

Interuniversity Institute for Biostatistics
and statistical Bioinformatics

An introduction to R: Basic skills in R Studio and R Markdown

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Updated: 05/25



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<https://github.com/eR-Biostat>



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Overview

- R Studio/R markdown.
- How to produce output using R markdown ?
- How to develop output using R markdown ?
- Main concept:
 - we run the same analysis multiple times and show how to produce different type of output.
- Analysis:
 - simple plot + simple linear regression.

Rmd programs for the class today

- To run the analysis presented in the slides you need the following Rmd programs:

Dataset	Rmd file	Output
mtcars	R_course_UHasselt_demo_V0.Rmd	R code in a RMakdown file
mtcars	R_course_UHasselt_demo_V1.Rmd	Produce simple HTML/PDF output for a report
Airquality	R_course_UHasselt_2021(html)_V1.Rmd	Produce a HTML output (example how to work with R markdown)
Airquality	R_course_UHasselt_2021(pdf)_V1.Rmd	Produce HTML/PDF output
Old Faithful	R_course_UHasselt_2021(pdf)_V2.Rmd	A report for an example of a simple analysis (HTML/PDF)

See later in the slides how these files are used and which type of output can be produced.

R Studio

What is R Studio ?

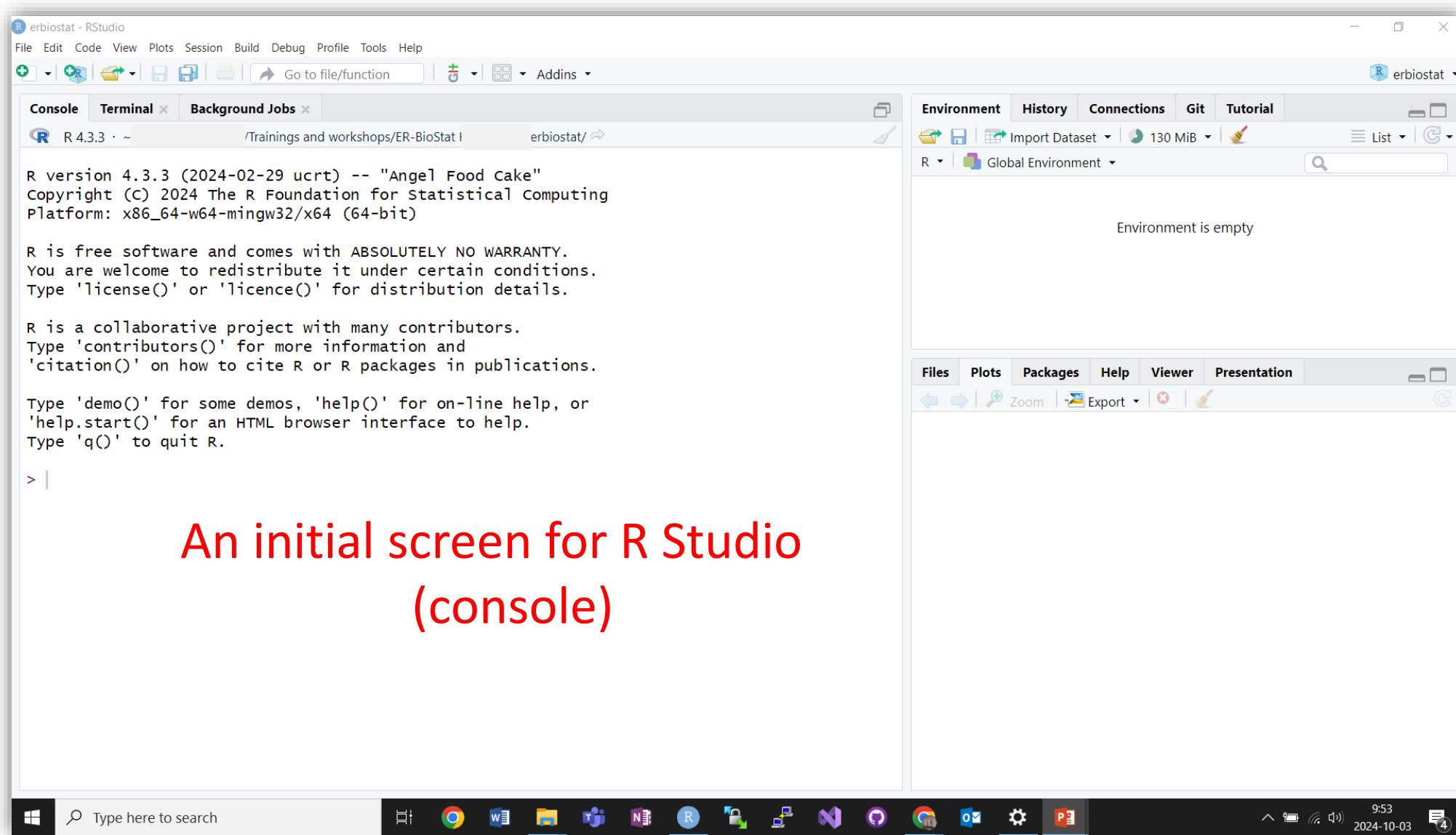
- R Studio is an integrated development environment (IDE) for R and Python.
 - It includes a **console, syntax-highlighting editor** that supports direct code execution.
 - Tools for plotting, history, debugging and workspace management.
- R Studio is available in **open source** and **commercial** editions and runs on the desktop (Windows, Mac, and Linux).

