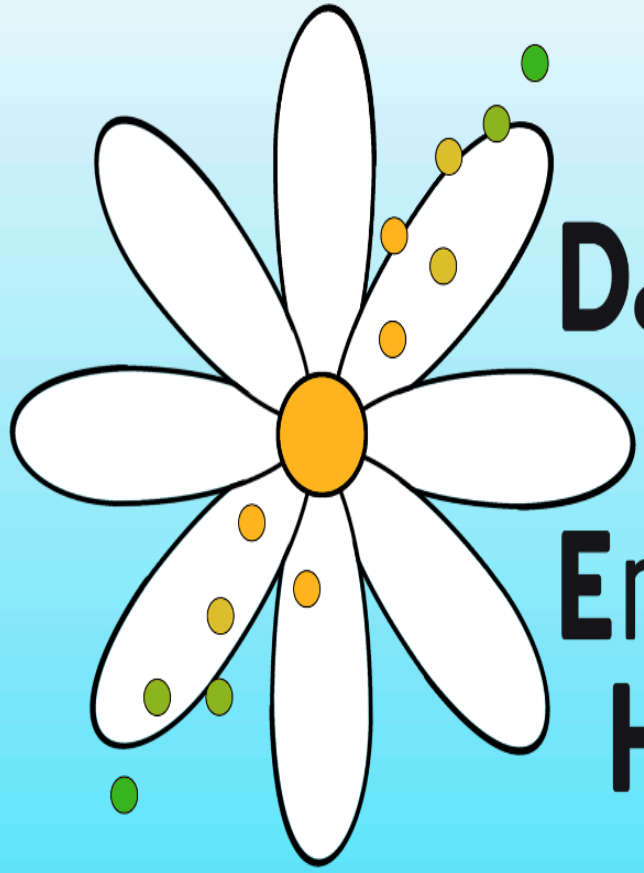
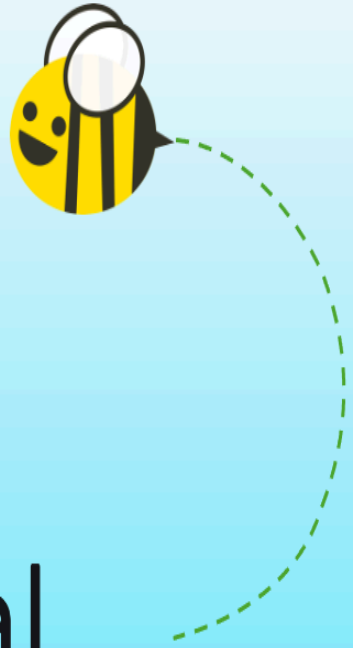


Data Science for Environmental Health



Factors

Factors

A `factor` is a special `character` vector where the elements have pre-defined groups or 'levels'. You can think of these as qualitative or categorical variables:

```
x <- c("yellow", "red", "red", "blue", "yellow", "blue")
class(x)
```

```
## [1] "character"
```

```
x_fact <- factor(x) # factor() is a function
class(x_fact)
```

```
## [1] "factor"
```

Factors

Factors have **levels** (character types do not).

```
x
```

```
## [1] "yellow" "red"    "red"    "blue"   "yellow" "blue"
```

```
x_fact
```

```
## [1] yellow red    red    blue   yellow blue
## Levels: blue red yellow
```

Note that levels are, by default, in **alphanumerical** order.

Factors

Extract the levels of a `factor` vector using `levels()`:

```
levels(x_fact)
```

```
## [1] "blue"   "red"    "yellow"
```

`forcats` package

A package called `forcats` is really helpful for working with factors.

`factor()` vs `as_factor()`

`factor()` is from base R and `as_factor()` is from `forcats`

Both can change a variable to be of class factor.

- `factor()` will order **alphabetically** unless told otherwise.
- `as_factor()` will order by **first appearance** unless told otherwise.

