

Intro to R

Manipulating Data in R

Introduction to R for Public Health Researchers

Reshaping Data

In this module, we will show you how to:

1. Reshape data from wide (fat) to long (tall)
2. Reshape data from long (tall) to wide (fat)
3. Merge Data/Joins
4. Perform operations by a grouping variable

Setup

We will show you how to do each operation in base R then show you how to use the `dplyr` or `tidyr` package to do the same operation (if applicable).

See the “Data Wrangling Cheat Sheet using `dplyr` and `tidyr`”:

- <https://www.rstudio.com/wp-content/uploads/2015/02/data-wrangling-cheatsheet.pdf>

What is wide/long data?

See http://www.cookbook-r.com/Manipulating_data/Converting_data_between_wide_and_long_format/

- Wide - multiple columns per observation
 - e.g. visit1, visit2, visit3

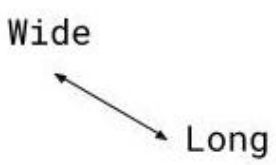
```
# A tibble: 2 x 4
  id visit1 visit2 visit3
<int> <dbl> <dbl> <dbl>
1     1     10     4      3
2     2      5     6     NA
```

- Long - multiple rows per observation

```
# A tibble: 5 x 3
  id visit value
<dbl> <int> <dbl>
1     1     1    10
2     1     2     4
3     1     3     3
4     2     1     5
5     2     2     6
```

What is wide/long data?

More accurately, data is wide or long **with respect** to certain variables.



The diagram illustrates the transformation of data from a wide format to a long format. The wide table on the left has two rows (Patient 1 and Patient 2) and three columns (Day 1, Day 2, Day 3). The long table on the right has six rows (repeating Patient 1 and Patient 2 for each day) and two columns (Day, Value). An arrow labeled 'Wide' points to the wide table, and an arrow labeled 'Long' points to the long table.

	Day 1	Day 2	Day 3
Patient 1	A	B	C
Patient 2	D	E	F

	Day	Value
Patient 1	Day 1	A
Patient 1	Day 2	B
Patient 1	Day 3	C
Patient 2	Day 1	D
Patient 2	Day 2	E
Patient 2	Day 3	F

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Data used: Charm City Circulator

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

```
circ = read_csv(  
  paste0("http://jhudatascience.org/intro_to_r/",  
        "data/Charm_City_Circulator_Ridership.csv"))  
head(circ, 2)
```

```
# A tibble: 2 x 15  
  day      date      orangeBoardings orangeAlightings orangeAverage purpleBoardin  
  <chr>    <chr>          <dbl>             <dbl>             <dbl>          <dbl>  
1 Monday  01/11/...         877             1027             952  
2 Tuesday 01/12/...         777             815             796  
# ... with 9 more variables: purpleAlightings <dbl>, purpleAverage <dbl>,  
#   greenBoardings <dbl>, greenAlightings <dbl>, greenAverage <dbl>,  
#   bannerBoardings <dbl>, bannerAlightings <dbl>, bannerAverage <dbl>,  
#   daily <dbl>
```

```
class(circ$date)
```

```
[1] "character"
```

Creating a Date class from a character date

```
library(lubridate) # great for dates!
```

```
sum(is.na(circ$date))
```

```
[1] 0
```

```
sum( circ$date == "")
```

```
[1] 0
```

```
circ = mutate(circ, date = mdy(date))  
sum( is.na(circ$date) ) # all converted correctly
```

```
[1] 0
```

```
head(circ$date, 3)
```

```
[1] "2010-01-11" "2010-01-12" "2010-01-13"
```

```
class(circ$date)
```

```
[1] "Date"
```

Reshaping data from wide (fat) to long (tall): base R

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

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
- `unite` - multiple columns into one string
- All the “join” functions for merging are in `dplyr`

Reshaping data from wide (fat) to long (tall): tidyr

`tidyr::pivot_longer` - puts column data into rows.