What is R Studio ?

- More information:

<https://rstudio.com/products/rstudio/>

R Studio



The cars dataset in R

The data give the speed of cars and the distances taken to stop. Note that the data were recorded in the 1920s.

Two variables:

- Cars' speed.
- Cars' stopping distance.

```
> head(cars)
```

	speed	dist
--	-------	------

1	4	2
2	4	10
3	7	4
4	7	22
5	8	16
6	9	10

R Studio: example

erbiostat - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Console Terminal Background Jobs

R 4.3.3 · ~/Bernard OSANG'IR/Trainings and workshops/ER-BioStat Kenya 2024/erbiostat/

```
R version 4.3.3 (2024-02-29 ucrt) -- "Angel Food Cake"
Copyright (C) 2024 The R Foundation for statistical computing
Platform: x86_64-w64-mingw32/x64 (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.

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.

> plot(cars$speed, cars$dist)
>
```

A plot in R Studio

- The **cars** dataset.
- Plot of the car's speed versus stopping distance.

Plot Zoom

plot (x, y)

Version

- 1.50.0
- 1.4-5
- 1.1-4.1
- 1.7-22
- 0.35
- 0.1-2
- 0.17-6
- 1.64.1

Type here to search

10:26
2024-10-03

R: example

RGui (64-bit)

File History Resize Windows

R Console

```
R version 4.3.3 (2024-02-29 ucrt) -- "Angel Food Cake"
Copyright (C) 2024 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

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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.

[Previously saved workspace restored]

> plot(cars$speed, cars$dist)
> |
```

Untitled - R Editor

```
plot(cars$speed, cars$dist)
```

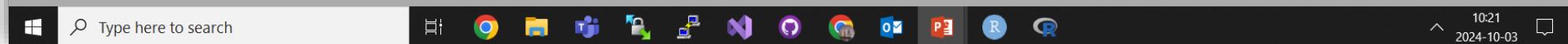
R Graphics: Device 2 (ACTIVE)

A scatter plot showing the relationship between car speed (x-axis) and stopping distance (y-axis). The x-axis is labeled 'cars\$speed' and ranges from 5 to 25. The y-axis is labeled 'cars\$dist' and ranges from 0 to 120. The plot shows a positive correlation, with data points scattered across the plot area, generally increasing from left to right.

- The **cars** dataset.
- Plot of the car's speed versus stopping distance.

plot (x, y)

A similar plot in R



General structure of R

- R Functions.
- R packages (written by developers) as a part of the software:
 - `glm()`
- R packages (written by developers) uploaded in CRAN, Bioconductor, Github....
- R packages (written by the user=you).