If you are assigning your levels manually either function is fine!

`as_factor()` function

```
x <- c("yellow", "red", "red", "blue", "yellow", "blue")
x_fact_2 <- as_factor(x)
x_fact_2
```

```
## [1] yellow red    red    blue   yellow blue
## Levels: yellow red blue
```

```
# Compare to factor() method:
x_fact
```

```
## [1] yellow red    red    blue   yellow blue
## Levels: blue red yellow
```

A Factor Example

We will use data on heat-related visits to the ER from the State of Colorado, separated by age category, for 2011-2022. More on this data can be found here: https://coepht.colorado.gov/heat-related-illness

You can download the data from the DaSEH website here:
https://daseh.org/data/CO_ER_heat_visits_by_age_data.csv

This dataset is also available in the `dasehr` package.

We will limit the data to only one of the `gender` categories - we will choose "Both genders" because of data missingness.

```
library(dasehr)
er_visits_age <- CO_heat_ER_byage

#er_visits_age <- read_csv("https://daseh.org/data/CO_ER_heat_visits_by_age_data.csv")

er_visits_age <- er_visits_age %>%
  filter(str_detect(GENDER, "Both genders"))
```

The data

```
head(er_visits_age)
```

```
## # A tibble: 6 × 7
##    YEAR GENDER       AGE              RATE L95CL U95CL VISITS
##   <dbl> <chr>        <chr>           <dbl> <dbl> <dbl>  <dbl>
## 1  2011 Both genders 0-4 years old    3.52  1.82  6.16     12
## 2  2011 Both genders 15-34 years old  7.34  5.95  8.74    106
## 3  2011 Both genders 35-64 years old  5.84  4.80  6.88    121
## 4  2011 Both genders 5-14 years old   5.20  3.50  6.90     36
## 5  2011 Both genders 65+ years old    8.34  5.98 10.7      48
## 6  2011 Both genders All ages         6.30  5.62  6.99    323
```

Notice that `AGE` is a `chr` variable. This indicates that the values are **character** strings.

R does not realize that there is any order related to the `AGE` values. It will assume that it is **alphabetical** (for numbers, this means ascending order).

However, we know that the order is: **0-4 years old**, **5-14 years old**, **15-34 years old**, **35-64 years old**, **65+ years old**, and **All ages**.

For the next steps, let's take a subset of data.

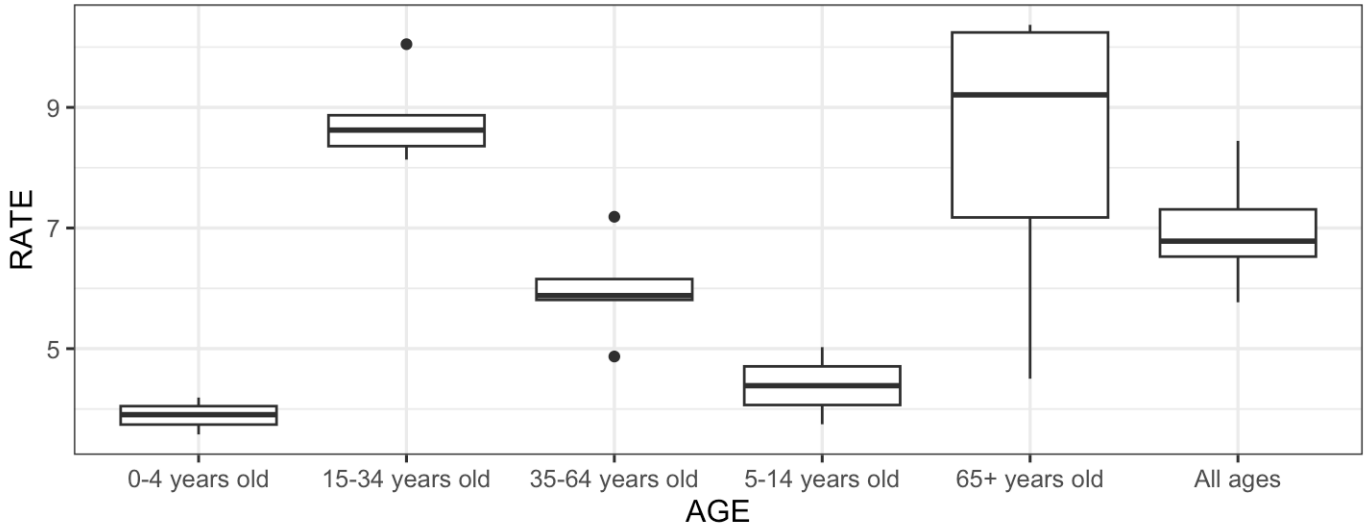
Use `set.seed()` to take the same random sample each time.

```
set.seed(123)
er_visits_age_subset <- slice_sample(er_visits_age, n = 32)
```

