Data Wrangling in R with the Tidyverse (Part 1)

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slides: bit.ly/berd_tidy1
pdf: bit.ly/berd_tidy1_pdf

Load files for today's workshop

- Open the slides of this workshop: bit.ly/berd_tidy1
- 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")
library(tidyverse)
library(lubridate)
demo_data <-
read_csv("data/yrbss_demo.csv")
```

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Learning objectives

Part 1:

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

Part 2:

- Reshaping (long/wide format) data
- Join/merge data sets
- Data cleaning, including examples for dealing with:
  - Missing data
  - Strings/character vectors
  - Factors/categorical variables
  - Dates

Getting started

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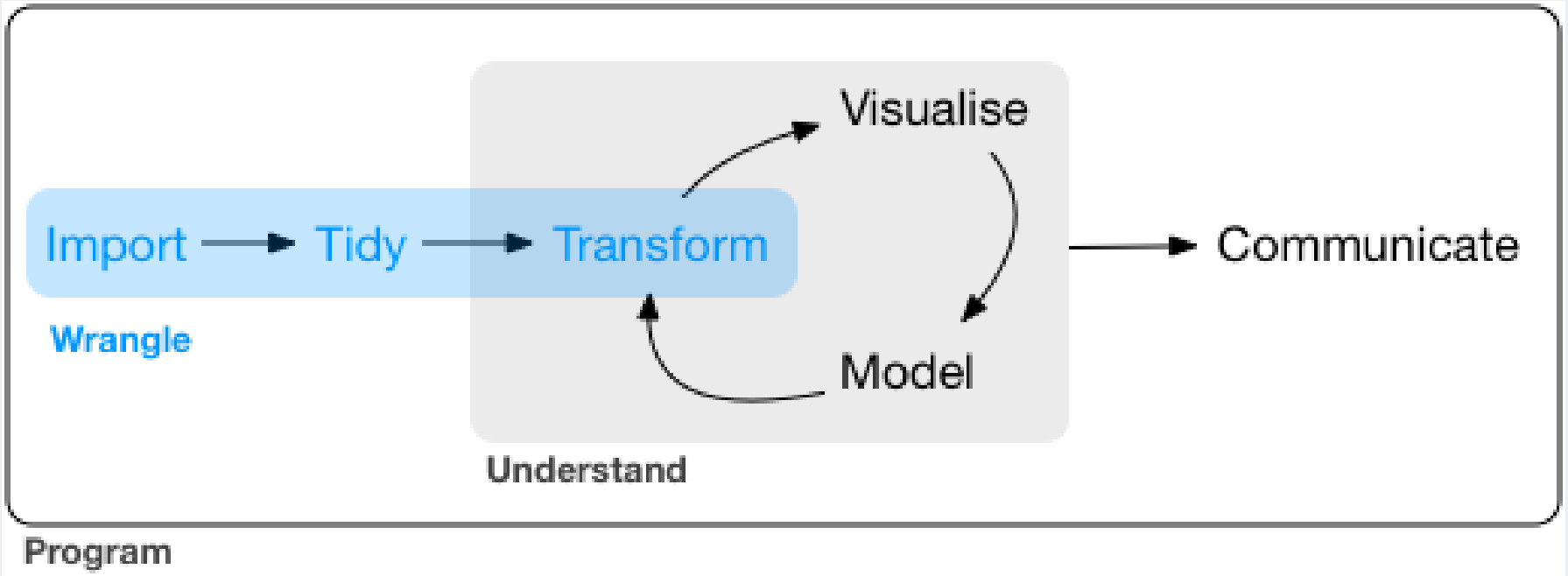
What is data wrangling?

- "data janitor work"
- importing data
- cleaning data
- changing shape of data

- fixing errors and poorly formatted data elements
- transforming columns and rows
- filtering, subsetting



G. Grolemond & H. Wickham's R for Data Science

Good practices in RStudio

Use projects (read this)

- Create an RStudio project for each data analysis project
- A project is associated with a directory folder
    - Keep data files there
    - Keep scripts there; edit them, run them in bits or as a whole
    - Save your outputs (plots and cleaned data) there
- Only use relative paths, never absolute paths
    - relative (good): `read_csv("data/mydata.csv")`
    - absolute (bad): `read_csv("/home/yourname/Documents/stuff/mydata.csv")`

Advantages of using projects

- standardize file paths
- keep everything together
- a whole folder can be shared and run on another computer

Useful keyboard shortcuts

action	mac	windows/linux
run code in script	cmd + enter	ctrl + enter
<-	option + -	alt + -
%>% (covered later)	cmd + shift + m	ctrl + shift + m

Try typing (with shortcut) and running

```
y <- 5
y
```

Now, in the console, press the up arrow.

Others: (see full list)

action	mac	windows/linux
interrupt currently executing command	esc	esc
in console, go to previously run code	up/down	up/down
keyboard shortcut help	option + shift + k	alt + shift + k

Tibbles

hexbin

Data frames vs. tibbles

Previously we learned about *data frames*

