

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).

summary function



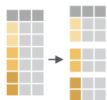
summarise(.data, ...)
Compute table of summaries.
`summarise(mtcars, avg = mean(mpg))`



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))`

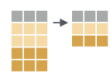
Manipulate Cases

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()

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

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. <code>mpg:cyl</code>
ends_with(match)	all_of(x)/any_of(x, ..., vars)	∴ e.g. <code>-gear</code>
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.

```
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 `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
#   abbreviated name:
#   1`TB incidence, all forms (per 100 000 population per year)`
#   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)
```

```
spec_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" "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
 - 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	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

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 info about the data at: <https://www.cdc.gov/tobacco/about-data/surveys/national-youth-tobacco-survey.html>

```
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

```
# 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)  
#   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

```
#   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

```
#   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

```
#   9,784 more rows
```

```
#   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

```
#   9,784 more rows
```

```
#   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:

```
yt$ %>%  
  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... Cigarette... Smoking St... YTS
8  2015 AZ        Arizona    Tobacco Use... Cigarette... Smoking St... YTS
9  2015 AZ        Arizona    Tobacco Use... Cigarette... Smoking St... YTS
10 2015 AZ        Arizona    Tobacco Use... Cigarette... Smoking St... YTS
#   9,784 more rows
#   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

```
#   9,784 more rows
```

```
#   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

```
#   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()`.

```
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

- `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)

Resources & Lab Part 2

- ▮ [Class Website](#)
- ▮ [Lab](#)
- ▮ [Day 4 Cheatsheet](#)
- ▮ [Posit's data transformation Cheatsheet](#)



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**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:

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

is the same as..

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