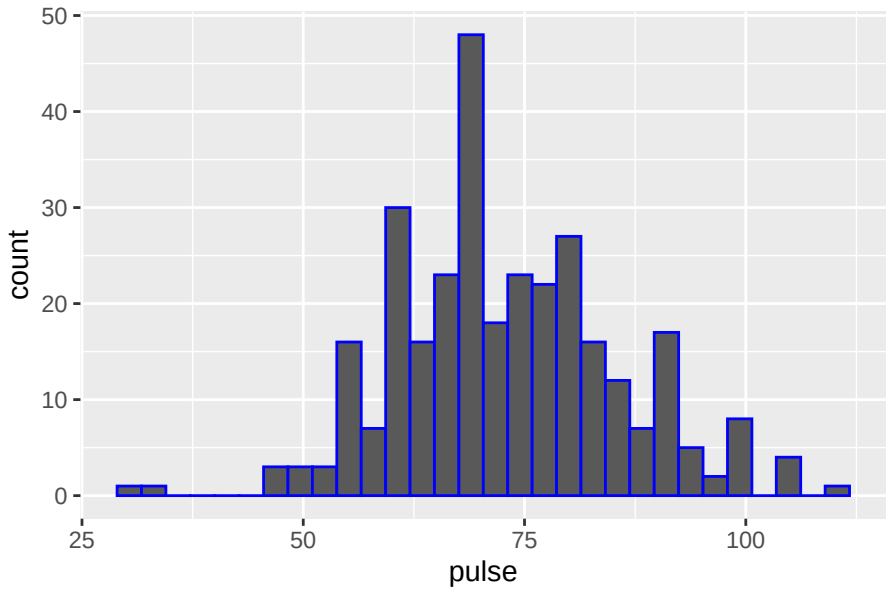
2



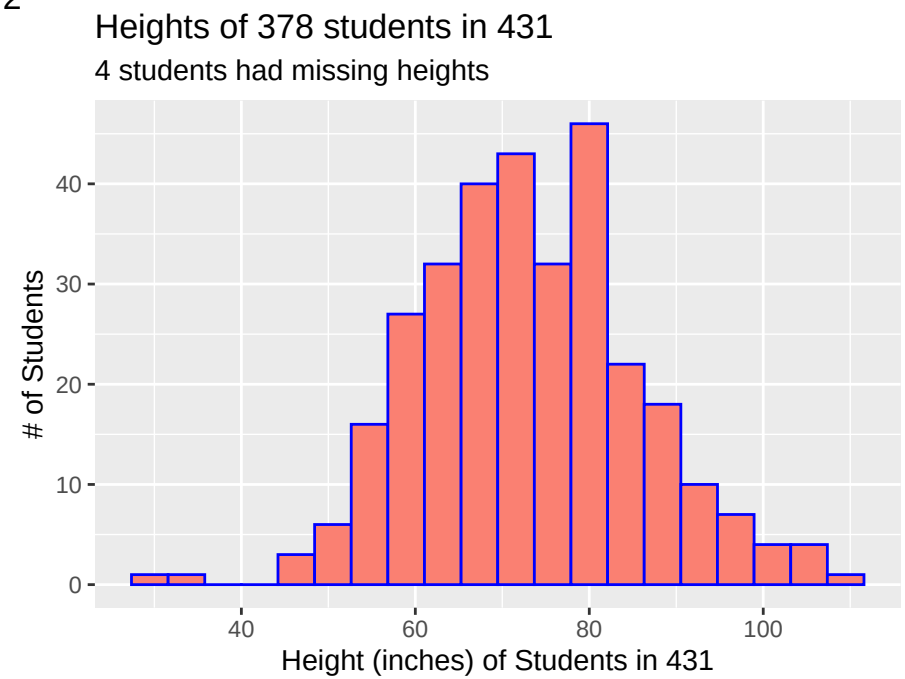
- What do we need to change?
- salmon color for the "fill" of the histogram's bars
- specify 20 bins in the histogram

How do we get from plot 1 to plot 2?

1



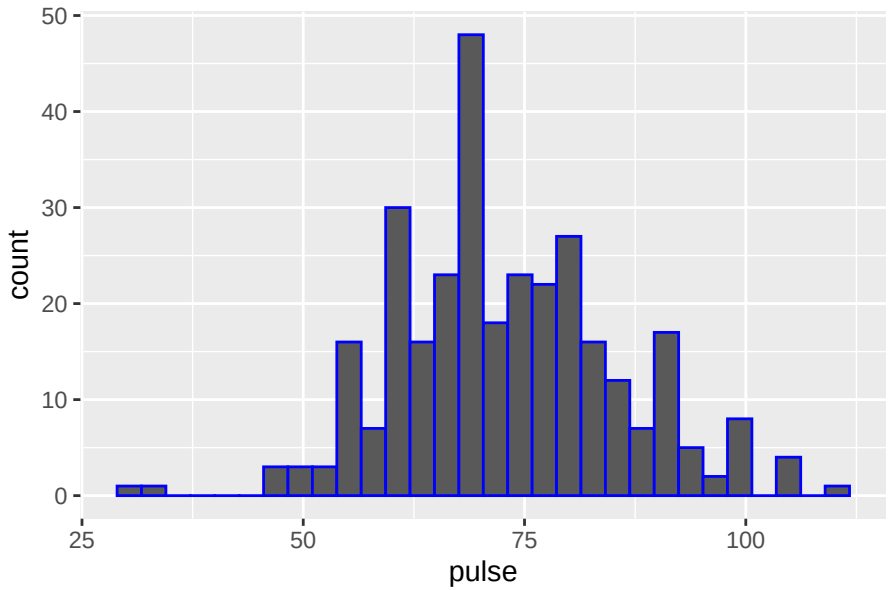
2



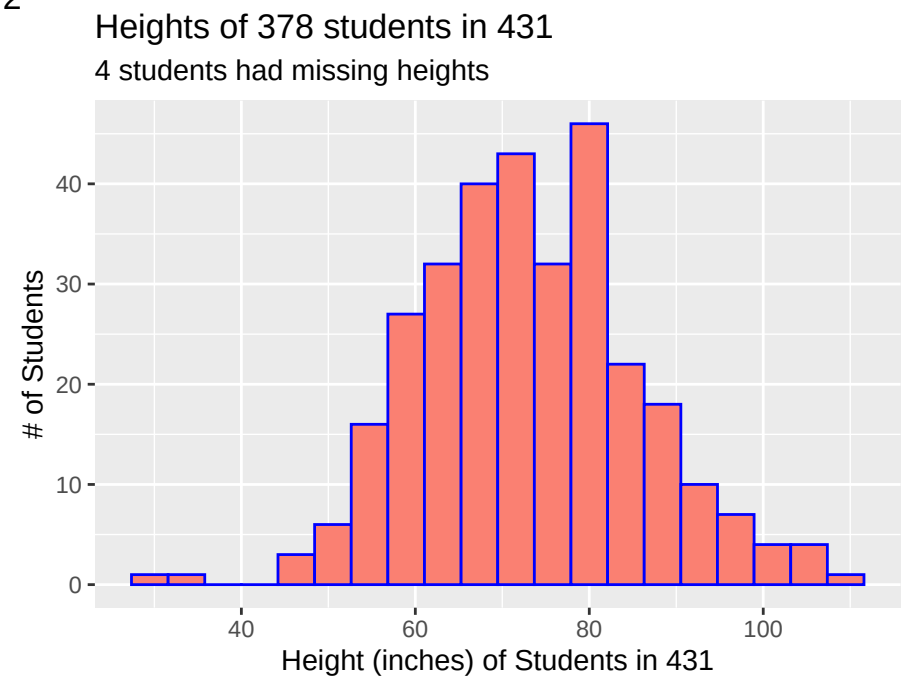
- What do we need to change?
- salmon color for the "fill" of the histogram's bars
- specify 20 bins in the histogram
- relabel the x and y axes

How do we get from plot 1 to plot 2?

