

# Manipulating tables with `dplyr`

*Data Wrangling, Session 3*

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Code Horizons

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**dplyr** is your toolkit for tabular  
data

So let's  
play with  
some **data**

woohoo!

# Load our libraries

```
library(here)      # manage file paths  
library(socviz)    # data and some useful functions  
library(tidyverse) # your friend and mine
```

# Tidyverse components, again

```
library(tidyverse)
```

Call the package and ...

```
Loading tidyverse: ggplot2
```

◁ Draw graphs

```
Loading tidyverse: tibble
```

◁ Nicer data tables

```
Loading tidyverse: tidyr
```

◁ Tidy your data

```
Loading tidyverse: readr
```

◁ Get data into R

```
Loading tidyverse: purrr
```

◁ Fancy Iteration

```
Loading tidyverse: dplyr
```

◁ Action verbs for tables

# Other tidyverse components

`forcats`

▷ Deal with factors

`haven`

▷ Import Stata, SPSS, etc

`lubridate`

▷ Dates, Durations, Times

`readxl`

▷ Import from spreadsheets

`stringr`

▷ Strings and Regular Expressions

`reprex`

▷ Make reproducible examples

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▷ Make reproducible examples

Not all of these are attached when we do `library(tidyverse)`

**dplyr** lets you work with tibbles

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Remember, tibbles are tables of data where the columns can be of different types, such as numeric, logical, character, factor, etc.

We'll use dplyr to *transform* and *summarize* our data.

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Remember, tibbles are tables of data where the columns can be of different types, such as numeric, logical, character, factor, etc.

We'll use dplyr to *transform* and *summarize* our data.

We'll use the pipe operator, `>`, to chain together sequences of actions on our tables.

# dplyr's core verbs

**dplyr** draws on the  
logic and language  
of **database queries**

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**Mutate** the data. That is, change something at the *current* level of grouping. Mutating adds new columns to the table, or changes the content of an existing column. It never changes the number of rows.

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**Summarize** or aggregate the data. That is, make something new at a *higher* level of grouping. E.g., calculate means or counts by some grouping variable. This will generally result in a smaller, *summary* table. Usually this will have the same number of *rows* as there are *groups* being summarized.

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**Subset** has one action for rows and one for columns. We `filter()` rows and `select()` columns.

**Mutate** tables (i.e. add new columns, or re-make existing ones) using `mutate()`.

**Summarize** tables (i.e. perform aggregating calculations) using `summarize()`.

# Group and Summarize

# General Social Survey data: gss\_sm

```
## library(socviz) # if not loaded
gss_sm

# A tibble: 2,867 × 32
  year    id ballot      age child� sibs degree race   sex   region income16
  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct> <fct>
1 2016     1 1           47     3 2   Bach... White Male  New E... $170000...
2 2016     2 2           61     0 3   High ... White Male  New E... $50000 ...
3 2016     3 3           72     2 3   Bach... White Male  New E... $75000 ...
4 2016     4 1           43     4 3   High ... White Fema... New E... $170000...
5 2016     5 3           55     2 2   Gradu... White Fema... New E... $170000...
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8 2016     8 3           23     3 6   High ... Other Fema... Middl... $30000 ...
9 2016     9 1           45     3 5   High ... Black Male  Middl... $60000 ...
10 2016    10 3          71     4 1   Junio... White Male  Middl... $60000 ...
# i 2,857 more rows
# i 21 more variables: relig <fct>, marital <fct>, padeg <fct>, madeg <fct>,
# partyid <fct>, polviews <fct>, happy <fct>, partners <fct>, grass <fct>,
# zodiac <fct>, pres12 <labelled>, wtssall <dbl>, income_rc <fct>,
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# bigregion <fct>, partners_rc <fct>, obama <dbl>
```

Notice how the tibble already tells us a lot.

# Summarizing a Table

Here's what we're going to do:

## 1. Individual-Level GSS Data on Region and Religion

<code>id</code>	<code>bigregion</code>	<code>religion</code>
1014	Midwest	Protestant
1544	South	Protestant
665	Northeast	None
1618	South	None
2115	West	Catholic
417	South	Protestant
2045	West	Protestant
1863	Northeast	Other
1884	Midwest	Christian
1628	South	Protestant

## 2. Summary Count of Religious Preferences by Census Region

<code>bigregion</code>	<code>religion</code>	<code>N</code>
Northeast	Protestant	123
Northeast	Catholic	149
Northeast	Jewish	15
Northeast	None	97
Northeast	Christian	14
Northeast	Other	31

## 3. Percent Religious Preferences by Census Region

<code>bigregion</code>	<code>religion</code>	<code>N</code>	<code>pct</code>
Northeast	Protestant	123	28.3
Northeast	Catholic	149	34.3
Northeast	Jewish	15	3.4
Northeast	None	97	22.3
Northeast	Christian	14	3.2
Northeast	Other	31	7.1

# Summarizing a Table

```
gss_sm ▷  
  select(id, bigregion, religion)  
  
# A tibble: 2,867 × 3  
  id    bigregion religion  
  <dbl> <fct>     <fct>  
1 1    Northeast   None  
2 2    Northeast   None  
3 3    Northeast   Catholic  
4 4    Northeast   Catholic  
5 5    Northeast   None  
6 6    Northeast   None  
7 7    Northeast   None  
8 8    Northeast   Catholic  
9 9    Northeast   Protestant  
10 10   Northeast  None  
# i 2,857 more rows
```

We're just taking a look at the relevant columns here.

# Group by *one* column or variable

```
gss_sm ▷  
  group_by(bigregion)

# A tibble: 2,867 × 32
# Groups:   bigregion [4]
  year    id ballot      age child� sibs degree race   sex   region income16
  <dbl>  <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct>
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```

Grouping just changes the logical structure of the tibble.

# Group and summarize by *one* column

gss\_sm

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# A tibble: 2,867 × 32
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group_by(bigregion)
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# Group and summarize by *one* column

```
gss_sm %>  
  group_by(bigregion) %>  
  summarize(total = n())
```

```
# A tibble: 4 × 2  
  bigregion total  
  <fct>     <int>  
1 Northeast   488  
2 Midwest    695  
3 South      1052  
4 West       632
```

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The function `n()` counts up the rows within each group.

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All the other columns are dropped in the summary operation

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The function `n()` counts up the rows within each group.

All the other columns are dropped in the summary operation

Your original `gss_sm` table is untouched

# Group and summarize by *two* columns

```
gss_sm
```

```
# A tibble: 2,867 × 32
  year   id ballot      age child� sibs degree race   sex   region income16
  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct>
1 2016    1 1             47     3 2  Bach... White Male New E.. $170000...
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#   agegrp <fct>, ageq <fct>, siblings <fct>, kids <fct>, religion <fct>,
#   bigregion <fct>, partners_rc <fct>, obama <dbl>
```

# Group and summarize by *two* columns

```
gss_sm ▷  
group_by(bigregion, religion)  
  
# A tibble: 2,867 × 32  
# Groups:   bigregion, religion [24]  
  year    id ballot      age childs sibs degree race sex   region income16  
  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct>  
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```

# Group and summarize by *two* columns

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  summarize(total = n())
```

```
# A tibble: 24 x 3  
# Groups:   bigregion [4]  
  bigregion religion   total  
  <fct>     <fct>     <int>  
1 Northeast Protestant  158  
2 Northeast Catholic   162  
3 Northeast Jewish     27  
4 Northeast None       112  
5 Northeast Other      28  
6 Northeast <NA>       1  
7 Midwest   Protestant 325  
8 Midwest   Catholic   172  
9 Midwest   Jewish     3  
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# i 14 more rows
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# i 14 more rows
```

The function `n()` counts up the rows within the *innermost* (i.e. the rightmost) group.

# Calculate frequencies

gss\_sm

```
# A tibble: 2,867 × 32
  year   id ballot      age child� sibs degree race   sex   region income16
  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct>
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  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct>  
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# i 14 more rows
```

# Calculate frequencies

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  summarize(total = n()) %>  
  mutate(freq = total / sum(total),  
        pct = round((freq*100), 1))
```

```
# A tibble: 24 x 5  
# Groups:   bigregion [4]  
  bigregion religion    total     freq     pct  
  <fct>     <fct>     <int>    <dbl>    <dbl>  
1 Northeast Protestant    158  0.324    32.4  
2 Northeast Catholic      162  0.332    33.2  
3 Northeast Jewish         27  0.0553   5.5  
4 Northeast None           112  0.230    23  
5 Northeast Other          28  0.0574   5.7  
6 Northeast <NA>            1  0.00205  0.2  
7 Midwest   Protestant     325  0.468    46.8  
8 Midwest   Catholic       172  0.247    24.7  
9 Midwest   Jewish          3  0.00432  0.4  
10 Midwest  None            157  0.226   22.6  
# i 14 more rows
```

# Calculate frequencies

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  summarize(total = n()) %>  
  mutate(freq = total / sum(total),  
        pct = round((freq*100), 1))
```