```
data.frame(name = c("Sarah","Ana","Jose"),
           rank = 1:3,
           age = c(35.5, 25, 58),
           city = c(NA,"New York","LA"))
```

```
   name rank  age      city
1 Sarah    1 35.5      <NA>
2   Ana    2 25.0 New York
3  Jose    3 58.0        LA
```

A *tibble* is a data frame but with perks

```
tibble(name = c("Sarah","Ana","Jose"),
       rank = 1:3,
       age = c(35.5, 25, 58),
       city = c(NA,"New York","LA"))
```

```
# A tibble: 3 x 4
  name   rank   age city
  <chr> <int> <dbl> <chr>
1 Sarah     1  35.5 <NA>
2 Ana       2  25   New York
3 Jose      3  58   LA
```

How are these two datasets different?

Import data as a data frame (try this)

Base R functions import data as data frames (`read.csv`, `read.table`, etc)

```
mydata_df <- read.csv("data/small_data.csv")
mydata_df
```

```
        id              age    sex grade                    race4
1   335340 17 years old Female  10th                    White
2   638618 16 years old Female   9th                     <NA>
3   922382 14 years old   Male   9th                    White
4   923122 15 years old   Male   9th                    White
5   923963 15 years old   Male  10th Black or African American
6   925603 16 years old   Male  10th            All other races
7   933724 16 years old Female  10th            All other races
8   935435 17 years old Female  12th            All other races
9  1096564 15 years old   Male  10th            All other races
10 1108114 17 years old Female   9th Black or African American
11 1306150 16 years old   Male  10th            Hispanic/Latino
12 1307481 17 years old   Male  12th            Hispanic/Latino
13 1307872 17 years old   Male  11th            Hispanic/Latino
14 1311617 15 years old Female  10th            Hispanic/Latino
15 1313153 16 years old Female  11th            Hispanic/Latino
16 1313291 16 years old Female  11th                    White
```

Import data as a tibble (try this)

`tidyverse` functions import data as tibbles (`read_csv`, `read_excel()`, etc)

```
mydata_tib <- read_csv("data/small_data.csv")
mydata_tib
```

```
# A tibble: 20 x 11
       id age   sex    grade race4   bmi weight_kg text_while_driv…
    <dbl> <chr> <chr>  <chr> <chr> <dbl>     <dbl> <chr>
 1 3.35e5 17 y… Fema… 10th  White  27.6      66.2 <NA>
 2 6.39e5 16 y… Fema… 9th   <NA>   29.3      84.8 <NA>
 3 9.22e5 14 y… Male  9th   White  18.2      57.6 <NA>
 4 9.23e5 15 y… Male  9th   White  21.4      60.3 <NA>
 5 9.24e5 15 y… Male  10th  Blac…  19.6      63.5 <NA>
 6 9.26e5 16 y… Male  10th  All …  22.2      70.3 <NA>
 7 9.34e5 16 y… Fema… 10th  All …  21.0      45.4 <NA>
 8 9.35e5 17 y… Fema… 12th  All …  17.5      43.1 <NA>
 9 1.10e6 15 y… Male  10th  All …  22.5      79.4 <NA>
10 1.11e6 17 y… Fema… 9th   Blac…  26.6      68.0 <NA>
11 1.31e6 16 y… Male  10th  Hisp…  21.2      67.1 0 days
12 1.31e6 17 y… Male  12th  Hisp…  19.5      56.2 1 or 2 days
13 1.31e6 17 y… Male  11th  Hisp…  20.6      61.7 1 or 2 days
14 1.31e6 15 y… Fema… 10th  Hisp…  27.5      70.3 0 days
```

Compare & contrast data frame and tibble

Run the code below

data frame

```
glimpse(mydata_df)
str(mydata_df)        # How are glimpse() and str() different?
head(mydata_df)
summary(mydata_df)
class(mydata_df)      # What information does class() give?
```

tibble

