Enter the tidyverse: Processing across rows

Managing and Manipulating Data Using R

Introduction

What we will do today

1. Introduction

2. Introduce group_by() and summarize()
   - 2.1 group_by
   - 2.2 summarize()

3. Combining group_by() and summarize()
   - 3.1 summarize() and Counts
   - 3.2 summarize() and means
   - 3.3 summarize() and logical vectors, part II

4. Summarize multiple columns

5. Attach aggregate measures to your data frame

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 we will use today

Data on off-campus recruiting events by public universities

- Object `df_event`
    - One observation per university, recruiting event

```
rm(list = ls()) # remove all objects

#load dataset with one obs per recruiting event
load(url("https://github.com/ozanj/rclass/raw/master/data/recruiting/recruit_ev
#load("../../data/recruiting/recruit_event_allvars.Rdata")
```

Processing across variables vs. processing across observations

Visits by UC Berkeley to public high schools

```
#> # A tibble: 5 x 6
#>   school_id    state tot_stu_pub fr_lunch pct_fr_lunch med_inc
#>   <chr>        <chr>       <dbl>    <dbl>        <dbl>   <dbl>
#> 1 340882002126 NJ           1846       29       0.0157 178732
#> 2 340147000250 NJ           1044       50       0.0479  62288
#> 3 340561003796 NJ           1505      298       0.198  100684.
#> 4 340165005124 NJ           1900       43       0.0226 160476.
#> 5 341341003182 NJ           1519      130       0.0856 144346
```

So far, we have focused on “processing across variables’’

- Performing calculations across columns (i.e., vars), typically within a row (i.e., observation)
- Example: percent free-reduced lunch (above)

Processing across obs (focus of today’s lecture)

- Performing calculations across rows (i.e., obs), often within a column (i.e., variable)
- Example: Average household income of visited high schools, by state

Why processing across observations

Note

- In today's lecture, I'll use the terms "observations" and "rows" interchangeably

Creation of analysis datasets often requires calculations across obs

Examples:

- You have a dataset with one observation per student-term and want to create a variable of credits attempted per term
- You have a dataset with one observation per student-term and want to create a variable of GPA for the semester or cumulative GPA for all semesters
- Number of off-campus recruiting events university makes to each state
- Average household income at visited versus non-visited high schools

Creating graphs and tables of descripive stats usually require calculations across obs

Example: Want to create a graph that shows number of recruiting events by event "type" (e.g., public HS, private HS) for each university

- Start with `df_event` dataset that has one obervation per university, recruiting event
- Create new data frame object that has one observation per university and event type and has variable for number of events
  - this variable calculated by counting number of rows in each combination of university and event type
- This new data frame object is the input for creating desired graph

Introduce group_by() and summarize()

Strategy for teaching processing across obs

In `tidyverse` the `group_by()` and `summarize()` functions are the primary means of performing calculations across observations

- Usually, processing across observations requires using `group_by()` and `summarize()` together
- `group_by()` typically not very useful by itself
- `summarize()` [with or without `group_by()`] can be helpful for creating summary statistics that are the inputs for tables or graphs you create

How we'll teach:

- introduce `group_by()` and `summarize()` separately
  - goal: you understand what each function does
- then we'll combine them

group_by

group_by()

Description: “ `group_by()` takes an existing data frame and converts it into a grouped data frame where operations are performed”by group“. `ungroup()` removes grouping.”

- part of **dplyr** package within **tidyverse**; not part of **Base R**
- works best with pipes `%>%` and `summarize()` function [described below]

Basic syntax: `group_by(.data, ...)`

- `.data` argument refers to name of data frame
- `...` argument refers to names of “group_by” variables, separated by commas
  - Can “group by” one or many variables
  - Typically, “group_by” variables are character, factor, or integer variables

Possible “group by” variables in `df_event` data:

- university name/id; event type (e.g., public HS, private HS); state

Example: in `df_event`, create frequency count of `event_type` [output omitted]

```
names(df_event)
#without group_by()
df_event %>% count(event_type)
df_event %>% count(instnm)
#group_by() university
df_event %>% group_by(instnm) %>% count(event_type)
```

group_by()

By itself `group_by()` doesn't do much; it just prints data

- Below, group `df_event` data by university, event type, and event state

```
#print object
df_event
#group_by (without pipes)
group_by(df_event, univ_id, event_type, event_state)
#group_by (with pipes)
df_event %>% group_by(univ_id, event_type, event_state)
df_event %>% group_by(univ_id, event_type, event_state) %>% glimpse()
```

But once an object is grouped, all subsequent functions are run separately “by group”

- recall that `count()` counts number of observations by group

```
# count number of observations in group, ungrouped data
df_event  %>% count()
#group by and then count obs
df_event %>% group_by(univ_id) %>% count()
df_event %>% group_by(univ_id) %>% count() %>% glimpse()

df_event %>% group_by(univ_id, event_type) %>% count()
df_event %>% group_by(univ_id, event_type) %>% count() %>% glimpse()

df_event %>% group_by(univ_id, event_type, event_state) %>% count()

#df_event %>% group_by(as_factor(univ_id), as_factor(event_type), as_factor(even
df_event %>% group_by(univ_id, event_type, event_state) %>% count() %>% gli
```

Grouping not retained unless you **assign** it

Below, we'll use `class()` function to show whether data frame is grouped

- will talk more about `class()` next week, but for now, just think of it as a function that provides information about an object
- similar to `typeof()`, but `class()` provides different info about object

Grouping is not retained unless you **assign** it

```
class(df_event)
#> [1] "tbl_df"     "tbl"        "data.frame"
```

```
df_event %>% group_by(univ_id, event_type, event_state)
df_event_grp <- df_event %>% group_by(univ_id, event_type, event_state) # using
```

```
class(df_event_grp)
#> [1] "grouped_df" "tbl_df"     "tbl"        "data.frame"
```