1



2

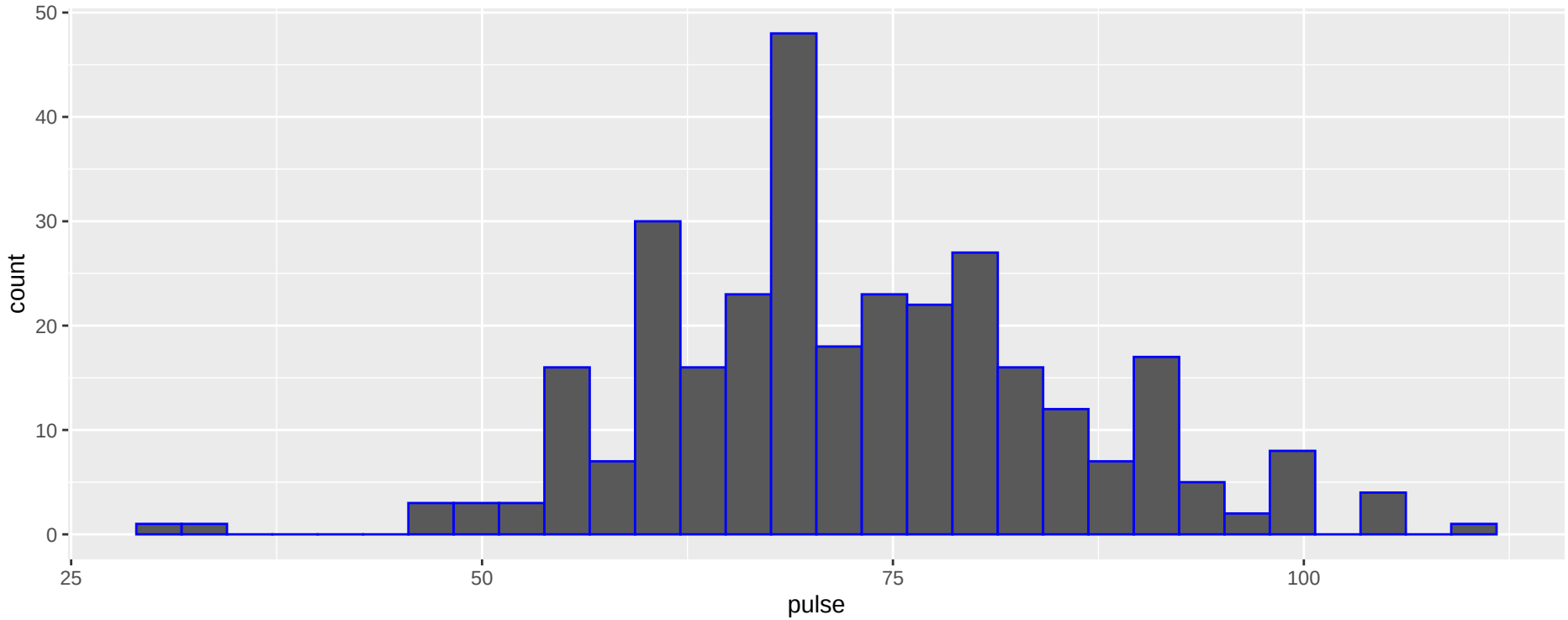


- What do we need to change?
- salmon color for the "fill" of the histogram's bars
- specify 20 bins in the histogram
- relabel the x and y axes
- add title and subtitle

Starting with Plot 1. Initial Attempt

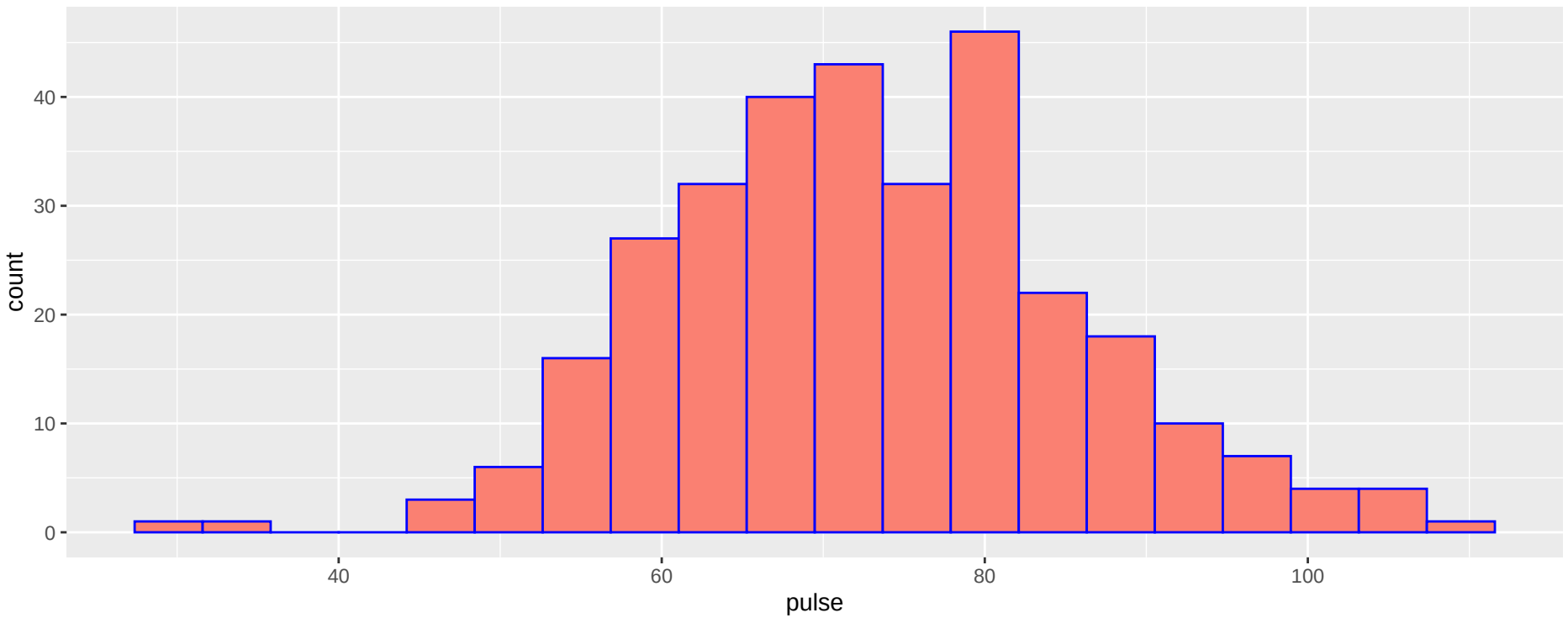
```
day1 %>% filter(complete.cases(pulse)) %>%
  ggplot(data = ., aes(x = pulse)) +
  geom_histogram(col = "blue")
```

```
`stat_bin()` using `bins = 30`. Pick better value
with `binwidth`.
```



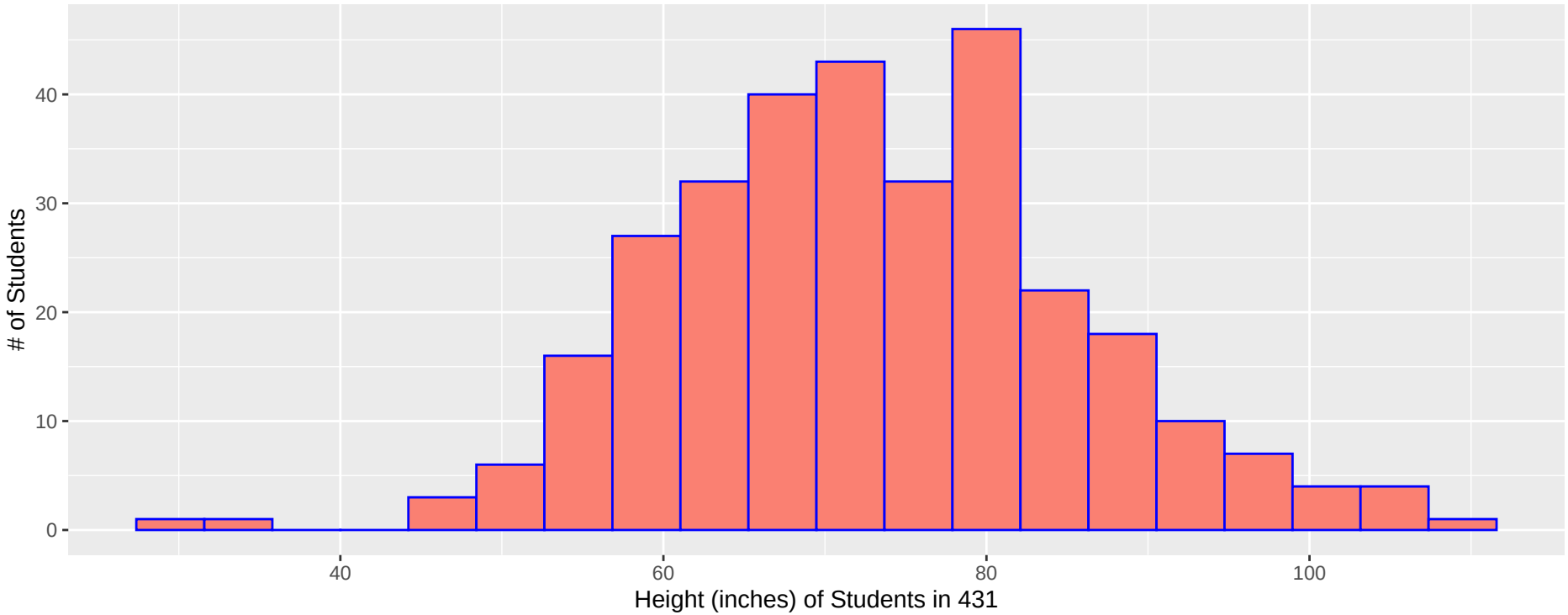
Add salmon fill, use 20 bins

```
day1 %>% filter(complete.cases(pulse)) %>%
  ggplot(data = ., aes(x = pulse)) +
  geom_histogram(bins = 20, col = "blue", fill = "salmon")
```



