R09: Summarizing data with `tidyverse`

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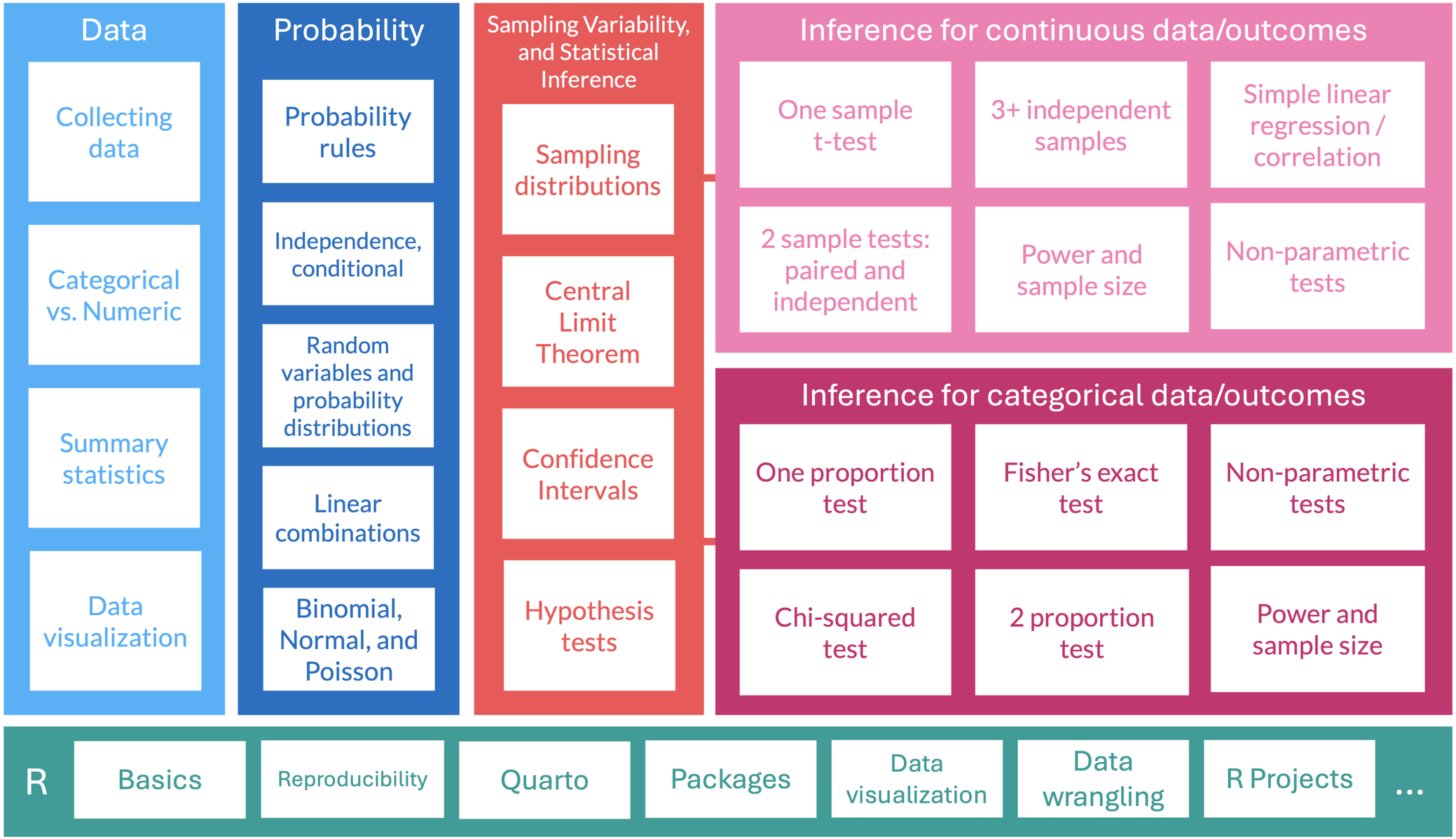
Where are we?