Un-grouping an object

Use `ungroup(object)` to un-group grouped data

```
class(df_event_grp)
#> [1] "grouped_df" "tbl_df"     "tbl"        "data.frame"
df_event_grp <- ungroup(df_event_grp)
class(df_event_grp)
#> [1] "tbl_df"     "tbl"        "data.frame"
rm(df_event_grp)
```

`group_by()` student exercise

1. Group by “instnm” and get a frequency count.
   - How many rows and columns do you have? What do the number of rows mean?
2. Now group by “instnm” **and** “event_type” and get a frequency count.
   - How many rows and columns do you have? What do the number of rows mean?
3. **Bonus:** In the same code chunk, group by “instnm” and “event_type”, but this time filter for observations where “med_inc” is greater than 75000 and get a frequency count.

group_by() student exercise solutions

1. Group by "instnm" and get a frequency count.
   - How many rows and columns do you have? What do the number of rows mean?

```
df_event %>%
  group_by(instnm) %>%
  count()
#> # A tibble: 16 x 2
#>    instnm          n
#>    <chr>       <int>
#>  1 Arkansas      994
#>  2 Bama         4258
#>  3 Cinci         679
#>  4 CU Boulder   1439
#>  5 Kansas       1014
#>  6 NC State      640
#>  7 Pitt         1225
#>  8 Rutgers      1135
#>  9 S Illinois    549
#> 10 Stony Brook   730
#> 11 UC Berkeley   879
#> 12 UC Irvine     539
#> 13 UGA           827
#> 14 UM Amherst    908
#> 15 UNL          1397
#> 16 USCC         1467
```

group_by() student exercise solutions

2. Now group by "instnm" **and** "event_type" and get a frequency count.
    - How many rows and columns do you have? What do the number of rows mean?

```
df_event %>%
  group_by(instnm, event_type) %>%
  count()
#> # A tibble: 80 x 3
#>    instnm   event_type      n
#>    <chr>    <chr>       <int>
#>  1 Arkansas 2yr college    32
#>  2 Arkansas 4yr college    14
#>  3 Arkansas other         112
#>  4 Arkansas private hs    222
#>  5 Arkansas public hs     614
#>  6 Bama     2yr college   127
#>  7 Bama     4yr college   158
#>  8 Bama     other         608
#>  9 Bama     private hs    963
#> 10 Bama     public hs    2402
#> # ... with 70 more rows
```

group_by() student exercise solutions

3. **Bonus:** Group by "instnm" and "event_type", but this time filter for observations where "med_inc" is greater than 75000 and get a frequency count.

```
df_event %>%
  group_by(instnm, event_type) %>%
  filter(med_inc > 75000) %>%
  count()
#> # A tibble: 80 x 3
#>    instnm   event_type      n
#>    <chr>    <chr>       <int>
#>  1 Arkansas 2yr college     7
#>  2 Arkansas 4yr college     3
#>  3 Arkansas other          30
#>  4 Arkansas private hs     99
#>  5 Arkansas public hs     303
#>  6 Bama     2yr college    21
#>  7 Bama     4yr college    42
#>  8 Bama     other         249
#>  9 Bama     private hs    477
#> 10 Bama     public hs    1478
#> # ... with 70 more rows
```

summarize()

`summarize()` function

Description: `summarize()` calculates across rows; then collapses into single row

- `summarize()` create scalar vars summarizing variables of existing data frame
- if you first group data frame using `group_by()`, `summarize()` creates summary vars separately for each group, returning object with one row per group
- if data frame not grouped, `summarize()` will result in one row.

Syntax: `summarize(.data, ...)`

- `.data`: a data frame; omit if using `summarize()` after pipe `%>%`
- `...`: Name-value pairs of summary functions separated by commas
  - "name" will be the name of new variable you will create
  - "value" should be expression that returns a single value like `min(x)`, `n()`
  - variable names do not need to be placed within quotes

Value (what `summarize()` returns/creates)

- Object of same class as `.data.`; object will have one obs per "by group"

Useful functions (i.e., "helper functions")

- Standalone functions called *within* `summarize()`, e.g., `mean()`, `n()`
- e.g., count function `n()` takes no arguments; returns number of rows in group

Example: Count total number of events (output omitted)

```
summarize(df_event, num_events=n()) # without pipes
df_event %>% summarize(num_events=n()) # using pipes
```

Investigate objects created by `summarize()`

Example: Count total number of events

```
df_event %>% summarize(num_events=n())
df_event %>% summarize(num_events=n()) %>% str()
```

Example: What is max value of `med_inc` across all events

```
df_event %>% summarize(max_inc=max(med_inc, na.rm = TRUE))
df_event %>% summarize(max_inc=max(med_inc, na.rm = TRUE)) %>% str()
```

Example: Count total number of events AND max value of median income

```
df_event %>% summarize(num_events=n(),
                       max_inc=max(med_inc, na.rm = TRUE))
df_event %>% summarize(num_events=n(),
                       max_inc=max(med_inc, na.rm = TRUE)) %>% str()
#keep object created by summarize
df_event_temp <- df_event %>% summarize(num_events=n(),
                       max_inc=max(med_inc, na.rm = TRUE))
df_event_temp
rm(df_event_temp)
#what if we forgot na.rm = TRUE
df_event %>% summarize(num_events=n(),
                       max_inc=max(med_inc, na.rm = FALSE))
```

Takeaways

- by default, objects created by `summarize()` are data frames that contain variables created within `summarize()` and one observation [per "by group"]
- most "helper" functions (e.g., `max()` , `mean()` have option `na.rm` to keep/remove missing obs before performing calculations)
  - `na.rm = FALSE` (default); don't remove `NAs` prior to calculation
    - if any obs missing, then result of calculation is `NA`
  - `na.rm = TRUE` (default); remove `NAs` prior to calculation

Retaining objects created by `summarize()`

Object created by summarize() not retained unless you **assign** it

```
event_temp <- df_event %>% summarize(num_events=n(),
  mean_inc=mean(med_inc, na.rm = TRUE))

event_temp
#> # A tibble: 1 x 2
#>   num_events mean_inc
#>        <int>    <dbl>
#> 1      18680   89089.
rm(event_temp)
```

