Manipulating data

This guide is partly based on online material from Amy Willis, Kiirsti Owen and Amelia McNamara, and the book "R for Data Science" by Hadley Wickham and Garrett Grolemund. Thank you amazing R community!

Load packages

We will be using the readr, tidyr and dplyr packages from the Tidyverse family of packages. We will also load the "here" package that we will use to read in our data.

```
library(readr)
library(tidyr)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(here)
```

```
## here() starts at /home/myke/Desktop/Intro2HDS_R_WEEK5_MAIN
```

```
library(ggplot2)
```

First, let's practice with pivoting

We will start with a toy non-tidy dataset:

```
patient_ID <- c(1,2)
test_result_month1 <- c("a1" ,"a2")
test_result_month2 <- c("b1" ,"b2")
test_result_month3 <- c("c1" ,"c2")

patient_tests <- data.frame(patient_ID,test_result_month1,test_result_month2,test_result_month3)

patient_tests
```

```
##   patient_ID test_result_month1 test_result_month2 test_result_month3
## 1          1                 a1                 b1                 c1
## 2          2                 a2                 b2                 c2
```

The dataset is not tidy because each row contains three observations, one per month. A tidy dataset has one observation per row. To do this, we use pivot_longer.

- The first argument is the dataset to reshape, but as we are using the pipe (%>%) we are skipping the first argument.
- The next argument describes which columns need to be reshaped. In this case, it's every column apart from patient_ID.
- The names_to gives the name of the variable that will be created from the data stored in the column names, in this case the month.
- The values_to gives the name of the variable that will be created from the data stored in the cell value, in this case the test result.

```
tidy_patient_tests <- patient_tests %>%
  pivot_longer(
    c('test_result_month1','test_result_month2','test_result_month3'),
    names_to= 'month',
    values_to='test_result'
    )

tidy_patient_tests
```

```
## # A tibble: 6 x 3
##   patient_ID month              test_result
##        <dbl> <chr>              <chr>
## 1          1 test_result_month1 a1
## 2          1 test_result_month2 b1
## 3          1 test_result_month3 c1
## 4          2 test_result_month1 a2
## 5          2 test_result_month2 b2
## 6          2 test_result_month3 c2
```

As you can see, the data frame is now tidy (one observation per row), but it would be better if the "month" column just contained the month number (1,2,3). To do this we can add the arguments names_prefix to strip off the test_result_month prefix, and names_transform to convert month into an integer:

```
tidy_patient_tests <- patient_tests %>%
  pivot_longer(
    c('test_result_month1','test_result_month2','test_result_month3'),
    names_to= 'month',
    names_prefix = 'test_result_month',
    names_transform = list(month = as.integer),
    values_to='test_result'
    )
tidy_patient_tests
```

```
## # A tibble: 6 x 3
##   patient_ID month test_result
##        <dbl> <int> <chr>
```

```
## 1           1      1 a1
## 2           1      2 b1
## 3           1      3 c1
## 4           2      1 a2
## 5           2      2 b2
## 6           2      3 c2
```

Reading in the FEV data

We will use the same data as last week. So read in the data from file fev.csv and save it in an object called fev_data:

```
# Add your code here!
fev_data <- read_csv(here("INPUTS/WEEK6/fev.csv"))
```

```
## Rows: 654 Columns: 7
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## dbl (7): seqnbr, subjid, age, fev, height, sex, smoke
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Tip: If you got an error that "fev.csv" does not exist, check that you are working in the correct directory!

Operating on data: subsets

To select subsets of the data (not just columns with $) use square brackets:

```
fev_data$fev[32] # 32nd element of the fev column
```

```
## [1] 3
```

```
fev_data[32,3] # 32nd element of the 3rd column
```

```
## # A tibble: 1 x 1
##     age
##   <dbl>
## 1     9
```

```
fev_data[32,"age"]  # Same thing, but using the name of the 3rd column - better, as it is more readable
```

```
## # A tibble: 1 x 1
##     age
##   <dbl>
## 1     9
```

```
fev_data[32, ] # Everything in the 3rd row
```

```
## # A tibble: 1 x 7
##   seqnbr subjid   age   fev height   sex smoke
##    <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1     32   7201     9     3   65.5     1     0
```

```r
fev_data[32,1:3]
```

```
## # A tibble: 1 x 3
##   seqnbr subjid   age
##    <dbl>  <dbl> <dbl>
## 1     32   7201     9
```

```r
fev_data[32,-5]
```

```
## # A tibble: 1 x 6
##   seqnbr subjid   age   fev   sex smoke
##    <dbl>  <dbl> <dbl> <dbl> <dbl> <dbl>
## 1     32   7201     9     3     1     0
```

```r
fev_data[32,-1:-2]
```

```
## # A tibble: 1 x 5
##     age   fev height   sex smoke
##   <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1     9     3   65.5     1     0
```

```r
fev_data[32,c(1,3,5)] #c(1,3,5) is a vector of numbers (c means "combine")
```

```
## # A tibble: 1 x 3
##   seqnbr   age height
##    <dbl> <dbl>  <dbl>
## 1     32     9   65.5
```

```r
c(1,3,5) %>%
  length
```

```
## [1] 3
```

–> How would you drop the 1st, 3rd and 5th column?

