

Data Visualization with ggplot2

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What is ggplot2?

- ggplot2 is a R package for creating statistical and data graphics
- ggplot2's approach to graphics is based on **The Grammar of Graphics**
- Mature package
- Powerful and extensible

Grammar of Graphics

- Big idea: a visualization is constructed from many independent components
- We put together different components to create our desired visualization
- Components of a plot:
 - Data
 - Aesthetic mappings
 - Geometric objects
 - Scales
 - Facet specification
 - Statistical Transformation
 - Coordinate System

US Midwest Demographics

- Let's use ggplot2 on a **dataset** containing demographics information for the US Midwest from the 2000 Census

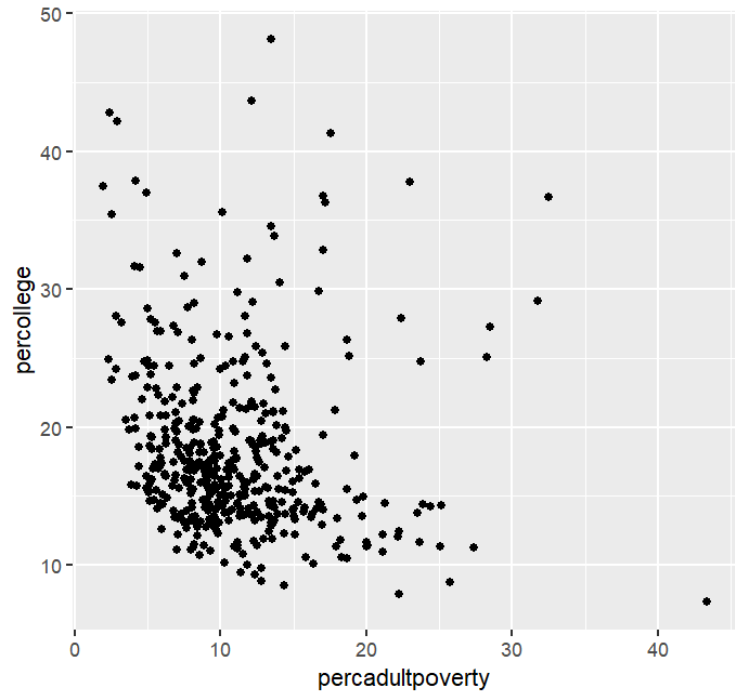
```
midwest <- ggplot2::midwest
midwest[1, c(1,2,3,4,5)]
#> # A tibble: 1 x 5
#>   PID county state area poptotal
#>   <int> <chr>  <chr> <dbl>   <int>
#> 1   561 ADAMS  IL    0.052   66090
dim(midwest)
#> [1] 437 28
colnames(midwest)
#> [1] "PID" "county" "state"
#> [4] "area" "poptotal" "popdensity"
#> [7] "popwhite" "popblack" "popamerindian"
#> [10] "popasian" "popother" "percwhite"
#> [13] "percblack" "percamerindian" "percasian"
#> [16] "percother" "popadults" "perchsd"
#> [19] "percollege" "percprof" "poppovertyknown"
#> [22] "percpovertyknown" "percbelowpoverty" "percchildbelowpovert"
#> [25] "percadultpoverty" "percelderlypoverty" "inmetro"
#> [28] "category"
```

Scatterplot example

- Suppose we wanted to know the relationship between the percent of people below poverty line and the percent of people college educated
- What would you expect the graph to look like?

Scatterplot example

```
ggplot(midwest) +  
  aes(x = percadultpoverty,  
      y = percollege) +  
  geom_point()
```



