

Intro to R

Manipulating Data in R

Recap of Data Cleaning

- `is.na()`, `any(is.na())`, `count()`, and functions from `naniar` like `gg_miss_var()` can help determine if we have NA values
- `filter()` automatically removes NA values - can't confirm or deny if condition is met (need `| is.na()` to keep them)
- `drop_na()` can help you remove NA values from a variable or an entire data frame
- NA values can change your calculation results
- think about what NA values represent

Recap of Data Cleaning

- `recode()` can help with simple recoding (not based on condition but simple swap)
- `case_when()` can recode **entire values** based on conditions
 - remember `case_when()` needs `TRUE ~ variable` to keep values that aren't specified by conditions, otherwise will be `NA`
- `stringr` package has great functions for looking for specific **parts of values** especially `filter()` and `str_detect()` combined
 - also has other useful string manipulation functions like `str_replace()` and more!
 - `separate()` can split columns into additional columns
 - `unite()` can combine columns
- [Day 5 Cheatsheet](#)

Manipulating Data

In this module, we will show you how to:

1. Reshape data from wide to long
2. Reshape data from long to wide
3. Merge Data/Joins

What is wide/long data?

<https://github.com/gadenbuie/tidyexplain/blob/main/images/tidyr-pivoting.gif>

wide

| id | x | y | z |
|----|---|---|---|
| 1 | a | c | e |
| 2 | b | d | f |

What is wide/long data?

Data is stored *differently* in the tibble.

Wide: has many columns

```
# A tibble: 1 × 4
  State    June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>    <chr>           <chr>         <chr>
1 Alabama 37.2%           36.0%         32.4%
```

Long: column names become data

```
# A tibble: 3 × 3
  State    name          value
  <chr>    <chr>         <chr>
1 Alabama June_vacc_rate 37.2%
2 Alabama May_vacc_rate  36.0%
3 Alabama April_vacc_rate 32.4%
```

What is wide/long data?

Wide: multiple columns per individual, values spread across multiple columns

```
# A tibble: 2 × 4
```

| | State | June_vacc_rate | May_vacc_rate | April_vacc_rate |
|---|---------|----------------|---------------|-----------------|
| | <chr> | <chr> | <chr> | <chr> |
| 1 | Alabama | 37.2% | 36.0% | 32.4% |
| 2 | Alaska | 47.5% | 46.2% | 41.7% |

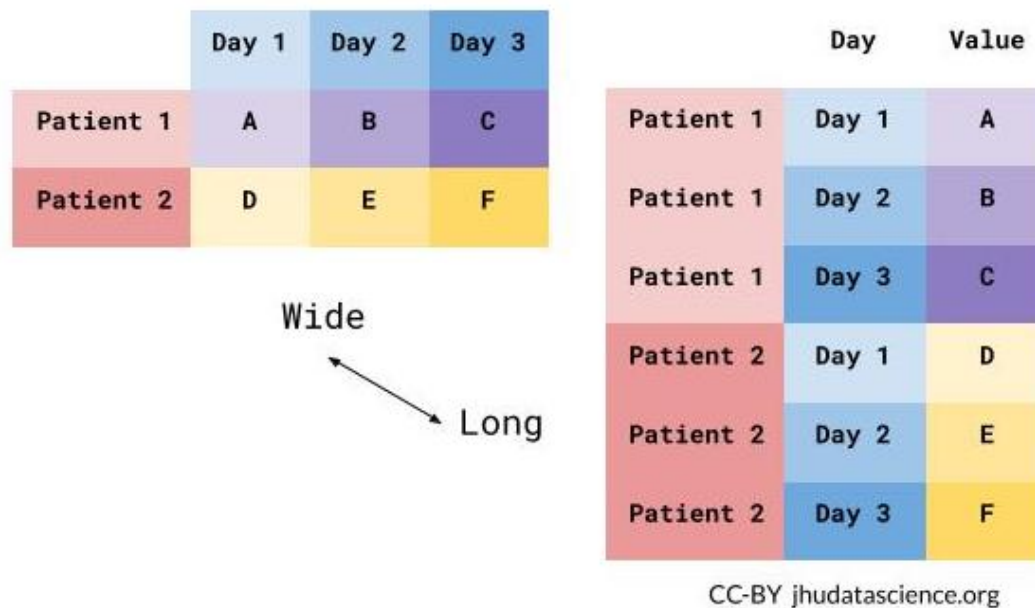
Long: multiple rows per observation, a single column contains the values

```
# A tibble: 6 × 3
```

