

# Descriptive analysis

Characteristic		Death, N = 2,562 <sup>a</sup>	Recover, N = 1,983 <sup>a</sup>
Age (years)		15.9 (12.3)	16.1 (13.0)
Missing		32	28
Gender			
f		1,227 / 2,455 (50%)	953
m		1,228 / 2,455 (50%)	950
Missing		127	
fever			
no		458 / 2,460 (19%)	361
yes		2,002 / 2,460 (81%)	1,543
Missing		122	
Temperature		38.6 (1.0)	
Missing		60	
Hospital			
Central Hospital		193 / 2,582 (7.5%)	165 / 1,983 (8.3%)
Military Hospital		399 / 2,582 (15%)	309 / 1,983 (16%)
Missing		611 / 2,582 (24%)	514 / 1,983 (26%)
Other		395 / 2,582 (15%)	290 / 1,983 (15%)
Port Hospital		785 / 2,582 (30%)	579 / 1,983 (29%)
St. Mark's Maternity Hospital (SMMH)		199 / 2,582 (7.7%)	126 / 1,983 (6.4%)

```
## # A tibble: 6 x 7
##   hospital cases delay_max delay_mean delay_sd delay_3
##   <chr>   <int>   <dbl>   <dbl>   <dbl>   <int>
## 1 Central H~ 454      12      1.9      1.9     108
## 2 Military ~ 896      15      2.1      2.4     253
## 3 Missing   1469     22      2.1      2.3     399
## 4 Other     885      18      2.2      2.2     234
## 5 Port Hosp~ 1762     16      2.1      2.2     470
## 6 St. Mark'~ 422      18      2.1      2.3     116
## # ... with 1 more variable: pct_delay_3 <chr>
```

```
##           Gender
## Age Category  f    m
##      0-4      22.8% 14.8%
##      5-9      22.8% 14.7%
##     10-14     18.5% 13.7%
##     15-19     12.8% 13.0%
##     20-29     16.7% 20.5%
##     30-49      6.4% 19.9%
##     50-69      0.1%  3.2%
##     70+       0.0%  0.2%
##    <NA>       0.0%  0.0%
##      Total 100.0% 100.0%
```

<sup>a</sup>Mean (SD); n / N (%)

This page demonstrates the use of **janitor**, **dplyr**, and **base R** to summarise data and create tables with descriptive statistics.

Here we'll learn how to *create* the underlying tables, whereas in the next chapter we'll see how to nicely format and print them.

## Data Preparation

### Load packages

```
pacman::p_load(
  rio,           # File import
  here,          # File locator
  skimr,         # get overview of data
  tidyverse,     # data management + ggplot2 graphics
  gtsummary,     # summary statistics and tests
  janitor,       # adding totals and percents to tables
  scales,        # easily convert proportions to percents
  flextable      # converting tables to pretty images
)
```

### Import data

We import the dataset of cases from a simulated Ebola epidemic. If you want to follow along, click to download the “clean” linelist (as .rds file).

```
# import the linelist
linelist <- import("linelist_cleaned.rds")
```

## Browse data

### Summary statistics

You can use **base** R functions to return summary statistics on a numeric column. You can return most of the useful summary statistics for a numeric column using `summary()`, as below. Note that the data frame name must also be specified as shown below.

```
summary(linelist$age_years)
```

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
0.00	6.00	13.00	16.02	23.00	84.00	86

You can access and save one specific part of it with index brackets `[ ]`:

```
summary(linelist$age_years)[[2]]          # return only the 2nd element
```

```
[1] 6
```

```
# equivalent, alternative to above by element name
# summary(linelist$age_years)[["1st Qu."]]
```

You can return individual statistics with **base** R functions like `max()`, `min()`, `median()`, `mean()`, `quantile()`, `sd()`, and `range()`.

#### Warning

If your data contain missing values, R wants you to know this and so will return `NA` unless you specify to the above mathematical functions that you want R to ignore missing values, via the argument `na.rm = TRUE`.

## janitor package

The **janitor** package offers the `tabyl()` function to produce tabulations and cross-tabulations, which can be “adorned” or modified with helper functions to display percents, proportions, counts, etc.

Below, we pipe the `linelist` data frame to **janitor** functions and print the result. If desired, you can also save the resulting tables with the assignment operator `<-`.

### Simple tabyl

The default use of `tabyl()` on a specific column produces the unique values, counts, and column-wise “percents” (actually proportions). The proportions may have many digits. You can adjust the number of decimals with `adorn_rounding()` as described below.

```
linelist %>% tabyl(age_cat)
```

age_cat	n	percent	valid_percent
0-4	1095	0.185971467	0.188728025
5-9	1095	0.185971467	0.188728025
10-14	941	0.159816576	0.162185453
15-19	743	0.126188859	0.128059290
20-29	1073	0.182235054	0.184936229
30-49	754	0.128057065	0.129955188
50-69	95	0.016134511	0.016373664
70+	6	0.001019022	0.001034126
<NA>	86	0.014605978	NA

As you can see above, if there are missing values they display in a row labeled `<NA>`. You can suppress them with `show_na = FALSE`. If there are no missing values, this row will not appear. If there are missing values, all proportions are given as both raw (denominator inclusive of NA counts) and “valid” (denominator excludes NA counts).

If the column is class Factor and only certain levels are present in your data, all levels will still appear in the table. You can suppress this feature by specifying `show_missing_levels = FALSE`.

## Cross-tabulation

Cross-tabulation counts are achieved by adding one or more additional columns within `tabyl()`. Note that now only counts are returned - proportions and percents can be added with additional steps shown below.

```
linelist %>% tabyl(age_cat, gender)
```

```
age_cat  f   m NA_
0-4    640 416 39
5-9    641 412 42
10-14   518 383 40
15-19   359 364 20
20-29   468 575 30
30-49   179 557 18
50-69     2  91  2
70+      0   5  1
<NA>     0   0 86
```

## “Adorning” the tabyl

Use **janitor**’s “adorn” functions to add totals or convert to proportions, percents, or otherwise adjust the display. Often, you will pipe the `tabyl` through several of these functions.