Now relabel x and y axes

```
day1 %>% filter(complete.cases(pulse)) %>%
  ggplot(data = ., aes(x = pulse)) +
  geom_histogram(bins = 20, col = "blue", fill = "salmon") +
  labs(x = "Height (inches) of Students in 431",
       y = "# of Students")
```



How many students provided their height?

```
nrow(day1)
```

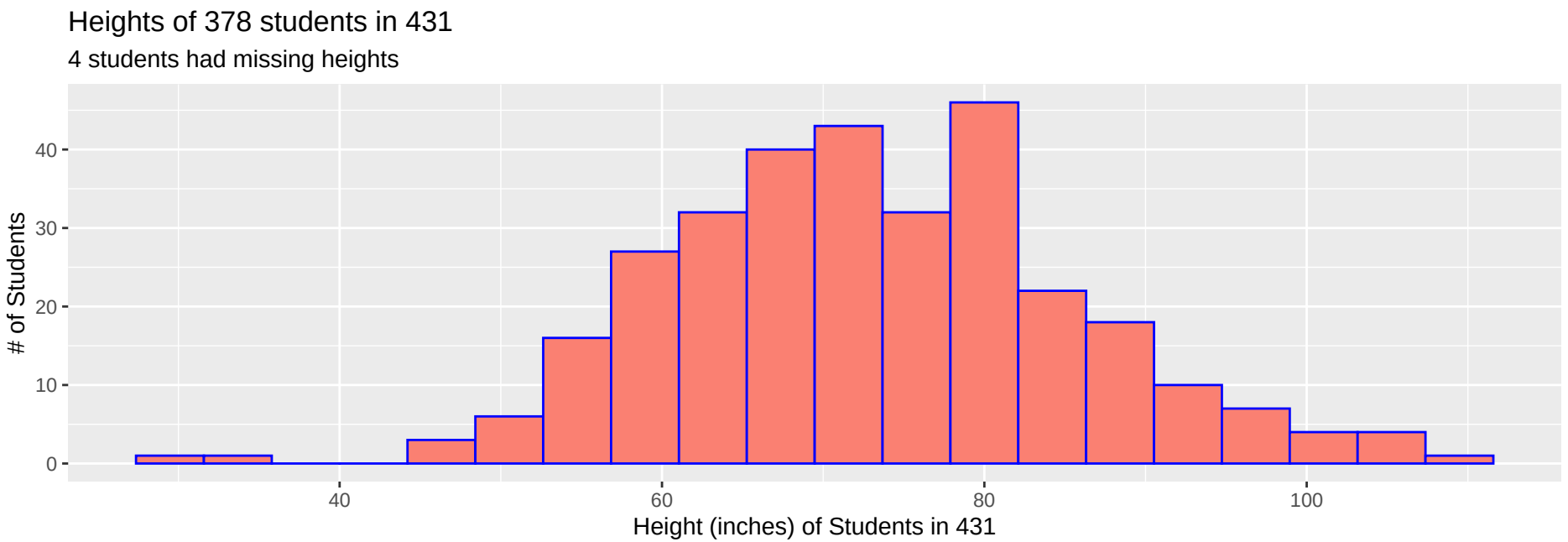
```
[1] 382
```

```
mosaic::favstats(~ height.in, data = day1)
```

```
 min Q1 median Q3  max     mean     sd   n missing
  57 64     67 70 77.5 67.11905 3.7355 378       4
```

Actual Code for Plot 2 (adds title and subtitle)

```
day1 %>% filter(complete.cases(pulse)) %>%
  ggplot(data = ., aes(x = pulse)) +
  geom_histogram(bins = 20, col = "blue", fill = "salmon") +
  labs(x = "Height (inches) of Students in 431",
       y = "# of Students",
       title = "Heights of 378 students in 431",
       subtitle = "4 students had missing heights")
```



Violin Plots and Boxplots to Compare Distributions of a Quantitative Variable across levels of a Categorical Variable

Can we look at the Height Distributions by Year?

```
ggplot(day1, aes(x = factor(year), y = height.in)) +
  geom_violin()
```

```
Warning: Removed 4 rows containing non-finite values
(stat_ydensity).
```

Remove missing values, revise axis labels

```
day1 %>% filter(complete.cases(year, height.in)) %>%
  ggplot(., aes(x = factor(year), y = height.in)) +
  geom_violin() +
  labs(x = "Year", y = "Height (inches)")
```

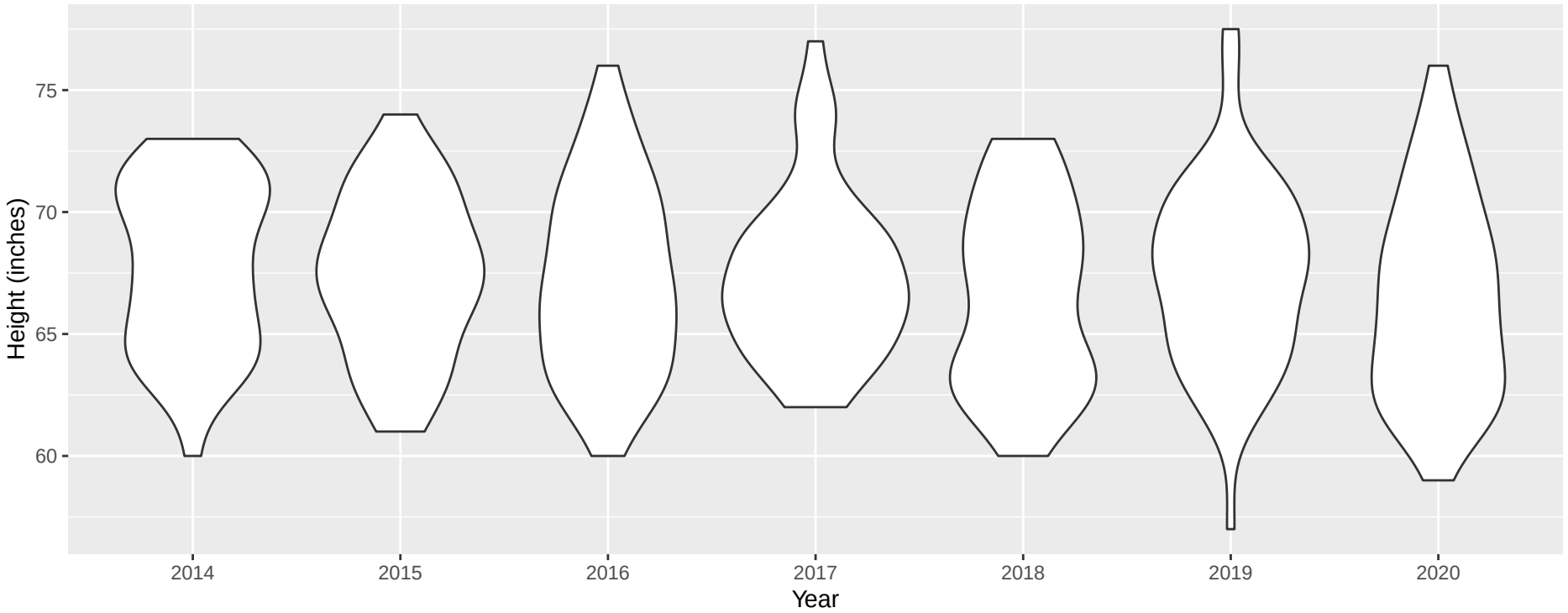


Table summarizing Student Heights, by Year

```
mosaic::favstats(height.in ~ year, data = day1) %>%
  kable(digits = 1)
```

year	min	Q1	median	Q3	max	mean	sd	n	missing
2014	60	64.8	68	71.0	73.0	67.8	3.5	40	2
2015	61	65.0	68	70.0	74.0	67.3	3.3	49	0
2016	60	64.0	67	70.0	76.0	67.2	3.9	64	0
2017	62	65.0	67	69.0	77.0	67.4	3.5	48	0
2018	60	63.0	66	70.0	73.0	66.5	3.8	51	0
2019	57	65.0	68	70.0	77.5	67.4	3.8	60	1
2020	59	63.0	66	69.8	76.0	66.4	4.1	66	1

What's in a Boxplot

- The central box in a boxplot indicates the 25th (Q1), 50th (median) and 75th (Q3) percentiles.
- It uses the interquartile range (IQR = Q3 - Q1) as a measure of spread.
- Points more than 1.5 IQR below Q1 or more than 1.5 IQR above Q3 are candidate **outliers**.
- The "whiskers" in the plot extend from Q1 down to the smallest non-outlier and from Q3 up to the largest non-outlier.