| | State | name | value |
|---|---------|-----------------|-------|
| | <chr> | <chr> | <chr> |
| 1 | Alabama | June_vacc_rate | 37.2% |
| 2 | Alabama | May_vacc_rate | 36.0% |
| 3 | Alabama | April_vacc_rate | 32.4% |
| 4 | Alaska | June_vacc_rate | 47.5% |
| 5 | Alaska | May_vacc_rate | 46.2% |
| 6 | Alaska | April_vacc_rate | 41.7% |

What is wide/long data?

Data is wide or long **with respect to** certain variables.



Why do we need to switch between wide/long data?

Wide: **Easier for humans to read**

```
# A tibble: 2 × 4
  State    June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>    <chr>          <chr>          <chr>
1 Alabama 37.2%          36.0%          32.4%
2 Alaska 47.5%          46.2%          41.7%
```

Long: **Easier for R to make plots & do analysis**

```
# A tibble: 6 × 3
  State    name          value
  <chr>    <chr>          <chr>
1 Alabama June_vacc_rate 37.2%
2 Alabama May_vacc_rate  36.0%
3 Alabama April_vacc_rate 32.4%
4 Alaska  June_vacc_rate 47.5%
5 Alaska  May_vacc_rate  46.2%
6 Alaska  April_vacc_rate 41.7%
```

Pivoting using **tidyr** package

`tidyr` allows you to “tidy” your data. We will be talking about:

- `pivot_longer` - make multiple columns into variables, (wide to long)
- `pivot_wider` - make a variable into multiple columns, (long to wide)
- `separate` - string into multiple columns (review)

The `reshape` command exists. It is a **confusing** function. Don't use it.

You might see old functions `gather` and `spread` when googling. These are the old names for `pivot_longer` and `pivot_wider`, respectively.

pivot_longer...

Reshaping data from **wide** to **long**

`pivot_longer()` - puts column data into rows (`tidyr` package)

- First describe which columns we want to “pivot_longer”

```
{long_data} <- {wide_data} %>% pivot_longer(cols = {columns to pivot})
```

Reshaping data from wide to long

```
wide_data
```

```
# A tibble: 1 × 3  
  June_vacc_rate May_vacc_rate April_vacc_rate  
  <chr>          <chr>          <chr>  
1 37.2%          36.0%          32.4%
```

```
long_data <- wide_data %>% pivot_longer(cols = everything())  
long_data
```

```
# A tibble: 3 × 2  
  name          value  
  <chr>         <chr>  
1 June_vacc_rate 37.2%  
2 May_vacc_rate  36.0%  
3 April_vacc_rate 32.4%
```

Reshaping data from wide to long

`pivot_longer()` - puts column data into rows (tidyr package)

- First describe which columns we want to “pivot_longer”
- `names_to` = gives a new name to the pivoted columns
- `values_to` = gives a new name to the values that used to be in those columns

```
{long_data} <- {wide_data} %>% pivot_longer(cols = {columns to pivot},  
                                             names_to = {New column name: contains old column names},  
                                             values_to = {New column name: contains cell values})
```

Reshaping data from wide to long

wide_data

```
# A tibble: 1 × 3
  June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>          <chr>          <chr>
1 37.2%          36.0%          32.4%
```

```
long_data <- wide_data %>% pivot_longer(cols = everything(),
                                         names_to = "Month",
                                         values_to = "Rate")
```

long_data

```
# A tibble: 3 × 2
  Month      Rate
  <chr>      <chr>
1 June_vacc_rate 37.2%
2 May_vacc_rate  36.0%
3 April_vacc_rate 32.4%
```

