Data Summarization

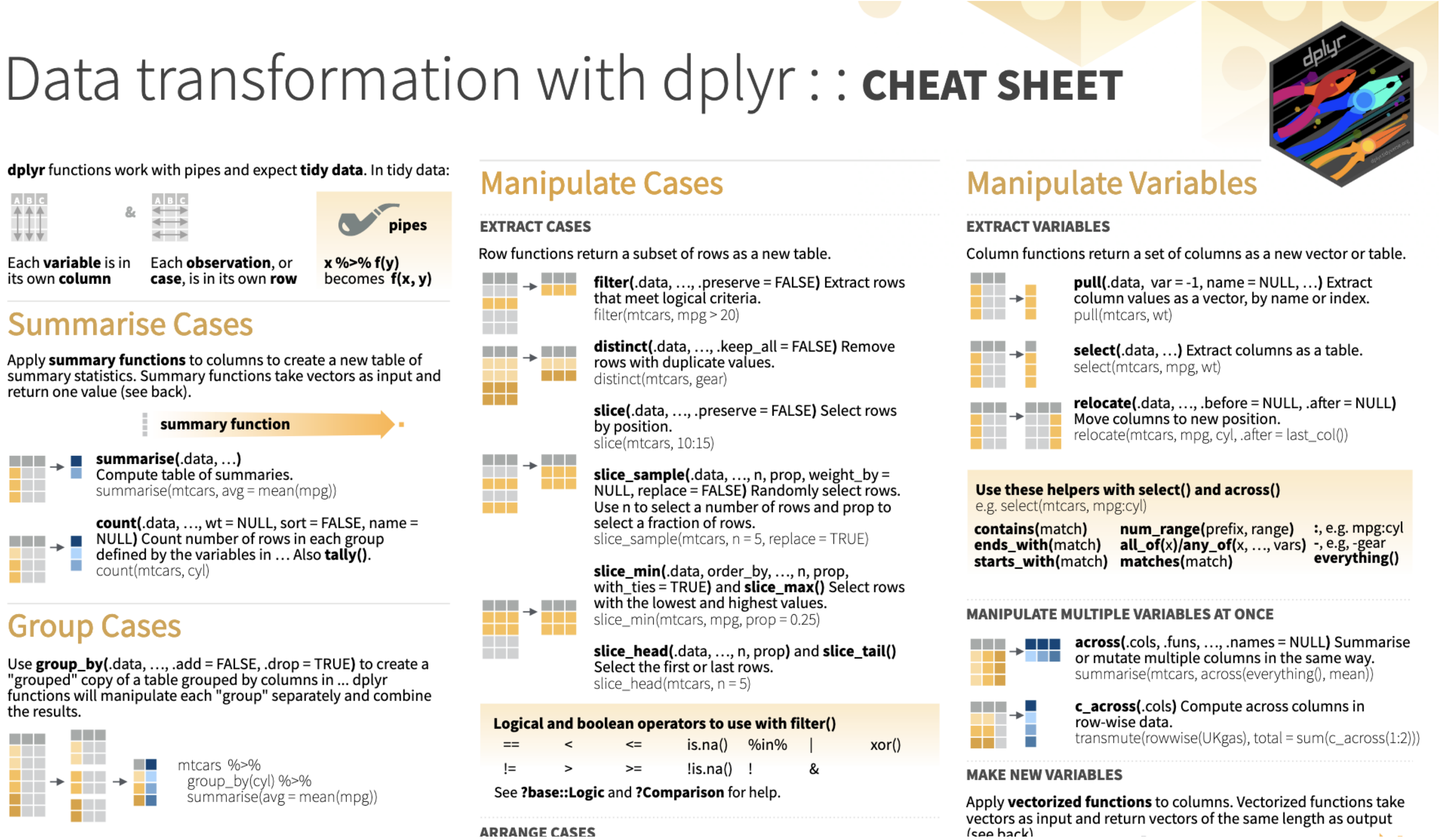
Recap

- `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 `!` mark (`!col_name`)
- you can do sequential steps: especially using pipes `%>%`