Function	Outcome
<code>adorn_totals()</code>	Adds totals ( <b>where</b> = “row”, “col”, or “both”). Set <b>name</b> = for “Total”.
<code>adorn_percentages()</code>	Convert counts to proportions, with <b>denominator</b> = “row”, “col”, or “all”
<code>adorn_pct_formatting()</code>	Converts proportions to percents. Specify <b>digits</b> =. Remove the “%” symbol with <b>affix_sign</b> = FALSE.
<code>adorn_rounding()</code>	To round proportions to <b>digits</b> = places. To round percents use <code>adorn_pct_formatting()</code> with <b>digits</b> =.
<code>adorn_ns()</code>	Add counts to a table of proportions or percents. Indicate <b>position</b> = “rear” to show counts in parentheses, or “front” to put the percents in parentheses.
<code>adorn_title()</code>	Add string via arguments <b>row_name</b> = and/or <b>col_name</b> =

Be conscious of the order you apply the above functions. Below are some examples.

A simple one-way table with percents instead of the default proportions.

```
linelist %>%           # case linelist
  tabyl(age_cat) %>%    # tabulate counts and proportions by age category
  adorn_pct_formatting() # convert proportions to percents
```

age_cat	n	percent	valid_percent
0-4	1095	18.6%	18.9%
5-9	1095	18.6%	18.9%
10-14	941	16.0%	16.2%
15-19	743	12.6%	12.8%
20-29	1073	18.2%	18.5%
30-49	754	12.8%	13.0%
50-69	95	1.6%	1.6%
70+	6	0.1%	0.1%
<NA>	86	1.5%	-

A cross-tabulation with a total row and row percents.

```
linelist %>%
  tabyl(age_cat, gender) %>%           # counts by age and gender
  adorn_totals(where = "row") %>%      # add total row
  adorn_percentages(denominator = "row") %>% # convert counts to proportions
  adorn_pct_formatting(digits = 1)      # convert proportions to percents
```

age_cat	f	m	NA_
0-4	58.4%	38.0%	3.6%
5-9	58.5%	37.6%	3.8%
10-14	55.0%	40.7%	4.3%
15-19	48.3%	49.0%	2.7%
20-29	43.6%	53.6%	2.8%
30-49	23.7%	73.9%	2.4%
50-69	2.1%	95.8%	2.1%
70+	0.0%	83.3%	16.7%
<NA>	0.0%	0.0%	100.0%
Total	47.7%	47.6%	4.7%

A cross-tabulation adjusted so that both counts and percents are displayed.

```

linelist %>%
  tabyl(age_cat, gender) %>%
  adorn_totals(where = "row") %>%
  adorn_percentages(denominator = "col") %>%
  adorn_pct_formatting() %>%
  adorn_ns(position = "front") %>%
  adorn_title(
    row_name = "Age Category",
    col_name = "Gender")
# case linelist
# cross-tabulate counts
# add a total row
# convert to proportions
# convert to percents
# display as: "count (percent)"
# adjust titles

```

Age Category	Gender					
	f		m		NA_	
0-4	640	(22.8%)	416	(14.8%)	39	(14.0%)
5-9	641	(22.8%)	412	(14.7%)	42	(15.1%)
10-14	518	(18.5%)	383	(13.7%)	40	(14.4%)
15-19	359	(12.8%)	364	(13.0%)	20	(7.2%)
20-29	468	(16.7%)	575	(20.5%)	30	(10.8%)
30-49	179	(6.4%)	557	(19.9%)	18	(6.5%)
50-69	2	(0.1%)	91	(3.2%)	2	(0.7%)
70+	0	(0.0%)	5	(0.2%)	1	(0.4%)
<NA>	0	(0.0%)	0	(0.0%)	86	(30.9%)
Total	2,807	(100.0%)	2,803	(100.0%)	278	(100.0%)

## Printing the tabyl

By default, the tabyl will print raw to your R console.

Alternatively, you can pass the tabyl to **flextable** or similar package to print as a “pretty” image in the RStudio Viewer, which could be exported as .png, .jpeg, .html, etc. Note that if printing in this manner and using `adorn_titles()`, you must specify `placement = "combined"`.

```

linelist %>%
  tabyl(age_cat, gender) %>%
  adorn_totals(where = "col") %>%
  adorn_percentages(denominator = "col") %>%
  adorn_pct_formatting() %>%
  adorn_ns(position = "front") %>%
  adorn_title(
    row_name = "Age Category",
    col_name = "Gender",

```

```

  placement = "combined") %>% # this is necessary to print as image
flextable::flextable() %>%    # convert to pretty image
flextable::autofit()          # format to one line per row

```

Age Category/Gender	f	m	NA__	Total
0-4	640 (22.8%)	416 (14.8%)	39 (14.0%)	1,095 (18.6%)
5-9	641 (22.8%)	412 (14.7%)	42 (15.1%)	1,095 (18.6%)
10-14	518 (18.5%)	383 (13.7%)	40 (14.4%)	941 (16.0%)
15-19	359 (12.8%)	364 (13.0%)	20 (7.2%)	743 (12.6%)
20-29	468 (16.7%)	575 (20.5%)	30 (10.8%)	1,073 (18.2%)
30-49	179 (6.4%)	557 (19.9%)	18 (6.5%)	754 (12.8%)
50-69	2 (0.1%)	91 (3.2%)	2 (0.7%)	95 (1.6%)
70+	0 (0.0%)	5 (0.2%)	1 (0.4%)	6 (0.1%)
	0 (0.0%)	0 (0.0%)	86 (30.9%)	86 (1.5%)

## Use on other tables

You can use **janitor**'s `adorn_*()` functions on other tables, such as those created by `summarise()` and `count()` from **dplyr**, or `table()` from **base** R. Simply pipe the table to the desired **janitor** function. For example:

```

linelist %>%
  count(hospital) %>% # dplyr function
  adorn_totals()      # janitor function

