Manipulating Tables with dplyr

Data Wrangling: Session 3

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Statistical Horizons, December 2022

Time to play with some data

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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)
Loading tidyverse: ggplot2
Loading tidyverse: tibble
Loading tidyverse: tidyr
Loading tidyverse: readr
Loading tidyverse: purrr
Loading tidyverse: dplyr
```

Tidyverse components, again

```
library(tidyverse)
Loading tidyverse: ggplot2
Loading tidyverse: tibble
Loading tidyverse: tidyr
Loading tidyverse: readr
Loading tidyverse: purrr
Loading tidyverse: dplyr
```

Call the package and ...

<| **Draw graphs**
<| **Nicer data tables**
<| **Tidy your data**
<| **Get data into R**
<| **Fancy Iteration**
<| **Action verbs for tables**

Other tidyverse components

```
forcats
haven
lubridate
readxl
stringr
reprex
```

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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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.

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

`dplyr` draws on the logic and language of **database queries**, where the focus is on manipulating tables

Some actions to take on a single table

Some **actions** to take on a single table

Group the data at the level we want, such as "*Religion by Region*" or "*Children by School*".

Subset either the rows or columns of or table—i.e. remove them before doing anything.

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.

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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Group using `group_by()`.

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

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

General Social Survey data: gss_sm

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

```
## # A tibble: 2,867 × 32
##     year    id ballot   age childs sibs  degree race  sex   region incom…¹ relig
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <fct> <fct> <fct>  <fct>   <fct>
##  1  2016     1 1         47      3 2     Bache… White Male  New E… $17000… None
##  2  2016     2 2         61      0 3     High … White Male  New E… $50000… None
##  3  2016     3 3         72      2 3     Bache… White Male  New E… $75000… Cath…
##  4  2016     4 1         43      4 3     High … White Fema… New E… $17000… Cath…
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##  8  2016     8 3         23      3 6     High … Other Fema… Middl… $30000… Cath…
##  9  2016     9 1         45      3 5     High … Black Male  Middl… $60000… Prot…
## 10  2016    10 3         71      4 1     Junio… White Male  Middl… $60000… None
## # … with 2,857 more rows, 20 more variables: 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>, and
## #   abbreviated variable name ¹income16
```

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## # A tibble: 2,867 × 32
##     year    id ballot   age childs sibs  degree race  sex   region incom…¹ relig
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```

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

id	bigregion	religion
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

bigregion	religion	N
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

bigregion	religion	N	pct
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

```
## Just take a look at the columns we will work on
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
## # … with 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 childs sibs  degree race  sex   region incom…¹ relig
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <fct> <fct> <fct>  <fct>   <fct>
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Grouping just changes the logical structure of the tibble.

Group and summarize by *one* column

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gss_sm
```

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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 childs sibs  degree race  sex   region incom…
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <fct> <fct> <fct>  <fct>
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## #   religion <fct>, bigregion <fct>, partners_rc <fct>, obama <dbl>, and
## #   abbreviated variable name ¹income16
```

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 incom…
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <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 × 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
## 10 Midwest   None         157
## # … with 14 more rows
```

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```

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 childs sibs  degree race  sex   region incom…¹ r
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <fct> <fct> <fct>  <fct>   <
##  1  2016     1 1         47      3 2     Bache… White Male  New E… $17000… N
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gss_sm |>
  group_by(bigregion, religion) |>
  summarize(total = n())
```

```
## # A tibble: 24 × 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
## 10 Midwest   None         157
## # … with 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 × 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
## # … with 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 × 5
## # Groups:   bigregion [4]
##    bigregion religion   total    freq   pct
##    <fct>     <fct>      <int>   <dbl> <dbl>
##  1 Northeast Protestant   158 0.324    32.4
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## # … with 14 more rows
```

The function `n()` counts up the rows

Calculate frequencies

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

```
## # 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
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##  4 Northeast None         112 0.230    23
##  5 Northeast Other         28 0.0574    5.7
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##  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
## # … with 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 × 5
## # Groups:   bigregion [4]
##    bigregion religion   total    freq   pct
##    <fct>     <fct>      <int>   <dbl> <dbl>
##  1 Northeast Protestant   158 0.324    32.4
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## 10 Midwest   None         157 0.226    22.6
## # … with 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         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
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## 10 Midwest   None         157 0.226    22.6
## # … with 14 more rows
```

