Lecture 4: Pipes and variable creation

Managing and Manipulating Data Using R

Introduction

What we will do today

Libraries we will use today

"Load" the package we will use today (output omitted)

- **you must run this code chunk**

```
library(tidyverse)
```

If package not yet installed, then must install before you load. Install in "console" rather than .Rmd file

- Generic syntax: `install.packages("package_name")`
- Install "tidyverse": `install.packages("tidyverse")`

Note: when we load package, name of package is not in quotes; but when we install package, name of package is in quotes:

- `install.packages("tidyverse")`
- `library(tidyverse)`

Data for lecture

Lecture 3 data: prospects purchased by Western Washington U.

The "Student list" business

- Universities identify/target "prospects" by buying "student lists" from College Board/ACT (e.g., $.40 per prospect)
- Prospect lists contain contact info (e.g., address, email), academic achievement, socioeconomic, demographic characteristics
- Universities choose which prospects to purchase by filtering on criteria like zip-code, GPA, test score range, etc.

```
#load prospect list data
load(url("https://github.com/ozanj/rclass/raw/master/data/prospect_list/wwlist_
```

Object `wwlist`

- De-identified list of prospective students purchased by Western Washington University from College Board
- We collected these data using FOIA request
  - ASIDE: Become an expert on collecting data via FOIA requests and you will become a superstar!

Lecture 3 data: prospects purchased by Western Washington U.

Observations on `wwlist`

- each observation represents a prospective student

```
typeof(wwlist)
#> [1] "list"
dim(wwlist)
#> [1] 268396     41
```

Variables on `wwlist`

- some vars provide de-identified data on individual prospects
  - e.g., `psat_range`, `state`, `sex`, `ethn_code`
- some vars provide data about zip-code student lives in
  - e.g., `med_inc`, `pop_total`, `pop_black`
- some vars provide data about school student enrolled in
  - e.g., `fr_lunch` is number of students on free/reduced lunch
  - note: bad merge between prospect-level data and school-level data

```
names(wwlist)
str(wwlist)
glimpse(wwlist) # tidyverse function, similar to str()
```

Lecture 3 data: prospects purchased by Western Washington U.

Variable `firstgen` identifies whether prospect is a first-generation college student

Imagine we want to isolate all the first-generation prospects

1. Investigate variable type/structure.

- A dichotomous var, but stored as character in `wwlist`. So must use quotes (`''` or `""`) to filter/subset based on values of `firstgen`

```
str(wwlist$firstgen)
#>  chr [1:268396] NA "N" "N" "N" NA "N" "N" "Y" "Y" "N" "N" "N" "N" "N" ...
```

2. Create frequency table to identify possible values of `firstgen`

```
table(wwlist$firstgen, useNA = "always")
#>
#>      N      Y   <NA>
#> 193333  65046  10017
```

3. Isolate all the first-gen prospects

```
filter(wwlist, firstgen == "Y")
#> # A tibble: 65,046 x 41
#>    receive_date psat_range state zip9  for_country sex   hs_ceeb_code
#>    <date>       <chr>      <chr> <chr> <chr>       <chr>        <int>
#>  1 2016-05-31   1170-1520  WA    9812~ <NA>        F           481128
#>  2 2016-05-31   930-1160   WA    9829~ <NA>        M           481335
#>  3 2016-05-31   1030-1160  CO    8012~ <NA>        M            60926
#>  4 2016-05-31   930-1160   WA    9837~ <NA>        F           480442
#>  5 2016-05-31   930-1160   WA    9811~ <NA>        F           481085
```

Pipes

What are "pipes", %>%

Pipes are a means of perfoming multiple steps in a single line of code

- When writing code, the pipe symbol is `%>%`
- Basic flow of using pipes in code:
  - `object %>% some_function %>% some_function %>% some_function`
- Pipes work from left to right:
  - The object from left of `%>%` pipe symbol is input as the first argument of the function to the right of the `%>%` pipe symbol
  - In turn, the resulting output becomes the input (the first argument) of the function to the right of the next `%>%` pipe symbol
- Pipes are part of **tidyverse** suite of packages, not **base R**

Intuitive mnemonic device for understanding pipes

- whenever you see a pipe `%>%` think of the words "**and then...**"

Example: isolate all the first-generation prospects [output omitted]

- in words: start with object `wwlist` **and then** filter first generation students

```
wwlist %>% filter(firstgen == "Y")
```

Do task with and without pipes

Task: Using object `wwlist` print data for "first-gen" prospects (`firstgen == "Y"`)

```
# without pipes
filter(wwlist, firstgen == "Y")

# with pipes
wwlist %>% filter(firstgen == "Y")
```

Comparing the two approaches:

- "without pipes", object `wwlist` is the first argument `filter()` function
- In "pipes" approach, you don't specify object `wwlist` as first argument in `filter()`
  - Why? Because `%>%` "pipes" the object to the left of the `%>%` operator into the function to the right of the `%>%` operator

Main takeaway:

- When writing code using pipes, functions to right of `%>%` pipe operator should not explicitly name object that is the input to the function.
- Rather, object to the left of `%>%` pipe operator is automatically the input.

More intuition on the pipe operator, `%>%`

The pipe operator "pipes" (verb) an object from left of `%>%` operator into the function to the right of the %>% operator

Example, the "structure" function `str()`, with and without pipes

- Examine syntax for `str()`: `str(object, ...)`

```
?str
```

- Investigate structure of dataframe `wwlist` without and with pipes

```
str(wwlist) # without pipe

wwlist %>% str() # with pipe
```

Questions:

- In the pipes approach, `wwlist %>% str()`, why didn't we need to insert argument values inside `str()`
- What would happen if we just ran this line of code?

```
str()
```

Do task with and without pipes

Task: Using object `wwlist`, print data for "first-gen" prospects for selected variables [output omitted]

```
#Without pipes
select(filter(wwlist, firstgen == "Y"), state, hs_city, sex)
#With pipes
wwlist %>% filter(firstgen == "Y") %>% select(state, hs_city, sex)
```

Comparing the two approaches:

- In the "without pipes" approach, code is written "inside out"
  - The first step in the task – identifying the object – is the innermost part of code
  - The last step in task – selecting variables to print – is the outermost part of code
- In "pipes" approach the left-to-right order of code matches how we think about the task
  - First, we start with an object ***and then*** (`%>%`) we use `filter()` to isolate first-gen students ***and then*** (`%>%`) we select which variables to print

Important: `str()` function helpful for understanding what object is piped in from one function to another

```
#object that was "piped" into `select()` from `filter()`
wwlist %>% filter(firstgen == "Y") %>% str()

#object that was created after `select()` function
wwlist %>% filter(firstgen == "Y") %>% select(state, hs_city, sex) %>% str()
```

Aside: `count()` function

`count()` function from `dplyr` package counts the number of obs by group

Syntax [see help file for full syntax]

- `count(x,...)`

Arguments [see help file for full arguments]

- `x`: an object, often a data frame
- `...`: variables to group by

Examples of using `count()`

- Without vars in `...` argument, counts number of obs in object

```
count(wwlist)
wwlist %>% count()
```

- With vars in `...` argument, counts number of obs per variable value
  - This is the best way to create frequency table, better than `table()`
  - note: by default, `count()` always shows `NAs` [this is good!]

```
count(wwlist,school_category)
wwlist %>% count(school_category)
```

pipe operators and new lines

Often want to insert line breaks to make long line of code more readable

- When inserting line breaks, **pipe operator `%>%` should be the last thing before a line break, not the first thing after a line break**

This works

```
wwlist %>% filter(firstgen == "Y") %>%
  select(state, hs_city, sex) %>%
  count(sex)
```

This works too

```
wwlist %>% filter(firstgen == "Y",
                  state != "WA") %>%
  select(state, hs_city, sex) %>%
  count(sex)
```

This doesn't work

```
wwlist %>% filter(firstgen == "Y")
  %>% select(state, hs_city, sex)
  %>% count(sex)
```

The power of pipes

You might be thinking, "what's the big deal?"

TasK:

- in one line of code, modify `wwlist` and create bar chart that counts number of prospects purchased by race/ethnicity, separately for in-state vs. out-of-state

```
wwlist %>%  filter(is.na(state)==0) %>% # drop obs where variable state missing
  mutate( # create out-of-state indicator; create recoded ethnicity var
    out_state = as_factor(if_else(state != "WA", "out-of-state", "in-state")),
    ethn_race = recode(ethn_code,
      "american indian or alaska native" = "nativeam",
      "asian or native hawaiian or other pacific islander" = "api",
      "black or african american" = "black",
      "cuban" = "latinx",
      "mexican/mexican american" = "latinx",
      "not reported" = "not_reported",
      "other-2 or more" = "multirace",
      "other spanish/hispanic" = "latinx",
      "puerto rican" = "latinx",
      "white" = "white")) %>%
    group_by(out_state) %>% # group_by "in-state" vs. "out-of-state"
    count(ethn_race) %>% # count of number of prospects purchased by race
    ggplot(aes(x=ethn_race, y=n)) +  # plot
    ylab("number of prospects") + xlab("race/ethnicity") +
    geom_col() +  coord_flip() + facet_wrap(~ out_state)
```

The power of pipes

TasK:

- in one line of code, modify `wwlist` and create bar chart of median income (in zip-code) of prospects purchased by race/ethnicity, separately for in-state vs. out-of-state

```
wwlist %>%  filter(is.na(state)==0) %>% # drop obs where variable state missing
  mutate( # create out-of-state indicator; create recoded ethnicity var
    out_state = as_factor(if_else(state != "WA", "out-of-state", "in-state")),
    ethn_race = recode(ethn_code,
      "american indian or alaska native" = "nativeam",
      "asian or native hawaiian or other pacific islander" = "api",
      "black or african american" = "black",
      "cuban" = "latinx",
      "mexican/mexican american" = "latinx",
      "not reported" = "not_reported",
      "other-2 or more" = "multirace",
      "other spanish/hispanic" = "latinx",
      "puerto rican" = "latinx",
      "white" = "white")) %>%
    group_by(out_state, ethn_race) %>% # group_by "out-state" and ethnicity
    summarize(avg_inc_zip = mean(med_inc_zip, na.rm = TRUE)) %>% # calculate av
    ggplot(aes(x=out_state, y=avg_inc_zip)) +
    ylab("avg. income in zip code") + xlab("") +
    geom_col() +  coord_flip() + facet_wrap(~ ethn_race) # plot
```

The power of pipes

Example R script from Ben Skinner, which creates analysis data for Skinner (2018)

- Link to R script

Other relevant links

- Link to Github repository for Skinner (2018)
- Link to published paper
- Link to Skinner's Github page
  - A lot of cool stuff here
- Link to Skinner's personal website
  - A lot of cool stuff here

Do task with and without pipes [STUDENTS WORK ON THEIR OWN]

Task:

- Count the number "first-generation" prospects from the state of Washington

Without pipes

```
count(filter(wwlist, firstgen == "Y", state == "WA"))
#> # A tibble: 1 x 1
#>       n
#>   <int>
#> 1 32428
```

With pipes

```
wwlist %>% filter(firstgen == "Y", state == "WA") %>% count()
#> # A tibble: 1 x 1
#>       n
#>   <int>
#> 1 32428
```

Do task with and without pipes [STUDENTS WORK ON THEIR OWN]

Task: frequency table of `school_type` for non first-gen prospects from WA

without pipes

```
wwlist_temp <- filter(wwlist, firstgen == "N", state == "WA")
table(wwlist_temp$school_type, useNA = "always")
#>
#> private  public    <NA>
#>      11   46146   12489
rm(wwlist_temp) # cuz we don't need after creating table
```

With pipes

```
wwlist %>% filter(firstgen == "N", state == "WA") %>% count(school_type)
#> # A tibble: 3 x 2
#>   school_type     n
#>   <chr>       <int>
#> 1 private        11
#> 2 public      46146
#> 3 <NA>        12489
```

Comparison of two approaches

- without pipes, task requires multiple lines of code (this is quite common)
  - first line creates object; second line analyzes object
- with pipes, task can be completed in one line of code and you aren't left with objects you don't care about

Student exercises with pipes

1. Using object `wwlist` select the following variables (state, firstgen, ethn_code) and assign `<-` them to object `wwlist_temp`. (ex. wwlist_temp <- wwlist)
2. Using the object you just created `wwlist_temp`, create a frequency table of `ethn_code` for first-gen prospects from California.
3. **Bonus**: Try doing question 1 and 2 together. Use original object `wwlist`, but do not assign to a new object.