```

```

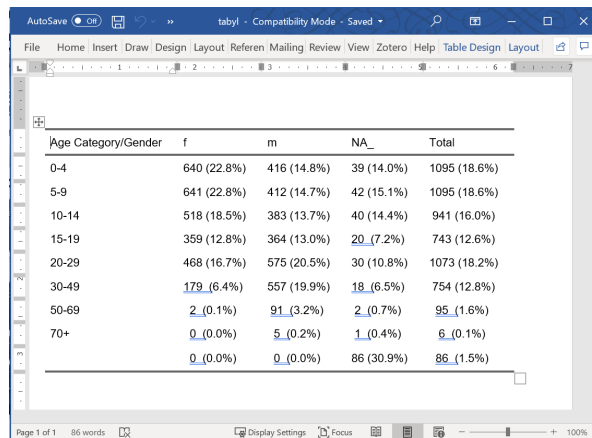
              hospital    n
Central Hospital  454
Military Hospital  896
Missing          1469
Other            885
Port Hospital    1762
St. Mark's Maternity Hospital (SMMH)  422
Total           5888

```

## Saving the tabyl

If you convert the table to a “pretty” image with a package like **flextable**, you can save it with functions from that package - like `save_as_html()`, `save_as_word()`, `save_as_ppt()`, and `save_as_image()` from **flextable**. Below, the table is saved as a Word document, in which it can be further hand-edited.

```
linelist %>%
  tabyl(age_cat, gender) %>%
  adorn_totals(where = "col") %>%
  adorn_percentages(denominator = "col") %>%
  adorn_pct_formatting() %>%
  adorn_ns(position = "front") %>%
  adorn_title(
    row_name = "Age Category",
    col_name = "Gender",
    placement = "combined") %>%
  flextable::flextable() %>%           # convert to image
  flextable::autofit() %>%           # ensure only one line per row
  flextable::save_as_docx(path = "tabyl.docx") # save as Word document to filepath
```



Age Category/Gender	f	m	NA_	Total
0-4	640 (22.8%)	416 (14.8%)	39 (14.0%)	1095 (18.6%)
5-9	641 (22.8%)	412 (14.7%)	42 (15.1%)	1095 (18.6%)
10-14	518 (18.5%)	383 (13.7%)	40 (14.4%)	941 (16.0%)
15-19	359 (12.8%)	364 (13.0%)	20 (7.2%)	743 (12.6%)
20-29	468 (16.7%)	575 (20.5%)	30 (10.8%)	1073 (18.2%)
30-49	179 (6.4%)	557 (19.9%)	18 (6.5%)	754 (12.8%)
50-69	2 (0.1%)	91 (3.2%)	2 (0.7%)	95 (1.6%)
70+	0 (0.0%)	5 (0.2%)	1 (0.4%)	6 (0.1%)
	0 (0.0%)	0 (0.0%)	86 (30.9%)	86 (1.5%)

## Statistics

You can apply statistical tests on tabyls, like `chisq.test()` or `fisher.test()` from the **stats** package, as shown below. Note missing values are not allowed so they are excluded from the tabyl with `show_na = FALSE`.



```
age_by_outcome <- linelist %>%
  tabyl(age_cat, outcome, show_na = FALSE)

chisq.test(age_by_outcome)
```

Pearson's Chi-squared test

```
data: age_by_outcome
X-squared = 6.4931, df = 7, p-value = 0.4835
```

## dplyr package

**dplyr** is part of the **tidyverse** packages and is an very common data management tool. Creating tables with **dplyr** functions `summarise()` and `count()` is a useful approach to calculating summary statistics, summarize *by group*, or pass tables to `ggplot()`.

`summarise()` creates a *new, summary data frame*. If the data are *ungrouped*, it will return a one-row dataframe with the specified summary statistics of the entire data frame. If the data are *grouped*, the new data frame will have one row per *group*.

Within the `summarise()` parentheses, you provide the names of each new summary column followed by an equals sign and a statistical function to apply.

### Tip

The summarise function works with both UK and US spelling (`summarise()` and `summarize()`).

## Get counts

The most simple function to apply within `summarise()` is `n()`. Leave the parentheses empty to count the number of rows.

```
linelist %>%                                # begin with linelist
  summarise(n_rows = n())                   # return new summary dataframe with column n_rows
```

```
  n_rows
1  5888
```

This gets more interesting if we have grouped the data beforehand.

```
linelist %>%  
  group_by(age_cat) %>%      # group data by unique values in column age_cat  
  summarise(n_rows = n())    # return number of rows *per group*
```

```
# A tibble: 9 x 2  
  age_cat n_rows  
  <fct>   <int>  
1 0-4     1095  
2 5-9     1095  
3 10-14    941  
4 15-19    743  
5 20-29   1073  
6 30-49    754  
7 50-69     95  
8 70+        6  
9 <NA>     86
```

The above command can be shortened by using the `count()` function instead. `count()` does the following:

- 1) Groups the data by the columns provided to it
- 2) Summarises them with `n()` (creating column `n`)
- 3) Un-groups the data

```
linelist %>%  
  count(age_cat)
```

```
age_cat    n  
1    0-4 1095  
2    5-9 1095  
3   10-14 941  
4   15-19 743  
5   20-29 1073  
6   30-49 754  
7   50-69 95  
8    70+ 6  
9   <NA> 86
```

You can change the name of the counts column from the default `n` to something else by specifying it to `name =`.