```
glimpse(mydata_tib)
str(mydata_tib)
head(mydata_tib)
summary(mydata_tib)
class(mydata_tib)
```

Tibble perks

Viewing tibbles:

- variable types are given (character, factor, double, integer, boolean, date)
- number of rows & columns shown are limited for easier viewing

Other perks:

- tibbles can typically be used anywhere a `data.frame` is needed
- `read_*()` functions don't read character columns as factors (no surprises)

Tidy Data

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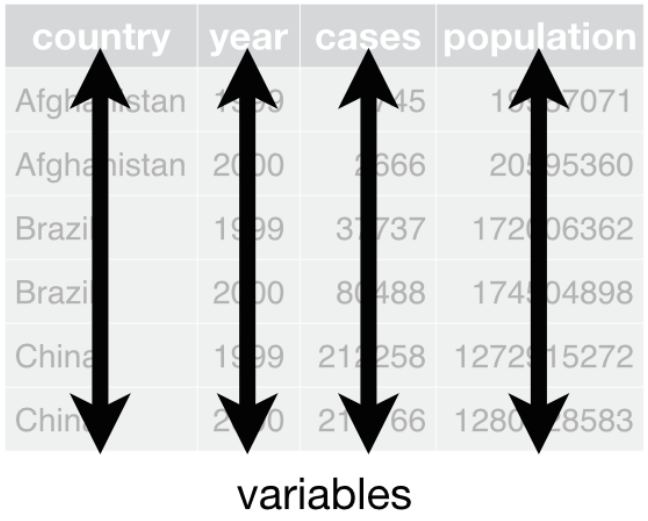
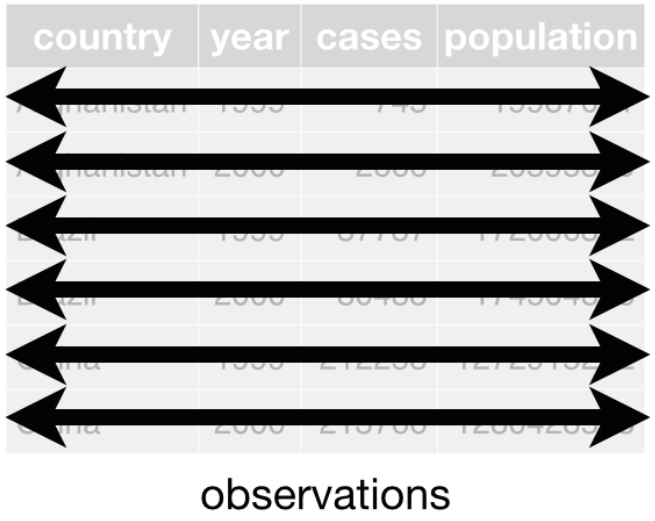
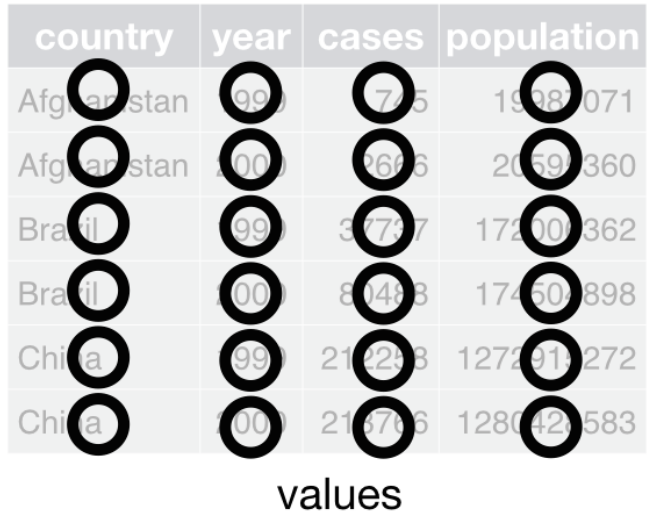
What are tidy data?

1. Each variable forms a column
2. Each observation forms a row
3. Each value has its own cell







G. Grolemond & H. Wickham's R for Data Science

Untidy data: example 1

```
untidy_data <- tibble(
  name = c("Ana","Bob","Cara"),
  meds = c("advil 600mg 2xday","tylenol 650mg 4xday", "advil 200mg 3xday")
)
untidy_data
```

```
# A tibble: 3 x 2
  name  meds
  <chr> <chr>
1 Ana   advil 600mg 2xday
2 Bob   tylenol 650mg 4xday
3 Cara  advil 200mg 3xday
```

Tidy data: example 1

You will learn how to do this!

```
untidy_data %>%
  separate(col = meds, into = c("med_name","dose_mg","times_per_day"), sep=" ") %>%
  mutate(times_per_day = as.numeric(str_remove(times_per_day, "xday")),
         dose_mg = as.numeric(str_remove(dose_mg, "mg")))
```

```
# A tibble: 3 x 4
  name  med_name dose_mg times_per_day
  <chr> <chr>      <dbl>         <dbl>
1 Ana   advil        600             2
2 Bob   tylenol      650             4
3 Cara  advil        200             3
```

Untidy data: example 2

```
untidy_data2 <- tibble(
  name = c("Ana","Bob","Cara"),
  wt_07_01_2018 = c(100, 150, 140),
  wt_08_01_2018 = c(104, 155, 138),
  wt_09_01_2018 = c(NA, 160, 142)
)
untidy_data2
```

```
# A tibble: 3 x 4
  name  wt_07_01_2018 wt_08_01_2018 wt_09_01_2018
  <chr>         <dbl>         <dbl>         <dbl>
1 Ana             100           104            NA
2 Bob             150           155           160
3 Cara            140           138           142
```

Tidy data: example 2

You will learn how to do this!

