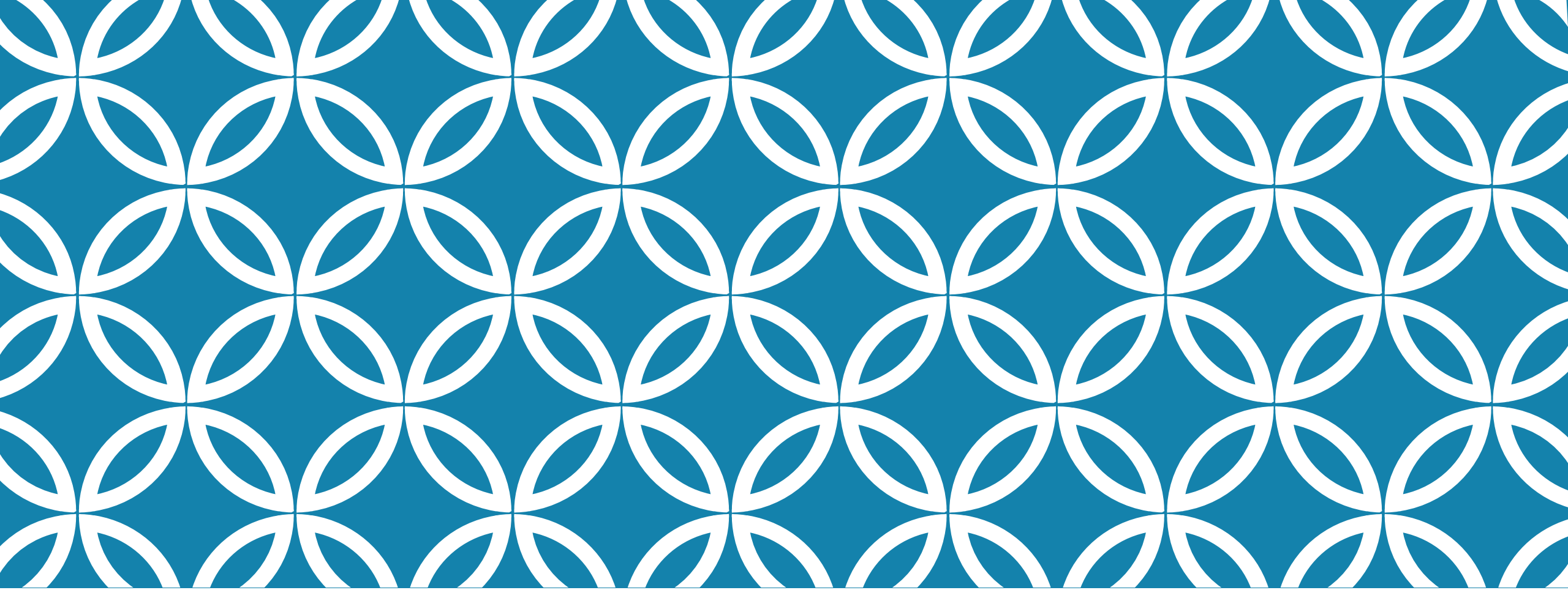


Grouping and Summarizing Data

Patrick Mathias

Lesson 6

DLMP Core

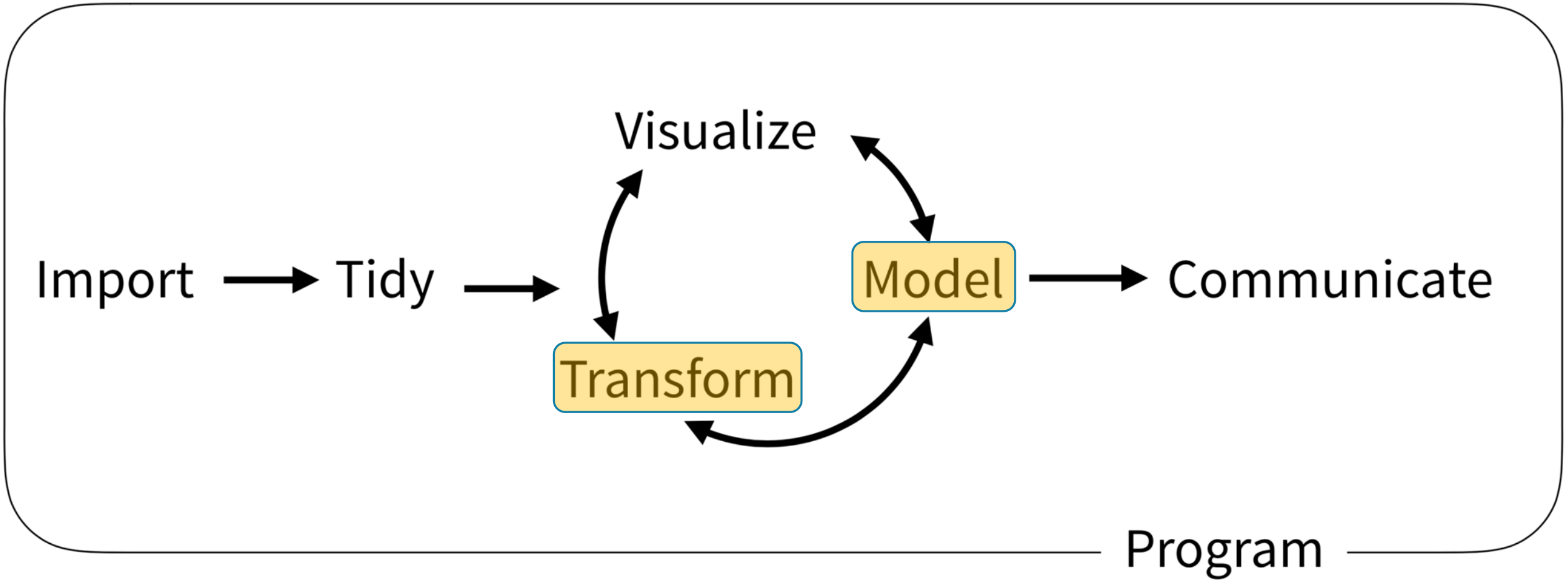
Goals

1. Learn dplyr tools for grouping and summarizing data in R

Objectives

1. Calculate a summary statistic for a variable using the summarize() function
2. Creates groupings of data using the group_by() function
3. Combine group_by() and summarize() functions to calculate summary statistics for groups of data

