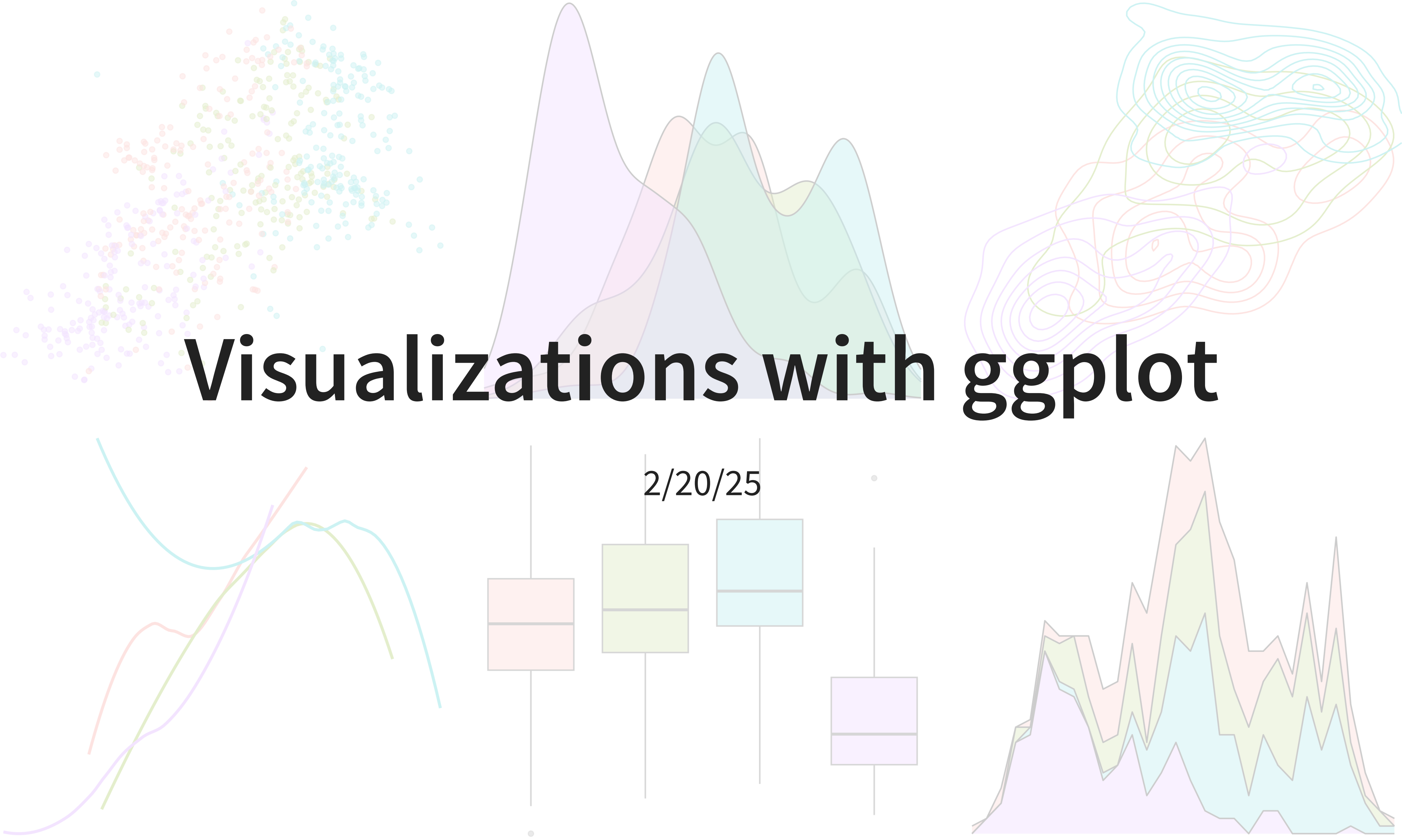
# Visualizations with ggplot

2/20/25



# Exploratory data analysis

- **Exploratory data analysis (EDA)** is an approach to analyzing data sets to summarize the main characteristics.
  - Often visual through plots
- Because of its name “exploratory”, we typically perform EDA at the beginning of a project
- Can also calculate summary statistics and perform data wrangling/manipulation/transformation at (or before) this stage of the analysis

# Tidy data

- When working with data in R, always look at the data to ensure it is in **tidy** format:
  - Each row represents an observation, each column represents a variable describing the observations
- `anscombe` data frame: four datasets each with 11 observations each and the same two variables

Non-tidy version:

```
   x1 x2 x3 x4    y1   y2    y3    y4
1  10 10 10  8  8.04 9.14  7.46  6.58
2   8  8  8  8  6.95 8.14  6.77  5.76
3  13 13 13  8  7.58 8.74 12.74  7.71
4   9  9  9  8  8.81 8.77  7.11  8.84
5  11 11 11  8  8.33 9.26  7.81  8.47
6  14 14 14  8  9.96 8.10  8.84  7.04
7   6  6  6  8  7.24 6.13  6.08  5.25
8   4  4  4 19  4.26 3.10  5.39 12.50
9  12 12 12  8 10.84 9.13  8.15  5.56
10  7  7  7  8  4.82 7.26  6.42  7.91
11  5  5  5  8  5.68 4.74  5.73  6.89
```

Tidy version (first 15 rows):

```
   set  x     y
1    I 10  8.04
2    I  8  6.95
3    I 13  7.58
4    I  9  8.81
5    I 11  8.33
6    I 14  9.96
7    I  6  7.24
8    I  4  4.26
9    I 12 10.84
10   I  7  4.82
11   I  5  5.68
12  II 10  9.14
13  II  8  8.14
14  II 13  8.74
15  II  9  8.77
```

# Data visualization

- **Data visualization** is the creation and study of the visual representation of data
- We have learned how to use base `R` code to make simple histograms and scatterplots. We will now use `ggplot2` which makes customization easier

# Why do we visualize?

- Summary statistics from each of the four datasets in `anscombe`:

```
# A tibble: 4 × 5
  set   mean_x mean_y  sd_x  sd_y
  <fct>  <dbl>  <dbl> <dbl> <dbl>
1 I          9   7.50  3.32  2.03
2 II         9   7.50  3.32  2.03
3 III        9   7.5   3.32  2.03
4 IV         9   7.50  3.32  2.03
```

- Let’s visualize the four data sets. What would be an appropriate type of plot to examine the relationship between the two variables `x` and `y`?

