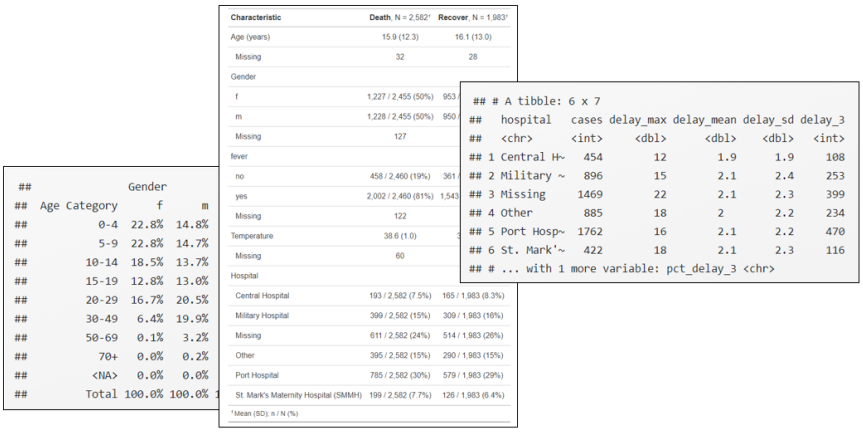
# Descriptive analysis



| Characteristic | Death, N = 2,582[1] | Recover, N = 1,983[1] |
|---|---|---|
| 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%) |

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

```
##              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% 1
```

```
## # 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     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>
```

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.

## Preparation

### Load packages

This code chunk shows the loading of packages required for the analyses. In this handbook we emphasize `p_load()` from **pacman**, which installs the package if necessary *and* loads it for use. You can also load installed packages with `library()` from **base** R. See the page on [R basics] for more information on R 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 your data with the `import()` function from the **rio** package (it accepts many file types like .xlsx, .rds, .csv - see the [Import and export] page for details).

```
# 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()`. See the [R basics] page for a complete list.

***CAUTION:*** 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** packages 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`. Read more on the [Factors] page.

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

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

| | Gender | | | | | |
|---|---|---|---|---|---|---|
| Age Category | 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. This is discussed in the page [Tables for presentation]. 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:

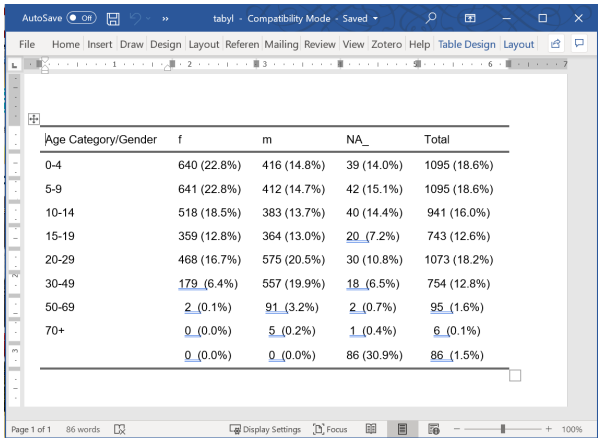
```
linelist %>%
  count(hospital) %>%   # dplyr function
  adorn_totals()        # janitor function
```

```
                              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** (as discussed more extensively in the [Tables for presentation] page). 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
```




### 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`.

```r
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
```

See the page on [Simple statistical tests] for more code and tips about statistics.

### Other tips

- Include the argument `na.rm = TRUE` to exclude missing values from any of the above calculations.
- If applying any `adorn_*()` helper functions to tables not created by `tabyl()`, you can specify particular column(s) to apply them to like `adorn_percentage(,,,c(cases,deaths))` (specify them to the 4th unnamed argument). The syntax is not simple. Consider using `summarise()` instead.
- You can read more detail in the janitor page and this tabyl vignette.

## 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* (see [Grouping data] page).

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. See the page on [Pivoting data] to learn about "long" and "wide" data formats.

```
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. As explained in the Grouping data page, *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).

```r
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`.