Once finished you can `rm(wwlist_temp)`

Solution to exercises with pipes

1. Using object `wwlist` select the following variables (state, firstgen, ethn_code) and assign them to object `wwlist_temp`

```
wwlist_temp <- wwlist %>%
  select(state, firstgen, ethn_code)
```

Solution to exercises with pipes

2. Using the object you just created `wwlist_temp`, create a frequency table of `ethn_code` for first-gen prospects from California.

```
#names(wwlist)
wwlist_temp %>%
  filter(firstgen == "Y", state == "CA") %>% count(ethn_code)
#> # A tibble: 10 x 2
#>    ethn_code                                          n
#>    <chr>                                          <int>
#>  1 american indian or alaska native                   4
#>  2 asian or native hawaiian or other pacific islander   86
#>  3 black or african american                         10
#>  4 cuban                                              1
#>  5 mexican/mexican american                         643
#>  6 not reported                                     113
#>  7 other-2 or more                                 4197
#>  8 other spanish/hispanic                           179
#>  9 puerto rican                                       8
#> 10 white                                          2933
```

Solution to exercises with pipes

3. **Bonus**: Try doing question 1 and 2 together.

```
wwlist %>%
  select(state, firstgen, ethn_code) %>%
  filter(firstgen == "Y", state == "CA") %>%
  count(ethn_code)
#> # A tibble: 10 x 2
#>    ethn_code                                          n
#>    <chr>                                          <int>
#>  1 american indian or alaska native                   4
#>  2 asian or native hawaiian or other pacific islander  86
#>  3 black or african american                         10
#>  4 cuban                                              1
#>  5 mexican/mexican american                         643
#>  6 not reported                                     113
#>  7 other-2 or more                                 4197
#>  8 other spanish/hispanic                           179
#>  9 puerto rican                                       8
#> 10 white                                          2933
#rm(wwlist_temp)
```

```
rm(wwlist_temp)
```

Creating variables using mutate (tidyverse approach)

Our plan for learning how to create new variables

Recall that `dplyr` package within `tidyverse` provide a set of functions that can be described as "verbs": **subsetting**, **sorting**, and **transforming**

What we've done	Where we're going
Subsetting data	**Transforming data**
- `select()` variables	- `mutate()` creates new variables
- `filter()` observations	- `summarize()` calculates across rows
Sorting data	- `group_by()` to calculate across rows within groups
- `arrange()`	

Today

- we'll use `mutate()` to create new variables based on calculations across columns within a row

Next week

- we'll combine `mutate()` with `summarize()` and `group_by()` to create variables based on calculations across rows

Create new data frame based on `df_school_all`

Data frame `df_school_all` has one obs per US high school and then variables identifying number of visits by particular universities

```
load(url("https://github.com/ozanj/rclass/raw/master/data/recruiting/recruit_sc
names(df_school_all)
#>  [1] "state_code"          "school_type"         "ncessch"
#>  [4] "name"                "address"             "city"
#>  [7] "zip_code"            "pct_white"           "pct_black"
#> [10] "pct_hispanic"        "pct_asian"           "pct_amerindian"
#> [13] "pct_other"           "num_fr_lunch"        "total_students"
#> [16] "num_took_math"       "num_prof_math"       "num_took_rla"
#> [19] "num_prof_rla"        "avgmedian_inc_2564"  "latitude"
#> [22] "longitude"           "visits_by_196097"    "visits_by_186380"
#> [25] "visits_by_215293"    "visits_by_201885"    "visits_by_181464"
#> [28] "visits_by_139959"    "visits_by_218663"    "visits_by_100751"
#> [31] "visits_by_199193"    "visits_by_110635"    "visits_by_110653"
#> [34] "visits_by_126614"    "visits_by_155317"    "visits_by_106397"
#> [37] "visits_by_149222"    "visits_by_166629"    "total_visits"
#> [40] "inst_196097"         "inst_186380"         "inst_215293"
#> [43] "inst_201885"         "inst_181464"         "inst_139959"
#> [46] "inst_218663"         "inst_100751"         "inst_199193"
#> [49] "inst_110635"         "inst_110653"         "inst_126614"
#> [52] "inst_155317"         "inst_106397"         "inst_149222"
#> [55] "inst_166629"
```

Create new data frame based on `df_school_all`

Create new version of data frame, called `school_v2`, which we'll use to introduce how to create new variables

```
school_v2 <- df_school_all %>%
  select(-contains("inst_")) %>% # remove vars that start with "inst_"
  rename( # rename selected variables
    visits_by_berkeley = visits_by_110635,
    visits_by_boulder = visits_by_126614,
    visits_by_bama = visits_by_100751,
    visits_by_stonybrook = visits_by_196097,
    visits_by_rutgers = visits_by_186380,
    visits_by_pitt = visits_by_215293,
    visits_by_cinci = visits_by_201885,
    visits_by_nebraska = visits_by_181464,
    visits_by_georgia = visits_by_139959,
    visits_by_scarolina = visits_by_218663,
    visits_by_ncstate = visits_by_199193,
    visits_by_irvine = visits_by_110653,
    visits_by_kansas = visits_by_155317,
    visits_by_arkansas = visits_by_106397,
    visits_by_sillinois = visits_by_149222,
    visits_by_umass = visits_by_166629,
    num_took_read = num_took_rla,
    num_prof_read = num_prof_rla,
    med_inc = avgmedian_inc_2564
  )
```

Introduce mutate() function

Introduce `mutate()` function

`mutate()` is **tidyverse** approach to creating variables (not **Base R** approach)

Description of `mutate()`

- creates new columns (variables) that are functions of existing columns
- After creating a new variable using `mutate()`, every row of data is retained
- `mutate()` works best with pipes `%>%`

Task:

- Using data frame `school_v2` create new variable that measures the pct of students on free/reduced lunch (output omitted)

```
# create new dataset with fewer vars; not necessary to do this
school_sml <- school_v2 %>%
  select(ncessch, school_type, num_fr_lunch, total_students)

# create new var
school_sml %>%
  mutate(pct_fr_lunch = num_fr_lunch/total_students)

# remove data frame object
rm(school_sml)
```