Plot the data

Let's make a plot first.

```
er_visits_age_subset %>%
  ggplot(mapping = aes(x = AGE, y = RATE)) +
  geom_boxplot() +
  theme_bw(base_size = 12) # make all labels size 12
```



OK this is very useful, but it is a bit difficult to read. We expect the values to be plotted by the order that we know, not by alphabetical order.

Change to factor

Currently `AGE` is class `character` but let's change that to class `factor` which allows us to specify the levels or order of the values.

```
er_visits_age_fct <-
  er_visits_age_subset %>%
  mutate(AGE = factor(AGE,
    levels = c("0-4 years old", "5-14 years old", "15-34 years old", "35-64 ye
  ))

er_visits_age_fct %>%
  pull(AGE) %>%
  levels()
```

```
## [1] "0-4 years old"   "5-14 years old"  "15-34 years old" "35-64 years old"
## [5] "65+ years old"   "All ages"
```

Change to a factor

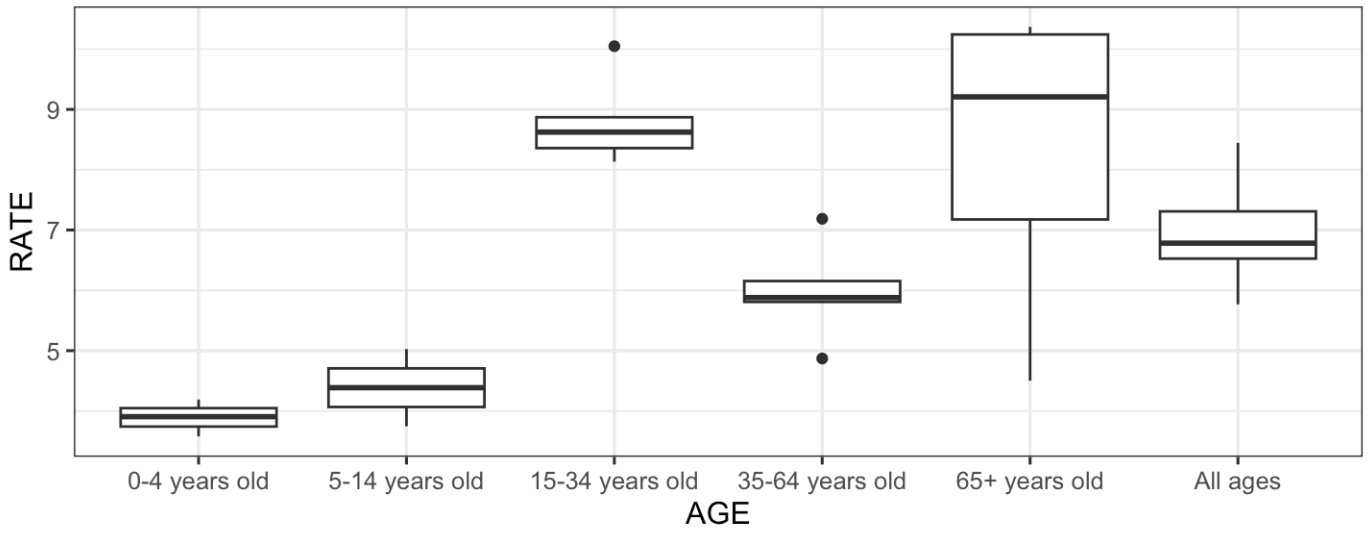
```
head(er_visits_age_fct)
```

```
## # A tibble: 6 × 7
##    YEAR GENDER       AGE              RATE L95CL U95CL VISITS
##   <dbl> <chr>        <fct>           <dbl> <dbl> <dbl>  <dbl>
## 1  2016 Both genders 0-4 years old    4.19  2.29  7.03     14
## 2  2019 Both genders 35-64 years old  7.19  6.07  8.30    159
## 3  2013 Both genders 15-34 years old  8.13  6.69  9.58    121
## 4  2022 Both genders 0-4 years old   NA    NA    NA         NA
## 5  2017 Both genders All ages         5.77  5.14  6.40    323
## 6  2019 Both genders 15-34 years old  8.34  6.94  9.73    137
```