```
untidy_data2 %>%
  gather(key = "date", value = "weight", -name) %>%
  mutate(date = str_remove(date,"wt_"),
         date = dmy(date))     # dmy() is a function in the lubridate package
```

```
# A tibble: 9 x 3
  name  date       weight
  <chr> <date>      <dbl>
1 Ana   2018-01-07    100
2 Bob   2018-01-07    150
3 Cara  2018-01-07    140
4 Ana   2018-01-08    104
5 Bob   2018-01-08    155
6 Cara  2018-01-08    138
7 Ana   2018-01-09     NA
8 Bob   2018-01-09    160
9 Cara  2018-01-09    142
```

How to tidy?

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Tools for tidying data

- `tidyverse` functions
  - **`tidyverse`** is a suite of packages that implement **`tidy`** methods for data importing, cleaning, and wrangling
  - load the **`tidyverse`** packages by running the code **`library(tidyverse)`**
    - see pre-workshop homework for code to install **`tidyverse`**

- Functions to easily work with rows and columns, such as
  - subset rows/columns
  - add new rows/columns
  - split apart or unite columns
  - join together different data sets (part 2)
  - make data *long* or *wide* (part 2)

- Often many steps to tidy data
  - string together commands to be performed sequentially
  - do this using pipes `%>%`

How to use the pipe %>%

The pipe operator %>% strings together commands to be performed sequentially

```
mydata_tib %>% head(n=3)       # prounounce %>% as "then"
```

```
# A tibble: 3 x 11
      id age   sex    grade race4   bmi weight_kg text_while_driv…
   <dbl> <chr> <chr>  <chr> <chr> <dbl>     <dbl> <chr>
1 335340 17 y… Fema… 10th  White  27.6      66.2 <NA>
2 638618 16 y… Fema… 9th   <NA>   29.3      84.8 <NA>
3 922382 14 y… Male  9th   White  18.2      57.6 <NA>
# … with 3 more variables: smoked_ever <chr>, bullied_past_12mo <lgl>,
#   height_m <dbl>
```

- Always *first list the tibble* that the commands are being applied to
- Can use **multiple pipes** to run multiple commands in sequence
  - What does the following code do?

```
mydata_tib %>% head(n=3) %>% summary()
```

About the data

Data from the CDC's Youth Risk Behavior Surveillance System (YRBSS)

- complex survey data
- national school-based survey
  - conducted by CDC and state, territorial, and local education and health agencies and tribal governments
- monitors six categories of health-related behaviors
  - that contribute to the leading causes of death and disability among youth and adults
  - including alcohol & drug use, unhealthy & dangerous behaviors, sexuality, and physical activity
  - see Questionnaires

- the data in `yrbss_demo.csv` are a subset of data in the R package `yrbss`, which includes YRBSS from 1991-2013

- Look at your *Environment* tab to make sure `demo_data` is already loaded

```
demo_data <- read_csv("data/yrbss_demo.csv")
```

Subsetting data

Subset Observations (Rows)

Subset Variables (Columns)

`filter()` ~ rows

filter data based on rows

- math: >, <, >=, <=
- double = for "is equal to": ==
- & (and)
- | (or)
- != (not equal)

- `is.na()` to filter based on missing values
- `%in%` to filter based on group membership
- `!` in front negates the statement, as in
  - `!is.na(age)`
  - `!(grade %in% c("9th","10th"))`

```
demo_data %>% filter(bmi > 20)
```

```
# A tibble: 10,375 x 8
    record age          sex    grade race4          race7           bmi stweight
     <dbl> <chr>        <chr>  <chr> <chr>          <chr>         <dbl>    <dbl>
 1  333862 17 years o… Fema… 12th  White          White          20.2      57.2
 2 1095530 15 years o… Male  10th  Black or Af… Black or Af…  28.0      85.7
 3 1303997 14 years o… Male  9th   All other r… Multiple - …  24.5      66.7
 4  926649 16 years o… Male  11th  All other r… Asian          20.5      70.3
 5  506337 18 years o… Male  12th  Hispanic/La… Hispanic/La…  33.1     123.
 6 1307180 16 years o… Male  10th  Hispanic/La… Hispanic/La…  21.8      66.7
 7 1312128 15 years o… Fema… 10th  White          White          22.0      65.8
```

Compare to base R

- **Bracket method**: need to repeat tibble name
- Need to use `$`
- Very nested and confusing to read

```
demo_data[demo_data$grade=="9th",]
```

```
# A tibble: 5,625 x 8
    record age       sex    grade race4
     <dbl> <chr>     <chr>  <chr> <chr>
 1 1303997 14 years… Male   9th   All other
 2  261619 17 years… Male   9th   All other
 3 1096939 15 years… Male   9th   <NA>
 4  180968 15 years… Male   9th   White
 5  924270 15 years… Male   9th   All other
 6  330828 15 years… Female 9th   Hispanic/
 7 1311252 15 years… Female 9th   Hispanic/
 8   36853 14 years… Female 9th   All other
 9 1310689 14 years… Female 9th   Hispanic/
10 1310726 14 years… Female 9th   All other
# … with 5,615 more rows
```

- **Pipe method**: list tibble name once
- No `$` needed since uses "non-standard evaluation": `filter()` knows `grade` is a column in `demo_data`

