Data Wrangling in R with the Tidyverse (Part 2)

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2019/04/18 (Part 1) & 2019/04/25 (Part 2)
and again! 2019/05/16 (Part 1) & 2019/05/23 (Part 2)

slides: bit.ly/berd_tidy2
pdf: bit.ly/berd_tidy2_pdf

Load files for today's workshop

- Open the slides of this workshop: bit.ly/berd_tidy2
- If you haven't already,
  - Open the pre-workshop homework
  - Follow steps 1-5
  - Download zip folder
  - Open `berd_tidyverse_project.Rproj`
- **Open a new R script and run the commands to the right**

```
# install.packages("tidyverse","janitor","glue")
library(tidyverse)
library(lubridate)
library(janitor)
library(glue)
demo_data <- read_csv("data/yrbss_demo.csv")
qn_data <- read_csv("data/yrbss_qn.csv")
```

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Learning objectives

Previously, in Part 1:

- What is data wrangling?
- A few good practices in R/RStudio
- What is tidy data?
- What is tidyverse?
- Manipulate data

Part 2:

- Summarizing data
- Combine (join) data sets
- Reshaping data: wide vs. long formats
- Data cleaning:
  - Missing data
  - Strings/character vectors
  - Dates
  - Factors
  - Messy names

More data wrangling

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Review Part 1: manipulating data

Columns (part 1 slides)

- `select()` to subset columns
- `rename()` to rename columns
- `mutate()` to add new columns or change values within existing columns
  - `separate()` and `unite()` are shortcuts for specific `mutate` type operations

Rows (part 1 slides)

- `filter()` to subset rows
  - `na.omit()` and `distinct()` are shortcuts for specific `filter` type operations
- `arrange()` to order the data

Changing *all* columns at once (part 1 slides)

`mutate_all()`, `rename_all()`: applies a function to *all* columns:
`mutate_all(FUNCTION, FUNCTION_ARGUMENTS)`

```
# mutate_all changes the data in all columns
demo_data %>% mutate_all(as.character) %>% head(2)
```

```
# A tibble: 2 x 8
  record age          sex    grade race4 race7 bmi     stweight
  <chr>  <chr>        <chr>  <chr> <chr> <chr> <chr>   <chr>
1 931897 15 years old Female 10th  White White 17.179  54.43
2 333862 17 years old Female 12th  White White 20.2487 57.15
```

```
# rename_all changes all column names
demo_data %>% rename_all(str_sub, end = 2) %>% head(3)
```

```
# A tibble: 3 x 8
      re ag                se     gr    ra           ra              bm    st
   <dbl> <chr>             <chr>  <chr> <chr>        <chr>        <dbl> <dbl>
1 931897 15 years old      Female 10th  White        White         17.2  54.4
2 333862 17 years old      Female 12th  White        White         20.2  57.2
3  36253 18 years old or… Male   11th  Hispanic/La… Hispanic/L…   NA    NA
```

Changing *some* columns at once (part 1 slides)

`mutate_at()`, `rename_at()`: uses `vars()` to select specific variables to apply a function to i.e. `mutate_at(vars(SELECT), FUNCTION, FUNCTION_ARGUMENTS)`

```
# mutate_at changes the data in specified columns
demo_data %>% mutate_at(vars(contains("race"), sex), as.factor) %>% head(2)
```

```
# A tibble: 2 x 8
  record age          sex    grade race4 race7   bmi stweight
   <dbl> <chr>        <fct>  <chr> <fct> <fct> <dbl>    <dbl>
1 931897 15 years old Female 10th  White White  17.2     54.4
2 333862 17 years old Female 12th  White White  20.2     57.2
```

```
# rename_at changes specified column names
demo_data %>% rename_at(vars(record:grade),toupper) %>% head(3)
```

```
# A tibble: 3 x 8
  RECORD AGE             SEX    GRADE race4       race7        bmi stweight
   <dbl> <chr>           <chr>  <chr> <chr>       <chr>      <dbl>    <dbl>
1 931897 15 years old    Female 10th  White       White       17.2     54.4
2 333862 17 years old    Female 12th  White       White       20.2     57.2
3  36253 18 years old o… Male   11th  Hispanic/L… Hispanic/…  NA       NA
```

Changing *some* columns at once (part 1 slides)

`mutate_if()`, `rename_if()`, `select_if()`: uses a function that returns TRUE/FALSE to select columns and applies function on the TRUE columns:
`mutate_if(BOOLEAN, FUNCTION, FUNCTION_ARGUMENTS)`

```
demo_data %>% mutate_if(is.numeric, round, digits = 0) %>% head(3)
```

```
# A tibble: 3 x 8
  record age              sex    grade race4       race7        bmi stweight
   <dbl> <chr>            <chr>  <chr> <chr>       <chr>      <dbl>    <dbl>
1 931897 15 years old     Female 10th  White       White         17       54
2 333862 17 years old     Female 12th  White       White         20       57
3  36253 18 years old o… Male   11th  Hispanic/L… Hispanic/…    NA       NA
```

```
demo_data %>% rename_if(is.character, str_sub, end = 2) %>% head(3)
```

```
# A tibble: 3 x 8
  record ag               se     gr    ra          ra           bmi stweight
   <dbl> <chr>            <chr>  <chr> <chr>       <chr>      <dbl>    <dbl>
1 931897 15 years old     Female 10th  White       White       17.2     54.4
2 333862 17 years old     Female 12th  White       White       20.2     57.2
```

Add one or more rows: add_row()

```
demo_data %>% add_row(record=100, age=NA, sex="Female", grade="9th") %>%
  arrange(record) %>% head(3)
```

```
# A tibble: 3 x 8
  record age   sex    grade race4           race7              bmi stweight
   <dbl> <chr> <chr>  <chr> <chr>           <chr>            <dbl>    <dbl>
1    100 <NA>  Female 9th   <NA>            <NA>                NA       NA
2  30592 <NA>  <NA>   <NA>  <NA>            <NA>                NA       NA
3  30593 <NA>  <NA>   9th   Hispanic/Latino Hispanic/Latino     NA       NA
```

```
demo_data %>% add_row(record=100:102, bmi=c(25,30,18)) %>%
  arrange(record) %>% head(3)
```

```
# A tibble: 3 x 8
  record age   sex   grade race4 race7   bmi stweight
   <dbl> <chr> <chr> <chr> <chr> <chr> <dbl>    <dbl>
1    100 <NA>  <NA>  <NA>  <NA>  <NA>     25       NA
2    101 <NA>  <NA>  <NA>  <NA>  <NA>     30       NA
3    102 <NA>  <NA>  <NA>  <NA>  <NA>     18       NA
```

Add one or more columns: add_column()

```
demo_data %>% add_column(study_date = "2019-04-10", .after="record") %>%
  head(3)
```

```
# A tibble: 3 x 9
  record study_date age         sex    grade race4    race7      bmi stweight
   <dbl> <chr>      <chr>       <chr>  <chr> <chr>    <chr>    <dbl>    <dbl>
1 931897 2019-04-10 15 years … Female 10th  White    White     17.2      54.4
2 333862 2019-04-10 17 years … Female 12th  White    White     20.2      57.2
3  36253 2019-04-10 18 years … Male   11th  Hispani… Hispan…  NA        NA
```

```
demo_data %>% add_column(id = 1:nrow(demo_data), .before="record") %>%
  head(3)
```

```
# A tibble: 3 x 9
     id record age           sex    grade race4      race7        bmi stweight
  <int>  <dbl> <chr>         <chr>  <chr> <chr>      <chr>      <dbl>    <dbl>
1     1 931897 15 years old Female 10th  White      White       17.2      54.4
2     2 333862 17 years old Female 12th  White      White       20.2      57.2
3     3  36253 18 years ol… Male   11th  Hispanic… Hispanic…  NA        NA
```

