

# Introduction to R for Basic Statistics

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## Learning Objectives

- Use R through the interface R studio
- Import/load data into R
- Implement basic calculation in R
- Manipulate data in R
- Create descriptive analysis in R
- Create simple plots in R

# Structure of the course

- Today:
  - Download/Install R
  - Rstudio interface
  - What can R do?
  - Data structures in R
  - Data manipulation with R (Part I)
  - Descriptive analysis in R
- Wednesday:
  - Data manipulation in R (Part II)
  - Basic graphics in R

# About me

## **What I do with R**

- Write R code to test/develop methods
- Data analysis, visualisation and reporting for applied projects

## **What I like about R**

- open source
- flexible and dynamic
- lot of support by statisticians

## **What I expect from this course**

- lot of questions
- there is no right way to code something, be creative!
- error and warning are our friends

# Install R

1. Go to the link <https://cran.r-project.org/>
2. Click on *Download R for* (Windows/Mac/Linux) depending on your operation system
  - For Windows users: Install R for the first time → Download R-4.x.x for Windows
  - for Mac users: choose the latest release that supports the version of your operation system
  - For Linux users: choose the link corresponding to your distribution of Linux and follow instructions

## Install Rstudio

1. Go to the link <https://posit.co/download/rstudio-desktop/download>
2. Click the appropriate link under Installers that correspond to your operation system and version

# Rstudio Interface

The screenshot shows the RStudio interface with the following components and annotations:

- Console:** A red box at the bottom left points to the console area, which contains the R version information and project details. The text in the console is: 

```
R 4.3.0 · ~/Desktop/KVN2021/QuantReg/sim_KM/

R version 4.3.0 (2023-04-21) -- "Already Tomorrow"
Copyright (C) 2023 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

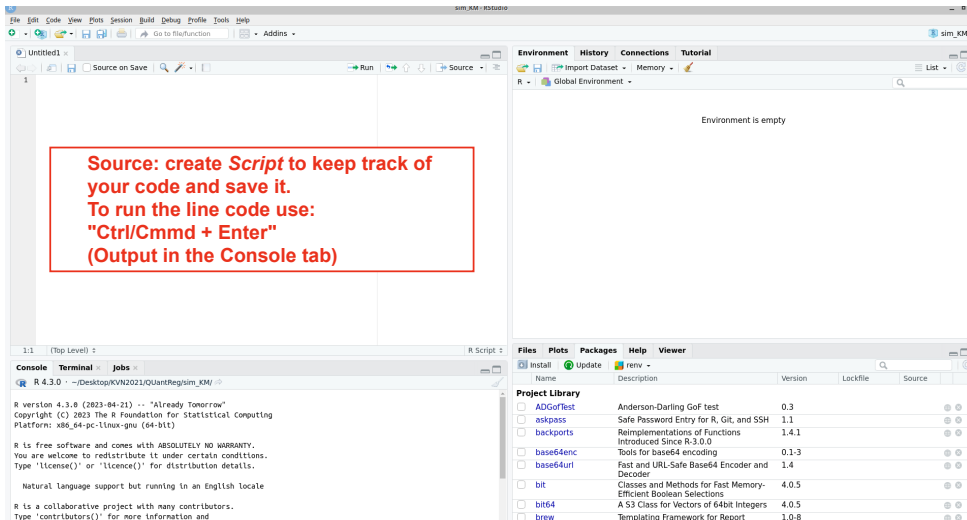
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

- Project '~/Desktop/KVN2021/QuantReg/sim_KM/' loaded. [renv 1.0.0]
- The project is out-of-sync -- use 'renv::status()' for details.
>
```
- Environment:** A red box on the right side points to the Environment pane, which is currently empty. The text in the box is: **Enviroment: list of all loaded/initialized objects in R during the current session**
- Files:** A red box at the bottom right points to the Files pane, which shows the project's file structure. The text in the box is: **Files: you can navigate through your files and open them**
- Plots:** A red box at the bottom right points to the Plots pane, which is currently empty. The text in the box is: **Plots: visualize produced plots**
- Packages:** A red box at the bottom right points to the Packages pane, which shows the installed and loaded packages. The text in the box is: **Packages: installed/loaded packages in the current session**
- Help:** A red box at the bottom right points to the Help pane, which shows the vignettes for support on functions. The text in the box is: **Help: Vignettes for support on functions**