Data used: Charm City Circulator

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

```
library(jhur)
circ <- read_circulator()
head(circ, 5)
```

```
# A tibble: 5 × 15
```

| | day | date | orangeBoardings | orangeAlightings | orangeAverage | purpleBoardings |
|---|-----------|---------|-----------------|------------------|---------------|-----------------|
| | <chr> | <chr> | <dbl> | <dbl> | <dbl> | <dbl> |
| 1 | Monday | 01/1... | 877 | 1027 | 952 | |
| 2 | Tuesday | 01/1... | 777 | 815 | 796 | |
| 3 | Wednesday | 01/1... | 1203 | 1220 | 1212. | |
| 4 | Thursday | 01/1... | 1194 | 1233 | 1214. | |
| 5 | Friday | 01/1... | 1645 | 1643 | 1644 | |

```
# ... with 9 more variables: purpleAlightings <dbl>, purpleAverage <dbl>,
#   greenBoardings <dbl>, greenAlightings <dbl>, greenAverage <dbl>,
#   bannerBoardings <dbl>, bannerAlightings <dbl>, bannerAverage <dbl>,
#   daily <dbl>
```


Reshaping data from wide to long

```
long <- circ %>%  
  pivot_longer(starts_with(c("orange", "purple", "green", "banner")))  
long
```

```
# A tibble: 13,752 × 5  
  day      date      daily name      value  
  <chr>   <chr>    <dbl> <chr>    <dbl>  
1 Monday 01/11/2010    952 orangeBoardings    877  
2 Monday 01/11/2010    952 orangeAlightings  1027  
3 Monday 01/11/2010    952 orangeAverage      952  
4 Monday 01/11/2010    952 purpleBoardings    NA  
5 Monday 01/11/2010    952 purpleAlightings    NA  
6 Monday 01/11/2010    952 purpleAverage      NA  
7 Monday 01/11/2010    952 greenBoardings     NA  
8 Monday 01/11/2010    952 greenAlightings     NA  
9 Monday 01/11/2010    952 greenAverage       NA  
10 Monday 01/11/2010    952 bannerBoardings    NA  
# ... with 13,742 more rows
```

Reshaping data from wide to long

There are many ways to select the columns we want. Use `?tidyr_tidy_select` to look at more column selection options.

```
long <- circ %>%  
  pivot_longer( !c(day, date, daily))  
long
```

```
# A tibble: 13,752 × 5  
   day      date      daily name      value  
   <chr>   <chr>    <dbl> <chr>    <dbl>  
1 Monday 01/11/2010    952 orangeBoardings    877  
2 Monday 01/11/2010    952 orangeAlightings  1027  
3 Monday 01/11/2010    952 orangeAverage      952  
4 Monday 01/11/2010    952 purpleBoardings    NA  
5 Monday 01/11/2010    952 purpleAlightings    NA  
6 Monday 01/11/2010    952 purpleAverage      NA  
7 Monday 01/11/2010    952 greenBoardings     NA  
8 Monday 01/11/2010    952 greenAlightings     NA  
9 Monday 01/11/2010    952 greenAverage       NA  
10 Monday 01/11/2010    952 bannerBoardings    NA  
# ... with 13,742 more rows
```

Reshaping data from wide to long

```
long %>% count(name)
```

```
# A tibble: 12 × 2
```

| | name <chr> | n <int> |
|----|------------------|------------|
| 1 | bannerAlightings | 1146 |
| 2 | bannerAverage | 1146 |
| 3 | bannerBoardings | 1146 |
| 4 | greenAlightings | 1146 |
| 5 | greenAverage | 1146 |
| 6 | greenBoardings | 1146 |
| 7 | orangeAlightings | 1146 |
| 8 | orangeAverage | 1146 |
| 9 | orangeBoardings | 1146 |
| 10 | purpleAlightings | 1146 |
| 11 | purpleAverage | 1146 |
| 12 | purpleBoardings | 1146 |

Cleaning up long data

We will use `str_replace` from the `stringr` package to put `_` in the names

```
long <- long %>% mutate(  
  name = str_replace(name, "Board", "_Board"),  
  name = str_replace(name, "Alight", "_Alight"),  
  name = str_replace(name, "Average", "_Average")  
)  
long
```

A tibble: 13,752 × 5

| | day | date | daily | name | value |
|----|--------|------------|-------|-------------------|-------|
| | <chr> | <chr> | <dbl> | <chr> | <dbl> |
| 1 | Monday | 01/11/2010 | 952 | orange_Boardings | 877 |
| 2 | Monday | 01/11/2010 | 952 | orange_Alightings | 1027 |
| 3 | Monday | 01/11/2010 | 952 | orange_Average | 952 |
| 4 | Monday | 01/11/2010 | 952 | purple_Boardings | NA |
| 5 | Monday | 01/11/2010 | 952 | purple_Alightings | NA |
| 6 | Monday | 01/11/2010 | 952 | purple_Average | NA |
| 7 | Monday | 01/11/2010 | 952 | green_Boardings | NA |
| 8 | Monday | 01/11/2010 | 952 | green_Alightings | NA |
| 9 | Monday | 01/11/2010 | 952 | green_Average | NA |
| 10 | Monday | 01/11/2010 | 952 | banner_Boardings | NA |