R functions

Example:

```
function (data)
```

```
> var (x)
```

The R function

data

A procedure that was programmed in R that uses data to produce output.

Calculate the sample variance.

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

R packages

- A package in R: a **collection of functions** that can be used for analysis or data management.
- Example: the `nlme` package for linear mixed models.
- Some packages are included in R, and some can be installed from CRAN/Bioconductor.
- **CRAN**: website with R packages ready to be installed and used.

<https://cran.r-project.org/>

R Studio: packages

The screenshot shows the R Studio interface. The console window displays the R startup message and a command to plot cars data. A red arrow points from the text "Upload new a package to R Studio" to the "Install Packages" dialog box. A callout box contains the text: "If you try to run the Rmd programs, you will probably need to install some packages." The environment pane shows an empty global environment. Red arrows point to the "Plots" and "Packages" tabs in the bottom navigation bar. The package manager dialog box is open, showing the "User Library" with various R packages listed.

erbiostat - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Console Terminal x Background Jobs x

R 4.3.3 · ~/Bernard OSANG'IR/Trainings and workshops/ER-BioStat Kenya 2024/erbiostat/ ↗

```
R version 4.3.3 (2024-02-29 ucrt) -- "Angel Food Cake"  
Copyright (c) 2024 The R Foundation for Statistical Computing  
Platform: x86_64-w64-mingw32/x64 (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.  
  
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.  
  
> plot(cars$speed, cars$dist)
```

Upload new a package to R Studio

If you try to run the Rmd programs, you will probably need to install some packages.

Install Packages

Install from: Repository (CRAN) Configuring Repositories

Packages (separate multiple with space or comma):

Install to Library: C:/Users/bosangir/AppData/Local/R/win-library/4.3 [Default]

Install dependencies

Install Cancel

Environment History Connections Git Tutorial

Global Environment

Environment is empty

File Plots Packages Help Viewer Presentation

Install Update Name Description Vers...

User Library

Name	Description	Vers...
a4Core	Automated Affymetrix Array Analysis Core Package	1.50.0
abind	Combine Multidimensional Arrays	1.4-5
additivity...	Additivity Tests in the Two Way Anova with Single Sub-Class Numbers	1.1-4.1
ade4	Analysis of Ecological Data: Exploratory and Euclidean Methods in Environmental Sciences	1.7-22
admisc	Adrian Dusa's Miscellaneous	0.35
alluvial	Alluvial Diagrams	0.1-2
analogue	Analogue and Weighted Averaging Methods for Paleoenvironmental	0.17-6

10:41 2024-10-03

Example 1

The mtcars data

Part 1: R and R Studio

- Example of a data analysis: the `mtcars` data.
 - Use `help(mtcars)` to get information about the data.
-
- ✓ Running the analysis in R.
 - ✓ Running the analysis in R-Studio.

The mtcars data: analysis in R

- Use `help(mtcars)` in R.

A screenshot of an R session in RGui (64-bit). The R Console window shows the following text:

```
R version 4.3.3 (2024-02-29 ucrt)
Copyright (C) 2024 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (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 details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information.
Type 'citation()' on how to cite R or R packages.
Type 'demo()' for some demos, 'help()'
'help.start()' for an HTML browser interface,
Type 'q()' to quit R.

[Previously saved workspace restored]

> help(mtcars)
starting httpd help server ... done
>

> |
```

The R Help window displays the documentation for the mtcars dataset. The title is "R: Motor Trend Car Road Tests". The "Description" section states: "The data was extracted from the 1974 *Motor Trend* US magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973–74 models)." The "Format" section describes it as "A data frame with 32 observations on 11 (numeric) variables." Below this, a list of variables is shown:

- [, 1] mpg Miles/(US) gallon ←
- [, 2] cyl Number of cylinders
- [, 3] disp Displacement (cu.in.)
- [, 4] hp Gross horsepower
- [, 5] drat Rear axle ratio
- [, 6] wt Weight (1000 lbs) ←
- [, 7] qsec 1/4 mile time
- [, 8] vs Engine (0 = V-shaped, 1 = straight)
- [, 9] am Transmission (0 = automatic, 1 = manual)
- [,10] gear Number of forward gears
- [,11] carb Number of carburetors

A red arrow points to the first item in the list, and another red arrow points to the sixth item in the list.