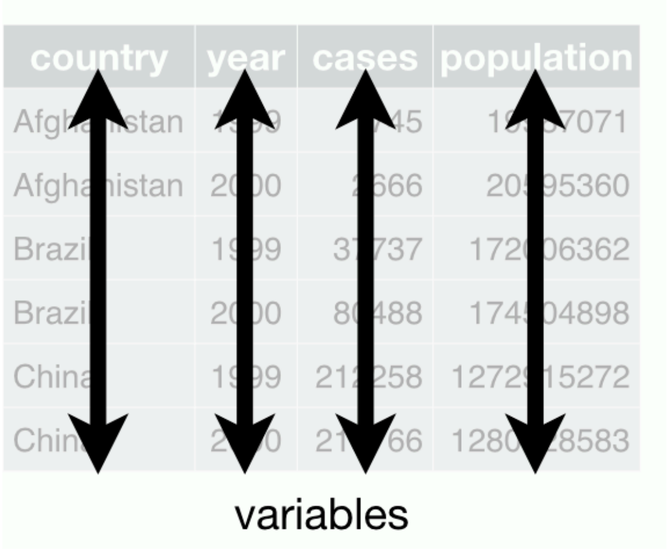

Data
Collecting data
Categorical vs. Numeric
Summary statistics
Data visualization
Probability
Probability rules
Independence, conditional
Random variables and probability distributions
Linear combinations
Binomial, Normal, and Poisson
Sampling Variability, and Statistical Inference
Sampling distributions
Central Limit Theorem
Confidence Intervals
Hypothesis tests
Inference for continuous data/outcomes
One sample t-test
3+ independent samples
Simple linear regression / correlation
2 sample tests: paired and independent
Power and sample size
Non-parametric tests
Inference for categorical data/outcomes
One proportion test
Fisher's exact test
Non-parametric tests
Chi-squared test
2 proportion test
Power and sample size
R
Basics
Reproducibility
Quarto
Packages
Data visualization
Data wrangling
R Projects
...

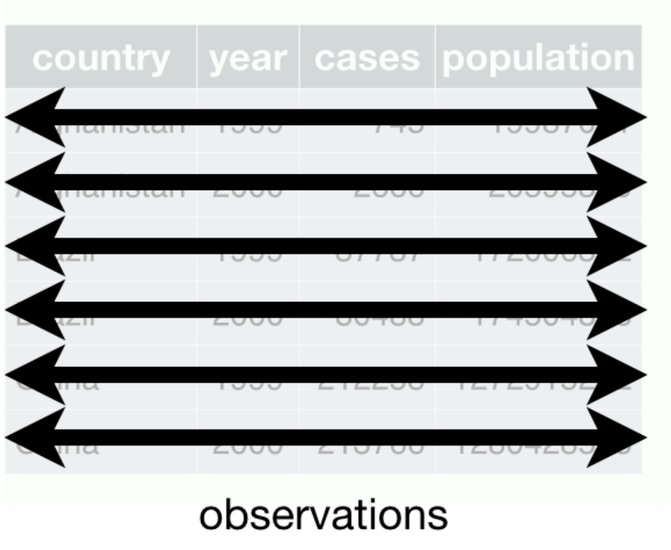
What is the tidyverse? (revisited)

The **tidyverse** is a collection of R packages designed for data science. All packages share an underlying design philosophy, grammar, and data structures.

- **ggplot2** - data visualisation
- **dplyr** - data manipulation
- **tidyr** - tidy data
- **readr** - read rectangular data
- **purrr** - functional programming
- **tibble** - modern data frames
- **stringr** - string manipulation
- **forcats** - factors
- and many more …

Tidy data[1]





1. Each variable must have its own column.
2. Each observation must have its own row.
3. Each value must have its own cell.

Pipe operator (`magrittr`)

- The pipe operator (`%>%`) allows us to step through sequential functions in the same way we follow if-then statements or steps from instructions

I want to find my keys, then start my car, then drive to work, then park my car.