Using [] operator to filter observations within summarize

Imagine we want to calculate avg. income, separately for in-state vs. out-of-state visits

- first, let's use `filter()` to make sure we can identify in-state vs. out-of-state

```
#in state
df_event %>% filter(event_state == instst) %>% count() %>% as_vector()
#>    n
#> 5425
#out state
df_event %>% filter(event_state != instst) %>% count() %>% as_vector()
#>     n
#> 13255
```

- calculate mean income for: all events; in-state events; out-of-state events

```
df_event %>%
  summarize(avg_inc = mean(med_inc, na.rm = TRUE), # all events
    avg_inc_inst = mean(med_inc[event_state == instst], na.rm = TRUE), # in-sta
    avg_inc_outst = mean(med_inc[event_state != instst], na.rm = TRUE) # out-st
  )
#> # A tibble: 1 x 3
#>   avg_inc avg_inc_inst avg_inc_outst
#>     <dbl>        <dbl>         <dbl>
#> 1  89089.       71589.        96162.
```

Using summarize() to create descriptive statistics table

Often helpful to use summarize() to calculate summary statistics that are the basis for a table of descriptive statistics

Task: create a table of descriptive statistics about variable med_inc

- want these measures: number of non-missing obs; mean; standard deviation

```r
df_event %>% mutate(non_miss_inc = is.na(med_inc)==0) %>%
  summarize(
    n = sum(non_miss_inc, na.rm = TRUE), #SAMPLE SIZE all
    avg_inc = mean(med_inc, na.rm = TRUE), # MEAN
    std_inc = sd(med_inc, na.rm = TRUE) # STANDARD DEVIATION all events
  )
```

Task: same as above but separate measures for: all events; in-state; out-of-state

```r
df_event %>% mutate(non_miss_inc = is.na(med_inc)==0) %>%
  summarize(
    n = sum(non_miss_inc, na.rm = TRUE), #SAMPLE SIZE
    n_inst = sum(non_miss_inc[event_state == instst], na.rm = TRUE),
    n_outst = sum(non_miss_inc[event_state != instst], na.rm = TRUE),
    avg_inc = mean(med_inc, na.rm = TRUE), # MEAN
    avg_inc_inst = mean(med_inc[event_state == instst], na.rm = TRUE),
    avg_inc_outst = mean(med_inc[event_state != instst], na.rm = TRUE),
    std_inc = sd(med_inc, na.rm = TRUE), # STANDARD DEVIATION
    std_inc_inst = sd(med_inc[event_state == instst], na.rm = TRUE),
    std_inc_outst = sd(med_inc[event_state != instst], na.rm = TRUE)
  )
```

`summarize()` student exercise

1. What is the min value of `med_inc` across all events?
   - Hint: Use min()
2. What is the mean value of `fr_lunch` across all events?
   - Hint: Use mean()

summarize() student exercise

1. What is min value of `med_inc` across all events?

```
df_event %>%
  summarize(min_med_income = min(med_inc, na.rm = TRUE))
#> # A tibble: 1 x 1
#>   min_med_income
#>            <dbl>
#> 1         12894.
```

`summarize()` student exercise

2. What is the mean value of `fr_lunch` across all events?
    - Hint: Use mean()

```
df_event %>%
  summarize(mean_fr_lunch = mean(fr_lunch, na.rm = TRUE))
#> # A tibble: 1 x 1
#>   mean_fr_lunch
#>           <dbl>
#> 1          475.
```

Combining group_by() and summarize()

Combining `summarize()` and `group_by`

`summarize()` on ungrouped vs. grouped data:

- By itself, `summarize()` performs calculations across all rows of data frame then collapses the data frame to a single row
- When data frame is grouped, `summarize()` performs calculations across rows within a group and then collapses to a single row for each group

Example: Count the number of events for each university

- remember: `df_event` has one observation per university, recruiting event

```
df_event %>% summarize(num_events=n())
df_event %>% group_by(instnm) %>% summarize(num_events=n())
#> `summarise()` ungrouping output (override with `.groups` argument)
```

- Investigate the object created above

```
df_event %>% group_by(instnm) %>% summarize(num_events=n()) %>% str()
#> `summarise()` ungrouping output (override with `.groups` argument)
```

- Or we could retain object for later use

```
event_by_univ <- df_event %>% group_by(instnm) %>% summarize(num_events=n())
#> `summarise()` ungrouping output (override with `.groups` argument)
str(event_by_univ)
event_by_univ # print
rm(event_by_univ)
```

Combining `summarize()` and `group_by`

Task

- Count number of recruiting events by institution and event_type

```
df_event %>% group_by(instnm, event_type) %>% summarize(num_events=n())
#> `summarise()` regrouping output by 'instnm' (override with `.groups` argument

#investigate object created
df_event %>% group_by(instnm, event_type) %>% summarize(num_events=n()) %>% gli
#> `summarise()` regrouping output by 'instnm' (override with `.groups` argument
```

Note that data frame object created by `group_by()` and `summarize()` can be input to graph

```
#bar chart of number of events, all universities combined
df_event %>% group_by(instnm, event_type) %>%
  summarize(num_events=n()) %>%
    ggplot(aes(x=event_type, y=num_events)) +  # plot
    ylab("Number of events") + xlab("Event type") +geom_col()

#bar chart of number of events, separete chart for each university
df_event %>% group_by(instnm, event_type) %>%
  summarize(num_events=n()) %>%
    ggplot(aes(x=event_type, y=num_events)) +  # plot
    ylab("Number of events") + xlab("Event type") + geom_col() +
    coord_flip() + facet_wrap(~ instnm)
```

Combining `summarize()` and `group_by`

Task. Count number of recruiting events by institution, event_type, and whether event is in- or out-of-state (var= `event_inst`)