... with 13,742 more rows

Cleaning up long data

Now each `var` is Boardings, Averages, or Alightings. We use “`into =`” to name the new columns and “`sep =`” to show where the separation should happen.

```
long <- long %>%  
  separate(name, into = c("line", "type"), sep = "_")  
long
```

```
# A tibble: 13,752 × 6
```

| | day <chr> | date <chr> | daily <dbl> | line <chr> | type <chr> | value <dbl> |
|----|--------------|---------------|----------------|---------------|---------------|----------------|
| 1 | Monday | 01/11/2010 | 952 | orange | Boardings | 877 |
| 2 | Monday | 01/11/2010 | 952 | orange | Alightings | 1027 |
| 3 | Monday | 01/11/2010 | 952 | orange | Average | 952 |
| 4 | Monday | 01/11/2010 | 952 | purple | Boardings | NA |
| 5 | Monday | 01/11/2010 | 952 | purple | Alightings | NA |
| 6 | Monday | 01/11/2010 | 952 | purple | Average | NA |
| 7 | Monday | 01/11/2010 | 952 | green | Boardings | NA |
| 8 | Monday | 01/11/2010 | 952 | green | Alightings | NA |
| 9 | Monday | 01/11/2010 | 952 | green | Average | NA |
| 10 | Monday | 01/11/2010 | 952 | banner | Boardings | NA |

```
# ... with 13,742 more rows
```

pivot_wider...

Reshaping data from **long** to **wide**

`pivot_wider()` - spreads row data into columns (`tidyr` package)

- `names_from` = the old column whose contents will be spread into multiple new column names.
- `values_from` = the old column whose contents will fill in the values of those new columns.

```
{wide_data} <- {long_data} %>%  
  pivot_wider(names_from = {Old column name: contains new column names},  
              values_from = {Old column name: contains new cell values})
```

Reshaping data from long to wide

long_data

```
# A tibble: 3 × 2
  Month      Rate
<chr>      <chr>
1 June_vacc_rate 37.2%
2 May_vacc_rate  36.0%
3 April_vacc_rate 32.4%
```

```
wide_data <- long_data %>% pivot_wider(names_from = "Month",
                                       values_from = "Rate")
```

wide_data

```
# A tibble: 1 × 3
  June_vacc_rate May_vacc_rate April_vacc_rate
<chr>          <chr>          <chr>
1 37.2%         36.0%         32.4%
```


Reshaping Charm City Circulator

long

```
# A tibble: 13,752 × 6
```

| | day <chr> | date <chr> | daily <dbl> | line <chr> | type <chr> | value <dbl> |
|----|--------------|---------------|----------------|---------------|---------------|----------------|
| 1 | Monday | 01/11/2010 | 952 | orange | Boardings | 877 |
| 2 | Monday | 01/11/2010 | 952 | orange | Alightings | 1027 |
| 3 | Monday | 01/11/2010 | 952 | orange | Average | 952 |
| 4 | Monday | 01/11/2010 | 952 | purple | Boardings | NA |
| 5 | Monday | 01/11/2010 | 952 | purple | Alightings | NA |
| 6 | Monday | 01/11/2010 | 952 | purple | Average | NA |
| 7 | Monday | 01/11/2010 | 952 | green | Boardings | NA |
| 8 | Monday | 01/11/2010 | 952 | green | Alightings | NA |
| 9 | Monday | 01/11/2010 | 952 | green | Average | NA |
| 10 | Monday | 01/11/2010 | 952 | banner | Boardings | NA |

```
# ... with 13,742 more rows
```