Nested

```
park(drive(start_car(find("keys")),
           to = "work"))
```

Piped

```
find("keys") %>%
  start_car() %>%
  drive(to = "work") %>%
  park()
```

Using `summarize()`

`group_by()`: group by one or more variables

- What if I want to quickly look at group differences?
- It will not change how the data look, but changes the actions of following functions

I want to group my data by sex assigned at birth.

```
1 dds.discr5 = dds.discr2 %>%
2   group_by(SAB)
3 glimpse(dds.discr5)
```

```
Rows: 1,000
Columns: 7
Groups: SAB [2]
$ id           <int> 10210, 10409, 10486, 10538, 10568, 10690, 10711, 10778, 1…
$ age.cohort   <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17, 13-…
$ age          <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ SAB          <fct> Female, Male, Male, Female, Male, Female, Female, Male, F…
$ expenditures <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021, 28…
$ R_E          <fct> White not Hispanic, White not Hispanic, Hispanic, Hispani…
$ exp_to_age   <dbl> 124.2941, 1133.0811, 484.6667, 336.8421, 339.3846, 304.40…
```

- Let's see how the groups change something like the `summarize()` function in the next slide

`summarize()`: summarize your data or grouped data into one row

- What if I want to calculate specific descriptive statistics for my variables?
- This function is often best used with `group_by()`
- If only presenting the summaries, functions like `tbl_summary()` is better
- `summarize()` creates a new data frame, which means you can plot and manipulate the summarized data

Over whole sample:

```
dds.discr2 %>%
  summarize(
    ave = mean(expenditures),
    SD = sd(expenditures),
    med = median(expenditures))
```

```
# A tibble: 1 × 3
     ave     SD   med
   <dbl>  <dbl> <dbl>
1 18066. 19543.  7026
```

Grouped by sex assigned at birth:

```
dds.discr2 %>%
  group_by(SAB) %>%
  summarize(
    ave = mean(expenditures),
    SD = sd(expenditures),
    med = median(expenditures))
```

```
# A tibble: 2 × 4
  SAB       ave     SD   med
  <fct>   <dbl>  <dbl> <int>
1 Female 18130. 20020.  6400
2 Male   18001. 19068.  7219
```

Using `get_summary_stats()`

get_summary_stats() from rstatix package

```
dds.discr2 %>% get_summary_stats()
```

```
# A tibble: 4 × 13
  variable      n    min   max median      q1      q3    iqr    mad    mean      sd
  <fct>     <dbl>  <dbl> <dbl>  <dbl>   <dbl>   <dbl>  <dbl>  <dbl>   <dbl>   <dbl>
1 id         1000 1.02e4 99898 55384. 31809.  76135. 44326  3.27e4 54663.  25644.
2 age        1000 0          95    18     12      26     14  1.04e1    22.8    18.5
3 expendi…   1000 2.22e2 75098  7026   2899. 37713. 34814  7.76e3 18066.  19543.
4 exp_to_…   1000 2.76e1   Inf   462.    274.   938.   664. 3.54e2   Inf      NaN
# ℹ 2 more variables: se <dbl>, ci <dbl>
```

```
dds.discr2 %>%
  group_by(R_E) %>%
  get_summary_stats(expenditures, type = "common")
```

```
# A tibble: 8 × 11
  R_E       variable      n   min   max median    iqr   mean     sd     se     ci
  <fct>     <fct>     <dbl> <dbl> <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
1 American… expendi…     4  3726 58392 41818. 34085. 36438. 25694. 12847. 40885.
2 Asian     expendi…   129   374 75098  9369  30892  18392. 19209.  1691.  3346.
3 Black     expendi…    59   240 60808  8687  37987  20885. 20549.  2675.  5355.
4 Hispanic  expendi…   376   222 65581  3952   7961. 11066. 15630.   806.  1585.
5 Multi Ra… expendi…    26   669 38619  2622   2060.  4457.  7332.  1438.  2962.
6 Native H… expendi…     3 37479 50141 40727   6331  42782.  6576.  3797. 16337.
7 Other     expendi…     2  2018  4615  3316.  1298.  3316.  1836.  1298. 16499.
```

How to force all output to be shown? (1/2)

