

Data Summarization

Recap

- `select()`: subset and/or reorder columns
- `filter()`: remove rows
- `arrange()`: reorder rows
- `mutate()`: create new columns or modify them
- `select()` and `filter()` can be combined together
- remove a column: `select()` with negative sign (`-col_name`)
- you can do sequential steps: especially using pipes `%>%`

▮ [Cheatsheet](#)

Data Summarization

- Basic statistical summarization
 - `mean(x)`: takes the mean of `x`
 - `sd(x)`: takes the standard deviation of `x`
 - `median(x)`: takes the median of `x`
 - `quantile(x)`: displays sample quantiles of `x`. Default is min, IQR, max
 - `range(x)`: displays the range. Same as `c(min(x), max(x))`
 - `sum(x)`: sum of `x`
 - `max(x)`: maximum value in `x`
 - `min(x)`: minimum value in `x`
- **all have the `na.rm` = argument for missing data**

Statistical summarization

The vector getting summarized goes inside the parentheses:

```
x <- c(1, 5, 7, 4, 2, 8)
```

```
mean(x)
```

```
[1] 4.5
```

```
range(x)
```

```
[1] 1 8
```

```
sum(x)
```

```
[1] 27
```

Statistical summarization

Note that many of these functions have additional inputs regarding missing data, typically requiring the `na.rm` argument (“remove NAs”).

```
x <- c(1, 5, 7, 4, 2, 8, NA)
mean(x)
```

```
[1] NA
```

```
mean(x, na.rm = TRUE)
```

```
[1] 4.5
```

```
quantile(x)
```

```
Error in quantile.default(x): missing values and NaN's not allowed if 'na.rm' is FALSE
```

```
quantile(x, na.rm = TRUE)
```

0%	25%	50%	75%	100%
1.0	2.5	4.5	6.5	8.0

Statistical summarization

We will talk more about data types later, but you can only do summarization on numeric or logical types. Not characters.

```
x <- c(1, 5, 7, 4, 2, 8)
sum(x)
```

```
[1] 27
```

```
y <- c(TRUE, FALSE, FALSE, TRUE) # FALSE == 0 and TRUE == 1
sum(y)
```

```
[1] 2
```

```
z <- c("TRUE", "FALSE", "FALSE", "TRUE")
sum(z)
```

```
Error in sum(z): invalid 'type' (character) of argument
```

Some examples

We can use the `jhu_cars` to explore different ways of summarizing data. The `head` command displays the first rows of an object:

```
library(jhur)
head(jhu_cars)
```

	car	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
1	Mazda RX4	21.0	6	160	110	3.90	2.620	16.46	0	1	4	4
2	Mazda RX4 Wag	21.0	6	160	110	3.90	2.875	17.02	0	1	4	4
3	Datsun 710	22.8	4	108	93	3.85	2.320	18.61	1	1	4	1
4	Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1
5	Hornet Sportabout	18.7	8	360	175	3.15	3.440	17.02	0	0	3	2
6	Valiant	18.1	6	225	105	2.76	3.460	20.22	1	0	3	1

Statistical summarization

You might see base R `$` to reference/select columns from a `data.frame/tibble`:

```
mean(jhu_cars$hp)
```

```
[1] 146.6875
```

```
quantile(jhu_cars$hp)
```

0%	25%	50%	75%	100%
52.0	96.5	123.0	180.0	335.0

Statistical summarization

The “tidy” way:

```
jhu_cars %>% pull(hp) %>% mean() # alt: pull(jhu_cars, hp) %>% mean()
```

```
[1] 146.6875
```

```
jhu_cars %>% pull(hp) %>% quantile()
```

0%	25%	50%	75%	100%
52.0	96.5	123.0	180.0	335.0

Statistical summarization

```
jhu_cars %>% pull(wt) %>% median()
```

```
[1] 3.325
```

```
jhu_cars %>% pull(wt) %>% quantile(probs = 0.6)
```

```
60%  
3.44
```

Data Summarization on data frames

- Basic statistical summarization
 - `rowMeans(x)`: takes the means of each row of `x`
 - `colMeans(x)`: takes the means of each column of `x`
 - `rowSums(x)`: takes the sum of each row of `x`
 - `colSums(x)`: takes the sum of each column of `x`
 - `summary(x)`: for data frames, displays the quantile information

TB Incidence

Let's read in a `tibble` of values from TB incidence.

If you have the `jhur` package installed successfully:

```
tb <- jhur::read_tb()
```

If not, download the `xlsx` file from this link and read it in using `read_csv()`:

http://jhudatascience.org/intro_to_r/data/tb_incidence.xlsx

TB Incidence

Check out the data:

```
head(tb)
```

```
# A tibble: 6 × 19
  `TB incidence, all f...` `1990` `1991` `1992` `1993` `1994` `1995` `1996` `1997`
  <chr>          <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 Afghanistan    168   168   168   168   168   168   168   168
2 Albania         25    24    25    26    26    27    27    28
3 Algeria         38    38    39    40    41    42    43    44
4 American Samoa  21     7     2     9     9    11     0    12
5 Andorra         36    34    32    30    29    27    26    26
6 Angola         205   209   214   218   222   226   231   236
# ... with 10 more variables: `1998` <dbl>, `1999` <dbl>, `2000` <dbl>,
#   `2001` <dbl>, `2002` <dbl>, `2003` <dbl>, `2004` <dbl>, `2005` <dbl>,
#   `2006` <dbl>, `2007` <dbl>
```