Plot again

Now let's make our plot again:

```
er_visits_age_fct %>%
  ggplot(mapping = aes(x = AGE, y = RATE)) +
  geom_boxplot() +
  theme_bw(base_size = 12)
```



Now that's more like it! Notice how the data is automatically plotted in the order we would like.

What about if we `arrange()` the data by grade ?

Character data is arranged alphabetically (if letters) or by ascending first number (if numbers).

```
er_visits_age_subset %>%
  arrange(AGE)
```

```
## # A tibble: 32 × 7
##     YEAR GENDER       AGE              RATE L95CL U95CL VISITS
##    <dbl> <chr>        <chr>           <dbl> <dbl> <dbl>  <dbl>
##  1  2016 Both genders 0-4 years old    4.19  2.29  7.03     14
##  2  2022 Both genders 0-4 years old   NA    NA    NA        NA
##  3  2018 Both genders 0-4 years old    3.91  2.08  6.68     13
##  4  2015 Both genders 0-4 years old   NA    NA    NA        NA
##  5  2021 Both genders 0-4 years old   NA    NA    NA        NA
##  6  2012 Both genders 0-4 years old    3.58  1.85  6.25     12
##  7  2020 Both genders 0-4 years old   NA    NA    NA        NA
##  8  2014 Both genders 0-4 years old   NA    NA    NA        NA
##  9  2013 Both genders 15-34 years old  8.13  6.69  9.58    121
## 10  2019 Both genders 15-34 years old  8.34  6.94  9.73    137
## # ℹ 22 more rows
```

Notice that the order is not what we would hope for!

Arranging Factors

Factor data is arranged by level.

```
er_visits_age_fct %>%
  arrange(AGE)
```

```
## # A tibble: 32 × 7
##     YEAR GENDER       AGE             RATE L95CL U95CL VISITS
##    <dbl> <chr>        <fct>          <dbl> <dbl> <dbl>  <dbl>
##  1  2016 Both genders 0-4 years old   4.19  2.29  7.03     14
##  2  2022 Both genders 0-4 years old  NA    NA    NA        NA
##  3  2018 Both genders 0-4 years old   3.91  2.08  6.68     13
##  4  2015 Both genders 0-4 years old  NA    NA    NA        NA
##  5  2021 Both genders 0-4 years old  NA    NA    NA        NA
##  6  2012 Both genders 0-4 years old   3.58  1.85  6.25     12
##  7  2020 Both genders 0-4 years old  NA    NA    NA        NA
##  8  2014 Both genders 0-4 years old  NA    NA    NA        NA
##  9  2022 Both genders 5-14 years old  3.75  2.31  5.19     26
## 10  2015 Both genders 5-14 years old  5.03  3.38  6.67     36
## # ℹ 22 more rows
```

Nice! Now this is what we would want!