We first describe which columns we want to “pivot_longer.” We want the column names in a “var” variable in the output dataset and the values in a “number” variable:

```
long = pivot_longer(circ, !c(day, date, daily), # NOT pivoting these
                    names_to = "var", values_to = "number")
head(long, 4)
```

```
# A tibble: 4 x 5
  day    date    daily var              number
<chr> <date> <dbl> <chr>              <dbl>
1 Monday 2010-01-11  952 orangeBoardings    877
2 Monday 2010-01-11  952 orangeAlightings  1027
3 Monday 2010-01-11  952 orangeAverage     952
4 Monday 2010-01-11  952 purpleBoardings    NA
```

Reshaping data from wide (fat) to long (tall): tidyr

- Could be explicit on what we want to pivot

```
long = pivot_longer(circ,  
                    starts_with(c("orange", "purple", "green", "banner")),  
                    names_to = "var", values_to = "number")
```

long

```
# A tibble: 13,752 x 5
```

	day	date	daily	var	number
	<chr>	<date>	<dbl>	<chr>	<dbl>
1	Monday	2010-01-11	952	orangeBoardings	877
2	Monday	2010-01-11	952	orangeAlightings	1027
3	Monday	2010-01-11	952	orangeAverage	952
4	Monday	2010-01-11	952	purpleBoardings	NA
5	Monday	2010-01-11	952	purpleAlightings	NA
6	Monday	2010-01-11	952	purpleAverage	NA
7	Monday	2010-01-11	952	greenBoardings	NA
8	Monday	2010-01-11	952	greenAlightings	NA
9	Monday	2010-01-11	952	greenAverage	NA
10	Monday	2010-01-11	952	bannerBoardings	NA

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

Reshaping data from wide (fat) to long (tall): tidyr

```
long %>% count(var)
```

```
# A tibble: 12 x 2
```

	var <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

Lab Part 1

[Website](#)

Making a separator

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

```
long = long %>% mutate(  
  var = var %>%  
    str_replace("Board", " _Board") %>%  
    str_replace("Alight", " _Alight") %>%  
    str_replace("Average", " _Average")  
)  
long %>% count(var)
```

```
# A tibble: 12 x 2  
  var                n  
  <chr>            <int>  
1 banner _Alightings 1146  
2 banner _Average    1146  
3 banner _Boardings  1146  
4 green _Alightings  1146  
5 green _Average     1146  
6 green _Boardings   1146  
7 orange _Alightings 1146  
8 orange _Average    1146  
9 orange _Boardings  1146  
10 purple _Alightings 1146  
11 purple _Average    1146  
12 purple _Boardings  1146
```

Reshaping data from wide (fat) to long (tall): tidyr

Now each `var` is `boardings`, `averages`, or `alightings`. We want to separate these so we can have these by line. Remember `"."` is special character:

```
long = separate(long, var, into = c("line", "type"), sep = "_")
head(long, 2)
```

```
# A tibble: 2 x 6
  day    date      daily line    type      number
<chr> <date>    <dbl> <chr> <chr>
1 Monday 2010-01-11    952 orange Boardings      877
2 Monday 2010-01-11    952 orange Alightings    1027
```

```
unique(long$line)
```

```
[1] "orange" "purple" "green"  "banner"
```

```
unique(long$type)
```

```
[1] "Boardings" "Alightings" "Average"
```

Re-uniting all the lines

If we had the opposite problem, we could use the `unite` function:

```
reunited = long %>%  
  unite(col = var, line, type, sep = "_")  
reunited %>% select(day, var) %>% head(3) %>% print
```

```
# A tibble: 3 x 2  
  day      var  
  <chr>   <chr>  
1 Monday orange_Boardings  
2 Monday orange_Alightings  
3 Monday orange_Average
```

We could also use `paste/paste0`.