TB Incidence

Check out the data:

```
str(tb)
```

```
tibble [208 × 19] (S3: tbl_df/tbl/data.frame)
```

```
$ TB incidence, all forms (per 100 000 population per year): chr [1:208] "Afghanistan" "Albania"  
$ 1990 : num [1:208] 168 25 38 21 36 205 2  
$ 1991 : num [1:208] 168 24 38 7 34 209 24  
$ 1992 : num [1:208] 168 25 39 2 32 214 24  
$ 1993 : num [1:208] 168 26 40 9 30 218 24  
$ 1994 : num [1:208] 168 26 41 9 29 222 23  
$ 1995 : num [1:208] 168 27 42 11 27 226 2  
$ 1996 : num [1:208] 168 27 43 0 26 231 23  
$ 1997 : num [1:208] 168 28 44 12 26 236 2  
$ 1998 : num [1:208] 168 28 46 6 25 240 23  
$ 1999 : num [1:208] 168 27 47 8 23 245 23  
$ 2000 : num [1:208] 168 25 48 6 22 250 23  
$ 2001 : num [1:208] 168 23 49 6 21 255 22  
$ 2002 : num [1:208] 168 23 50 4 21 260 22  
$ 2003 : num [1:208] 168 22 51 5 20 265 22  
$ 2004 : num [1:208] 168 21 53 9 20 270 22  
$ 2005 : num [1:208] 168 20 54 10 19 276 2  
$ 2006 : num [1:208] 168 18 55 7 19 281 22  
$ 2007 : num [1:208] 168 17 57 5 19 287 22
```

Indicator of TB

Before we go further, let's rename the first column using the `rename()` function in `dplyr`.

In this case, we have to use the backticks (```) because there are spaces and funky characters in the name:

```
library(dplyr)
tb <- tb %>% rename(country = `TB incidence, all forms (per 100 000 population per year)`)
```

Indicator of TB

`colnames()` will show us the column names and show that country is renamed:

```
colnames(tb)
```

```
[1] "country" "1990"    "1991"    "1992"    "1993"    "1994"    "1995"
[8] "1996"    "1997"    "1998"    "1999"    "2000"    "2001"    "2002"
[15] "2003"    "2004"    "2005"    "2006"    "2007"
```


Summarize the data: **dplyr** `summarize()` function

`summarize` creates a summary table of a column you're interested in.

General format - Not the code!

```
{data to use} %>%  
  summarize({summary column name} = {operator(source column)})
```

```
tb %>%  
  summarize(mean_2006 = mean(`2006`, na.rm = TRUE))
```

A tibble: 1 × 1

```
mean_2006  
  <dbl>  
1      135.
```

Summarize the data: `dplyr summarize()` function

`summarize()` can do multiple operations at once. Just separate by a comma.

```
tb %>%
  summarize(mean_2006 = mean(`2006`, na.rm = TRUE),
            median_2007 = median(`2007`, na.rm = TRUE),
            median(`2004`, na.rm = TRUE))

# A tibble: 1 × 3
  mean_2006 median_2007 `median(\`2004\`, na.rm = TRUE)`
    <dbl>      <dbl>          <dbl>
1    135.         53            56
```

Notice how when we forget to provide a new name, output is still provided, but the column name is messy.

Summarize the data: `dplyr summarize()` function

This looks better.

```
tb %>%  
  summarize(mean_2006 = mean(`2006`, na.rm = TRUE),  
            median_2007 = median(`2007`, na.rm = TRUE),  
            median_2004 = median(`2004`, na.rm = TRUE))
```

```
# A tibble: 1 × 3  
  mean_2006 median_2007 median_2004  
    <dbl>         <dbl>         <dbl>  
1    135.           53           56
```

Iterative summaries: **dplyr** `summarize()` and `across()` functions

Use the `across` function with `summarize()` to summarize across multiple columns of your data.

General format - Not the code!

```
across({ columns to go across }, ~ { summarization_function(.x, na.rm = ..) })
```

```
tb %>%
```

```
  summarize(across( c(`1990`, `1991`, `1992`, `1993`), ~ sum(.x, na.rm = TRUE)))
```

```
# A tibble: 1 × 4
```

```
  `1990` `1991` `1992` `1993`  
  <dbl>  <dbl>  <dbl>  <dbl>  
1  21855  22288  22421  22836
```

Iterative summaries: `dplyr` `summarize()` and `across()` functions

Another example using select helpers:

```
tb %>%  
  summarize(across( starts_with("2"), ~ range(.x, na.rm = TRUE)))
```

```
# A tibble: 2 × 8
```

	`2000` <dbl>	`2001` <dbl>	`2002` <dbl>	`2003` <dbl>	`2004` <dbl>	`2005` <dbl>	`2006` <dbl>	`2007` <dbl>
1	0	0	3	0	0	0	0	0
2	801	916	994	1075	1127	1141	1169	1198

Row means

`colMeans()` and `rowMeans()` require **all numeric data**.

