

Data Summarization

Recap

- `select()`: subset and/or reorder columns
- `filter()`: remove rows
- `arrange()`: reorder rows
- `mutate()`: create new columns or modify them
- `select()` and `filter()` can be combined together
- remove a column: `select()` with `!` mark (`!col_name`)
- you can do sequential steps: especially using pipes `%>%`

▮ [Day 3 Cheatsheet](#)

The Data

We can use the CO heat-related ER visits dataset to explore different ways of summarizing data.

Reminder: This dataset contains information about the number and rate of visits for heat-related illness to ERs in Colorado from 2011-2022, adjusted for age.

The Data

We can use the CO heat-related ER visits dataset to explore different ways of summarizing data.

The `head` function displays the first rows of an object:

```
er <-  
  read_csv("https://daseh.org/data/CO_ER_heat_visits.csv")
```

```
head(er)
```

```
# A tibble: 6 × 6  
  county  rate lower95cl upper95cl visits  year  
  <chr>  <dbl>    <dbl>    <dbl>  <dbl> <dbl>  
1 Adams  6.73      NA      9.24     29  2011  
2 Adams  4.84     2.85     NA      23  2012  
3 Adams  6.84     4.36     9.31     31  2013  
4 Adams  3.08     1.71     4.85     15  2014  
5 Adams  3.36     1.89     5.23     16  2015  
6 Adams  8.85     6.12    11.6     42  2016
```

Behavior of `pull()` function

`pull()` converts a single data column into a **vector**.

```
er %>% pull(visits)
```

Data Summarization

Now that we have a [vector of numbers](#).. what can we do with it?

- Basic statistical summarization
 - `mean(x)`: takes the mean of x
 - `sd(x)`: takes the standard deviation of x
 - `median(x)`: takes the median of x
 - `quantile(x)`: displays sample quantiles of x. Default is min, IQR, max
 - `range(x)`: displays the range. Same as `c(min(x), max(x))`
 - `sum(x)`: sum of x
 - `max(x)`: maximum value in x
 - `min(x)`: minimum value in x

Pipe (%>%) vectors into summarizing functions

A vector can be summarized:

```
er %>% pull(visits) %>% mean()
```

```
[1] NA
```

Add the `na.rm` = argument for missing data

```
er %>% pull(visits) %>% mean(na.rm=T)
```

```
[1] 7.189247
```

GUT CHECK!

What kind of object do we need to run summary operators like `mean()` ?

- A. A vector of numbers
- B. A vector of characters
- C. A dataset

Summarization on tibbles (data frames)

Summarize the data: **dplyr** `summarize()` function

`summarize` works on datasets without `pull()`.

Multiple summary statistics can be calculated at once!

General format - Not the code!

```
{data to use} %>%
```

```
  summarize({summary column name} = {function(source column)},  
            {summary column name} = {function(source column)})
```

Summarize the data: `dplyr summarize()` function

```
er %>%  
  summarize(mean_visits = mean(visits))
```

```
# A tibble: 1 × 1  
  mean_visits  
    <dbl>  
1          NA
```

```
er %>%  
  summarize(mean_visits = mean(visits, na.rm = TRUE))
```

```
# A tibble: 1 × 1  
  mean_visits  
    <dbl>  
1        7.19
```

Summarize the data: `dplyr summarize()` function

`summarize()` can do multiple operations at once. Just separate by a comma.

```
er %>%
```

```
  summarize(mean_visits = mean(visits, na.rm = TRUE),  
            median_visits = median(visits, na.rm = TRUE),  
            mean_rate = mean(rate, na.rm = TRUE))
```

```
# A tibble: 1 × 3
```

```
  mean_visits median_visits mean_rate  
    <dbl>         <dbl>         <dbl>  
1      7.19           0          2.43
```

Summarize the data: **dplyr** `summarize()` function

Note that `summarize()` creates a separate tibble from the original data.