Reshaping Charm City Circulator

```
wide <- long %>% pivot_wider(names_from = "type",
                             values_from = "value")
wide
```

```
# A tibble: 4,584 × 7
   day      date      daily line Boardings Alightings Average
  <chr>   <chr>   <dbl> <chr>   <dbl>   <dbl>   <dbl>
1 Monday 01/11/2010  952 orange    877    1027    952
2 Monday 01/11/2010  952 purple     NA     NA     NA
3 Monday 01/11/2010  952 green     NA     NA     NA
4 Monday 01/11/2010  952 banner     NA     NA     NA
5 Tuesday 01/12/2010  796 orange    777    815    796
6 Tuesday 01/12/2010  796 purple     NA     NA     NA
7 Tuesday 01/12/2010  796 green     NA     NA     NA
8 Tuesday 01/12/2010  796 banner     NA     NA     NA
9 Wednesday 01/13/2010 1212. orange   1203   1220  1212.
10 Wednesday 01/13/2010 1212. purple     NA     NA     NA
# ... with 4,574 more rows
```

Summary

- `tidyr` package helps us convert between wide and long data
- `pivot_longer()` goes from wide -> long
 - Specify columns you want to pivot
 - Specify `names_to =` and `values_to =` for custom naming
- `pivot_wider()` goes from long -> wide
 - Specify `names_from =` and `values_from =`

Lab Part 1

[Class Website](#)

[Lab](#)

Joining in `dplyr`

- Merging/joining data sets together - usually on key variables, usually "id"
- `?join` - see different types of joining for `dplyr`
- `inner_join(x, y)` - only rows that match for x and y are kept
- `full_join(x, y)` - all rows of x and y are kept
- `left_join(x, y)` - all rows of x are kept even if not merged with y
- `right_join(x, y)` - all rows of y are kept even if not merged with x
- `anti_join(x, y)` - all rows from x not in y keeping just columns from x.

Merging: Simple Data

data_As

```
# A tibble: 2 × 3
  State      June_vacc_rate May_vacc_rate
<chr>      <chr>           <chr>
1 Alabama  37.2%              36.0%
2 Alaska   47.5%              46.2%
```

data_cold

```
# A tibble: 2 × 2
  State      April_vacc_rate
<chr>      <chr>
1 Maine    32.4%
2 Alaska   41.7%
```

Inner Join

<https://github.com/gadenbuie/tidyexplain/blob/main/images/inner-join.gif>

`inner_join(x, y)`



Inner Join

```
ij = inner_join(data_As, data_cold)
```

```
Joining, by = "State"
```

```
ij
```

```
# A tibble: 1 × 4
```

| | State | June_vacc_rate | May_vacc_rate | April_vacc_rate |
|---|--------|----------------|---------------|-----------------|
| | <chr> | <chr> | <chr> | <chr> |
| 1 | Alaska | 47.5% | 46.2% | 41.7% |

Left Join

<https://raw.githubusercontent.com/gadenbuie/tidyexplain/main/images/left-join.gif>

`left_join(x, y)`



Left Join

```
lj = left_join(data_As, data_cold)
```

```
Joining, by = "State"
```

```
lj
```

```
# A tibble: 2 × 4
```

| | State | June_vacc_rate | May_vacc_rate | April_vacc_rate |
|---|---------|----------------|---------------|-----------------|
| | <chr> | <chr> | <chr> | <chr> |
| 1 | Alabama | 37.2% | 36.0% | <NA> |
| 2 | Alaska | 47.5% | 46.2% | 41.7% |

Install **tidylog** package to log outputs

```
# install.packages("tidylog")
library(tidylog)
left_join(data_As, data_cold)
```

```
Joining, by = "State"
left_join: added one column (April_vacc_rate)
> rows only in x 1
> rows only in y (1)
> matched rows 1
> ===
> rows total 2
```

```
# A tibble: 2 × 4
  State      June_vacc_rate May_vacc_rate April_vacc_rate
  <chr>      <chr>          <chr>          <chr>
1 Alabama  37.2%           36.0%          <NA>
2 Alaska   47.5%           46.2%          41.7%
```

Right Join

<https://raw.githubusercontent.com/gadenbuie/tidyexplain/main/images/right-join.gif>

`right_join(x, y)`



Right Join

```
rj <- right_join(data_As, data_cold)
```

```
Joining, by = "State"  
right_join: added one column (April_vacc_rate)  
> rows only in x (1)  
> rows only in y 1  
> matched rows 1  
> ===  
> rows total 2
```

```
rj
```

```
# A tibble: 2 × 4  
  State   June_vacc_rate May_vacc_rate April_vacc_rate  
  <chr>   <chr>           <chr>         <chr>  
1 Alaska 47.5%           46.2%         41.7%  
2 Maine  <NA>            <NA>          32.4%
```