```
# A tibble: 24 x 5  
# Groups:   bigregion [4]  
  bigregion religion    total     freq     pct  
  <fct>     <fct>     <int>    <dbl>    <dbl>  
1 Northeast Protestant    158  0.324    32.4  
2 Northeast Catholic      162  0.332    33.2  
3 Northeast Jewish         27  0.0553   5.5  
4 Northeast None           112  0.230    23  
5 Northeast Other          28  0.0574   5.7  
6 Northeast <NA>            1  0.00205  0.2  
7 Midwest   Protestant     325  0.468    46.8  
8 Midwest   Catholic       172  0.247    24.7  
9 Midwest   Jewish          3  0.00432  0.4  
10 Midwest  None            157  0.226   22.6  
# i 14 more rows
```

The function `n()` counts up the rows

# Calculate frequencies

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  summarize(total = n()) %>  
  mutate(freq = total / sum(total),  
        pct = round((freq*100), 1))
```

```
# A tibble: 24 x 5  
# Groups:   bigregion [4]  
  bigregion religion    total     freq     pct  
  <fct>     <fct>     <int>     <dbl>    <dbl>  
1 Northeast Protestant    158  0.324    32.4  
2 Northeast Catholic      162  0.332    33.2  
3 Northeast Jewish         27  0.0553   5.5  
4 Northeast None           112  0.230    23  
5 Northeast Other          28  0.0574   5.7  
6 Northeast <NA>            1  0.00205  0.2  
7 Midwest   Protestant     325  0.468    46.8  
8 Midwest   Catholic       172  0.247    24.7  
9 Midwest   Jewish          3  0.00432  0.4  
10 Midwest  None            157  0.226   22.6  
# i 14 more rows
```

The function **n()** counts up the rows

Which rows? The ones fed down the pipeline

# Calculate frequencies

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  summarize(total = n()) %>  
  mutate(freq = total / sum(total),  
        pct = round((freq*100), 1))
```

```
# A tibble: 24 x 5  
# Groups:   bigregion [4]  
  bigregion religion    total     freq     pct  
  <fct>     <fct>     <int>     <dbl>    <dbl>  
1 Northeast Protestant    158  0.324    32.4  
2 Northeast Catholic      162  0.332    33.2  
3 Northeast Jewish         27  0.0553   5.5  
4 Northeast None           112  0.230    23  
5 Northeast Other          28  0.0574   5.7  
6 Northeast <NA>            1  0.00205  0.2  
7 Midwest   Protestant     325  0.468    46.8  
8 Midwest   Catholic       172  0.247    24.7  
9 Midwest   Jewish          3  0.00432  0.4  
10 Midwest  None            157  0.226   22.6  
# i 14 more rows
```

The function `n()` counts up the rows

Which rows? The ones fed down the pipeline

The *innermost* (i.e. the rightmost) group.

# Pipelines carry assumptions forward

```
gss_sm >
  group_by(bigregion, religion) >
  summarize(total = n()) >
  mutate(freq = total / sum(total),
        pct = round((freq*100), 1))

# A tibble: 24 × 5
# Groups:   bigregion [4]
  bigregion religion    total     freq     pct
  <fct>     <fct>     <int>     <dbl>   <dbl>
1 Northeast Protestant    158 0.324    32.4
2 Northeast Catholic      162 0.332    33.2
3 Northeast Jewish         27 0.0553   5.5
4 Northeast None           12 0.230    23
5 Northeast Other          28 0.0574   5.7
6 Northeast <NA>           1 0.00205  0.2
7 Midwest Protestant       325 0.468    46.8
8 Midwest Catholic          72 0.247    24.7
9 Midwest Jewish            3 0.00432  0.4
10 Midwest None            157 0.226   22.6
# i 14 more rows
```

Groups are carried forward till summarized or explicitly ungrouped

Summary calculations are done on the innermost group, which then “disappears”.

# Pipelines carry assumptions forward

```
gss_sm >
  group_by(bigregion, religion) >
  summarize(total = n()) >
  mutate(freq = total / sum(total),
        pct = round((freq*100), 1))  
  
# A tibble: 24 × 5  
# Groups:   bigregion [4]  
  bigregion religion    total     freq     pct  
  <fct>     <fct>     <int>     <dbl>     <dbl>  
1 Northeast Protestant    158  0.324    32.4  
2 Northeast Catholic      162  0.332    33.2  
3 Northeast Jewish         27  0.0553    5.5  
4 Northeast None           112  0.230    23  
5 Northeast Other          28  0.0574    5.7  
6 Northeast <NA>            1  0.00205   0.2  
7 Midwest Protestant       325  0.468    46.8  
8 Midwest Catholic          72  0.247    24.7  
9 Midwest Jewish             3  0.00432   0.4  
10 Midwest None            157  0.226   22.6  
# i 14 more rows
```

**mutate()** is quite clever. See how we can immediately use **freq**, even though we are creating it in the same **mutate()** expression.

# Convenience functions

```
gss_sm ▷  
  group_by(bigregion, religion) ▷  
  summarize(total = n()) ▷  
  mutate(freq = total / sum(total),  
        pct = round((freq*100), 1))  
  
# A tibble: 24 × 5  
# Groups:   bigregion [4]  
  bigregion religion  total    freq    pct  
  <fct>     <fct>     <int>    <dbl>   <dbl>  
1 Northeast Protestant  158  0.324    32.4  
2 Northeast Catholic   162  0.332    33.2  
3 Northeast Jewish      27  0.0553   5.5  
4 Northeast None        112  0.230    23  
5 Northeast Other       28  0.0574   5.7  
6 Northeast <NA>        1  0.00205  0.2  
7 Midwest   Protestant  325  0.468    46.8  
8 Midwest   Catholic   172  0.247    24.7  
9 Midwest   Jewish      3  0.00432  0.4  
10 Midwest  None        157  0.226   22.6  
# i 14 more rows
```

We're going to be doing this `group_by()` ... `n()` step a lot. Some shorthand for it would be useful.

# Three options for counting up rows

Use `n()`

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  summarize(n = n())
```

```
# A tibble: 24 x 3  
# Groups: bigregion [4]  
  bigregion religion     n  
  <fct>    <fct>    <int>  
1 Northeast Protestant  158  
2 Northeast Catholic   162  
3 Northeast Jewish     27  
4 Northeast None       112  
5 Northeast Other      28  
6 Northeast <NA>       1  
7 Midwest Protestant   325  
8 Midwest Catholic     172  
9 Midwest Jewish        3  
10 Midwest None        157  
# i 14 more rows
```

Use `tally()`

```
gss_sm %>  
  group_by(bigregion, religion) %>  
  tally()
```

```
# A tibble: 24 x 3  
# Groups: bigregion [4]  
  bigregion religion     n  
  <fct>    <fct>    <int>  
1 Northeast Protestant  158  
2 Northeast Catholic   162  
3 Northeast Jewish     27  
4 Northeast None       112  
5 Northeast Other      28  
6 Northeast <NA>       1  
7 Midwest Protestant   325  
8 Midwest Catholic     172  
9 Midwest Jewish        3  
10 Midwest None        157  
# i 14 more rows
```

Use `count()`

```
gss_sm %>  
  count(bigregion, religion)
```

```
# A tibble: 24 x 3  
  bigregion religion     n  
  <fct>    <fct>    <int>  
1 Northeast Protestant  158  
2 Northeast Catholic   162  
3 Northeast Jewish     27  
4 Northeast None       112  
5 Northeast Other      28  
6 Northeast <NA>       1  
7 Midwest Protestant   325  
8 Midwest Catholic     172  
9 Midwest Jewish        3  
10 Midwest None        157  
# i 14 more rows
```

Group it yourself;  
result is grouped.

More compact; result  
is grouped.

One step; result is  
not grouped.

# Pass results on to ... a **table**

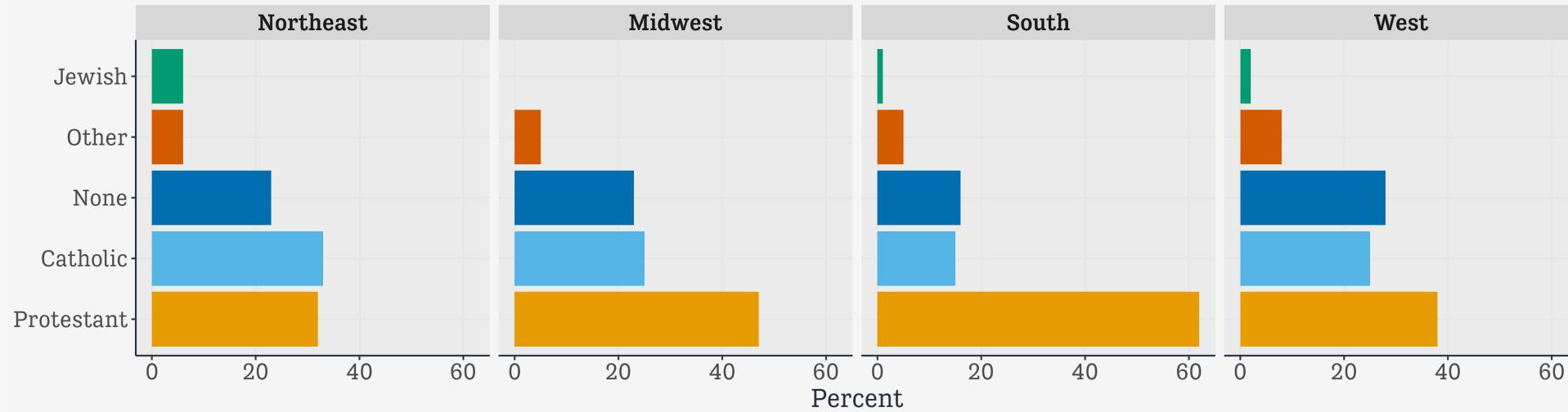
```
gss_sm ▷  
  count(bigregion, religion) ▷  
  pivot_wider(names_from = bigregion, values_from = n) ▷  
  tinytable :: tt()
```

religion	Northeast	Midwest	South	West
Protestant	158	325	650	238
Catholic	162	172	160	155
Jewish	27	3	11	10
None	112	157	170	180
Other	28	33	50	48
NA	1	5	11	1

More on **pivot\_wider()** soon ...