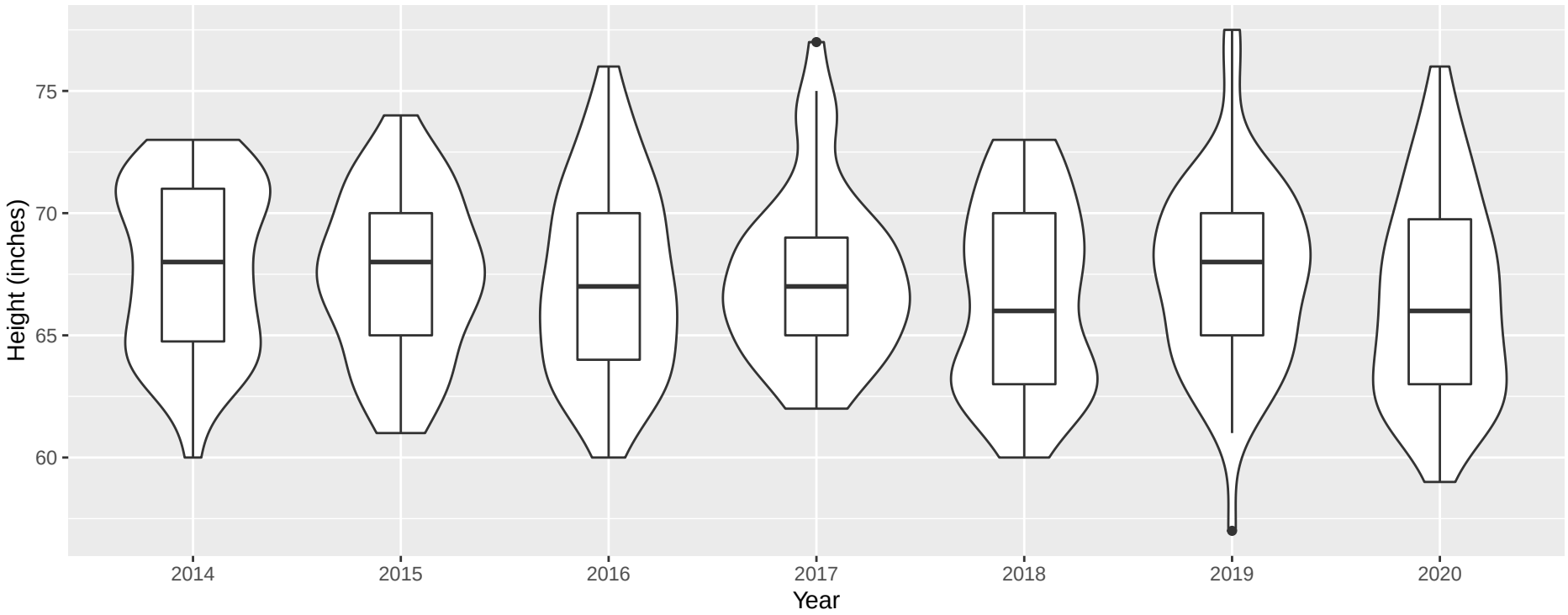
Who invented the boxplot (or box-and-whiskers plot)? John **Tukey**.

Numerical quantities focus on expected values, graphical summaries on unexpected values.

-- John Tukey

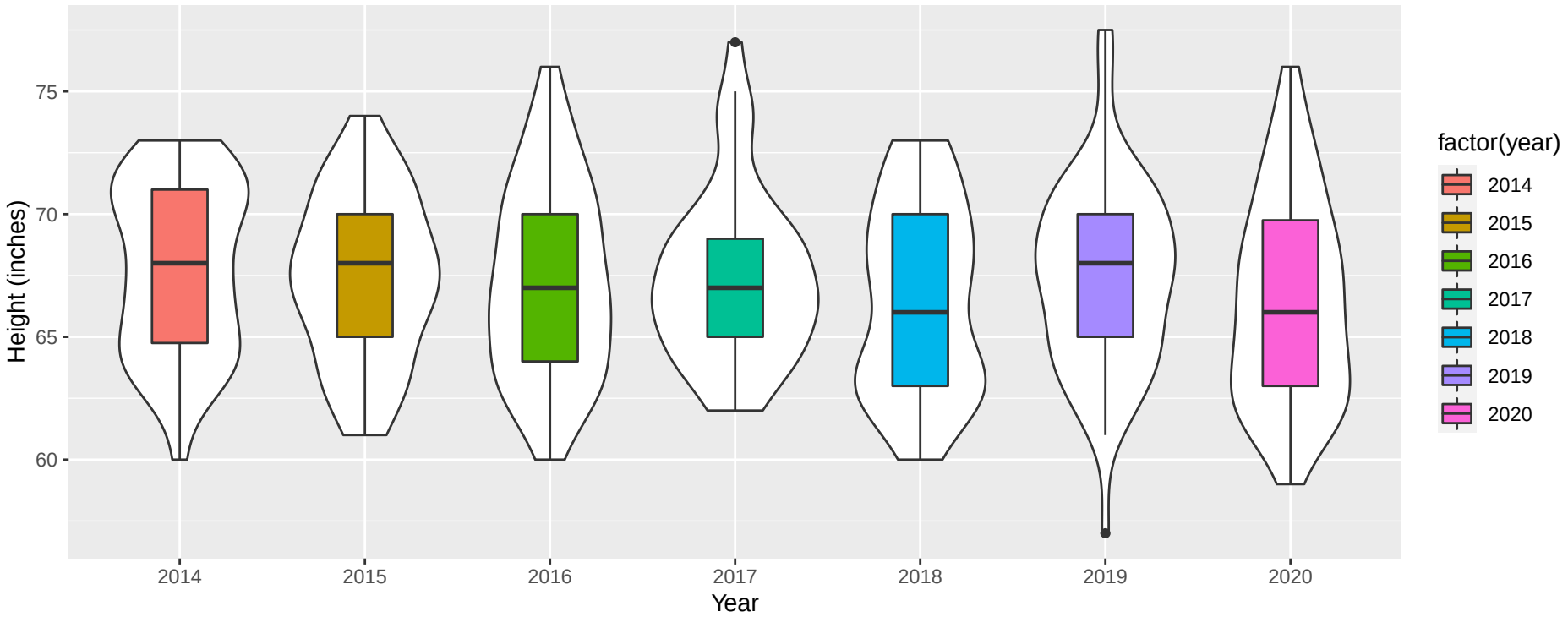
Add Boxplots: Height Distributions by Year?

```
day1 %>% filter(complete.cases(year, height.in)) %>%
  ggplot(., aes(x = factor(year), y = height.in)) +
  geom_violin() +
  geom_boxplot(width = 0.3) +
  labs(x = "Year", y = "Height (inches)")
```



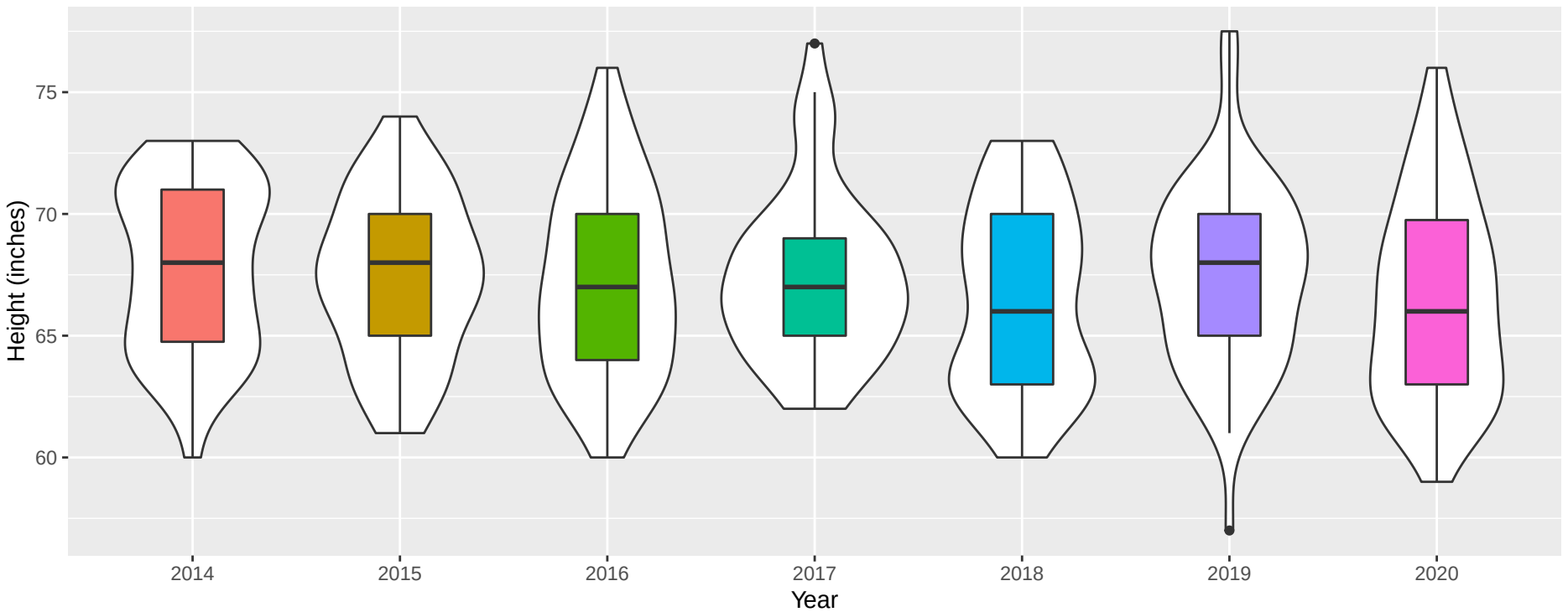
Add fill for the boxes?

```
day1 %>% filter(complete.cases(year, height.in)) %>%
  ggplot(., aes(x = factor(year), y = height.in)) +
  geom_violin() +
  geom_boxplot(aes(fill = factor(year)), width = 0.3) +
  labs(x = "Year", y = "Height (inches)")
```