# Rstudio Interface

*File → New File → R script*





## Set the Working Directory

When working on a project it is important to create a new folder where to save all relevant files: codes scripts, Data, reports, etc...

We can set the R Working Directory to that folder so to save everything directly there.

### How?

- check the current working directory by the Command `getwd()` on the Console tab
- *Session → Set Working Directory → Choose Directory*
- Use the Command `setwd` (set working directory) on the Console Tab:

```
setwd("~/Desktop/KVN2023/Course/IntrotoR")
```

**What can R do?**

## R as a calculator:

Operator	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Exponent
...	...
sqrt()	Square root
exp()	Exponential
abs()	Aboslute value
log( , base=b)	Logarithm (base b)

R follows the standard ordering of operations: exponents and roots, then multiplication and divison, then addition and subtraction.

We can use parentheses to change the order.

## Functions in R

**Functions** are chunks of **reusable code** designed to perform a specific task. They take *input arguments*, process them, and return a result.

```
square<-function(x){  x.squared<-x*x  
                      x.squared  
                      }
```

```
square(10)
```

- $x$  is the input argument
- **x.squared** is what we return as result
- **square** is the name of the function

## Functions in R

We can also use pre-coded functions in R for calculations, create plots, implement some statistical tools.

Any function in R is used by writing the name of the function and *passing* the needed *arguments*.

We can check them with the help commands

- `?NameofFunction`
- `help(NameofFunction)`

Example:

```
> help(round)
```

# Functions in R

## Rounding of Numbers

### Description

`ceiling` takes a single numeric argument `x` and returns a numeric vector containing the smallest integers not less than the corresponding elements of `x`.

`floor` takes a single numeric argument `x` and returns a numeric vector containing the largest integers not greater than the corresponding elements of `x`.

`trunc` takes a single numeric argument `x` and returns a numeric vector containing the integers formed by truncating the values in `x` toward 0.

`round` rounds the values in its first argument to the specified number of decimal places (default 0). See 'Details' about "round to even" when rounding off a 5.

`signif` rounds the values in its first argument to the specified number of *significant* digits. Hence, for numeric `x`, `signif(x, dig)` is the same as `round(x, dig - ceiling(log10(abs(x))))`. For [complex](#) `x`, this is not the case, see the 'Details'.

### Usage

```
ceiling(x)
floor(x)
trunc(x, ...)
```

```
round(x, digits = 0)
signif(x, digits = 6)
```

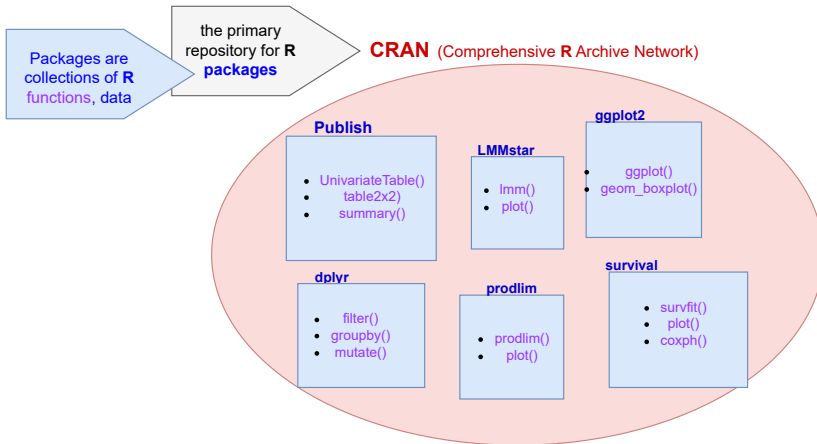
### Arguments

`x` a numeric vector. Or, for `round` and `signif`, a complex vector.