Investigate `mutate()` syntax

Usage (i.e., syntax)

- `mutate(.data,...)`

Arguments

- `.data` : a data frame
  - if using `mutate()` after pipe operator `%>%` , then this argument can be omitted
    - Why? Because data frame object to left of `%>%` "piped in" to first argument of `mutate()`
- `...` : expressions used to create new variables
  - "Name-value pairs of expressions"
  - "The name of each argument will be the name of a new variable, and the value will be its corresponding value."
  - "Use a `NULL` value in mutate to drop a variable."
  - "New variables overwrite existing variables of the same name"

Value

- returns a (data frame) object that contains the original input data frame and new variables that were created by `mutate()`

Investigate `mutate()` syntax

Can create variables using standard mathematical or logical operators [output omitted]

```
#glimpse(school_v2)
school_v2 %>%
  select(state_code,school_type,ncessch,med_inc,num_fr_lunch,total_students,num
  mutate( # each argument creates a new variable, name of argument is name of va
    one = 1,
    med_inc000 = med_inc/1000,
    pct_fr_lunch = num_fr_lunch/total_students*100,
    took_math_na = is.na(num_took_math)==1
  ) %>%
  select(state_code,school_type,ncessch,one,med_inc,med_inc000,num_fr_lunch,tot
```

Can create variables using "helper functions" called within `mutate()` [output omitted]

- These are standalone functions can be called *within* `mutate()`
  - e.g., `if_else()`, `recode()`, `case_when()`
- will walk through helper functions in more detail in subsequent sections of lecture

```
school_v2 %>%
  select(state_code,ncessch,name,school_type) %>%
  mutate(public = if_else(school_type == "public", 1, 0))
```

Introduce `mutate()` function

New variable not retained unless we **assign** `<-` it to an object (existing or new)

- `mutate()` **without assignment**

```
school_v2 %>% mutate(pct_fr_lunch = num_fr_lunch/total_students)

names(school_v2)
```

- `mutate()` **with assignment**

```
school_v2_temp <- school_v2 %>%
  mutate(pct_fr_lunch = num_fr_lunch/total_students)

names(school_v2_temp)
rm(school_v2_temp)
```

`mutate()` can create multiple variables at once

`mutate()` can create multiple variables at once

```
school_v2 %>%
  mutate(pct_fr_lunch = num_fr_lunch/total_students,
         pct_prof_math= num_prof_math/num_took_math) %>%
  select(num_fr_lunch, total_students, pct_fr_lunch,
         num_prof_math, num_took_math, pct_prof_math)
```

Or we could write code this way:

```
school_v2 %>%
  select(num_fr_lunch, total_students, num_prof_math, num_took_math) %>%
  mutate(pct_fr_lunch = num_fr_lunch/total_students,
         pct_prof_math= num_prof_math/num_took_math)
```

`mutate()` can use variables previously created within `mutate()`

```
school_v2 %>%
  select(num_prof_math, num_took_math, num_took_read,num_prof_read) %>%
  mutate(pct_prof_math = num_prof_math/num_took_math,
         pct_prof_read = num_prof_read/num_took_read,
         avg_pct_prof_math_read = (pct_prof_math + pct_prof_read)/2)
```

`mutate()`, removing variables created by `mutate()`

Within `mutate()` use syntax `var_name = NULL` to remove variable from data frame

- note: Variable not permanently removed from data frame unless you use assignment `<-` to create new data frame or overwrite existing data frame

```
ncol(school_v2)
school_v2 %>%
  select(num_prof_math, num_took_math, num_took_read,num_prof_read) %>% glimpse

school_v2 %>%
  select(num_prof_math, num_took_math, num_took_read,num_prof_read) %>%
  mutate(num_prof_math = NULL, num_took_math = NULL) %>% glimpse()
#But variables not permanently removed because we didn't use assignment
ncol(school_v2)
```

Why would we remove variables within `mutate()` rather `select()`?

- remove temporary "work" variables used to create desired variable
- Example: measure of average of pct who passed math and pct who passed reading

```
school_v2 %>%
  select(num_prof_math, num_took_math, num_took_read,num_prof_read) %>%
  mutate(pct_prof_math = num_prof_math/num_took_math, # create work var
         pct_prof_read = num_prof_read/num_took_read, # create work var
         avg_pct_prof_math_read = (pct_prof_math + pct_prof_read)/2, #create an
         pct_prof_math = NULL, # remove work var
         pct_prof_read = NULL) %>% # remove work var
  glimpse()
```

Student exercise using mutate()

1. Using the object `school_v2`, select the following variables (`num_prof_math`, `num_took_math`, `num_prof_read`, `num_took_read`) and create a measure of percent proficient in math `pct_prof_math` and percent proficient in reading `pct_prof_read`.
2. Now using the code for question 1, filter schools where at least 50% of students are proficient in math **&** reading.
3. Count the number of schools from question 2.
4. Using `school_v2`, using `mutate()` combined with `is.na()` create a dichotomous indicator variable `med_inc_na` that identifies whether `med_inc` is missing (`NA`) or not. And then use syntax `count(var_name)` to create frequency table of variable `med_inc_na`. How many observations are missing? [XIN - YOU WILL NEED TO CREATE SOLUTION FOR THIS SLIDE]

Solutions for exercise using mutate()

1. Using the object `school_v2`, select the following variables (`num_prof_math`, `num_took_math`, `num_prof_read`, `num_took_read`) and create a measure of percent proficient in math `pct_prof_math` and percent proficient in reading `pct_prof_read`.

```
school_v2 %>%
  select(num_prof_math, num_took_math, num_prof_read, num_took_read) %>%
  mutate(pct_prof_math = num_prof_math/num_took_math,
         pct_prof_read = num_prof_read/num_took_read)
#> # A tibble: 21,301 x 6
#>    num_prof_math num_took_math num_prof_read num_took_read pct_prof_math
#>            <dbl>         <dbl>         <dbl>         <dbl>         <dbl>
#>  1          24.8           146          25.0           147          0.17
#>  2           1.7            17           1.7            17          0.10
#>  3           3.5            14           3.5            14          0.25
#>  4           3              30           3              30          0.1
#>  5           2.8            28           2.8            28          0.10
#>  6           2.5            25           2.4            24          0.1
#>  7           1.55           62           1.55           62          0.025
#>  8           2.1            21           2.2            22          0.1
#>  9           2.3            23           2.3            23          0.10
#> 10           1.9            19           1.9            19          0.10
#> # ... with 21,291 more rows, and 1 more variable: pct_prof_read <dbl>
```