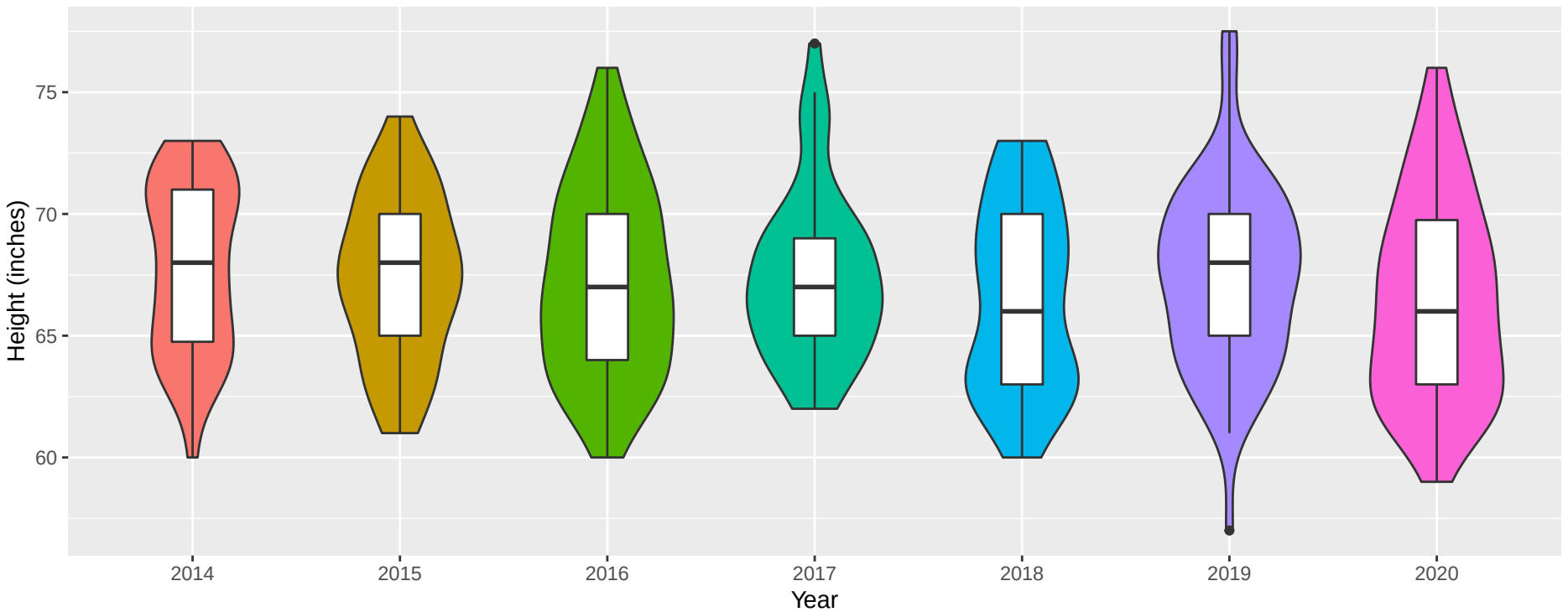
Drop unnecessary "guides" (legend)

```
day1 %>% filter(complete.cases(year, height.in)) %>%
  ggplot(., aes(x = factor(year), y = height.in)) +
  geom_violin() +
  geom_boxplot(aes(fill = factor(year)), width = 0.3) +
  guides(fill = FALSE) +
  labs(x = "Year", y = "Height (inches)")
```



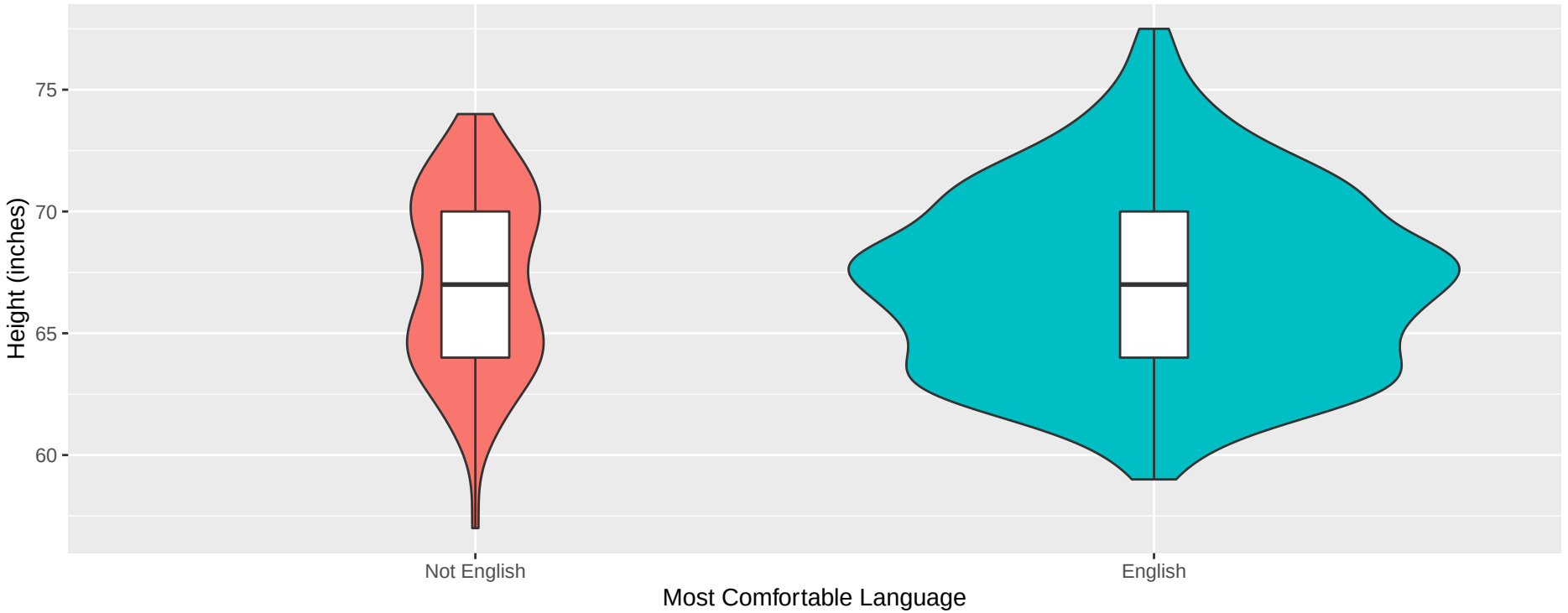
Scale violins by sample size and add fill

```
day1 %>% filter(complete.cases(year, height.in)) %>%
  ggplot(., aes(x = factor(year), y = height.in)) +
  geom_violin(aes(fill = factor(year)), scale = "count") +
  geom_boxplot(width = 0.2) +
  guides(fill = FALSE) +
  labs(x = "Year", y = "Height (inches)")
```



Association of height and language?

```
day1 %>% filter(complete.cases(english_det, height.in)) %>%
  ggplot(., aes(x = english_det, y = height.in)) +
  geom_violin(aes(fill = english_det), scale = "count") +
  geom_boxplot(width = 0.1) +
  guides(fill = FALSE) +
  labs(x = "Most Comfortable Language", y = "Height (inches)")
```