# Pass results on to ... a graph

```
gss_sm %>%
  group_by(bigregion, religion) %>%
  tally() %>%
  mutate(pct = round((n/sum(n))*100), 1) %>%
  drop_na() %>%
  ggplot(mapping = aes(x = pct, y = reorder(religion, -pct), fill = religion)) +
  geom_col() +
  labs(x = "Percent", y = NULL) +
  guides(fill = "none") +
  facet_wrap(~ bigregion, nrow = 1)
```



# Pass results on to ... an object

You can do it like this ...

```
rel_by_region ← gss_sm %>
  count(bigregion, religion) %>
  mutate(pct = round((n/sum(n))*100, 1))
```

```
rel_by_region
```

```
# A tibble: 24 × 4
  bigregion religion     n   pct
  <fct>    <fct>     <int> <dbl>
1 Northeast Protestant  158   5.5
2 Northeast Catholic   162   5.7
3 Northeast Jewish     27    0.9
4 Northeast None       112   3.9
5 Northeast Other      28    1
6 Northeast <NA>        1    0
7 Midwest   Protestant 325  11.3
8 Midwest   Catholic   172   6
9 Midwest   Jewish      3    0.1
10 Midwest  None       157   5.5
# i 14 more rows
```

# Pass results on to ... an object

You can do it like this ...

```
rel_by_region ← gss_sm ▷  
  count(bigregion, religion) ▷  
  mutate(pct = round((n/sum(n))*100, 1))
```

```
rel_by_region
```

```
# A tibble: 24 × 4  
  bigregion religion     n   pct  
  <fct>    <fct>    <int> <dbl>  
1 Northeast Protestant  158  5.5  
2 Northeast Catholic   162  5.7  
3 Northeast Jewish     27   0.9  
4 Northeast None       112  3.9  
5 Northeast Other      28   1  
6 Northeast <NA>       1   0  
7 Midwest Protestant   325 11.3  
8 Midwest Catholic     172  6  
9 Midwest Jewish        3   0.1  
10 Midwest None        157  5.5  
# i 14 more rows
```

Or like this!

```
gss_sm ▷  
  count(bigregion, religion) ▷  
  mutate(pct = round((n/sum(n))*100, 1)) →  
rel_by_region
```

```
rel_by_region
```

```
# A tibble: 24 × 4  
  bigregion religion     n   pct  
  <fct>    <fct>    <int> <dbl>  
1 Northeast Protestant  158  5.5  
2 Northeast Catholic   162  5.7  
3 Northeast Jewish     27   0.9  
4 Northeast None       112  3.9  
5 Northeast Other      28   1  
6 Northeast <NA>       1   0  
7 Midwest Protestant   325 11.3  
8 Midwest Catholic     172  6  
9 Midwest Jewish        3   0.1  
10 Midwest None        157  5.5  
# i 14 more rows
```

# Right assignment is a thing, like Left

Left assignment is standard

```
gss_tab ← gss_sm ▷  
    count(bigregion, religion)
```

This may feel awkward with a pipe:  
“**gss\_tab gets** the output of the  
following pipeline.”

Right assignment also works!

```
gss_sm ▷  
    count(bigregion, religion) → gss_tab
```

Without any authority, I assert that  
right-assignment should be read as,  
e.g., “This pipeline **begets** gss\_tab”

# Check by summarizing

```
rel_by_region ← gss_sm ▷  
  count(bigregion, religion) ▷  
  mutate(pct = round((n/sum(n))*100, 1))
```

```
rel_by_region
```

```
# A tibble: 24 × 4  
  bigregion religion     n   pct  
  <fct>    <fct>    <int> <dbl>  
1 Northeast Protestant  158   5.5  
2 Northeast Catholic   162   5.7  
3 Northeast Jewish     27    0.9  
4 Northeast None       112   3.9  
5 Northeast Other      28    1  
6 Northeast <NA>        1    0  
7 Midwest   Protestant 325  11.3  
8 Midwest   Catholic   172   6  
9 Midwest   Jewish     3    0.1  
10 Midwest  None      157   5.5  
# i 14 more rows
```

Hm, did I sum over right group?

# Check by summarizing

```
rel_by_region ← gss_sm ▷  
  count(bigregion, religion) ▷  
  mutate(pct = round((n/sum(n))*100, 1))
```

```
rel_by_region
```

```
# A tibble: 24 × 4  
  bigregion religion     n   pct  
  <fct>    <fct>    <int> <dbl>  
1 Northeast Protestant  158   5.5  
2 Northeast Catholic   162   5.7  
3 Northeast Jewish     27    0.9  
4 Northeast None       112   3.9  
5 Northeast Other      28    1  
6 Northeast <NA>        1    0  
7 Midwest Protestant   325  11.3  
8 Midwest Catholic     172   6  
9 Midwest Jewish       3    0.1  
10 Midwest None        157   5.5  
# i 14 more rows
```

```
## Each region should sum to ~100  
rel_by_region ▷  
  group_by(bigregion) ▷  
  summarize(total = sum(pct))
```

```
# A tibble: 4 × 2  
  bigregion total  
  <fct>     <dbl>  
1 Northeast  17  
2 Midwest   24.3  
3 South     36.7  
4 West      22
```

No! What has gone wrong here?

Hm, did I sum over right group?

# Check by summarizing

```
rel_by_region ← gss_sm ▷  
  count(bigrregion, religion) ▷  
  mutate(pct = round((n/sum(n))*100, 1))
```

`count()` returns ungrouped results, so there are no groups carry forward to the `mutate()` step.

```
rel_by_region ▷  
  summarize(total = sum(pct))
```

```
# A tibble: 1 × 1  
  total  
  <dbl>  
1 100
```

With `count()`, the `pct` values here are the marginals for the whole table.

# Check by summarizing

```
rel_by_region ← gss_sm ▷  
  count(bigregion, religion) ▷  
  mutate(pct = round((n/sum(n))*100, 1))
```

`count()` returns ungrouped results, so there are no groups carry forward to the `mutate()` step.

```
rel_by_region ▷  
  summarize(total = sum(pct))
```

```
# A tibble: 1 × 1  
  total  
  <dbl>  
1 100
```

With `count()`, the `pct` values here are the marginals for the whole table.

```
rel_by_region ← gss_sm ▷  
  group_by(bigregion, religion) ▷  
  tally() ▷  
  mutate(pct = round((n/sum(n))*100, 1))
```

```
# Check  
rel_by_region ▷  
  group_by(bigregion) ▷  
  summarize(total = sum(pct))
```

```
# A tibble: 4 × 2  
  bigregion total  
  <fct>     <dbl>  
1 Northeast   100  
2 Midwest    99.9  
3 South      100  
4 West       100.
```

We get some rounding error because we used `round()` after summing originally.

# Two lessons

Check your tables!

# Two lessons

## Check your tables!

Pipelines feed their content forward, so you need to make sure your results are not incorrect.

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Often, complex tables and graphs can be disturbingly plausible even when wrong.

# Two lessons

## Check your tables!

Pipelines feed their content forward, so you need to make sure your results are not incorrect.

Often, complex tables and graphs can be disturbingly plausible even when wrong.

So, figure out what the result should be and test it!

# Two lessons

## Check your tables!

Pipelines feed their content forward, so you need to make sure your results are not incorrect.

Often, complex tables and graphs can be disturbingly plausible even when wrong.

So, figure out what the result should be and test it!

Starting with simple or toy cases can help with this process.

# Two lessons

**Inspect your pipes!**

# Two lessons

## Inspect your pipes!

Understand pipelines by running them forward or peeling them back a step at a time.

# Two lessons

## Inspect your pipes!

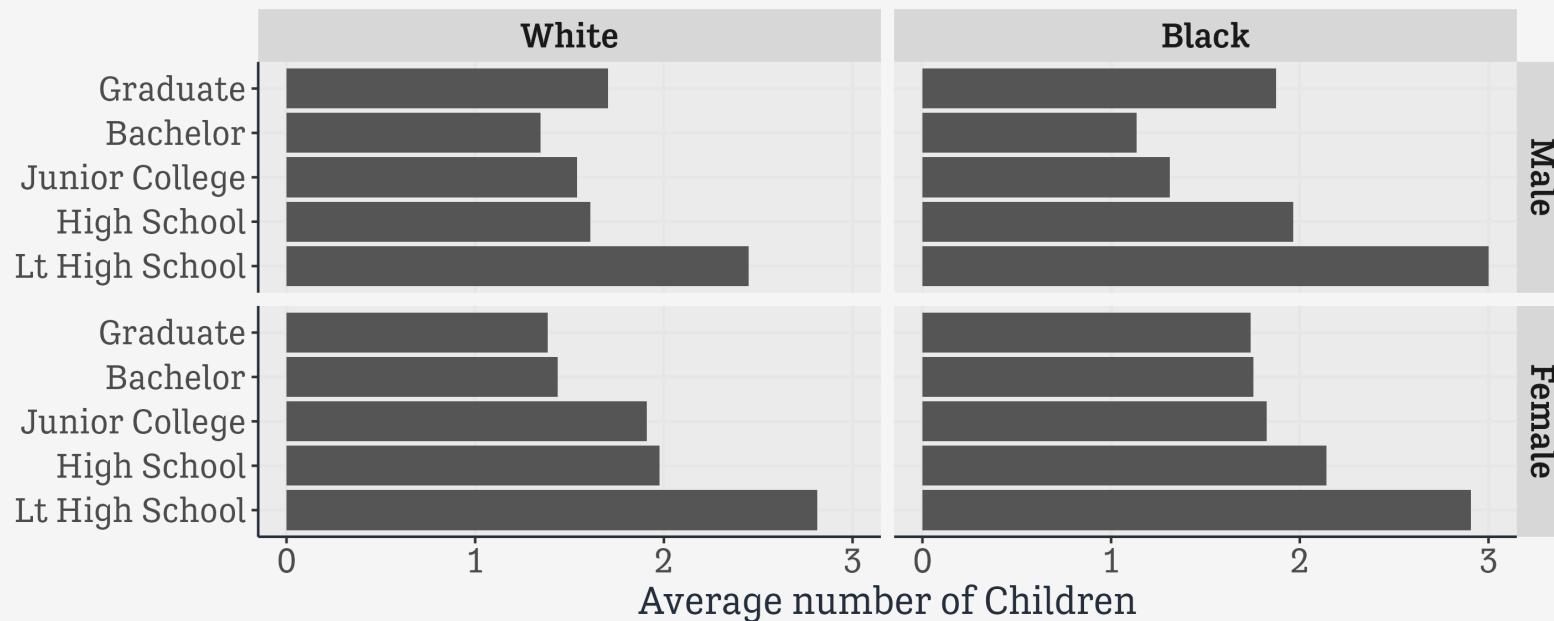
Understand pipelines by running them forward or peeling them back a step at a time.