`digits` integer indicating the number of decimal places (`round`) or significant digits (`signif`) to be used. For `round`, negative values are allowed (see 'Details').

arguments to be passed to methods

# CRAN in R



## R packages

In R functions are stored in units, referred to as *packages*.

- In this course we use only the *basic packages* (base,graphics,...)
- Other packages need to be installed (only one time)

```
>install.packages("Publish")
```

- To use the functions we have to *load* the package (every time you open Rstudio)

```
>library("Publish")
```

- You can check the installed version of R and loaded packages

```
>sessionInfo()
```



## Data Structures in R

## Types of Variable in R

Every object in R has a specific type.

Type	Value
Numeric	integer double (decimal numbers)
Character	text: words, letters
Logical	TRUE/FALSE
Factor	categorical variable
Date	calendar date
...	...

We can check the type of the variable using the command `typeof()`

## Initialize a variable

When we want to **save** an object in our environment (because we might need it for later) we need to **initialize** it by giving it a name with "<-"

```
a<-1  
c<-"0,3" #when using " " is a character
```

```
> typeof(a)  
[1] "double"  
> typeof(b)  
[1] "double"  
> typeof(c)  
[1] "character"  
> is.numeric(b)  
[1] TRUE
```

## Data structures in R

When programming it is important to organizing the data in the correct way. In R we can use several data structures depending on the type of information we want to store.

The data structure is designed so that data can be accessed and worked with in specific ways.

Base data structures in R :

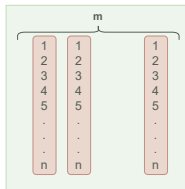
- vectors : collection of elements of the same type
- matrix: collection of vectors of the same type, access by row and column
- data.frame: collection of vectors of different type, access by row and column
- list: collection of different data structures of different type

# Data structures in R

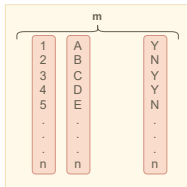
**Vector:**  
one dimension



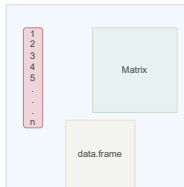
**Matrix:**  
two-dimensions



**Data frame:**  
two dimensions



**List:**  
more structures



## Vector

One dimensional collection of elements of the same type.

Create a vector using `c()`

```
v1<-c(0,0.3,7,20)
v2<-c("Male","Female")
```

```
> typeof(v1)
[1] "double"
> typeof(v2)
[1] "character"
```

Length of a vector:

```
> length(v1)
[1] 4
```

## Vector

Create a vector with pre-coded function in R:

- Ordered sequence of integers:

```
> ID<-1:10
```

```
> ID
```

```
[1]  1  2  3  4  5  6  7  8  9 10
```

```
> weight=0.5:0.7
```

```
> weight
```

```
[1] 0.5
```

## Vector

Create a vector with pre-coded functions in R:

- Sequence of numbers from min to max with a specific lag or of a specific length:

```
> ID<-seq(1,10)
```

```
> ID
```

```
[1] 1 2 3 4 5 6 7 8 9 10
```

```
> weight<-seq(0.5,0.7, by=0.1)
```

```
> weight
```

```
[1] 0.5 0.6 0.7
```

```
> weight2<-seq(0.5,0.7, length.out=4)
```

```
> weight2
```

```
[1] 0.5000000 0.5666667 0.6333333 0.7000000
```



## Vector

Create a vector with pre-coded functions in R:

- Vector with same repeated value(s):

```
> v1<-rep(0,3)
```

```
> v1
```

```
[1] 0 0 0
```

```
> v2<-rep(c(0,1),2)
```

```
> v2
```

```
[1] 0 1 0 1
```

```
> v3<-rep(c(0,1), c(2,2))
```

```
> v3
```