```r
# Add your code here!
fev_data %>% select(-c(1, 3, 5))
```

```
## # A tibble: 654 x 4
##    subjid   fev   sex smoke
##     <dbl> <dbl> <dbl> <dbl>
##  1    301  1.71     0     0
##  2    451  1.72     0     0
##  3    501  1.72     0     0
```

```
##   4    642  1.56     1     0
##   5    901  1.90     1     0
##   6   1701  2.34     0     0
##   7   1752  1.92     0     0
##   8   1753  1.42     0     0
##   9   1901  1.99     0     0
##  10   1951  1.94     0     0
## # i 644 more rows
```

Logicals

Besides numbers and strings of characters, R also stores logicals - TRUE and FALSE

Example: a new vector with elements that are TRUE if height is above 72 cm and FALSE otherwise:

```r
is_tall <- fev_data$height > 72
```

Useful summary command:

```r
table(is_tall)
```

```
## is_tall
## FALSE  TRUE
##   647     7
```

Which subjects in fev_data are tall?

```r
fev_data[is_tall,]
```

```
## # A tibble: 7 x 7
##   seqnbr subjid   age   fev height   sex smoke
##    <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1    401  18841    14  4.27   72.5     1     0
## 2    450  32741    13  4.22   74       1     0
## 3    464  37241    13  4.88   73       1     0
## 4    517  49541    13  5.08   74       1     0
## 5    550  59941    14  4.27   72.5     1     0
## 6    632  37441    17  5.63   73       1     0
## 7    636  44241    16  3.64   73.5     1     0
```

Filtering (selecting rows)

```r
fev_data %>%
  filter(height > 72)
```

```
## # A tibble: 7 x 7
##   seqnbr subjid   age   fev height   sex smoke
##    <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1    401  18841    14  4.27   72.5     1     0
## 2    450  32741    13  4.22   74       1     0
```

```
## 3    464  37241    13  4.88   73        1     0
## 4    517  49541    13  5.08   74        1     0
## 5    550  59941    14  4.27   72.5      1     0
## 6    632  37441    17  5.63   73        1     0
## 7    636  44241    16  3.64   73.5      1     0
```

```r
fev_data %>%
  filter(age == 6)
```

```
## # A tibble: 37 x 7
##     seqnbr subjid   age   fev height   sex smoke
##      <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1       7   1752     6  1.92   58       0     0
##  2       8   1753     6  1.42   56       0     0
##  3      11   1952     6  1.60   53       0     0
##  4      18   3551     6  1.88   53       0     0
##  5      49  10841     6  1.65   55       1     0
##  6      55  12241     6  1.63   54       1     0
##  7      63  14251     6  1.48   51       0     0
##  8      66  14541     6  1.75   57.5     1     0
##  9      80  16151     6  1.72   53       0     0
## 10      82  16252     6  1.70   53       0     0
## # i 27 more rows
```

```r
fev_data %>%
  filter(age != 20)
```

```
## # A tibble: 654 x 7
##     seqnbr subjid   age   fev height   sex smoke
##      <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1       1    301     9  1.71   57       0     0
##  2       2    451     8  1.72   67.5     0     0
##  3       3    501     7  1.72   54.5     0     0
##  4       4    642     9  1.56   53       1     0
##  5       5    901     9  1.90   57       1     0
##  6       6   1701     8  2.34   61       0     0
##  7       7   1752     6  1.92   58       0     0
##  8       8   1753     6  1.42   56       0     0
##  9       9   1901     8  1.99   58.5     0     0
## 10      10   1951     9  1.94   60       0     0
## # i 644 more rows
```

```r
fev_data %>%
  filter(age <= 20)
```

```
## # A tibble: 654 x 7
##     seqnbr subjid   age   fev height   sex smoke
##      <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1       1    301     9  1.71   57       0     0
##  2       2    451     8  1.72   67.5     0     0
##  3       3    501     7  1.72   54.5     0     0
##  4       4    642     9  1.56   53       1     0
```

```
##  5       5    901      9  1.90   57        1     0
##  6       6   1701      8  2.34   61        0     0
##  7       7   1752      6  1.92   58        0     0
##  8       8   1753      6  1.42   56        0     0
##  9       9   1901      8  1.99   58.5      0     0
## 10      10   1951      9  1.94   60        0     0
## # i 644 more rows
```

You can also filter by whether data are not a number (na):