This is a *very* effective way to understand your own and other people's code.

# Another example

# Following a pipeline

```
gss_sm %>
  group_by(race, sex, degree) %>
  summarize(n = n(),
            mean_age = mean(age, na.rm = TRUE),
            mean_kids = mean(childs, na.rm = TRUE)) %>
  mutate(pct = n/sum(n)*100) %>
  filter(race != "Other") %>
  drop_na() %>
  ggplot(mapping = aes(x = mean_kids, y = degree)) + # Some ggplot ...
  geom_col() + facet_grid(sex ~ race) +
  labs(x = "Average number of Children", y = NULL)
```



# Following a pipeline

gss\_sm

```
# A tibble: 2,867 × 32
  year   id ballot      age childs sibs degree race   sex   region income16
  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct> <fct>
1 2016    1 1           47     3 2  Bach... White Male New E.. $170000...
2 2016    2 2           61     0 3  High ... White Male New E.. $50000 ...
3 2016    3 3           72     2 3  Bach... White Male New E.. $75000 ...
4 2016    4 1           43     4 3  High ... White Fema... New E.. $170000...
5 2016    5 3           55     2 2  Gradu... White Fema... New E.. $170000...
6 2016    6 2           53     2 2  Junio... White Fema... New E.. $60000 ...
7 2016    7 1           50     2 2  High ... White Male New E.. $170000...
8 2016    8 3           23     3 6  High ... Other Fema... Middl... $30000 ...
9 2016    9 1           45     3 5  High ... Black Male Middl... $60000 ...
10 2016   10 3          71     4 1  Junio... White Male Middl... $60000 ...
# i 2,857 more rows
# i 21 more variables: relig <fct>, marital <fct>, padeg <fct>, madeg <fct>,
#   partyid <fct>, polviews <fct>, happy <fct>, partners <fct>, grass <fct>,
#   zodiac <fct>, pres12 <labelled>, wtssall <dbl>, income_rc <fct>,
#   agegrp <fct>, agedq <fct>, siblings <fct>, kids <fct>, religion <fct>,
#   bigregion <fct>, partners_rc <fct>, obama <dbl>
```

# Following a pipeline

```
gss_sm ▷  
group_by(race, sex, degree)
```

```
# A tibble: 2,867 × 32  
# Groups:   race, sex, degree [34]  
  year    id ballot      age child� sibs  degree race  sex  region income16  
  <dbl> <dbl> <labelled> <dbl> <dbl> <labe> <fct> <fct> <fct> <fct> <fct>  
1 2016     1 1           47     3 2  Bach... White Male New E... $170000...  
2 2016     2 2           61     0 3  High ... White Male New E... $50000 ...  
3 2016     3 3           72     2 3  Bach... White Male New E... $75000 ...  
4 2016     4 1           43     4 3  High ... White Fema... New E... $170000...  
5 2016     5 3           55     2 2  Gradu... White Fema... New E... $170000...  
6 2016     6 2           53     2 2  Junio... White Fema... New E... $60000 ...  
7 2016     7 1           50     2 2  High ... White Male New E... $170000...  
8 2016     8 3           23     3 6  High ... Other Fema... Middl... $30000 ...  
9 2016     9 1           45     3 5  High ... Black Male Middl... $60000 ...  
10 2016    10 3          71     4 1  Junio... White Male Middl... $60000 ...  
# i 2,857 more rows  
# i 21 more variables: relig <fct>, marital <fct>, padeg <fct>, madeg <fct>,  
#   partyid <fct>, polviews <fct>, happy <fct>, partners <fct>, grass <fct>,  
#   zodiac <fct>, pres12 <labelled>, wtssall <dbl>, income_rc <fct>,  
#   agegrp <fct>, ageq <fct>, siblings <fct>, kids <fct>, religion <fct>,  
#   bigregion <fct>, partners_rc <fct>, obama <dbl>
```

# Following a pipeline

```
gss_sm %>  
  group_by(race, sex, degree) %>  
  summarize(n = n(),  
            mean_age = mean(age, na.rm = TRUE),  
            mean_kids = mean(childs, na.rm = TRUE))
```

```
# A tibble: 34 × 6  
# Groups:   race, sex [6]  
  race   sex     degree       n  mean_age  mean_kids  
  <fct> <fct>   <fct>   <int>    <dbl>    <dbl>  
1 White  Male   Lt High School  96    52.9    2.45  
2 White  Male   High School   470    48.8    1.61  
3 White  Male   Junior College 65    47.1    1.54  
4 White  Male   Bachelor    208    48.6    1.35  
5 White  Male   Graduate    112    56.0    1.71  
6 White  Female Lt High School 101    55.4    2.81  
7 White  Female High School  587    51.9    1.98  
8 White  Female Junior College 101    48.2    1.91  
9 White  Female Bachelor   218    49.2    1.44  
10 White Female Graduate   138    53.6    1.38  
# i 24 more rows
```

# Following a pipeline

```
gss_sm %>
  group_by(race, sex, degree) %>
  summarize(n = n(),
            mean_age = mean(age, na.rm = TRUE),
            mean_kids = mean(childs, na.rm = TRUE)) %>
  mutate(pct = n/sum(n)*100)

# A tibble: 34 × 7
# Groups:   race, sex [6]
  race   sex     degree       n  mean_age mean_kids    pct
  <fct> <fct>   <fct>   <int>     <dbl>     <dbl>    <dbl>
1 White  Male   Lt High School 96      52.9      2.45 10.1
2 White  Male   High School   470     48.8      1.61 49.4
3 White  Male   Junior College 65      47.1      1.54  6.83
4 White  Male   Bachelor     208     48.6      1.35 21.9
5 White  Male   Graduate     112     56.0      1.71 11.8
6 White  Female Lt High School 101     55.4      2.81  8.79
7 White  Female High School  587     51.9      1.98 51.1
8 White  Female Junior College 101     48.2      1.91  8.79
9 White  Female Bachelor    218     49.2      1.44 19.0
10 White Female Graduate    138     53.6      1.38 12.0
# i 24 more rows
```

# Following a pipeline

```
gss_sm %>
  group_by(race, sex, degree) %>
  summarize(n = n(),
            mean_age = mean(age, na.rm = TRUE),
            mean_kids = mean(childs, na.rm = TRUE)) %>
  mutate(pct = n/sum(n)*100) %>
  filter(race != "Other")
```

# A tibble: 23 × 7  
# Groups: race, sex [4]  
 race sex degree n mean\_age mean\_kids pct  
 <fct> <fct> <fct> <int> <dbl> <dbl> <dbl>  
1 White Male Lt High School 96 52.9 2.45 10.1  
2 White Male High School 470 48.8 1.61 49.4  
3 White Male Junior College 65 47.1 1.54 6.83  
4 White Male Bachelor 208 48.6 1.35 21.9  
5 White Male Graduate 112 56.0 1.71 11.8  
6 White Female Lt High School 101 55.4 2.81 8.79  
7 White Female High School 587 51.9 1.98 51.1  
8 White Female Junior College 101 48.2 1.91 8.79  
9 White Female Bachelor 218 49.2 1.44 19.0  
10 White Female Graduate 138 53.6 1.38 12.0  
# i 13 more rows