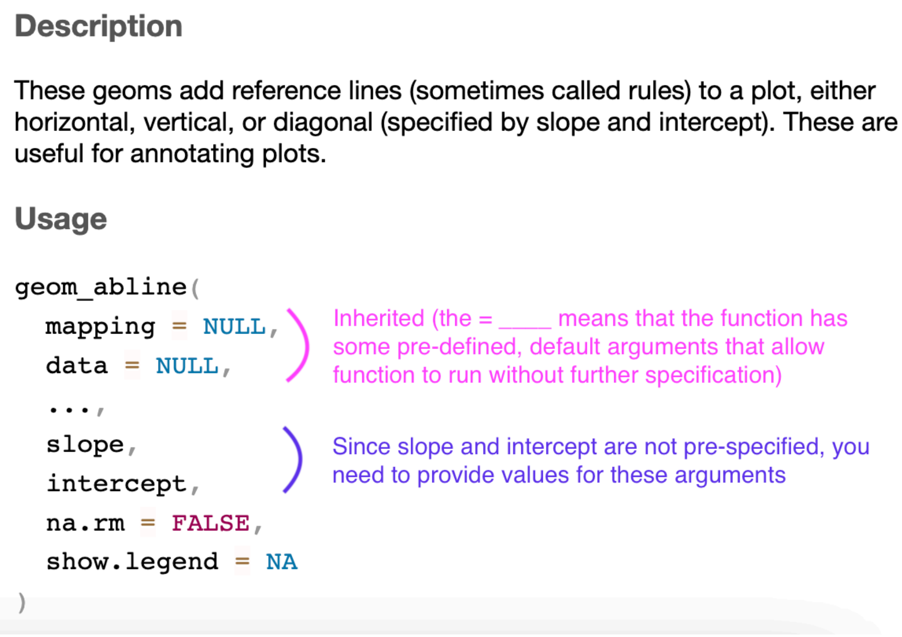
# Introduction to ggplot

- We will learn how to create histograms, box plots, and scatterplots using the `ggplot()` function from the `ggplot2` library
  - Plots are constructed in layers
- At a *minimum*, we need to specify 1) the dataset, 2) variable(s) from the dataset we'd like to plot, and 3) the type of plot
  - How does this differ from the previous coding practice?
- This is what the code will generally look like. Values in < > and `xxx` denote what you as the coder need to specify.

```
ggplot(data = <dataset>, # specify data frame
       mapping = aes(x = <x-var>)) + #  specify variables to be used in plot
  geom_xxx() + # specify plot type
  <other options>
```

# Inheriting arguments

- Many functions related to plotting in ggplot take the form `geom_xxx()`
- The Help file for these functions show that the first two arguments are `mapping` and `data`. These are *automatically inherited* from the `mapping` and `data` arguments in the first layer `ggplot()` function
  - i.e. you don't need to re-specify them, unless you are trying to add a new data frame's data to your visualization



**Description**

These geoms add reference lines (sometimes called rules) to a plot, either horizontal, vertical, or diagonal (specified by slope and intercept). These are useful for annotating plots.

**Usage**

```
geom_abline(
  mapping = NULL,
  data = NULL,
  ...,
  slope,
  intercept,
  na.rm = FALSE,
  show.legend = NA
)
```

Inherited (the = ____ means that the function has some pre-defined, default arguments that allow function to run without further specification)

Since slope and intercept are not pre-specified, you need to provide values for these arguments

# Additional variables + modifications

- We emphasize making informative and useful visualizations.
  - Informative titles and labels
  - Plot should tell a meaningful story
- Depending on the plot and data, we can map additional variables by:
  1. Specifying visual cues via **aesthetics**: color, size, shape, alpha (transparency)
  2. *Faceting* (will see this next week)