Let's see what the mean is across each row (country):

```
tb_2 <- column_to_rownames(tb, var = "country") # opposite of rownames_to_column() !
head(tb_2, n = 2)
```

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Afghanistan	168	168	168	168	168	168	168	168	168	168	168	168	168
Albania	25	24	25	26	26	27	27	28	28	27	25	23	23

	2003	2004	2005	2006	2007
Afghanistan	168	168	168	168	168
Albania	22	21	20	18	17

```
rowMeans(tb_2, na.rm = TRUE)
```

Afghanistan	168.000000
Albania	24.000000
Algeria	46.388889
Andorra	24.944444
Anguilla	22.833333
Argentina	43.666667
Australia	6.444444
Azerbaijan	
Bahamas	
Bahrain	
Barbados	
Belarus	
Belgium	
Belize	
Benin	
Bhutan	
Bolivia	
Bosnia and Herzegovina	
Brazil	
Bulgaria	
Burkina Faso	
Burundi	
Cambodia	
Cameroon	
Canada	
Cape Verde	
Cayman Islands	
Central African Republic	
Chad	
Chile	
China	
Cote d'Ivoire	
Croatia	
Cuba	
Cyprus	
Czechia	
Dominica	
Dominican Republic	
DRC	
Ecuador	
Egypt	
El Salvador	
Equatorial Guinea	
Eritrea	
Estonia	
Ethiopia	
Fiji	
Finland	
France	
Gabon	
Gambia	
Georgia	
Germany	
Ghana	
Greece	
Guatemala	
Haiti	
Honduras	
Hungary	
Iceland	
India	
Indonesia	
Iran	
Iraq	
Ireland	
Israel	
Italy	
Jamaica	
Japan	
Jordan	
Kazakhstan	
Kenya	
Korea	
Kosovo	
Kuwait	
Kyrgyzstan	
Laos	
Lao PDR	
Latvia	
Lebanon	
Lesotho	
Liberia	
Lithuania	
Luxembourg	
Madagascar	
Mali	
Maldives	
Malta	
Martinique	
Mauritania	
Mauritius	
Mexico	
Moldova	
Mongolia	
Montenegro	
Morocco	
Mozambique	
Myanmar	
Nicaragua	
Niger	
Nigeria	
North Macedonia	
North Korea	
Oman	
Pakistan	
Panama	
Papua New Guinea	
Paraguay	
Peru	
Philippines	
Poland	
Portugal	
Romania	
Russia	
Rwanda	
Saint Kitts and Nevis	
Saint Lucia	
Saint Vincent and the Grenadines	
Samoa	
San Marino	
Saudi Arabia	
Senegal	
Serbia	
Seychelles	
Sierra Leone	
Singapore	
Slovakia	
Slovenia	
South Africa	
South Korea	
South Sudan	
Spain	
Sri Lanka	
Sudan	
Suriname	
Swaziland	
Sweden	
Switzerland	
Taiwan	
Tajikistan	
Tanzania	
Togo	
Tonga	
Turkey	
Turkmenistan	
Tuvalu	
Uganda	
Ukraine	
United Arab Emirates	
United Kingdom	
United States	
Uruguay	
Uzbekistan	
Venezuela	
Vietnam	
Yemen	
Zambia	
Zimbabwe	

Row means

`colMeans()` gives you very similar output to functions we've seen previously in this lecture (`summarize()` and `across()`).

```
colMeans(tb_2, na.rm = TRUE)
```

	1990	1991	1992	1993	1994	1995	1996	1997
	105.5797	107.6715	108.3140	110.3188	111.9662	114.1981	115.3527	118.8792
	1998	1999	2000	2001	2002	2003	2004	2005
	121.5169	125.0435	127.8454	130.7488	136.1739	136.1932	136.9662	135.6683
	2006	2007						
	134.6106	133.3865						

```
tb_2 %>%  
  summarize(across( colnames(tb_2), ~ mean(.x, na.rm = TRUE)))
```

	1990	1991	1992	1993	1994	1995	1996	1997
1	105.5797	107.6715	108.314	110.3188	111.9662	114.1981	115.3527	118.8792
	1998	1999	2000	2001	2002	2003	2004	2005
1	121.5169	125.0435	127.8454	130.7488	136.1739	136.1932	136.9662	135.6683
	2006	2007						
1	134.6106	133.3865						

summary() Function

Using `summary()` can give you rough snapshots of each numeric column (character columns are skipped):

```
summary(tb)
```