# Following a pipeline

```
gss_sm %>
  group_by(race, sex, degree) %>
  summarize(n = n(),
            mean_age = mean(age, na.rm = TRUE),
            mean_kids = mean(childs, na.rm = TRUE)) %>
  mutate(pct = n/sum(n)*100) %>
  filter(race != "Other") %>
  drop_na()

# A tibble: 20 × 7
# Groups:   race, sex [4]
  race   sex     degree       n  mean_age mean_kids    pct
  <fct> <fct>   <fct> <int>     <dbl>     <dbl> <dbl>
  1 White  Male   Lt High School 96      52.9      2.45 10.1
  2 White  Male   High School   470     48.8      1.61 49.4
  3 White  Male   Junior College 65      47.1      1.54  6.83
  4 White  Male   Bachelor     208     48.6      1.35 21.9
  5 White  Male   Graduate     112     56.0      1.71 11.8
  6 White  Female Lt High School 101     55.4      2.81  8.79
  7 White  Female High School  587     51.9      1.98 51.1
  8 White  Female Junior College 101     48.2      1.91  8.79
  9 White  Female Bachelor    218     49.2      1.44 19.0
 10 White Female Graduate    138     53.6      1.38 12.0
 11 Black  Male   Lt High School 17      56.1      3     8.21
 12 Black  Male   High School   142     43.6      1.96 68.6
 13 Black  Male   Junior College 16      47.1      1.31  7.73
 14 Black  Male   Bachelor     22      41.6      1.14 10.6
 15 Black  Male   Graduate     8       53.1      1.88  3.86
 16 Black  Female Lt High School 43      51.0      2.91 15.2
 17 Black  Female High School  150     43.1      2.14 53.0
 18 Black  Female Junior College 17      45.8      1.82  6.01
 19 Black  Female Bachelor    49      47.0      1.76 17.3
 20 Black  Female Graduate    23      51.2      1.74  8.13
```

# Following a pipeline

```
gss_sm %>  
  group_by(race, sex, degree) %>  
  summarize(n = n(),  
            mean_age = mean(age, na.rm = TRUE),  
            mean_kids = mean(childs, na.rm = TRUE)) %>  
  mutate(pct = n/sum(n)*100) %>  
  filter(race != "Other") %>  
  drop_na() %>  
  summarize(grp_totpct = sum(pct))
```

```
# A tibble: 4 × 3  
# Groups:   race [2]  
  race   sex    grp_totpct  
  <fct> <fct>     <dbl>  
1 White  Male      100  
2 White  Female    99.7  
3 Black  Male      99.0  
4 Black  Female    99.6
```

# Conditional selection

# Conditionals in `select()` & `filter()`

Some new data, this time on national rates of cadaveric organ donation:

```
# library(socviz)
organdata

# A tibble: 238 × 21
  country   year     donors    pop  pop_dens    gdp  gdp_lag health health_lag
  <chr>     <date>   <dbl>   <int>    <dbl>   <int>   <dbl>    <dbl>    <dbl>
1 Australia NA      17065 0.220 16774 16591 1300    1224
2 Australia 1991-01-01 12.1 17284 0.223 17171 16774 1379    1300
3 Australia 1992-01-01 12.4 17495 0.226 17914 17171 1455    1379
4 Australia 1993-01-01 12.5 17667 0.228 18883 17914 1540    1455
5 Australia 1994-01-01 10.2 17855 0.231 19849 18883 1626    1540
6 Australia 1995-01-01 10.2 18072 0.233 21079 19849 1737    1626
7 Australia 1996-01-01 10.6 18311 0.237 21923 21079 1846    1737
8 Australia 1997-01-01 10.3 18518 0.239 22961 21923 1948    1846
9 Australia 1998-01-01 10.5 18711 0.242 24148 22961 2077    1948
10 Australia 1999-01-01 8.67 18926 0.244 25445 24148 2231    2077
# i 228 more rows
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

# Conditionals in `select()` & `filter()`

```
organdata %>  
  filter(consent_law == "Informed" & donors > 15)  
  
# A tibble: 30 × 21  
#>   country     year    donors    pop  pop_dens    gdp  gdp_lag  health  health_lag  
#>   <chr>     <date>   <dbl>  <int>    <dbl>  <int>    <dbl>      <dbl>  
#> 1 Canada 2000-01-01  15.3 30770  0.309  28472  26658    2541     2400  
#> 2 Denmark 1992-01-01 16.1  5171  12.0   19644  19126    1660     1603  
#> 3 Ireland 1991-01-01 19.0  3534  5.03   13495  12917    884      791  
#> 4 Ireland 1992-01-01 19.5  3558  5.06   14241  13495    1005     884  
#> 5 Ireland 1993-01-01 17.1  3576  5.09   14927  14241    1041     1005  
#> 6 Ireland 1994-01-01 20.3  3590  5.11   15990  14927    1119     1041  
#> 7 Ireland 1995-01-01 24.6  3609  5.14   17789  15990    1208     1119  
#> 8 Ireland 1996-01-01 16.8  3636  5.17   19245  17789    1269     1208  
#> 9 Ireland 1997-01-01 20.9  3673  5.23   22017  19245    1417     1269  
#> 10 Ireland 1998-01-01 23.8  3715  5.29   23995  22017    1487     1417  
#> # i 20 more rows  
#> # i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,  
#> # assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,  
#> # consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

# Conditionals in `select()` & `filter()`

```
organdata >
  select(country, year, where(is.integer))

# A tibble: 238 × 8
  country     year   pop    gdp  gdp_lag cerebvas assault external
  <chr>      <date> <int>  <int>   <int>    <int>    <int>
1 Australia NA        17065 16774  16591     682      21     444
2 Australia 1991-01-01 17284 17171  16774     647      19     425
3 Australia 1992-01-01 17495 17914  17171     630      17     406
4 Australia 1993-01-01 17667 18883  17914     611      18     376
5 Australia 1994-01-01 17855 19849  18883     631      17     387
6 Australia 1995-01-01 18072 21079  19849     592      16     371
7 Australia 1996-01-01 18311 21923  21079     576      17     395
8 Australia 1997-01-01 18518 22961  21923     525      17     385
9 Australia 1998-01-01 18711 24148  22961     516      16     410
10 Australia 1999-01-01 18926 25445  24148     493      15     409
# i 228 more rows
```

Use `where()` to test columns.

# Conditionals in `select()` & `filter()`

When telling `where()` to use `is.integer()` to test each column, we don't put parentheses at the end of its name. If we did, R would try to evaluate `is.integer()` right then, and fail:

```
> orgadata >
+   select(country, year, where(is.integer()))
Error: 0 arguments passed to 'is.integer' which requires 1
Run `rlang::last_error()` to see where the error occurred.
```

This is true in similar situations elsewhere as well.

# Conditionals in `select()` & `filter()`

```
organdata >  
  select(country, year, where(is.character))  
  
# A tibble: 238 × 8  
  country    year   world opt  consent_law consent_practice consistent ccode  
  <chr>     <date> <chr> <chr> <chr>           <chr>           <chr>       <chr>  
1 Austral... NA     Libe... In   Informed   Informed      Yes        Oz  
2 Austral... 1991-01-01 Libe... In   Informed   Informed      Yes        Oz  
3 Austral... 1992-01-01 Libe... In   Informed   Informed      Yes        Oz  
4 Austral... 1993-01-01 Libe... In   Informed   Informed      Yes        Oz  
5 Austral... 1994-01-01 Libe... In   Informed   Informed      Yes        Oz  
6 Austral... 1995-01-01 Libe... In   Informed   Informed      Yes        Oz  
7 Austral... 1996-01-01 Libe... In   Informed   Informed      Yes        Oz  
8 Austral... 1997-01-01 Libe... In   Informed   Informed      Yes        Oz  
9 Austral... 1998-01-01 Libe... In   Informed   Informed      Yes        Oz  
10 Austral... 1999-01-01 Libe... In  Informed   Informed      Yes        Oz  
# i 228 more rows
```

We have functions like e.g. `is.character()`, `is.numeric()`, `is.logical()`, `is.factor()`, etc. All return either `TRUE` or `FALSE`.

# Conditionals in `select()` & `filter()`

Sometimes we don't pass a function, but do want to use the result of one:

```
organdata %>  
  select(country, year, starts_with("gdp"))  
  
# A tibble: 238 × 4  
  country     year     gdp gdp_lag  
  <chr>     <date>   <int>   <int>  
1 Australia NA        16774   16591  
2 Australia 1991-01-01 17171   16774  
3 Australia 1992-01-01 17914   17171  
4 Australia 1993-01-01 18883   17914  
5 Australia 1994-01-01 19849   18883  
6 Australia 1995-01-01 21079   19849  
7 Australia 1996-01-01 21923   21079  
8 Australia 1997-01-01 22961   21923  
9 Australia 1998-01-01 24148   22961  
10 Australia 1999-01-01 25445   24148  
# i 228 more rows
```

We have `starts_with()`, `ends_with()`, `contains()`, `matches()`, and `num_range()`. Collectively these are “tidy selectors”.