```r
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 installe
```

Show 12 entries Search:

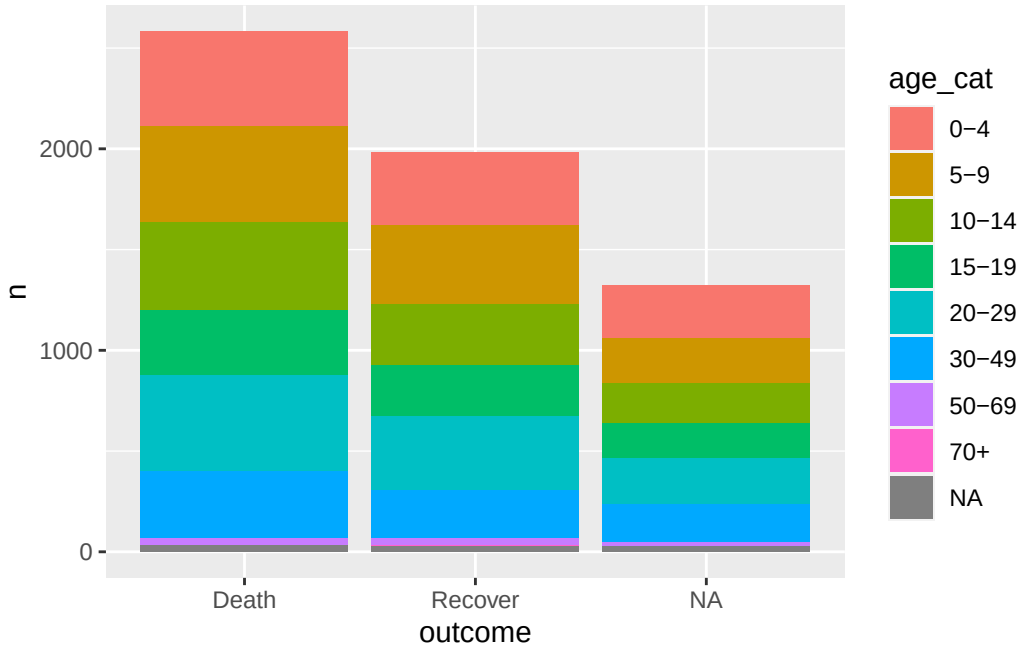
| outcome | | | age_cat |
|---|---|---|---|
| Death | 0-4 | 471 | 18.242% |
| Death | 5-9 | 476 | 18.435% |
| Death | 10-14 | 438 | 16.964% |
| Death | 15-19 | 323 | 12.510% |
| Death | 20-29 | 477 | 18.474% |
| Death | 30-49 | 329 | 12.742% |
| Death | 50-69 | 33 | 1.278% |
| Death | 70+ | 3 | 0.116% |
| 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 calculati
  summarise(                                                           # only the below summ
    cases       = n(),                                                  # number of rows per
    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, rounde
    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 wit
    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.

In the [Characters and strings] page, various options for combining columns are discussed, including `unite()`, and `paste0()`. In this use case, we advocate for `str_glue()` because it is more flexible than `unite()` and has more simple syntax than `paste0()`.

Below, the `summary_table` data frame (created above) is mutated such that columns `delay_mean` and `delay_sd` are combined, parentheses formating 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.! (see the [Tables for presentation] page).

```
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 | % delay 3+ days |
|---|---|---|---|---|---|
| Central Hospital | 454 | 12 | 1.9 (1.9) | 108 | 24% |
| Military Hospital | 896 | 15 | 2.1 (2.4) | 253 | 28% |
| 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 | |

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.

```r
# 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.

```r
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.

```r
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>
```

### Pivot wider

If you prefer your table in "wide" format you can transform it using the **tidyr** `pivot_wider()` function. You will likely need to re-name the columns with `rename()`. For more information see the page on [Pivoting data].

The example below begins with the "long" table `age_by_outcome` from the proportions section. We create it again and print, for clarity:

```
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
```

Show 5 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% |

Showing 1 to 5 of 26 entries Previous 1 2 3 4 5 6 Next

To pivot wider, we create the new columns from the *values* in the existing column `age_cat` (by setting `names_from = age_cat`). We also specify that the new table values will come from the existing column `n`, with `values_from = n`. The columns not mentioned in our pivoting command (`outcome`) will remain unchanged on the far left side.

```
age_by_outcome %>%
  select(-percent) %>%   # keep only counts for simplicity
  pivot_wider(names_from = age_cat, values_from = n)
```

```
# A tibble: 3 x 10
# Groups:   outcome [3]
  outcome `0-4` `5-9` `10-14` `15-19` `20-29` `30-49` `50-69` `70+`  `NA`
  <chr>   <int> <int>   <int>   <int>   <int>   <int>   <int> <int> <int>
1 Death     471   476     438     323     477     329      33     3    32
2 Recover   364   391     303     251     367     238      38     3    28
3 <NA>      260   228     200     169     229     187      24    NA    26
```

### 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 outcom
    n_death  = sum(outcome == "Death", na.rm=T),    # Number of rows in group where outcom
    n_recover = sum(outcome == "Recover", na.rm=T), # Number of rows in group where outcom
  ) %>%
```

```
  adorn_totals() %>%                                  # Adorn total row (sums of each numeri
  adorn_percentages("col") %>%                        # Get column proportions
  adorn_pct_formatting() %>%                          # Convert proportions to percents
  adorn_ns(position = "front")                        # display % and counts (with counts in
```

```
 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. To do the binding you can use `bind_rows()` from **dplyr** s described in the [Joining data] page. Below is an example:

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 ind
    N = n(),                                            # Number of rows per hospital-outc
    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 h
      summarise(
        N = n(),                                        # These statistics are now by outco
        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()` (see [Cleaning data and core functions] page).

```
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. See the section on pivoting wider above, and the [Pivoting data] page. 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 outcom
  mutate(                                               # Add new columns
    N_Known = N_Death + N_Recover,                                  # number with known outco
    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 | | | |
|---|---|---|---|---|---|
| | | Total | % of cases | Median CT values | To |
| 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 |
| **Port Hospital** | **1,364** | **579** | **42.4%** | **21** | **78** |
| 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")`

```r
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`.

```r
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.

```r
# 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
```