# Live code

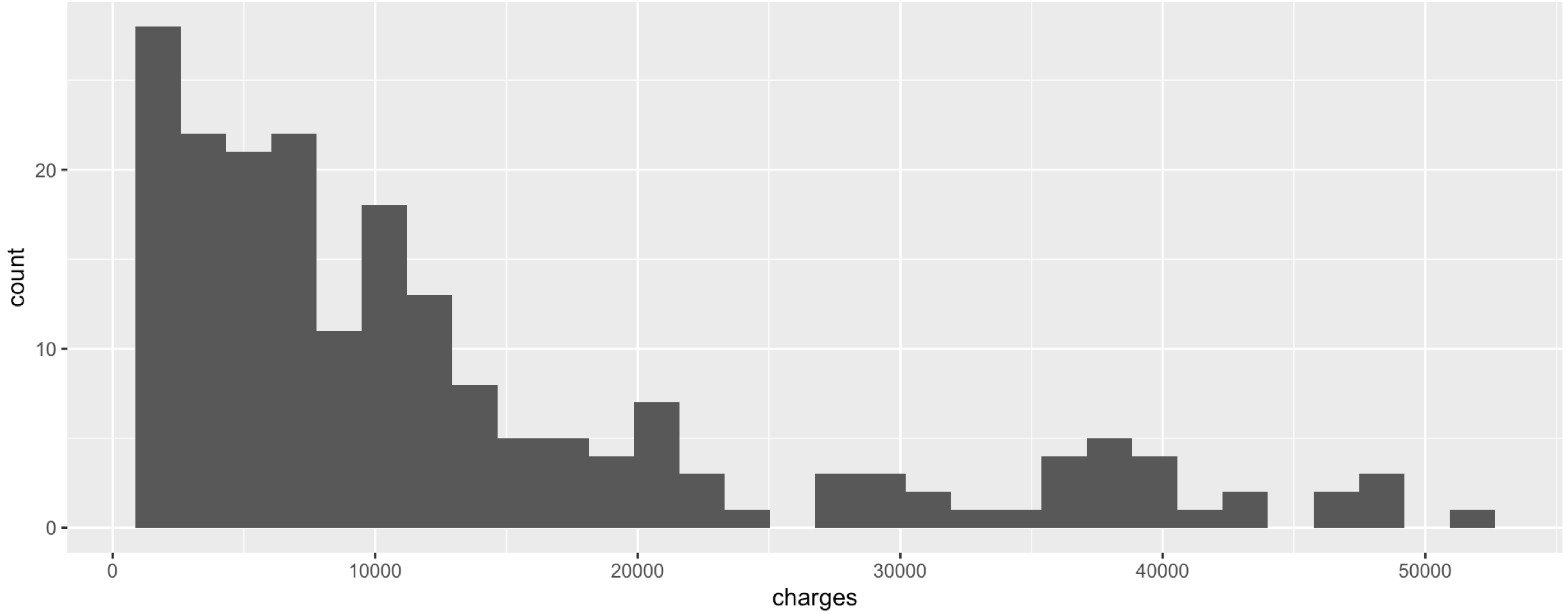
Note: most of the code I will show is included in the remaining slides. However, we will most likely go off-script based on questions from the class!

# Slides on ggplot()

# geom_histogram()

```r
ggplot(data = insurance,  mapping = aes(x = charges)) +
  geom_histogram()
```

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



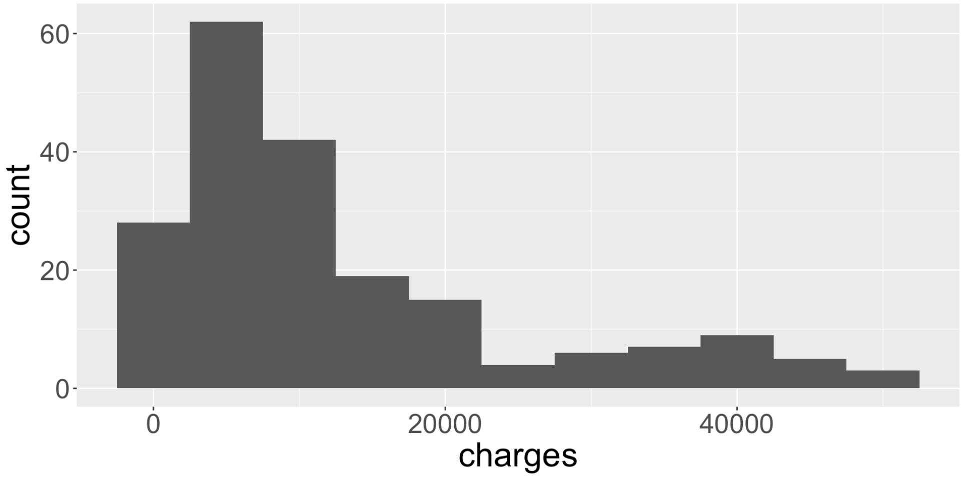
Note the message provided when you execute this code!

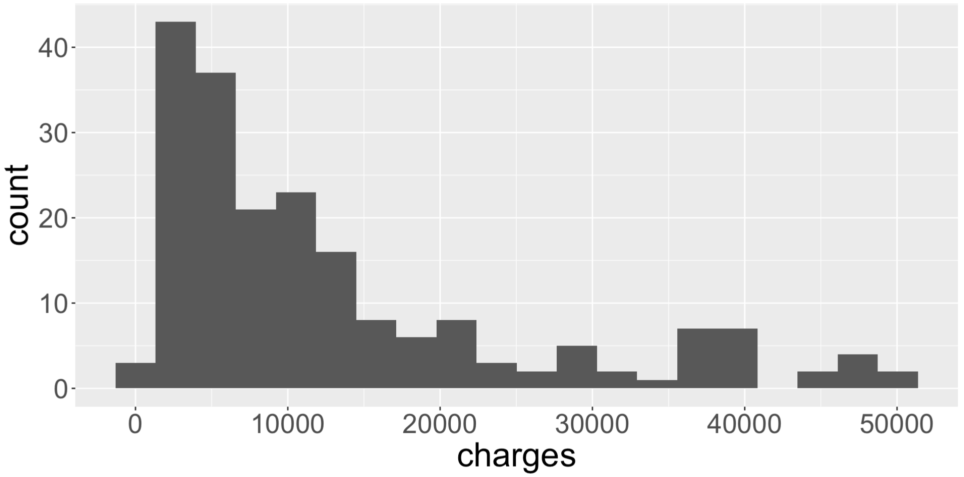
# geom_histogram() cont.