Tabulating counts of two or more grouping columns are still returned in “long” format, with the counts in the `n` column.

```
linelist %>%  
  count(age_cat, outcome)
```

	age_cat	outcome	n
1	0-4	Death	471
2	0-4	Recover	364
3	0-4	<NA>	260
4	5-9	Death	476
5	5-9	Recover	391
6	5-9	<NA>	228
7	10-14	Death	438
8	10-14	Recover	303
9	10-14	<NA>	200
10	15-19	Death	323
11	15-19	Recover	251
12	15-19	<NA>	169
13	20-29	Death	477
14	20-29	Recover	367
15	20-29	<NA>	229
16	30-49	Death	329
17	30-49	Recover	238
18	30-49	<NA>	187
19	50-69	Death	33
20	50-69	Recover	38
21	50-69	<NA>	24
22	70+	Death	3
23	70+	Recover	3
24	<NA>	Death	32
25	<NA>	Recover	28
26	<NA>	<NA>	26

### Show all levels

If you are tabling a column of class *factor* you can ensure that *all* levels are shown (not just the levels with values in the data) by adding `.drop = FALSE` into the `summarise()` or `count()` command.

This technique is useful to standardise your tables/plots. For example if you are creating figures for multiple sub-groups, or repeatedly creating the figure for routine reports. In each of these circumstances, the presence of values in the data may fluctuate, but you can define levels that remain constant.

## Proportions

Proportions can be added by piping the table to `mutate()` to create a new column. Define the new column as the counts column (`n` by default) divided by the `sum()` of the counts column (this will return a proportion).

Note that in this case, `sum()` in the `mutate()` command will return the sum of the whole column `n` for use as the proportion denominator. If `sum()` is used in *grouped* data (e.g. if the `mutate()` immediately followed a `group_by()` command), it will return sums *by group*. As stated just above, `count()` finishes its actions by *ungrouping*. Thus, in this scenario we get full column proportions.

To easily display percents, you can wrap the proportion in the function `percent()` from the package **scales** (note this convert to class character).

```
age_summary <- linelist %>%
  count(age_cat) %>%                                # group and count by gender (produces "n" column)
  mutate(                                             # create percent of column - note the denominator
    percent = scales::percent(n / sum(n)))

# print
age_summary
```

	age_cat	n	percent
1	0-4	1095	18.60%
2	5-9	1095	18.60%
3	10-14	941	15.98%
4	15-19	743	12.62%
5	20-29	1073	18.22%
6	30-49	754	12.81%
7	50-69	95	1.61%
8	70+	6	0.10%
9	<NA>	86	1.46%

Below is a method to calculate proportions *within groups*. It relies on different levels of data grouping being selectively applied and removed. First, the data are grouped on `outcome` via `group_by()`. Then, `count()` is applied. This function further groups the data by `age_cat`

and returns counts for each `outcome-age-cat` combination. Importantly - as it finishes its process, `count()` also *ungroups* the `age_cat` grouping, so the only remaining data grouping is the original grouping by `outcome`. Thus, the final step of calculating proportions (denominator `sum(n)`) is still grouped by `outcome`.

```
age_by_outcome <- linelist %>%           # begin with linelist
  group_by(outcome) %>%                 # group by outcome
  count(age_cat) %>%                   # group and count by age_cat, and then rem
  mutate(percent = scales::percent(n / sum(n))) # calculate percent - note the denominator
```

PhantomJS not found. You can install it with `webshot::install_phantomjs()`. If it is installed

Show 12 entries

Search:

outcome			age_cat
Death	0-4	471	18.242%
Death	5-9	476	18.435%
Death	10-14	438	16.964%
Death	15-19	323	12.510%
Death	20-29	477	18.474%
Death	30-49	329	12.742%
Death	50-69	33	1.278%
Death	70+	3	0.116%
Death		32	1.239%
Recover	0-4	364	18.36%
Recover	5-9	391	19.72%
Recover	10-14	303	15.28%

Showing 1 to 12 of 26 entries

Previous

1

2

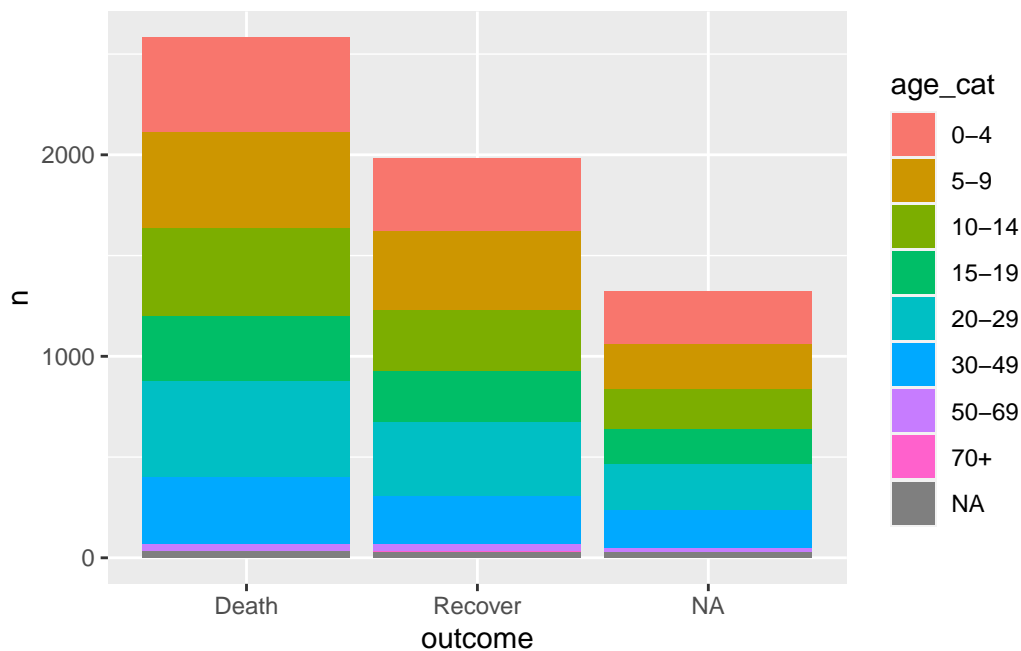
3

Next

## Plotting

To display a “long” table output like the above with `ggplot()` is relatively straight-forward. The data are naturally in “long” format, which is naturally accepted by `ggplot()`.

```
linelist %>%                                # begin with linelist
  count(age_cat, outcome) %>%               # group and tabulate counts by two columns
  ggplot()+                                 # pass new data frame to ggplot
  geom_col(                                # create bar plot
    mapping = aes(
      x = outcome,                          # map outcome to x-axis
      fill = age_cat,                       # map age_cat to the fill
      y = n))                              # map the counts column `n` to the height
```



## Summary statistics

One major advantage of `dplyr` and `summarise()` is the ability to return more advanced statistical summaries like `median()`, `mean()`, `max()`, `min()`, `sd()` (standard deviation), and percentiles. You can also use `sum()` to return the number of rows that meet certain logical criteria. As above, these outputs can be produced for the whole data frame set, or by group.