Lab Part 2

[Website](#)

Reshaping data from long (tall) to wide (fat): tidyr

In `tidyr`, the `pivot_wider` function spreads rows into columns. Now we have a long data set, but we want to separate the Average, Alightings and Boardings into different columns:

```
# have to remove missing days
wide = long %>% filter(!is.na(date))
wide = wide %>% pivot_wider(names_from = "type",
                           values_from = "number")
head(wide)
```

```
# A tibble: 6 x 7
```

	day	date	daily	line	Boardings	Alightings	Average
	<chr>	<date>	<dbl>	<chr>	<dbl>	<dbl>	<dbl>
1	Monday	2010-01-11	952	orange	877	1027	952
2	Monday	2010-01-11	952	purple	NA	NA	NA
3	Monday	2010-01-11	952	green	NA	NA	NA
4	Monday	2010-01-11	952	banner	NA	NA	NA
5	Tuesday	2010-01-12	796	orange	777	815	796
6	Tuesday	2010-01-12	796	purple	NA	NA	NA

Lab Part 3

[Website](#)

Merging: Simple Data

base has baseline data for ids 1 to 10 and Age

```
base <- tibble(id = 1:10, Age = seq(55, 60, length=10))  
head(base, 2)
```

```
# A tibble: 2 x 2  
  id   Age  
  <int> <dbl>  
1     1  55  
2     2 55.6
```

visits has ids 1 to 8, then 11 (new id), and 3 visits and outcome

```
visits <- tibble(id = c(rep(1:8, 3), 11), visit= c(rep(1:3, 8), 3),  
                 Outcome = seq(10, 50, length=25))  
tail(visits, 2)
```

```
# A tibble: 2 x 3  
  id visit Outcome  
  <dbl> <dbl>   <dbl>  
1     8     3   48.3  
2    11     3    50
```

Joining in `dplyr`

- Merging/joining data sets together - usually on key variables, usually “id”
- `?join` - see different types of joining for `dplyr`
- Let's look at <https://www.rstudio.com/wp-content/uploads/2015/02/data-wrangling-cheatsheet.pdf>
- `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`.

Inner Join

```
ij = inner_join(base, visits)
```

```
Joining, by = "id"
```

```
dim(ij)
```

```
[1] 24  4
```

```
tail(ij)
```

```
# A tibble: 6 x 4
   id    Age visit Outcome
  <dbl> <dbl> <dbl>   <dbl>
1     7  58.3     1     20
2     7  58.3     3    33.3
3     7  58.3     2    46.7
4     8  58.9     2    21.7
5     8  58.9     1     35
6     8  58.9     3    48.3
```

Left Join

```
lj = left_join(base, visits)
```

```
Joining, by = "id"
```

```
dim(lj)
```

```
[1] 26  4
```

```
tail(lj)
```

```
# A tibble: 6 x 4
   id    Age visit Outcome
  <dbl> <dbl> <dbl>   <dbl>
1     7  58.3     2    46.7
2     8  58.9     2    21.7
3     8  58.9     1     35
4     8  58.9     3    48.3
5     9  59.4    NA     NA
6    10  60     NA     NA
```

Logging the joins

The `tidylog` package can show you log outputs from `dplyr` (newly added). You will need to install to use.

```
library(tidylog)
left_join(base, visits)
```

Joining, by = "id"

left_join: added 2 columns (visit, Outcome)

> rows only in x 2

> rows only in y (1)

> matched rows 24 (includes duplicates)

> =====

> rows total 26

A tibble: 26 x 4

	id	Age	visit	Outcome
	<dbl>	<dbl>	<dbl>	<dbl>
1	1	55	1	10
2	1	55	3	23.3
3	1	55	2	36.7
4	2	55.6	2	11.7
5	2	55.6	1	25