Quick tips on summarizing data

categorical data

numerical data

janitor, dplyr

Frequency tables: janitor package's tabyl function

```
# default table
demo_data %>% tabyl(grade)
```

```
 grade    n percent valid_percent
  10th 4907 0.24535     0.2504338
  11th 4891 0.24455     0.2496172
  12th 4577 0.22885     0.2335919
   9th 5219 0.26095     0.2663570
  <NA>  406 0.02030            NA
```

```
# output can be treated as tibble
demo_data %>% tabyl(grade) %>% select(-n)
```

```
 grade percent valid_percent
  10th 0.24535     0.2504338
  11th 0.24455     0.2496172
  12th 0.22885     0.2335919
   9th 0.26095     0.2663570
  <NA> 0.02030            NA
```

adorn_ your table!

```
demo_data %>%
  tabyl(grade) %>%
  adorn_totals("row") %>%
  adorn_pct_formatting(digits=2)
```

```
 grade     n percent valid_percent
  10th  4907  24.54%         25.04%
  11th  4891  24.45%         24.96%
  12th  4577  22.88%         23.36%
   9th  5219  26.10%         26.64%
  <NA>   406   2.03%             -
 Total 20000 100.00%        100.00%
```

2x2 tabyls

```
# default 2x2 table
demo_data %>% tabyl(grade, sex)
```

grade	Female	Male	NA_
10th	2332	2539	36
11th	2365	2496	30
12th	2277	2263	37
9th	2492	2684	43
<NA>	126	195	85

What adornments does the tabyl to right have?

```
demo_data %>% tabyl(grade, sex) %>%
  adorn_percentages(denominator = "col") %>%
  adorn_totals("row") %>%
  adorn_pct_formatting(digits = 1) %>%
  adorn_ns()
```

grade	Female	Male	NA_
10th	24.3% (2332)	24.9% (2539)	15.6% (36)
11th	24.7% (2365)	24.5% (2496)	13.0% (30)
12th	23.7% (2277)	22.2% (2263)	16.0% (37)
9th	26.0% (2492)	26.4% (2684)	18.6% (43)
<NA>	1.3% (126)	1.9% (195)	36.8% (85)
Total	100.0% (9592)	100.0% (10177)	100.0% (231)

- Notice **grade** is not sorted in a pleasing way. We will learn how to deal with this when we discuss **factors** as a data type in R.
- Base R has a **table** function, but it is clunkier and the output is not a data frame.
- See the tabyl vignette for more information, adorn options, & 3-way **tabyls**

Numerical data summaries: summarize()

- We can summarize data as a whole, or in groups with `group_by()`
- `group_by()` is very powerful, see data wrangling cheatsheet
- Can also use `summarize_at()`, `summarize_if()`, `summarize_all()`

```
# summary of all data as a whole
demo_data %>%
  summarize(bmi_mean =mean(bmi,na.rm=TRUE),
            bmi_sd = sd(bmi,na.rm=TRUE))
```

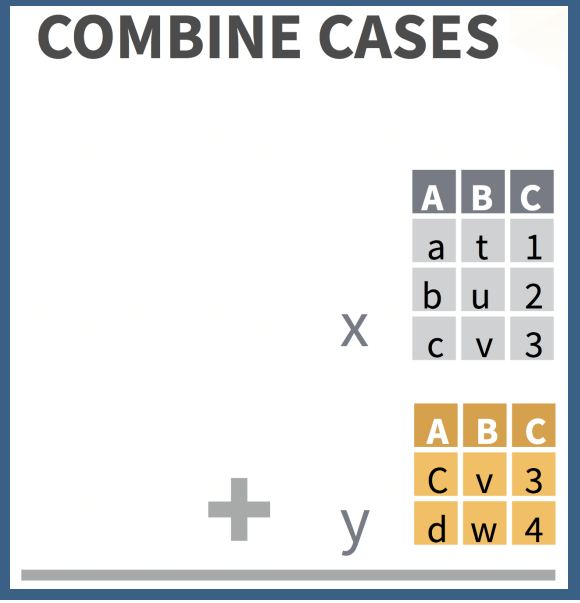
```
# A tibble: 1 x 2
  bmi_mean bmi_sd
     <dbl>  <dbl>
1     23.5   4.99
```

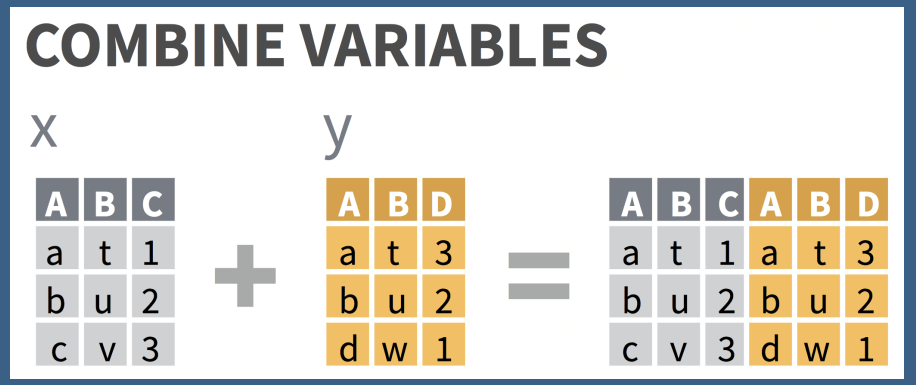
What does `na.rm=TRUE` do and what happens if we leave it out?

```
# summary by group variable
demo_data %>%
  group_by(grade) %>%
  summarize(n_per_group = n(),
            bmi_mean =mean(bmi,na.rm=TRUE),
            bmi_sd = sd(bmi,na.rm=TRUE))
```

```
# A tibble: 5 x 4
  grade n_per_group bmi_mean bmi_sd
  <chr>       <int>    <dbl>  <dbl>
1 <NA>          406     23.5   6.45
2 10th         4907     23.2   4.76
3 11th         4891     23.8   4.89
4 12th         4577     24.2   5.20
5 9th          5219     22.8   4.92
```

Combining data sets





be careful!!!

dplyr data transformation cheatsheet

Rows (cases): paste data below each other

`bind_rows()` combines rows from different data sets
& accounts for different column names

```
data1
```

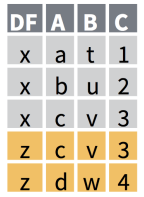
```
# A tibble: 2 x 4
     id name  height   age
  <int> <chr>  <dbl> <dbl>
1     1 Nina       2     4
2     2 Yi         1     2
```

```
data2
```

```
# A tibble: 3 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
1     7 Bo       2       3
2     8 Al       1.7     1
3     9 Juan     1.8     2
```

```
bind_rows(data1,data2, .id = "group")
```

```
# A tibble: 5 x 6
  group    id name  height   age years
  <chr> <int> <chr>  <dbl> <dbl> <dbl>
1 1         1 Nina       2     4    NA
2 1         2 Yi         1     2    NA
3 2         7 Bo         2    NA     3
4 2         8 Al         1.7  NA     1
5 2         9 Juan       1.8  NA     2
```



bind_rows(…, .id = NULL**)**
Returns tables one on top of the other as a single table. Set .id to a column name to add a column of the original table names (as pictured)

dplyr data transformation cheatsheet

Columns (variables): *DO NOT USE `bind_cols()`!!*

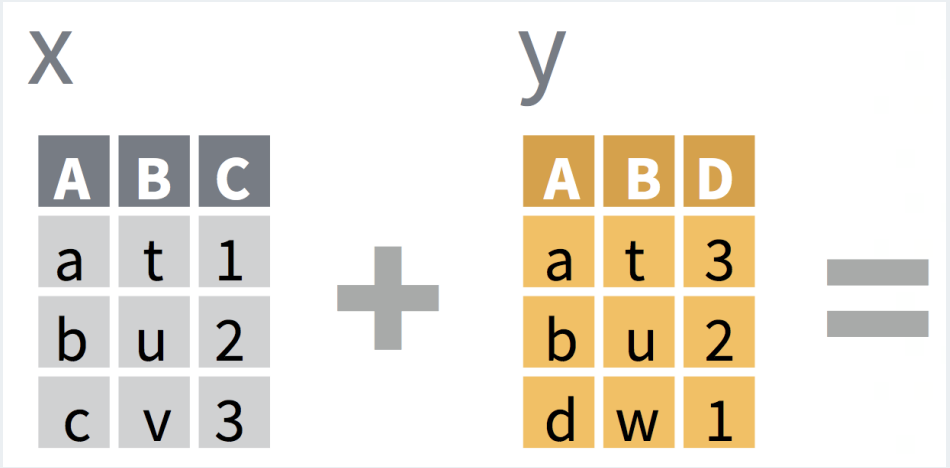
- `bind_cols()` blindly pastes columns next to each other without preserving order of variables that they have in common
  - Use `join` to preserve ordering - see next slides

```
# datasets must have same number of rows to use bind_cols()
demo_sub <- demo_data %>% slice(1:20) # first 20 rows of demo_data
qn_sub <- qn_data %>% slice(1:20)     # first 20 rows of qn_data
bind_cols(demo_sub, qn_sub)           # blindly bind columns; 2nd record column got renamed
```