country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Length:208	Min. : 0.0	Min. : 4.0	Min. : 2.0	Min. : 4.0	Min. : 0	Min. : 3.0	Min. : 0.0	Min. : 0.0	Min. : 0.0	Min. : 0.0	Min. : 0.0	Min. : 0.0
Class :character	1st Qu.: 27.5	1st Qu.: 27.0	1st Qu.: 27.0	1st Qu.: 27.5	1st Qu.: 26	1st Qu.: 26.5	1st Qu.: 25.5	1st Qu.: 24.5	1st Qu.: 23.5	1st Qu.: 22.5	1st Qu.: 21.5	1st Qu.: 19.0
Mode :character	Median : 60.0	Median : 58.0	Median : 56.0	Median : 56.0	Median : 57	Median : 58.0	Median : 60.0	Median : 64.0	Median : 63.0	Median : 66.0	Median : 60.0	Median : 59.0
	Mean :105.6	Mean :107.7	Mean :108.3	Mean :110.3	Mean :112	Mean :114.2	Mean :115.4	Mean :118.9	Mean :121.5	Mean :125.0	Mean :127.8	Mean :130.7
	3rd Qu.:165.0	3rd Qu.:171.0	3rd Qu.:171.5	3rd Qu.:171.0	3rd Qu.:174	3rd Qu.:177.5	3rd Qu.:179.0	3rd Qu.:181.0	3rd Qu.:188.5	3rd Qu.:192.5	3rd Qu.:191.0	3rd Qu.:189.5
	Max. :585.0	Max. :594.0	Max. :606.0	Max. :618.0	Max. :630	Max. :642.0	Max. :655.0	Max. :668.0	Max. :681.0	Max. :695.0	Max. :801.0	Max. :916.0
	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1

Lab Part 1

▮ [Class Website](#)

▮ [Lab](#)

Youth Tobacco Survey

Here we will be using the Youth Tobacco Survey data:

http://jhudatascience.org/intro_to_r/data/Youth_Tobacco_Survey_YTS_Data.csv

```
yts <- jhur::read_yts()
head(yts)
```

```
# A tibble: 6 × 31
```

	YEAR	LocationAbbr	LocationDesc	TopicType	TopicDesc	MeasureDesc	DataSource
	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>
1	2015	AZ	Arizona	Tobacco Use ...	Cessatio...	Percent of...	YTS
2	2015	AZ	Arizona	Tobacco Use ...	Cessatio...	Percent of...	YTS
3	2015	AZ	Arizona	Tobacco Use ...	Cessatio...	Percent of...	YTS
4	2015	AZ	Arizona	Tobacco Use ...	Cessatio...	Quit Attem...	YTS
5	2015	AZ	Arizona	Tobacco Use ...	Cessatio...	Quit Attem...	YTS
6	2015	AZ	Arizona	Tobacco Use ...	Cessatio...	Quit Attem...	YTS

```
# ... with 24 more variables: Response <chr>, Data_Value_Unit <chr>,
#   Data_Value_Type <chr>, Data_Value <dbl>, Data_Value_Footnote_Symbol <chr>,
#   Data_Value_Footnote <chr>, Data_Value_Std_Err <dbl>,
#   Low_Confidence_Limit <dbl>, High_Confidence_Limit <dbl>, Sample_Size <dbl>,
#   Gender <chr>, Race <chr>, Age <chr>, Education <chr>, GeoLocation <chr>,
#   TopicTypeId <chr>, TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>,
#   StratificationID2 <chr>, StratificationID3 <chr>, ...
```

Column to vector

Let's work with one column as a vector using `pull()`.

```
locations <- yts %>% pull(LocationDesc)
locations
```

```
[1] "Arizona"
[3] "Arizona"
[5] "Arizona"
[7] "Arizona"
[9] "Arizona"
[11] "Arizona"
[13] "Arizona"
[15] "Arizona"
[17] "Arizona"
[19] "Arizona"
[21] "Arizona"
[23] "Arizona"
[25] "Connecticut"
[27] "Connecticut"
[29] "Connecticut"
[31] "Connecticut"
[33] "Connecticut"
[35] "Connecticut"
[37] "Connecticut"
[39] "Connecticut"
[41] "Connecticut"
[43] "Connecticut"
[45] "Connecticut"
[47] "Connecticut"
```

Length and unique

`unique(x)` will return the unique elements of `x`

```
unique(locations)
```

```
[1] "Arizona"           "Connecticut"
[3] "Georgia"           "Hawaii"
[5] "Illinois"          "Louisiana"
[7] "Mississippi"       "Utah"
[9] "Missouri"          "National (States and DC)"
[11] "Nebraska"          "New Jersey"
[13] "North Carolina"    "North Dakota"
[15] "Pennsylvania"      "South Carolina"
[17] "West Virginia"     "Alabama"
[19] "Delaware"          "Minnesota"
[21] "Guam"              "Ohio"
[23] "Indiana"           "Kansas"
[25] "Oklahoma"          "Wisconsin"
[27] "Michigan"          "New Hampshire"
[29] "Arkansas"          "Kentucky"
[31] "Iowa"              "South Dakota"
[33] "Virginia"          "Puerto Rico"
[35] "Rhode Island"      "New Mexico"
[37] "Tennessee"         "Vermont"
[39] "Virgin Islands"    "California"
[41] "Idaho"             "Florida"
[43] "Maryland"          "Massachusetts"
[45] "New York"          "Maine"
[47] "Colorado"          "District of Columbia"
[49] "Texas"             "Wyoming"
```

Length and unique

`length` will tell you the length of a vector. Combined with `unique`, tells you the number of unique elements:

```
length(unique(locations))
```

```
[1] 50
```

table and dplyr: count

table(x) will return a frequency table of unique elements of x

```
table(locations)
```

```
locations
```