Making tables with characters

Tables grouped by a character are arranged alphabetically (if letters) or by ascending first number (if numbers).

```
er_visits_age_subset %>%
  group_by(AGE) %>%
  summarize(total_visits = sum(VISITS, na.rm = T))
```

```
## # A tibble: 6 × 2
##   AGE             total_visits
##   <chr>                  <dbl>
## 1 0-4 years old             39
## 2 15-34 years old          831
## 3 35-64 years old          649
## 4 5-14 years old            62
## 5 65+ years old            389
## 6 All ages                1943
```

Making tables with factors

Tables grouped by a factor are arranged by level.

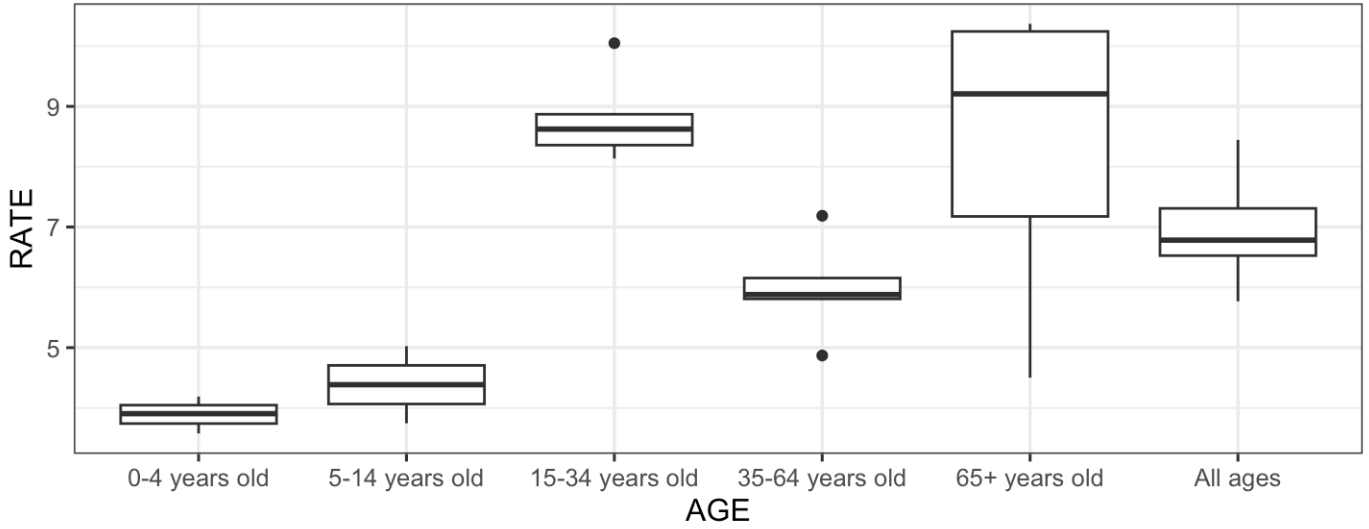
```
er_visits_age_fct %>%
  group_by(AGE) %>%
  summarize(total_visits = sum(VISITS, na.rm = T))
```

```
## # A tibble: 6 × 2
##   AGE             total_visits
##   <fct>                  <dbl>
## 1 0-4 years old             39
## 2 5-14 years old            62
## 3 15-34 years old          831
## 4 35-64 years old          649
## 5 65+ years old            389
## 6 All ages                1943
```

`forcats` for ordering

What if we wanted to order `AGE` by increasing `` `RATE` ``?

```
library(forcats)

er_visits_age_fct %>%
  ggplot(mapping = aes(x = AGE, y = RATE)) +
  geom_boxplot() +
  theme_bw(base_size = 12)
```