- Note: in `group_by()` , the optional `drop` argument controls whether empty groups dropped. default is `drop = TRUE`

```
df_event %>% group_by(instnm, event_type, event_inst) %>%
  summarize(num_events=n())
#> `summarise()` regrouping output by 'instnm', 'event_type' (override with `.gr

df_event %>% group_by(instnm, event_type, event_inst, .drop = TRUE) %>%
  summarize(num_events=n())
#> `summarise()` regrouping output by 'instnm', 'event_type' (override with `.gr

df_event %>%
  group_by(as.factor(instnm), as.factor(event_type), as.factor(event_inst),
           .drop = FALSE) %>% summarize(num_events=n()) %>% arrange(num_events)
#> `summarise()` regrouping output by 'as.factor(instnm)', 'as.factor(event_type
# .drop=FALSE affects only grouping columns that are coded as factors
# combinations that include non-factor grouping variables are still
# silently dropped even with .drop=FALSE.
```

Combining `summarize()` and `group_by`

Make a graph, showing in/out state as fill color of bar

```
df_event %>% group_by(instnm, event_type, event_inst) %>%
  summarize(num_events=n()) %>%
    ggplot(aes(x=event_type, y=num_events, fill = event_inst)) +  # plot
    ylab("Number of events") + xlab("Event type") + geom_col() +
    coord_flip() + facet_wrap(~ instnm)
```

Combining `summarize()` and `group_by`

Task

- By university, event type, event_inst count the number of events and calculate the avg. pct white in the zip-code

```
df_event %>% group_by(instnm, event_type, event_inst) %>%
  summarize(num_events=n(),
    mean_pct_white=mean(pct_white_zip, na.rm = TRUE)
  )
#> `summarise()` regrouping output by 'instnm', 'event_type' (override with `.gr

#investigate object you created
df_event %>% group_by(instnm, event_type, event_inst) %>%
  summarize(num_events=n(),
    mean_pct_white=mean(pct_white_zip, na.rm = FALSE)
  ) %>% glimpse()
#> `summarise()` regrouping output by 'instnm', 'event_type' (override with `.gr
```

Combining `summarize()` and `group_by`

Recruiting events by UC Berkeley

```
df_event %>% filter(univ_id == 110635) %>%
  group_by(event_type) %>% summarize(num_events=n())
#> `summarise()` ungrouping output (override with `.groups` argument)
```

Let's create a dataset of recruiting events at UC Berkeley

```
event_berk <- df_event %>% filter(univ_id == 110635)

event_berk %>% count(event_type)
```

summarize() and Counts

summarize() : Counts

The count function n() takes no arguments and returns the size of the current group

```
event_berk %>% group_by(event_type, event_inst) %>%
  summarize(num_events=n())
#> `summarise()` regrouping output by 'event_type' (override with `.groups` argu
```

Because counts are so important, dplyr package includes separate count() function that can be called outside summarize() function

```
event_berk %>% group_by(event_type, event_inst) %>% count()
```

summarize() : count with logical vectors and sum()

Logical vectors have values TRUE and FALSE.

- When used with numeric functions, TRUE converted to 1 and FALSE to 0.

sum() is a numeric function that returns the sum of values

```
sum(c(5,10))
sum(c(TRUE,TRUE,FALSE,FALSE))
```

is.na() returns TRUE if value is NA and otherwise returns FALSE

```
is.na(c(5,NA,4,NA))
#> [1] FALSE  TRUE FALSE  TRUE

sum(is.na(c(5,NA,4,NA,5)))
#> [1] 2
sum(!is.na(c(5,NA,4,NA,5)))
#> [1] 3
```

Application: How many missing/non-missing obs in variable [**very important**]

```
event_berk %>% group_by(event_type) %>%
  summarize(
    n_events = n(),
    n_miss_inc = sum(is.na(med_inc)),
    n_nonmiss_inc = sum(!is.na(med_inc)),
    n_nonmiss_fr_lunch = sum(!is.na(fr_lunch))
  )
#> `summarise()` ungrouping output (override with `.groups` argument)
```

`summarize()` and count student exercise

Use one code chunk for this exercise. You could tackle this a step at a time and run the entire code chunk when you have answered all parts of this question. Create your own variable names.

1. Using the `event_berk` object, filter observations where `event_state` is VA and group by `event_type`.
   - 1.1 Using the summarize function to create a variable that represents the count for each `event_type`.
   - 1.2 Create a variable that represents the sum of missing obs for `med_inc`.
   - 1.3 Create a variable that represents the sum of non-missing obs for `med_inc`.
   - 1.4 **Bonus**: Arrange variable you created representing the count of each `event_type` in descending order.

summarize() and count student exercise SOLUTION

1. Using the event_berk object filter observations where event_state is VA and group by event_type .
   1.1 Using the summarize function, create a variable that represents the count for each event_type .
   1.2 Now get the sum of missing obs for med_inc .
   1.3 Now get the sum of non-missing obs for med_inc .

```
event_berk %>%
  filter(event_state == "VA") %>%
  group_by(event_type) %>%
  summarize(
    n_events = n(),
    n_miss_inc = sum(is.na(med_inc)),
    n_nonmiss_inc = sum(!is.na(med_inc))) %>%
  arrange(desc(n_events))
#> `summarise()` ungrouping output (override with `.groups` argument)
#> # A tibble: 3 x 4
#>   event_type n_events n_miss_inc n_nonmiss_inc
#>   <chr>         <int>      <int>         <int>
#> 1 public hs        20          0            20
#> 2 private hs       13          0            13
#> 3 other             3          0             3
```

summarize() and means

`summarize()`: means

The `mean()` function within `summarize()` calculates means, separately for each group

```
event_berk %>% group_by(event_inst, event_type) %>% summarize(
  n_events=n(),
  mean_inc=mean(med_inc, na.rm = TRUE),
  mean_pct_white=mean(pct_white_zip, na.rm = TRUE))
#> `summarise()` regrouping output by 'event_inst' (override with `.groups` argu
#> # A tibble: 10 x 5
#>    event_inst event_type  n_events mean_inc mean_pct_white
#>    <chr>      <chr>          <int>    <dbl>          <dbl>
#>  1 In-State   2yr college      111   78486.           40.1
#>  2 In-State   4yr college       14  131691.           58.0
#>  3 In-State   other             49   75040.           37.6
#>  4 In-State   private hs        35   95229.           48.4
#>  5 In-State   public hs        259   87097.           39.6
#>  6 Out-State  2yr college        1  153070.           89.7
#>  7 Out-State  4yr college        4   76913.           65.8
#>  8 Out-State  other             89   69004.           56.5
#>  9 Out-State  private hs       134   87654.           64.3
#> 10 Out-State  public hs        183  103603.           62.0
```

`summarize()` : means and `na.rm` argument

Default behavior of “aggregation functions” (e.g., `summarize()`)

- if *input* has any missing values (`NA`), than output will be missing.