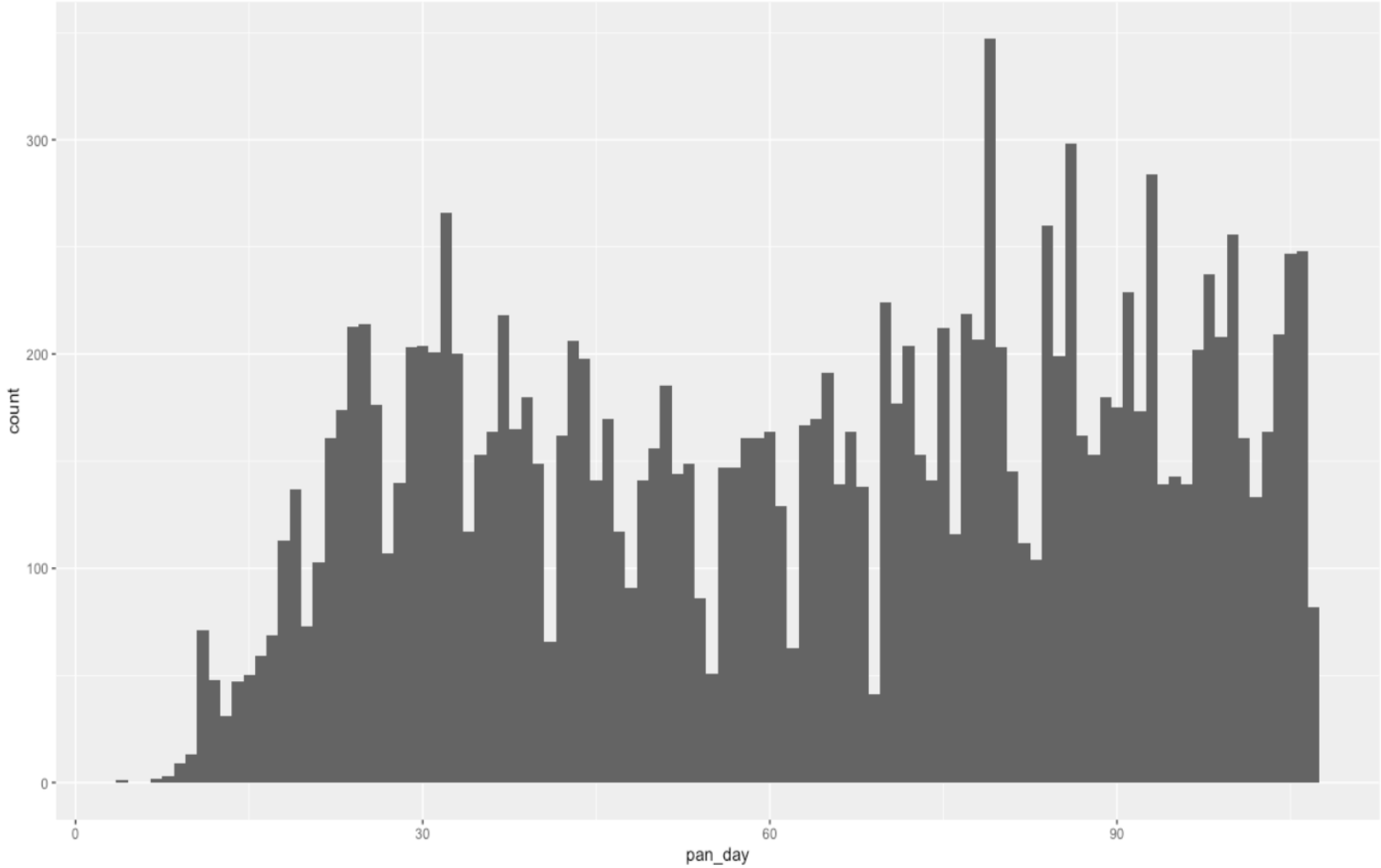
Typical Data Science Pipeline



From *R for Data Science* (https://r4ds.had.co.nz/introduction.html)

Summarize the data set

Q: How many tests are ordered per day?



summarize()

- Make summaries of your data

summarize()

- Make summaries of your data

```
covid_testing |>
    summarize(new_variable = calculation)
```

name for new variable

Value or function

Performs calculation across all rows of data frame

summarize()

- Make summaries of your data

```
covid_testing |>
      select(mrn, pan_day) |>
      head(4) |>
      summarize(order_count = n())
```

function that returns number of observations

mrn	pan_day
5001412	4
5000533	7
5009134	7
5008518	8

→

order_count
4

summarize()

- Additional summaries = new columns

```
covid_testing |>
      select(mrn, pan_day) |>
      head(4) |>
      summarize(order_count = n(),
                day_count = n_distinct(pan_day))
```

function that returns number of distinct values

mrn	pan_day
5001412	4
5000533	7
5009134	7
5008518	8

→

order_count	day_count
4	3

summarize()

- Summarize supports calculations on summary stats

```
covid_testing |>
      summarize(order_count = n(),
                day_count = n_distinct(pan_day),
                orders_per_day = order_count/day_count)
```

mrn	pan_day
5001412	4
5000533	7
5009134	7
5008518	8

→

order_count	day_count	orders_per_day
15524	102	152

Your Turn #1

- Open “06 – Group by and Summarize.Rmd”

- Run the setup chunk