This would be useful for identifying easily which age group to focus on.

forcats for ordering

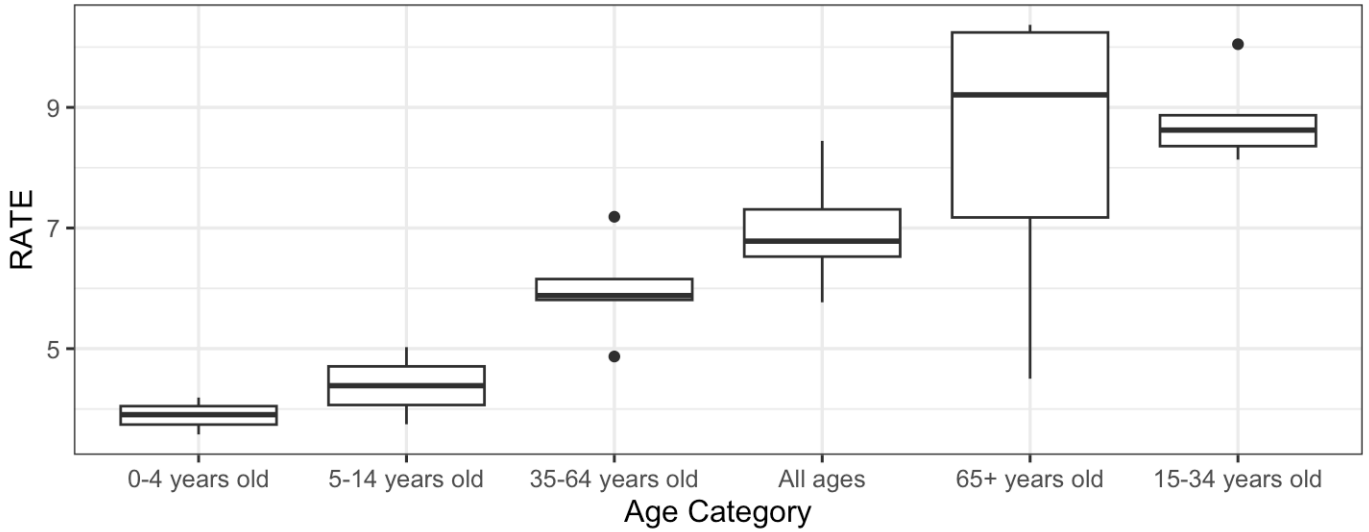
We can order a factor by another variable by using the `fct_reorder()` function of the `forcats` package.

```
fct_reorder({column getting changed}, {guiding column}, {summarizing function})
```