Many functions have argument `na.rm` (means “remove `NAs` ”)

- `na.rm = FALSE` [the default for `mean()`]
  - Do not remove missing values from input before calculating
  - Therefore, missing values in input will cause output to be missing
- `na.rm = TRUE`
  - Remove missing values from input before calculating
  - Therefore, missing values in input will not cause output to be missing

```
#na.rm = FALSE; the default setting
event_berk %>% group_by(event_inst, event_type) %>% summarize(
  n_events=n(),
  n_miss_inc = sum(is.na(med_inc)),
  mean_inc=mean(med_inc, na.rm = FALSE),
  n_miss_frlunch = sum(is.na(fr_lunch)),
  mean_fr_lunch=mean(fr_lunch, na.rm = FALSE))
#> `summarise()` regrouping output by 'event_inst' (override with `.groups` argu
#na.rm = TRUE
event_berk %>% group_by(event_inst, event_type) %>% summarize(
  n_events=n(),
  n_miss_inc = sum(is.na(med_inc)),
  mean_inc=mean(med_inc, na.rm = TRUE),
  n_miss_frlunch = sum(is.na(fr_lunch)),
  mean_fr_lunch=mean(fr_lunch, na.rm = TRUE))
```

Student exercise

1. Using the `event_berk` object, group by `instnm`, `event_inst`, & `event_type`.
    1.1 Create vars for number non_missing for these racial/ethnic groups (`pct_white_zip`, `pct_black_zip`, `pct_asian_zip`, `pct_hispanic_zip`, `pct_amerindian_zip`, `pct_nativehawaii_zip`)
    1.2 Create vars for mean percent for each racial/ethnic group

Student exercise solutions

```
event_berk %>% group_by(instnm, event_inst, event_type) %>%
  summarize(
  n_events=n(),
  n_miss_white = sum(!is.na(pct_white_zip)),
  mean_white = mean(pct_white_zip, na.rm = TRUE),
  n_miss_black = sum(!is.na(pct_black_zip)),
  mean_black = mean(pct_black_zip, na.rm = TRUE),
  n_miss_asian = sum(!is.na(pct_asian_zip)),
  mean_asian = mean(pct_asian_zip, na.rm = TRUE),
  n_miss_lat = sum(!is.na(pct_hispanic_zip)),
  mean_lat = mean(pct_hispanic_zip, na.rm = TRUE),
  n_miss_na = sum(!is.na(pct_amerindian_zip)),
  mean_na = mean(pct_amerindian_zip, na.rm = TRUE),
  n_miss_nh = sum(!is.na(pct_nativehawaii_zip)),
  mean_nh = mean(pct_nativehawaii_zip, na.rm = TRUE)) %>%
  head(6)
#> `summarise()` regrouping output by 'instnm', 'event_inst' (override with `.gr
#> # A tibble: 6 x 16
#>   instnm event_inst event_type n_events n_miss_white mean_white n_miss_black
#>   <chr>  <chr>      <chr>         <int>        <int>      <dbl>        <int>
#> 1 UC Be~ In-State   2yr colle~      111          106       40.1          106
#> 2 UC Be~ In-State   4yr colle~       14           12       58.0           12
#> 3 UC Be~ In-State   other            49           48       37.6           48
#> 4 UC Be~ In-State   private hs       35           35       48.4           35
#> 5 UC Be~ In-State   public hs       259          258       39.6          258
#> 6 UC Be~ Out-State  2yr colle~        1            1       89.7            1
#> # ... with 9 more variables: mean_black <dbl>, n_miss_asian <int>,
```

summarize() and logical vectors, part II

`summarize()` : counts with logical vectors, part II

Logical vectors (e.g., `is.na()`) useful for counting obs that satisfy some condition

```
is.na(c(5,NA,4,NA))
#> [1] FALSE  TRUE FALSE  TRUE
typeof(is.na(c(5,NA,4,NA)))
#> [1] "logical"
sum(is.na(c(5,NA,4,NA)))
#> [1] 2
```

Task: Using object `event_berk`, calculate the following measures for each combination of `event_type` and `event_inst`:

- count of number of rows for each group
- count of rows non-missing for both `pct_black_zip` and `pct_hispanic_zip`
- count of number of visits to communities where the `sum` of Black and Latinx people comprise more than 50% of the total population

```
event_berk %>% group_by (event_inst, event_type) %>%
  summarize(
    n_events=n(),
    n_nonmiss_latbl = sum(!is.na(pct_black_zip) & !is.na(pct_hispanic_zip)),
    n_majority_latbl= sum(pct_black_zip+ pct_hispanic_zip>50, na.rm = TRUE)
  )
#> `summarise()` regrouping output by 'event_inst' (override with `.groups` argu
```

`summarize()` : logical vectors to count *proportions*

Synatx: `group_by(vars) %>% summarize(prop = mean(TRUE/FALSE conditon))`

Task: separately for in-state/out-of-state, what proportion of visits to public high schools are to communities with median income greater than $100,000?