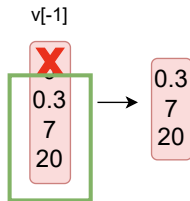
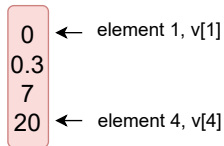
```
[1] 0 0 1 1
```

## Access a Vector

We can access to subsequences of vectors by using square brackets [ ]

- Specify the element(s) with the *index*

```
> v1  
[1] 0.0 0.3 7.0 20.0  
  
> v1[2]  
[1] 0.3  
  
> v1[-1] # negative index  
[1] 0.3 7.0 20.0  
  
> v1[c(1,3)]  
[1] 0.0 7.0
```



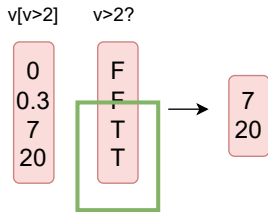
## Access a Vector

- Specify the element(s) by conditions:

```
> v1>2
FALSE FALSE TRUE TRUE
> v1[v1>2]
[1] 7 20
```

```
> v3
[1] "B" "A" "C" "C" "C" "C" "B" "C" "B" "B"
```

```
> v3[v3 %in% c("A","C")]
[1] "A" "C" "C" "C" "C" "C"
```



## Operation with vectors

$a=c(1,2,3)$ ,  $b=c(3,4,5)$

```
> sum(a)
```

```
[1] 6
```

```
> a+b
```

```
[1] 4 6 8
```

```
> a*a
```

```
[1] 1 4 9
```

```
> prod(a)
```

```
[1] 6
```

## Comparison and logical operators

A *logical value* is a value indicating whether something is TRUE or FALSE. This is the usual output of comparative operators:

Comparative operators	test if
Equality operator ==	operands are equal
Inequality operator !=	operands are not equal
Disequality operator <, <=, >, >=	less (more) than or equal to
"in" operator %in%	elements are equal to one of a list of values

Logical operators are used to combine more comparison operators:

- : AND operator
- |: OR operator
- !: not operator

## Comparison operators in R

```
> income<-c("low","low","medium","high","medium","high")
```

```
> income=="low"
```

```
[1]  TRUE TRUE FALSE  FALSE FALSE FALSE
```

```
> !(income %in% c("low","high"))
```

```
[1] FALSE FALSE  TRUE FALSE  TRUE FALSE
```

```
> (income=="low" | income=="high")
```

```
[1]  TRUE  TRUE FALSE  TRUE FALSE  TRUE
```

```
> (income=="low" & income=="high") ??
```

## Exercise I

**Exercise:** We want to conduct a research study about effect of hormonal contraception on **weight change after 3 months of treatment**. We are interested in comparing **two** types of contraception (oral,spiral) in women between **15-30** years old.

1. Define 5/6 variables that you would collect for this study (such as ID, treatment type, weight..)
2. Create a vector for each of the chosen variable for 10 patients (5 in each treatment group)
3. What is the treatment given to patients with an initial weight  $> 60$ ?

**+: Use <https://padlet.com/alessandrameddis/intro-to-r-jl6hoio79ssxfhqm>  
Write down problems/questions you encountered during the Exercise**

## Matrix

A matrix is a two dimensional collection of elements of the same type.