- Fill-in gaps to calculate: Mean count of orders per clinic

COUNTS

dplyr::**n()** - number of values/rows
dplyr::**n_distinct()** - # of uniques
sum(!is.na()) - # of non-NA's

LOCATION

mean() - mean, also **mean(!is.na())**
median() - median

LOGICALS

mean() - Proportion of TRUE's
sum() - # of TRUE's

POSITION/ORDER

dplyr::**first()** - first value
dplyr::**last()** - last value
dplyr::**nth()** - value in nth location of vector

RANK

quantile() - nth quantile
min() - minimum value
max() - maximum value

SPREAD

IQR() - Inter-Quartile Range
mad() - median absolute deviation
sd() - standard deviation
var() - variance

Vector Functions

TO USE WITH MUTATE ()

torized
olumns.
nput and
output.

n()

l values <=
= min, no

nin

aled to [0,1]
= "first"

etic ops

nparisons

nt
se()
s by

lse()
s with NA

witch()

Summary Functions

TO USE WITH SUMMARISE ()

summarise() applies summary functions to columns to create a new table. Summary functions take vectors as input and return single values as output.

summary function

COUNTS

dplyr::**n()** - number of values/rows
dplyr::**n_distinct()** - # of uniques
sum(!is.na()) - # of non-NA's

LOCATION

mean() - mean, also **mean(!is.na())**
median() - median

LOGICALS

mean() - Proportion of TRUE's
sum() - # of TRUE's

POSITION/ORDER

dplyr::**first()** - first value
dplyr::last() - last value
dplyr::nth() - value in nth location of vector

RANK

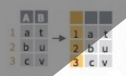
quantile() - nth quantile
min() - minimum value
max() - maximum value