To improve on histogram we change the bin width.

```r
ggplot(data = insurance,
       mapping = aes(x = charges)) +
  geom_histogram(binwidth = 5000)
```

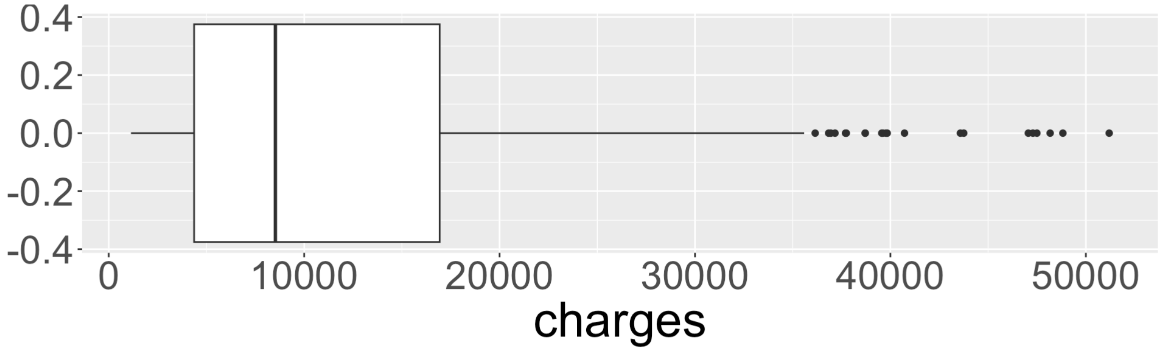
```r
ggplot(data = insurance,
       mapping = aes(x = charges)) +
  geom_histogram(bins = 20)
```



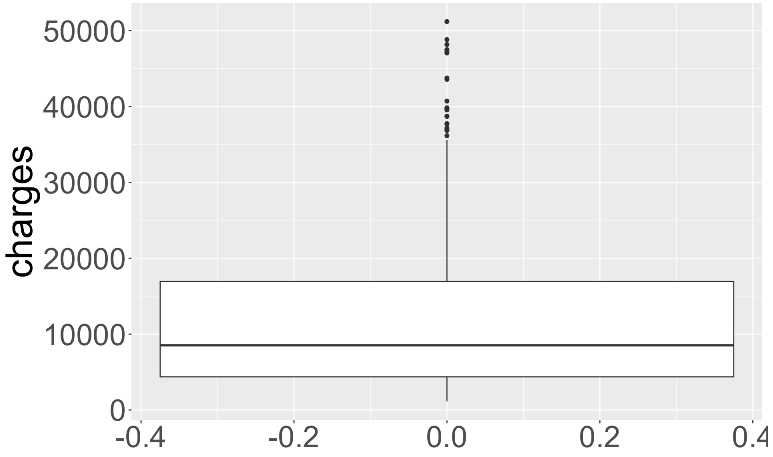


# geom_boxplot()

```
ggplot(data = insurance, mapping = aes(x = charges)) +
  geom_boxplot()
```

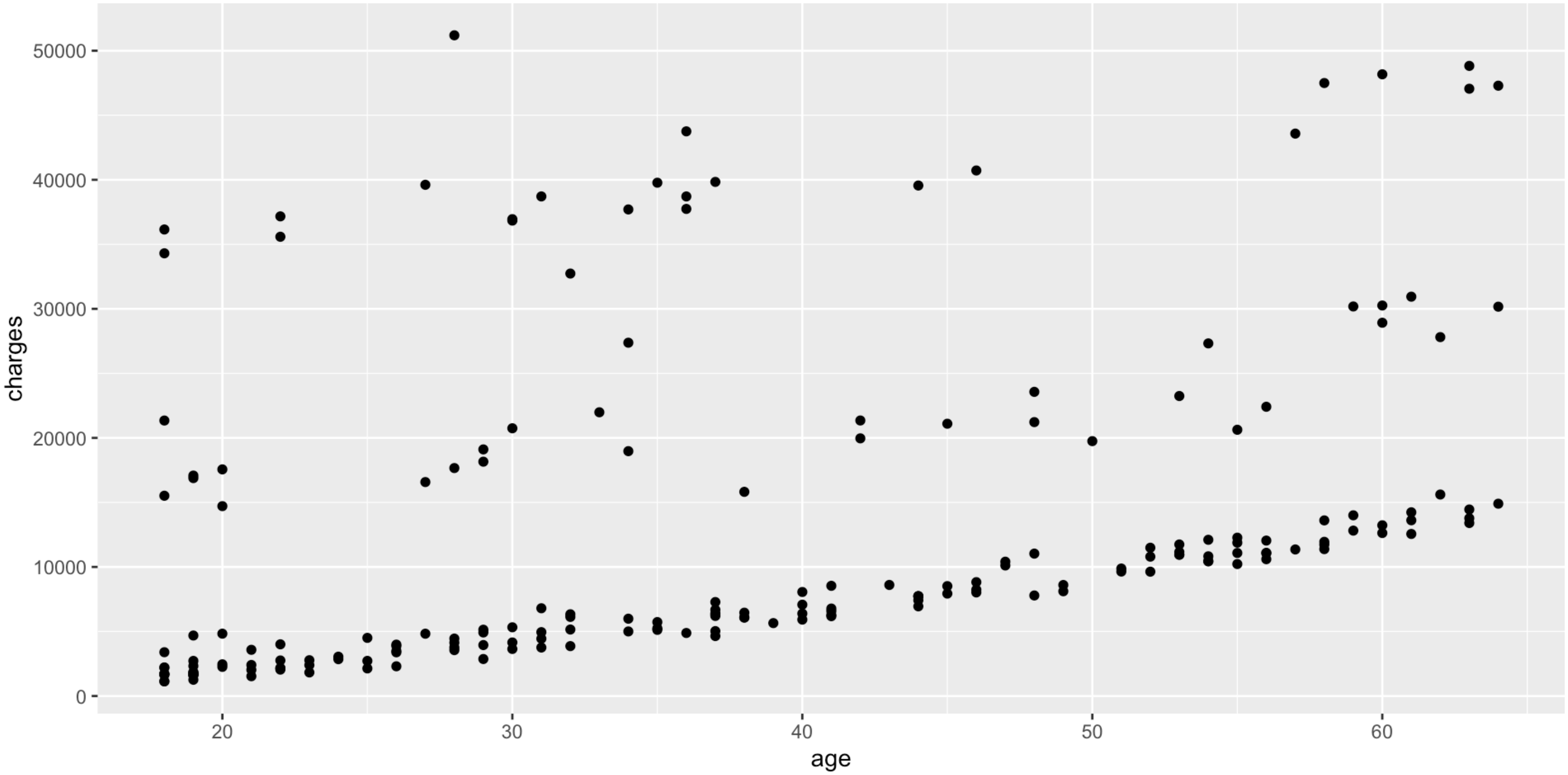


```
ggplot(data = insurance,
       mapping = aes(y = charges)) +
  geom_boxplot()
```