Solutions for exercise using mutate()

2. Now using the code for question 1, filter schools where at least 50% of students are proficient in math **&** reading.

```
school_v2 %>%
  select(num_prof_math, num_took_math, num_prof_read, num_took_read) %>%
  mutate(pct_prof_math = num_prof_math/num_took_math,
         pct_prof_read = num_prof_read/num_took_read) %>%
  filter(pct_prof_math >= 0.5 & pct_prof_read >= 0.5)
#> # A tibble: 7,760 x 6
#>    num_prof_math num_took_math num_prof_read num_took_read pct_prof_math
#>            <dbl>         <dbl>         <dbl>         <dbl>          <dbl>
#>  1          135.           260          149.           261          0.520
#>  2          299.           475          418            475          0.63
#>  3          213.           410          332.           410          0.52
#>  4           54.6          105           96.6          105          0.52
#>  5          111.           121          118.           121          0.92
#>  6         1057.          1994         1477.          2204          0.530
#>  7          100.           103          125.           128          0.975
#>  8           56.4           99           84.4          148          0.570
#>  9          445.           586          392.           594          0.76
#> 10           56.0           59           53.1           61          0.95
#> # ... with 7,750 more rows, and 1 more variable: pct_prof_read <dbl>
```

Solutions for exercise using mutate()

3. Count the number of schools from question 2.

```
school_v2 %>%
  select(num_prof_math, num_took_math, num_prof_read, num_took_read) %>%
  mutate(pct_prof_math = num_prof_math/num_took_math,
         pct_prof_read = num_prof_read/num_took_read) %>%
  filter(pct_prof_math >= 0.5 & pct_prof_read >= 0.5) %>%
  count()
#> # A tibble: 1 x 1
#>       n
#>   <int>
#> 1  7760
```

Solutions for exercise using mutate()

4. Using `school_v2`, using `mutate()` combined with `is.na()` create a dichotomous indicator variable `med_inc_na` that identifies whether `med_inc` is missing (`NA`) or not. And then use syntax `count(var_name)` to create frequency table of variable `med_inc_na`. How many observations are missing? [XIN - YOU WILL NEED TO CREATE SOLUTION FOR THIS SLIDE]

XIN - PLEASE EDIT/MODIFY THIS SLIDE AS NECESSARY

```
school_v2 %>%
  mutate(med_inc_na = is.na(med_inc)==1) %>%
  count(med_inc_na)
#> # A tibble: 2 x 2
#>   med_inc_na     n
#>   <lgl>      <int>
#> 1 FALSE      20677
#> 2 TRUE         624
```

Using ifelse() function within mutate()

Using `ifelse()` function within `mutate()`

Description

- if `logical condition` `TRUE`, assign a value; if `logical condition` `FALSE` assign a value

Usage (i.e., syntax)

- `if_else(logical condition, true, false, missing = NULL)`

Arguments

- `logical condition`: a condition that evaluates to `TRUE` or `FALSE`
- `true`: value to assign if condition `TRUE`
- `false`: value to assign if condition `FALSE`
- `missing`: value to assign to rows that have value `NA` for condition
  - default is `missing = NULL`; means that if condition is `NA`, then new_var == `NA`
  - But can assign different values to `NA`s, e.g., `missing = -9`

Value

- "Where condition is TRUE, the matching value from true, where it's FALSE, the matching value from false, otherwise NA."
- Unless otherwise specified, `NA`s in "input" var(s) assigned `NA` in "output var"

Example: Create 0/1 indicator of whether got at least one visit from Berkeley

```
school_v2 %>%
  mutate(got_visit_berkeley = ifelse(visits_by_berkeley>0,1,0)) %>%
  count(got_visit_berkeley)
```

`ifelse()` within `mutate()` to create 0/1 indicator variables

We often create dichotomous (0/1) indicator variables of whether something happened (or whether something is TRUE)

- Variables that are of substantive interest to project
  - e.g., did student graduate from college
- Variables that help you investigate data, check quality
  - e.g., indicator of whether an observation is missing/non-missing for a particular variable

Using `ifelse()` within `mutate()`

Task

- Create 0/1 indicator if school has median income greater than $100,000

Usually a good idea to investigate "input" variables **before** creating analysis vars

```
str(school_v2$med_inc) # investigate variable type
school_v2 %>% count(med_inc) # frequency count, but this isn't very helpful

school_v2 %>% filter(is.na(med_inc)) %>% count(med_inc)
# shows number of obs w/ missing med_inc
```

Create variable

```
school_v2 %>% select(med_inc) %>%
  mutate(inc_gt_100k= ifelse(med_inc>100000,1,0)) %>%
  count(inc_gt_100k) # note how NA values of med_inc treated
#> # A tibble: 3 x 2
#>   inc_gt_100k     n
#>         <dbl> <int>
#> 1           0 18632
#> 2           1  2045
#> 3          NA   624
```

Using `ifelse()` within `mutate()`

Task: Create 0/1 indicator if school has median income greater than $100,000. This time, let's experiment with the `missing` argument of `if_else()`

XIN - WHY ISN'T THIS WORKING? ALSO, CAN YOU INVESTIGATE HOW I CAN MODIFY CODE SUCH THAT OBS WHERE CONDITION IS MISSING HAVE A VALUE OF (JUST FOR EXAMPLE) -9 IN THE NEW VARIABLE?