Create it with `matrix()`

```
m1<-matrix(c(1,2,3,4,5,6), nrow=2)
```

```
m2<-matrix(c(1,2,3,4,5,6), nrow=2, byrow = TRUE)
```

```
> m1
```

	[,1]	[,2]	[,3]
[1,]	1	3	5
[2,]	2	4	6

```
> m2
```

	[,1]	[,2]	[,3]
[1,]	1	2	3
[2,]	4	5	6



## Create a Matrix from vectors

```
> v1
[1] 0.0 0.3 7.0 20.0
> v2
[1] 1 4 3 5
> rbind(v1,v2)
      [,1] [,2] [,3] [,4]
v1      0 0.3   7   20
v2      1 4.0   3    5
> cbind(v1,v2)
      v1 v2
[1,] 0.0 1
[2,] 0.3 4
[3,] 7.0 3
[4,] 20.0 5
```

## Access a Matrix

To access to one specific row/column/element we use  $[r, c]$  where  $r, c$  are the index of the row and column of interest

```
> m1
```

	[,1]	[,2]	[,3]
[1,]	1	3	5
[2,]	2	4	6

```
> m1[,2]
```

```
[1] 3 4
```

```
> m1[2,]
```

```
[1] 2 4 6
```

```
> m1[2,2]
```

```
[1] 4
```

	column 1	column 2	column 3
	m[,1]	m[,2]	m[,3]
row1 m[1,]	1	2	3
row2 m[2,]	4	5	6 ← m[2,3]

## Access a Matrix

As for vectors, we can use conditions :

```
> m1
```

	[,1]	[,2]	[,3]
[1,]	1	3	5
[2,]	2	4	6

```
> m1[m1>2]
```

[1]	3	4	5	6
-----	---	---	---	---

## Data frame

Collection of vectors with same dimension that can be of different type. Create a Data set with `data.frame()`

```
> db1<-data.frame(id=c(1,2,3), sex=c("Male","Female","Male"),  
                  age=c(46,53,38))
```

```
> db1
```

	id	sex	age
1	1	Male	46
2	2	Female	53
3	3	Male	38

## Access a Data frame

To access to one specific row/column/element we can use [ ] as for matrices or *\$NameofColumn*

```
> db1$sex  
[1] "Male"    "Female" "Male"
```

```
> db1[,2]  
[1] "Male"    "Female" "Male"
```

```
> db1[2,]  
  id    sex age  
2  2 Female 53
```

## Exercise I

**Exercise:** We want to conduct a research study about effect of hormonal contraception on **weight change after 3 months of treatment**. We are interested in comparing **two** types of contraception (oral,spiral) in women between **15-30** years old.

4. Create a `data.frame` for 10 patients with the chosen 6 variables
5. Create a new vector for BMI from *weight0* and *height* (careful with units)
6. Add the new variable to the `data.frame`  
(to add it, you can use the command  
`db<-data.frame(db,NameColumn=NameVector))`)

+: Use <https://padlet.com/alessandrameddis/intro-to-r-jl6hoio79ssxfhqm>  
Write down the error/warning you encountered during the Exercise

## List

Collection of different data structures of different type. Create it with `list()`

```
family<-list(n=3,  
  kids=data.frame(mum.id=c(1,1,2,3),  
                  age=c(6,10,8,4),  
                  IQ=c(97,101,103,102)),  
  mother=data.frame(id=c(1,2,3),  
                    smoker=c("Yes","No","Yes"))  
)
```

## Access a list

To access to one object of the list we can use  $[i]$  where  $i$  is the index of the object in the list OR `["NameofObjects"]` OR `$NameofObject`

```
> family[1]
```

```
$n
```

```
[1] 3
```

```
> family["n"]
```

```
[1] 3
```

```
> family$kids
```

	id	age	IQ
1	1	6	97
2	1	10	101
3	2	8	103
4	3	4	102



## Useful functions

Function	
<code>str()</code>	shows internal structure of an object
<code>length()</code>	dimension of vectors and lists
<code>dim()</code>	dimensions for matrix and data.frame
<code>nrow(), ncols()</code>	number of rows/columns in matrix and data.frame
<code>rownames(), colnames()</code>	check/assign names to row and columns

## Missing data

Real-world data sets have missing observations. In R

- NA: missing data (it has a type: logical)
- NaN: not a number
- NULL: empty object

```
> sex<-c("female",NA,"male","male","female","NA")  
> is.na(sex)  
[1] FALSE TRUE FALSE FALSE FALSE FALSE
```

```
> 0/0  
[1] NaN
```

```
> height<-NULL #initialize objects  
> height  
NULL
```