If you want to save a summary statistic in the original data, use `mutate()` instead to create a new column for the summary statistic.

summary() Function

Using `summary()` can give you rough snapshots of each numeric column (character columns are skipped):

```
summary(er)
```

county	rate	lower95cl	upper95cl
Length:768	Min. : 0.000	Min. : 0.000	Min. : 0.000
Class :character	1st Qu.: 0.000	1st Qu.: 0.000	1st Qu.: 0.000
Mode :character	Median : 0.000	Median : 0.000	Median : 0.000
	Mean : 2.431	Mean : 1.449	Mean : 3.526
	3rd Qu.: 3.509	3rd Qu.: 1.895	3rd Qu.: 5.173
	Max. :89.275	Max. :43.398	Max. :151.420
	NA's :303	NA's :304	NA's :304

visits	year
Min. : 0.000	Min. :2011
1st Qu.: 0.000	1st Qu.:2014
Median : 0.000	Median :2016
Mean : 7.189	Mean :2016
3rd Qu.:13.000	3rd Qu.:2019
Max. :48.000	Max. :2022
NA's :303	

Summary & Lab Part 1

- `pull()` creates a *vector*
- don't forget the `na.rm = TRUE` argument!
- `summary(x)`: quantile information
- `summarize`: creates a summary table of columns of interest
- summary stats (`mean()`) work with vectors or with `summarize()`

▢ [Class Website](#)

▢ [Lab](#)

distinct() values

`distinct(x)` will return the unique elements of column x.

```
er %>%  
  distinct(county)
```

```
# A tibble: 64 × 1  
  county  
  <chr>  
1 Adams  
2 Alamosa  
3 Arapahoe  
4 Archuleta  
5 Baca  
6 Bent  
7 Boulder  
8 Broomfield  
9 Chaffee  
10 Cheyenne  
#   54 more rows
```


How many `distinct()` values?

`n_distinct()` tells you the number of unique elements.

It needs a vector so you *must pull the column first!*

```
er %>%  
  pull(county) %>%  
  n_distinct()
```

```
[1] 64
```

Use `count()` to return row count per category.

```
er %>% count(county)
```

```
# A tibble: 64 × 2
  county      n
  <chr>    <int>
1 Adams      12
2 Alamosa     12
3 Arapahoe    12
4 Archuleta   12
5 Baca        12
6 Bent        12
7 Boulder     12
8 Broomfield  12
9 Chaffee     12
10 Cheyenne   12
#   54 more rows
```

Looks like 12 rows/observations per county!

Multiple columns listed further subdivides the `count()`

```
er %>% count(county, year)
```

```
# A tibble: 768 × 3
```

	county	year	n
	<chr>	<dbl>	<int>
1	Adams	2011	1
2	Adams	2012	1
3	Adams	2013	1
4	Adams	2014	1
5	Adams	2015	1
6	Adams	2016	1
7	Adams	2017	1
8	Adams	2018	1
9	Adams	2019	1
10	Adams	2020	1

```
#   758 more rows
```

Looks like 1 row/observation per county and year!

GUT CHECK!

The `count()` function can help us tally:

- A. Sample size
- B. Rows per each category
- C. How many categories

Grouping

Goal

We want to find the mean number of ER visits per year in the dataset.

How do we do this?

Perform Operations By Groups: dplyr

First, let's group the data.