Steps:

1. Filter public HS visits
2. group by in-state vs. out-of-state
3. Create measure

```r
event_berk %>% filter(event_type == "public hs") %>% # filter public hs visits
  group_by (event_inst) %>% # group by in-state vs. out-of-state
  summarize(
    n_events=n(), # number of events by group
    n_nonmiss_inc = sum(!is.na(med_inc)), # w/ nonmissings values median inc,
    p_incgt100k = mean(med_inc>100000, na.rm=TRUE)) # proportion visits to $100k
#> `summarise()` ungrouping output (override with `.groups` argument)
#> # A tibble: 2 x 4
#>   event_inst n_events n_nonmiss_inc p_incgt100k
#>   <chr>         <int>         <int>       <dbl>
#> 1 In-State        259           256       0.273
#> 2 Out-State       183           183       0.519
```

`summarize()` : logical vectors to count *proportions*

What if we forgot to put `na.rm=TRUE` in the above task?

Task: separately for in-state/out-of-state, what proportion of visits to public high schools are to communities with median income greater than $100,000?

```
event_berk %>% filter(event_type == "public hs") %>% # filter public hs visits
  group_by (event_inst) %>% # group by in-state vs. out-of-state
  summarize(
    n_events=n(), # number of events by group
    n_nonmiss_inc = sum(!is.na(med_inc)), # w/ nonmissings values median inc,
    p_incgt100k = mean(med_inc>100000, na.rm=TRUE)) # proportion visits to $100
#> `summarise()` ungrouping output (override with `.groups` argument)
#> # A tibble: 2 x 4
#>   event_inst n_events n_nonmiss_inc p_incgt100k
#>   <chr>         <int>         <int>       <dbl>
#> 1 In-State        259           256       0.273
#> 2 Out-State       183           183       0.519
```

`summarize()` : Other "helper" functions

Lots of other functions we can use within `summarize()`

Common functions to use with `summarize()` :

Function	Description
`n`	count
`n_distinct`	count unique values
`mean`	mean
`median`	median
`max`	largest value
`min`	smallest value
`sd`	standard deviation
`sum`	sum of values
`first`	first value
`last`	last value
`nth`	nth value
`any`	condition true for at least one value

Note: These functions can also be used on their own or with `mutate()`

`summarize()` : Other functions

Maximum value in a group

```
max(c(10,50,8))
#> [1] 50
```

Task: For each combination of in-state/out-of-state and event type, what is the maximum value of `med_inc`?

```
event_berk %>% group_by(event_type, event_inst) %>%
  summarize(max_inc = max(med_inc)) # oops, we forgot to remove NAs!
#> `summarise()` regrouping output by 'event_type' (override with `.groups` argu
#> # A tibble: 10 x 3
#>    event_type  event_inst max_inc
#>    <chr>       <chr>        <dbl>
#>  1 2yr college In-State        NA
#>  2 2yr college Out-State  153070.
#>  3 4yr college In-State        NA
#>  4 4yr college Out-State       NA
#>  5 other       In-State        NA
#>  6 other       Out-State       NA
#>  7 private hs  In-State   250001
#>  8 private hs  Out-State       NA
#>  9 public hs   In-State        NA
#> 10 public hs   Out-State  223556.

event_berk %>% group_by(event_type, event_inst) %>%
  summarize(max_inc = max(med_inc, na.rm = TRUE))
#> `summarise()` regrouping output by 'event_type' (override with `.groups` argu
```

`summarize()`: Other functions

Isolate first/last/nth observation in a group

```
x <- c(10,15,20,25,30)
first(x)
last(x)
nth(x,1)
nth(x,3)
nth(x,10)
```

Task: after sorting object `event_berk` by `event_type` and `event_datetime_start`, what is the value of `event_date` for:

- first event for each event type?
- the last event for each event type?
- the 50th event for each event type?

```
event_berk %>% arrange(event_type, event_datetime_start) %>%
  group_by(event_type) %>%
  summarize(
    n_events = n(),
    date_first= first(event_date),
    date_last= last(event_date),
    date_50th= nth(event_date, 50)
  )
#> `summarise()` ungrouping output (override with `.groups` argument)
```

Student exercise

Identify value of `event_date` for the *nth* event in each by group

Specific task:

- arrange (i.e., sort) by `event_type` and `event_datetme_start`, then group by `event_type`, and then identify the value of `event_date` for:
  - the first event in each by group (`event_type`)
  - the second event in each by group
  - the third event in each by group
  - the fourth event in each by group
  - the fifth event in each by group

Student exercise solution

```
event_berk %>% arrange(event_type, event_datetime_start) %>%
  group_by(event_type) %>%
  summarize(
    n_events = n(),
    date_1st= first(event_date),
    date_2nd= nth(event_date,2),
    date_3rd= nth(event_date,3),
    date_4th= nth(event_date,4),
    date_5th= nth(event_date,5))
#> `summarise()` ungrouping output (override with `.groups` argument)
#> # A tibble: 5 x 7
#>   event_type  n_events date_1st   date_2nd   date_3rd   date_4th   date_5th
#>   <chr>          <int> <date>     <date>     <date>     <date>     <date>
#> 1 2yr college      112 2017-04-25 2017-09-05 2017-09-05 2017-09-06 2017-09-06
#> 2 4yr college       18 2017-04-30 2017-05-01 2017-05-06 2017-09-13 2017-09-14
#> 3 other            138 2017-04-11 2017-04-23 2017-04-25 2017-04-29 2017-05-14
#> 4 private hs       169 2017-04-23 2017-04-24 2017-04-29 2017-04-30 2017-09-05
#> 5 public hs        442 2017-04-14 2017-04-24 2017-04-26 2017-04-27 2017-04-27
```

Summarize multiple columns

What are “scoped” variants of a function?

“Scoped” variants of a function apply the function to a selection of variables.

Three kinds of scoped variants exist:

1. Verbs (i.e., functions) suffixed with `_all()` apply an operation on all variables.
   - e.g.: `summarize_all()`, `mutate_all()`
2. Verbs suffixed with `_at()` (e.g., `summarize_at()`) apply an operation on a subset of variables specified with quoting function `vars()`.
   - This quoting function accepts helpers functions like `starts_with()`
3. Verbs suffixed with `_if()` apply an operation on the subset of variables for which a predicate function returns TRUE.