Left Join: Switching arguments

```
lj2 <- left_join(data_cold, data_As)
```

```
Joining, by = "State"  
left_join: added 2 columns (June_vacc_rate, May_vacc_rate)  
> rows only in x 1  
> rows only in y (1)  
> matched rows 1  
> ===  
> rows total 2
```

```
lj2
```

```
# A tibble: 2 × 4  
  State April_vacc_rate June_vacc_rate May_vacc_rate  
  <chr>   <chr>           <chr>         <chr>  
1 Maine  32.4%           <NA>         <NA>  
2 Alaska 41.7%           47.5%        46.2%
```

Full Join

<https://raw.githubusercontent.com/gadenbuie/tidyexplain/main/images/full-join.gif>

`full_join(x, y)`



FullJoin

```
fj <- full_join(data_As, data_cold)
```

```
Joining, by = "State"  
full_join: added one column (April_vacc_rate)  
> rows only in x 1  
> rows only in y 1  
> matched rows 1  
> ===  
> rows total 3
```

```
fj
```

```
# A tibble: 3 × 4  
  State    June_vacc_rate May_vacc_rate April_vacc_rate  
  <chr>    <chr>          <chr>         <chr>  
1 Alabama 37.2%          36.0%         <NA>  
2 Alaska 47.5%          46.2%         41.7%  
3 Maine  <NA>           <NA>          32.4%
```


Watch out for “includes duplicates”

data_As

```
# A tibble: 2 × 2
  State    state_bird
  <chr>    <chr>
1 Alabama wild turkey
2 Alaska  willow ptarmigan
```

data_cold

```
# A tibble: 3 × 3
  State    vacc_rate month
  <chr>    <chr>    <chr>
1 Maine  32.4%    April
2 Alaska 41.7%    April
3 Alaska 46.2%    May
```

Watch out for “includes duplicates”

```
lj <- left_join(data_As, data_cold)
```

```
Joining, by = "State"  
left_join: added 2 columns (vacc_rate, month)  
> rows only in x 1  
> rows only in y (1)  
> matched rows 2 (includes duplicates)  
> ===  
> rows total 3
```

Watch out for “includes duplicates”

Data including the joining column (“State”) has been duplicated.

```
lj
```

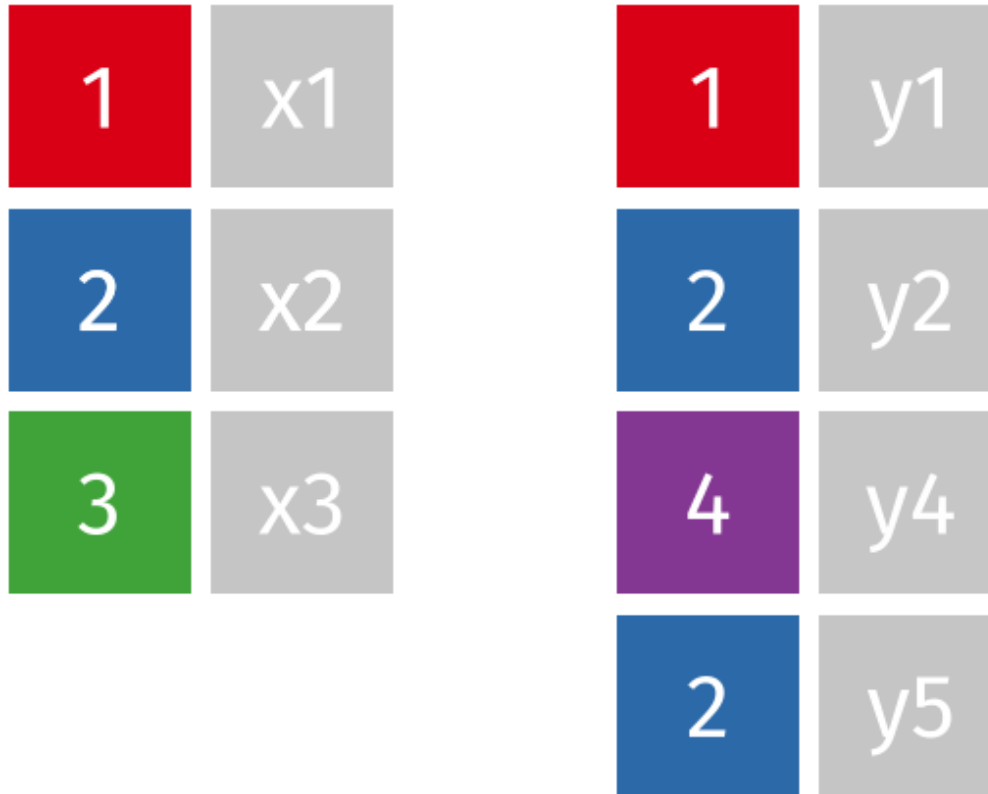
```
# A tibble: 3 × 4
  State    state_bird      vacc_rate month
<chr>    <chr>          <chr>    <chr>
1 Alabama wild turkey    <NA>    <NA>
2 Alaska  willow ptarmigan 41.7%    April
3 Alaska  willow ptarmigan 46.2%    May
```