The syntax is the same - within the `summarise()` parentheses you provide the names of each new summary column followed by an equals sign and a statistical function to apply. Within the statistical function, give the column(s) to be operated on and any relevant arguments (e.g. `na.rm = TRUE` for most mathematical functions).

You can also use `sum()` to return the number of rows that meet a logical criteria. The expression within is counted if it evaluates to `TRUE`. For example:

- `sum(age_years < 18, na.rm=T)`
- `sum(gender == "male", na.rm=T)`
- `sum(response %in% c("Likely", "Very Likely"))`

Below, `linelist` data are summarised to describe the days delay from symptom onset to hospital admission (column `days_onset_hosp`), by hospital.

```
summary_table <- linelist %>%                                # begin with linelist
  group_by(hospital) %>%                                     # group all calculations
  summarise(                                                 # only the below summary
    cases      = n(),                                         # number of rows per hospital
    delay_max   = max(days_onset_hosp, na.rm = T),           # max delay
    delay_mean  = round(mean(days_onset_hosp, na.rm=T), digits = 1), # mean delay, rounded
    delay_sd    = round(sd(days_onset_hosp, na.rm = T), digits = 1), # standard deviation
    delay_3     = sum(days_onset_hosp >= 3, na.rm = T),      # number of rows with delay >= 3
    pct_delay_3 = scales::percent(delay_3 / cases)           # convert previously
  )

summary_table # print
```

```
# A tibble: 6 x 7
  hospital      cases delay_max delay_mean delay_sd delay_3 pct_delay_3
  <chr>         <int>    <dbl>    <dbl>    <dbl>    <int> <chr>
1 Central Hospital      454      12      1.9      1.9     108 24%
2 Military Hospital     896     15      2.1      2.4     253 28%
3 Missing             1469     22      2.1      2.3     399 27%
4 Other                885     18      2      2.2     234 26%
5 Port Hospital       1762     16      2.1      2.2     470 27%
6 St. Mark's Maternity ~  422     18      2.1      2.3     116 27%
```

Some tips:



- Use `sum()` with a logic statement to “count” rows that meet certain criteria (`==`)
- Note the use of `na.rm = TRUE` within mathematical functions like `sum()`, otherwise NA will be returned if there are any missing values
- Use the function `percent()` from the **scales** package to easily convert to percents
  - Set `accuracy` = to 0.1 or 0.01 to ensure 1 or 2 decimal places respectively
- Use `round()` from **base R** to specify decimals
- To calculate these statistics on the entire dataset, use `summarise()` without `group_by()`
- You may create columns for the purposes of later calculations (e.g. denominators) that you eventually drop from your data frame with `select()`.

## Conditional statistics

You may want to return *conditional statistics* - e.g. the maximum of rows that meet certain criteria. This can be done by subsetting the column with brackets `[ ]`. The example below returns the maximum temperature for patients classified having or not having fever. Be aware however - it may be more appropriate to add another column to the `group_by()` command and `pivot_wider()` (as demonstrated [below](#)).

```
linelist %>%
  group_by(hospital) %>%
  summarise(
    max_temp_fvr = max(temp[fever == "yes"], na.rm = T),
    max_temp_no = max(temp[fever == "no"], na.rm = T)
  )
```

```
# A tibble: 6 x 3
  hospital                max_temp_fvr max_temp_no
  <chr>                  <dbl>      <dbl>
1 Central Hospital      40.4         38
2 Military Hospital     40.5         38
3 Missing               40.6         38
4 Other                 40.8        37.9
5 Port Hospital         40.6         38
6 St. Mark's Maternity Hospital (SMMH) 40.6        37.9
```

## Glueing together

The function `str_glue()` from **stringr** is useful to combine values from several columns into one new column. In this context this is typically used *after* the `summarise()` command.

Below, the `summary_table` data frame (created above) is mutated such that columns `delay_mean` and `delay_sd` are combined, parentheses formatting is added to the new column, and their respective old columns are removed.

Then, to make the table more presentable, a total row is added with `adorn_totals()` from **janitor** (which ignores non-numeric columns). Lastly, we use `select()` from **dplyr** to both re-order and rename to nicer column names.

Now you could pass to **flextable** and print the table to Word, .png, .jpeg, .html, Powerpoint, RMarkdown, etc.! .

```
summary_table %>%  
  mutate(delay = str_glue("{delay_mean} ({delay_sd})")) %>% # combine and format other va  
  select(-c(delay_mean, delay_sd)) %>% # remove two old columns  
  adorn_totals(where = "row") %>% # add total row  
  select( # order and rename cols  
    "Hospital Name" = hospital,  
    "Cases" = cases,  
    "Max delay" = delay_max,  
    "Mean (sd)" = delay,  
    "Delay 3+ days" = delay_3,  
    "% delay 3+ days" = pct_delay_3  
  )
```

	Hospital Name	Cases	Max delay	Mean (sd)	Delay 3+ days
	Central Hospital	454	12	1.9 (1.9)	108
	Military Hospital	896	15	2.1 (2.4)	253
	Missing	1469	22	2.1 (2.3)	399
	Other	885	18	2 (2.2)	234
	Port Hospital	1762	16	2.1 (2.2)	470
	St. Mark's Maternity Hospital (SMMH)	422	18	2.1 (2.3)	116
	Total	5888	101	-	1580
% delay 3+ days					
					24%
					28%
					27%
					26%
					27%
					27%