- manually write out the default value for `missing`

```
school_v2 %>% select(med_inc) %>%
  mutate(inc_gt_100k= ifelse(med_inc>100000,1,0, missing = NULL)) %>%
  count(inc_gt_100k) # note how NA values of med_inc treated

school_v2 %>% select(med_inc) %>%
  mutate(inc_gt_100k= ifelse(med_inc>100000,1,0, NA_integer_)) %>%
  count(inc_gt_100k) # note how NA values of med_inc treated
```

OWN EXPERIMENTATION W/ IF_ELSE. WORKS HERE [ALTHOUGH IT IS SENSITIVE]

```
x <- c(-5:5, NA)
x
#>  [1] -5 -4 -3 -2 -1  0  1  2  3  4  5 NA
if_else(x < 0, -x, x)
#>  [1]  5  4  3  2  1  0  1  2  3  4  5 NA
if_else(x < 0, "negative", "positive", "missing")
#>  [1] "negative" "negative" "negative" "negative" "negative" "positive"
#>  [7] "positive" "positive" "positive" "positive" "positive" "missing"
```

Using `ifelse()` function within `mutate()`

Task

- Create 0/1 indicator variable `nonmiss_math` which indicates whether school has non-missing values for the variable `num_took_math`
  - note: `num_took_math` refers to number of students at school that took state math proficiency test

Usually a good to investigate "input" variables before creating analysis vars

```
school_v2 %>% count(num_took_math) # this isn't very helpful
school_v2 %>% filter(is.na(num_took_math)) %>% count(num_took_math) # shows numb
```

Create variable

```
school_v2 %>% select(num_took_math) %>%
  mutate(nonmiss_math= ifelse(!is.na(num_took_math),1,0)) %>%
  count(nonmiss_math) # note how NA values treated
#> # A tibble: 2 x 2
#>   nonmiss_math     n
#>          <dbl> <int>
#> 1            0  4103
#> 2            1 17198
```

Student exercises `ifelse()`

1. Using the object `school_v2`, create 0/1 indicator variable `in_state_berkeley` that equals `1` if the high school is in the same state as UC Berkeley (i.e., `state_code=="CA"`).
2. Create 0/1 indicator `berkeley_and_irvine` of whether a school got at least one visit from UC Berkeley **AND** from UC Irvine.
3. Create 0/1 indicator `berkeley_or_irvine` of whether a school got at least one visit from UC Berkeley **OR** from UC Irvine.

Exercise `ifelse()` solutions

1. Using the object `school_v2`, create 0/1 indicator variable `in_state_berkeley` that equals `1` if the high school is in the same state as UC Berkeley (i.e., `state_code=="CA"`).

```
str(school_v2$state_code) # investigate input variable
school_v2 %>% filter(is.na(state_code)) %>% count() # investigate input var

#Create var
school_v2 %>% mutate(in_state_berkeley=ifelse(state_code=="CA",1,0)) %>%
  count(in_state_berkeley)
```

Exercise `ifelse()` solutions

2. Create 0/1 indicator `berkeley_and_irvine` of whether a school got at least one visit from UC Berkeley **AND** from UC Irvine.

```
#investigate input vars
school_v2 %>% select(visits_by_berkeley, visits_by_irvine) %>% str()
school_v2 %>% filter(is.na(visits_by_berkeley)) %>% count()
school_v2 %>% filter(is.na(visits_by_irvine)) %>% count()

#create variable
school_v2 %>%
  mutate(berkeley_and_irvine=ifelse(visits_by_berkeley>0
    & visits_by_irvine>0,1,0)) %>%
  count(berkeley_and_irvine)
```

Exercise `ifelse()` solutions

3. Create 0/1 indicator `berkeley_or_irvine` of whether a school got at least one visit from UC Berkeley **OR** from UC Irvine.

```
school_v2 %>%
  mutate(berkeley_or_irvine=ifelse(visits_by_berkeley>0 | visits_by_irvine>0,1,
  count(berkeley_or_irvine)
```

Using recode() function within mutate()

Using `recode()` function within `mutate()`

Description: Recode values of a variable

Usage (i.e., syntax)

- recode(.x, ..., .default = NULL, .missing = NULL)

Arguments [see help file for further details]

- `.x` A vector (e.g., variable) to modify
- `...` Specifications for recode, of form `current_value = new_recoded_value`
- `.default` : If supplied, all values not otherwise matched given this value.
- `.missing` : If supplied, any missing values in .x replaced by this value.

Example: Using data frame `wwlist` , create new 0/1 indicator `public_school` from variable `school_type`

```
str(wwlist$school_type)
wwlist %>% count(school_type)

wwlist_temp <- wwlist %>% select(school_type) %>%
  mutate(public_school = recode(school_type,"public" = 1, "private" = 0))

wwlist_temp %>% head(n=10)
str(wwlist_temp$public_school) # note: numeric variable
wwlist_temp %>% count(public_school) # note the NAs
rm(wwlist_temp)
```

Using `recode()` function within `mutate()`

Recoding `school_type` could have been accomplished using `if_else()`

- Use `recode()` when new variable has more than two categories

Task: Create `school_catv2` based on `school_category` with these categories:

- "regular"; "alternative"; "special"; "vocational"

Investigate input var

```
str(wwlist$school_category) # character variable
wwlist %>% count(school_category)
```

Recode

```
wwlist_temp <- wwlist %>% select(school_category) %>%
  mutate(school_catv2 = recode(school_category,
    "Alternative Education School" = "alternative",
    "Alternative/other" = "alternative",
    "Regular elementary or secondary" = "regular",
    "Regular School" = "regular",
    "Special Education School" = "special",
    "Special program emphasis" = "special",
    "Vocational Education School" = "vocational")
  )
str(wwlist_temp$school_catv2) # character variable created
wwlist_temp %>% count(school_catv2)
rm(wwlist_temp)
```

Using `recode()` within `mutate()`

Task: Create `school_catv2` based on `school_category` with these categories:

- "regular"; "alternative"; "special"; "vocational"
- This time use the `.missing` argument to recode `NAs` to "unknown"

```
wwlist_temp <- wwlist %>% select(school_category) %>%
  mutate(school_catv2 = recode(school_category,
    "Alternative Education School" = "alternative",
    "Alternative/other" = "alternative",
    "Regular elementary or secondary" = "regular",
    "Regular School" = "regular",
    "Special Education School" = "special",
    "Special program emphasis" = "special",
    "Vocational Education School" = "vocational",
    .missing = "unknown")
  )
str(wwlist_temp$school_catv2)
wwlist_temp %>% count(school_catv2)
wwlist %>% count(school_category)
rm(wwlist_temp)
```