Recap

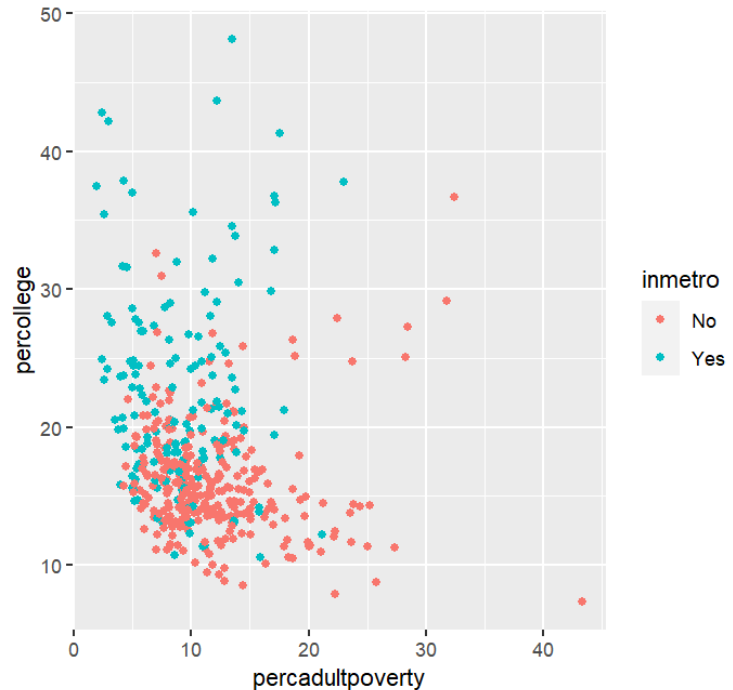
- Initialize a plot with the `ggplot` function
- Specify our data source
- *Aesthetic* properties: choose which variables to use for x and y position
- *Geometric* object (geom): Specify the type of plot
- We used the *point geom* `geom_point()` which produces a scatterplot

Extending the plot

- Suppose we wanted to see how the relationship between the percent of people below poverty line and the percent of people college educated depends on if someone lives in a metropolitan area
- We can display this visually by assigning another aesthetic element to your desired variable
- Let's use the color aesthetic and map it to the `inmetro` variable
- List of common aesthetics: color, shape, size, line type, line size, transparency

Scatterplot example

```
midwest$inmetro <-  
  factor(midwest$inmetro,  
        levels = c("0", "1"),  
        labels = c("No", "Yes"))  
ggplot(midwest) +  
  aes(x = percadultpoverty,  
      y = percollege,  
      color = inmetro) +  
  geom_point()
```

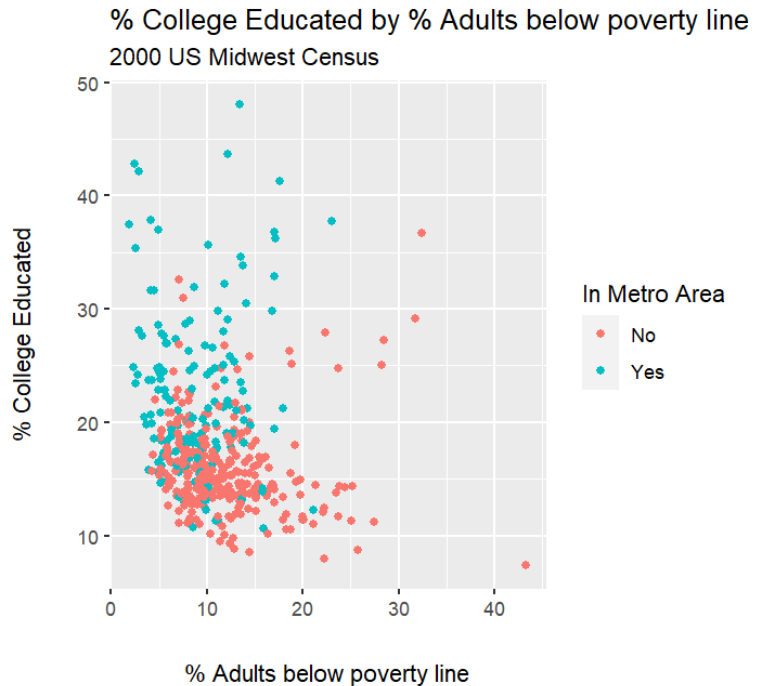


Improving the scatterplot

- Let's make some adjustment to the formatting of the plot
- List of changes:
 - Add descriptive plot title
 - Make axis labels more descriptives
 - Change legend title
 - Add spacing between axis and axis labels