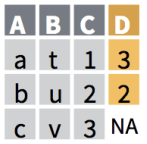
```
# A tibble: 20 x 13
   record age   sex   grade race4 race7   bmi stweight record1 q8    q12
    <dbl> <chr> <chr> <chr> <chr> <chr> <dbl>    <dbl>   <dbl> <chr> <chr>
 1 9.32e5 15 y… Fema… 10th  White White  17.2     54.4  922375 Neve… <NA>
 2 3.34e5 17 y… Fema… 12th  White White  20.2     57.2   36718 Neve… <NA>
 3 3.63e4 18 y… Male  11th  Hisp… Hisp…  NA       NA    187667 Did … <NA>
 4 1.10e6 15 y… Male  10th  Blac… Blac…  28.0     85.7  109951 Did … <NA>
 5 1.30e6 14 y… Male  9th   All … Mult…  24.5     66.7 1109733 Neve… <NA>
 6 2.62e5 17 y… Male  9th   All … <NA>   NA       NA    761127 Most… <NA>
 7 9.27e5 16 y… Male  11th  All … Asian  20.5     70.3  930811 Neve… <NA>
 8 1.31e6 17 y… Male  12th  White White  19.3     59.0  401921 Rare… <NA>
 9 5.06e5 18 y… Male  12th  Hisp… Hisp…  33.1    123.    42244 Rare… <NA>
```

*join*ing your data sets

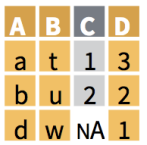
- `Join` uses overlapping or selected columns to combine two or more data sets.
- Also called "merging" or "mutating join".
- Function names are based off of SQL operations for databases.



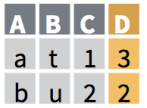
Use a "**Mutating Join**" to join one table to columns from another, matching values with the rows that they correspond to. Each join retains a different combination of values from the tables.



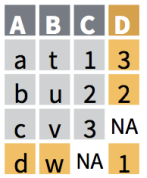
left_join(x, y, by = NULL, copy=FALSE, suffix=c(".x",".y"),…**)**
Join matching values from y to x.



right_join(x, y, by = NULL, copy = FALSE, suffix=c(".x",".y"),…**)**
Join matching values from x to y.

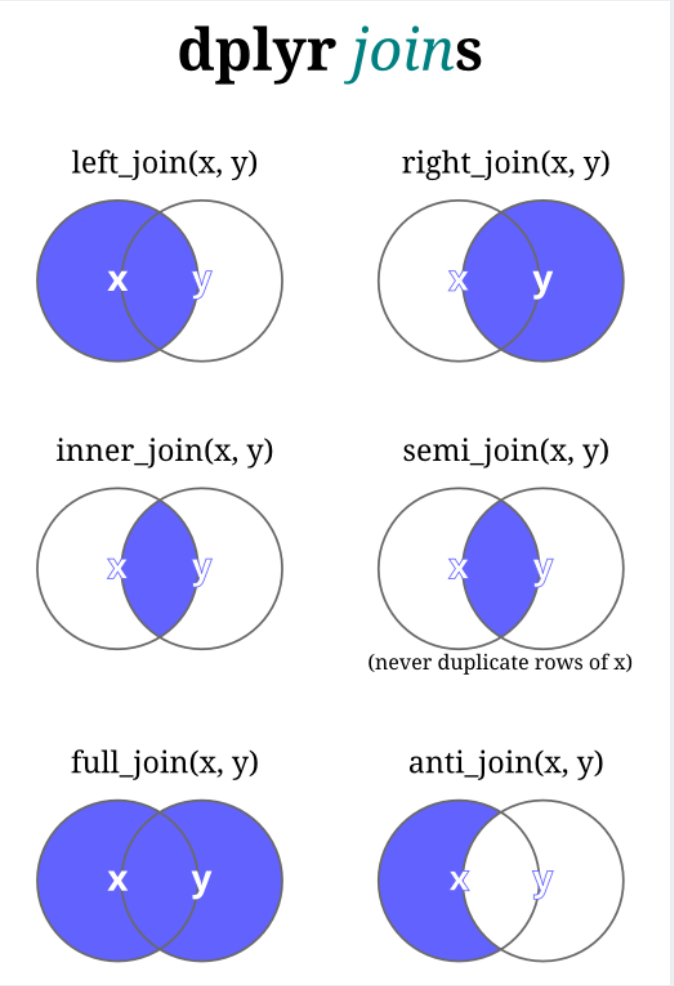


inner_join(x, y, by = NULL, copy = FALSE, suffix=c(".x",".y"),…**)**
Join data. Retain only rows with matches.



full_join(x, y, by = NULL, copy=FALSE, suffix=c(".x",".y"),…**)**
Join data. Retain all values, all rows.

`join` options visually



Hiroaki Yutani

Most commonly used: `left_join()`

- `left_join(x,y)` includes all observations in `x`, regardless of whether they match ones in `y` or not.
- It includes all columns in `y`, but only rows that match `x`'s observations.

```
df1 <- tibble(a = c(1, 2), b = 2:1)
df2 <- tibble(a = c(1, 3), c = 10:11)
df1
df2
```

```
# A tibble: 2 x 2
      a     b
  <dbl> <int>
1     1     2
2     2     1
# A tibble: 2 x 2
      a     c
  <dbl> <int>
1     1    10
2     3    11
```

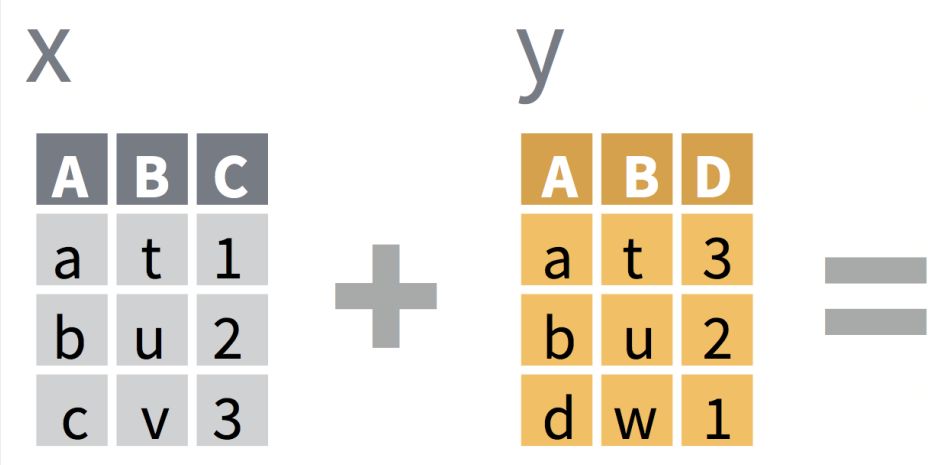
```
left_join(df1, df2)
```

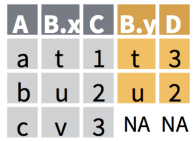
```
# A tibble: 2 x 3
      a     b     c
  <dbl> <int> <int>
1     1     2    10
2     2     1    NA
```

- Which common column(s) were used to merge the datasets?
- What if we want to specify which columns to join by when merging?
  see next slide...

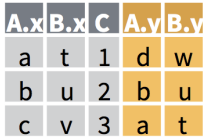
Which columns will be used to join?