Alabama	Arizona	Arkansas
378	240	210
California	Colorado	Connecticut
96	48	384
Delaware	District of Columbia	Florida
312	48	96
Georgia	Guam	Hawaii
282	48	270
Idaho	Illinois	Indiana
48	282	264
Iowa	Kansas	Kentucky
276	186	255
Louisiana	Maine	Maryland
240	48	96
Massachusetts	Michigan	Minnesota
48	138	141
Mississippi	Missouri	National (States and DC)
567	294	26
Nebraska	New Hampshire	New Jersey
234	180	387
New Mexico	New York	North Carolina
24	90	366
North Dakota	Ohio	Oklahoma
330	255	318

table and dplyr: count

Use count directly on a data.frame and column without needing to use pull().

```
yts %>% count(LocationDesc)
```

```
# A tibble: 50 × 2
```

	LocationDesc	n
	<chr>	<int>
1	Alabama	378
2	Arizona	240
3	Arkansas	210
4	California	96
5	Colorado	48
6	Connecticut	384
7	Delaware	312
8	District of Columbia	48
9	Florida	96
10	Georgia	282

```
# ... with 40 more rows
```

table and dplyr: count

Multiple columns listed further subdivides the count.

```
yts %>% count(LocationDesc, TopicDesc)
```

```
# A tibble: 146 × 3
```

	LocationDesc	TopicDesc	n
	<chr>	<chr>	<int>
1	Alabama	Cessation (Youth)	90
2	Alabama	Cigarette Use (Youth)	144
3	Alabama	Smokeless Tobacco Use (Youth)	144
4	Arizona	Cessation (Youth)	60
5	Arizona	Cigarette Use (Youth)	99
6	Arizona	Smokeless Tobacco Use (Youth)	81
7	Arkansas	Cessation (Youth)	42
8	Arkansas	Cigarette Use (Youth)	78
9	Arkansas	Smokeless Tobacco Use (Youth)	90
10	California	Cessation (Youth)	24

```
# ... with 136 more rows
```


table and dplyr: count

Multiple columns listed further subdivides the count.

```
yts %>% count(LocationDesc, TopicDesc)
```

```
# A tibble: 146 × 3
```

	LocationDesc <chr>	TopicDesc <chr>	n <int>
1	Alabama	Cessation (Youth)	90
2	Alabama	Cigarette Use (Youth)	144
3	Alabama	Smokeless Tobacco Use (Youth)	144
4	Arizona	Cessation (Youth)	60
5	Arizona	Cigarette Use (Youth)	99
6	Arizona	Smokeless Tobacco Use (Youth)	81
7	Arkansas	Cessation (Youth)	42
8	Arkansas	Cigarette Use (Youth)	78
9	Arkansas	Smokeless Tobacco Use (Youth)	90
10	California	Cessation (Youth)	24

```
# ... with 136 more rows
```

Note: count() includes NAs but table() does not

Grouping

Perform Operations By Groups: dplyr

`group_by` allows you group the data set by variables/columns you specify:

```
# Regular data  
yts
```

```
# A tibble: 9,794 × 31
```

	YEAR	LocationAbbr	LocationDesc	TopicType	TopicDesc	MeasureDesc	DataSource
	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>
1	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
2	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
3	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
4	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
5	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
6	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
7	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
8	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
9	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
10	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS

```
# ... with 9,784 more rows, and 24 more variables: Response <chr>,  
# Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,  
# Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,  
# Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,  
# High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,  
# Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,  
# TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>, ...
```

Perform Operations By Groups: dplyr

`group_by` allows you group the data set by variables/columns you specify:

```
yts_grouped <- yts %>% group_by(Response)
yts_grouped
```

```
# A tibble: 9,794 × 31
```

```
# Groups:   Response [4]
```

	YEAR	LocationAbbr	LocationDesc	TopicType	TopicDesc	MeasureDesc	DataSource
	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>
1	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
2	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
3	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
4	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
5	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
6	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
7	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
8	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
9	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
10	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS

```
# ... with 9,784 more rows, and 24 more variables: Response <chr>,
# Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
# Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
# Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
# High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
# Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
# TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>, ...
```

Summarize the grouped data

It's grouped! Grouping doesn't change the data in any way, but how **functions operate on it**. Now we can summarize `Data_Value` (percent of respondents) by group:

```
yts_grouped %>% summarize(avg_percent = mean(Data_Value, na.rm = TRUE))
```

```
# A tibble: 4 × 2
  Response avg_percent
  <chr>      <dbl>
1 Current    9.68
2 Ever      26.1
3 Frequent   3.48
4 <NA>      53.5
```

Use the **pipe** to string these together!

Pipe `yts` into `group_by`, then pipe that into `summarize`:

```
yts %>%  
  group_by(Response) %>%  
  summarize(avg_percent = mean(Data_Value, na.rm = TRUE),  
            max_percent = max(Data_Value, na.rm = TRUE))
```

A tibble: 4 × 3

	Response	avg_percent	max_percent
	<chr>	<dbl>	<dbl>
1	Current	9.68	40.6
2	Ever	26.1	98
3	Frequent	3.48	23.9
4	<NA>	53.5	81.9

Ungroup the data

The `ungroup` function will allow you to clear the groups from the data. You can also overwrite the first `group_by` with a new one.

```
yts = ungroup(yts)
yts
```

```
# A tibble: 9,794 × 31
```