Right Join

```
rj = right_join(base, visits)
```

```
Joining, by = "id"
```

```
right_join: added 2 columns (visit, Outcome)
```

```
> rows only in x ( 2)
```

```
> rows only in y 1
```

```
> matched rows 24
```

```
> =====
```

```
> rows total 25
```

```
tail(rj, 3)
```

```
# A tibble: 3 x 4
  id    Age visit Outcome
<dbl> <dbl> <dbl>   <dbl>
1     8  58.9     1     35
2     8  58.9     3    48.3
3    11   NA     3     50
```

Right Join: Switching arguments

```
rj2 = right_join(visits, base)
```

Joining, by = "id"

right_join: added one column (Age)

```
> rows only in x ( 1)
```

```
> rows only in y 2
```

```
> matched rows 24 (includes duplicates)
```

```
> =====
```

```
> rows total 26
```

```
tail(rj2, 3)
```

```
# A tibble: 3 x 4
```

	id	visit	Outcome	Age
	<dbl>	<dbl>	<dbl>	<dbl>
1	8	3	48.3	58.9
2	9	NA	NA	59.4
3	10	NA	NA	60

select: no changes

select: columns reordered (id, visit, Outcome, Age)

Full Join

```
fj = full_join(base, visits)
```

```
Joining, by = "id"
```

```
full_join: added 2 columns (visit, Outcome)
```

```
> rows only in x      2
```

```
> rows only in y      1
```

```
> matched rows      24      (includes duplicates)
```

```
>                      =====
```

```
> rows total          27
```

```
tail(fj, 4)
```

```
# A tibble: 4 x 4
```

	id	Age	visit	Outcome
	<dbl>	<dbl>	<dbl>	<dbl>
1	8	58.9	3	48.3
2	9	59.4	NA	NA
3	10	60	NA	NA
4	11	NA	3	50

Using the `by` argument

By default - uses intersection of column names. If `by` specified, then uses that, but if other columns with same name, adds `suffix`.

```
base = base %>% mutate(x = 5)
visits = visits %>% mutate(x = 4)
head(full_join(base, visits))
```

Joining, `by = c("id", "x")`

```
# A tibble: 6 x 5
   id    Age      x visit Outcome
<dbl> <dbl> <dbl> <dbl>   <dbl>
1     1    55      5     NA      NA
2     2   55.6      5     NA      NA
3     3   56.1      5     NA      NA
4     4   56.7      5     NA      NA
5     5   57.2      5     NA      NA
6     6   57.8      5     NA      NA
```

```
head(full_join(base, visits, by = "id"))
```

```
# A tibble: 6 x 6
   id    Age  x.x visit Outcome  x.y
<dbl> <dbl> <dbl> <dbl>   <dbl> <dbl>
1     1    55      5      1      10      4
2     1    55      5      3     23.3     4
3     1    55      5      2     36.7     4
4     2   55.6      5      2     11.7     4
```

Duplicated

- The `duplicated` command can give you indications if there are duplications in a **vector**:

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

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

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

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

```
fj %>% mutate(dup_id = duplicated(id))
```

```
# A tibble: 27 x 5
   id    Age visit Outcome dup_id
  <dbl> <dbl> <dbl>   <dbl> <lgl>
1     1   55     1     10  FALSE
2     1   55     3    23.3  TRUE
3     1   55     2    36.7  TRUE
4     2  55.6     2    11.7  FALSE
5     2  55.6     1     25   TRUE
6     2  55.6     3    38.3  TRUE
7     3  56.1     3    13.3  FALSE
8     3  56.1     2    26.7  TRUE
9     3  56.1     1     40   TRUE
10    4  56.7     1     15  FALSE
# ... with 17 more rows
```

Lab Part 4

[Website](#)

Finding the First (or Last) record

`pivot_longer` and `pivot_wider` are new (as of 2019) `tidyr` functions.