```
fev_data %>%
  filter(is.na(age))  # opposite: !is.na(age)
```

```
## # A tibble: 0 x 7
## # i 7 variables: seqnbr <dbl>, subjid <dbl>, age <dbl>, fev <dbl>,
## #   height <dbl>, sex <dbl>, smoke <dbl>
```

You can combine multiple expressions with Boolean operators: & is "and", | is "or", and ! is "not"

```
fev_data %>%
  filter(age == 14 & smoke !=0)    # age is 14 AND smoker
```

```
## # A tibble: 7 x 7
##   seqnbr subjid   age   fev height   sex smoke
##    <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
## 1    332   4952    14  2.24     66     0     1
## 2    358  10053    14  3.43     64     0     1
## 3    370  11642    14  3.96     72     1     1
## 4    384  15751    14  3.07     65     0     1
## 5    439  30042    14  4.31     69     1     1
## 6    556  61941    14  2.28     66     1     1
## 7    602  82743    14  4.76     68     1     1
```

```
fev_data %>%
  filter(age < 5 | height < 50)  # younger than 5 OR shorter than 50 cm
```

```
## # A tibble: 18 x 7
##    seqnbr subjid   age   fev height   sex smoke
##     <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1     21   4351     5 1.4     49        0     0
##  2     23   5152     4 0.839   48        0     0
##  3     26   5642     3 1.40    51.5      1     0
##  4     31   6851     5 1.28    49        0     0
##  5     59  13751     4 1.57    50        0     0
##  6     64  14252     4 1.58    49        0     0
##  7    104  23841     4 0.796   47        1     0
##  8    118  28551     5 1.20    46.5      0     0
##  9    157  38242     6 1.54    48        1     0
## 10    173  40541     4 1.79    52        1     0
## 11    181  43242     7 1.16    47        1     0
## 12    216  49551     4 1.10    48        0     0
```

```
## 13    222  50951     3 1.07    46        0     0
## 14    225  51341     6 1.42    49.5      1     0
## 15    233  54751     4 1.39    48        0     0
## 16    286  75951     4 1.42    49        0     0
## 17    299  80841     4 1.00    48        1     0
## 18    300  81241     6 1.43    49.5      1     0
```

Rules for filtering for categorical data: sex == "F" or sex != "F" sex %in% c("M","F")

Selecting columns

```r
fev_data %>%
  select(fev, height, age)
```

```
## # A tibble: 654 x 3
##      fev height   age
##    <dbl>  <dbl> <dbl>
##  1  1.71   57       9
##  2  1.72   67.5     8
##  3  1.72   54.5     7
##  4  1.56   53       9
##  5  1.90   57       9
##  6  2.34   61       8
##  7  1.92   58       6
##  8  1.42   56       6
##  9  1.99   58.5     8
## 10  1.94   60       9
## # i 644 more rows
```

```r
fev_data %>%
  select(-seqnbr, -subjid)
```

```
## # A tibble: 654 x 5
##      age   fev height   sex smoke
##    <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1     9  1.71   57       0     0
##  2     8  1.72   67.5     0     0
##  3     7  1.72   54.5     0     0
##  4     9  1.56   53       1     0
##  5     9  1.90   57       1     0
##  6     8  2.34   61       0     0
##  7     6  1.92   58       0     0
##  8     6  1.42   56       0     0
##  9     8  1.99   58.5     0     0
## 10     9  1.94   60       0     0
## # i 644 more rows
```

Summarising data

```r
fev_data %>%
  filter(age == 14 & smoke != 0) %>%
  summarise(mean(fev))
```

```
## # A tibble: 1 x 1
##   `mean(fev)`
##         <dbl>
## 1        3.43
```

You can name the summary variable:

```r
fev_data %>%
  filter(age == 14 & smoke != 0) %>%
  summarise(my_mean = mean(fev))
```

```
## # A tibble: 1 x 1
##   my_mean
##     <dbl>
## 1    3.43
```

```r
fev_data %>%
  filter(age == 14 & smoke != 0) %>%
  summarise(mean(fev), sd(fev))
```

```
## # A tibble: 1 x 2
##   `mean(fev)` `sd(fev)`
##         <dbl>     <dbl>
## 1        3.43     0.976
```

To get the average FEV for both smokers and non-smokers we don't need to repeat for smoke==0. We can create a grouping variable:

```r
fev_data %>%
  group_by(smoke)
```

```
## # A tibble: 654 x 7
## # Groups:   smoke [2]
##    seqnbr subjid   age   fev height   sex smoke
##     <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1      1    301     9  1.71   57       0     0
##  2      2    451     8  1.72   67.5     0     0
##  3      3    501     7  1.72   54.5     0     0
##  4      4    642     9  1.56   53       1     0
##  5      5    901     9  1.90   57       1     0
##  6      6   1701     8  2.34   61       0     0
##  7      7   1752     6  1.92   58       0     0
##  8      8   1753     6  1.42   56       0     0
##  9      9   1901     8  1.99   58.5     0     0
## 10     10   1951     9  1.94   60       0     0
## # i 644 more rows
```

(Same exact data, it just prints the two groups)

```r
fev_data %>%
  group_by(smoke) %>%
  summarise(mean(fev), sd(fev))
```

```
## # A tibble: 2 x 3
##   smoke `mean(fev)` `sd(fev)`
##   <dbl>       <dbl>     <dbl>
## 1     0        2.57     0.851
## 2     1        3.28     0.750
```

But what is the size of each group? n() gives us the number of observations in each group:

```r
fev_data %>%
  group_by(smoke) %>%
  summarise(n = n(), mean = mean(fev), sd = sd(fev))
```

```
## # A tibble: 2 x 4
##   smoke     n  mean    sd
##   <dbl> <int> <dbl> <dbl>
## 1     0   589  2.57 0.851
## 2     1    65  3.28 0.750
```

You can also group by your own variables:

```r
fev_data %>%
  group_by(height < 60) %>%
  summarise(n(), mean(fev))
```

```
## # A tibble: 2 x 3
##   `height < 60` `n()` `mean(fev)`
##   <lgl>         <int>       <dbl>
## 1 FALSE           409        3.10
## 2 TRUE            245        1.86
```

A useful function: arrange

```r
fev_data %>%
  group_by(age) %>%
  summarise(n(), mean(fev)) %>%
  arrange(age) # arrange by increasing age
```

```
## # A tibble: 17 x 3
##      age `n()` `mean(fev)`
##    <dbl> <int>       <dbl>
##  1     3     2        1.24
##  2     4     9        1.28
##  3     5    28        1.55
##  4     6    37        1.66
##  5     7    54        1.87
```

```
##   6     8    85         2.12
##   7     9    94         2.43
##   8    10    81         2.69
##   9    11    90         3.04
## 10    12    57         3.22
## 11    13    43         3.48
## 12    14    25         3.58
## 13    15    19         3.48
## 14    16    13         3.67
## 15    17     8         4.30
## 16    18     6         3.59
## 17    19     3         3.99
```

```
fev_data %>%
  group_by(age) %>%
  summarise(n(), mean(fev)) %>%
  arrange(desc(age)) # arrange by decreasing age
```

```
## # A tibble: 17 x 3
##       age `n()` `mean(fev)`
##     <dbl> <int>       <dbl>
##   1    19     3        3.99
##   2    18     6        3.59
##   3    17     8        4.30
##   4    16    13        3.67
##   5    15    19        3.48
##   6    14    25        3.58
##   7    13    43        3.48
##   8    12    57        3.22
##   9    11    90        3.04
## 10    10    81        2.69
## 11     9    94        2.43
## 12     8    85        2.12
## 13     7    54        1.87
## 14     6    37        1.66
## 15     5    28        1.55
## 16     4     9        1.28
## 17     3     2        1.24
```

Sorting columns

```
fev_data$age %>% sort #Sort a column
```

```
##   [1] 3 3 4 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5
##  [26] 5 5 5 5 5 5 5 5 5 5 5 5 5 5 6 6 6 6 6 6 6 6 6 6 6
##  [51] 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
##  [76] 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
## [101] 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
## [126] 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
## [151] 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
## [176] 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
## [201] 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 9 9 9 9 9 9 9 9 9 9
```

```
## [226]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [251]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [276]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [301]  9  9  9  9  9  9  9  9  9 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [326] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [351] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
## [376] 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 11 11 11 11 11 11 11 11 11 11
## [401] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [426] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [451] 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11
## [476] 11 11 11 11 11 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [501] 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
## [526] 12 12 12 12 12 12 12 12 12 12 12 12 13 13 13 13 13 13 13 13 13 13 13 13 13
## [551] 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13
## [576] 13 13 13 13 13 14 14 14 14 14 14 14 14 14 14 14 14 14 14 14 14 14 14 14 14
## [601] 14 14 14 14 14 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 16
## [626] 16 16 16 16 16 16 16 16 16 16 16 16 17 17 17 17 17 17 17 17 18 18 18 18 18
## [651] 18 19 19 19
```

```r
fev_data$age %>% unique %>% sort # Sort unique values in a column
```

```
##  [1]  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
```

table() gives you a count of a particular factor or combination of factor levels:

```r
table(fev_data$age)
```

```
## 
##  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 
##  2  9 28 37 54 85 94 81 90 57 43 25 19 13  8  6  3
```

```r
table(fev_data$age,fev_data$smoke)
```

```
##     
##       0  1
##   3   2  0
##   4   9  0
##   5  28  0
##   6  37  0
##   7  54  0
##   8  85  0
##   9  93  1
##   10 76  5
##   11 81  9
##   12 50  7
##   13 30 13
##   14 18  7
##   15  9 10
##   16  6  7
##   17  6  2
##   18  4  2
##   19  1  2
```

–> **Problem 1**: Which subjects are male and which are female? (i.e. what does sex == 1 mean?)