SPREAD

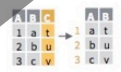
IQR() - Inter-Quartile Range
mad() - median absolute deviation
sd() - standard deviation
var() - variance

Row Names

Tidy data does not use rownames, which store a variable outside of the columns. To work with the rownames, first move them into a column.



rownames_to_column()
Move row names into col.
a <- rownames_to_column(iris, var = "C")

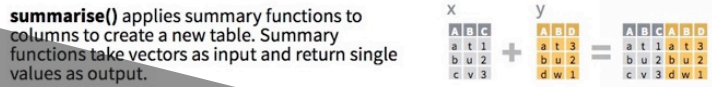


column_to_rownames()
Move col in row names.
column_to_rownames(a, var = "C")

Also **has_rownames()**, **remove_rownames()**

Combine Tables

COMBINE VARIABLES



Use **bind_cols()** to paste tables beside each other as they are.

bind_cols(…) Returns tables placed side by side as a single table.
BE SURE THAT ROWS ALIGN.

Use a "**Mutating Join**" to join one table to columns from another, matching values with the rows that they correspond to. Each join retains a different combination of values from the tables.

left_join(x, y, by = NULL, copy=FALSE, suffix=c(".x",".y"),…)
Join matching values from y to x.

right_join(x, y, by = NULL, copy = FALSE, suffix=c(".x",".y"),…)
Join matching values from x to y.

inner_join(x, y, by = NULL, copy = FALSE, suffix=c(".x",".y"),…)
Join data. Retain only rows with matches.

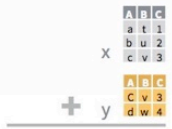
full_join(x, y, by = NULL, copy=FALSE, suffix=c(".x",".y"),…)
Join data. Retain all values, all rows.

Use **by = c("col1", "col2")** to specify the column(s) to match on.
left_join(x, y, by = "A")

Use a named vector, **by = c("col1" = "col2")**, to match on columns with different names in each data set.
left_join(x, y, by = c("C" = "D"))

Use **suffix** to specify suffix to give to duplicate column names.
left_join(x, y, by = c("C" = "D"), suffix = c("1", "2"))

COMBINE CASES



Use **bind_rows()** to paste tables below each other as they are.

bind_rows(…, .id = NULL)
Returns tables one on top of the other as a single table. Set .id to a column name to add a column of the original table names (as pictured)

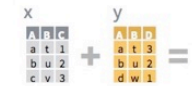
intersect(x, y, …)
Rows that appear in both x and y.

setdiff(x, y, …)
Rows that appear in x but not y.

union(x, y, …)
Rows that appear in x or y.
(Duplicates removed). union_all() retains duplicates.

Use **setequal()** to test whether two data sets contain the exact same rows (in any order).

EXTRACT ROWS



Use a "**Filtering Join**" to filter one table against the rows of another.

semi_join(x, y, by = NULL, …)
Return rows of x that have a match in y.
USEFUL TO SEE WHAT WILL BE JOINED.

anti_join(x, y, by = NULL, …)
Return rows of x that do not have a match in y. USEFUL TO SEE WHAT WILL NOT BE JOINED.

Output the last day

```
covid_testing |>
    summarize(last_day = last(pan_day))
```

mrn	pan_day
5001412	4
5000533	7
5009134	7
5008518	8

last_day
8

Calculate the median turnaround time

```
covid_testing |>
  mutate(col_ver_tat = col_rec_tat + rec_ver_tat) |>
  summarize(col_ver_tat_mean = mean(col_ver_tat))
```

mrn	pan_day	col_ver_tat
5001412	4	6
5000533	7	8
5009134	7	10
5008518	8	11

→

col_ver_tat_mean
8.75

Calculate the 75th percentile turnaround time

```
covid_testing |>
 mutate(col_ver_tat = col_rec_tat + rec_ver_tat) |>
 summarize(col_ver_tat_mean = mean(col_ver_tat),
           col_ver_75_pctile = quantile(col_ver_tat, 0.75)
```

mrn	pan_day	col_ver_tat
5001412	4	6
5000533	7	8
5009134	7	10
5008518	8	11

col_ver_tat_mean	col_ver_tat_mean
8.75	9.6

Your Turn #2

For the covid_testing data frame, calculate both the median and the 95th percentile collect-to-verify turnaround time.

Pop Quiz

How would you calculate the median number of orders per day?