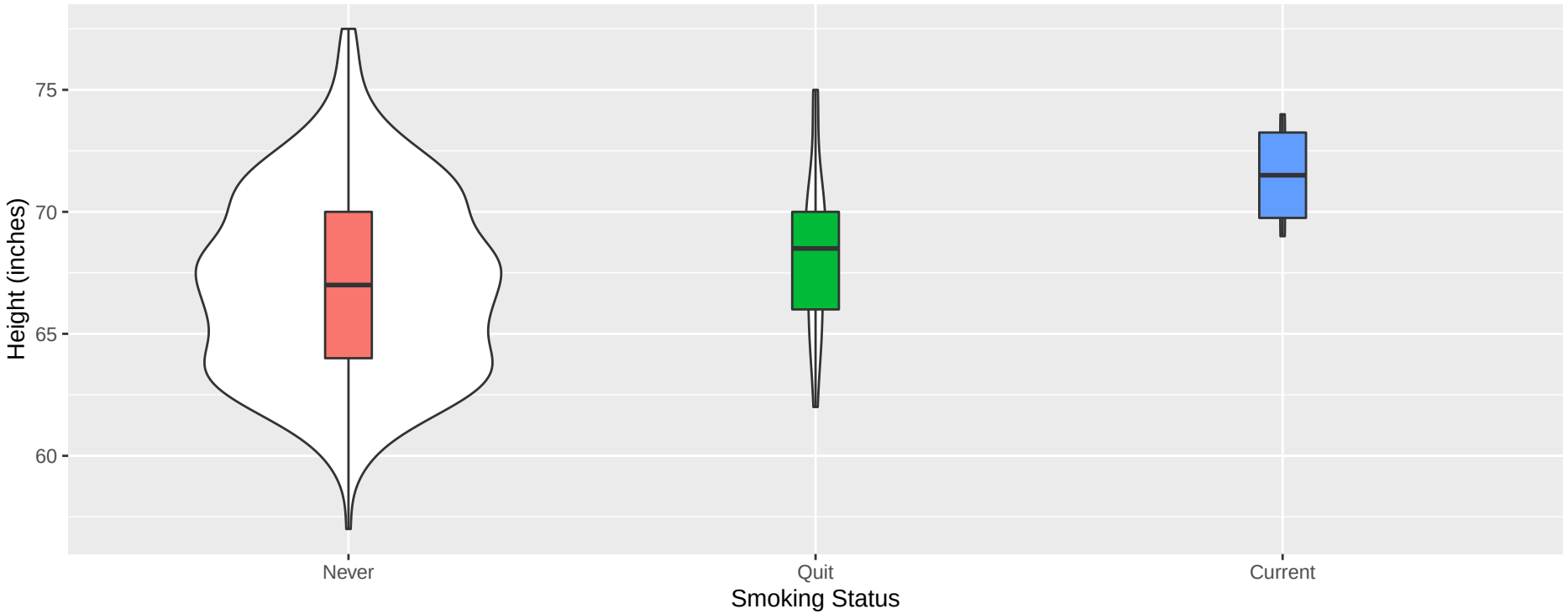
Height by Language

```
mosaic::favstats(height.in ~ english_det, data = day1) %>%
  kable(digits = 1)
```

english_det	min	Q1	median	Q3	max	mean	sd	n	missing
Not English	57	64	67	70	74.0	67.1	3.7	72	1
English	59	64	67	70	77.5	67.2	3.8	303	3

Association of height with smoking status?

```
day1 %>% filter(complete.cases(smoke_det, height.in)) %>%
  ggplot(., aes(x = smoke_det, y = height.in)) +
  geom_violin(scale = "count") +
  geom_boxplot(aes(fill = smoke_det), width = 0.1) +
  guides(fill = FALSE) +
  labs(x = "Smoking Status", y = "Height (inches)")
```



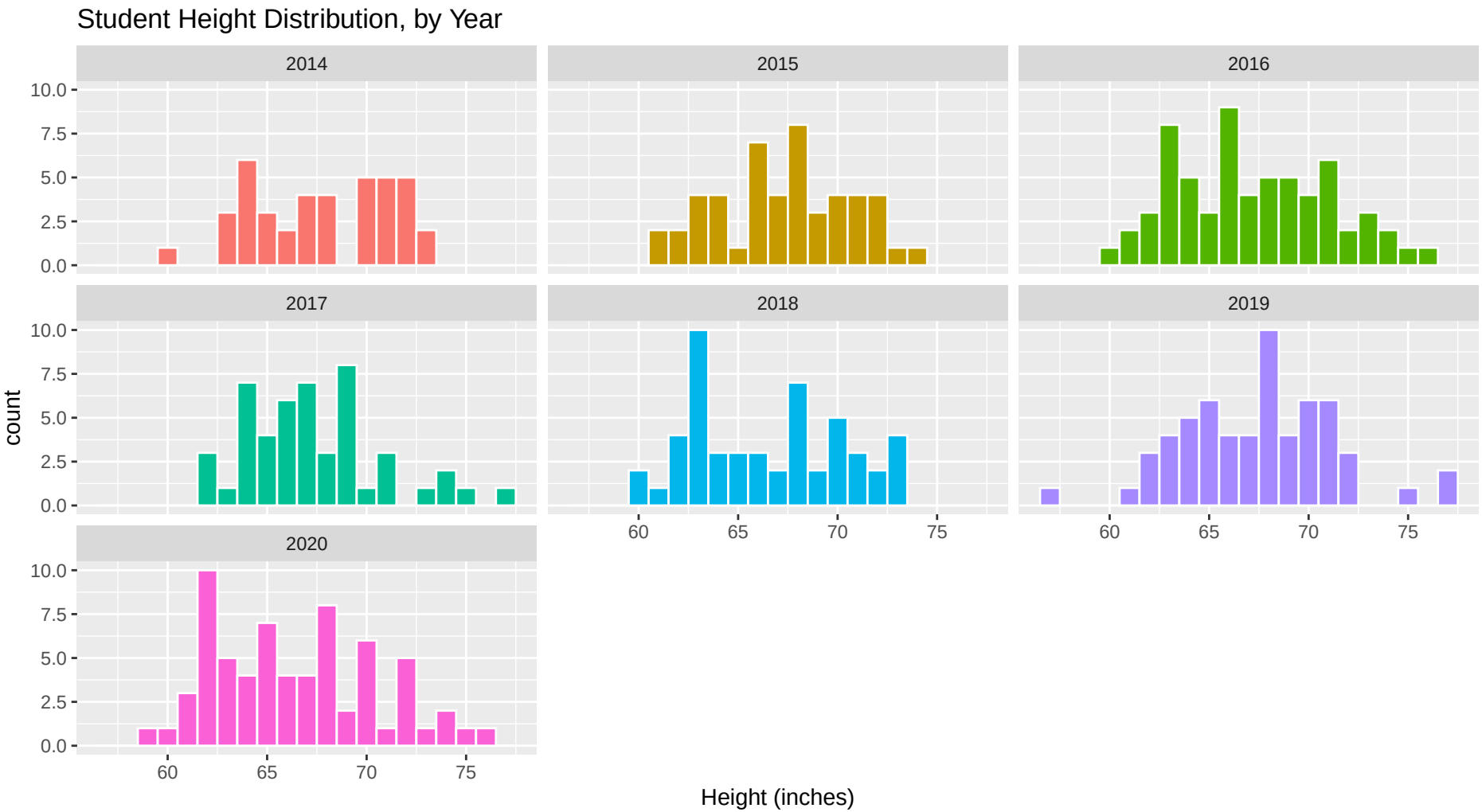
Height by Smoking Status

```
mosaic::favstats(height.in ~ smoke_det, data = day1) %>%
  kable(digits = 1)
```

smoke_det	min	Q1	median	Q3	max	mean	sd	n	missing
Never	57	64.0	67.0	70.0	77.5	67.0	3.7	355	3
Quit	62	66.0	68.5	70.0	75.0	68.4	3.4	18	0
Current	69	69.8	71.5	73.2	74.0	71.5	2.4	4	0