- If no columns are specified to join by, then *all* overlapping (intersecting) column names will be used
- Often we want to specify which columns to use,
  - and also how to rename duplicated columns that were not merged

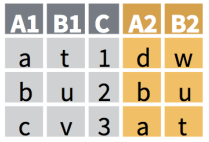




Use **by = c("col1", "col2", ...)** to specify one or more common columns to match on.
left_join(x, y, by = "A")



Use a named vector, **by = c("col1" = "col2")**, to match on columns that have different names in each table.
left_join(x, y, by = c("C" = "D"))



Use **suffix** to specify the suffix to give to unmatched columns that have the same name in both tables.
left_join(x, y, by = c("C" = "D"), suffix = c("1", "2"))

dplyr data transformation cheatsheet

Check for overlapping column names

Goal: merge the demographics (`demo_data`) and questionnaire (`qn_data`) together.

What column names do these datasets have in common?

```
colnames(demo_data)
```

```
[1] "record"   "age"      "sex"      "grade"    "race4"    "race7"
[7] "bmi"      "stweight"
```

```
colnames(qn_data)
```

```
[1] "record" "q8"     "q12"    "q31"    "qn24"
```

```
intersect(colnames(demo_data), colnames(qn_data))
```

```
[1] "record"
```

Merge demo_data and qn_data together

Let's do a full join so that we keep all data from both datasets

```
merged_data <-
  full_join(demo_data, qn_data,
            by = "record")

# Check dimensions of original and new data
```

```
dim(demo_data); dim(qn_data); dim(merged_da
```

```
[1] 20000     8
```

```
[1] 10000     5
```

```
[1] 20000    12
```

```
merged_data
```

```
# A tibble: 20,000 x 12
   record age   sex   grade race4 race7   bmi stweight q8    q12   q31
    <dbl> <chr> <chr> <chr> <chr> <chr> <dbl>    <dbl> <chr> <chr> <chr>
 1 9.32e5 15 y… Fema… 10th  White White  17.2     54.4 Neve… <NA>  Yes
 2 3.34e5 17 y… Fema… 12th  White White  20.2     57.2 <NA>  <NA>  <NA>
 3 3.63e4 18 y… Male  11th  Hisp… Hisp…  NA       NA   Neve… <NA>  <NA>
 4 1.10e6 15 y… Male  10th  Blac… Blac…  28.0     85.7 Neve… <NA>  Yes
 5 1.30e6 14 y… Male  9th   All … Mult…  24.5     66.7 <NA>  <NA>  <NA>
```

Learn more about `joining` data

- Two-table verbs vignette for `dplyr` package
- Jenny Bryan's STAT545 dplyr cheatsheet for join
- R for Data Science's "Relational data" chapter (great diagrams)

Practice

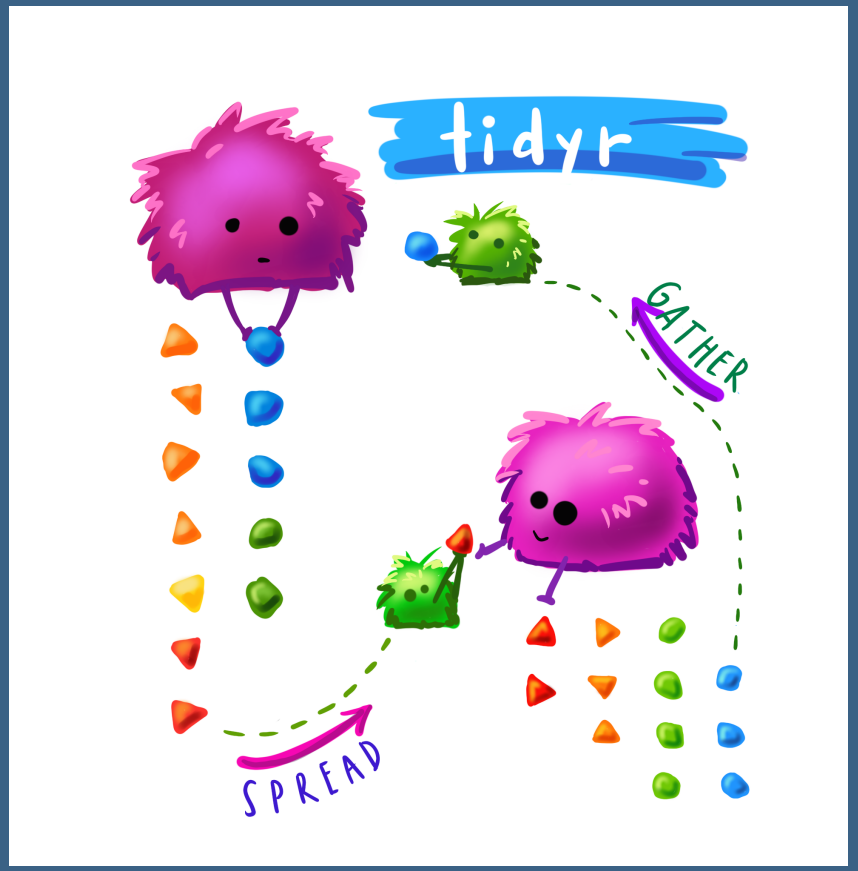
1. Add a column of `1`'s to `qn_data` called `qn_yes` and save the resulting data as `qn_data2`.
2. Join `demo_data` and `qn_data2` by column `record`. Keep all rows from `demo_data` and only rows from `qn_data2` that match records in `demo_data`. Call the resulting data `all_data`.
3. Create a `tabyl()` of `qn_yes` for the data `all_data`.
4. Create a 2x2 table of `qn_yes` vs `grade`.

Note about the data:

- q8 = How often wear bicycle helmet
- q12 = Texted while driving
- q31 = Ever smoked
- qn24 = Bullied past 12 months

Reshaping data

wide vs. long



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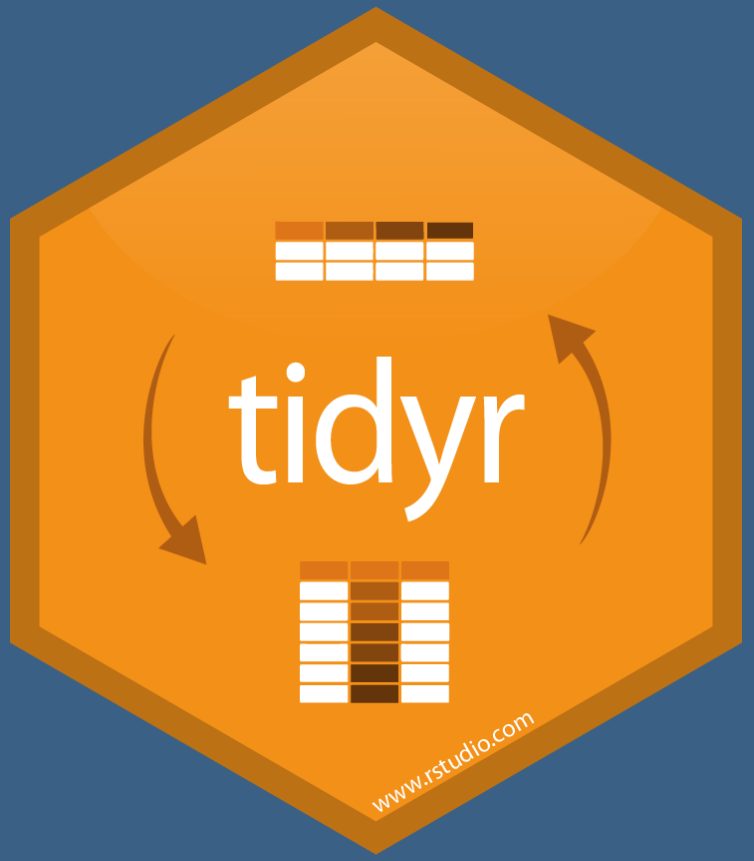


tidyr

Wide vs. long data

- **Wide** data has one row per subject, with multiple columns for their repeated measurements
- **Long** data has multiple rows per subject, with one column for the measurement variable and another indicating from when/where the repeated measures are from

wide

id	SBP_visit1	SBP_visit2	SBP_visit3
a	130	110	112
b	120	116	122
c	130	136	138
d	119	106	118

long

id	visit	SBP
a	1	130
b	1	120
c	1	130
d	1	119
a	2	110
b	2	116
c	2	136
d	2	106
a	3	112
b	3	122
c	3	138
d	3	118

Example wide dataset

Copy and paste the code below into R to create this example dataset

```
BP_wide <- tibble(id = letters[1:4],
                  sex = c("F", "M", "M", "F"),
                  SBP_v1 = c(130, 120, 130, 119),
                  SBP_v2 = c(110, 116, 136, 106),
                  SBP_v3 = c(112, 122, 138, 118))
BP_wide
```

```
# A tibble: 4 x 5
  id    sex   SBP_v1 SBP_v2 SBP_v3
  <chr> <chr>  <dbl>  <dbl>  <dbl>
1 a     F        130    110    112
2 b     M        120    116    122
3 c     M        130    136    138
4 d     F        119    106    118
```

- What do you think the data in the table are measures of?
- How can we tell the data are wide?