Grouping your data

group_by()

group_by()

- *Grouping observations based on a specific variable's values*

```
covid_testing |>
    group_by(variable)
```

name of variable to group by

group_by()

- *Group observations by pan_day*

```
covid_testing |>
    group_by(pan_day)
```

```
# A tibble: 15,524 x 17
# Groups:   pan_day [102]
      mrn first_name last_name gender pan_day
    <dbl> <chr>      <chr>     <chr>     <dbl>
1 5.00e6 jhezane    westerli… female        4
2 5.00e6 penny      targaryen female        7
3 5.01e6 grunt      rivers    male          7
4 5.01e6 melisandre swyft     female        8
5 5.01e6 rolley     karstark  male          8
```

group_by()

- *Group observations by `pan_day` and `clinic_name`*

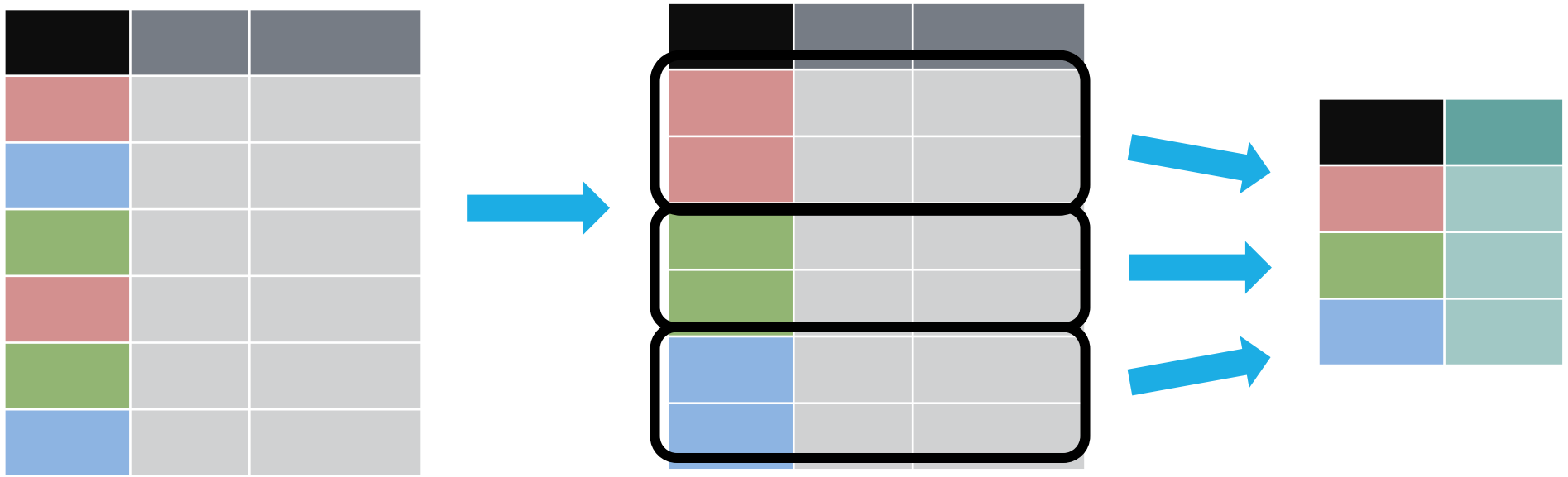
```
covid_testing |>
    select(mrn, pan_day, clinic_name) |>
    group_by(pan_day, clinic_name)
```

```
# A tibble: 15,524 x 3
# Groups:   pan_day, clinic_name [2,526]
       mrn pan_day clinic_name
     <dbl>   <dbl> <chr>
 1 5001412       4 inpatient ward a
 2 5000533       7 clinical lab
 3 5009134       7 clinical lab
 4 5008518       8 clinical lab
 5 5008967       8 emergency dept
```

group_by() |> summarize()

group_by() |> summarize()

Make summaries of your data *by group*



group_by() |> summarize()

- Make summaries of your data

```
covid_testing |>

    summarize(order_count = n())
```

mrn	pan_day
5001412	4
5000533	7
5009134	7
5008518	8

→

order_count
15524

group_by() |> summarize()

- Make summaries of your data

```
covid_testing |>
    group_by(pan_day) |>
    summarize(order_count = n())
```

mrn	pan_day
5001412	4
5000533	7
5009134	7
5008518	8

→

pan_day	order_count
4	1
7	2
8	3
9	9

Your Turn #3

Calculate:

a) The median collect-to-verify turnaround time for each day

b) The median collect-to-verify turnaround time for each clinic/unit

c) The median number of orders per day

Calculate the 95th percentile of turnaround time

```
covid_testing |>
  group_by(clinic_name) |>
  summarize(tat_95th_pctile = quantile(rec_ver_tat, 0.95))
```

clinic_name	rec_ver_tat
inpatient ward a	4.7
clinical lab	6.4
picu	5.6
emergency dept	7.1