Groups are carried forward till summarized or explicitly ungrouped

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
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##  9 Midwest   Jewish         3 0.00432   0.4
## 10 Midwest   None         157 0.226    22.6
## # … with 14 more rows
```

Groups are carried forward till summarized or explicitly ungrouped

Summary calculations are done on the innermost group, which then "disappears". (Notice how it's no longer a group in the output.)

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
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##  8 Midwest   Catholic     172 0.247    24.7
##  9 Midwest   Jewish         3 0.00432   0.4
## 10 Midwest   None         157 0.226    22.6
## # … with 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
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##  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
## # … with 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

Do it yourself with `n()`

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

```
## # A tibble: 24 × 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
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##  9 Midwest   Jewish         3
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## # … with 14 more rows
```

Result is a grouped tibble.

Three options for counting up rows

Do it yourself with `n()`

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gss_sm |>
  group_by(bigregion, religion) |>
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## # A tibble: 24 × 3
## # Groups:   bigregion [4]
##    bigregion religion       n
##    <fct>     <fct>      <int>
##  1 Northeast Protestant   158
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##  6 Northeast <NA>           1
##  7 Midwest   Protestant   325
##  8 Midwest   Catholic     172
##  9 Midwest   Jewish         3
## 10 Midwest   None         157
## # … with 14 more rows
```

Result is a grouped tibble.

use `tally()`

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

```
## # A tibble: 24 × 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
## # … with 14 more rows
```

Group it yourself; result is grouped.

Three options for counting up rows

Do it yourself with `n()`

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

```
## # A tibble: 24 × 3
## # Groups:   bigregion [4]
##    bigregion religion       n
##    <fct>     <fct>      <int>
##  1 Northeast Protestant   158
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##  9 Midwest   Jewish         3
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## # … with 14 more rows
```

Result is a grouped tibble.

use `tally()`

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

```
## # A tibble: 24 × 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
## # … with 14 more rows
```

Group it yourself; result is grouped.

use `count()`

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

```
## # A tibble: 24 × 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
## # … with 14 more rows
```

One step; result is not grouped.

Pass your pipeline on to … a table

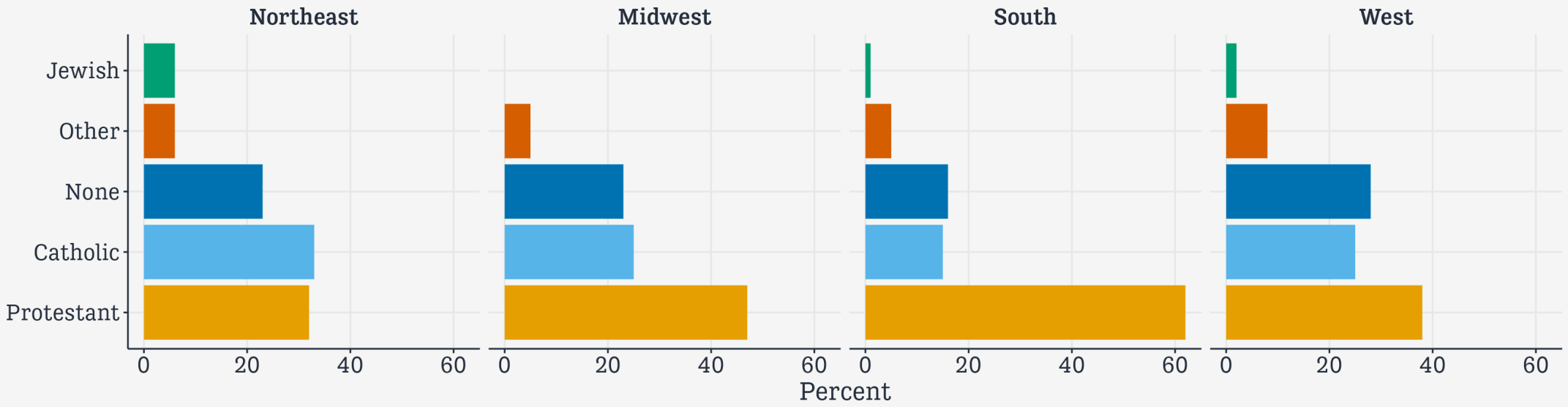
```
gss_sm |>
  count(bigregion, religion) |>
  pivot_wider(names_from = bigregion, values_from = n) |>
  knitr::kable()
```

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()` and `kable()` soon …

Pass your pipeline 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 your pipeline 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
## # … with 14 more rows
```

Pass your pipeline 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
## # … with 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
## # … with 14 more rows
```

Right assignmment 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 assignmment 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`"

Pipelined tables can be quickly checked

```
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
## # … with 14 more rows
```

Hm, did I sum over right group?