```
demo_data %>% filter(grade=="9th")
```

```
# A tibble: 5,219 x 8
    record age       sex    grade race4
     <dbl> <chr>     <chr>  <chr> <chr>
 1 1303997 14 years… Male   9th   All other
 2  261619 17 years… Male   9th   All other
 3 1096939 15 years… Male   9th   <NA>
 4  180968 15 years… Male   9th   White
 5  924270 15 years… Male   9th   All other
 6  330828 15 years… Female 9th   Hispanic/
 7 1311252 15 years… Female 9th   Hispanic/
 8   36853 14 years… Female 9th   All other
 9 1310689 14 years… Female 9th   Hispanic/
10 1310726 14 years… Female 9th   All other
# … with 5,209 more rows
```

`filter()` practice

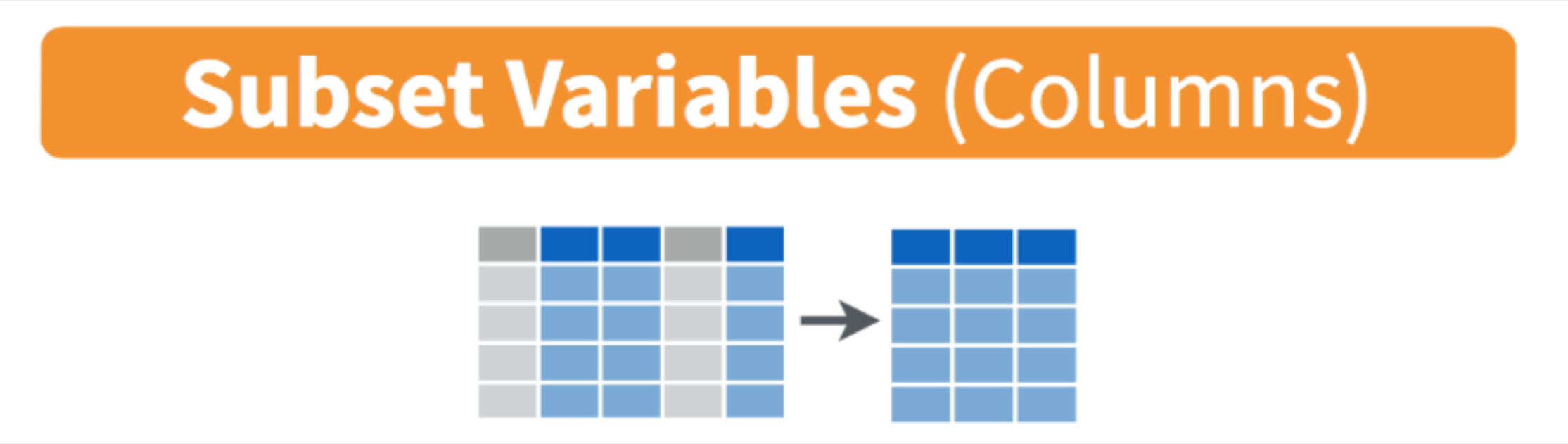
What do these commands do? Try them out:

```
demo_data %>% filter(bmi < 5)
demo_data %>% filter(bmi/stweight < 0.5)    # can do math
demo_data %>% filter((bmi < 15) | (bmi > 50))
demo_data %>% filter(bmi < 20, stweight < 50, sex == "Male") # filter on multiple variables

demo_data %>% filter(record == 506901)      # note the use of == instead of just =
demo_data %>% filter(sex == "Female")
demo_data %>% filter(!(grade == "9th"))
demo_data %>% filter(grade %in% c("10th", "11th"))

demo_data %>% filter(is.na(bmi))
demo_data %>% filter(!is.na(bmi))
```

Subset by columns



tidyverse data wrangling cheatsheet

`select()` ~ columns

- select columns (variables)
- no quotes needed around variable names
- can be used to rearrange columns
- uses special syntax that is flexible and has many options

```
demo_data %>% select(record, grade)
```

```
# A tibble: 20,000 x 2
    record grade
     <dbl> <chr>
 1  931897 10th
 2  333862 12th
 3   36253 11th
 4 1095530 10th
 5 1303997 9th
 6  261619 9th
 7  926649 11th
 8 1309082 12th
 9  506337 12th
10  180494 10th
# … with 19,990 more rows
```

Compare to base R

- Need brackets
- Need quotes around column names