→

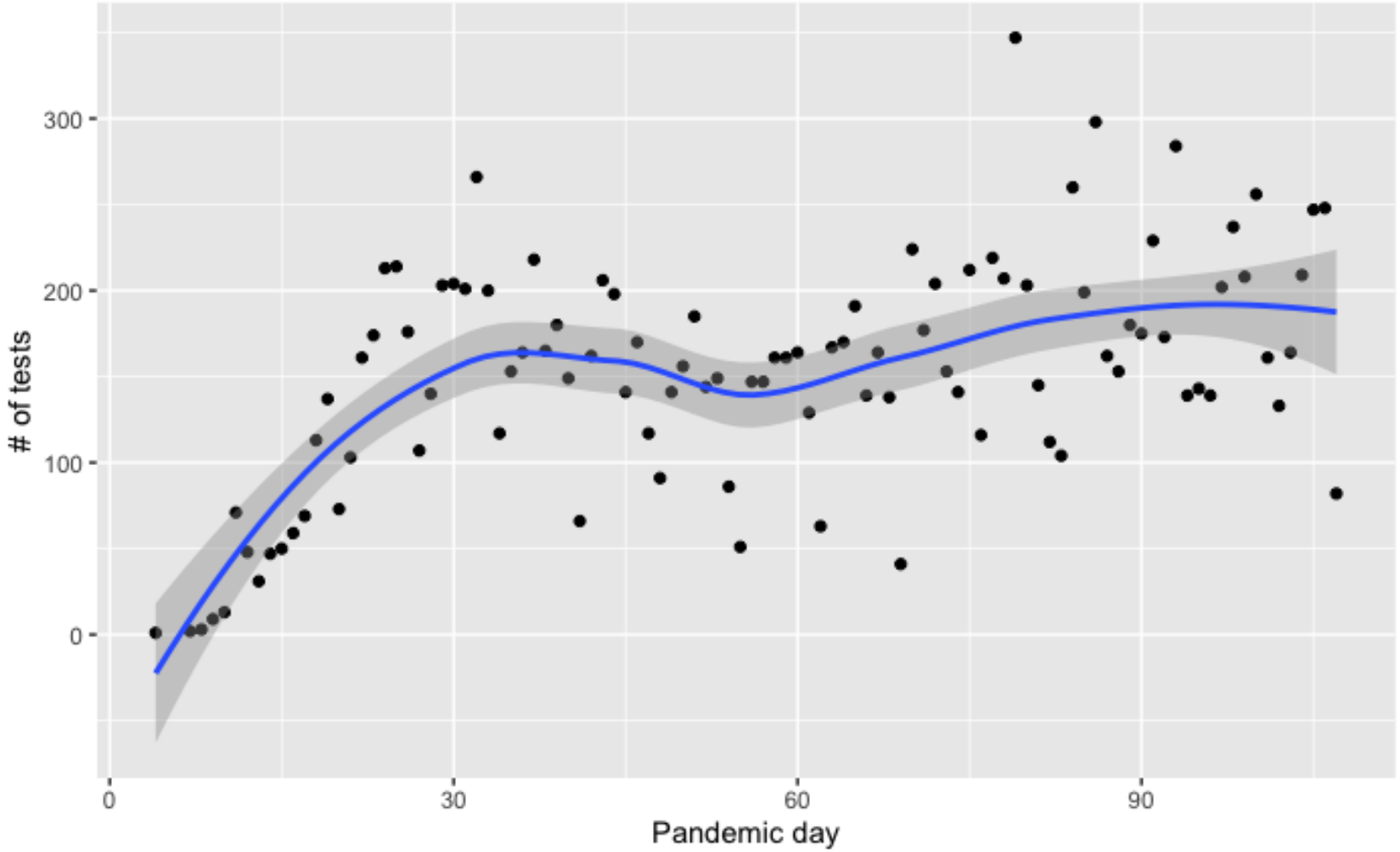
clinic_name	tat_95th_pctile
clinical lab	8.9
emergency dept	9.6
inpatient ward a	9.3
picu	9.1

Count tests per day, then visualize

```
tmp <- covid_testing |>
  group_by(pan_day) |>
  summarize(n_tests = n())
```

```
ggplot(data = tmp) +
  geom_point(aes(x = pan_day, y = n_tests)) +
  geom_smooth(aes(x = pan_day, y = n_tests), method = 'loess') +
  ylab("# of tests") +
  xlab("Pandemic day")
```

group_by() |> summarize(): Example



Recap

Summarize() is a function that enables us to calculate summaries of variables (columns).