Cheatsheet

Another Cheatsheet

https://raw.githubusercontent.com/rstudio/cheatsheets/main/data-transformation.pdf



Data transformation with dplyr : : CHEAT SHEET

dplyr functions work with pipes and expect **tidy data**. In tidy data:

Each **variable** is in its own **column** & Each **observation**, or **case**, is in its own **row**

x %>% f(y) becomes **f(x, y)**

Summarise Cases

Apply **summary functions** to columns to create a new table of summary statistics. Summary functions take vectors as input and return one value (see back).

summarise(.data, …**)** Compute table of summaries.
summarise(mtcars, avg = mean(mpg))

count(.data, …, wt = NULL, sort = FALSE, name = NULL**)** Count number of rows in each group defined by the variables in … Also **tally()**.
count(mtcars, cyl)

Group Cases

Use **group_by(**.data, …, .add = FALSE, .drop = TRUE**)** to create a "grouped" copy of a table grouped by columns in ... dplyr functions will manipulate each "group" separately and combine the results.

```
mtcars %>%
  group_by(cyl) %>%
  summarise(avg = mean(mpg))
```

Manipulate Cases

EXTRACT CASES

Row functions return a subset of rows as a new table.

filter(.data, …, .preserve = FALSE**)** Extract rows that meet logical criteria.
filter(mtcars, mpg > 20)

distinct(.data, …, .keep_all = FALSE**)** Remove rows with duplicate values.
distinct(mtcars, gear)

slice(.data, …, .preserve = FALSE**)** Select rows by position.
slice(mtcars, 10:15)

slice_sample(.data, …, n, prop, weight_by = NULL, replace = FALSE**)** Randomly select rows. Use n to select a number of rows and prop to select a fraction of rows.
slice_sample(mtcars, n = 5, replace = TRUE)

slice_min(.data, order_by, …, n, prop, with_ties = TRUE**)** and **slice_max()** Select rows with the lowest and highest values.
slice_min(mtcars, mpg, prop = 0.25)

slice_head(.data, …, n, prop**)** and **slice_tail()** Select the first or last rows.
slice_head(mtcars, n = 5)

Logical and boolean operators to use with filter()

==	<	<=	is.na()	%in%	|	xor()
!=	>	>=	!is.na()	!	&	

See **?base::Logic** and **?Comparison** for help.

ARRANGE CASES

Manipulate Variables

EXTRACT VARIABLES

Column functions return a set of columns as a new vector or table.

pull(.data, var = -1, name = NULL, …**)** Extract column values as a vector, by name or index.
pull(mtcars, wt)

select(.data, …**)** Extract columns as a table.
select(mtcars, mpg, wt)

relocate(.data, …, .before = NULL, .after = NULL**)** Move columns to new position.
relocate(mtcars, mpg, cyl, .after = last_col())

Use these helpers with select() and across()
e.g. select(mtcars, mpg:cyl)

contains(match**)**	**num_range(**prefix, range**)**	**:**, e.g. mpg:cyl
ends_with(match**)**	**all_of(**x**)/any_of(**x, …, vars**)**	**-**, e.g, -gear
starts_with(match**)**	**matches(**match**)**	**everything()**

MANIPULATE MULTIPLE VARIABLES AT ONCE

across(.cols, .funs, …, .names = NULL**)** Summarise or mutate multiple columns in the same way.
summarise(mtcars, across(everything(), mean))

c_across(.cols**)** Compute across columns in row-wise data.
transmute(rowwise(UKgas), total = sum(c_across(1:2)))

MAKE NEW VARIABLES

Apply **vectorized functions** to columns. Vectorized functions take vectors as input and return vectors of the same length as output (see back)

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.

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

```
[1] 27
```

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

```
[1] 2
```

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

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

Some examples

We can use the `mtcars` built-in dataset. “The data was extracted from the 1974 Motor Trend US magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973-74 models).”