```
demo_data[, c("record","age","sex")]
```

```
# A tibble: 20,000 x 3
    record age                    sex
     <dbl> <chr>                  <chr>
 1  931897 15 years old           Female
 2  333862 17 years old           Female
 3   36253 18 years old or older  Male
 4 1095530 15 years old           Male
 5 1303997 14 years old           Male
 6  261619 17 years old           Male
 7  926649 16 years old           Male
 8 1309082 17 years old           Male
 9  506337 18 years old or older  Male
10  180494 14 years old           Male
# … with 19,990 more rows
```

- No quotes needed and easier to read.
- More flexible, either of following work:

```
demo_data %>% select(record, age, sex)
demo_data %>% select(record:sex)
```

```
# A tibble: 20,000 x 3
    record age                    sex
     <dbl> <chr>                  <chr>
 1  931897 15 years old           Female
 2  333862 17 years old           Female
 3   36253 18 years old or older  Male
 4 1095530 15 years old           Male
 5 1303997 14 years old           Male
 6  261619 17 years old           Male
 7  926649 16 years old           Male
 8 1309082 17 years old           Male
 9  506337 18 years old or older  Male
10  180494 14 years old           Male
# … with 19,990 more rows
# A tibble: 20,000 x 3
```

Column selection syntax options

There are many ways to select a set of variable names (columns):

- `var1:var20`: all columns from `var1` to `var20`
- `one_of(c("a", "b", "c"))`: all columns with names in the specified character vector of names
- **Removing columns**
  - `-var1`: remove the column`var1`
  - `-(var1:var20)`: remove all columns from `var1` to `var20`
- **Select using text within column names**
  - `contains("date")`, `contains("_")`: all variable names that contain the specified string
  - `starts_with("a")` or `ends_with("last")`: all variable names that start or end with the specificed string
- **Rearranging columns**
  - use `everything()` to select all columns not already named
  - example: `select(var1, var20, everything())` moves the column `var20` to the second position

See other examples in the data wrangling cheatsheet.

`select()` practice

Which columns are selected & in what order using these commands?
First guess and then try them out.

```
demo_data %>% select(record:sex)
demo_data %>% select(one_of(c("age","stweight")))

demo_data %>% select(-grade,-sex)
demo_data %>% select(-(record:sex))

demo_data %>% select(contains("race"))
demo_data %>% select(starts_with("r"))
demo_data %>% select(-contains("r"))

demo_data %>% select(record, race4, race7, everything())
```

`rename()` ~ columns

- renames column variables

```
demo_data %>% rename(id = record)    # order: new_name = old_name
```

```
# A tibble: 20,000 x 8
        id age          sex    grade race4          race7            bmi stweight
     <dbl> <chr>        <chr>  <chr> <chr>          <chr>          <dbl>    <dbl>
 1  931897 15 years o… Fema… 10th  White          White           17.2     54.4
 2  333862 17 years o… Fema… 12th  White          White           20.2     57.2
 3   36253 18 years o… Male  11th  Hispanic/La… Hispanic/La…  NA       NA
 4 1095530 15 years o… Male  10th  Black or Af… Black or Af…  28.0     85.7
 5 1303997 14 years o… Male  9th   All other r… Multiple - …  24.5     66.7
 6  261619 17 years o… Male  9th   All other r… <NA>           NA       NA
 7  926649 16 years o… Male  11th  All other r… Asian          20.5     70.3
 8 1309082 17 years o… Male  12th  White          White           19.3     59.0
 9  506337 18 years o… Male  12th  Hispanic/La… Hispanic/La…  33.1    123.
10  180494 14 years o… Male  10th  Black or Af… Black or Af…  NA       NA
# … with 19,990 more rows
```

Practice

```
# Remember: to save output into the same tibble you would use <-
newdata <- newdata %>% select(-record)
```

Do the following data wrangling steps in order so that the output from the previous step is the input for the next step. Save the results in each step as `newdata`.

1. Import `demo_data.csv` in the `data` folder if you haven't already done so.
2. Subset the data so that only character variables are included and save the result as `newdata`.
3. Filter `newdata` to only keep Asian or Native Hawaiian/other PI subjects that are in the 9th grade, and save again as `newdata`.
4. Filter `newdata` to remove subjects younger than 13, and save as `newdata`.
5. Remove the column `race4`, and save as `newdata`.
6. How many rows does the resulting `newdata` have? How many columns?

Changing the data

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Make new variables

tidyverse data wrangling cheatsheet

mutate()

Use `mutate()` to add new columns to a tibble

- many options in how to define new column of data

```
newdata <- demo_data %>%
  mutate(height_m = sqrt(stweight / bmi))    # use = (not <- or ==) to define new variable

newdata %>% select(record, bmi, stweight)
```

```
# A tibble: 20,000 x 3
    record   bmi stweight
     <dbl> <dbl>    <dbl>
 1  931897  17.2     54.4
 2  333862  20.2     57.2
 3   36253  NA       NA
 4 1095530  28.0     85.7
 5 1303997  24.5     66.7
 6  261619  NA       NA
 7  926649  20.5     70.3
 8 1309082  19.3     59.0
 9  506337  33.1    123.
10  180494  NA       NA
```

mutate() practice

What do the following commands do?
First guess and then try them out.