Wide to long: gather()

```
BP_wide
```

```
# A tibble: 4 x 5
  id    sex   SBP_v1 SBP_v2 SBP_v3
  <chr> <chr>  <dbl>  <dbl>  <dbl>
1 a     F        130    110    112
2 b     M        120    116    122
3 c     M        130    136    138
4 d     F        119    106    118
```

gather columns into rows to make the data long. Need to **specify**:

- **new column names**
  - **key**: stores row names of wide data's gathered columns
  - **value**: stores data values
- **which columns to gather**

```
BP_long <- BP_wide %>%
  gather(key = "visit", value = "SBP",
         SBP_v1:SBP_v3)
BP_long
```

```
# A tibble: 12 x 4
   id    sex   visit    SBP
   <chr> <chr> <chr>  <dbl>
 1 a     F     SBP_v1   130
 2 b     M     SBP_v1   120
 3 c     M     SBP_v1   130
 4 d     F     SBP_v1   119
 5 a     F     SBP_v2   110
 6 b     M     SBP_v2   116
 7 c     M     SBP_v2   136
 8 d     F     SBP_v2   106
 9 a     F     SBP_v3   112
10 b     M     SBP_v3   122
11 c     M     SBP_v3   138
12 d     F     SBP_v3   118
```

Long to wide: spread()

```
BP_long
```

```
# A tibble: 12 x 4
   id    sex   visit    SBP
   <chr> <chr> <chr>  <dbl>
 1 a     F     SBP_v1   130
 2 b     M     SBP_v1   120
 3 c     M     SBP_v1   130
 4 d     F     SBP_v1   119
 5 a     F     SBP_v2   110
 6 b     M     SBP_v2   116
 7 c     M     SBP_v2   136
 8 d     F     SBP_v2   106
 9 a     F     SBP_v3   112
10 b     M     SBP_v3   122
11 c     M     SBP_v3   138
12 d     F     SBP_v3   118
```

spread rows into columns to make the data wide. Need to **specify** which columns in the long data to use:

- **key** column: has the variable names
- **value** column: has the data values

```
BP_wide2 <- BP_long %>%
  spread(key = "visit", value = "SBP")
BP_wide2
```

```
# A tibble: 4 x 5
  id    sex   SBP_v1 SBP_v2 SBP_v3
  <chr> <chr>  <dbl>  <dbl>  <dbl>
1 a     F        130    110    112
2 b     M        120    116    122
3 c     M        130    136    138
4 d     F        119    106    118
```

Clean up long data's visit column (key column)

```
BP_long
```

```
# A tibble: 12 x 4
   id    sex   visit    SBP
   <chr> <chr> <chr>  <dbl>
 1 a     F     SBP_v1   130
 2 b     M     SBP_v1   120
 3 c     M     SBP_v1   130
 4 d     F     SBP_v1   119
 5 a     F     SBP_v2   110
 6 b     M     SBP_v2   116
 7 c     M     SBP_v2   136
 8 d     F     SBP_v2   106
 9 a     F     SBP_v3   112
10 b     M     SBP_v3   122
11 c     M     SBP_v3   138
12 d     F     SBP_v3   118
```

Goal: remove the string `SBP_v` from the `visit` variable's values.

```
BP_long2 <- BP_long %>%
  mutate(visit =
           str_replace(visit,"SBP_v",""))
BP_long2
```

```
# A tibble: 12 x 4
   id    sex   visit   SBP
   <chr> <chr> <chr> <dbl>
 1 a     F     1       130
 2 b     M     1       120
 3 c     M     1       130
 4 d     F     1       119
 5 a     F     2       110
 6 b     M     2       116
 7 c     M     2       136
 8 d     F     2       106
 9 a     F     3       112
10 b     M     3       122
11 c     M     3       138
12 d     F     3       118
```

Make cleaned-up long data wide

```
head(BP_long2, 2)
```

```
# A tibble: 2 x 4
  id    sex   visit   SBP
  <chr> <chr> <chr> <dbl>
1 a     F     1       130
2 b     M     1       120
```

```
BP_wide3 <- BP_long2 %>%
  spread(key = "visit", value = "SBP")
BP_wide3
```

```
# A tibble: 4 x 5
  id    sex     `1`   `2`   `3`
  <chr> <chr> <dbl> <dbl> <dbl>
1 a     F       130   110   112
2 b     M       120   116   122
3 c     M       130   136   138
4 d     F       119   106   118
```

Problem: have numbers as column names, since **spread**'s default is to use the levels of the **key** as the new row names.

Solution: have row names start with the **key** column's name **sep**arated by a character

```
BP_wide4 <- BP_long2 %>%
  spread(key = "visit", value = "SBP",
         sep="_") # specify separating char
BP_wide4
```

```
# A tibble: 4 x 5
  id    sex   visit_1 visit_2 visit_3
  <chr> <chr>   <dbl>   <dbl>   <dbl>
1 a     F         130     110     112
2 b     M         120     116     122
3 c     M         130     136     138
4 d     F         119     106     118
```

Practice

Copy and paste the code below into R to create the dataset `DBP_wide`

```
DBP_wide <- tibble(id = letters[1:4],
                   sex = c("F", "M", "M", "F"),
                   v1.DBP = c(88, 84, 102, 70),
                   v2.DBP = c(78, 78, 96, 76),
                   v3.DBP = c(94, 82, 94, 74),
                   age=c(23, 56, 41, 38)
                   )
```

1. Make `DBP_wide` into a long dataframe based on the repeated DBP columns and save it as `DBP_long`.

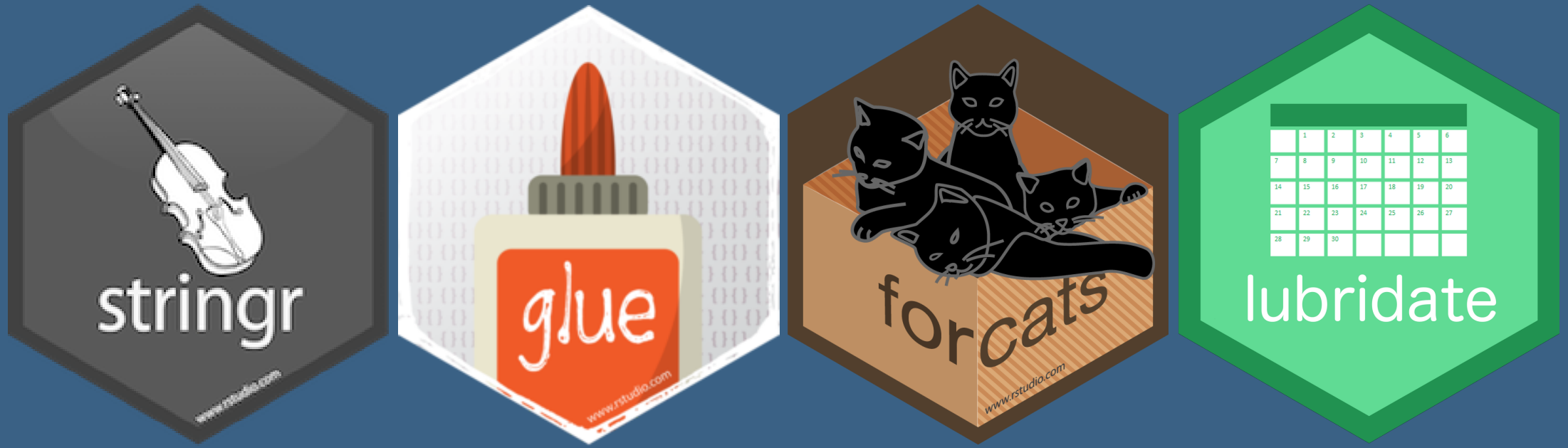
2. Clean up the visit column of `DBP_long` so that the values are 1, 2, 3, and save it as `DBP_long`.