Pipelined tables can be quickly checked

```
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
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##  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
## # … with 14 more rows
```

Hm, did I sum over right group?

```
## 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?

Pipelined tables can be quickly checked

```
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.

Pipelined tables can be quickly checked

```
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!

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.

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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

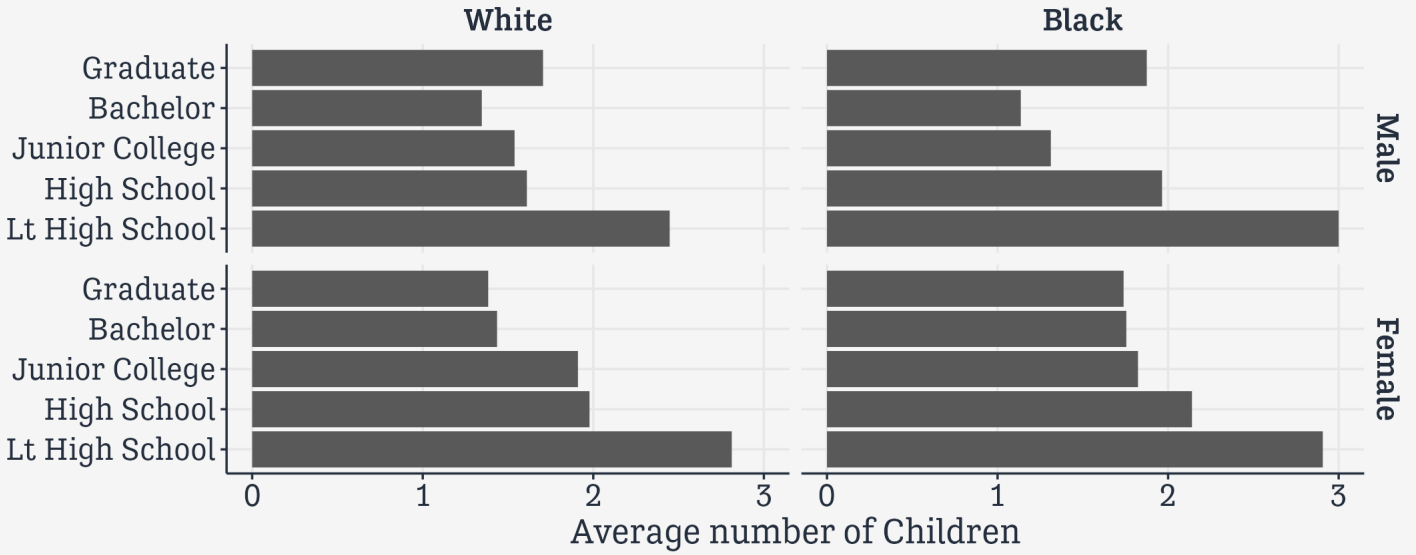
Inspect your pipes!

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.

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)) + # I'm sorry I can't talk more about the graphs
  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 incom…¹ r
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <fct> <fct> <fct>  <fct>   <
##  1  2016     1 1         47      3 2     Bache… White Male  New E… $17000… N
##  2  2016     2 2         61      0 3     High … White Male  New E… $50000… N
##  3  2016     3 3         72      2 3     Bache… White Male  New E… $75000… C
##  4  2016     4 1         43      4 3     High … White Fema… New E… $17000… C
##  5  2016     5 3         55      2 2     Gradu… White Fema… New E… $17000… N
##  6  2016     6 2         53      2 2     Junio… White Fema… New E… $60000… N
##  7  2016     7 1         50      2 2     High … White Male  New E… $17000… N
##  8  2016     8 3         23      3 6     High … Other Fema… Middl… $30000… C
##  9  2016     9 1         45      3 5     High … Black Male  Middl… $60000… F
## 10  2016    10 3         71      4 1     Junio… White Male  Middl… $60000… N
## # … with 2,857 more rows, 20 more variables: 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>, and
## #   abbreviated variable name ¹income16
```