Scatterplot example

```
ggplot(midwest) +
  aes(x = percadultpoverty,
      y = percollege,
      color = inmetro) +
  geom_point() +
  labs(title = "% College Educated by",
       subtitle = "2000 US Midwest Cer",
       color = "In Metro Area",
       x = "% Adults below poverty lin",
       y = "% College Educated") +
  theme(
    axis.title.x =
      element_text(
        margin = margin(t = 20, r = 0,
                        b = 0, l = 0),
        color = "red",
        size = 14),
    axis.title.y =
      element_text(
        margin = margin(t = 0, r = 20,
                        b = 0, l = 0),
        color = "red",
        size = 14)
  )
```



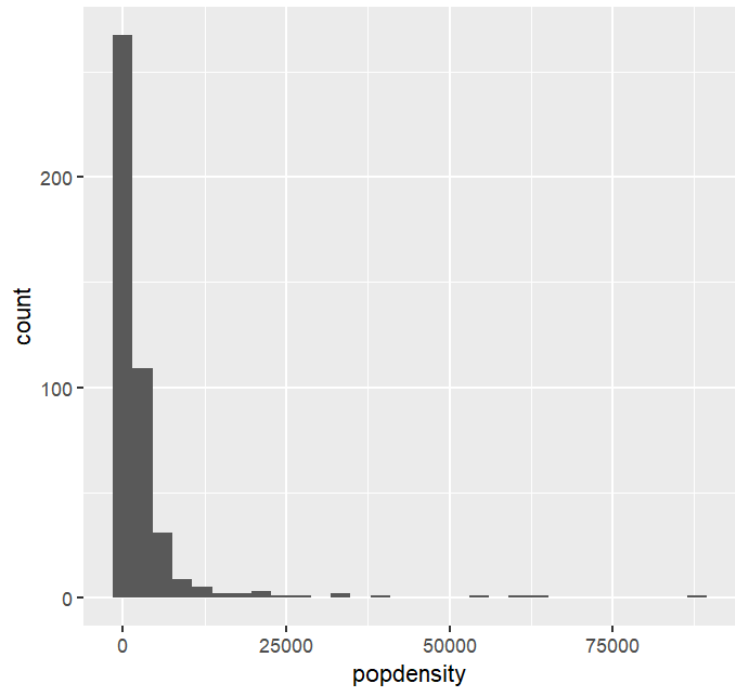
Histogram example

- Suppose we want to know the population density distribution for all counties
- A histogram can be used to view the distribution
- The histogram geom (`geom_histogram`) in `ggplot2` displays a histogram

Histogram example

```
ggplot(midwest) +  
  aes(x = popdensity) +  
  geom_histogram()
```

#> `stat_bin()` using `bins = 30`. Pick better

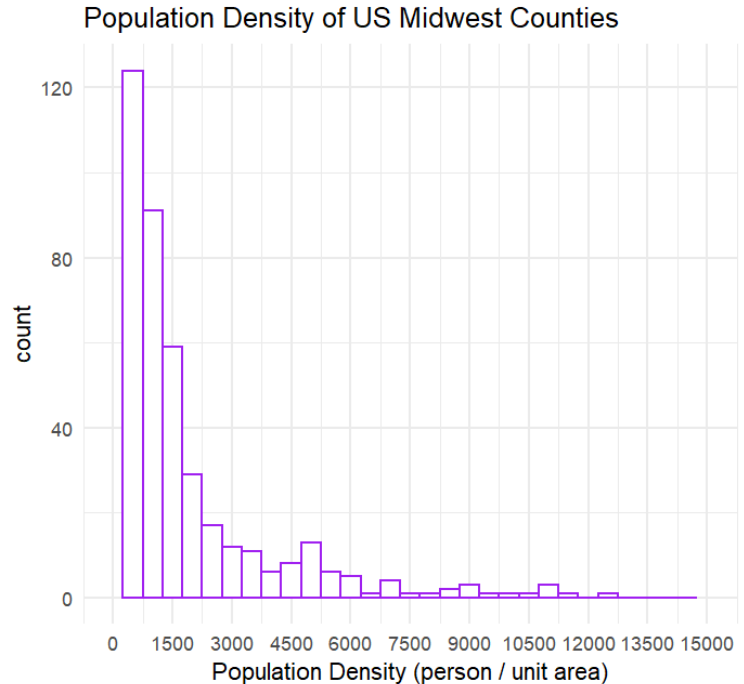


Improving the histogram

- The x-axis label can be changed to be more descriptive
- We can tinker with the binwidth (how wide each individual bar is) to display our desired plot
- Increase the number of x-axis *breaks* (positions on the axis that are marked)
- Adjust the x-axis *limits* to only include the majority of the data
- Make the bars hollow and have an outline color for the bars