3. Make `DBP_long` wide with column names `visit.1, visit.2, visit.3` for the DBP values, and save it as `DBP_wide2`.

4. Join `DBP_long` with `BP_long2` so that we have one data frame with columns id, sex, visit, SBP, DBP, and age. Save this as `BP_both_long`.

Data cleaning

(messy NAs, names, strings, dates, factors)



Removing missing data: drop_na()

A small data example:

```
mydata <- tibble(id = 7:9,
                 name = c("Bo","Al","Juan")
                 height = c(2, NA, 1.8),
                 years = c(51,35,NA))
mydata
```

```
# A tibble: 3 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
1     7 Bo       2      51
2     8 Al      NA      35
3     9 Juan     1.8    NA
```

Remove *all* rows with **any missing data**

```
mydata %>% drop_na()
```

```
# A tibble: 1 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
1     7 Bo       2      51
```

Remove rows with NA in **selected columns**

```
mydata %>% drop_na(height)
```

```
# A tibble: 2 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
1     7 Bo       2      51
2     9 Juan     1.8    NA
```

Replace NAs with another value: `replace_na()`

Use with `mutate()`

```
mydata
```

```
# A tibble: 3 x 4
     id name  height years
  <int> <chr>  <dbl> <dbl>
1     7 Bo       2      51
2     8 Al      NA      35
3     9 Juan     1.8    NA
```

```
mydata %>%
  mutate(height = replace_na(height, "Unknown"),
         years = replace_na(years, 0) )
```

```
# A tibble: 3 x 4
     id name  height  years
  <int> <chr> <chr>   <dbl>
1     7 Bo    2          51
2     8 Al    Unknown    35
3     9 Juan  1.8         0
```

replace_na() advanced example

Replaces NAs in all columns starting with "q" with the string "No answer"

```
qn_data %>%
  mutate_at(vars(starts_with("q")),
            .funs = list(~replace_na(.,"No answer"))) %>%
  tabyl(q8, q31)
```

```
                          q8   No No answer  Yes
          Always wore a helmet  411        58  216
        Did not ride a bicycle 1318       343 1223
 Most of the time wore a helmet  320        31  173
           Never wore a helmet 1429       418 1672
                     No answer  267       212  300
          Rarely wore a helmet  481        73  405
       Sometimes wore a helmet  351        53  246
```

Convert (i.e. "No answer", 9999, etc) to NA: na_if()

```
all_data %>% tabyl(race4)
```

```
                    race4    n percent valid_percent
          All other races 4713 0.23565     0.2443235
 Black or African American 4093 0.20465     0.2121825
          Hispanic/Latino 4670 0.23350     0.2420943
                    White 5814 0.29070     0.3013997
                     <NA>  710 0.03550            NA
```

```
all_data %>%
  mutate(race4 = na_if(race4, "All other races")) %>%
  tabyl(race4)
```

```
                    race4    n percent valid_percent
 Black or African American 4093 0.20465     0.2807848
          Hispanic/Latino 4670 0.23350     0.3203677
                    White 5814 0.29070     0.3988475
                     <NA> 5423 0.27115            NA
```

`na_if()` for all your data

Avoid this by reading in your data correctly:

```
smalldata <- read_csv("data/small_data.csv",
                      na = c("","9999","NA")) # specify your own missing values
```

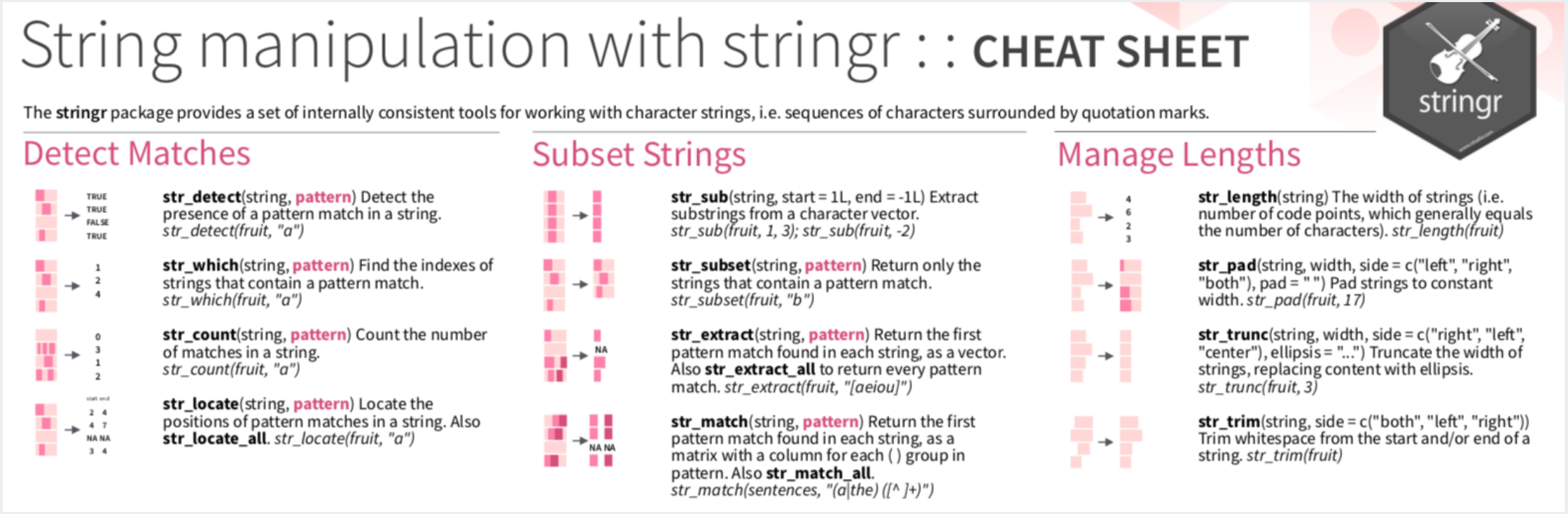
Otherwise `na_if()` everything:

```
# replace all "" with NA
all_data %>%
  mutate_if(is.character, .funs = na_if(.,""))

# replace all 9999's with NA
all_data %>%
  mutate_if(is.numeric, .funs = na_if(.,9999))
```

Working with character strings

- Use the package `stringr` (loaded with `tidyverse`)
- Paste strings or values together with package `glue` (installed, not loaded w/ `tidyverse`)
- *advanced tip*: learn "regular expressions" (regex) for pattern matching (see cheatsheet) and matching multiple characters/strings at once



String manipulation with stringr : : CHEAT SHEET

The **stringr** package provides a set of internally consistent tools for working with character strings, i.e. sequences of characters surrounded by quotation marks.