# Conditionals in `select()` & `filter()`

```
organdata %>  
  filter(country == "Australia" | country == "Canada")  
  
# A tibble: 28 × 21  
  country     year    donors    pop  pop_dens    gdp  gdp_lag health health_lag  
  <chr>       <date>   <dbl>   <int>    <dbl>   <int>   <dbl>    <dbl>  
1 Australia  NA        NA    17065    0.220  16774  16591    1300     1224  
2 Australia 1991-01-01 12.1    17284    0.223  17171  16774    1379     1300  
3 Australia 1992-01-01 12.4    17495    0.226  17914  17171    1455     1379  
4 Australia 1993-01-01 12.5    17667    0.228  18883  17914    1540     1455  
5 Australia 1994-01-01 10.2    17855    0.231  19849  18883    1626     1540  
6 Australia 1995-01-01 10.2    18072    0.233  21079  19849    1737     1626  
7 Australia 1996-01-01 10.6    18311    0.237  21923  21079    1846     1737  
8 Australia 1997-01-01 10.3    18518    0.239  22961  21923    1948     1846  
9 Australia 1998-01-01 10.5    18711    0.242  24148  22961    2077     1948  
10 Australia 1999-01-01 8.67   18926    0.244  25445  24148    2231     2077  
# i 18 more rows  
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,  
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,  
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

This could get cumbersome fast.

# Use %in% for multiple selections

```
my_countries ← c("Australia", "Canada", "United States", "Ireland")

organdata ▷
  filter(country %in% my_countries)

# A tibble: 56 × 21
  country     year    donors    pop  pop_dens    gdp  gdp_lag health health_lag
  <chr>      <date>   <dbl>   <int>    <dbl>   <int>   <dbl>    <dbl>
1 Australia  NA        17065  0.220  16774  16591  1300    1224
2 Australia  1991-01-01 12.1    17284  0.223  17171  16774  1379    1300
3 Australia  1992-01-01 12.4    17495  0.226  17914  17171  1455    1379
4 Australia  1993-01-01 12.5    17667  0.228  18883  17914  1540    1455
5 Australia  1994-01-01 10.2    17855  0.231  19849  18883  1626    1540
6 Australia  1995-01-01 10.2    18072  0.233  21079  19849  1737    1626
7 Australia  1996-01-01 10.6    18311  0.237  21923  21079  1846    1737
8 Australia  1997-01-01 10.3    18518  0.239  22961  21923  1948    1846
9 Australia  1998-01-01 10.5    18711  0.242  24148  22961  2077    1948
10 Australia 1999-01-01  8.67   18926  0.244  25445  24148  2231   2077
# i 46 more rows
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

# Negating %in%

```
my_countries ← c("Australia", "Canada", "United States", "Ireland")

organdata ▷
  filter(!(country %in% my_countries))

# A tibble: 182 × 21
  country year      donors    pop  pop_dens     gdp  gdp_lag health health_lag
  <chr>   <date>    <dbl> <int>    <dbl> <int>    <dbl>    <dbl>
1 Austria NA        7678     9.16 18914    17425    1344     1255
2 Austria 1991-01-01 27.6  7755     9.25 19860    18914    1419     1344
3 Austria 1992-01-01 23.1  7841     9.35 20601    19860    1551     1419
4 Austria 1993-01-01 26.2  7906     9.43 21119    20601    1674     1551
5 Austria 1994-01-01 21.4  7936     9.46 21940    21119    1739     1674
6 Austria 1995-01-01 21.5  7948     9.48 22817    21940    1865     1739
7 Austria 1996-01-01 24.7  7959     9.49 23798    22817    1986     1865
8 Austria 1997-01-01 19.5  7968     9.50 24364    23798    1848     1986
9 Austria 1998-01-01 20.7  7977     9.51 25423    24364    1953     1848
10 Austria 1999-01-01 25.9  7992     9.53 26513    25423    2069     1953
# i 172 more rows
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

Also a bit awkward. There's no built-in "Not in" operator. (Soon there will be!)

# A custom operator

```
`%nin%` ← Negate(`%in%`) # this operator is included in the socviz package

organdata %>
  filter(country %nin% my_countries)

# A tibble: 182 × 21
  country year      donors    pop  pop_dens     gdp gdp_lag health health_lag
  <chr>   <date>    <dbl> <int>    <dbl> <int>    <dbl>    <dbl>
1 Austria NA        NA    7678     9.16 18914  17425    1344    1255
2 Austria 1991-01-01 27.6  7755     9.25 19860  18914    1419    1344
3 Austria 1992-01-01 23.1  7841     9.35 20601  19860    1551    1419
4 Austria 1993-01-01 26.2  7906     9.43 21119  20601    1674    1551
5 Austria 1994-01-01 21.4  7936     9.46 21940  21119    1739    1674
6 Austria 1995-01-01 21.5  7948     9.48 22817  21940    1865    1739
7 Austria 1996-01-01 24.7  7959     9.49 23798  22817    1986    1865
8 Austria 1997-01-01 19.5  7968     9.50 24364  23798    1848    1986
9 Austria 1998-01-01 20.7  7977     9.51 25423  24364    1953    1848
10 Austria 1999-01-01 25.9  7992     9.53 26513  25423    2069    1953
# i 172 more rows
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

The backticks are special here because we need to name an operator.

# Using across()

# Do more than one thing

Earlier we saw this:

```
gss_sm %>
  group_by(race, sex, degree) %>
  summarize(n = n(),
            mean_age = mean(age, na.rm = TRUE),
            mean_kids = mean(childs, na.rm = TRUE))

# A tibble: 34 × 6
# Groups:   race, sex [6]
  race   sex   degree       n  mean_age  mean_kids
  <fct> <fct> <fct>     <int>    <dbl>      <dbl>
1 White  Male  Lt High School  96    52.9       2.45
2 White  Male  High School    470    48.8       1.61
3 White  Male  Junior College 65    47.1       1.54
4 White  Male  Bachelor       208    48.6       1.35
5 White  Male  Graduate       112    56.0       1.71
6 White  Female Lt High School 101    55.4       2.81
7 White  Female High School   587    51.9       1.98
8 White  Female Junior College 101    48.2       1.91
9 White  Female Bachelor      218    49.2       1.44
10 White Female Graduate      138    53.6       1.38
# i 24 more rows
```

# Do more than one thing

Similarly for `organdata` we might want to do:

```
organdata %>
  group_by(consent_law, country) %>
  summarize(donors_mean = mean(donors, na.rm = TRUE),
            donors_sd = sd(donors, na.rm = TRUE),
            gdp_mean = mean(gdp, na.rm = TRUE),
            health_mean = mean(health, na.rm = TRUE),
            roads_mean = mean(roads, na.rm = TRUE))

# A tibble: 17 × 7
# Groups:   consent_law [2]
  consent_law country     donors_mean  donors_sd  gdp_mean  health_mean  roads_mean
  <chr>       <chr>        <dbl>      <dbl>      <dbl>      <dbl>      <dbl>
1 Informed    Australia     10.6       1.14     22179.     1958.      105.
2 Informed    Canada       14.0       0.751     23711.     2272.      109.
3 Informed    Denmark      13.1       1.47     23722.     2054.      102.
4 Informed    Germany      13.0       0.611     22163.     2349.      113.
5 Informed    Ireland      19.8       2.48     20824.     1480.      118.
6 Informed    Netherlands   13.7       1.55     23013.     1993.      76.1 
7 Informed    United Kin...  13.5       0.775     21359.     1561.      67.9 
8 Informed    United Sta...  20.0       1.33     29212.     3988.      155.
9 Presumed    Austria      23.5       2.42     23876.     1875.      150.
10 Presumed   Belgium      21.9       1.94     22500.     1958.      155.
11 Presumed   Finland      18.4       1.53     21019.     1615.      93.6 
12 Presumed   France       16.8       1.60     22603.     2160.      156.
13 Presumed   Italy        11.1       4.28     21554.     1757.      122.
14 Presumed   Norway      15.4       1.11     26448.     2217.      70.0 
15 Presumed   Spain        28.1       4.96     16933.     1289.      161.
```

# Use `across()`

Instead, use `across()` to apply a function to more than one column.

```
my_vars ← c("gdp", "donors", "roads")

## nested parens again, but it's worth it
organdata %>
  group_by(consent_law, country) %>
  summarize(across(all_of(my_vars),
                  list(avg = \((x) mean(x, na.rm = TRUE)))
                  )
  )
```

```
# A tibble: 17 × 5
# Groups:   consent_law [2]
  consent_law country      gdp_avg donors_avg roads_avg
  <chr>       <chr>      <dbl>     <dbl>     <dbl>
1 Informed    Australia    22179.    10.6     105.
2 Informed    Canada      23711.    14.0     109.
3 Informed    Denmark     23722.    13.1     102.
4 Informed    Germany     22163.    13.0     113.
5 Informed    Ireland     20824.    19.8     118.
6 Informed    Netherlands  23013.    13.7     76.1
7 Informed    United Kingdom 21359.    13.5     67.9
8 Informed    United States 29212.    20.0     155.
9 Presumed    Austria     23876.    23.5     150.
10 Presumed   Belgium     22500.    21.9     155.
11 Presumed   Finland     21019.    18.4     93.6
12 Presumed   France      22603.    16.8     156.
13 Presumed   Italy       21554.    11.1     122.
14 Presumed   Norway      26448.    15.4     70.0
15 Presumed   Spain       16833.    28.1     161.
```

# Let's look at that again

```
my_vars ← c("gdp", "donors", "roads")
```

# Let's look at that again

```
my_vars ← c("gdp", "donors", "roads")
## nested parens again, but it's worth it
organdata
```

```
# A tibble: 238 × 21
  country     year    donors    pop  pop_dens    gdp gdp_lag health health_lag
  <chr>      <date>   <dbl>   <int>    <dbl> <int>   <dbl>    <dbl>
1 Australia NA        NA  17065  0.220 16774 16591  1300  1224
2 Australia 1991-01-01 12.1 17284  0.223 17171 16774  1379  1300
3 Australia 1992-01-01 12.4 17495  0.226 17914 17171  1455  1379
4 Australia 1993-01-01 12.5 17667  0.228 18883 17914  1540  1455
5 Australia 1994-01-01 10.2 17855  0.231 19849 18883  1626  1540
6 Australia 1995-01-01 10.2 18072  0.233 21079 19849  1737  1626
7 Australia 1996-01-01 10.6 18311  0.237 21923 21079  1846  1737
8 Australia 1997-01-01 10.3 18518  0.239 22961 21923  1948  1846
9 Australia 1998-01-01 10.5 18711  0.242 24148 22961  2077  1948
10 Australia 1999-01-01 8.67 18926  0.244 25445 24148  2231  2077
# i 228 more rows
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

# Let's look at that again