```r
# Add your code here!
fev_data_mutate_sex <- fev_data %>%
  mutate(gender = ifelse(sex == 0, "male", "female")) # Can also replace gender with sex to overwrite t
head(fev_data_mutate_sex)
```

```
## # A tibble: 6 x 8
##   seqnbr subjid   age   fev height   sex smoke gender
##    <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl> <chr>
## 1      1    301     9  1.71   57       0     0 male
## 2      2    451     8  1.72   67.5     0     0 male
## 3      3    501     7  1.72   54.5     0     0 male
## 4      4    642     9  1.56   53       1     0 female
## 5      5    901     9  1.90   57       1     0 female
## 6      6   1701     8  2.34   61       0     0 male
```

–> **Problem 2**: Why do smokers appear to have better lung function (higher forced expiratory volume - FEV)?

```r
# Add your code here!
fev_data %>%
  group_by(smoke) %>%
  summarise(count = n(), age_mean = mean(age), fev_mean = mean(fev)) # Mean age tends to be higher for
```

```
## # A tibble: 2 x 4
##   smoke count age_mean fev_mean
##   <dbl> <int>    <dbl>    <dbl>
## 1     0   589     9.53     2.57
## 2     1    65    13.5      3.28
```

```r
fev_data %>%
  group_by(smoke) %>%
  slice_sample(n = 50) %>% # Let's try to compare both groups again when n is equal
  summarise(count = n(), age_mean = mean(age), fev_mean = mean(fev)) # Still similar trend
```

```
## # A tibble: 2 x 4
##   smoke count age_mean fev_mean
##   <dbl> <int>    <dbl>    <dbl>
## 1     0    50     9.68     2.66
## 2     1    50    13.4      3.25
```

```r
fev_data %>%
  mutate(age_group = ifelse(age < mean(age), paste0("<", round(mean(age), 1)), paste0(">=", round(mean(a
  group_by(smoke, age_group) %>%
  slice_sample(n = 5) %>%
  summarise(count = n(), age_mean = mean(age), fev_mean = mean(fev), .groups = "drop") # Still have a c
```

```
## # A tibble: 4 x 5
##   smoke age_group count age_mean fev_mean
##   <dbl> <chr>     <int>    <dbl>    <dbl>
```

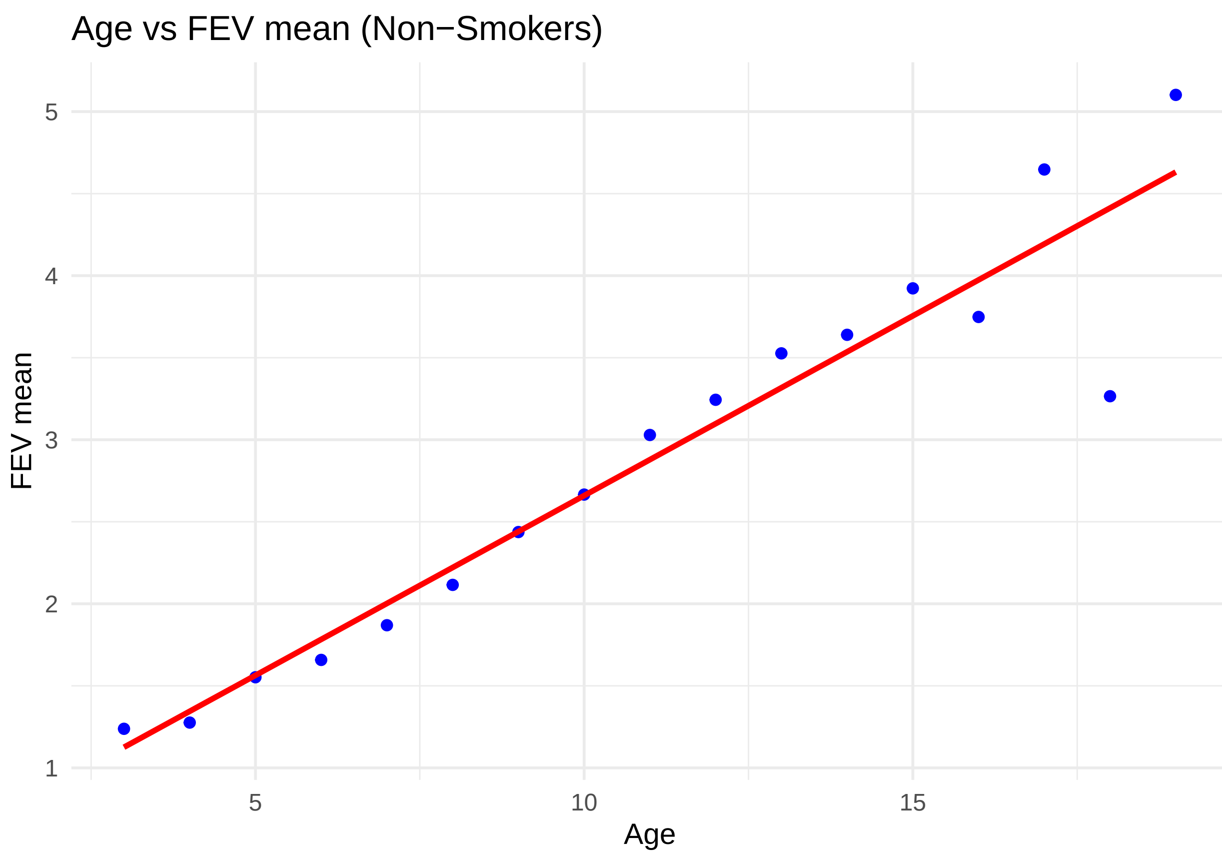
```
## 1     0 <9.9          5      8.6     2.30
## 2     0 >=9.9         5     12       3.67
## 3     1 <9.9          1      9       1.95
## 4     1 >=9.9         5     14.8     3.45
```