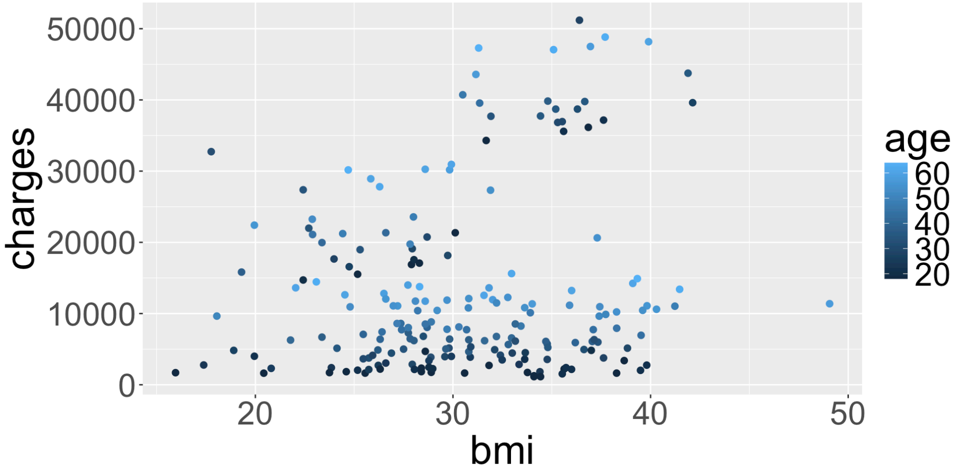
# geom_point()

```r
ggplot(data = insurance, mapping = aes(x = age, y = charges)) +
  geom_point()
```

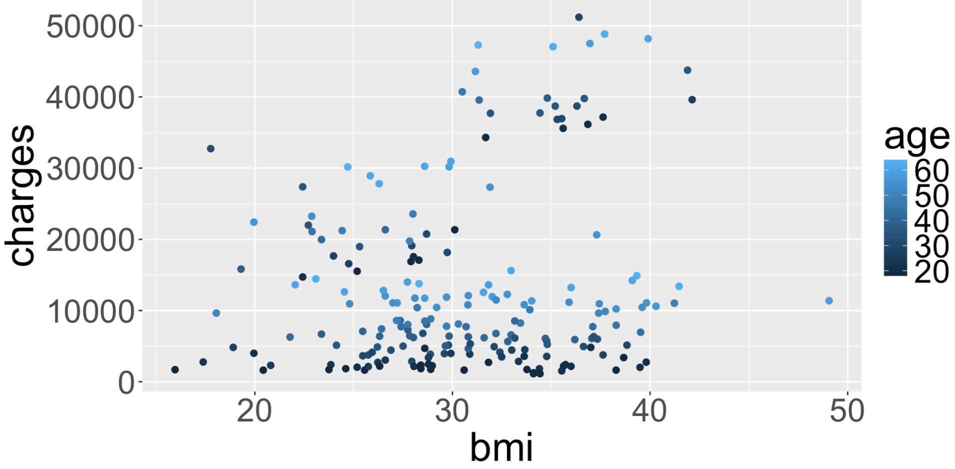


# Aesthetics: color

```r
ggplot(data = insurance,
       mapping = aes(x = bmi, y = charges,
                     col = age)) +
  geom_point()
```

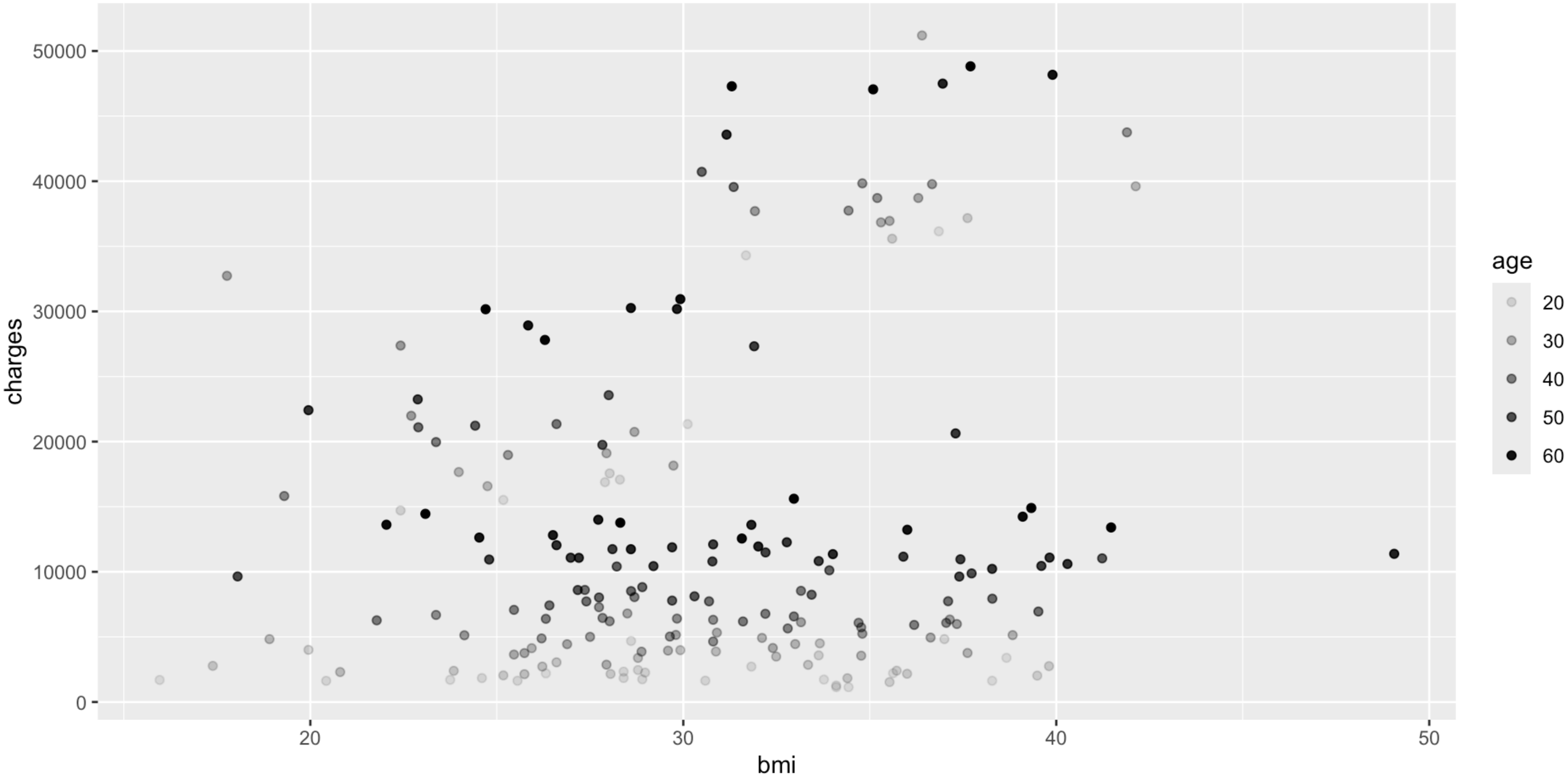


```r
ggplot(data = insurance,
       mapping = aes(x = bmi, y = charges)) +
  geom_point(aes(col = age))
```