```
my_vars ← c("gdp", "donors", "roads")
## nested parens again, but it's worth it
organdata >
  group_by(consent_law, country)
```

```
# A tibble: 238 × 21
# Groups:   consent_law, country [17]
  country     year    donors    pop  pop_dens    gdp gdp_lag health health_lag
  <chr>     <date>    <dbl>  <int>    <dbl> <int>  <int>    <dbl>    <dbl>
1 Australia  NA        NA    17065    0.220 16774  16591   1300    1224
2 Australia 1991-01-01 12.1   17284    0.223 17171  16774   1379    1300
3 Australia 1992-01-01 12.4   17495    0.226 17914  17171   1455    1379
4 Australia 1993-01-01 12.5   17667    0.228 18883  17914   1540    1455
5 Australia 1994-01-01 10.2   17855    0.231 19849  18883   1626    1540
6 Australia 1995-01-01 10.2   18072    0.233 21079  19849   1737    1626
7 Australia 1996-01-01 10.6   18311    0.237 21923  21079   1846    1737
8 Australia 1997-01-01 10.3   18518    0.239 22961  21923   1948    1846
9 Australia 1998-01-01 10.5   18711    0.242 24148  22961   2077    1948
10 Australia 1999-01-01 8.67   18926    0.244 25445  24148   2231   2077
# i 228 more rows
# i 12 more variables: pubhealth <dbl>, roads <dbl>, cerebvas <int>,
# assault <int>, external <int>, txp_pop <dbl>, world <chr>, opt <chr>,
# consent_law <chr>, consent_practice <chr>, consistent <chr>, ccode <chr>
```

# Let's look at that again

```
my_vars ← c("gdp", "donors", "roads")
## nested parens again, but it's worth it
organdata %>
  group_by(consent_law, country) %>
  summarize(across(all_of(my_vars),
    list(avg = \((x) mean(x, na.rm = TRUE)
  )
)
```

# A tibble: 17 × 5  
# Groups: consent\_law [2]  
 consent\_law country gdp\_avg donors\_avg roads\_avg  
 <chr> <chr> <dbl> <dbl> <dbl>  
1 Informed Australia 22179. 10.6 105.  
2 Informed Canada 23711. 14.0 109.  
3 Informed Denmark 23722. 13.1 102.  
4 Informed Germany 22163. 13.0 113.  
5 Informed Ireland 20824. 19.8 118.  
6 Informed Netherlands 23013. 13.7 76.1  
7 Informed United Kingdom 21359. 13.5 67.9  
8 Informed United States 29212. 20.0 155.  
9 Presumed Austria 23876. 23.5 150.  
10 Presumed Belgium 22500. 21.9 155.  
11 Presumed Finland 21019. 18.4 93.6  
12 Presumed France 22603. 16.8 156.  
13 Presumed Italy 21554. 11.1 122.  
14 Presumed Norway 26448. 15.4 70.0  
15 Presumed Spain 16933. 28.1 161.  
16 Presumed Sweden 22415. 13.1 72.3  
17 Presumed Switzerland 27233. 14.2 96.4

# Let's look at that again

```
my_vars ← c("gdp", "donors", "roads")  
  
## nested parens again, but it's worth it  
organdata %>  
  group_by(consent_law, country) %>  
  summarize(across(all_of(my_vars),  
    list(avg = \`(x) mean(x, na.rm = TRUE)  
  ))  
)
```

# A tibble: 17 × 5  
# Groups: consent\_law [2]  
 consent\_law country gdp\_avg donors\_avg roads\_avg  
 <chr> <chr> <dbl> <dbl> <dbl>  
1 Informed Australia 22179. 10.6 105.  
2 Informed Canada 23711. 14.0 109.  
3 Informed Denmark 23722. 13.1 102.  
4 Informed Germany 22163. 13.0 113.  
5 Informed Ireland 20824. 19.8 118.  
6 Informed Netherlands 23013. 13.7 76.1  
7 Informed United Kingdom 21359. 13.5 67.9  
8 Informed United States 29212. 20.0 155.  
9 Presumed Austria 23876. 23.5 150.  
10 Presumed Belgium 22500. 21.9 155.  
11 Presumed Finland 21019. 18.4 93.6  
12 Presumed France 22603. 16.8 156.  
13 Presumed Italy 21554. 11.1 122.  
14 Presumed Norway 26448. 15.4 70.0  
15 Presumed Spain 16933. 28.1 161.  
16 Presumed Sweden 22415. 13.1 72.3  
17 Presumed Switzerland 27233. 14.2 96.4

my\_vars are selected by **across()**

# Let's look at that again

consent_law	country	gdp_avg	donors_avg	roads_avg
1 Informed	Australia	22179.	10.6	105.
2 Informed	Canada	23711.	14.0	109.
3 Informed	Denmark	23722.	13.1	102.
4 Informed	Germany	22163.	13.0	113.
5 Informed	Ireland	20824.	19.8	118.
6 Informed	Netherlands	23013.	13.7	76.1
7 Informed	United Kingdom	21359.	13.5	67.9
8 Informed	United States	29212.	20.0	155.
9 Presumed	Austria	23876.	23.5	150.
10 Presumed	Belgium	22500.	21.9	155.
11 Presumed	Finland	21019.	18.4	93.6
12 Presumed	France	22603.	16.8	156.
13 Presumed	Italy	21554.	11.1	122.
14 Presumed	Norway	26448.	15.4	70.0
15 Presumed	Spain	16933	28.1	161.
16 Presumed	Sweden	22415.	13.1	72.3
17 Presumed	Switzerland	27233	14.2	96.4

my\_vars are selected by across()

We use all\_of() or any\_of() to be explicit

# Let's look at that again

```
my_vars ← c("gdp", "donors", "roads")  
  
## nested parens again, but it's worth it  
organdata %>  
  group_by(consent_law, country) %>  
  summarize(across(all_of(my_vars),  
    list(avg = \((x) mean(x, na.rm = TRUE)  
  ))  
)
```

	consent_law	country	gdp_avg	donors_avg	roads_avg
1	Informed	Australia	22179.	10.6	105.
2	Informed	Canada	23711.	14.0	109.
3	Informed	Denmark	23722.	13.1	102.
4	Informed	Germany	22163.	13.0	113.
5	Informed	Ireland	20824.	19.8	118.
6	Informed	Netherlands	23013.	13.7	76.1
7	Informed	United Kingdom	21359.	13.5	67.9
8	Informed	United States	29212.	20.0	155.
9	Presumed	Austria	23876.	23.5	150.
10	Presumed	Belgium	22500.	21.9	155.
11	Presumed	Finland	21019.	18.4	93.6
12	Presumed	France	22603.	16.8	156.
13	Presumed	Italy	21554.	11.1	122.
14	Presumed	Norway	26448.	15.4	70.0
15	Presumed	Spain	16933	28.1	161.
16	Presumed	Sweden	22415.	13.1	72.3
17	Presumed	Switzerland	27233	14.2	96.4

my\_vars are selected by across()

We use all\_of() or any\_of() to be explicit

list() of the form result = function gives the new columns that will be calculated.

# Let's look at that again

```
my_vars <- c("gdp", "donors", "roads")  
  
## nested parens again, but it's worth it  
organdata %>  
  group_by(consent_law, country) %>  
  summarize(across(all_of(my_vars),  
    list(avg = \`(x) mean(x, na.rm = TRUE)  
  ))  
)
```

	consent_law	country	gdp_avg	donors_avg	roads_avg
1	Informed	Australia	22179.	10.6	105.
2	Informed	Canada	23711.	14.0	109.
3	Informed	Denmark	23722.	13.1	102.
4	Informed	Germany	22163.	13.0	113.
5	Informed	Ireland	20824.	19.8	118.
6	Informed	Netherlands	23013.	13.7	76.1
7	Informed	United Kingdom	21359.	13.5	67.9
8	Informed	United States	29212.	20.0	155.
9	Presumed	Austria	23876.	23.5	150.
10	Presumed	Belgium	22500.	21.9	155.
11	Presumed	Finland	21019.	18.4	93.6
12	Presumed	France	22603.	16.8	156.
13	Presumed	Italy	21554.	11.1	122.
14	Presumed	Norway	26448.	15.4	70.0
15	Presumed	Spain	16933	28.1	161.
16	Presumed	Sweden	22415.	13.1	72.3
17	Presumed	Switzerland	27233	14.2	96.4

my\_vars are selected by across()

We use all\_of() or any\_of() to be explicit

list() of the form result = function gives the new columns that will be calculated.

The thing inside the list is an *anonymous function* with the “waving person”

# We can calculate more than one thing

```
my_vars ← c("gdp", "donors", "roads")

organdata ▷
  group_by(consent_law, country) ▷
  summarize(across(all_of(my_vars),
    list(avg = \`(x) mean(x, na.rm = TRUE),
        sd = \`(x) var(x, na.rm = TRUE),
        md = \`(x) median(x, na.rm = TRUE)))
  )
)