## Factors

Categorical variables can be represented as a vector of characters. However, using *factors* is more convenient with easier representation.

```
> income<- c("low","low","high","medium","low","high","medium")
> income[1:3]
[1] "low"  "low"  "high"

> income2<-factor(income, levels=c("low","medium","high"))
> income2[1:3]
[1] low  low  high
Levels: low medium high
```

In the factor version the levels are explicitly listed, so it is clear that the two included levels are not all the possible levels.

## Conversion

We made a difference between types of variables.

We can *convert* one variable to be from one to another type

```
> weight<-c(10L,15L,27L,18L,22L) #with L we specify it is an integer
> typeof(weight)
[1] "integer"
```

```
> as.character(weight)
[1] "10"    "25.4"  "27"    "18"    "22"
```

```
> weight[2]<-25.4
> typeof(weight) #R converts it automatically
[1] "double"
```

## Coercion

Vectors can contain only elements of the same type. Therefore, if more options are included in a vector R *coerces* the vector to be only of one type. This also happens when 2 different types of variables are used for one operation:

```
> c(0,1,FALSE,TRUE) # FALSE:0 TRUE:1  
[1] 0 1 0 1
```

```
> c("low","high",2)  
[1] "low" "high" "2"
```

```
> as.numeric(c("0.4","0.2","0,1"))  
[1] 0.4 0.2 NA
```

Warning message:

NAs introduced by coercion

## Exercise I:

ID	treatment	weight0	weight3	age	height
1	A	56	58	21	157
2	A	52.3	51	16	160
...					

7. Check the type of variable for the *treatment* (use the function `typeof()`)
8. Create a new variable to convert *treatment* into a factor (use the function `factor()`) and add it to the data.frame
9. Check the dimension of your data.frame (number of cols, number of rows)  
Use the function `nrow()`, `ncol()`, `dim()`

## Exercise I:

ID	treatment	weight0	weight3	age	height	BMI	trt.factor
1	A	56	58	21	157	22.7	A
2	A	52.3	51	16	160	20.5	A
...							...

10. Create a new vector for the difference in weights after three months
11. Calculate the average weight difference, formula for the mean:  
$$\frac{diff_1 + diff_2 + \dots + diff_{10}}{10}$$
  
(you can use the function `sum()`)

## **Data manipulation in R**



# Data Import and Export

What we need to know about the data to import/export:

1. format of data (.csv, .xlsx, .txt, .rda ...)
2. where data are located

## **Text Files:**

- csv : Comma Separated Values. Data re stored in plain text and each line can be separated by commas (,) or semicolons(;) )
- txt: Data are stored in plain text and values are separated by spaces or tabs.

## Loading CSV files

To import a .csv file, we have to specify:

- How values are separated
- Is first row the variable names? (header=TRUE/FALSE)
- How missing values are formatted (na.string= " ")
- Decimal numbers are with periods (.) or commas (,) (dec=".")

Use the function `read.csv`:

```
data<- read.csv( "~/Desktop/KVN2023/Course/IntrotoR/data_ex.csv",  
  header=TRUE, na.string=" ", sep="," ,dec=".")
```

## Export CSV files

A data set can be exported as .csv or .txt files so that the data can be used in other programs.

We use the function `write.csv` where we need to precise

- `x`: object to save
- `file`: where to save it
- `row.names=TRUE/FALSE`: Is first row the variable names?

## Exploring the data

We can use several functions to check the structure of the data:

- `View()`: view data in spreadsheet style in the source tab
- `head()`: print first 6 rows of the data set
- `str()`: overview on the structure of the data (with types of variables)
- `summary()`: summary of all variables in the data set with `min`, `max`, `mean` for numeric variables and number of observation by levels for categorical variables.