Following a pipeline

```
gss_sm |>
  group_by(race, sex, degree)
```

```
## # A tibble: 2,867 × 32
## # Groups:   race, sex, degree [34]
##     year    id ballot   age childs sibs  degree race  sex   region incom…¹ r
##    <dbl> <dbl> <labe> <dbl>  <dbl> <lab> <fct>  <fct> <fct> <fct>  <fct>   <
##  1  2016     1 1         47      3 2     Bache… White Male  New E… $17000… N
##  2  2016     2 2         61      0 3     High … White Male  New E… $50000… N
##  3  2016     3 3         72      2 3     Bache… White Male  New E… $75000… C
##  4  2016     4 1         43      4 3     High … White Fema… New E… $17000… C
##  5  2016     5 3         55      2 2     Gradu… White Fema… New E… $17000… N
##  6  2016     6 2         53      2 2     Junio… White Fema… New E… $60000… N
##  7  2016     7 1         50      2 2     High … White Male  New E… $17000… N
##  8  2016     8 3         23      3 6     High … Other Fema… Middl… $30000… C
##  9  2016     9 1         45      3 5     High … Black Male  Middl… $60000… P
## 10  2016    10 3         71      4 1     Junio… White Male  Middl… $60000… N
## # … with 2,857 more rows, 20 more variables: 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>, and
## #   abbreviated variable name ¹income16
```

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
## # … with 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
## # … with 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
## # … with 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
```

Conditionals in `select()` and `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_d…¹   gdp gdp_lag health healt…² pubhe…³
##    <chr>    <date>      <dbl> <int>   <dbl> <int>   <int>  <dbl>   <dbl>   <dbl>
##  1 Austral… NA           NA    17065   0.220 16774   16591   1300    1224     4.8
##  2 Austral… 1991-01-01  12.1   17284   0.223 17171   16774   1379    1300     5.4
##  3 Austral… 1992-01-01  12.4   17495   0.226 17914   17171   1455    1379     5.4
##  4 Austral… 1993-01-01  12.5   17667   0.228 18883   17914   1540    1455     5.4
##  5 Austral… 1994-01-01  10.2   17855   0.231 19849   18883   1626    1540     5.4
##  6 Austral… 1995-01-01  10.2   18072   0.233 21079   19849   1737    1626     5.5
##  7 Austral… 1996-01-01  10.6   18311   0.237 21923   21079   1846    1737     5.6
##  8 Austral… 1997-01-01  10.3   18518   0.239 22961   21923   1948    1846     5.7
##  9 Austral… 1998-01-01  10.5   18711   0.242 24148   22961   2077    1948     5.9
## 10 Austral… 1999-01-01   8.67  18926   0.244 25445   24148   2231    2077     6.1
## # … with 228 more rows, 11 more variables: 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>,
## #   and abbreviated variable names ¹pop_dens, ²health_lag, ³pubhealth
```

Conditionals in `select()` and `filter()`

```
organdata |>
  filter(consent_law == "Informed" & donors > 15)
```

```
## # A tibble: 30 × 21
##    country year       donors   pop pop_dens   gdp gdp_lag health healt…¹ pubhe…²
##    <chr>   <date>      <dbl> <int>    <dbl> <int>   <int>  <dbl>   <dbl>   <dbl>
##  1 Canada  2000-01-01   15.3 30770    0.309 28472   26658   2541    2400     6.3
##  2 Denmark 1992-01-01   16.1  5171   12.0   19644   19126   1660    1603     7
##  3 Ireland 1991-01-01   19    3534    5.03  13495   12917    884     791     4.8
##  4 Ireland 1992-01-01   19.5  3558    5.06  14241   13495   1005     884     5
##  5 Ireland 1993-01-01   17.1  3576    5.09  14927   14241   1041    1005     5.1
##  6 Ireland 1994-01-01   20.3  3590    5.11  15990   14927   1119    1041     5
##  7 Ireland 1995-01-01   24.6  3609    5.14  17789   15990   1208    1119     4.9
##  8 Ireland 1996-01-01   16.8  3636    5.17  19245   17789   1269    1208     4.7
##  9 Ireland 1997-01-01   20.9  3673    5.23  22017   19245   1417    1269     4.8
## 10 Ireland 1998-01-01   23.8  3715    5.29  23995   22017   1487    1417     4.7
## # … with 20 more rows, 11 more variables: 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>,
## #   and abbreviated variable names ¹health_lag, ²pubhealth
```

Conditionals in `select()` and `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>    <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
## # … with 228 more rows
```

Use `where()` to test columns.

Conditionals in `select()` and `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:

```
> organdata |>
+   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()` and `filter()`

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

```
## # A tibble: 238 × 8
##    country   year       world   opt   consent_law consent_practice consi…¹ ccode
##    <chr>     <date>     <chr>   <chr> <chr>       <chr>             <chr>   <chr>
##  1 Australia NA         Liberal In    Informed    Informed          Yes     Oz
##  2 Australia 1991-01-01 Liberal In    Informed    Informed          Yes     Oz
##  3 Australia 1992-01-01 Liberal In    Informed    Informed          Yes     Oz
##  4 Australia 1993-01-01 Liberal In    Informed    Informed          Yes     Oz
##  5 Australia 1994-01-01 Liberal In    Informed    Informed          Yes     Oz
##  6 Australia 1995-01-01 Liberal In    Informed    Informed          Yes     Oz
##  7 Australia 1996-01-01 Liberal In    Informed    Informed          Yes     Oz
##  8 Australia 1997-01-01 Liberal In    Informed    Informed          Yes     Oz
##  9 Australia 1998-01-01 Liberal In    Informed    Informed          Yes     Oz
## 10 Australia 1999-01-01 Liberal In    Informed    Informed          Yes     Oz
## # … with 228 more rows, and abbreviated variable name ¹consistent
```

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

Conditionals in `select()` and `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
## # … with 228 more rows
```

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

Conditionals in `select()` and `filter()`

```
organdata |>
  filter(country == "Australia" | country == "Canada")
```

```
## # A tibble: 28 × 21
##    country  year       donors   pop pop_d…¹   gdp gdp_lag health healt…² pubhe…³
##    <chr>    <date>      <dbl> <int>   <dbl> <int>   <int>  <dbl>   <dbl>   <dbl>
##  1 Austral… NA           NA    17065   0.220 16774   16591   1300    1224     4.8
##  2 Austral… 1991-01-01  12.1   17284   0.223 17171   16774   1379    1300     5.4
##  3 Austral… 1992-01-01  12.4   17495   0.226 17914   17171   1455    1379     5.4
##  4 Austral… 1993-01-01  12.5   17667   0.228 18883   17914   1540    1455     5.4
##  5 Austral… 1994-01-01  10.2   17855   0.231 19849   18883   1626    1540     5.4
##  6 Austral… 1995-01-01  10.2   18072   0.233 21079   19849   1737    1626     5.5
##  7 Austral… 1996-01-01  10.6   18311   0.237 21923   21079   1846    1737     5.6
##  8 Austral… 1997-01-01  10.3   18518   0.239 22961   21923   1948    1846     5.7
##  9 Austral… 1998-01-01  10.5   18711   0.242 24148   22961   2077    1948     5.9
## 10 Austral… 1999-01-01   8.67  18926   0.244 25445   24148   2231    2077     6.1
## # … with 18 more rows, 11 more variables: 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>,
## #   and abbreviated variable names ¹pop_dens, ²health_lag, ³pubhealth
```

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_d…¹   gdp gdp_lag health healt…² pubhe…³
##    <chr>    <date>      <dbl> <int>   <dbl> <int>   <int>  <dbl>   <dbl>   <dbl>
##  1 Austral… NA           NA    17065   0.220 16774   16591   1300    1224     4.8
##  2 Austral… 1991-01-01  12.1   17284   0.223 17171   16774   1379    1300     5.4
##  3 Austral… 1992-01-01  12.4   17495   0.226 17914   17171   1455    1379     5.4
##  4 Austral… 1993-01-01  12.5   17667   0.228 18883   17914   1540    1455     5.4
##  5 Austral… 1994-01-01  10.2   17855   0.231 19849   18883   1626    1540     5.4
##  6 Austral… 1995-01-01  10.2   18072   0.233 21079   19849   1737    1626     5.5
##  7 Austral… 1996-01-01  10.6   18311   0.237 21923   21079   1846    1737     5.6
##  8 Austral… 1997-01-01  10.3   18518   0.239 22961   21923   1948    1846     5.7
##  9 Austral… 1998-01-01  10.5   18711   0.242 24148   22961   2077    1948     5.9
## 10 Austral… 1999-01-01   8.67  18926   0.244 25445   24148   2231    2077     6.1
## # … with 46 more rows, 11 more variables: 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>,
## #   and abbreviated variable names ¹pop_dens, ²health_lag, ³pubhealth
```