Improving the histogram

```
ggplot(midwest) +  
  aes(x = popdensity) +  
  geom_histogram(binwidth = 500,  
                 fill = "white",  
                 color = "purple") +  
  scale_x_continuous(breaks = seq(0, 15000, 1500),  
                    limits = c(0, 15000)) +  
  labs(title = "Population Density of  
         x = "Population Density (person / unit area)"  
  theme_minimal()
```

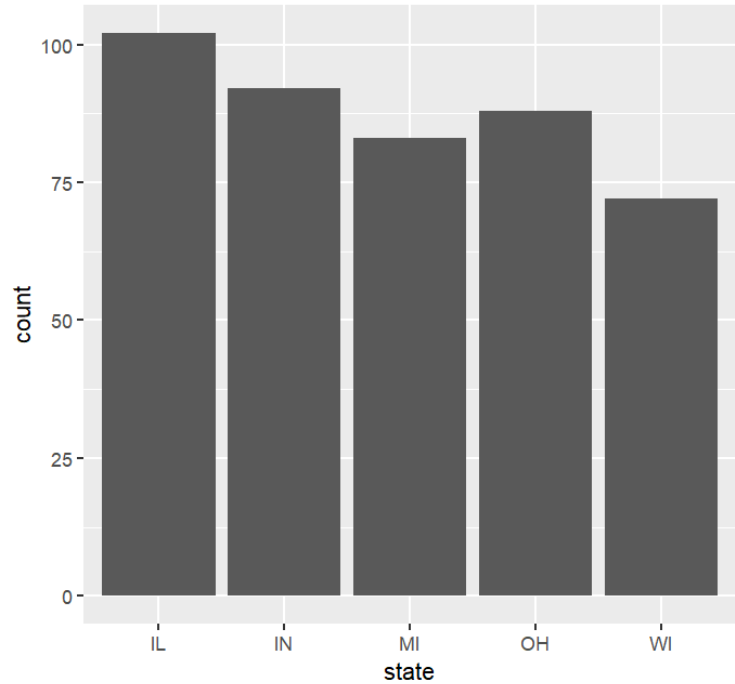


Barplot example

- Now, let's see how many counties are in each state
- A barplot can be used to view the distribution of a qualitative variable
- The bar geom (`geom_bar`) or the col geom (`geom_col`) in `ggplot2` displays a barplot
- The difference between `geom_bar` and `geom_col` is that `geom_bar` makes the height of the bar proportional to the number of each case in each group and `geom_col` makes the heights of the bars represent values in the data