## head() function in R

```
> dim(db1_ex)
```

```
[1] 50  4
```

```
> head(db1_ex)
```

	ID	year	weight	height
1	1	2000	57.48904	1.677647
2	2	2002	60.65766	1.613070
3	3	2000	59.60541	1.708943
4	4	2002	64.43392	1.794873
5	5	2000	60.58486	1.586404
6	6	2002	61.59315	1.749023

## str() function in R

```
> str(db1_ex)
'data.frame': 50 obs. of  4 variables:
 $ ID      : int   1 2 3 4 5 6 7 8 9 10 ...
 $ year    : num   2000 2002 2000 2002 2000 ...
 $ weight: num   57.5 60.7 59.6 64.4 60.6 ...
 $ height: num   1.68 1.61 1.71 1.79 1.59 ...
```

## summary() function in R

```
> summary(db1_ex)
```

ID	year	weight	height
Min. : 1	Min. :2000	Min. :50.61	Min. :1.586
1st Qu.: 7	1st Qu.:2000	1st Qu.:57.87	1st Qu.:1.649
Median :13	Median :2001	Median :60.33	Median :1.696
Mean :13	Mean :2001	Mean :60.41	Mean :1.696
3rd Qu.:19	3rd Qu.:2002	3rd Qu.:62.97	3rd Qu.:1.735
Max. :25	Max. :2002	Max. :71.55	Max. :1.829

## Create a new variable

```
> db1_ex$BMI=db1_ex$weight/(db1_ex$height)^2
```

```
> head(db1_ex)
```

	ID	year	weight	height	BMI
1	1	2000	57.48904	1.677647	20.42603
2	2	2002	60.65766	1.613070	23.31198
3	3	2000	59.60541	1.708943	20.40941
4	4	2002	64.43392	1.794873	20.00078
5	5	2000	60.58486	1.586404	24.07336
6	6	2002	61.59315	1.749023	20.13452



## Remove a variable

```
> db2<-db1_ex[,-1]

>db2<-db1_ex[, 2:ncol(db1_ex)]

>db2<-db1_ex
>db2$ID<-NULL

> head(db2)
```

	year	weight	height	BMI
1	2000	57.48904	1.677647	20.42603
2	2002	60.65766	1.613070	23.31198
3	2000	59.60541	1.708943	20.40941
4	2002	64.43392	1.794873	20.00078
5	2000	60.58486	1.586404	24.07336
6	2002	61.59315	1.749023	20.13452

## Subsetting by condition

Several packages can be used for data management but we will only consider basic R .

```
> db3<-subset(db1_ex, BMI<20)
> head(db3)
```

	ID	year	weight	height	BMI
8	8	2002	63.57266	1.791244	19.81350
9	9	2000	55.87370	1.769065	17.85336
14	14	2002	63.69920	1.829098	19.03970
17	17	2000	58.05573	1.731900	19.35529
19	19	2000	55.43093	1.696504	19.25938
21	21	2000	57.80955	1.722445	19.48538

## From numerical to binary variable: ifelse()

```
> db1_ex$BMI.cat=ifelse(db1_ex$BMI<20,"underweight","normal")
> head(db1_ex)
```

	ID	year	weight	height	BMI	BMI.cat
1	1	2000	57.48904	1.677647	20.42603	normal
2	2	2002	60.65766	1.613070	23.31198	normal
3	3	2000	59.60541	1.708943	20.40941	normal
4	4	2002	64.43392	1.794873	20.00078	normal
5	5	2000	60.58486	1.586404	24.07336	normal
6	6	2002	61.59315	1.749023	20.13452	normal

## From numerical to categorical variable: cut()

```
> db1_ex$BMI.cat2<-cut(db1_ex$BMI, breaks=c(15,24,30))
> table(db1_ex$BMI.cat2)
(15,24] (24,30]
      47       3
```

```
> db1_ex$BMI.cat2<-cut(db1_ex$BMI, breaks=c(15,20,24,30),
                        labels = c("underweight","normal","overweight"))
> table(db1_ex$BMI.cat2)
underweight      normal  overweight
        12         35         3
```