-

## \* Percentiles

*Percentiles* and quantiles in **dplyr** deserve a special mention. To return quantiles, use `quantile()` with the defaults or specify the value(s) you would like with `probs =`.

```
# get default percentile values of age (0%, 25%, 50%, 75%, 100%)
linelist %>%
  summarise(age_percentiles = quantile(age_years, na.rm = TRUE))
```

Warning: Returning more (or less) than 1 row per ``summarise()`` group was deprecated in dplyr 1.1.0.

i Please use ``reframe()`` instead.

i When switching from ``summarise()`` to ``reframe()``, remember that ``reframe()`` always returns an ungrouped data frame and adjust accordingly.

```
age_percentiles
1          0
2          6
3         13
4         23
5         84
```

```
# get manually-specified percentile values of age (5%, 50%, 75%, 98%)
linelist %>%
  summarise(
    age_percentiles = quantile(
      age_years,
      probs = c(.05, 0.5, 0.75, 0.98),
      na.rm=TRUE)
  )
```

Warning: Returning more (or less) than 1 row per ``summarise()`` group was deprecated in dplyr 1.1.0.

i Please use ``reframe()`` instead.

i When switching from ``summarise()`` to ``reframe()``, remember that ``reframe()`` always returns an ungrouped data frame and adjust accordingly.

	age_percentiles
1	1
2	13
3	23
4	48

If you want to return quantiles *by group*, you may encounter long and less useful outputs if you simply add another column to `group_by()`. So, try this approach instead - create a column for each quantile level desired.

```
# get manually-specified percentile values of age (5%, 50%, 75%, 98%)
linelist %>%
  group_by(hospital) %>%
  summarise(
    p05 = quantile(age_years, probs = 0.05, na.rm=T),
    p50 = quantile(age_years, probs = 0.5, na.rm=T),
    p75 = quantile(age_years, probs = 0.75, na.rm=T),
    p98 = quantile(age_years, probs = 0.98, na.rm=T)
  )
```

```
# A tibble: 6 x 5
  hospital                p05    p50    p75    p98
  <chr>          <dbl> <dbl> <dbl> <dbl>
1 Central Hospital      1     12     21     48
2 Military Hospital      1     13     24     45
3 Missing                1     13     23    48.2
4 Other                  1     13     23     50
5 Port Hospital          1     14     24     49
6 St. Mark's Maternity Hospital (SMMH)  2     12     22    50.2
```

## Summarise aggregated data

If you begin with aggregated data, using `n()` return the number of *rows*, not the sum of the aggregated counts. To get sums, use `sum()` on the data's counts column.

For example, let's say you are beginning with the data frame of counts below, called `linelist_agg` - it shows in "long" format the case counts by outcome and gender.

Below we create this example data frame of `linelist` case counts by outcome and gender (missing values removed for clarity).

```
linelist_agg <- linelist %>%
  drop_na(gender, outcome) %>%
  count(outcome, gender)

linelist_agg
```

	outcome	gender	n
1	Death	f	1227
2	Death	m	1228
3	Recover	f	953
4	Recover	m	950

To sum the counts (in column `n`) by group you can use `summarise()` but set the new column equal to `sum(n, na.rm=T)`. To add a conditional element to the sum operation, you can use the subset bracket `[ ]` syntax on the counts column.

```
linelist_agg %>%
  group_by(outcome) %>%
  summarise(
    total_cases = sum(n, na.rm=T),
    male_cases  = sum(n[gender == "m"], na.rm=T),
    female_cases = sum(n[gender == "f"], na.rm=T))
```

```
# A tibble: 2 x 4
  outcome total_cases male_cases female_cases
  <chr>      <int>      <int>      <int>
1 Death      2455        1228        1227
2 Recover    1903         950         953
```

### **across() multiple columns**

You can use `summarise()` across multiple columns using `across()`. This makes life easier when you want to calculate the same statistics for many columns. Place `across()` within `summarise()` and specify the following:

- `.cols` = as either a vector of column names `c()` or “tidyselect” helper functions (explained below)
- `.fns` = the function to perform (no parentheses) - you can provide multiple within a `list()`

Below, `mean()` is applied to several numeric columns. A vector of columns are named explicitly to `.cols =` and a single function `mean` is specified (no parentheses) to `.fns =`. Any additional arguments for the function (e.g. `na.rm=TRUE`) are provided after `.fns =`, separated by a comma.

It can be difficult to get the order of parentheses and commas correct when using `across()`. Remember that within `across()` you must include the columns, the functions, and any extra arguments needed for the functions.

```
linelist %>%
  group_by(outcome) %>%
  summarise(across(.cols = c(age_years, temp, wt_kg, ht_cm), # columns
                    .fns = mean,                             # function
                    na.rm=T))                                # extra arguments
```

Warning: There was 1 warning in `summarise()`.

i In argument: `across(...)`.

i In group 1: `outcome = "Death"`.

Caused by warning:

! The `...` argument of `across()` is deprecated as of dplyr 1.1.0.

Supply arguments directly to `.fns` through an anonymous function instead.

```
# Previously
```

```
across(a:b, mean, na.rm = TRUE)
```

```
# Now
```

```
across(a:b, \(x) mean(x, na.rm = TRUE))
```

```
# A tibble: 3 x 5
```

```
  outcome age_years temp wt_kg ht_cm
  <chr>      <dbl> <dbl> <dbl> <dbl>
1 Death      15.9  38.6  52.6  125.
2 Recover    16.1  38.6  52.5  125.
3 <NA>       16.2  38.6  53.0  125.
```