Description of the data in the help system.

The mtcars data in R

```
> head(mtcars)
```

		mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Mazda	RX4	21.0	6	160	110	3.90	2.620	16.46	0	1	4	4
Mazda	RX4 Wag	21.0	6	160	110	3.90	2.875	17.02	0	1	4	4
Datsun	710	22.8	4	108	93	3.85	2.320	18.61	1	1	4	1
Hornet	4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1
Hornet	Sportabout	18.7	8	360	175	3.15	3.440	17.02	0	0	3	2
Valiant		18.1	6	225	105	2.76	3.460	20.22	1	0	3	1

- 
- Variables in the data.
 - For our example: **mpg** and **wt**.

Analysis

- Plot mpg Vs. weight.
- Calculate the mean weight.
- Fit a simple regression model for mpg on Weight.

To run the analysis in the example, use the program in R Studio:

[R_course_UHasselt_demo_V0.Rmd](#)

Analysis in basic R & output

RGui (64-bit)

File History Resize Windows

R Console

```
> plot(mtcars$wt, mtcars$mpg)
> mean(mtcars$mpg)
[1] 20.09062
> fit.lm<-lm(mtcars$mpg~mtcars$wt)
> summary(fit.lm)

Call:
lm(formula = mtcars$mpg ~ mtcars$wt)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.5432 -2.3647 -0.1252  1.4096  6.8727 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 37.2851    1.8776 19.858 < 2e-16 ***
mtcars$wt   -5.3445    0.5591 -9.559 1.29e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 ' 
Residual standard error: 3.046 on 30 degrees of freedom
Multiple R-squared:  0.7528, Adjusted R-squared:  0.7497 
F-statistic: 91.38 on 1 and 30 DF, p-value: 1.294e-30

> |
```

The estimated model

see next slide

Limited - R Editor

```
summary(mtcars)
plot(mtcars$wt, mtcars$mpg)
mean(mtcars$mpg)
fit.lm<-lm(mtcars$mpg~mtcars$wt)
summary(fit.lm)
```

R Graphics: Device 2 (ACTIVE)

11:25 2024-10-03

The R code for the analysis

```
summary(mtcars)
plot(mtcars$wt, mtcars$mpg)
mean(mtcars$mpg)
fit.lm<-lm(mtcars$mpg~mtcars$wt) —————> fit a simple linear regression
model
summary(fit.lm)
```

The regression output

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

mtcars\$mpg
response

mtcars\$wt
predictor

The mtcars data: an analysis in R Studio

The screenshot shows the R Studio interface with the following components:

- Source Editor:** Displays the R Markdown file `R_Course_UHasselt_demo_V0.Rmd`. The code is annotated with a red box around lines 18-22, which are highlighted in yellow. A red arrow points from the text "The R code" to this box.
- Console:** Shows the output of the R code, including the results of `summary(mtcars)`, `plot(mtcars$wt, mtcars$mpg)`, `mean(mtcars$mpg)`, the creation of a linear model `fit.lm <- lm(mtcars$mpg ~ mtcars$wt)`, and the summary of the model `summary(fit.lm)`. The output also includes the regression coefficients and their significance levels.
- Environment:** Shows the global environment with an object named `fit.lm` listed as a `List of 12`.
- Packages:** Shows the user library with various packages installed, such as `a4Core`, `abind`, `additivityT...`, `ade4`, `admisc`, `alluvial`, `analogue`, and `Annotatio...`.