```
fev_sum_smoke_0 <- fev_data %>%
  filter(smoke == 0) %>%
  group_by(age) %>%
  summarise(fev_mean = mean(fev), .groups = "drop")
fev_sum_smoke_0
```

```
## # A tibble: 17 x 2
##      age fev_mean
##    <dbl>    <dbl>
##  1     3     1.24
##  2     4     1.28
##  3     5     1.55
##  4     6     1.66
##  5     7     1.87
##  6     8     2.12
##  7     9     2.44
##  8    10     2.67
##  9    11     3.03
## 10    12     3.24
## 11    13     3.53
## 12    14     3.64
## 13    15     3.92
## 14    16     3.75
## 15    17     4.65
## 16    18     3.27
## 17    19     5.10
```

```
ggplot(fev_sum_smoke_0, aes(x = age, y = fev_mean)) +
  geom_point(color = "blue") +
  geom_smooth(method = "lm", se = FALSE, color = "red") +
  labs(title = "Age vs FEV mean (Non-Smokers)",
       x = "Age", y = "FEV mean") +
  theme_minimal() # So age has a linear relationship with fev for non-smokers
```

```
## `geom_smooth()` using formula = 'y ~ x'
```



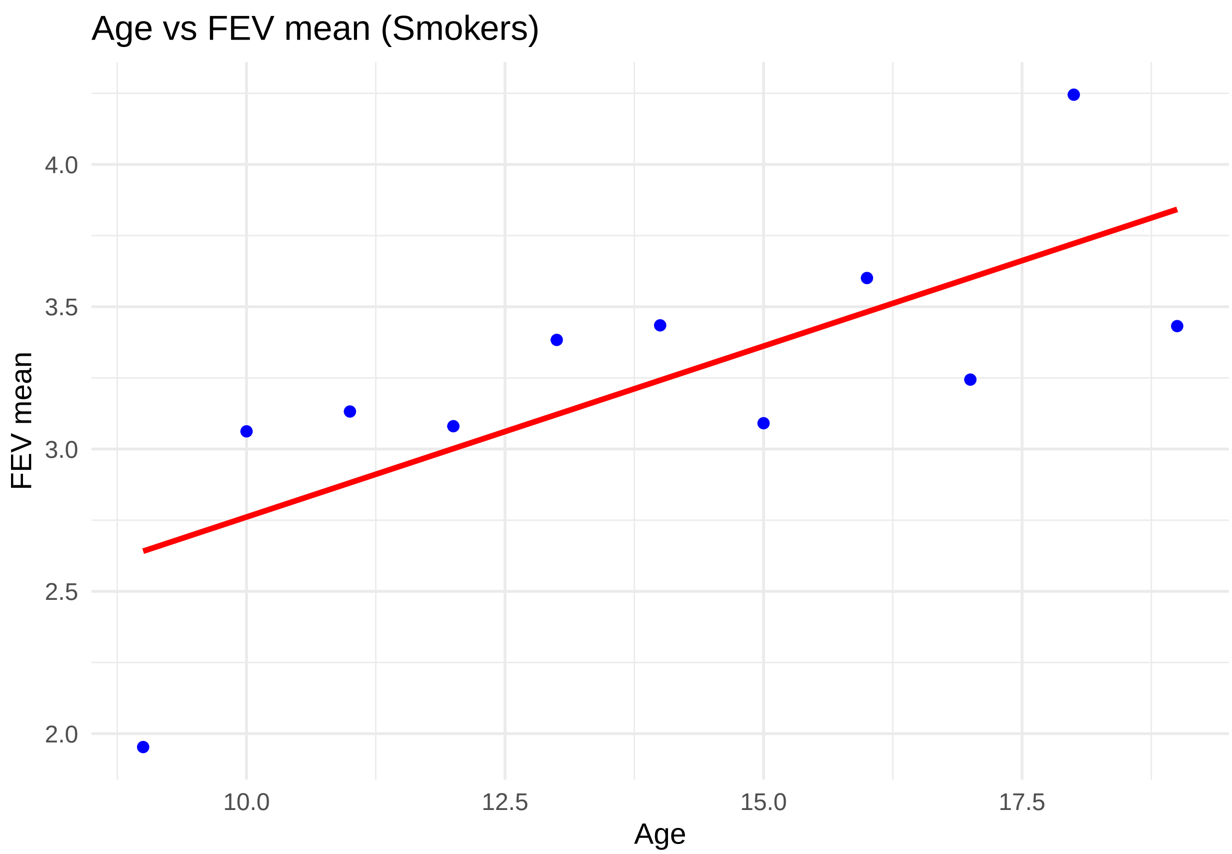