Arguments of scoped variants

- `.tbl` A tbl object (data frame)
- `.funs` specifies which function(s) to perform (e.g., calculate mean)
  - Argument values: A function `fun`; a quosure style lambda ~ fun(.); or a list of either form (e.g., ‘list(mean,min,max).
- `.vars` which variables to apply function to:
  - argument values: A list of columns generated by `vars()`, a character vector of column names, a numeric vector of column positions, or `NULL`.
- `.predicate` A predicate function to be applied to the columns or a logical vector. The variables for which .predicate is or returns `TRUE` are selected.
- `...` Additional arguments for function calls in `.funs`, evaluated once w/ tidy dots support

What are “scoped” variants of a function?

Why/when use “scoped” variants of a function

- When you want to perform an operation on multiple variables without naming each individual variable

“verbs” (i.e., functions) from the `dplyr` package that have scoped variants `_all()`, `_at()`, and `_if()`

- `mutate()` and `transmute()` [see `?mutate_all`]
- `summarize()` [see `?summarize_all`]
- `filter()`
- `group_by()`
- `rename()` and `select()`
- `arrange()`

Scoped variants of summarize()

Description. The “scoped variants” of `summarize()` apply `summarize()` to multiple variables. Three variants:

- `summarize_all()` affects every variable
- `summarize_at()` affects variables selected with a character vector or vars()
- `summarize_if()` affects variables selected with a predicate function

Syntax

- `summarize_all(.tbl, .funs, ...)`
- `summarize_at(.tbl, .vars, .funs, ...)`
- `summarize_if(.tbl, .predicate, .funs, ...)`

Arguments

- `.tbl` A tbl object (data frame)
- `.funs` specifies which function(s) to perform (e.g., calculate mean)
  - Argument values: A function `fun`; a quosure style lambda ~ fun(.); or a list of either form (e.g., ‘list(mean,min,max).
- `.vars` which variables to apply function to:
  - argument values: A list of columns generated by `vars()`, a character vector of column names, a numeric vector of column positions, or `NULL`.
- `.predicate` A predicate function to be applied to the columns or a logical vector. The variables for which .predicate is or returns `TRUE` are selected.
- `...` Additional arguments for the function calls in `.funs`.
  - These are evaluated only once, with tidy dots support.

summarize_all() affects every variable

Syntax: `summarize_all(.tbl, .funs, ...)`

- `.tbl` A tbl object (data frame)
- `.funs` specifies which function(s) to perform. Argument values:
  - A function `fun` ; a quosure style lambda ~ fun(.); a list (e.g., `list(mean,min)`
- `...` Additional arguments for function calls in `.funs` . These are evaluated once

Task:

- For U. Pittsburgh (`univ_id = 215293`) events at public and private high schools, caclulate the **mean** value of `med_inc` and `pct_white_zip` for each combination of `event_type` and `event_inst`

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pct_white_zip) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = mean)
```

Try again, this time applying `na.rm = TRUE`

- this is an example of a `...` argument “for the function calls in `.funs` .”

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pct_white_zip) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = mean, na.rm = TRUE)
```

summarize_all() affects every variable

Syntax: `summarize_all(.tbl, .funs, ...)`

- `.tbl` A tbl object (data frame)
- `.funs` specifies which function(s) to perform. Argument values:
  - A function `fun`; a quosure style lambda ~ fun(.); a list (e.g., `list(mean,min)`
- `...` Additional arguments for function calls in `.funs`. These are evaluated once

Task:

- For U. Pittsburgh (`univ_id = 215293`) events at public and private high schools, caclulate **mean** and **standard deviation** of `med_inc` and `pct_white_zip` for each combination of `event_type` and `event_inst`

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pct_white_zip) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = list(mean,sd), na.rm = TRUE)
```

Use this syntax to control variable name suffixes:

- `.funs = list(var_name_suffix = function_name,...)`

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pct_white_zip) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = list(avg = mean, std = sd), na.rm = TRUE)
```

summarize_all() affects every variable

Task:

- Same task as before, but now calculate **mean**, **standard deviation**, **min**, and **max** of `med_inc` and `pct_white_zip` for each combination of `event_type` and `event_inst`

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pct_white_zip) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = list(avg = mean, std = sd, low = min, high = max),
    na.rm = TRUE)
#> # A tibble: 4 x 10
#>   event_type event_inst med_inc_avg pct_white_zip_a~ med_inc_std
#>   <chr>      <chr>            <dbl>            <dbl>       <dbl>
#> 1 private hs In-State        77115.             78.9      36559.
#> 2 private hs Out-State      103915.             63.3      44220.
#> 3 public hs  In-State        78408.             83.0      25841.
#> 4 public hs  Out-State      114212.             67.5      39745.
#> # ... with 5 more variables: pct_white_zip_std <dbl>, med_inc_low <dbl>,
#> #   pct_white_zip_low <dbl>, med_inc_high <dbl>, pct_white_zip_high <dbl>
```

summarize_all(), quosure style lambdas ~ func_name(.)

Syntax: `summarize_all(.tbl, .funs, ...)`

- `.funs` specifies which function(s) to perform. Argument values:
  - A function `fun` ; a quosure style lambda `~ fun(.)` ; a list (e.g., `list(mean,min)`

Task: Calculate mean, number of obs, and number of non-missing obs for variables

- Functions you specify within `.funs` require different options (e.g., some require `na.rm = TRUE` but others don't take arguments)
- Within `.funs` argument, specify functions using "quosure style lambda"
  - Syntax: `.funs = list(~ func_name(., options), ~ func_name(., options))`

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pop_total) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = list(~ mean(., na.rm = TRUE), ~ n(), ~ sum(!is.na(.))))
```