```
demo_data %>% mutate(bmi_high = (bmi > 30))

demo_data %>% mutate(male = (sex == "Male"))
demo_data %>% mutate(male = 1 * (sex == "Male"))

demo_data %>% mutate(grade_num = as.numeric(str_remove(grade, "th")))
```

`case_when()` with `mutate()`

Use `case_when()` to create multi-valued variables that depend on an existing column

- Example: create BMI groups based off of the `bmi` variable

```
demo_data2 <- demo_data %>%
  mutate(
    bmi_group = case_when(
      bmi < 18.5 ~ "underweight",                # condition ~ new_value
      bmi >= 18.5 & bmi <= 24.9 ~ "normal",
      bmi > 24.9 & bmi <= 29.9 ~ "overweight",
      bmi > 29.9 ~ "obese")
    )
demo_data2 %>% select(bmi, bmi_group) %>% head()
```

```
# A tibble: 6 x 2
    bmi bmi_group
  <dbl> <chr>
1  17.2 underweight
2  20.2 normal
3  NA   <NA>
4  28.0 overweight
5  24.5 normal
```

separate() and unite()

separate(): one column to many

- when one column has multiple types of information
- removes original column by default

```
demo_data %>%
  separate(age,c("a","y","o","w","w2"),
           sep = " ") %>%
  select(a:w2)
```

```
# A tibble: 20,000 x 5
   a     y     o     w     w2
   <chr> <chr> <chr> <chr> <chr>
 1 15    years old   <NA>  <NA>
 2 17    years old   <NA>  <NA>
 3 18    years old   or    older
 4 15    years old   <NA>  <NA>
 5 14    years old   <NA>  <NA>
 6 17    years old   <NA>  <NA>
```

unite(): many columns to one

- paste columns together using a separator
- removes original columns by default

```
demo_data %>%
  unite("sexgr", sex, grade, sep=":") %>%
  select(sexgr)
```

```
# A tibble: 20,000 x 1
   sexgr
   <chr>
 1 Female:10th
 2 Female:12th
 3 Male:11th
 4 Male:10th
 5 Male:9th
 6 Male:9th
 7 Male:11th
```

`separate()` and `unite()` practice

What do the following commands do?

First guess and then try them out.

```
demo_data %>% separate(age, c("agenum","yrs"), sep = " ")
demo_data %>% separate(age, c("agenum","yrs"), sep = " ", remove = FALSE)

demo_data %>% separate(grade, c("grade_n"), sep = "th")
demo_data %>% separate(grade, c("grade_n"), sep = "t")
demo_data %>% separate(race4, c("race4_1", "race4_2"), sep = "/")

demo_data %>% unite("sex_grade", sex, grade, sep = "::::")
demo_data %>% unite("sex_grade", sex, grade)       # what is the default `sep` for unite?
demo_data %>% unite("race", race4, race7)          # what happens to NA values?
```

More commands to filter rows

Remove rows with missing data

`na.omit` removes *all* rows with *any* missing (`NA`) values in *any* column

```
demo_data %>% na.omit()
```

```
# A tibble: 12,897 x 8
    record age          sex    grade race4          race7           bmi stweight
     <dbl> <chr>        <chr>  <chr> <chr>          <chr>         <dbl>    <dbl>
 1  931897 15 years o… Fema… 10th  White          White          17.2     54.4
 2  333862 17 years o… Fema… 12th  White          White          20.2     57.2
 3 1095530 15 years o… Male  10th  Black or Af… Black or Af…  28.0     85.7
 4 1303997 14 years o… Male  9th   All other r… Multiple - …  24.5     66.7
 5  926649 16 years o… Male  11th  All other r… Asian          20.5     70.3
 6 1309082 17 years o… Male  12th  White          White          19.3     59.0
 7  506337 18 years o… Male  12th  Hispanic/La… Hispanic/La…  33.1    123.
 8 1307180 16 years o… Male  10th  Hispanic/La… Hispanic/La…  21.8     66.7
 9 1312128 15 years o… Fema… 10th  White          White          22.0     65.8
10  770177 16 years o… Fema… 10th  White          White          32.4     86.2
# … with 12,887 more rows
```

We will discuss dealing with missing data more in part 2

Remove rows with duplicated data

`distinct()` removes rows that are duplicates of other rows

```
data_dups <- tibble(
  name = c("Ana","Bob","Cara", "Ana"),
  race = c("Hispanic","Other", "White", "Hispanic")
)
```

```
data_dups
```

```
# A tibble: 4 x 2
  name  race
  <chr> <chr>
1 Ana   Hispanic
2 Bob   Other
3 Cara  White
4 Ana   Hispanic
```

```
data_dups %>% distinct()
```

```
# A tibble: 3 x 2
  name  race
  <chr> <chr>
1 Ana   Hispanic
2 Bob   Other
3 Cara  White
```

Order rows: `arrange()`

Use `arrange()` to order the rows by the values in specified columns