Using `recode()` within `mutate()`

Task: Create `school_catv2` based on `school_category` with these categories:

- "regular"; "alternative"; "special"; "vocational"
- This time use the `.default` argument to assign the value "regular"

```
wwlist_temp <- wwlist %>% select(school_category) %>%
  mutate(school_catv2 = recode(school_category,
    "Alternative Education School" = "alternative",
    "Alternative/other" = "alternative",
    "Special Education School" = "special",
    "Special program emphasis" = "special",
    "Vocational Education School" = "vocational",
    .default = "regular")
  )
str(wwlist_temp$school_catv2)
wwlist_temp %>% count(school_catv2)
wwlist %>% count(school_category)
rm(wwlist_temp)
```

Using `recode()` within `mutate()`

Task: Create `school_catv2` based on `school_category` with these categories:

- This time create a numeric variable rather than character:
  - `1` for "regular"; `2` for "alternative"; `3` for "special"; `4` for "vocational"

```
wwlist_temp <- wwlist %>% select(school_category) %>%
  mutate(school_catv2 = recode(school_category,
    "Alternative Education School" = 2,
    "Alternative/other" = 2,
    "Regular elementary or secondary" = 1,
    "Regular School" = 1,
    "Special Education School" = 3,
    "Special program emphasis" = 3,
    "Vocational Education School" = 4)
  )
str(wwlist_temp$school_catv2) # note: numeric variable now
wwlist_temp %>% count(school_catv2)
wwlist %>% count(school_category)
rm(wwlist_temp)
```

Student exercise using `recode()` within `mutate()`

```
load(url("https://github.com/ozanj/rclass/raw/master/data/recruiting/recruit_ev
names(df_event)
```

1. Using object `df_event`, assign new object `df_event_temp` and a numeric variable create `event_typev2` based on `event_type` with these categories:
   - `1` for "2yr college"; `2` for "4yr college"; `3` for "other"; `4` for "private hs"; `5` for "public hs"
2. This time use the `.default` argument to assign the value `5` for "public hs"

Exercise using `recode()` within `mutate()` solutions

Check input variable

```
names(df_event)
str(df_event$event_type)
df_event %>% count(event_type)
```

Exercise using `recode()` within `mutate()` solutions

1. Using object `df_event`, assign new object `df_event_temp` and create a numeric variable `event_typev2` based on `event_type` with these categories:
   - `1` for "2yr college"; `2` for "4yr college"; `3` for "other"; `4` for "private hs"; `5` for "public hs"

```
df_event_temp <- df_event %>%
  select(event_type) %>%
  mutate(event_typev2 = recode(event_type,
                               "2yr college" = 1,
                               "4yr college" = 2,
                               "other" = 3,
                               "private hs" = 4,
                               "public hs" = 5)
         )
str(df_event_temp$event_typev2)
df_event_temp %>% count(event_typev2)
df_event %>% count(event_type)
```

Exercise using `recode()` within `mutate()` solutions

2. This time assign the value use the `.default` argument to assign the value `5` for "public hs"

```
df_event_temp <- df_event %>% select(event_type) %>%
  mutate(event_typev2 = recode(event_type,
    "2yr college" = 1,
    "4yr college" = 2,
    "other" = 3,
    "private hs" = 4,
    .default = 5)
  )
str(df_event_temp$event_typev2)
df_event_temp %>% count(event_typev2)
df_event %>% count(event_type)
```

Using case_when() function within mutate()

Using `case_when()` function within `mutate()`

`case_when()` useful for creating variable that is a function of multiple "input" variables

Usage (i.e., syntax): `case_when(...)`

Arguments [from help file; see help file for more details]

- `...`: A sequence of two-sided formulas.
  - The left hand side (LHS) determines which values match this case.
    - LHS must evaluate to a logical vector.
  - The right hand side (RHS) provides the replacement value.

Example task: Using data frame `wwlist` and input vars `state` and `firstgen`, create a 4-category var with following categories:

- "instate_firstgen"; "instate_nonfirstgen"; "outstate_firstgen"; "outstate_nonfirstgen"

```
wwlist_temp <- wwlist %>% select(state,firstgen) %>%
  mutate(state_gen = case_when(
    state == "WA" & firstgen =="Y" ~ "instate_firstgen",
    state == "WA" & firstgen =="N" ~ "instate_nonfirstgen",
    state != "WA" & firstgen =="Y" ~ "outstate_firstgen",
    state != "WA" & firstgen =="N" ~ "outstate_nonfirstgen")
  )
str(wwlist_temp$state_gen)
wwlist_temp %>% count(state_gen)
```

Using `case_when()` function within `mutate()`

Task: Using data frame `wwlist` and input vars `state` and `firstgen`, create a 4-category var

Let's take a closer look at how values of inputs are coded into values of outputs

```
wwlist %>% select(state,firstgen) %>% str()
count(wwlist,state)
count(wwlist,firstgen)
```

Create variable

```
wwlist_temp <- wwlist %>% select(state,firstgen) %>%
  mutate(state_gen = case_when(
    state == "WA" & firstgen =="Y" ~ "instate_firstgen",
    state == "WA" & firstgen =="N" ~ "instate_nonfirstgen",
    state != "WA" & firstgen =="Y" ~ "outstate_firstgen",
    state != "WA" & firstgen =="N" ~ "outstate_nonfirstgen")
  )
```

Compare values of input vars to value of output var

```
wwlist_temp %>% count(state_gen)
wwlist_temp %>% filter(is.na(state)) %>% count(state_gen)
wwlist_temp %>% filter(is.na(firstgen)) %>% count(state_gen)
```

Take-away: by default var created by `case_when()` equals `NA` for obs where one of the inputs equals `NA`

Student exercise using `case_when()` within `mutate()`

1. Using the object `school_v2` and input vars `school_type`, and `state_code`, create a 4-category var `state_type` with following categories:
   - "instate_public"; "instate_private"; "outstate_public"; "outstate_private"
   - Note: We are referring to CA as in-state for this example

Exercise using `case_when()` within `mutate()` solution

Investigate

```
school_v2 %>% select(state_code,school_type) %>% str()
count(school_v2,state_code)
school_v2 %>% filter(is.na(state_code)) %>% count()

count(school_v2,school_type)
school_v2 %>% filter(is.na(school_type)) %>% count()
```