Common summary activities include counting observations using **n()**, counting unique observations using **n_distinct()**, and calculating means using **mean()**.

Group_by() is a function that enables us to create subsets of data by a variable. Data can also be grouped by multiple variables.

Combining the **group_by()** and **summarize()** functions is a powerful way to look at summarizations across groups.

What else?

Data transformation with dplyr : : **CHEAT SHEET**

dplyr functions work with pipes and expect **tidy data**. In tidy data:

Each **variable** is in its own **column**

Each **observation**, or **case**, is in its own **row**

pipes

x %>% f(y) becomes **f(x, y)**

Summarise Cases

Apply **summary functions** to columns to create a new table of summary statistics. Summary functions take vectors as input and return one value (see back).

summary function

summarise(.data, …**)** Compute table of summaries.
summarise(mtcars, avg = mean(mpg))

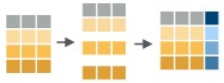
count(.data, …, wt = NULL, sort = FALSE, name = NULL**)** Count number of rows in each group defined by the variables in … Also **tally()**.
count(mtcars, cyl)

Group Cases

Use **group_by(**.data, …, .add = FALSE, .drop = TRUE**)** to create a "grouped" copy of a table grouped by columns in ... dplyr functions will manipulate each "group" separately and combine the results.

```
mtcars %>%
  group_by(cyl) %>%
  summarise(avg = mean(mpg))
```

Use **rowwise(**.data, …**)** to group data into individual rows. dplyr functions will compute results for each row. Also apply functions to list-columns. See tidyr cheat sheet for list-column workflow.



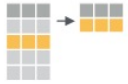
```
starwars %>%
  rowwise() %>%
  mutate(film_count = length(films))
```

ungroup(x, …**)** Returns ungrouped copy of table.
ungroup(g_mtcars)

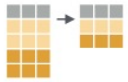
Manipulate Cases

EXTRACT CASES

Row functions return a subset of rows as a new table.



filter(.data, …, .preserve = FALSE**)** Extract rows that meet logical criteria.
filter(mtcars, mpg > 20)

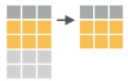


distinct(.data, …, .keep_all = FALSE**)** Remove rows with duplicate values.
distinct(mtcars, gear)

slice(.data, …, .preserve = FALSE**)** Select rows by position.
slice(mtcars, 10:15)

slice_sample(.data, …, n, prop, weight_by = NULL, replace = FALSE**)** Randomly select rows. Use n to select a number of rows and prop to select a fraction of rows.
slice_sample(mtcars, n = 5, replace = TRUE)

slice_min(.data, order_by, …, n, prop, with_ties = TRUE**)** and **slice_max()** Select rows with the lowest and highest values.
slice_min(mtcars, mpg, prop = 0.25)



slice_head(.data, …, n, prop**)** and **slice_tail()** Select the first or last rows.
slice_head(mtcars, n = 5)

Logical and boolean operators to use with filter()

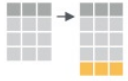
==	<	<=	is.na()	%in%	|	xor()
!=	>	>=	!is.na()	!	&	

See **?base::Logic** and **?Comparison** for help.

ARRANGE CASES

arrange(.data, …, .by_group = FALSE**)** Order rows by values of a column or columns (low to high), use with **desc()** to order from high to low.
arrange(mtcars, mpg)
arrange(mtcars, desc(mpg))

ADD CASES



add_row(.data, …, .before = NULL, .after = NULL**)** Add one or more rows to a table.
add_row(cars, speed = 1, dist = 1)

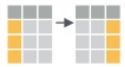
Manipulate Variables

EXTRACT VARIABLES

Column functions return a set of columns as a new vector or table.

pull(.data, var = -1, name = NULL, …**)** Extract column values as a vector, by name or index.
pull(mtcars, wt)

select(.data, …**)** Extract columns as a table.
select(mtcars, mpg, wt)

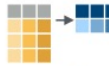


relocate(.data, …, .before = NULL, .after = NULL**)** Move columns to new position.
relocate(mtcars, mpg, cyl, .after = last_col())