```
demo_data %>% arrange(bmi, stweight) %>% head(n=3)
```

```
# A tibble: 3 x 8
   record age        sex    grade race4          race7            bmi stweight
    <dbl> <chr>      <chr>  <chr> <chr>          <chr>          <dbl>    <dbl>
1  635432 13 years… Female 9th   Hispanic/Lat… Hispanic/Lat…  13.2      27.7
2  501608 15 years… Male   9th   All other ra… Asian          13.2      47.6
3 1097740 16 years… Male   9th   Black or Afr… Black or Afr…  13.3      45.4
```

```
demo_data %>% arrange(desc(bmi), stweight) %>% head(n=3)
```

```
# A tibble: 3 x 8
   record age          sex    grade race4          race7            bmi stweight
    <dbl> <chr>        <chr>  <chr> <chr>          <chr>          <dbl>    <dbl>
1  324452 16 years old Male   11th  Black or Af… Black or Af…  53.9      91.2
2 1310082 18 years ol… Male   11th  Black or Af… Black or Af…  53.5     160.
3  328160 18 years ol… Male   <NA>  Black or Af… Black or Af…  53.4     128.
```

Practice

Do the following data wrangling steps in order so that the output from the previous step is the input for the next step. Save the results in each step as `newdata`.

1. Import `demo_data.csv` in the `data` folder if you haven't already done so.
2. Create a variable called `grade_num` that has the numeric grade number (use `as.numeirc`).
3. Filter the data to keep only students in grade 11 or higher.
4. Filter out rows when `bmi` is `NA`.
5. Create a binary variable called `bmi_normal` that is equal to 1 when `bmi` is between 18.5 to 24.9 and 0 when it is outside that range.
6. Arrange by `grade_num` from highest to lowest
7. Save all output to `newdata`.

Advanced column commands

Mutating multiple columns at once: `mutate_*`

- variants of `mutate()` that are useful for mutating multiple columns at once
  - `mutate_at()`, `mutate_if()`, `mutate_all()`, etc.
- which columns get mutated depends on a predicate, can be:
  - a function that returns TRUE/FALSE like `is.numeric()`, or
  - variable names through `vars()`

What do these commands do? Try them out:

```
# mutate_if
demo_data %>% mutate_if(is.numeric, as.character)   # as.character() is a function
demo_data %>% mutate_if(is.character, tolower)      # tolower() is a function
demo_data %>% mutate_if(is.double, round, digits=0) # arguments to function can go after

# mutate_at
demo_data %>% mutate_at(vars(age:grade), toupper)  # toupper() is a function
demo_data %>% mutate_at(vars(bmi,stweight), log)
demo_data %>% mutate_at(vars(contains("race")), str_detect, pattern = "White")

# mutate_all
demo_data %>% mutate_all(as.character)
```

Selecting & renaming multiple columns

- `select_*()` & `rename_*()` are variants of `select()` and `rename()`
- use like `mutate_*()` options on previous slide

What do these commands do? Try them out:

```
demo_data %>% select_if(is.numeric)

demo_data %>% rename_all(toupper)
demo_data %>% rename_if(is.character, toupper)

demo_data %>% rename_at(vars(contains("race")), toupper)
```

The pipe operator %>% revisited

- a function performed on (usually) a data frame or tibble
- the result is a transformed data set as a `tibble`
- Suppose you want to perform a series of operations on a data.frame or tibble `mydata` using hypothetical functions `f()`, `g()`, `h()`:
  - Perform `f(mydata)`
  - use the output as an argument to `g()`: `g(f(mydata))`
  - use the output as an argument to `h()`: `h(g(f(mydata)))`

One option:

```
h(g(f(mydata)))
```

A long tedious option:

```
fout <- f(mydata)
gout <- g(fout)
h(gout)
```

Using pipes - easier to read:

```
mydata %>%
  f() %>%
  g() %>%
  h()
```

Why use the pipe?

- makes code more readable
- `h(f(g(mydata)))` can get complicated with multiple arguments
  - i.e. `h(f(g(mydata, na.rm=T), print=FALSE), type = "mean")`

tidyverse way:

```
demo_data2 <- demo_data %>%
  na.omit %>%
  mutate(
    height_m = sqrt(stweight/bmi),
    bmi_high = 1*(bmi>30)
  ) %>%
  select_if(is.numeric)
demo_data2
```

base R way:

```
demo_data3 <- na.omit(demo_data)
demo_data3$height_m <- sqrt(demo_data3$stweight/demo
demo_data3$bmi_high <- 1*(demo_data3$bmi>30)
demo_data3 <- demo_data3[,c("record","bmi","stweight
demo_data3
```

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
- tables
- ggplot2 visualization
- advanced tidyverse: functions, purrr
- statistical modeling in R

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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, pdf