Barplot example

```
ggplot(midwest) +  
  aes(x = state) +  
  geom_bar()
```



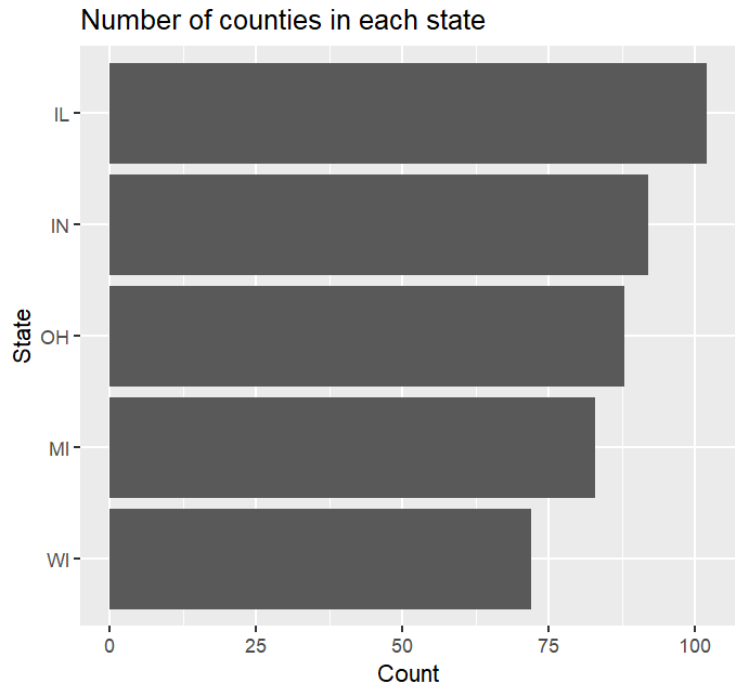
Improving the barplot

- Order the barplot by count
- Flip coordinate system
- Make the bars hollow and have an outline color for the bars

Improving the barplot

```
# count number of counties in each state
county_count <- as.data.frame(table(m
# rename column
colnames(county_count)[colnames(county

ggplot(county_count) +
  aes(x = reorder(state, Freq),
      y = Freq) +
  geom_col() +
  coord_flip() +
  labs(title = "Number of counties in
        x = "State",
        y = "Count")
```

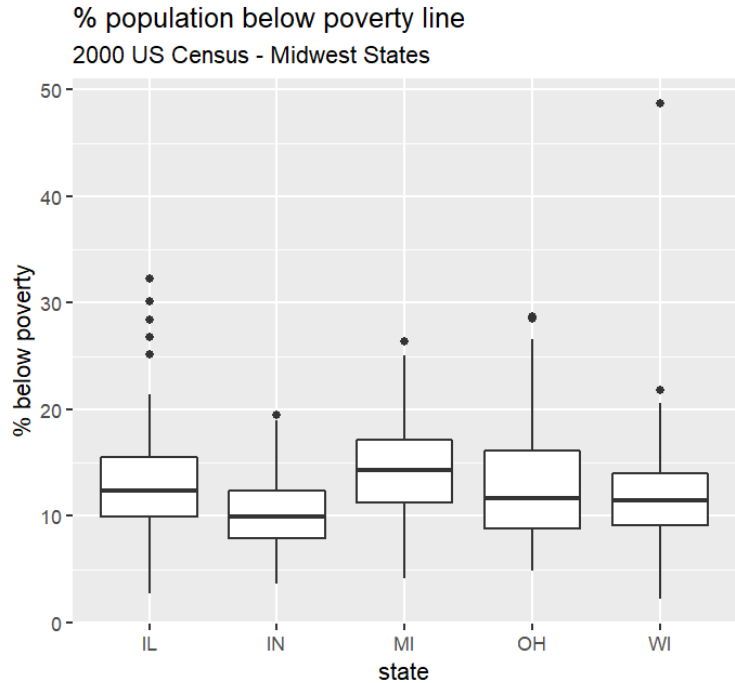


Boxplot example

- Now, let's see the distribution of the percent of people below the poverty line for each state
- A boxplot can be used to view the distribution of a quantitative variable by a categorical variable
- The boxplot geom (`geom_boxplot`) in `ggplot2` displays a boxplot

Boxplot example

```
ggplot(midwest) +  
  aes(x = state,  
      y = percbelowpoverty) +  
  geom_boxplot() +  
  labs(title = "% population below poverty",  
       subtitle = "2000 US Census - Midwest States",  
       y = "% below poverty")
```



Summary

- `ggplot2` builds a plot by combining multiple components
- Plots need a **data** source as well as variables to map to the x and y positions
- **Aesthetics** are visual properties of the plot - what you can see on the plot. Common aesthetics are the x position, y position, color, shape, and size.
- The selection of a **geom** determines the type of plot
- The **scale** can be modified to change how the data maps over to aesthetic properties. There is one scale for each aesthetic property.
- The **coord** can be modified to change the position of objects relative to the plane of the plot

Summary

- The **theme** controls the non-data components of the plot. Some examples: titles, labels, fonts, background, gridlines. See `?theme`.
- **Facets** specify how to display subsets of your data
- **Statistics** are transformations of your data that can be drawn on top of the data