Specify suffix of variable name

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,med_inc,pop_total) %>%
  group_by(event_type,event_inst) %>%
  summarize_all(.funs = list(avg = ~ mean(., na.rm = TRUE), nrow = ~ n(),
    n_nonmiss = ~ sum(!is.na(.))))
```

summarize_at() affects selected variables

Syntax: `summarize_at(.tbl, .vars, .funs, ...)`

- `.tbl` A tbl object (data frame)
- `.vars` which variables to operate on. Argument values:
  - A list of columns generated by vars(), a character vector of column names, a numeric vector of column positions, or NULL.
- `.funs` specifies which function(s) to perform. Argument values:
  - A function `fun`; a quosure style lambda ~ fun(.); a list (e.g., `list(mean,min)`
- `...` Additional arguments for function calls in `.funs`. These are evaluated once

Task: For U. Pittsburgh events at public and private high schools, caclulate **mean**, **min**, and **max** of variables `med_inc` and `event_date` for each combination of `event_type` and `event_inst`

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  group_by(event_type,event_inst) %>%
  summarize_at(.vars = vars(med_inc,event_date),
     .funs = list(avg = mean, low = min, high = max), na.rm = TRUE)
```

Alternative:

```
df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  group_by(event_type,event_inst) %>%
  summarize_at(.vars = c("med_inc","event_date"),
     .funs = list(avg = mean, low = min, high = max), na.rm = TRUE)
```

summarize_if() affects variables that satisfy some condition

Useful if you want to apply functions to variables that are particular `type` or `class`

Syntax: `summarize_if(.predicate, .tbl, .funs, ...)`

- `.tbl` A tbl object (data frame)
- `.predicate` A predicate function to be applied to columns or a logical vector. The variables for which .predicate is or returns `TRUE` are selected.
- `.funs` specifies which function(s) to perform.
- `...` Additional arguments for function calls in `.funs`.

Task: For events by U. Pittsburgh at public and private high schools, caclulate mean and standard deviation for **numeric variables**

```r
#First, which vars are numeric
df_event %>%
  select(event_type, event_inst,instnm,school_id,med_inc,pct_white_zip) %>%
  glimpse()

df_event %>%
  filter(univ_id == 215293, event_type %in% c("private hs","public hs")) %>%
  select(event_type, event_inst,instnm,school_id,med_inc,pct_white_zip) %>%
  group_by(event_type,event_inst) %>%
  summarize_if(.predicate = is.numeric, .funs = list(avg = mean,std = sd),
    na.rm = TRUE)
```

Attach aggregate measures to your data frame

Attach aggregate measures to your data frame

We can attach aggregate measures to a data frame by using group_by without summarize()

What do I mean by "attaching aggregate measures to a data frame"?

- Calculate measures at the by_group level, but attach them to original object rather than creating an object with one row for each by_group

Task: Using `event_berk` data frame, create (1) a measure of average income across all events and (2) a measure of average income for each event type

- resulting object should have same number of observations as `event_berk`

Steps:

1. create measure of avg. income across all events without using `group_by()` or `summarize()` and assign as (new) object
2. Using object from previous step, create measure of avg. income across by event type using `group_by()` without `summarize()` and assign as new object

Attach aggregate measures to your data frame

Task: Using `event_berk` data frame, create (1) a measure of average income across all events and (2) a measure of average income for each event type

1. Create measure of average income across all events

```
event_berk_temp <- event_berk %>%
  arrange(event_date) %>% # sort by event_date (optional)
  select(event_date, event_type,med_inc) %>% # select vars to be retained (optio
  mutate(avg_inc = mean(med_inc, na.rm=TRUE)) # create avg. inc measure

dim(event_berk_temp)
event_berk_temp %>% head(5)
```

2. Create measure of average income by event type

```
event_berk_temp <- event_berk_temp %>%
  group_by(event_type) %>% # grouping by event type
  mutate(avg_inc_type = mean(med_inc, na.rm=TRUE)) # create avg. inc measure

str(event_berk_temp)
event_berk_temp %>% head(5)
```

Attach aggregate measures to your data frame

Task: Using `event_berk_temp` from previous question, create a measure that identifies whether `med_inc` associated with the event is higher/lower than average income for all events of that type

Steps:

1. Create measure of average income for each event type [already done]
2. Create 0/1 indicator that identifies whether median income at event location is higher than average median income for events of that type

```
# average income at recruiting events across all universities
event_berk_tempv2 <- event_berk_temp %>%
  mutate(gt_avg_inc_type = med_inc > avg_inc_type) %>%
  select(-(avg_inc)) # drop avg_inc (optional)
event_berk_tempv2 # note how med_ic = NA are treated
```

Same as above, but this time create integer indicator rather than logical

```
event_berk_tempv2 <- event_berk_tempv2 %>%
  mutate(gt_avg_inc_type = as.integer(med_inc > avg_inc_type))
event_berk_tempv2  %>% head(4)
```

Student exercise

Task: is `pct_white_zip` at a particular event higher or lower than the average pct_white_zip for that `event_type` ?

- Note: all events attached to a particular zip_code
- `pct_white_zip` : pct of people in that zip_code who identify as white

Steps in task:

- Create measure of average pct white for each event_type
- Compare whether pct_white_zip is higher or lower than this average

Student exercise solution

Task: is `pct_white_zip` at a particular event higher or lower than the average pct_white_zip for that `event_type`?

```
event_berk_tempv3 <- event_berk %>%
  arrange(event_date) %>% # sort by event_date (optional)
  select(event_date, event_type, pct_white_zip) %>% #optional
  group_by(event_type) %>% # grouping by event type
  mutate(avg_pct_white = mean(pct_white_zip, na.rm=TRUE),
         gt_avg_pctwhite_type = as.integer(pct_white_zip > avg_pct_white))
event_berk_tempv3 %>% head(4)
#> # A tibble: 4 x 5
#>   event_date event_type pct_white_zip avg_pct_white gt_avg_pctwhite_type
#>   <date>     <chr>              <dbl>         <dbl>                <int>
#> 1 2017-04-11 other               37.2          49.7                    0
#> 2 2017-04-14 public hs           78.3          48.9                    1
#> 3 2017-04-23 private hs          84.7          61.0                    1
#> 4 2017-04-23 other               20.9          49.7                    0
```