Use `kable()` from the `knitr` package.

```
1 dds.discr2 %>% get_summary_stats() %>% kable()
```

variable	n	min	max	median	q1	q3	iqr	mad
id	1000	10210.000	99898	55384.500	31808.750	76134.750	44326.000	32734.325
age	1000	0.000	95	18.000	12.000	26.000	14.000	10.378
expenditures	1000	222.000	75098	7026.000	2898.750	37712.750	34814.000	7760.670
exp_to_age	1000	27.571	Inf	461.752	273.881	938.125	664.244	353.971

How to force all output to be shown? `knitr` (2/2)

Use `kable()` from the `knitr` package.

```
1 dds.discr2 %>%
2   group_by(R_E) %>%
3   get_summary_stats(expenditures, type = "common") %>%
4   kable()
```

R_E	variable	n	min	max	median	iqr	mean	sd	s
American Indian	expenditures	4	3726	58392	41817.5	34085.25	36438.250	25693.912	12846.95
Asian	expenditures	129	374	75098	9369.0	30892.00	18392.372	19209.225	1691.27
Black	expenditures	59	240	60808	8687.0	37987.00	20884.593	20549.274	2675.28
Hispanic	expenditures	376	222	65581	3952.0	7961.25	11065.569	15629.847	806.04
Multi Race	expenditures	26	669	38619	2622.0	2059.75	4456.731	7332.135	1437.95
Native Hawaiian	expenditures	3	37479	50141	40727.0	6331.00	42782.333	6576.462	3796.92
Other	expenditures	2	2018	4615	3316.5	1298.50	3316.500	1836.356	1298.50

R_E	variable	n	min	max	median	iqr	mean	sd	s
White not Hispanic	expenditures	401	340	68890	15718.0	39157.00	24697.549	20604.376	1028.93

Making a Table 1

Table 1 example

- Often, research studies will show a table with all the summary statistics (lovingly called “Table 1”)
- Basic Table 1 will show all variables with:
  - Mean and SD for the numeric variables
  - $n(\%)$ for categorical variables

Are We on the Same Page?: A Cross-Sectional Study of Patient-Clinician Goal Concordance in Rheumatoid Arthritis
J Barton et al.
Arthritis Care & Research.
2021 Sep 27
https://pubmed.ncbi.nlm.nih.gov/34569172/

Table 1. Patient characteristics, overall and by concordance

		Total N=204	Discordant N=40	Concordant N=164	p-value
Site, n (%)	OHSU	122 (62.7%)	26 (65.0%)	96 (62.2%)	0.86
	VA	76 (37.3%)	14 (35.0%)	62 (37.8%)	
Gender, n (%)	Male	85 (41.7%)	18 (45.0%)	67 (40.9%)	0.72
	Female	119 (58.3%)	22 (55.0%)	97 (59.1%)	
Age (years), mean (SD)		57.2 (14.2)	58.2 (15.1)	56.9 (14.0)	0.62
Language, n (%)	English	168 (84.4%)	35 (92.1%)	133 (82.6%)	0.21
	Spanish	31 (15.6%)	3 (7.9%)	28 (17.4%)	
Limited English language proficiency, n (%)		30 (15.1%)	3 (7.9%)	27 (16.8%)	0.17
Coupled, n (%)		110 (57.9%)	22 (61.1%)	88 (57.1%)	0.71
Education, n (%)	High school or less	60 (31.6%)	15 (40.5%)	45 (29.4%)	0.24
	Some college or more	130 (68.4%)	22 (59.5%)	108 (70.6%)	
Income, >$40,000, n (%)	Less than $40,000	85 (45.5%)	12 (33.3%)	73 (48.3%)	0.14
	Greater than $40,000	102 (54.5%)	24 (66.7%)	78 (51.7%)	
People in household, median (IQR)		2 (2-4)	2 (2-3)	2 (2-4)	0.92
Race/Ethnicity, n (%)	White	123 (68.3%)	25 (78.1%)	98 (66.2%)	0.62
	Black	6 (3.3%)	0 (0.0%)	6 (4.1%)	
	Latinx/Hispanic	39 (21.7%)	6 (18.8%)	33 (22.3%)	
	Other	12 (6.7%)	1 (3.1%)	11 (7.4%)	
Limited health literacy, n (%)		55 (28.6%)	13 (35.1%)	42 (27.1%)	0.42
Disease duration (years), median (IQR)		8 (4-16)	13 (5-21)	7 (4-15)	0.039
Number of medications, median (IQR)		1 (1-2)	1 (0-2)	1 (1-2)	0.10
Depressive symptoms, n (%)		38 (20.8%)	3 (8.1%)	35 (24.0%)	0.040
PTSD, n (%)		13 (7.1%)	2 (5.6%)	11 (7.5%)	1.00
Self-efficacy score, mean (SD)		6.3 (2.1)	6.3 (2.1)	6.3 (2.1)	0.96
Trust in Physician, n (%)		106 (53.8%)	19 (51.4%)	87 (%)	0.74
Disease activity score (CDAI), mean (SD)		12.8 (10.5)	10.5 (9.7)	13.2 (10.8)	0.21
Medication Adherence, n (%)	High	63 (33.5%)	7 (20.6%)	56 (36.4%)	0.11
	Low/Medium	125 (66.5%)	27 (79.4%)	98 (63.6%)	