	YEAR	LocationAbbr	LocationDesc	TopicType	TopicDesc	MeasureDesc	DataSource
	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>
1	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
2	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
3	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Percent of...	YTS
4	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
5	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
6	2015	AZ	Arizona	Tobacco Use...	Cessatio...	Quit Attem...	YTS
7	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
8	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
9	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS
10	2015	AZ	Arizona	Tobacco Use...	Cigarett...	Smoking St...	YTS

```
# ... with 9,784 more rows, and 24 more variables: Response <chr>,
# Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
# Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
# Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
# High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
# Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
# TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>, ...
```

group_by with mutate - just add data

We can also use `mutate` to calculate the mean value for each year and add it as a column:

```
yts %>%  
  group_by(YEAR) %>%  
  mutate(year_avg = mean(Data_Value, na.rm = TRUE)) %>%  
  select(LocationDesc, Data_Value, year_avg)
```

```
# A tibble: 9,794 × 4
```

```
# Groups:   YEAR [17]
```

	YEAR	LocationDesc	Data_Value	year_avg
	<dbl>	<chr>	<dbl>	<dbl>
1	2015	Arizona	NA	15.2
2	2015	Arizona	NA	15.2
3	2015	Arizona	NA	15.2
4	2015	Arizona	NA	15.2
5	2015	Arizona	NA	15.2
6	2015	Arizona	NA	15.2
7	2015	Arizona	3.2	15.2
8	2015	Arizona	3.2	15.2
9	2015	Arizona	3.1	15.2
10	2015	Arizona	12.5	15.2

```
# ... with 9,784 more rows
```


Counting

There are other functions, such as `n()` count the number of observations.

```
yts %>%  
  group_by(YEAR) %>%  
  summarize(n = n(),  
            mean = mean(Data_Value, na.rm = TRUE))
```

```
# A tibble: 17 × 3  
  YEAR      n  mean  
  <dbl> <int> <dbl>  
1  1999   372  26.1  
2  2000  1224  26.7  
3  2001   426  23.4  
4  2002  1016  25.2  
5  2003   498  21.3  
6  2004   611  20.7  
7  2005   636  21.8  
8  2006   518  21.8  
9  2007   516  20.0  
10 2008   483  18.2  
11 2009   686  18.3  
12 2010   447  17.8  
13 2011   521  17.8  
14 2012   244  15.5  
15 2013   685  16.7  
16 2014   334  15.7  
17 2015   577  15.2
```

Lab Part 2

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Preview: plotting

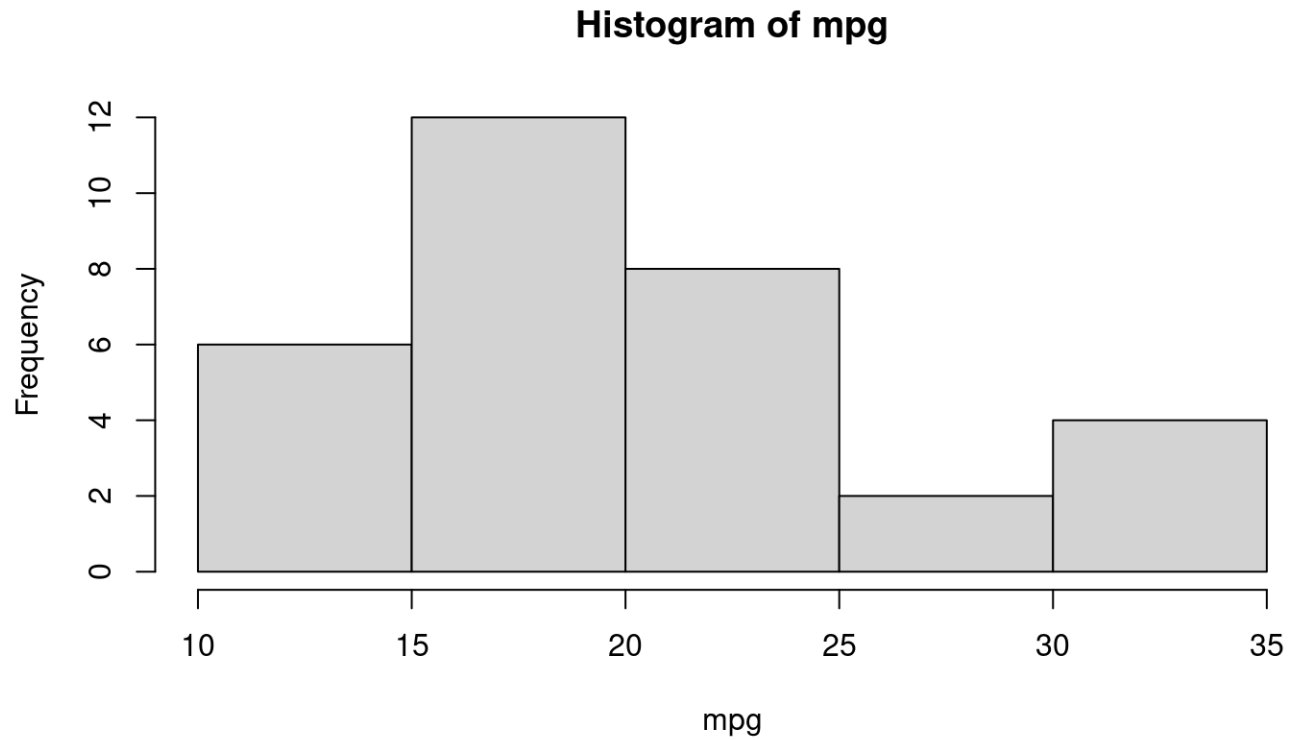
Basic Plots

Plotting is an important component of exploratory data analysis. These are some rough plots that you can use in real time while exploring your data. We will go over formatting and making plots look nicer in additional lectures.