```r
fev_sum_smoke_1 <- fev_data %>%
  filter(smoke == 1) %>%
  group_by(age) %>%
  summarise(fev_mean = mean(fev), .groups = "drop")
fev_sum_smoke_1
```

```
## # A tibble: 11 x 2
##      age fev_mean
##    <dbl>    <dbl>
##  1     9     1.95
##  2    10     3.06
##  3    11     3.13
##  4    12     3.08
##  5    13     3.38
##  6    14     3.43
##  7    15     3.09
##  8    16     3.60
##  9    17     3.24
## 10    18     4.24
## 11    19     3.43
```

```r
ggplot(fev_sum_smoke_1, aes(x = age, y = fev_mean)) +
  geom_point(color = "blue") +
  geom_smooth(method = "lm", se = FALSE, color = "red") +
  labs(title = "Age vs FEV mean (Smokers)",
```

```
      x = "Age", y = "FEV mean") +
  theme_minimal() # Also age has a linear relationship with fev for non-smokers
```

```
## `geom_smooth()` using formula = 'y ~ x'
```



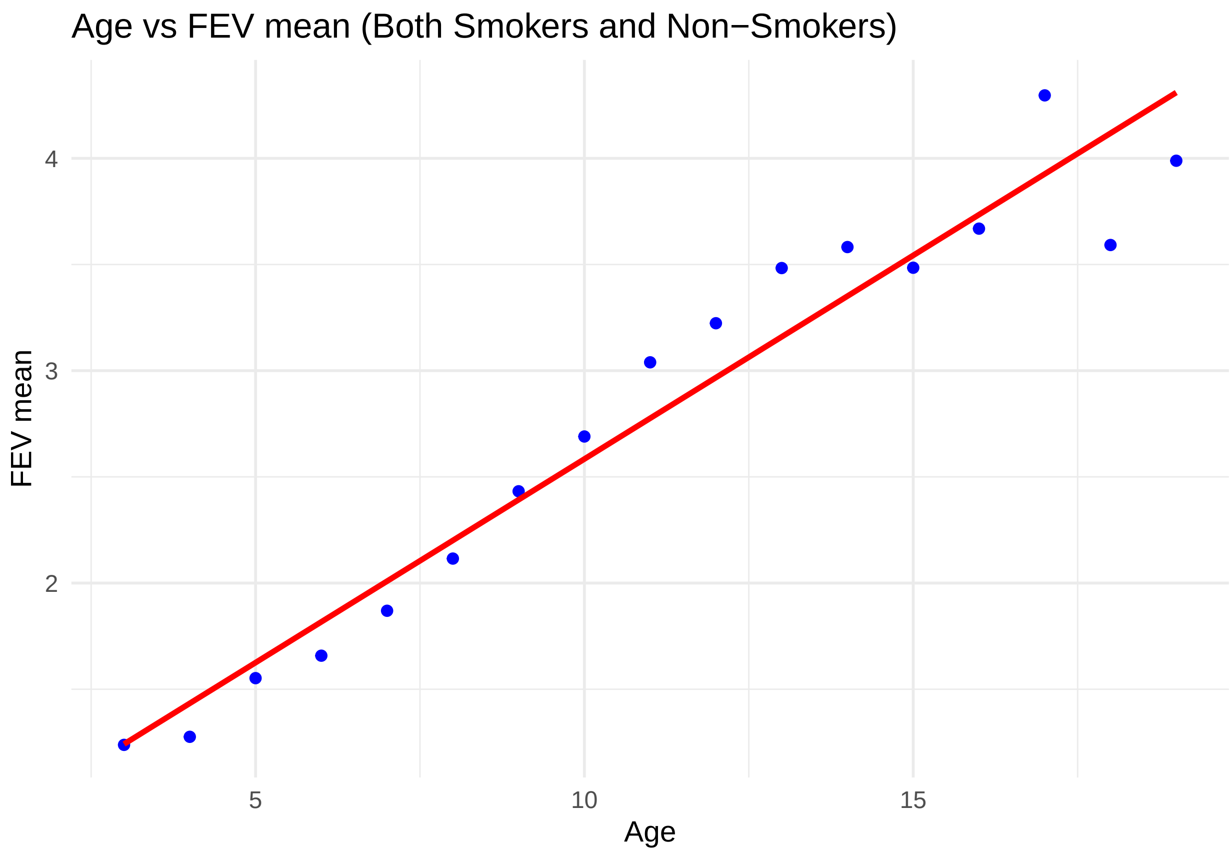

