

## Lecture 4: Pipes and variable creation

### Managing and Manipulating Data Using R

# Introduction

# What we will do today

## 1. Introduction

### 1.1 Data for lecture

## 2. Pipes

## 3. Creating variables using mutate (tidyverse approach)

### 3.1 Introduce mutate() function

### 3.2 Using ifelse() function within mutate()

### 3.3 Using recode() function within mutate()

### 3.4 Using case\_when() function within mutate()

## 4. Base R approach to creating new variables

## 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_eeb_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      181085
```



## Pipes

# What are “pipes”, %>%

**Pipes** are a means of performing 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 `wvlist` **and then** filter first generation students
- ```
wvlist %>% 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 avg
  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                                                |
|--------------------------------------|------------------------------------------------------------------|
| <b>Subsetting data</b>               | <b>Transforming data</b>                                         |
| - <code>select()</code> variables    | - <code>mutate()</code> creates new variables                    |
| - <code>filter()</code> observations | - <code>summarize()</code> calculates across rows                |
| <b>Sorting data</b>                  | - <code>group_by()</code> to calculate across rows within groups |
| - <code>arrange()</code>             |                                                                  |

## 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"      "necessch"  
#> [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(ncesssch, 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, ncesssch, 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, ncesssch, 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 show examples of this in subsequent slides

```
school_v2 %>%
  select(state_code, ncesssch, 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)
```

## 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()

- 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" "negative" "positive"  
#> [7] "positive" "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 num
```

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 `NA`s 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_typeev2` 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_typeev2 = recode(event_type,  
                                "2yr college" = 1,  
                                "4yr college" = 2,  
                                "other" = 3,  
                                "private hs" = 4,  
                                "public hs" = 5)  
  )  
str(df_event_temp$event_typeev2)  
df_event_temp %>% count(event_typeev2)  
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 approach 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
```