Multiple functions can be run at once. Below the functions `mean` and `sd` are provided to `.fns =` within a `list()`. You have the opportunity to provide character names (e.g. “mean” and “sd”) which are appended in the new column names.

```
linelist %>%
  group_by(outcome) %>%
  summarise(across(.cols = c(age_years, temp, wt_kg, ht_cm), # columns
```

```
.fns = list("mean" = mean, "sd" = sd), # multiple functions
na.rm=T)) # extra arguments
```

```
# A tibble: 3 x 9
  outcome age_years_mean age_years_sd temp_mean temp_sd wt_kg_mean wt_kg_sd
  <chr>         <dbl>         <dbl>         <dbl>    <dbl>         <dbl>    <dbl>
1 Death           15.9           12.3           38.6    0.962           52.6     18.4
2 Recover          16.1           13.0           38.6    0.997           52.5     18.6
3 <NA>             16.2           12.8           38.6    0.976           53.0     18.9
# i 2 more variables: ht_cm_mean <dbl>, ht_cm_sd <dbl>
```

Here are those “tidyselect” helper functions you can provide to `.cols =` to select columns:

- `everything()` - all other columns not mentioned
- `last_col()` - the last column
- `where()` - applies a function to all columns and selects those which are TRUE
- `starts_with()` - matches to a specified prefix. Example: `starts_with("date")`
- `ends_with()` - matches to a specified suffix. Example: `ends_with("_end")`
- `contains()` - columns containing a character string. Example: `contains("time")`
- `matches()` - to apply a regular expression (regex). Example: `contains("[pt]al")`
- `num_range()` -
- `any_of()` - matches if column is named. Useful if the name might not exist. Example: `any_of(date_onset, date_death, cardiac_arrest)`

For example, to return the mean of every numeric column use `where()` and provide the function `as.numeric()` (without parentheses). All this remains within the `across()` command.

```
linelist %>%
  group_by(outcome) %>%
  summarise(across(
    .cols = where(is.numeric), # all numeric columns in the data frame
    .fns = mean,
    na.rm=T))
```

```
# A tibble: 3 x 12
  outcome generation   age age_years   lon   lat wt_kg ht_cm ct_blood  temp
```

```

      <chr>          <dbl> <dbl>          <dbl> <dbl> <dbl> <dbl> <dbl>          <dbl> <dbl>
1 Death            16.7  15.9          15.9 -13.2  8.47  52.6  125.          21.3  38.6
2 Recover          16.4  16.2          16.1 -13.2  8.47  52.5  125.          21.1  38.6
3 <NA>             16.5  16.3          16.2 -13.2  8.47  53.0  125.          21.2  38.6
# i 2 more variables: bmi <dbl>, days_onset_hosp <dbl>

```

## Total rows

When `summarise()` operates on grouped data it does not automatically produce “total” statistics. Below, two approaches to adding a total row are presented:

### \* `janitor`’s `adorn_totals()`

If your table consists only of counts or proportions/percents that can be summed into a total, then you can add *sum* totals using `janitor`’s `adorn_totals()` as described in the section above. Note that this function can only sum the numeric columns - if you want to calculate other total summary statistics see the next approach with `dplyr`.

Below, `linelist` is grouped by gender and summarised into a table that described the number of cases with known outcome, deaths, and recovered. Piping the table to `adorn_totals()` adds a total row at the bottom reflecting the sum of each column. The further `adorn_*`() functions adjust the display as noted in the code.

```

linelist %>%
  group_by(gender) %>%
  summarise(
    known_outcome = sum(!is.na(outcome)),      # Number of rows in group where outcome is known
    n_death = sum(outcome == "Death", na.rm=T), # Number of rows in group where outcome is Death
    n_recover = sum(outcome == "Recover", na.rm=T), # Number of rows in group where outcome is Recover
  ) %>%
  adorn_totals() %>%                          # Adorn total row (sums of each numeric column)
  adorn_percentages("col") %>%               # Get column proportions
  adorn_pct_formatting() %>%                 # Convert proportions to percents
  adorn_ns(position = "front")               # display % and counts (with counts in front)

```

gender	known_outcome	n_death	n_recover
f	2,180 (47.8%)	1,227 (47.5%)	953 (48.1%)
m	2,178 (47.7%)	1,228 (47.6%)	950 (47.9%)
<NA>	207 (4.5%)	127 (4.9%)	80 (4.0%)
Total	4,565 (100.0%)	2,582 (100.0%)	1,983 (100.0%)



\* `summarise()` on “total” data and then `bind_rows()`

If your table consists of summary statistics such as `median()`, `mean()`, etc, the `adorn_totals()` approach shown above will *not* be sufficient. Instead, to get summary statistics for the entire dataset you must calculate them with a separate `summarise()` command and then bind the results to the original grouped summary table. You can make a summary table of outcome *by hospital* with `group_by()` and `summarise()` like this:

```
by_hospital <- linelist %>%
  filter(!is.na(outcome) & hospital != "Missing") %>% # Remove cases with missing outcome
  group_by(hospital, outcome) %>% # Group data
  summarise( # Create new summary columns of interest
    N = n(), # Number of rows per hospital-outcome
    ct_value = median(ct_blood, na.rm=T)) # median CT value per group

by_hospital # print table
```

# A tibble: 10 x 4

# Groups: hospital [5]

	hospital	outcome	N	ct_value
	<chr>	<chr>	<int>	<dbl>
1	Central Hospital	Death	193	22
2	Central Hospital	Recover	165	22
3	Military Hospital	Death	399	21
4	Military Hospital	Recover	309	22
5	Other	Death	395	22
6	Other	Recover	290	21
7	Port Hospital	Death	785	22
8	Port Hospital	Recover	579	21
9	St. Mark's Maternity Hospital (SMMH)	Death	199	22
10	St. Mark's Maternity Hospital (SMMH)	Recover	126	22

To get the totals, run the same `summarise()` command but only group the data by outcome (not by hospital), like this:

```
totals <- linelist %>%
  filter(!is.na(outcome) & hospital != "Missing") %>%
  group_by(outcome) %>% # Grouped only by outcome, not by hospital
  summarise( # These statistics are now by outcome
    N = n(),
    ct_value = median(ct_blood, na.rm=T))
```

```
totals # print table
```

```
# A tibble: 2 x 3
  outcome      N ct_value
  <chr>    <int>    <dbl>
1 Death    1971      22
2 Recover 1469      22
```

We can bind these two data frames together. Note that `by_hospital` has 4 columns whereas `totals` has 3 columns. By using `bind_rows()`, the columns are combined by name, and any extra space is filled in with `NA` (e.g the column `hospital` values for the two new `totals` rows). After binding the rows, we convert these empty spaces to “Total” using `replace_na()`.

```
table_long <- bind_rows(by_hospital, totals) %>%
  mutate(hospital = replace_na(hospital, "Total"))
```

Here is the new table with “Total” rows at the bottom.