Note that “Alaska willow ptarmigan” appears twice.

Watch out for “includes duplicates”

<https://github.com/gadenbuie/tidyexplain/blob/main/images/left-join-extra.gif>

`left_join(x, y)`



Stop tidylog

```
unloadNamespace("tidylog")
```

Duplicated

- The `uplicated` function can give you indications if there are duplicates in a **vector**:

```
duplicated(1:5)
```

```
[1] FALSE FALSE FALSE FALSE FALSE
```

```
duplicated(c(1:5, 1))
```

```
[1] FALSE FALSE FALSE FALSE FALSE TRUE
```

```
lj %>% mutate(dup_State = duplicated(State))
```

```
# A tibble: 3 × 5
```

| | State | state_bird | vacc_rate | month | dup_State |
|---|---------|------------------|-----------|-------|-----------|
| | <chr> | <chr> | <chr> | <chr> | <lgl> |
| 1 | Alabama | wild turkey | <NA> | <NA> | FALSE |
| 2 | Alaska | willow ptarmigan | 41.7% | April | FALSE |
| 3 | Alaska | willow ptarmigan | 46.2% | May | TRUE |

Using the **by** argument

By default joins use the intersection of column names. If **by** is specified, it uses that.

```
full_join(data_As, data_cold, by = "State")
```

```
# A tibble: 4 × 4
  State    state_bird      vacc_rate month
  <chr>    <chr>          <chr>    <chr>
1 Alabama wild turkey    <NA>     <NA>
2 Alaska  willow ptarmigan 41.7%    April
3 Alaska  willow ptarmigan 46.2%    May
4 Maine   <NA>            32.4%    April
```

Using the **by** argument

You can join based on multiple columns by using something like `by = c(col1, col2)`.

If the datasets have two different names for the same data, use:

```
full_join(x, y, by = c("a" = "b"))
```


Using “setdiff”

We might want to determine what indexes ARE in the first dataset that AREN'T in the second:

```
data_As
```

```
# A tibble: 2 × 2
  State    state_bird
  <chr>    <chr>
1 Alabama wild turkey
2 Alaska  willow ptarmigan
```

```
data_cold
```

```
# A tibble: 3 × 3
  State    vacc_rate month
  <chr>    <chr>    <chr>
1 Maine   32.4%    April
2 Alaska  41.7%    April
3 Alaska  46.2%    May
```

Using “setdiff”

Use `setdiff` to determine what indexes ARE in the first dataset that AREN'T in the second:

```
A_states <- data_As %>% pull(State)
cold_states <- data_cold %>% pull(State)
```

```
setdiff(A_states, cold_states)
```

```
[1] "Alabama"
```

```
setdiff(cold_states, A_states)
```

```
[1] "Maine"
```

Summary

- Merging/joining data sets together - assumes all column names that overlap
 - use the `by = c("a" = "b")` if they differ
- `inner_join(x, y)` - only rows that match for x and y are kept
- `full_join(x, y)` - all rows of x and y are kept
- `left_join(x, y)` - all rows of x are kept even if not merged with y
- `right_join(x, y)` - all rows of y are kept even if not merged with x
- Use the `tidylog` package for a detailed summary
- `setdiff(x, y)` shows what in x is missing from y

Lab Part 2

[Class Website](#)

[Lab](#)



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