- Basic summarization plots:
 - `hist(x)`: histogram of x
 - `plot(x, y)`: scatterplot of x and y
 - `boxplot(y~x)`: boxplot of y against levels of x

Histogram

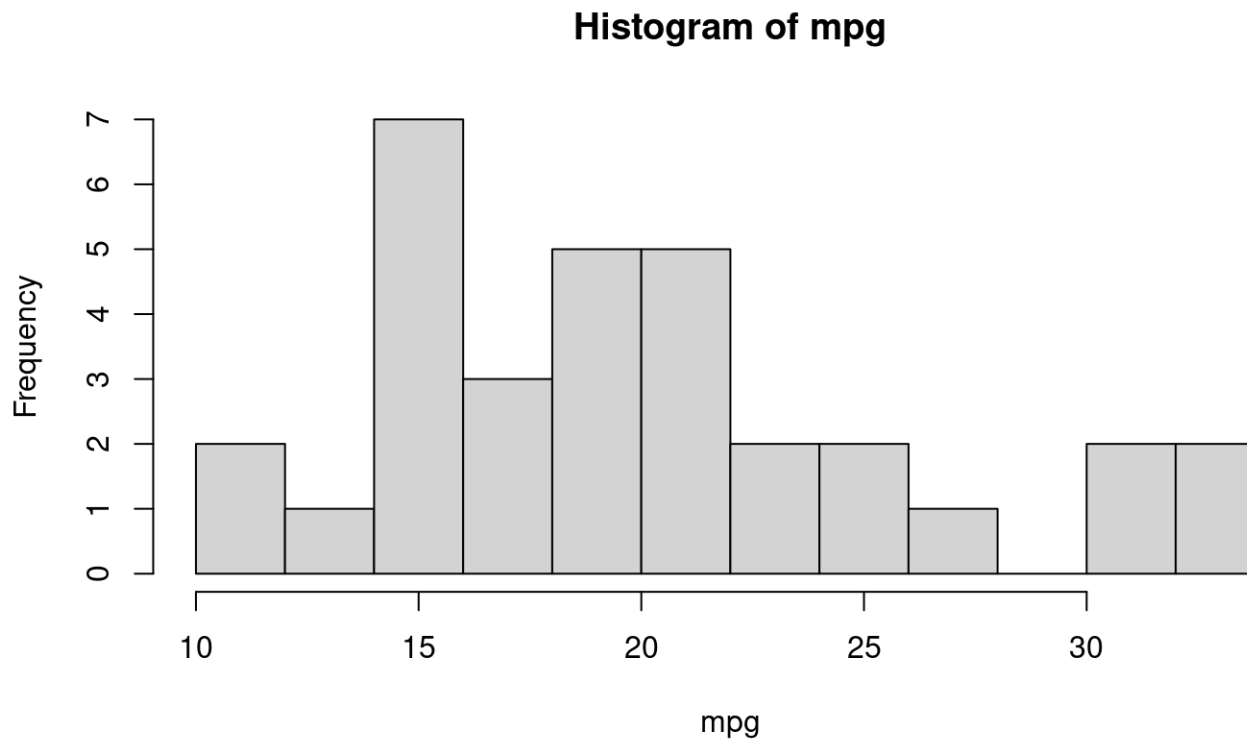
```
mpg <- jhu_cars %>% pull(mpg)  
hist(x = mpg)
```