Use these helpers with select() and across()
e.g. select(mtcars, mpg:cyl)

contains(match**)**	**num_range(**prefix, range**)**	**:**, e.g. mpg:cyl
ends_with(match**)**	**all_of(**x**)/any_of(**x, …, vars**)**	**-**, e.g, -gear
starts_with(match**)**	**matches(**match**)**	**everything()**

MANIPULATE MULTIPLE VARIABLES AT ONCE



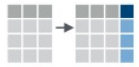
across(.cols, .funs, …, .names = NULL**)** Summarise or mutate multiple columns in the same way.
summarise(mtcars, across(everything(), mean))

c_across(.cols**)** Compute across columns in row-wise data.
transmute(rowwise(UKgas), total = sum(c_across(1:2)))

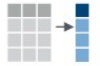
MAKE NEW VARIABLES

Apply **vectorized functions** to columns. Vectorized functions take vectors as input and return vectors of the same length as output (see back).

vectorized function



mutate(.data, …, .keep = "all", .before = NULL, .after = NULL**)** Compute new column(s). Also **add_column(), add_count(),** and **add_tally().**
mutate(mtcars, gpm = 1 / mpg)



transmute(.data, …**)** Compute new column(s), drop others.
transmute(mtcars, gpm = 1 / mpg)

rename(.data, …**)** Rename columns. Use **rename_with()** to rename with a function.
rename(cars, distance = dist)

Goals

1. Learn dplyr tools for grouping and summarizing data in R

Objectives

1. Calculate a summary statistic for a variable using the summarize() function
2. Creates groupings of data using the group_by() function
3. Combine group_by() and summarize() functions to calculate summary statistics for groups of data

Tests for Association

Q: Is there an association between insurance product and SARS-CoV-2 RT-PCR positivity?

payor_group_fac <chr>	negative <int>	positive <int>
commercial	3549	86
government	3318	242
other	309	17
unassigned	7182	520

4 rows

```
data |>
  fisher.test(simulate.p.value = T)
```

Data wrangling - 1

function that flexibly assigns values

```
covid_testing_2 <- covid_testing |>
  mutate(payor_group_fac = case_when(
                            is.na(payor_group)                          ~ "unassigned",
                            payor_group %in% c("charity care",
                                               "medical assistance",
                                               "self pay",
                                               "other")                 ~ "other",
                                                                  TRUE ~ payor_group)
  ) |>
  filter(result %in% c("positive", "negative"))
```

Data wrangling - 2

```
# Generate counts
tmp_table_tall <- covid_testing_2 |>
  group_by(payor_group_fac, result) |>
  summarize(n = n()) |>
  ungroup()
tmp_table_tall

# Pivot from tall to wide table
tmp_table_wide <- tmp_table_tall |>
  spread(key = "result", value = "n")
tmp_table_wide
```

Remove groupings

Maps key values to separate columns

Testing for association

payor_group_fac <chr>	negative <int>	positive <int>
commercial	3549	86
government	3318	242
other	309	17
unassigned	7182	520

4 rows

```
data |>
  fisher.test(simulate.p.value = T)
```

```
        Fisher's Exact Test for Count Data with simulated p-value (based on 2000 replicates)

data:  .
p-value = 0.0004998
alternative hypothesis: two.sided
```

Regression Modeling

> Q: Is the association between test positivity and a government insurance product explained by the age of the patient?

```
tmp <- covid_testing_2 |>
  filter(payor_group_fac %in% c("commercial", "government")) |>
  mutate(result_fac = factor(result,
                             levels=c("negative", "positive"),
                             ordered=T),
         payor_group_fac = (payor_group == "government"))
tmp_fit <- glm(result_fac ~ payor_group_fac + age,     # model formula
               data = tmp,                             # dataset
               family = "binomial"                     # type of model
  )
summary(tmp_fit)
exp(coefficients(tmp_fit))                             # odds
```

Output for logistic regression

```
Call:
glm(formula = result_fac ~ payor_group_fac + age, family = "binomial",
    data = tmp)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.6365  -0.3468  -0.2532  -0.1985   2.8393

Coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)        -4.016195   0.119611 -33.577  < 2e-16 ***
payor_group_facTRUE  1.136566   0.128761   8.827  < 2e-16 ***
age                  0.032897   0.004436   7.416 1.21e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 2666.6  on 7194  degrees of freedom
Residual deviance: 2535.2  on 7192  degrees of freedom
AIC: 2541.2

Number of Fisher Scoring iterations: 6

        (Intercept) payor_group_facTRUE                 age
         0.01802141          3.11604971          1.03344368
```

Odds for Payor Group and Age