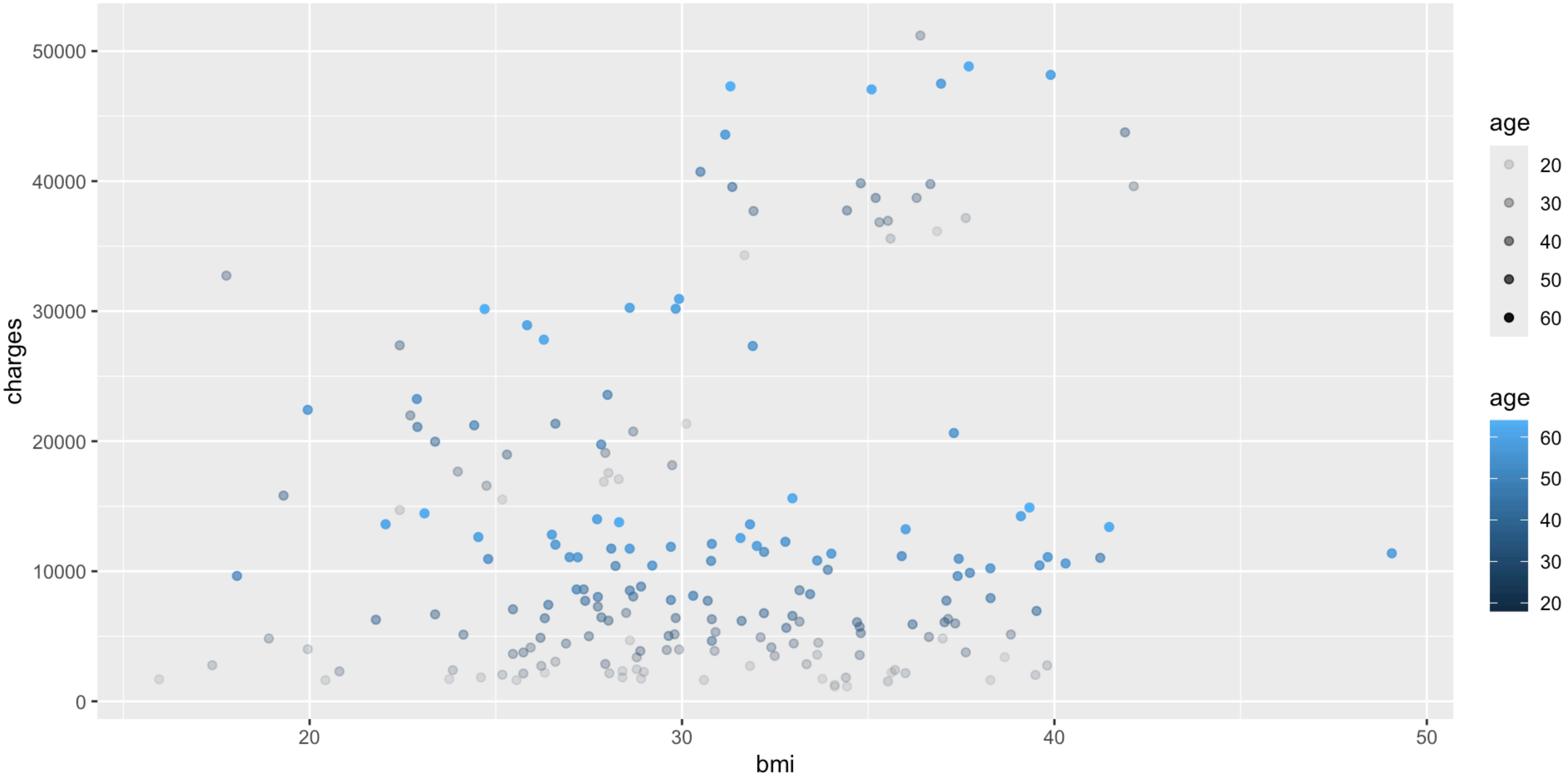
# Aesthetics: transparency

```r
ggplot(data = insurance, mapping = aes(x = bmi, y = charges,
                                       alpha = age)) +
  geom_point()
```