See link below:

<https://tidyr.tidyverse.org/dev/articles/pivot.html>

Website

Website

Reshaping data from long (tall) to wide (fat): tidyr

We can use `rowSums` to see if any values in the row is `NA` and keep if the row, which is a combination of date and line type has any non-missing data.

```
head(wide, 3)
```

```
# A tibble: 3 x 7
  day   date      daily line Boardings Alightings Average
<chr> <date>    <dbl> <chr>    <dbl>    <dbl>    <dbl>
1 Monday 2010-01-11    952 orange     877     1027     952
2 Monday 2010-01-11    952 purple      NA      NA      NA
3 Monday 2010-01-11    952 green      NA      NA      NA
```

```
not_namat = wide %>% select(Alightings, Average, Boardings)
not_namat = !is.na(not_namat)
head(not_namat, 2)
```

```
      Alightings Average Boardings
[1,]         TRUE      TRUE      TRUE
[2,]        FALSE      FALSE      FALSE
```

```
wide$good = rowSums(not_namat) > 0
```

Reshaping data from long (tall) to wide (fat): tidyr

Now we can filter only the good rows and delete the `good` column.

```
wide = wide %>% filter(good) %>% select(-good)
head(wide)
```

```
# A tibble: 6 x 7
  day      date      daily line Boardings Alightings Average
<chr> <date>    <dbl> <chr>    <dbl>    <dbl>    <dbl>
1 Monday 2010-01-11   952 orange     877     1027     952
2 Tuesday 2010-01-12   796 orange     777      815     796
3 Wednesday 2010-01-13 1212. orange    1203     1220    1212.
4 Thursday 2010-01-14 1214. orange    1194     1233    1214.
5 Friday 2010-01-15 1644 orange    1645     1643    1644
6 Saturday 2010-01-16 1490. orange    1457     1524    1490.
```

Finding the First (or Last) record

- `slice` allows you to select **records** (compared to first/last on a **vector**)

```
long = long %>% filter(!is.na(number) & number > 0)
first_and_last = long %>% arrange(date) %>% # arrange by date
  filter(type == "Boardings") %>% # keep boardings only
  group_by(line) %>% # group by line
  slice( c(1, n())) # select ("slice") first and last (n() command) lines
first_and_last %>% head(4)
```

```
# A tibble: 4 x 6
```

```
# Groups:   line [2]
```

	day	date	daily	line	type	number
	<chr>	<date>	<dbl>	<chr>	<chr>	<dbl>
1	Monday	2012-06-04	13342.	banner	Boardings	520
2	Friday	2013-03-01	NA	banner	Boardings	817
3	Tuesday	2011-11-01	8873	green	Boardings	887
4	Friday	2013-03-01	NA	green	Boardings	2592

Merging in base R (not covered)

Data Merging/Append in Base R

- `merge()` is the most common way to do this with data sets
 - we will use the “join” functions from `dplyr`
- `rbind/cbind` - row/column bind, respectively
 - `rbind` is the equivalent of “appending” in Stata or “setting” in SAS
 - `cbind` allows you to add columns in addition to the previous ways
- `t()` can transpose data but doesn't make it a `data.frame`

Merging

```
merged.data <- merge(base, visits, by = "id")  
head(merged.data, 5)
```

	id	Age	x.x	visit	Outcome	x.y
1	1	55.00000	5	1	10.00000	4
2	1	55.00000	5	3	23.33333	4
3	1	55.00000	5	2	36.66667	4
4	2	55.55556	5	2	11.66667	4
5	2	55.55556	5	1	25.00000	4

```
dim(merged.data)
```

```
[1] 24  6
```

Merging

```
all.data <- merge(base, visits, by = "id", all = TRUE)
tail(all.data)
```

	id	Age	x.x	visit	Outcome	x.y
22	8	58.88889	5	2	21.66667	4
23	8	58.88889	5	1	35.00000	4
24	8	58.88889	5	3	48.33333	4
25	9	59.44444	5	NA	NA	NA
26	10	60.00000	5	NA	NA	NA
27	11	NA	NA	3	50.00000	4

```
dim(all.data)
```

```
[1] 27  6
```