`group_by` allows you group the data set by variables/columns you specify:

```
er_grouped <- er %>% group_by(year)
er_grouped
```

```
# A tibble: 768 × 6
# Groups:   year [12]
  county rate lower95cl upper95cl visits year
  <chr> <dbl> <dbl> <dbl> <dbl> <dbl>
1 Adams 6.73 NA 9.24 29 2011
2 Adams 4.84 2.85 NA 23 2012
3 Adams 6.84 4.36 9.31 31 2013
4 Adams 3.08 1.71 4.85 15 2014
5 Adams 3.36 1.89 5.23 16 2015
6 Adams 8.85 6.12 11.6 42 2016
7 Adams 6.63 4.29 8.98 32 2017
8 Adams 7.11 4.77 9.44 37 2018
9 Adams 6.76 4.53 8.99 36 2019
10 Adams 4.76 2.82 6.70 24 2020
# 758 more rows
```

Summarize the grouped data

It's grouped! Grouping doesn't change the data in any way, but how **functions operate on it**. Now we can summarize **visits** by group:

```
er_grouped %>%  
  summarize(avg_visits = mean(visits, na.rm = TRUE))
```

```
# A tibble: 12 × 2  
  year avg_visits  
  <dbl>   <dbl>  
1  2011     5.20  
2  2012     5.89  
3  2013     5.63  
4  2014     4.12  
5  2015     6.4  
6  2016    10.1  
7  2017     7.24  
8  2018    11.7  
9  2019     9.12  
10 2020     6.26  
11 2021     8.06  
12 2022     9.29
```


Do it in one step: use %>% to string these together!

Pipe er into group_by, then pipe that into summarize:

```
er %>%  
  group_by(year) %>%  
  summarize(avg_visits = mean(visits, na.rm = TRUE))
```

```
# A tibble: 12 × 2  
  year avg_visits  
  <dbl>   <dbl>  
1  2011     5.20  
2  2012     5.89  
3  2013     5.63  
4  2014     4.12  
5  2015     6.4  
6  2016    10.1  
7  2017     7.24  
8  2018    11.7  
9  2019     9.12  
10 2020     6.26  
11 2021     8.06  
12 2022     9.29
```

Group by as many variables as you want

group_by county and year:

```
er %>%  
  group_by(year, county) %>%  
  summarize(avg_visits = mean(visits, na.rm = TRUE))
```

```
# A tibble: 768 × 3  
# Groups:   year [12]  
   year county      avg_visits  
   <dbl> <chr>      <dbl>  
1  2011 Adams         29  
2  2011 Alamosa        0  
3  2011 Arapahoe       33  
4  2011 Archuleta       0  
5  2011 Baca           0  
6  2011 Bent           0  
7  2011 Boulder       12  
8  2011 Broomfield    NaN  
9  2011 Chaffee        0  
10 2011 Cheyenne       0  
#   758 more rows
```

Counting rows/observations

There are other summarizing functions, such as `n()` count the number of rows/observations (NAs included).

```
er %>%  
  group_by(year) %>%  
  summarize(n = n(),  
            mean = mean(visits, na.rm = TRUE))
```

```
# A tibble: 12 × 3  
   year      n mean  
   <dbl> <int> <dbl>  
1  2011     64  5.20  
2  2012     64  5.89  
3  2013     64  5.63  
4  2014     64  4.12  
5  2015     64  6.4  
6  2016     64 10.1  
7  2017     64  7.24  
8  2018     64 11.7  
9  2019     64  9.12  
10 2020     64  6.26  
11 2021     64  8.06  
12 2022     64  9.29
```

Counting: `count()` and `n()`

`count()` and `n()` can give very similar information.

```
# Here we use count()  
er %>% count(year)
```

```
# A tibble: 12 × 2
```

	year	n
	<dbl>	<int>
1	2011	64
2	2012	64
3	2013	64
4	2014	64
5	2015	64
6	2016	64
7	2017	64
8	2018	64
9	2019	64
10	2020	64
11	2021	64
12	2022	64

Counting: `count()` and `n()`

`count()` and `n()` can give very similar information.

```
# n() with summarize
```

```
er %>% group_by(year) %>% summarize(n())
```

```
# A tibble: 12 × 2
```

```
  year `n()`  
  <dbl> <int>  
1  2011     64  
2  2012     64  
3  2013     64  
4  2014     64  
5  2015     64  
6  2016     64  
7  2017     64  
8  2018     64  
9  2019     64  
10 2020     64  
11 2021     64  
12 2022     64
```

A few miscellaneous topics ..