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 healt…¹ pubhe…²
##    <chr>   <date>      <dbl> <int>    <dbl> <int>   <int>  <dbl>   <dbl>   <dbl>
##  1 Austria NA           NA    7678     9.16 18914   17425   1344    1255     5.2
##  2 Austria 1991-01-01   27.6  7755     9.25 19860   18914   1419    1344     5.2
##  3 Austria 1992-01-01   23.1  7841     9.35 20601   19860   1551    1419     5.5
##  4 Austria 1993-01-01   26.2  7906     9.43 21119   20601   1674    1551     5.9
##  5 Austria 1994-01-01   21.4  7936     9.46 21940   21119   1739    1674     5.9
##  6 Austria 1995-01-01   21.5  7948     9.48 22817   21940   1865    1739     5.8
##  7 Austria 1996-01-01   24.7  7959     9.49 23798   22817   1986    1865     5.8
##  8 Austria 1997-01-01   19.5  7968     9.50 24364   23798   1848    1986     5.3
##  9 Austria 1998-01-01   20.7  7977     9.51 25423   24364   1953    1848     5.4
## 10 Austria 1999-01-01   25.9  7992     9.53 26513   25423   2069    1953     5.4
## # … with 172 more rows, 11 more variables: 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>,
## #   and abbreviated variable names ¹health_lag, ²pubhealth
```

Also a bit awkward. There's no built-in "Not in" operator.

Negating `%in%`

We can make one!

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

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

Negating %in%

We can make one!

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

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

```
organdata |>
  filter(country %nin% my_countries)
```

```
## # A tibble: 182 × 21
##    country year       donors   pop pop_dens   gdp gdp_lag health healt…¹ pubhe…²
##    <chr>   <date>      <dbl> <int>    <dbl> <int>   <int>  <dbl>   <dbl>   <dbl>
##  1 Austria NA           NA    7678     9.16 18914   17425   1344    1255     5.2
##  2 Austria 1991-01-01   27.6  7755     9.25 19860   18914   1419    1344     5.2
##  3 Austria 1992-01-01   23.1  7841     9.35 20601   19860   1551    1419     5.5
##  4 Austria 1993-01-01   26.2  7906     9.43 21119   20601   1674    1551     5.9
##  5 Austria 1994-01-01   21.4  7936     9.46 21940   21119   1739    1674     5.9
##  6 Austria 1995-01-01   21.5  7948     9.48 22817   21940   1865    1739     5.8
##  7 Austria 1996-01-01   24.7  7959     9.49 23798   22817   1986    1865     5.8
##  8 Austria 1997-01-01   19.5  7968     9.50 24364   23798   1848    1986     5.3
##  9 Austria 1998-01-01   20.7  7977     9.51 25423   24364   1953    1848     5.4
## 10 Austria 1999-01-01   25.9  7992     9.53 26513   25423   2069    1953     5.4
## # … with 172 more rows, 11 more variables: 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>,
## #   and abbreviated variable names ¹health_lag, ²pubhealth
```

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
## # … with 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…¹
##    <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 Kingdom        13.5     0.775   21359.       1561.    67.9
##  8 Informed    United States         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.
## 16 Presumed    Sweden                13.1     1.75    22415.       1951.    72.3
```

Do more than one thing with `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(my_vars,
                   list(avg = mean),
                   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.
```

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_d…¹   gdp gdp_lag health healt…² pub
##    <chr>    <date>      <dbl> <int>   <dbl> <int>   <int>  <dbl>   <dbl>   <
##  1 Austral… NA           NA    17065   0.220 16774   16591   1300    1224
##  2 Austral… 1991-01-01  12.1   17284   0.223 17171   16774   1379    1300
##  3 Austral… 1992-01-01  12.4   17495   0.226 17914   17171   1455    1379
##  4 Austral… 1993-01-01  12.5   17667   0.228 18883   17914   1540    1455
##  5 Austral… 1994-01-01  10.2   17855   0.231 19849   18883   1626    1540
##  6 Austral… 1995-01-01  10.2   18072   0.233 21079   19849   1737    1626
##  7 Austral… 1996-01-01  10.6   18311   0.237 21923   21079   1846    1737
##  8 Austral… 1997-01-01  10.3   18518   0.239 22961   21923   1948    1846
##  9 Austral… 1998-01-01  10.5   18711   0.242 24148   22961   2077    1948
## 10 Austral… 1999-01-01   8.67  18926   0.244 25445   24148   2231    2077
## # … with 228 more rows, 11 more variables: 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>
## #   and abbreviated variable names ¹pop_dens, ²health_lag, ³pubhealth
```