## Combining groups

```
> db1_ex$BMI.cat2[db1_ex$BMI.cat2=="overweight"]<-"normal"
underweight      normal  overweight
           12           38           0
```

```
> db1_ex$BMI.cat2<-droplevels(db1_ex$BMI.cat2)
> summary(db1_ex$BMI.cat2)
underweight      normal
           12           38
```

## **Descriptive analysis with R**

# Descriptive analysis

When working with data, it is important to summarize the available data to provide an idea on the population under study.

**Example:** Danish users of hormonal contraception, it might be of importance to know the age distribution of women, how many women are taking a specific treatment and so on....

## Categorical Variable

- Create Tables with the numbers of individuals in each group
- Create Tables with proportion of individuals in each group

## Numerical Variable

- Calculate min/max and different quantiles of the distribution
- Calculate mean/median/sd

## Tables

```
> head(db1_ex)
  ID year  weight  height      BMI  BMI.cat
1  1 2000 58.33538 1.751734 19.01059 underweight
2  2 2002 66.81557 1.782675 21.02487      normal
3  3 2000 57.65426 1.699103 19.97065 underweight
4  4 2002 64.21438 1.698790 22.25118      normal
5  5 2000 52.71003 1.712512 17.97322 underweight
6  6 2002 57.99847 1.683144 20.47265      normal
```

### One-way Table:

```
> table(db1_ex$BMI.cat)
```

normal	underweight
30	20

### Two-way Table:

```
> table(db1_ex$BMI.cat,db1_ex$year)
```

	2000	2002
normal	11	19
underweight	14	6



## table(): more example

```
> table(db1_ex$weight>60, useNA="ifany")
```

FALSE	TRUE	<NA>
28	21	1

```
> table(db1_ex$weight>60,db1_ex$year,  
        useNA="ifany")
```

	2000	2002
FALSE	17	11
TRUE	7	14
<NA>	1	0

```
> prop.table(table(db1_ex$BMI.cat))
```

normal	underweight
0.6	0.4

## Quantitative variables

```
> mean(db1_ex$height)
```

```
[1] NA
```

```
> mean(db1_ex$height, na.rm=TRUE)
```

```
[1] 1.705973
```

```
> sd(db1_ex$weight, na.rm=TRUE)
```

```
[1] 3.884619
```

```
> min(db1_ex$height, na.rm=TRUE)
```

```
[1] 1.597908
```

```
> max(db1_ex$height, na.rm=TRUE)
```

```
[1] 1.80843
```

```
> median(db1_ex$height, na.rm=TRUE)
```

```
[1] 1.699103
```

## summary()

```
> summary(db1_ex$height)
  Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
1.598  1.687   1.699   1.706  1.729   1.808      1

> summary(db1_ex$BMI.cat)
  Length      Class      Mode
    50 character character

> summary(factor(db1_ex$BMI.cat))
  normal underweight
      30          20
```

quantile()

```
> quantile(db1_ex$BMI)
      0%      25%      50%      75%     100%
17.10270 19.58117 20.44042 21.79128 23.00572
```

```
> quantile(db1_ex$BMI, c(0.25,0.75))
      25%      75%
19.58117 21.79128
```

## Calculation groupwise

Sometimes we want to calculate summary statistics for different groups

**Example** we want to calculate mean of weight by BMI categories:

- `tapply()`

```
> tapply(db1_ex$weight, db1_ex$BMI.cat, mean, na.rm=TRUE)
      normal underweight 
61.60447    56.53733
```

- `aggregate()`

```
> aggregate(weight ~ BMI.cat, data=db1_ex, FUN=mean, na.rm=TRUE)
      BMI.cat  weight
1      normal 61.60447
2 underweight 56.53733
```