The `head` command displays the first rows of an object:

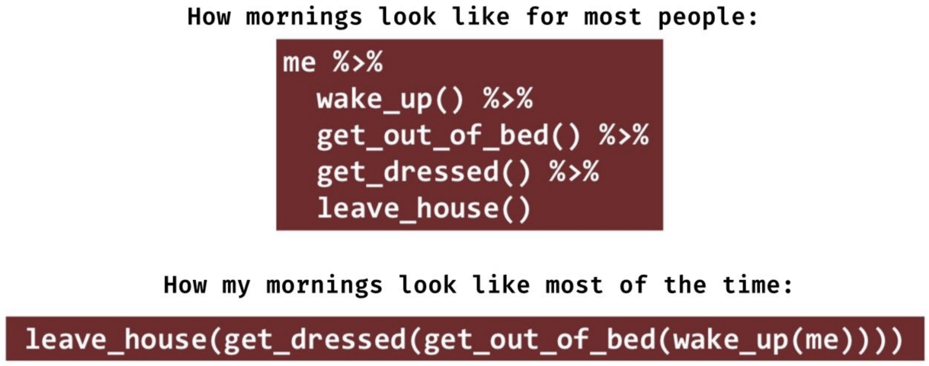
```
head(mtcars)
```

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

The `dplyr` pipe `%>%` operator

A nice and readable way to chain together multiple R functions.

Changes `f(x, y)` to `x %>% f(y)`.



How mornings look like for most people:

```
me %>%
  wake_up() %>%
  get_out_of_bed() %>%
  get_dressed() %>%
  leave_house()
```

How my mornings look like most of the time:

```
leave_house(get_dressed(get_out_of_bed(wake_up(me))))
```

Statistical summarization the “tidy” way

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

```
[1] 146.6875
```

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

```
[1] 3.325
```

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

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

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

```
 60%
3.44
```

Behavior of `pull()` function

`pull()` converts a single data column into a vector. This allows you to run summary functions on these data. Once you have “pulled” the data column out, you don’t have to name it again in any piped summary functions.

```
cars_wt <- mtcars %>% pull(wt)
class(cars_wt)
```

```
[1] "numeric"
```

```
cars_wt
```

```
 [1] 2.620 2.875 2.320 3.215 3.440 3.460 3.570 3.190 3.150 3.440 3.440 4.070
[13] 3.730 3.780 5.250 5.424 5.345 2.200 1.615 1.835 2.465 3.520 3.435 3.840
[25] 3.845 1.935 2.140 1.513 3.170 2.770 3.570 2.780
```

```
mtcars %>% pull(wt) %>% range(wt) # Incorrect
```

```
mtcars %>% pull(wt) %>% range() # Correct
```

```
[1] 1.513 5.424
```

GUT CHECK

What kind of object do we need to run summary operators like `mean()` ?

A. A vector of numbers

B. A vector of characters

C. A dataset

Summarization on tibbles (data frames)

TB incidence

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

“Tuberculosis incidence, all forms (per 100,000 population per year), for the period 1990-2007 across 208 countries/territories.”

```
tb <- read_csv("https://jhudatascience.org/intro_to_r/data/tb.csv")
```

TB incidence

Check out the data:

```
head(tb)
```

```
# A tibble: 6 × 19
  TB incidence, all fo…¹ `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
# ℹ abbreviated name:
#   ¹`TB incidence, all forms (per 100 000 population per year)`
# ℹ 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)
```

```
spc_tbl_ [208 × 19] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
 $ TB incidence, all forms (per 100 000 population per year): chr [1:208] "Afghanistan" "Albani
 $ 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
 - attr(*, "spec")=
  .. cols(
  ..   `TB incidence, all forms (per 100 000 population per year)` = col_character(),
  ..   `1990` = col_double(),
  ..   `1991` = col_double(),
```

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.

```
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.

Can run multiple summary statistics at once (unlike `pull()` which can only do a single calculation on one column).

You can also do more elaborate summaries across different groups of data using `group_by()`. More on this later!