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_d…¹   gdp gdp_lag health healt…² pub
##    <chr>    <date>      <dbl> <int>   <dbl> <int>   <int>  <dbl>   <dbl>   <
##  1 Austral… NA           NA    17065   0.220 16774   16591   1300    1224
##  2 Austral… 1991-01-01  12.1   17284   0.223 17171   16774   1379    1300
##  3 Austral… 1992-01-01  12.4   17495   0.226 17914   17171   1455    1379
##  4 Austral… 1993-01-01  12.5   17667   0.228 18883   17914   1540    1455
##  5 Austral… 1994-01-01  10.2   17855   0.231 19849   18883   1626    1540
##  6 Austral… 1995-01-01  10.2   18072   0.233 21079   19849   1737    1626
##  7 Austral… 1996-01-01  10.6   18311   0.237 21923   21079   1846    1737
##  8 Austral… 1997-01-01  10.3   18518   0.239 22961   21923   1948    1846
##  9 Austral… 1998-01-01  10.5   18711   0.242 24148   22961   2077    1948
## 10 Austral… 1999-01-01   8.67  18926   0.244 25445   24148   2231    2077
## # … with 228 more rows, 11 more variables: 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>
## #   and abbreviated variable names ¹pop_dens, ²health_lag, ³pubhealth
```

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(my_vars,
                   list(avg = mean),
                   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

```
my_vars <- c("gdp", "donors", "roads")

## nested parens again, but it's worth it
organdata |>
  group_by(consent_law, country) |>
  summarize(across(my_vars,
                   list(avg = mean),
                   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()`**

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

`na.rm = TRUE` is passed through to the functions inside the `list()`

We can calculate more than one thing

```
my_vars <- c("gdp", "donors", "roads")

organdata |>
  group_by(consent_law, country) |>
  summarize(across(my_vars,
                   list(avg = mean,
                        sd = var,
                        md = median),
                   na.rm = TRUE))
```

```
## # A tibble: 17 × 11
## # Groups:   consent_law [2]
##    conse…¹ country gdp_avg gdp_sd gdp_md donor…² donor…³ donor…⁴ roads…⁵ roads…⁶
##    <chr>   <chr>     <dbl>  <dbl>  <int>   <dbl>   <dbl>   <dbl>   <dbl>   <dbl>
##  1 Inform… Austra…  22179. 1.57e7  21923    10.6   1.31     10.4   105.    205.
##  2 Inform… Canada   23711. 1.57e7  22764    14.0   0.564    14.0   109.    313.
##  3 Inform… Denmark  23722. 1.52e7  23548    13.1   2.16     12.9   102.    154.
##  4 Inform… Germany  22163. 6.26e6  22164    13.0   0.374    13     113.    671.
##  5 Inform… Ireland  20824. 4.45e7  19245    19.8   6.14     19.2   118.    116.
##  6 Inform… Nether…  23013. 1.42e7  22541    13.7   2.41     13.8    76.1    98.6
##  7 Inform… United…  21359. 1.54e7  20839    13.5   0.601    13.5    67.9   110.
##  8 Inform… United…  29212. 2.09e7  28772    20.0   1.76     20.1   155.     69.8
##  9 Presum… Austria  23876. 1.12e7  23798    23.5   5.84     23.8   150.    917.
## 10 Presum… Belgium  22500. 1.01e7  22152    21.9   3.75     21.4   155.    423.
## 11 Presum… Finland  21019. 1.35e7  19842    18.4   2.33     19.4    93.6   361.
## 12 Presum… France   22603. 1.06e7  21990    16.8   2.55     16.6   156.    403.
## 13 Presum… Italy    21554. 7.74e6  21396    11.1  18.3      11.3   122.    103.
## 14 Presum… Norway   26448. 4.21e7  26218    15.4   1.23     15.4    70.0    44.6
## 15 Presum… Spain    16933  8.34e6  16416    28.1  24.6      28     161.   1243.
## 16 Presum… Sweden   22415. 1.03e7  22029    13.1   3.07     12.7    72.3   175.
```