Abbreviations: IQR, interquartile range; PTSD, post-traumatic stress disorder; SD, standard deviation; OHSU, Oregon Health & Science University; VA, Veterans Affairs; CDAI, Clinical Disease Activity Index

`tbl_summary()` : table summary (1/2)

- What if I want one of those fancy summary tables that are at the top of most research articles?

```
1  library(gtsummary)
2  tbl_summary(dds.discr2)
```

Characteristic	N = 1,000[1]
id	55,385 (31,759, 76,205)
age.cohort	
0-5	82 (8.2%)
6-12	175 (18%)
13-17	212 (21%)
18-21	199 (20%)
22-50	226 (23%)
51+	106 (11%)
age	18 (12, 26)
SAB	
Female	503 (50%)
Male	497 (50%)
expenditures	7,026 (2,898, 37,718)
R_E	
American Indian	4 (0.4%)
Asian	129 (13%)
Black	59 (5.9%)
Hispanic	376 (38%)
Multi Race	26 (2.6%)
Native Hawaiian	3 (0.3%)
Other	2 (0.2%)
White not Hispanic	401 (40%)
exp_to_age	462 (273, 938)

[1] Median (Q1, Q3); n (%)

`tbl_summary()` : table summary (2/2)

- Let's make this more presentable

```
dds.discr2 %>%
  select(-id, -age.cohort, -exp_to_age) %>%
  tbl_summary(label = c(age ~ "Age",
                        R_E ~ "Race/Ethnicity",
                        SAB ~ "Sex Assigned at Birth",
                        expenditures ~ "Expenditures"),
              statistic = list(all_continuous() ~
                                 "{mean} ({sd})"))
```

Characteristic	**N = 1,000**[1]
Age	23 (18)
Sex Assigned at Birth	
Female	503 (50%)
Male	497 (50%)
Expenditures	18,066 (19,543)
Race/Ethnicity	
American Indian	4 (0.4%)
Asian	129 (13%)
Black	59 (5.9%)
Hispanic	376 (38%)
Multi Race	26 (2.6%)
Native Hawaiian	3 (0.3%)
Other	2 (0.2%)
White not Hispanic	401 (40%)

[1] Mean (SD); n (%)

Resources

`dplyr` resources

- More `dpylr` functions to reference!

Additional details and examples are available in the vignettes:

- column-wise operations vignette
- row-wise operations vignette

and the dplyr 1.0.0 release blog posts:

- working across columns
- working within rows

R programming class at OHSU!

You can check out Dr. Jessica Minnier's R class page if you want more notes, videos, etc.

The larger tidy ecosystem

Just to name a few…

- janitor
- kableExtra
- patchwork
- gghighlight
- tidybayes

Credit to Mine Çetinkaya-Rundel

- These notes were built from Mine's notes
  - Most pages and code were left as she made them
  - I changed a few things to match our class
- Please see her Github repository for the original notes