# A tibble: 17 × 11
# Groups:   consent_law [2]
  consent_law country      gdp_avg gdp_sd gdp_md donors_avg donors_sd donors_md
  <chr>       <chr>      <dbl>   <dbl>   <int>     <dbl>     <dbl>     <dbl>
1 Informed    Australia    22179.  1.57e7  21923     10.6     1.31     10.4
2 Informed    Canada      23711.  1.57e7  22764     14.0     0.564    14.0
3 Informed    Denmark     23722.  1.52e7  23548     13.1     2.16     12.9
4 Informed    Germany     22163.  6.26e6  22164     13.0     0.374    13
5 Informed    Ireland     20824.  4.45e7  19245     19.8     6.14     19.2
6 Informed    Netherlands  23013.  1.42e7  22541     13.7     2.41     13.8
7 Informed    United King... 21359.  1.54e7  20839     13.5     0.601    13.5
8 Informed    United Stat... 29212.  2.09e7  28772     20.0     1.76     20.1
9 Presumed    Austria     23876.  1.12e7  23798     23.5     5.84     23.8
10 Presumed   Belgium     22500.  1.01e7  22152     21.9     3.75     21.4
11 Presumed   Finland     21019.  1.35e7  19842     18.4     2.33     19.4
12 Presumed   France      22603.  1.06e7  21990     16.8     2.55     16.6
13 Presumed   Italy       21554.  7.74e6  21396     11.1     18.3     11.3
14 Presumed   Norway      26448.  4.21e7  26218     15.4     1.23     15.4
15 Presumed   Spain       16933.  8.34e6  16416     28.1     24.6     28
```

# It's OK to use the function names

```
my_vars ← c("gdp", "donors", "roads")

organdata ▷
  group_by(consent_law, country) ▷
  summarize(across(all_of(my_vars),
    list(mean = \((x) mean(x, na.rm = TRUE),
        var = \((x) var(x, na.rm = TRUE),
        median = \((x) median(x, na.rm = TRUE)))
  )
)

# A tibble: 17 × 11
# Groups:   consent_law [2]
  consent_law country      gdp_mean gdp_var gdp_median donors_mean donors_var
  <chr>       <chr>       <dbl>     <dbl>      <int>      <dbl>      <dbl>
1 Informed    Australia    22179.  1.57e7    21923      10.6      1.31
2 Informed    Canada      23711.  1.57e7    22764      14.0      0.564
3 Informed    Denmark     23722.  1.52e7    23548      13.1      2.16
4 Informed    Germany     22163.  6.26e6    22164      13.0      0.374
5 Informed    Ireland     20824.  4.45e7    19245      19.8      6.14
6 Informed    Netherlands  23013.  1.42e7    22541      13.7      2.41
7 Informed    United Kingdom 21359.  1.54e7    20839      13.5      0.601
8 Informed    United States 29212.  2.09e7    28772      20.0      1.76
9 Presumed    Austria     23876.  1.12e7    23798      23.5      5.84
10 Presumed   Belgium     22500.  1.01e7    22152      21.9      3.75
11 Presumed   Finland     21019.  1.35e7    19842      18.4      2.33
12 Presumed   France      22603.  1.06e7    21990      16.8      2.55
13 Presumed   Italy       21554.  7.74e6    21396      11.1      18.3
14 Presumed   Norway      26448.  4.21e7    26218      15.4      1.23
15 Presumed   Spain       16933  8.34e6    16416      28.1      24.6
```

# Selection with `across(where())`

```
organdata %>
  group_by(consent_law, country) %>
  summarize(across(where(is.numeric),
    list(mean = \`(x) mean(x, na.rm = TRUE),
      var = \`(x) var(x, na.rm = TRUE),
      median = \`(x) median(x, na.rm = TRUE)))
  )
) %>
print(n = 3) # just to save slide space

# A tibble: 17 × 41
# Groups:   consent_law [2]
  consent_law country  donors_mean donors_var donors_median pop_mean  pop_var
  <chr>       <chr>        <dbl>      <dbl>        <dbl>     <dbl>      <dbl>
1 Informed    Australia     10.6       1.31       10.4     18318.   690385.
2 Informed    Canada       14.0       0.564      14.0     29608.  1422648.
3 Informed    Denmark      13.1       2.16       12.9     5257.    6497.
# i 14 more rows
# i 34 more variables: pop_median <int>, pop_dens_mean <dbl>,
#   pop_dens_var <dbl>, pop_dens_median <dbl>, gdp_mean <dbl>, gdp_var <dbl>,
#   gdp_median <int>, gdp_lag_mean <dbl>, gdp_lag_var <dbl>,
#   gdp_lag_median <dbl>, health_mean <dbl>, health_var <dbl>,
#   health_median <dbl>, health_lag_mean <dbl>, health_lag_var <dbl>,
#   health_lag_median <dbl>, pubhealth_mean <dbl>, pubhealth_var <dbl>, ...
```

# Name new columns with `.names`

```
organdata >
  group_by(consent_law, country) >
  summarize(across(where(is.numeric),
    list(mean = \`(x) mean(x, na.rm = TRUE),
     sd = \`(x) sd(x, na.rm = TRUE),
     median = \`(x) median(x, na.rm = TRUE)),
    .names = "{fn}_{col}"
  )
) >
print(n = 3)
```

```
# A tibble: 17 × 41
# Groups:   consent_law [2]
  consent_law country  mean_donors sd_donors median_donors mean_pop sd_pop
  <chr>      <chr>       <dbl>     <dbl>       <dbl>     <dbl>   <dbl>
1 Informed    Australia     10.6     1.14       10.4     18318.   831.
2 Informed    Canada       14.0     0.751      14.0     29608.   1193.
3 Informed    Denmark      13.1     1.47       12.9     5257.    80.6
# i 14 more rows
# i 34 more variables: median_pop <int>, mean_pop_dens <dbl>,
#   sd_pop_dens <dbl>, median_pop_dens <dbl>, mean_gdp <dbl>, sd_gdp <dbl>,
#   median_gdp <int>, mean_gdp_lag <dbl>, sd_gdp_lag <dbl>,
#   median_gdp_lag <dbl>, mean_health <dbl>, sd_health <dbl>,
#   median_health <dbl>, mean_health_lag <dbl>, sd_health_lag <dbl>,
#   median_health_lag <dbl>, mean_pubhealth <dbl>, sd_pubhealth <dbl>, ...
```

# Name new columns with `.names`

In tidyverse functions, arguments that begin with a “`.`” generally have it in order to avoid confusion with existing items, or are “pronouns” referring to e.g. “the name of the thing we’re currently talking about as we evaluate this function”.

# This all works with `mutate()`, too

```
organdata >
  mutate(across(where(is.character), toupper)) >
  select(where(is.character))

# A tibble: 238 × 7
  country   world   opt   consent_law consent_practice consistent ccode
  <chr>     <chr>  <chr> <chr>        <chr>          <chr>    <chr>
1 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
2 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
3 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
4 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
5 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
6 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
7 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
8 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
9 AUSTRALIA LIBERAL IN    INFORMED    INFORMED      YES      OZ
10 AUSTRALIA LIBERAL IN   INFORMED    INFORMED      YES      OZ
# i 228 more rows
```

# Arrange rows and columns

Sort rows with `arrange()`

```
organdata %>  
  group_by(consent_law, country) %>  
  summarize(donors = mean(donors, na.rm = TRUE)) %>  
  arrange(donors) %>  
  print(n = 5)
```

```
# A tibble: 17 × 3  
# Groups:   consent_law [2]  
  consent_law country   donors  
  <chr>      <chr>     <dbl>  
1 Informed    Australia  10.6  
2 Presumed    Italy      11.1  
3 Informed    Germany    13.0  
4 Informed    Denmark    13.1  
5 Presumed    Sweden     13.1  
# i 12 more rows
```

# Arrange rows and columns

## Sort rows with `arrange()`

```
organdata >  
  group_by(consent_law, country) >  
  summarize(donors = mean(donors, na.rm = TRUE)) >  
  arrange(donors) >  
  print(n = 5)
```

```
# A tibble: 17 × 3  
# Groups: consent_law [2]  
  consent_law country   donors  
  <chr>      <chr>     <dbl>  
1 Informed    Australia  10.6  
2 Presumed    Italy      11.1  
3 Informed    Germany    13.0  
4 Informed    Denmark    13.1  
5 Presumed    Sweden     13.1  
# i 12 more rows
```

```
organdata >  
  group_by(consent_law, country) >  
  summarize(donors = mean(donors, na.rm = TRUE)) >  
  arrange(desc(donors)) > ##<  
  print(n = 5)
```

```
# A tibble: 17 × 3  
# Groups: consent_law [2]  
  consent_law country       donors  
  <chr>      <chr>     <dbl>  
1 Presumed    Spain        28.1  
2 Presumed    Austria      23.5  
3 Presumed    Belgium      21.9  
4 Informed    United States 20.0  
5 Informed    Ireland      19.8  
# i 12 more rows
```

Using `arrange()` to order rows in this way won't respect groupings.

# More generally ...

```
organdata %>  
  group_by(consent_law, country) %>  
  summarize(donors = mean(donors, na.rm = TRUE)) %>  
  slice_max(donors, n = 5)  
  
# A tibble: 10 × 3  
# Groups:   consent_law [2]  
  consent_law country     donors  
  <chr>       <chr>      <dbl>  
1 Informed    United States  20.0  
2 Informed    Ireland      19.8  
3 Informed    Canada       14.0  
4 Informed    Netherlands  13.7  
5 Informed    United Kingdom 13.5  
6 Presumed    Spain        28.1  
7 Presumed    Austria      23.5  
8 Presumed    Belgium      21.9  
9 Presumed    Finland      18.4  
10 Presumed   France       16.8
```

You can see that `slice_max()` respects grouping.

There's `slice_min()`, `slice_head()`, `slice_tail()`, `slice_sample()`, and the most general one, `slice()`.