# Specifying multiple aesthetics

```r
ggplot(data = insurance, mapping = aes(x = bmi, y = charges, col = age, alpha = age)) +
  geom_point()
```

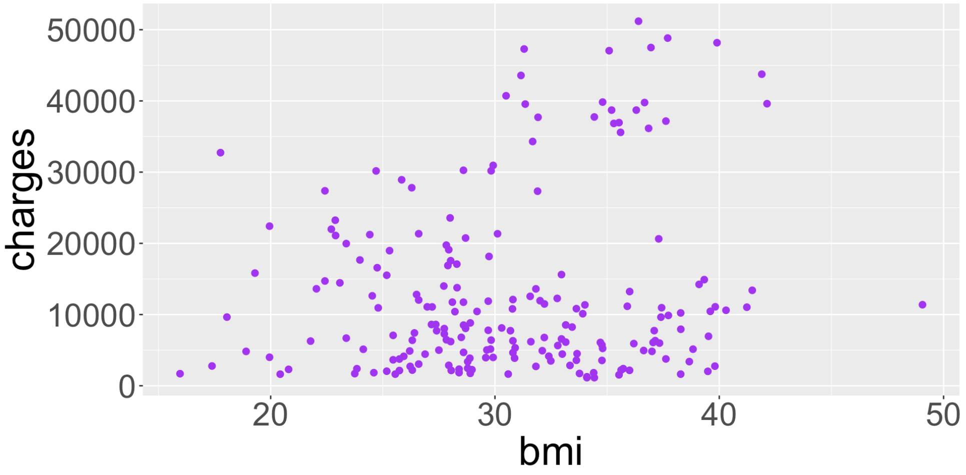


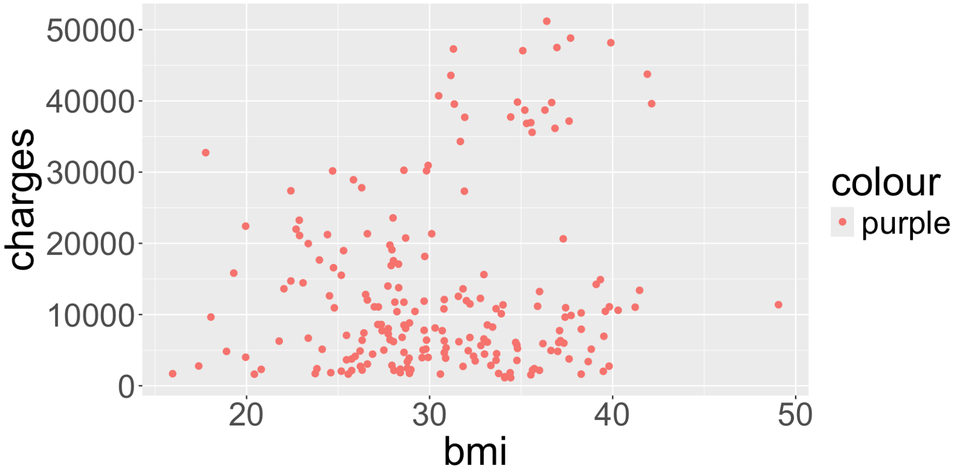
# When to map to variable

What’s going on here?

```r
ggplot(data = insurance,
       mapping = aes(x = bmi, y = charges)) +
  geom_point(col = "purple")
```

```r
ggplot(data = insurance,
       mapping = aes(x = bmi, y = charges)) +
  geom_point(aes(col = "purple"))
```