```
# General format - Not the code!
{data to use} %>%
   summarize({summary column name} = {function(source column)},
             {summary column name} = {function(source column)})
```

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} = {function(source column)})
```

```
tb %>%
  summarize(mean_1991 = mean(`1991`)) # Note the backticks, this is a column name!
```

```
# A tibble: 1 × 1
  mean_1991
      <dbl>
1        NA
```

```
tb %>%
  summarize(mean_1991 = mean(`1991`, na.rm = TRUE))
```

```
# A tibble: 1 × 1
  mean_1991
      <dbl>
1      108.
```

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

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

```
tb %>%
  summarize(mean_1991 = mean(`1991`, na.rm = TRUE),
            median_1991 = median(`1991`, na.rm = TRUE),
            median(`2000`, na.rm = TRUE))
```

```
# A tibble: 1 × 3
  mean_1991 median_1991 `median(\`2000\`, na.rm = TRUE)`
      <dbl>       <dbl>                            <dbl>
1      108.          58                               60
```

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_1991 = mean(`1991`, na.rm = TRUE),
            median_1991 = median(`1991`, na.rm = TRUE),
            median_2000 = median(`2000`, na.rm = TRUE))
```

```
# A tibble: 1 × 3
  mean_1991 median_1991 median_2000
      <dbl>       <dbl>       <dbl>
1      108.          58          60
```

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

Note that `summarize()` creates a separate tibble from the original data, so you don’t want to overwrite your original data if you decide to save the summary.

If you want to save a summary statistic in the original data, use `mutate()` instead to create a new column for the summary statistic.

`summary()` Function

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

```
summary(tb)
```

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

Summary & Lab Part 1

- `pull()` creates a *vector*
- don’t forget the `na.rm = TRUE` argument!
- `summary(x)`: quantile information
- `summarize`: creates a summary table of columns of interest
- summary stats (`mean()`) work with vectors or with `summarize()`

Class Website

Lab

Day 4 Cheatsheet

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

- Check out the data at: https://catalog.data.gov/dataset/youth-tobacco-survey-yts-data

```
yts <- read_csv("http://jhudatascience.org/intro_to_r/data/Youth_Tobacco_Survey_YTS_Data.csv")
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
# ℹ 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>, …
```

distinct() values

distinct(x) will return the unique elements of column x.

```
yts %>%
  distinct(LocationDesc)
```

```
# A tibble: 50 × 1
   LocationDesc
   <chr>
 1 Arizona
 2 Connecticut
 3 Georgia
 4 Hawaii
 5 Illinois
 6 Louisiana
 7 Mississippi
 8 Utah
 9 Missouri
10 National (States and DC)
# ℹ 40 more rows
```

How many `distinct()` values?

`n_distinct()` tells you the number of unique elements. It needs a vector so you *must pull the column first!*

```
yts %>%
  pull(LocationDesc) %>%
  n_distinct()
```

```
[1] 50
```

Use `count()` to return row count per category.

Use `count` to return a frequency table of unique elements of a data.frame.

```
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
# ℹ 40 more rows
```

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
# ℹ 136 more rows
```

Note: `count()` includes NAs

GUT CHECK

The `count()` function can help us tally:

A. Sample size

B. Rows per each category

C. How many categories

Grouping

Goal

We want to find the average frequency that youth use tobacco products in the dataset.

How do we do this?