It's OK to use the function names

```
my_vars <- c("gdp", "donors", "roads")

organdata |>
  group_by(consent_law, country) |>
  summarize(across(my_vars,
                   list(mean = mean,
                        var = var,
                        median = median),
                   na.rm = TRUE))
```

```
## # A tibble: 17 × 11
## # Groups:   consent_law [2]
##    consent_law country   gdp_m…¹ gdp_var gdp_m…² donor…³ donor…⁴ donor…⁵ roads…⁶
##    <chr>       <chr>       <dbl>   <dbl>   <int>   <dbl>   <dbl>   <dbl>   <dbl>
##  1 Informed    Australia  22179.  1.57e7   21923    10.6   1.31     10.4   105.
##  2 Informed    Canada     23711.  1.57e7   22764    14.0   0.564    14.0   109.
##  3 Informed    Denmark    23722.  1.52e7   23548    13.1   2.16     12.9   102.
##  4 Informed    Germany    22163.  6.26e6   22164    13.0   0.374    13     113.
##  5 Informed    Ireland    20824.  4.45e7   19245    19.8   6.14     19.2   118.
##  6 Informed    Netherla…  23013.  1.42e7   22541    13.7   2.41     13.8    76.1
##  7 Informed    United K…  21359.  1.54e7   20839    13.5   0.601    13.5    67.9
##  8 Informed    United S…  29212.  2.09e7   28772    20.0   1.76     20.1   155.
##  9 Presumed    Austria    23876.  1.12e7   23798    23.5   5.84     23.8   150.
## 10 Presumed    Belgium    22500.  1.01e7   22152    21.9   3.75     21.4   155.
## 11 Presumed    Finland    21019.  1.35e7   19842    18.4   2.33     19.4    93.6
## 12 Presumed    France     22603.  1.06e7   21990    16.8   2.55     16.6   156.
## 13 Presumed    Italy      21554.  7.74e6   21396    11.1  18.3      11.3   122.
## 14 Presumed    Norway     26448.  4.21e7   26218    15.4   1.23     15.4    70.0
## 15 Presumed    Spain      16933   8.34e6   16416    28.1  24.6      28     161.
## 16 Presumed    Sweden     22415.  1.03e7   22029    13.1   3.07     12.7    72.3
```

Selection with `across(where())`

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

```
## # A tibble: 17 × 41
## # Groups:   consent_law [2]
##   consent_law country   donors…¹ donor…² donor…³ pop_m…⁴ pop_var pop_m…⁵ pop_d…⁶
##   <chr>       <chr>        <dbl>   <dbl>   <dbl>   <dbl>   <dbl>   <int>   <dbl>
## 1 Informed    Australia     10.6   1.31     10.4  18318.  6.90e5   18311   0.237
## 2 Informed    Canada        14.0   0.564    14.0  29608.  1.42e6   29672   0.297
## 3 Informed    Denmark       13.1   2.16     12.9   5257.  6.50e3    5263  12.2
## # … with 14 more rows, 32 more variables: 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>, pubhealth_median <dbl>,
## #   roads_mean <dbl>, roads_var <dbl>, roads_median <dbl>, …
```

Name new columns with `.names`

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

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".

```
## # A tibble: 17 × 41
## # Groups:   consent_law [2]
##   consent_law country   mean_d…¹ var_d…² media…³ mean_…⁴ var_pop media…⁵ mean_…⁶
##   <chr>       <chr>        <dbl>   <dbl>   <dbl>   <dbl>   <dbl>   <int>   <dbl>
## 1 Informed    Australia     10.6   1.31     10.4  18318.  6.90e5   18311   0.237
## 2 Informed    Canada        14.0   0.564    14.0  29608.  1.42e6   29672   0.297
## 3 Informed    Denmark       13.1   2.16     12.9   5257.  6.50e3    5263  12.2
## # … with 14 more rows, 32 more variables: var_pop_dens <dbl>,
## #   median_pop_dens <dbl>, mean_gdp <dbl>, var_gdp <dbl>, median_gdp <int>,
## #   mean_gdp_lag <dbl>, var_gdp_lag <dbl>, median_gdp_lag <dbl>,
## #   mean_health <dbl>, var_health <dbl>, median_health <dbl>,
## #   mean_health_lag <dbl>, var_health_lag <dbl>, median_health_lag <dbl>,
## #   mean_pubhealth <dbl>, var_pubhealth <dbl>, median_pubhealth <dbl>,
## #   mean_roads <dbl>, var_roads <dbl>, median_roads <dbl>, …
```

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
## # … with 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
## # … with 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
## # … with 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()`**.