The title "The R code" is overlaid in red text on the left side of the Source Editor area.

```
1 ---  
2 title: "Demo 1"  
3 author: "Rudradev Sengupta, Bernard Osang'ir & Ziv Shkedy"  
4 date: "01/10/24"  
5 output:  
6   html_document: default  
7   word_document: default  
8   pdf_document: default  
9 params:  
10   snapshot: "lubridate::ymd_hms(\"2015-01-01 12:30:00\")"  
11   start: "lubridate::ymd(\"2015-01-01\")"  
12 ---  
13  
14 {r setup, include=FALSE}  
15 knitr::opts_chunk$set(echo = TRUE)  
16  
17  
18 summary(mtcars)  
19 plot(mtcars$wt, mtcars$mpg)  
20 mean(mtcars$mpg)  
21 fit.lm<-lm(mtcars$mpg~mtcars$wt)  
22 summary(fit.lm)|
```

(Intercept) 37.2851 1.8776 19.858 < 2e-16 ***
mtcars\$wt -5.3445 0.5591 -9.559 1.29e-10 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.046 on 30 degrees of freedom
Multiple R-squared: 0.7528, Adjusted R-squared: 0.7446
F-statistic: 91.38 on 1 and 30 DF, p-value: 1.294e-10

The mtcars data : an analysis in R Studio

The screenshot illustrates the workflow for analyzing the mtcars dataset in R Studio. The interface is divided into several panels:

- Code Editor (Source tab):** Shows the R code for setting up the environment and performing a linear regression analysis on the mtcars dataset. A red arrow points from this panel to the "Run" menu.
- Run Menu:** A context menu is open over the code editor, highlighting the "Run Selected Line(s)" option. Other options include "Run Current Chunk", "Run All Chunks Above", and "Run All". A large red arrow points from the menu towards the "Output" panel.
- Output Panel:** Displays the results of the R code execution, including the summary statistics of the mtcars dataset, the regression output (Call, Residual standard error, Multiple R-squared, Adjusted R-squared, F-statistic, p-value), and the signifi-
- Environment Panel:** Shows the global environment, listing objects like "fit.lm" which is a "List of 12".
- Console Panel:** Shows the command-line interface output, including the R version, working directory, and the regression results.
- Bottom Taskbar:** Contains icons for various applications and the R logo.

The R code (highlighted in blue box):

```
1 ---  
2 title: "Demo 1"  
3 author: "Rudradev Sengupta, Bernard Osang'ir & Ziv Shkedy"  
4 date: "01/10/24"  
5 output:  
6   html_document: default  
7   word_document: default  
8   pdf_document: default  
9 params:  
10   snapshot: "lubridate::ymd_hms(\"2015-01-01 12:30:00\")"  
11   start: "lubridate::ymd(\"2015-01-01\")"  
12 ---  
13  
14 `r setup, include=FALSE`  
15 knitr::opts_chunk$set(echo = TRUE)  
16  
17  
18 summary(mtcars)  
19 plot(mtcars$wt,mtcars$mpg)  
20 mean(mtcars$mpg)  
21 fit.lm<-lm(mtcars$mpg~mtcars$wt)  
22 summary(fit.lm)
```

The output (highlighted in blue box):

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
Residual standard error: 3.046 on 30 degrees of freedom  
Multiple R-squared:  0.7528,  Adjusted R-squared:  0.7446  
F-statistic: 91.38 on 1 and 30 DF,  p-value: 1.294e-10
```

Analysis in R Studio: the output

R erbiostat - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

R_Course_UHasselt_demo_V0.Rmd*

Go to file/function Addins

Source Visual