Working with Facets

Height Distributions, Faceted by Year



Code for plot on previous slide

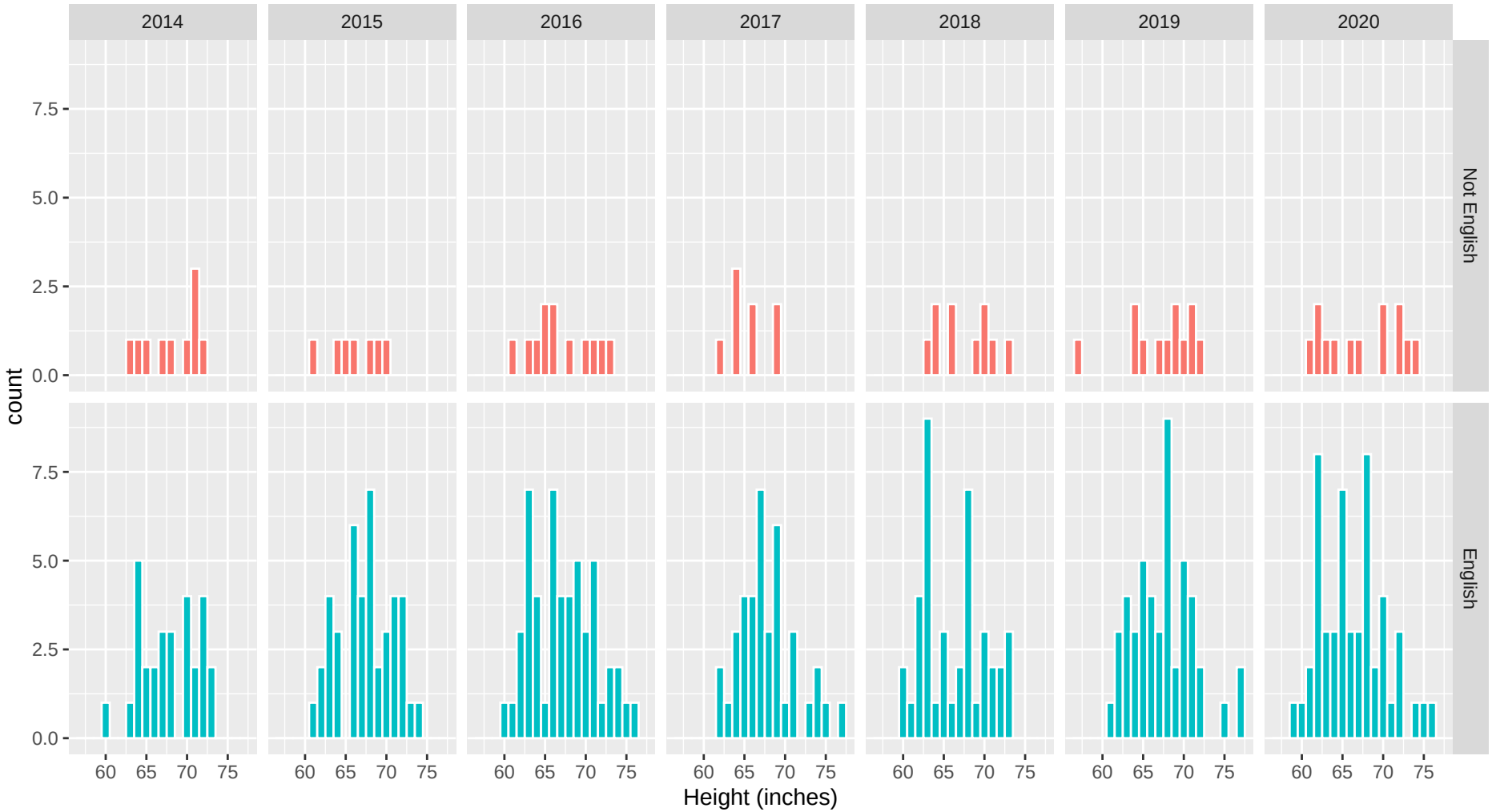
```
day1 %>% filter(complete.cases(height.in)) %>%
  ggplot(data = ., aes(x = height.in, fill = factor(year))) +
  geom_histogram(binwidth = 1, col = "white") +
  facet_wrap(~ year) +
  guides(fill = FALSE) +
  labs(title = "Student Height Distribution, by Year",
       x = "Height (inches)")
```

What do you think this will do?

```
day1 %>% filter(complete.cases(height.in, english_det, year))
  ggplot(data = .,
         aes(x = height.in, fill = factor(english_det))) +
  geom_histogram(binwidth = 1, col = "white") +
  facet_grid(english_det ~ year) +
  guides(fill = FALSE) +
  labs(x = "Height (inches)")
```

Result on next slide. . .

Faceted Histograms of Height by Language, Year

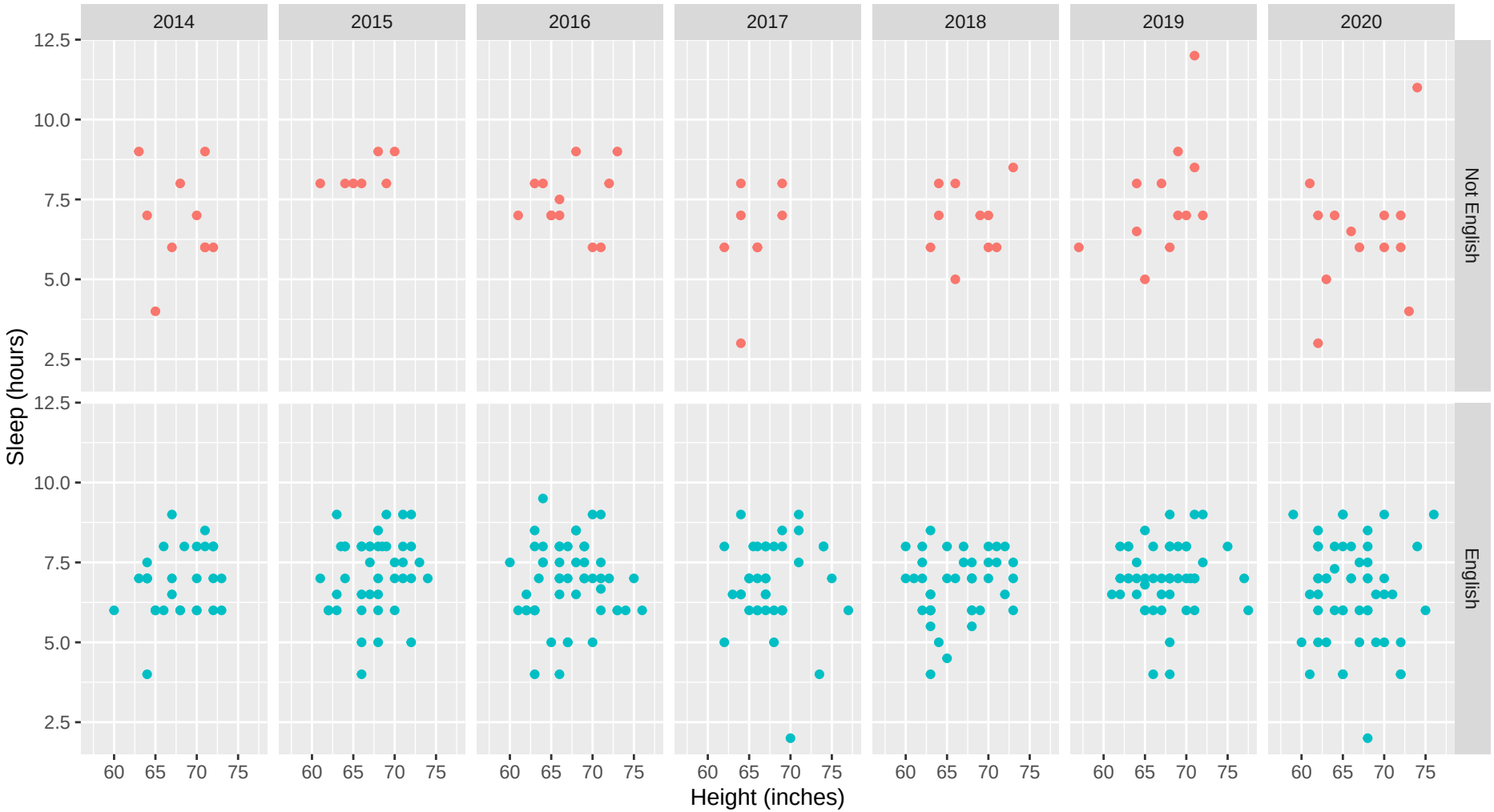


What do you think this will do?

```
day1 %>%
  filter(complete.cases(height.in, lastsleep,
                        english_det)) %>%
  ggplot(data = .,
         aes(x = height.in, y = lastsleep,
             color = english_det)) +
  geom_point() +
  facet_grid(english_det ~ year) +
  guides(color = FALSE) +
  labs(x = "Height (inches)", y = "Sleep (hours)")
```

Result on next slide. . .

Faceted Scatterplots from Previous Slide



Next Time

That's the end of the slides for Class 03.

- More intricate data work in R
- Visualizing associations
- Linking visualizations to models
- A new example

The remainder of this PDF looks at the age guessing activity we did in Class 01, but now you can compare 2020 results to previous years.