Exercise using `case_when()` within `mutate()` solution

1. Using the object `school_v2` and input vars `school_type` , and `state_code` , create a 4-category var `state_type` with following categories:
   - "instate_public"; "instate_private"; "outstate_public"; "outstate_private"

```
school_v2_temp <- school_v2 %>% select(state_code,school_type) %>%
  mutate(state_type = case_when(
    state_code == "CA" & school_type == "public"  ~ "instate_public",
    state_code == "CA" & school_type == "private" ~ "instate_private",
    state_code != "CA" & school_type == "public" ~ "outstate_public",
    state_code != "CA" & school_type == "private" ~ "outstate_private")
  )

school_v2_temp %>% count(state_type)
#> # A tibble: 4 x 2
#>   state_type           n
#>   <chr>            <int>
#> 1 instate_private    366
#> 2 instate_public    1404
#> 3 outstate_private  3456
#> 4 outstate_public  16075
#school_v2_temp %>% filter(is.na(state_code)) %>% count(state_type) #no missing
#school_v2_temp %>% filter(is.na(school_type)) %>% count(state_type) #no missing
```

Base R appraoch to creating new variables

Base R approach to creating new variables

Create new variables using assignment operator `<-` and subsetting operators `[]` and `$` to create new variables and set conditions of the input variables

Pseudo syntax: `df$newvar <- ...`

- where `...` argument is expression(s)/calculation(s) used to create new variables
  - expressions can include subsetting operators and/or other base R functions

Task: Create measure of percent of students on free-reduced lunch

base R approach

```
school_v2_temp<- school_v2 #create copy of dataset; not necessary
school_v2_temp$pct_fr_lunch <-
   school_v2_temp$num_fr_lunch/school_v2_temp$total_students

#investigate variable you created
str(school_v2_temp$pct_fr_lunch)
#>  num [1:21301] 0.723 1 0.967 0.93 1 ...
school_v2_temp$pct_fr_lunch[1:5] # print first 5 obs
#> [1] 0.7225549 1.0000000 0.9666667 0.9303483 1.0000000
```

tidyverse approach (with pipes)

```
school_v2_temp <- school_v2 %>%
  mutate(pct_fr_lunch = num_fr_lunch/total_students)
```

Base R approach to creating new variables

If creating new variable based on the condition/values of input variables, basically the tidyverse equivalent of `mutate()` **with** `ifelse()` or `recode()`

- Pseudo syntax: `df$newvar[logical condition]<- new value`
- `logical condition`: a condition that evaluates to `TRUE` or `FALSE`

Base R approach to creating new variables

Task: Create 0/1 indicator if school has median income greater than $100k

tidyverse approach (using pipes)

```
school_v2_temp %>% select(med_inc) %>%
  mutate(inc_gt_100k= ifelse(med_inc>100000,1,0)) %>%
  count(inc_gt_100k) # note how NA values of med_inc treated
#> # A tibble: 3 x 2
#>   inc_gt_100k     n
#>         <dbl> <int>
#> 1           0 18632
#> 2           1  2045
#> 3          NA   624
```

Base R approach

```
school_v2_temp$inc_gt_100k<-NA #initialize an empty column with NAs
                               # otherwise you'll get warning
school_v2_temp$inc_gt_100k[school_v2_temp$med_inc>100000] <- 1
school_v2_temp$inc_gt_100k[school_v2_temp$med_inc<=100000] <- 0
count(school_v2_temp, inc_gt_100k)
#> # A tibble: 3 x 2
#>   inc_gt_100k     n
#>         <dbl> <int>
#> 1           0 18632
#> 2           1  2045
#> 3          NA   624
```

Base R approach to creating new variables

Task: Using data frame `wwlist` and input vars `state` and `firstgen`, create a 4-category var with following categories:

- "instate_firstgen"; "instate_nonfirstgen"; "outstate_firstgen"; "outstate_nonfirstgen"

tidyverse approach (using pipes)

```
wwlist_temp <- wwlist %>%
  mutate(state_gen = case_when(
    state == "WA" & firstgen =="Y" ~ "instate_firstgen",
    state == "WA" & firstgen =="N" ~ "instate_nonfirstgen",
    state != "WA" & firstgen =="Y" ~ "outstate_firstgen",
    state != "WA" & firstgen =="N" ~ "outstate_nonfirstgen")
  )
str(wwlist_temp$state_gen)
#>  chr [1:268396] NA "instate_nonfirstgen" "instate_nonfirstgen" ...
wwlist_temp %>% count(state_gen)
#> # A tibble: 5 x 2
#>   state_gen                n
#>   <chr>                <int>
#> 1 instate_firstgen     32428
#> 2 instate_nonfirstgen  58646
#> 3 outstate_firstgen    32606
#> 4 outstate_nonfirstgen 134616
#> 5 <NA>                 10100
```

Base R approach to creating new variables

Task: Using `wwlist` and input vars `state` and `firstgen`, create a 4-category var

base R approach

```
wwlist_temp <- wwlist

wwlist_temp$state_gen <- NA
wwlist_temp$state_gen[wwlist_temp$state == "WA"
  & wwlist_temp$firstgen =="Y"] <- "instate_firstgen"
wwlist_temp$state_gen[wwlist_temp$state == "WA"
  & wwlist_temp$firstgen =="N"] <- "instate_nonfirstgen"
wwlist_temp$state_gen[wwlist_temp$state != "WA"
  & wwlist_temp$firstgen =="Y"] <- "outstate_firstgen"
wwlist_temp$state_gen[wwlist_temp$state != "WA"
  & wwlist_temp$firstgen =="N"] <- "outstate_nonfirstgen"

str(wwlist_temp$state_gen)
#>  chr [1:268396] NA "instate_nonfirstgen" "instate_nonfirstgen" ...
count(wwlist_temp, state_gen)
#> # A tibble: 5 x 2
#>   state_gen                n
#>   <chr>                <int>
#> 1 instate_firstgen     32428
#> 2 instate_nonfirstgen  58646
#> 3 outstate_firstgen    32606
#> 4 outstate_nonfirstgen 134616
#> 5 <NA>                 10100
```