Show 

12 ▾

 entries

Search:

hospital			
Central Hospital	Death	193	22
Central Hospital	Recover	165	22
Military Hospital	Death	399	21
Military Hospital	Recover	309	22
Other	Death	395	22
Other	Recover	290	21
Port Hospital	Death	785	22
Port Hospital	Recover	579	21
St. Mark's Maternity Hospital (SMMH)	Death	199	22
St. Mark's Maternity Hospital (SMMH)	Recover	126	22
Total	Death	1971	22
Total	Recover	1469	22

Showing 1 to 12 of 12 entries

Previous 

1

 Next

This table is in a “long” format, which may be what you want. *Optionally*, you can *pivot* this table *wider* to make it more readable (which we will learn about later). You can also add more columns, and arrange it nicely. This code is below.

```
table_long %>%

# Pivot wider and format
#####
mutate(hospital = replace_na(hospital, "Total")) %>%
pivot_wider(                                # Pivot from long to wide
  values_from = c(ct_value, N),            # new values are from ct and count
  names_from = outcome) %>%               # new column names are from outcome
mutate(                                     # Add new columns
  N_Known = N_Death + N_Recover,           # number with known outcome
  Pct_Death = scales::percent(N_Death / N_Known, 0.1), # percent cases who died
  Pct_Recover = scales::percent(N_Recover / N_Known, 0.1)) %>% # percent who recovered
select(                                    # Re-order columns
  hospital, N_Known,                      # Intro columns
  N_Recover, Pct_Recover, ct_value_Recover, # Recovered columns
  N_Death, Pct_Death, ct_value_Death) %>% # Death columns
arrange(N_Known)                          # Arrange rows from lowest to highest

# A tibble: 6 x 8
# Groups:   hospital [6]
  hospital      N_Known N_Recover Pct_Recover ct_value_Recover N_Death Pct_Death
  <chr>          <int>    <int> <chr>          <dbl>    <int> <chr>
1 St. Mark's M~    325      126 38.8%           22      199 61.2%
2 Central Hosp~    358      165 46.1%           22      193 53.9%
3 Other            685      290 42.3%           21      395 57.7%
4 Military Hos~    708      309 43.6%           22      399 56.4%
5 Port Hospital   1364      579 42.4%           21      785 57.6%
6 Total           3440     1469 42.7%           22     1971 57.3%
# i 1 more variable: ct_value_Death <dbl>
```

In the next chapter we’ll see how to create an attractive visualization of the table, as shown here:

Hospital	Total cases with known outcome	Recovered			To
		Total	% of cases	Median CT values	
St. Mark's Maternity Hospital (SMMH)	325	126	38.8%	22	19
Central Hospital	358	165	46.1%	22	19
Other	685	290	42.3%	21	39
Military Hospital	708	309	43.6%	22	39
Missing	1,125	514	45.7%	21	61
<b>Port Hospital</b>	<b>1,364</b>	<b>579</b>	<b>42.4%</b>	<b>21</b>	<b>78</b>
Total	3,440	1,469	42.7%	22	1,9

## base R

You can use the function `table()` to tabulate and cross-tabulate columns. Unlike the options above, you must specify the dataframe each time you reference a column name, as shown below.

### Warning

NA (missing) values will **not** be tabulated unless you include the argument `useNA = "always"` (which could also be set to “no” or “ifany”).

### Tip

You can use the `%%` from **magrittr** to remove the need for repeating data frame calls within **base** functions. For example the below could be written `linelist %>% table(outcome, useNA = "always")`

```
table(linelist$outcome, useNA = "always")
```

```
Death Recover <NA>
2582 1983 1323
```

Multiple columns can be cross-tabulated by listing them one after the other, separated by commas. Optionally, you can assign each column a “name” like `Outcome = linelist$outcome`.

```
age_by_outcome <- table(linelist$age_cat, linelist$outcome, useNA = "always") # save table
age_by_outcome      # print table
```

	Death	Recover	<NA>
0-4	471	364	260
5-9	476	391	228
10-14	438	303	200
15-19	323	251	169
20-29	477	367	229
30-49	329	238	187
50-69	33	38	24
70+	3	3	0
<NA>	32	28	26

## Proportions

To return proportions, passing the above table to the function `prop.table()`. Use the `margins` = argument to specify whether you want the proportions to be of rows (1), of columns (2), or of the whole table (3). For clarity, we pipe the table to the `round()` function from **base R**, specifying 2 digits.

```
# get proportions of table defined above, by rows, rounded
prop.table(age_by_outcome, 1) %>% round(2)
```

	Death	Recover	<NA>
0-4	0.43	0.33	0.24
5-9	0.43	0.36	0.21
10-14	0.47	0.32	0.21
15-19	0.43	0.34	0.23
20-29	0.44	0.34	0.21
30-49	0.44	0.32	0.25
50-69	0.35	0.40	0.25
70+	0.50	0.50	0.00
<NA>	0.37	0.33	0.30

## Totals

To add row and column totals, pass the table to `addmargins()`. This works for both counts and proportions.

```
addmargins(age_by_outcome)
```

	Death	Recover	<NA>	Sum
0-4	471	364	260	1095
5-9	476	391	228	1095
10-14	438	303	200	941
15-19	323	251	169	743
20-29	477	367	229	1073
30-49	329	238	187	754
50-69	33	38	24	95
70+	3	3	0	6
<NA>	32	28	26	86
Sum	2582	1983	1323	5888