Detect Matches

str_detect(string, pattern) Detect the presence of a pattern match in a string. *str_detect(fruit, "a")*

str_which(string, pattern) Find the indexes of strings that contain a pattern match. *str_which(fruit, "a")*

str_count(string, pattern) Count the number of matches in a string. *str_count(fruit, "a")*

str_locate(string, pattern) Locate the positions of pattern matches in a string. Also **str_locate_all**. *str_locate(fruit, "a")*

Subset Strings

str_sub(string, start = 1L, end = -1L) Extract substrings from a character vector. *str_sub(fruit, 1, 3); str_sub(fruit, -2)*

str_subset(string, pattern) Return only the strings that contain a pattern match. *str_subset(fruit, "b")*

str_extract(string, pattern) Return the first pattern match found in each string, as a vector. Also **str_extract_all** to return every pattern match. *str_extract(fruit, "[aeiou]")*

str_match(string, pattern) Return the first pattern match found in each string, as a matrix with a column for each ( ) group in pattern. Also **str_match_all**. *str_match(sentences, "(a|the) ([^]+)")*

Manage Lengths

str_length(string) The width of strings (i.e. number of code points, which generally equals the number of characters). *str_length(fruit)*

str_pad(string, width, side = c("left", "right", "both"), pad = " ") Pad strings to constant width. *str_pad(fruit, 17)*

str_trunc(string, width, side = c("right", "left", "center"), ellipsis = "...") Truncate the width of strings, replacing content with ellipsis. *str_trunc(fruit, 3)*

str_trim(string, side = c("both", "left", "right")) Trim whitespace from the start and/or end of a string. *str_trim(fruit)*

stringr cheatsheet

str_detect() find strings

```
mydata <- tibble(name = c("J.M.","Ella","Jay"), state = c("New Mexico","New York","Oregon"))
```

Filter based on string detection

```
mydata %>% filter(str_detect(name,"J"))
```

```
# A tibble: 2 x 2
  name  state
  <chr> <chr>
1 J.M.  New Mexico
2 Jay   Oregon
```

Creates a column of TRUE/FALSE if detected

```
mydata %>% mutate(
  new_state = str_detect(state,"New"))
```

```
# A tibble: 3 x 3
  name  state      new_state
  <chr> <chr>      <lgl>
1 J.M.  New Mexico TRUE
2 Ella  New York   TRUE
3 Jay   Oregon     FALSE
```

str_replace_all(), str_replace()

```
mydata %>% mutate(state_old = str_replace_all(state, "New", "Old"))
```

```
# A tibble: 3 x 3
  name  state      state_old
  <chr> <chr>      <chr>
1 J.M.  New Mexico Old Mexico
2 Ella  New York   Old York
3 Jay   Oregon     Oregon
```

```
mydata %>% mutate(
  name2 = str_replace(name, "l", "-"),           # first instance
  name3 = str_replace_all(name, "l", "-"),       # all instances
  name4 = str_replace_all(name, fixed("."), "")) # special characters with fixed()
```

```
# A tibble: 3 x 5
  name  state      name2 name3 name4
  <chr> <chr>      <chr> <chr> <chr>
1 J.M.  New Mexico J.M.  J.M.  JM
2 Ella  New York   E-la  E--a  Ella
3 Jay   Oregon     Jay   Jay   Jay
```

str_sub(): shorten strings

Based on position 1 (start = 1) to length of string (end = -1)

```
mydata %>% mutate(
  short_name  = str_sub(name, start = 1, end = 2),   # specify start to end
  short_name2 = str_sub(name, end = 2),              # specify only end
  short_state = str_sub(state, end = -3)             # negative endices, from end
  )
```

```
# A tibble: 3 x 5
  name  state      short_name short_name2 short_state
  <chr> <chr>      <chr>      <chr>       <chr>
1 J.M.  New Mexico J.         J.          New Mexi
2 Ella  New York   El         El          New Yo
3 Jay   Oregon     Ja         Ja          Oreg
```

Paste strings together with `glue()`

- `paste()` is the base R way of pasting strings (surprise, it's hard to use)
- `glue()` is most useful when pasting data columns together
- **column *names* or function *operations* go inside `{}`**
- See the glue vignette

```
all_data %>%
  mutate(info = glue("Student {record} is {age} with BMI = {round(bmi,1)}")) %>%
  select(record, info) %>% head(5)
```

```
# A tibble: 5 x 2
   record info
    <dbl> <S3: glue>
1  931897 Student 931897 is 15 years old with BMI = 17.2
2  333862 Student 333862 is 17 years old with BMI = 20.2
3   36253 Student 36253 is 18 years old or older with BMI = NA
4 1095530 Student 1095530 is 15 years old with BMI = 28
5 1303997 Student 1303997 is 14 years old with BMI = 24.5
```

Using glue to summarize data

- Useful for tables (will cover this more in another session)
- Example, calculate the S.E. of the mean and create a column with "mean (SE)" of bmi:

```
demo_data %>%
  group_by(sex) %>%
  summarize(n_sex = n(),
            bmi_mean = mean(bmi,na.rm=TRUE),
            bmi_sd = sd(bmi,na.rm=TRUE)) %>%
  mutate(bmi_mean_se = glue("{round(bmi_mean,1)} ({signif(bmi_sd/sqrt(n_sex),2)})"))
```

```
# A tibble: 3 x 5
  sex    n_sex bmi_mean bmi_sd bmi_mean_se
  <chr>  <int>    <dbl>  <dbl> <S3: glue>
1 <NA>     231    NaN   NaN    NaN (NaN)
2 Female  9592     23.3   4.96 23.3 (0.051)
3 Male   10177     23.7   5.01 23.7 (0.05)
```

Wrangle dates with `lubridate`

- Convert characters to special "Date" type
- Convert *terrible excel date formats* into workable data
- Easy date magic examples:
  - add and subtract dates
  - convert to minutes/years/etc
  - change timezones
  - add 1 month to a date...
- `lubridate` cheat sheet
- `read_csv` and `read_excel` etc automatically import dates correctly

Allison Horst

What kind of date do you have?

PARSE DATE-TIMES (Convert strings or numbers to date-times)

1. Identify the order of the year (**y**), month (**m**), day (**d**), hour (**h**), minute (**m**) and second (**s**) elements in your data.
2. Use the function below whose name replicates the order. Each accepts a wide variety of input formats.

2017-11-28T14:02:00	**ymd_hms**(), **ymd_hm**(), **ymd_h**(). *ymd_hms("2017-11-28T14:02:00")*
2017-22-12 10:00:00	**ydm_hms**(), **ydm_hm**(), **ydm_h**(). *ydm_hms("2017-22-12 10:00:00")*
11/28/2017 1:02:03	**mdy_hms**(), **mdy_hm**(), **mdy_h**(). *mdy_hms("11/28/2017 1:02:03")*
1 Jan 2017 23:59:59	**dmy_hms**(), **dmy_hm**(), **dmy_h**(). *dmy_hms("1 Jan 2017 23:59:59")*
20170131	**ymd**(), **ydm**(). *ymd(20170131)*
July 4th, 2000	**mdy**(), **myd**(). *mdy("July 4th, 2000")*
4th of July '99	**dmy**(), **dym**(). *dmy("4th of July '99")*
2001: Q3	**yq**() Q for quarter. *yq("2001: Q3")*
2:01	hms::**hms**() Also lubridate::**hms**(), **hm**() and **ms**(), which return periods.* *hms::hms(sec = 0, min= 1, hours = 2)*

`lubridate` cheat sheet

```
timedata <-
 tibble(name = c("Yi","Bo","DJ"),
        dob=c("10/31/1952","1/12/1984","2/02/2002"))
timedata %>%
  mutate(dob_date = mdy(dob),
         dob_wrong = dmy(dob)) # wrong order
```

```
# A tibble: 3 x 4
  name  dob        dob_date   dob_wrong
  <chr> <chr>      <date>     <date>
1 Yi    10/31/1952 1952-10-31 NA
2 Bo    1/12/1984  1984-01-12 1984-12-01
3 DJ    2/02/2002  2002-02-02 2002-02-02
```

Math with dates

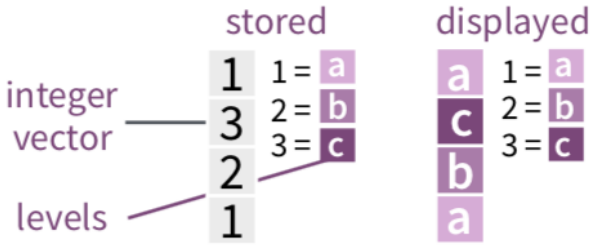
```
timedata %>% mutate(
  dob = mdy(dob),                          # convert to a date
  dob_year = year(dob),                    # extract the year
  time_since_birth = dob %--% today(),     # create an "interval"
  age = time_since_birth %/% years(1),     # modulus on "years"
  dobplus = dob + days(10)                 # add 10 days
  )
```

```
# A tibble: 3 x 6
  name  dob        dob_year time_since_birth                  age dobplus
  <chr> <date>        <dbl> <S4: Interval>                 <dbl> <date>
1 Yi    1952-10-31     1952 1952-10-31 UTC--2019-05-23 UTC    66 1952-11-10
2 Bo    1984-01-12     1984 1984-01-12 UTC--2019-05-23 UTC    35 1984-01-22
3 DJ    2002-02-02     2002 2002-02-02 UTC--2019-05-23 UTC    17 2002-02-12
```