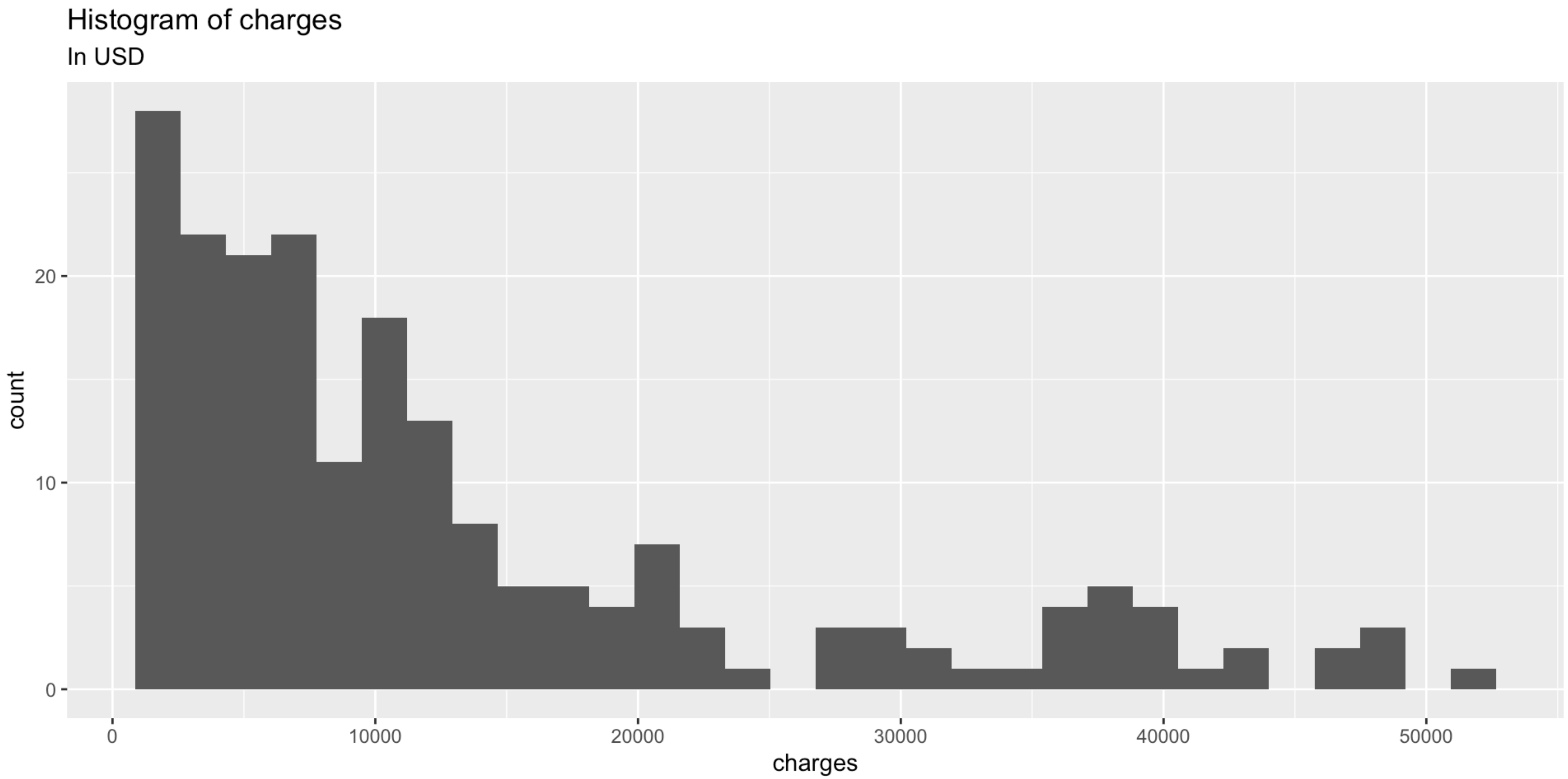




- Key takeaway: aesthetics should correspond/map to a variable in the data frame
    - “Fixed” visual cues are set outside of `aes()`

# Adding a title

```r
ggplot(data = insurance, mapping = aes(x = charges)) +
  geom_histogram() +
  ggtitle("Histogram of charges",
          subtitle = "In USD")
```

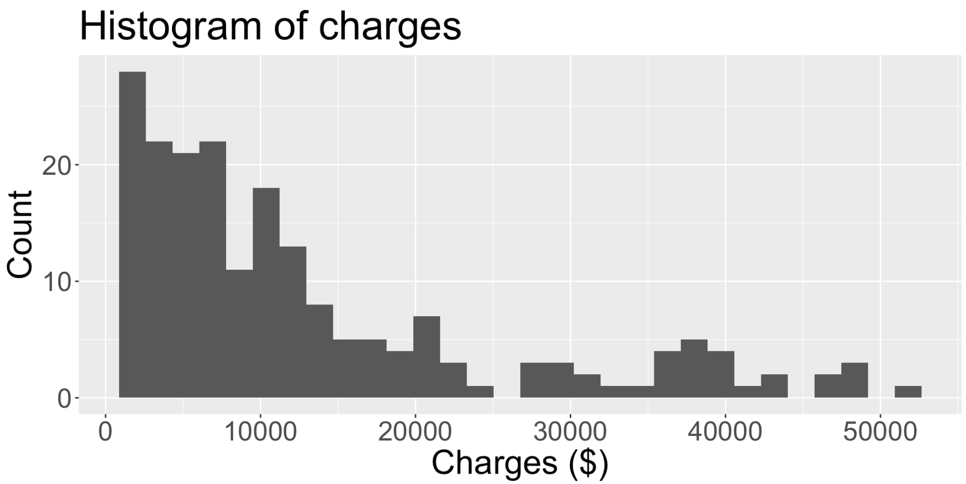


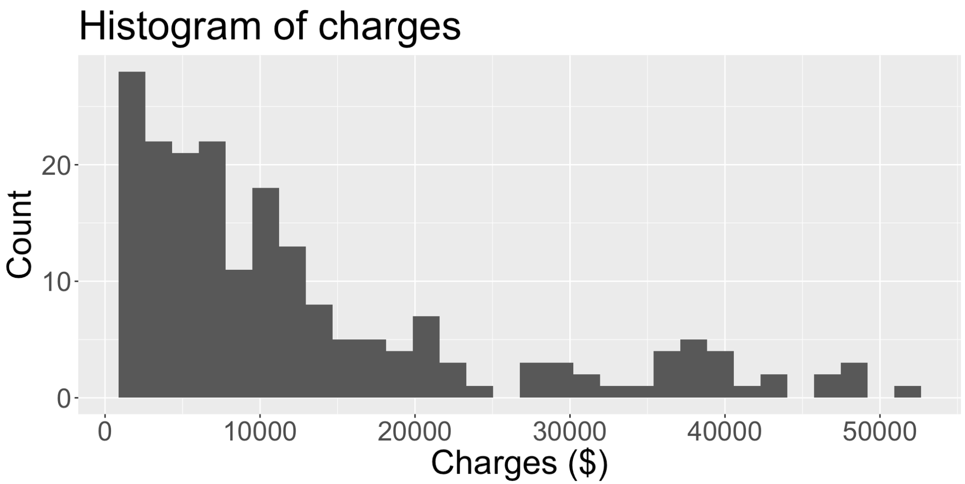
# Changing axis labels

By default, axis titles are taken from variable name specified in `aes()`. To change:

```r
ggplot(data = insurance,
       mapping = aes(x = charges)) +
  geom_histogram() +
  ggtitle("Histogram of charges") +
  xlab("Charges ($)")
```

```r
ggplot(data = insurance,
       mapping = aes(x = charges)) +
  geom_histogram() +
  labs(title = "Histogram of charges",
       x = "Charges ($)", y = "Count")
```


Histogram of charges
Count
Charges ($)


Histogram of charges
Count
Charges ($)