Base R functions you might see: **length** and **unique**

These functions require a column as a vector using `pull()`.

```
er_year <- er %>% pull(year) # pull() to make a vector
```

```
er_year %>% unique() # similar to distinct()
```

```
[1] 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
```

Base R functions you might see: **length** and **unique**

These functions require a column as a vector using `pull()`.

```
er_year %>% unique() %>% length() # similar to n_distinct()
```

```
[1] 12
```


summary() vs. summarize()

- `summary()` (base R) gives statistics table on a dataset.
- `summarize()` (dplyr) creates a more customized summary tibble/dataframe.

Summary

- `count(x)`: what unique values do you have?
 - `distinct()`: what are the distinct values?
 - `n_distinct()` with `pull()`: how many distinct values?
- `group_by()`: changes all subsequent functions
 - combine with `summarize()` to get statistics per group
- `summarize()` with `n()` gives the count (NAs included)

Lab Part 2

- ▢ [Class Website](#)
- ▢ [Lab](#)
- ▢ [Day 4 Cheatsheet](#)
- ▢ [Posit's data transformation Cheatsheet](#)

For more advanced learning:

- <https://www.danielsjoberg.com/gtsummary/> for tables
- extra slides in this file.



Image by [Gerd Altmann](#) from [Pixabay](#)

**Extra Slides: More advanced
summarization**

Data Summarization on data frames

- Statistical summarization across the data frame
 - `rowMeans(x)`: takes the means of each row of x
 - `colMeans(x)`: takes the means of each column of x
 - `rowSums(x)`: takes the sum of each row of x
 - `colSums(x)`: takes the sum of each column of x

```
yearly_co2 <-  
  read_csv("https://daseh.org/data/Yearly_CO2_Emissions_1000_tonnes.csv")
```

rowMeans() example

Get means for each row.

Let's see what the mean CO2 emissions is across the years 2010-2014 for each row (country):

```
yearly_co2 %>%  
  select(starts_with("201")) %>%  
  rowMeans(na.rm = TRUE) %>%  
  head(n = 5)
```

```
[1] 10254 5106 129800 487 32040
```

```
yearly_co2 %>%  
  group_by(country) %>%  
  summarize(mean = rowMeans(across(starts_with("201")), na.rm = TRUE)) %>%  
  head(n = 5)
```

```
# A tibble: 5 × 2  
  country      mean  
  <chr>      <dbl>  
1 Afghanistan 10254  
2 Albania      5106  
3 Algeria     129800  
4 Andorra       487  
5 Angola      32040
```

colMeans() example

Get means for each column.

Let's see what the mean is across each column (year):

```
yearly_co2 %>%  
  select(starts_with("201")) %>%  
  colMeans(na.rm = TRUE) %>%  
  head(n = 5)
```

	2010	2011	2012	2013	2014
	165334.1	171764.9	174033.4	174856.2	175992.5

```
yearly_co2 %>%  
  summarize(across(starts_with("201"), ~mean(.x, na.rm = TRUE)))
```

```
# A tibble: 1 × 5  
  `2010`    `2011`    `2012`    `2013`    `2014`  
  <dbl>    <dbl>    <dbl>    <dbl>    <dbl>  
1 165334. 171765. 174033. 174856. 175993.
```

* New! * Many dplyr functions now have a **.by=** argument

Pipe `er` into `group_by`, then pipe that into `summarize`:

```
er %>%  
  group_by(year) %>%  
  summarize(avg_visits = mean(visits, na.rm = TRUE),  
            max_visits = max(visits, na.rm = TRUE))
```

is the same as..

```
er %>%  
  summarize(avg_visits = mean(visits, na.rm = TRUE),  
            max_visits = max(visits, na.rm = TRUE),  
            .by = year)
```