Age Guessing Activity from Class 01

#1 Age **21**

#2 Age **64**

#3 Age **28**

#4 Age **14**

#5 Age **54**

#6 Age **74**

#7 Age **44**

#8 Age **83**

#9 Age **24**

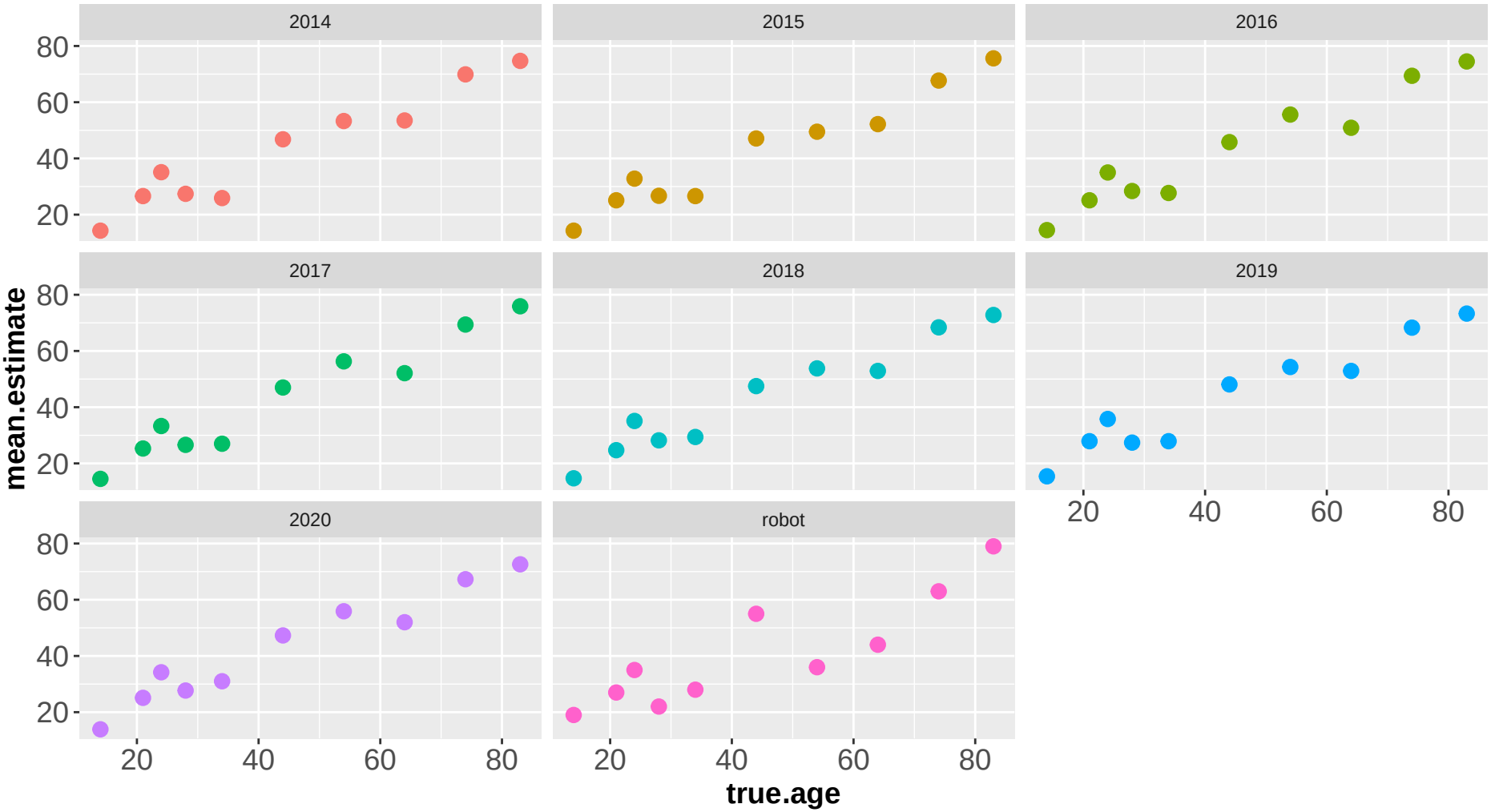
#10 Age **34**

Age Guessing (including 2020)

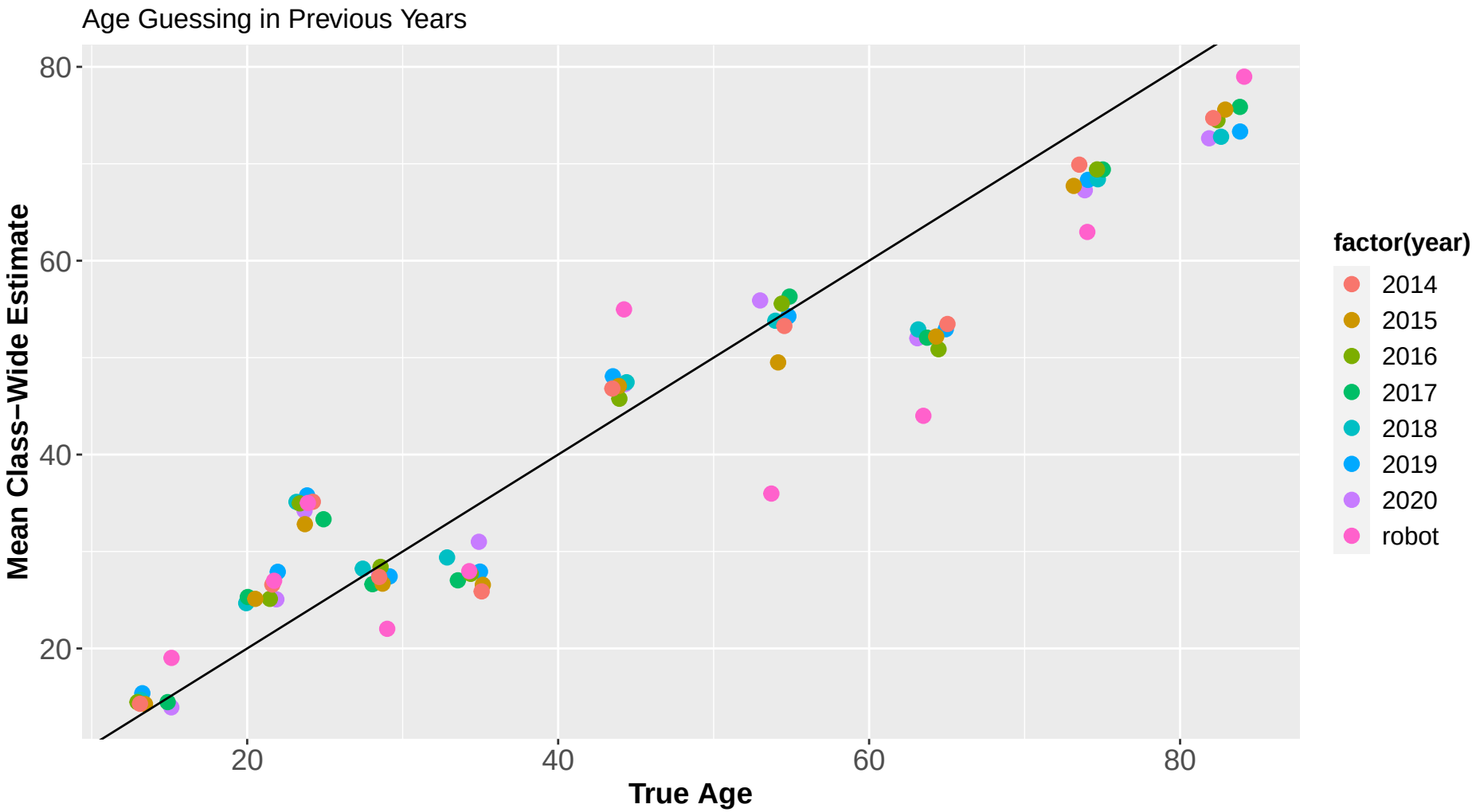
```
ageguess <- read_csv("data/photo-age-history-2020.csv")
```

card	label	true.age	sex	facing	year	mean.estimate	error
1	Chong	21	M	R	2020	25.1	-4.1
2	Archuleta	64	F	L	2020	52.0	12.0
3	Mayfield	28	F	L	2020	27.7	0.3
4	Love	14	M	L	2020	13.9	0.1
5	McGinn	54	F	R	2020	55.9	-1.9
6	Chaney	74	M	L	2020	67.3	6.7
7	Storm	44	M	R	2020	47.3	-3.3
8	Glantz	83	F	L	2020	72.6	10.4
9	Honey	24	M	L	2020	34.2	-10.2
10	Lawson	34	F	R	2020	31.0	3.0

Scatterplot of Results by Year, 1



Scatterplot of Results by Year, 2



Mean Class-Wide Guesses (2014-2020 combined)

	#1 Age **21**	#2 Age **64**	#3 Age **28**	#4 Age **14**	#5 Age **54**
2014-2020	25.7	52.4	27.5	14.5	54.1
Mean Guesses	68.6	47.1	74.2	34.5	27.9

#6 Age **74**	#7 Age **44**	#8 Age **83**	#9 Age **24**	#10 Age **34**

Scatterplot of 2020 Results with Labels