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
# ℹ 9,784 more rows
# ℹ 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>, …
```

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       
# ℹ 9,784 more rows
# ℹ 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>, …
```

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 
```

Do it in one step: use %>% 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
```

Group by as many variables as you want

`group_by` Response and Education:

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

```
# A tibble: 8 × 4
# Groups:   Response [4]
  Response Education     avg_percent max_percent
  <chr>    <chr>               <dbl>       <dbl>
1 Current  High School         14.1         40.6
2 Current  Middle School        5.73        26.1
3 Ever     High School         34.7         96.2
4 Ever     Middle School       18.6         98
5 Frequent High School          5.91        23.9
6 Frequent Middle School        1.33         8
7 <NA>     High School         53.8         78.9
8 <NA>     Middle School       53.2         81.9
```

Only the last `group_by` is recognized…

You can overwrite the first `group_by` with a new one.

```
yts %>%
  group_by(Response, Education)  %>%
  group_by(Education)
```

```
# A tibble: 9,794 × 31
# Groups:   Education [2]
    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       
# ℹ 9,784 more rows
# ℹ 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>, …
```

Ungroup the data

The `ungroup` function will allow you to clear the groups from the data.

```
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
# ℹ 9,784 more rows
# ℹ 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>, …
```

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
# ℹ 9,784 more rows
```

Counting

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

```
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
```

Counting

`count()` and `n()` can give very similar information.

```
yts %>% count(YEAR) %>% head(n = 3)
```

```
# A tibble: 3 × 2
   YEAR     n
  <dbl> <int>
1  1999   372
2  2000  1224
3  2001   426
```

```
yts %>% group_by(YEAR) %>% summarize(n = n()) %>% head(n = 3) # n() typically used with summarize
```

```
# A tibble: 3 × 2
   YEAR     n
  <dbl> <int>
1  1999   372
2  2000  1224
3  2001   426
```

A few miscellaneous topics

Base R functions you might see: **`length`** and **`unique`**

These functions require a column as a vector using `pull()`.

```
yts_loc <- yts %>% pull(LocationDesc) # pull() to make a vector
yts_loc %>% unique() # similar to distinct()
```

```
 [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"
```

Base R functions you might see: `length` and `unique`

These functions require a column as a vector using `pull()`.

```r
yts_loc %>% unique() %>% length() # similar to n_distinct()
```

```
[1] 50
```

`summary()` vs. `summarize()`

- `summary()` (base R) gives statistics table on a dataset.
- `summarize()` (dplyr) creates a more customized summary tibble/dataframe.

Functions you might also see

- `rowwise`()`: functions will compute results for each row
- `sum(!is.na())`: # of non-NAs in the data
- `first()`: first value in the data
- `last()`: last value in the data
- `range()`: minimum and maximum of the data
- `IQR()`: interquartile range of the data

Summary & Lab Part 2

- `count(x)`: what unique values do you have?
  - `distinct()`: what are the distinct values?
  - `n_distinct()` with `pull()`: how many distinct values?
- `group_by()`: changes subsequent functions (remove with `ungroup()`)
  - combine with `summarize()` to get statistics per group
  - combine with `mutate()` to add column
- `summarize()` with `n()` gives the count (NAs included)

Class Website

Lab

Day 4 Cheatsheet

Image by Gerd Altmann from Pixabay

Extra Slides: More advanced summarization

Data Summarization on data frames

- Statistical summarization across the data frame
  - `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

`rowMeans()` example

Get means for each row.

Let’s see what the mean TB incidence is across years each row (country):

```
tb %>%
  select(starts_with("year")) %>%
  rowMeans(na.rm = TRUE) %>%
  head(n = 5)
```

```
[1] NaN NaN NaN NaN NaN
```

```
tb %>%
  group_by(country) %>%
  summarize(mean = rowMeans(across(starts_with("year")), na.rm = TRUE)) %>%
  head(n = 5)
```

```
# A tibble: 5 × 2
  country         mean
  <chr>          <dbl>
1 Afghanistan      NaN
2 Albania          NaN
3 Algeria          NaN
4 American Samoa   NaN
5 Andorra          NaN
```

`colMeans()` example

Get means for each column.

Let’s see what the mean is across each column (year):

```
tb %>%
  select(starts_with("year")) %>%
  colMeans(na.rm = TRUE) %>%
  head(n = 5)
```

```
numeric(0)
```

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

```
# A tibble: 1 × 0
```

* New! * Many dplyr functions now have a `.by=` argument

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))
```

is the same as..

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