Histogram

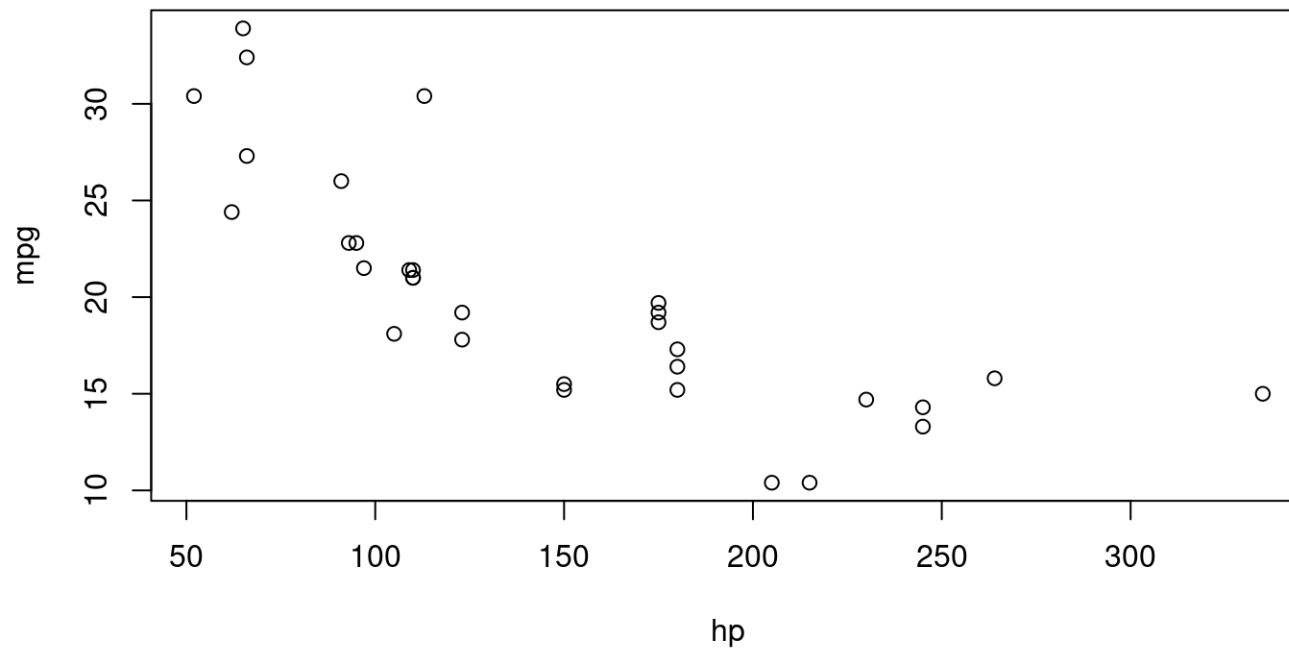
Use the `breaks` = argument to tweak the resolution:

```
hist(x = mpg, breaks = 10)
```



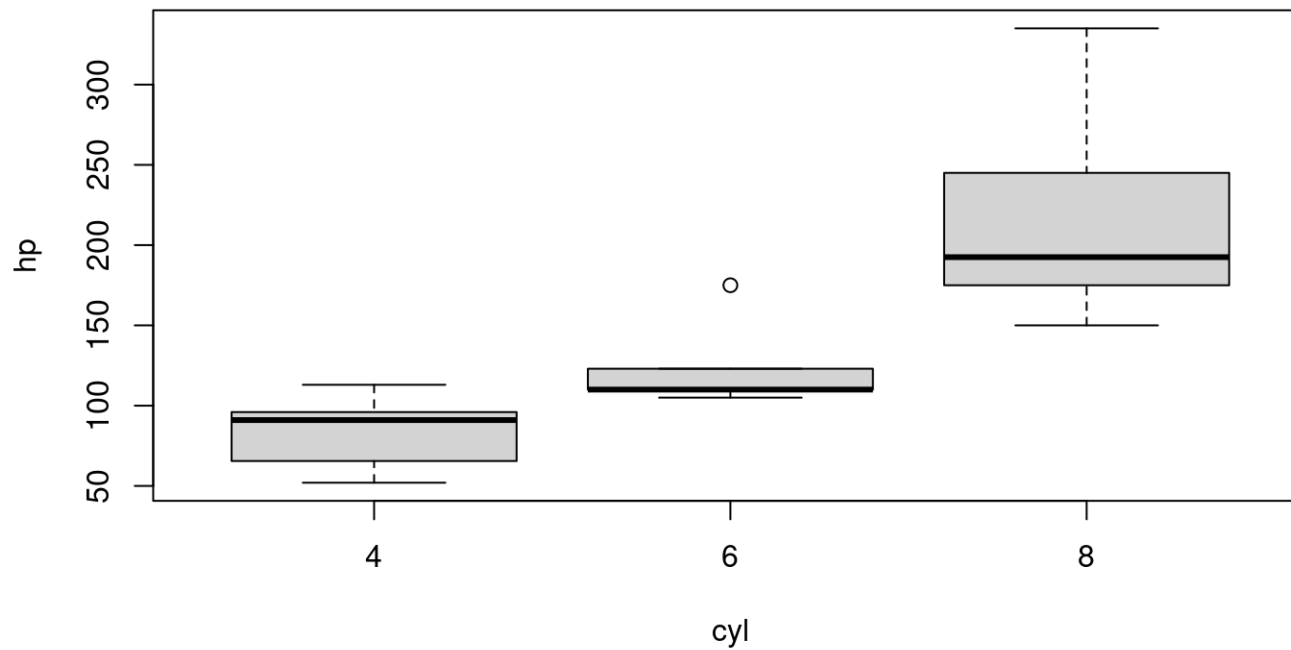
Scatterplot

```
mpg <- jhu_cars %>% pull(mpg)
hp <- jhu_cars %>% pull(hp)
plot(x = hp, y = mpg) # plot(hp, mpg)
```



Boxplot

```
cyl <- jhu_cars %>% pull(cyl)  
hp <- jhu_cars %>% pull(hp)  
boxplot(formula = hp ~ cyl)
```



Summary

- summary stats (`mean()`) work with `pull()`
- `summary(x)`: quantile information
- `summarize`: creates a summary table of columns of interest
 - combine with `across()` to programmatically select columns
- `count(x)`: what unique values do you have?
 - `pull() + table()`
 - `unique()` combined with `length()`
- `group_by()`: changes all subsequent functions
 - combine with `summarize()` to get statistics per group
- `plot()` and `hist()` are great for a **quick snapshot** of the data

Lab Part 3

▮ [Class Website](#)

▮ [Lab](#)