```
fev_sum_smoke_all <- fev_data %>%
  group_by(age) %>%
  summarise(fev_mean = mean(fev), .groups = "drop")
fev_sum_smoke_all
```

```
## # A tibble: 17 x 2
##      age fev_mean
##    <dbl>    <dbl>
##  1     3     1.24
##  2     4     1.28
##  3     5     1.55
##  4     6     1.66
##  5     7     1.87
##  6     8     2.12
##  7     9     2.43
##  8    10     2.69
##  9    11     3.04
## 10    12     3.22
## 11    13     3.48
```

```
## 12     14      3.58
## 13     15      3.48
## 14     16      3.67
## 15     17      4.30
## 16     18      3.59
## 17     19      3.99
```

```r
ggplot(fev_sum_smoke_all, aes(x = age, y = fev_mean)) +
  geom_point(color = "blue") +
  geom_smooth(method = "lm", se = FALSE, color = "red") +
  labs(title = "Age vs FEV mean (Both Smokers and Non-Smokers)",
       x = "Age", y = "FEV mean") +
  theme_minimal() # Finally, age still has a linear relationship with fev for both smokers and non-smok
```

```
## `geom_smooth()` using formula = 'y ~ x'
```




```r
# Conclusion: Why do smokers appear to have better lung function (higher forced expiratory volume - FEV
# It's because smokers are of the higher age group (have higher age mean), and since age has a direct p
```

Useful function: rename

```r
fev_data %>%
  rename(ID = subjid)
```

```
## # A tibble: 654 x 7
##    seqnbr    ID   age   fev height   sex smoke
##     <dbl> <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>
##  1      1   301     9  1.71   57       0     0
##  2      2   451     8  1.72   67.5     0     0
##  3      3   501     7  1.72   54.5     0     0
##  4      4   642     9  1.56   53       1     0
##  5      5   901     9  1.90   57       1     0
##  6      6  1701     8  2.34   61       0     0
##  7      7  1752     6  1.92   58       0     0
##  8      8  1753     6  1.42   56       0     0
##  9      9  1901     8  1.99   58.5     0     0
## 10     10  1951     9  1.94   60       0     0
## # i 644 more rows
```

Mutate: compute new column

```
fev_data %>%
  mutate(heightdiff = height - mean(height))
```

```
## # A tibble: 654 x 8
##    seqnbr subjid   age   fev height   sex smoke heightdiff
##     <dbl>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl>      <dbl>
##  1      1    301     9  1.71   57       0     0     -4.14
##  2      2    451     8  1.72   67.5     0     0      6.36
##  3      3    501     7  1.72   54.5     0     0     -6.64
##  4      4    642     9  1.56   53       1     0     -8.14
##  5      5    901     9  1.90   57       1     0     -4.14
##  6      6   1701     8  2.34   61       0     0     -0.144
##  7      7   1752     6  1.92   58       0     0     -3.14
##  8      8   1753     6  1.42   56       0     0     -5.14
##  9      9   1901     8  1.99   58.5     0     0     -2.64
## 10     10   1951     9  1.94   60       0     0     -1.14
## # i 644 more rows
```

Remember that to save these changes you need to assign to a new tibble:

```
new_fev_data <- fev_data %>%
  rename(id = subjid) %>%
  mutate(heightdiff = height - mean(height))
```