```
1 ---  
2 title: "Demo 1"  
3 author: "Rudradev Sengupta, Bernard Osang'ir & Ziv Sh  
4 date: "01/10/24"  
5 output:  
6 html_document: default  
7 word_document: default  
8 pdf_document: default  
9 params:  
10 snapshot: "lubridate::ymd_hms(\"2015-01-01 12:30:00")"  
11 start: "lubridate::ymd(\"2015-01-01\")"  
12 ---  
13  
14 ``{r setup, include=FALSE}  
15 knitr::opts_chunk$set(echo = TRUE)  
16 ``  
17  
18 summary(mtcars)  
19 plot(mtcars$wt,mtcars$mpg)  
20 mean(mtcars$mpg)  
21 fit.lm<-lm(mtcars$mpg~mtcars$wt)  
summary(fit.lm)
```

code

22:16 (Top Level) ↴

Console Terminal Background Jobs

R 4.3.3 · ~/Bernard OSANG'IR/Trainings and workshops/ER-BioStat Kenya 2024/erbiostat/

Min	1Q	Median	3Q	Max
-4.5432	-2.3647	-0.1252	1.4096	6.8727

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	37.2851	1.8776	19.858	< 2e-16 ***
mtcars\$wt	-5.3445	0.5591	-9.559	1.29e-10 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.046 on 30 degrees of freedom
Multiple R-squared: 0.7528, Adjusted R-squared: 0.7446
F-statistic: 91.38 on 1 and 30 DF, p-value: 1.294e-10

> |

Plot Zoom

mtcars\$mpg

mtcars\$wt

The estimated model

Environment History Connections Git Tutorial

Import Dataset 186 MB

Global Environment

fit.lm List

Files Plots Packages Help Viewer Presentation

Zoom

Graphical window

12:14 2024-10-03

R Studio

- So far, R Studio (in this setting): similar to R BUT....
- R Studio + R markdown: a different level of output.

R markdown

R markdown: what?

- Markdown allows you to write a file format independent document using an **easy-to-read** and **easy-to-write** plain text format.
- Instead of marking up text so that is easy for a computer to read
 - e.g. HTML: <html><body>Name</body></html>
- The goal is to mark down the text so that it is easy and human-readable (instead of machine-readable):
 - e.g. ****Name****
- The most easy way to understand it: R markdown allows us to write free text and run R together in the same file.

R markdown: what?

- Markdown is a specific Markup language which is structured very loosely
=> any file format can be generated using pandoc.
- Pandoc: R function to convert documents To other formats.
- From one Markdown document you can generate different file formats:
 - **HTML**
 - **PDF**
 - **Docx**
 - **slideshows**
 - **rtf, etc.**
- The downside is that there is slightly less control over formatting.

R markdown: what?

- Extension of Markdown via R:
 - Allowing *R code* and its *results* to be merged with Markdown.
 - Ensuring that *R Markdown documents are fully reproducible*.
 - Enabling extra modifications to the original markdown specification.
- Provides a *unified authoring framework for data science*, combining your code, its results, etc.
- In practice: just by changing the dataset, the entire analysis can be rerun, and the new report can be produced.
- Integrates a number of R packages and external tools.

R markdown: what?

- A lot of online materials.
- RMarkdown Cheat Sheet: *Help > Cheatsheets > R Markdown Cheat Sheet* (<https://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf>)
- RMarkdown Reference Guide: *Help > Cheatsheets > R Markdown Reference Guide*
- Both cheatsheets are also available at <http://rstudio.com/cheatsheets>
- *Help > Markdown Quick Reference*

The R markdown program: components

The screenshot shows the RStudio interface with an R Markdown file open. The file contains the following content:

```
1 ---  
2 title: "Demo"  
3 author: "Rudradev Sengupta"  
4 date: "16 July 2019"  
5 output: html_document  
6 ---  
7  
8 ```{r setup, include=FALSE}  
9 knitr::opts_chunk$set(echo = TRUE)  
10  
11 ## R Markdown  
12  
13 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.  
14  
15 when you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:  
16  
17 ```{r cars}  
18 summary(cars)  
19  
20 ## Including Plots  
21  
22 You can also embed plots, for example:  
23  
24 ```{r pressure, echo=FALSE}  
25 plot(pressure)  
26  
27 Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.  
28  
29  
30
```

Annotations in the screenshot:

- A bracket on the left labeled "YAML Header" points to the YAML header section.
- A bracket on the left labeled "Formatted Text" points to the introductory text and the "Including Plots" section.
- A bracket on the right labeled "Code Chunks" points to the R code blocks.
- A red arrow points from the text "summary(cars)" to the line "summary(cars)" in the code.
- A red arrow points from the text "plot(pressure)" to the line "plot(pressure)" in the code.

Programname.Rmd

There are principally three sections to an R Markdown document:

- YAML header surrounded by `---`
- Code chunks surrounded by `````
- Free text mixed with simple text formatting like `#heading` and `_italics_`

Starting point

- Available materials to try out:
 - <https://teams.microsoft.com/#/files/Reference%20Material?threadId=19:05ec12c79df7460ca9cdfbd8b620f16a@thread.skype&ctx=channel&context=Rmarkdown%2520Help> – templates by Stefan to create pdf/html/.. documents
 - <https://teams.microsoft.com/#/files/Reference%20Material?threadId=19:05ec12c79df7460ca9cdfbd8b620f16a@thread.skype&ctx=channel&context=Code%2520Repository%252FAssignment%25206> – solutions for Assignment 6, by different groups in US

Starting point

- Available materials to try out:
 - https://rmarkdown.rstudio.com/articles_intro.html
 - materials from RStudio

Example 1 (continue)

The mtcars data

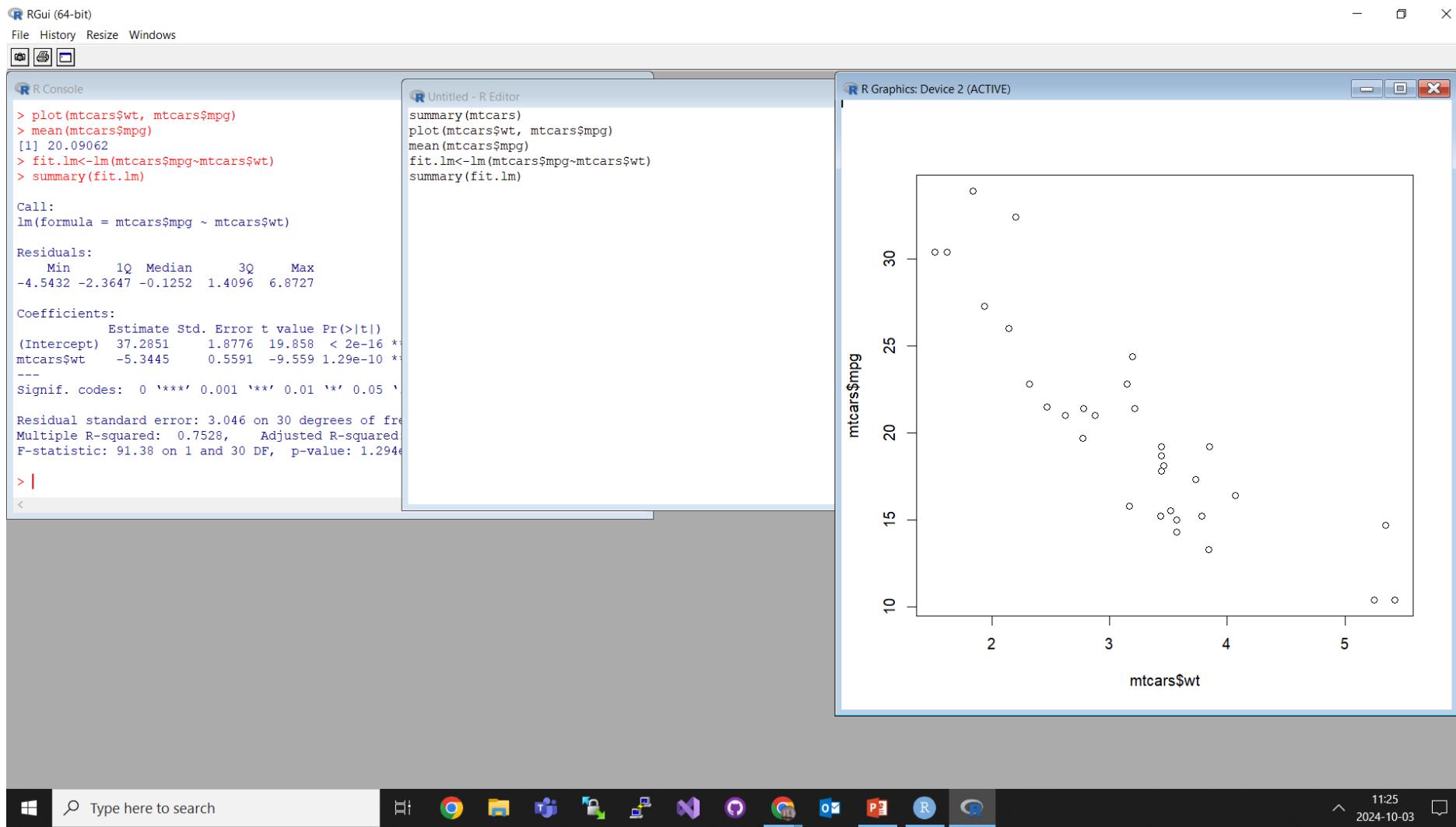
Part 1: Analysis with R and R Studio

Analysis

- Plot mpg Vs. weight.
- Calculate the mean weight.
- Fit a regression model for Mpg on Weight.
- R code: [see next page](#).

Analysis in R

- The same slides as 18-22.



Analysis in R Studio

The screenshot shows the R Studio interface with the following components:

- Top Bar:** File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help.
- Toolbar:** Includes icons for New Project, Open, Save, Run, Knit, and Addins.