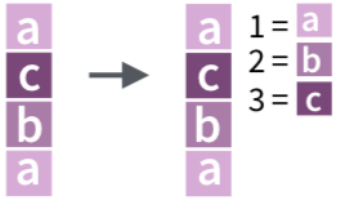
Factors - categorical data

- Clean and order factors with `forcats` package
- Will go over this for `ggplot2` (visualization), statistical modeling (i.e. for `lm()`), and probably a workshop for creating tables
- See `forcats` cheatsheet and `forcats` vignette

Factors



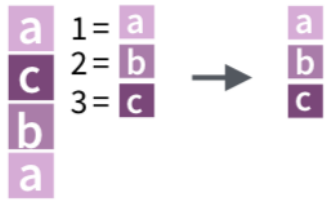
R represents categorical data with factors. A **factor** is an integer vector with a **levels** attribute that stores a set of mappings between integers and categorical values. When you view a factor, R displays not the integers, but the values associated with them.



Create a factor with factor()

factor(x = character(), levels, labels = levels, exclude = NA, ordered = is.ordered(x), nmax = NA) Convert a vector to a factor. Also **as_factor**.

f <- factor(c("a", "c", "b", "a"), levels = c("a", "b", "c"))



Return its levels with levels()

levels(x) Return/set the levels of a factor. *levels(f); levels(f) <- c("x","y","z")*

Use unclass() to see its structure

forcats examples - specify levels fct_relevel()

```
mydata <- tibble(
  id = 1:4,
  grade=c("9th","10th","11th","9th")) %>%
  mutate(grade_fac = factor(grade))
levels(mydata$grade_fac)
```

```
[1] "10th" "11th" "9th"
```

```
mydata %>% arrange(grade_fac)
```

```
# A tibble: 4 x 3
     id grade grade_fac
  <int> <chr> <fct>
1     2 10th  10th
2     3 11th  11th
3     1 9th   9th
4     4 9th   9th
```

```
mydata <- mydata %>%
  mutate(
    grade_fac =
      fct_relevel(grade_fac,
                  c("9th","10th","11th")))
levels(mydata$grade_fac)
```

```
[1] "9th"  "10th" "11th"
```

```
mydata %>% arrange(grade_fac)
```

```
# A tibble: 4 x 3
     id grade grade_fac
  <int> <chr> <fct>
1     1 9th   9th
2     4 9th   9th
3     2 10th  10th
4     3 11th  11th
```

forcats examples - collapse levels

```
mydata <- tibble(loc = c("SW","NW","NW","NE","SE","SE"))

mydata %>% mutate(
  loc_fac = factor(loc),
  loc2 = fct_collapse(loc_fac,                          # collapse levels
                      south = c("SW","SE"),
                      north = c("NE","NW")),
  loc3 = fct_lump(loc_fac, n=2, other_level = "other") # most common 2 levels + other
  )
```

```
# A tibble: 6 x 4
  loc   loc_fac loc2  loc3
  <chr> <fct>   <fct> <fct>
1 SW    SW      south other
2 NW    NW      north NW
3 NW    NW      north NW
4 NE    NE      north other
5 SE    SE      south SE
6 SE    SE      south SE
```

Other "janitor" work

Clean messy column names with clean_names()

```
mydata <- tibble("First Name"= c("Yi","DJ"), "last init" = c("C","R"),
                 "% in" = c(0.1, 0.5), "ñ$$$"= 1:2, " "=3:2,"     hi"=c("a","b"),
                 "null"=c(NA,NA))
mydata
```

```
# A tibble: 2 x 7
  `First Name` `last init` `% in` `ñ$$$`   ` ` `     hi` null
  <chr>        <chr>         <dbl>  <int> <int> <chr>     <lgl>
1 Yi           C               0.1      1     3 a         NA
2 DJ           R               0.5      2     2 b         NA
```

```
mydata %>% clean_names() %>%          # in the janitor package
  remove_empty(c("rows","cols"))      # also useful
```

```
# A tibble: 2 x 6
  first_name last_init percent_in     n     x hi
  <chr>      <chr>           <dbl> <int> <int> <chr>
1 Yi         C                 0.1     1     3 a
2 DJ         R                 0.5     2     2 b
```

Clean names of your excel sheet

	A	B	C	D	E	F	G	H	I
1	RECORD	Age	grade --- string	race	race	bmi (kg/m^2)	weight KG		
2	931897	15 years ol	10th	White	White	17.179	54.43	some random	
3	333862	17 years ol	12th	White	White	20.2487	57.15	notes	
4	36253	18 years ol	11th	Hispanic/La	Hispanic/Latino			I thought of	
5	1095530	15 years ol	10th	Black or Afi	Black or Afi	27.9935	85.73	why	WHY?
6	1303997	14 years ol	9th	All other ra	Multiple - N	24.4922	66.68		
7	261619	17 years ol	9th	All other races					

```
library(readxl)
read_excel("data/messy_names.xlsx", .name_repair = janitor::make_clean_names)
```

```
# A tibble: 20,000 x 9
    record age   grade_string race  race_2 bmi_kg_m_2 weight_kg x     x_2
     <dbl> <chr> <chr>        <chr> <chr>       <dbl>     <dbl> <chr> <chr>
 1  931897 15 y… 10th         White White        17.2      54.4 some… <NA>
 2  333862 17 y… 12th         White White        20.2      57.2 notes <NA>
 3   36253 18 y… 11th         Hisp… Hispa…       NA        NA   I th… <NA>
 4 1095530 15 y… 10th         Blac… Black…       28.0      85.7 why   WHY?
 5 1303997 14 y… 9th          All … Multi…       24.5      66.7 <NA>  <NA>
 6  261619 17 y… 9th          All … <NA>         NA        NA   <NA>  <NA>
```

Practice

Copy and paste the code below into R to create the dataset `messy_data`

```
messy_data <- tibble(NAME = c("J N","A C","D E"),
                     `months follow up` = c("", 10, 11),
                     `Date of visit` = c("July 31, 2003", "Nov 12, 2005", "Aug 3, 2007"))
```

1. Clean column names with `clean_names()`.
2. Replace missing ("") data in `months_follow_up` with NA.
3. Convert `months_follow_up` to a numeric variable.
4. Convert `date_of_visit` to a date.
5. Create a column called `date_last_visit` that is the date of visit *plus* months of follow up.
6. Remove rows (cases) with missing data in `months_follow_up`.
7. Remove the spaces in `name`.

This was a *lot*, but learning R gets easier!

Allison Horst

Resources - `tidyverse` & data wrangling

Links

- Learn the tidyverse
- Data wrangling cheatsheet

Some of this is drawn from materials in online books/lessons:

- R for Data Science - by Garrett Grolemund & Hadley Wickham
- Modern Dive - An Introduction to Statistical and Data Sciences via R by Chester Ismay & Albert Kim
- A gRadual intRoduction to the tidyverse - Workshop for Cascadia R 2017 by Chester Ismay and Ted Laderas
- "Tidy Data" by Hadley Wickham

Possible future workshop topics:

- reproducible reports in R (probably next)
  - R Markdown and knitr
  - Create dynamic Word, html, pdf documents with code + output
- tables
- ggplot2 visualization
- advanced tidyverse: functions, purrr
- statistical modeling in R

Fill out feedback forms to suggest more or help us prioritize!

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This workshop info:

- Code for these slides on github: jminnier/berd_r_courses
- all the R code in an R script
- answers to practice problems can be found here: html