forcats for ordering

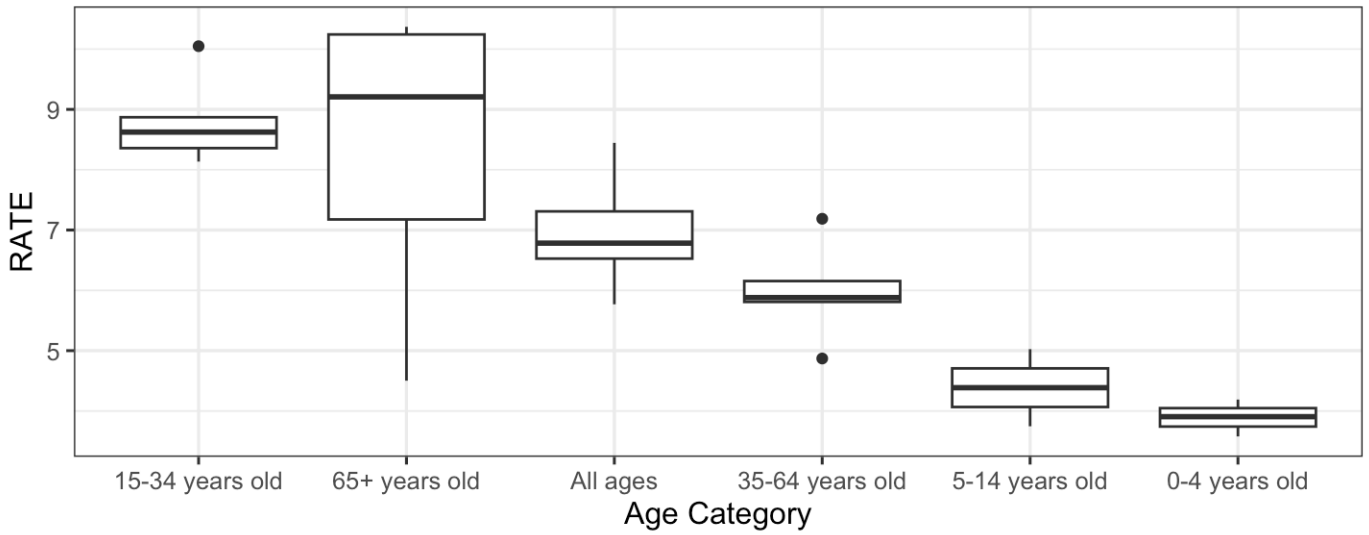
We can order a factor by another variable by using the `fct_reorder()` function of the `forcats` package.

```
library(forcats)

er_visits_age_fct %>%
  ggplot(mapping = aes(x = fct_reorder(AGE, RATE, mean), y = RATE)) +
  geom_boxplot() +
  labs(x = "Age Category") +
  theme_bw(base_size = 12)
```



forcats for ordering.. with `.desc =` argument

```
library(forcats)

er_visits_age_fct %>%
  ggplot(mapping = aes(x = fct_reorder(AGE, RATE, mean, .desc = TRUE), y = RATE)) +
  geom_boxplot() +
  labs(x = "Age Category") +
  theme_bw(base_size = 12)
```



forcats for ordering.. can be used to sort datasets

```
er_visits_age_fct %>% pull(AGE) %>% levels() # By year order
```

```
## [1] "0-4 years old"   "5-14 years old"  "15-34 years old" "35-64 years old"
## [5] "65+ years old"   "All ages"
```

```
er_visits_age_fct <- er_visits_age_fct %>%
  mutate(
    AGE = fct_reorder(AGE, RATE, mean)
  )

er_visits_age_fct %>% pull(AGE) %>% levels() # by increasing mean dropouts
```

```
## [1] "0-4 years old"   "5-14 years old"  "35-64 years old" "All ages"
## [5] "65+ years old"   "15-34 years old"
```

Checking Proportions with `fct_count()`

The `fct_count()` function of the `forcats` package is helpful for checking that the proportions of each level for a factor are similar. Need the `prop = TRUE` argument otherwise just counts are reported.

```
er_visits_age_fct %>%
  pull(AGE) %>%
  fct_count(prop = TRUE)
```

```
## # A tibble: 6 × 3
##   f                   n      p
##   <fct>           <int>  <dbl>
## 1 0-4 years old       8 0.25
## 2 5-14 years old      2 0.0625
## 3 35-64 years old     5 0.156
## 4 All ages            5 0.156
## 5 65+ years old       6 0.188
## 6 15-34 years old     6 0.188
```

Summary

- the factor class allows us to have a different order from alphanumeric for categorical data
- we can change data to be a factor variable using `mutate` and a factor creating function like `factor()` or `as_factor`
- the `as_factor()` is from the `forcats` package (first appearance order by default)
- the `factor()` base R function (alphabetical order by default)
- with `factor()` we can specify the levels with the `levels` argument if we want a specific order
- the `fct_reorder({variable_to_reorder}, {variable_to_order_by}, {summary function})` helps us reorder a variable by the values of another variable
- arranging, tabulating, and plotting the data will reflect the new order

Lab

Class Website
Lab

Image by Gerd Altmann from Pixabay