- Source Editor:** Displays the R Markdown file `R_Course_UHasselt_demo_V0.Rmd*`. The code includes YAML front matter and R code for summarizing the mtcars dataset and fitting a linear model.
- Console:** Shows the output of the R session, including the summary of mtcars, a plot of mpg vs wt, the fitted linear model `fit.lm`, and its summary statistics.
- Environment:** Shows the global environment with an object `fit.lm` which is a list of 12 items.
- Packages:** Shows the user library with packages like a4Core, abind, additivityT, ade4, admisc, alluvial, analogue, and Annotatio... listed.
- Bottom Bar:** Windows taskbar with various application icons.

Analysis in R Studio

The screenshot shows the R Studio interface with several panels:

- Source Editor:** Displays R code for a document named "R_Course_UHasselt_demo_V0.Rmd". A red arrow points from the text area to the "Run" button in the toolbar.
- Run Menu:** A context menu is open over the code, with the "Run Selected Line(s)" option highlighted. Other options include "Run Current Chunk", "Run All Chunks Above", and "Run All". A red arrow points from the menu to the "Run" button in the toolbar.
- Console:** Shows the R command "summary(mtcars)" and its output, which includes a regression analysis of mpg vs wt.
- Output:** A blue box labeled "The output" contains the text "The output" itself, indicating where the console output is displayed.
- Environment:** Shows the global environment with objects like "fit.lm" and "List of 12".
- Packages:** Shows the user library with packages such as a4Core, abind, additivityT..., ade4, admisc, alluvial, and analogue.

The R code

```
1 ---  
2 title: "Demo 1"  
3 author: "Rudradev Sengupta, Bernard Osang'ir & Ziv Shkedy"  
4 date: "01/10/24"  
5 output:  
6   html_document: default  
7   word_document: default  
8   pdf_document: default  
9 params:  
10   snapshot: "lubridate::ymd_hms(\"2015-01-01 12:30:00\")"  
11   start: "lubridate::ymd(\"2015-01-01\")"  
12 ---  
13  
14 {r setup, include=FALSE}  
15 knitr::opts_chunk$set(echo = TRUE)  
16  
17  
18 summary(mtcars)  
19 plot(mtcars$wt,mtcars$mpg)  
20 mean(mtcars$mpg)  
21 fit.lm<-lm(mtcars$mpg~mtcars$wt)  
22 summary(fit.lm)
```

The output

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
Residual standard error: 3.046 on 30 degrees of freedom  
Multiple R-squared:  0.7528,  Adjusted R-squared:  0.7446  
F-statistic: 91.38 on 1 and 30 DF,  p-value: 1.294e-10
```

Analysis in R Studio

R erbiostat - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

R_Course_UHasselt_demo_V0.Rmd*

Source Visual

```
1 ---  
2 title: "Demo 1"  
3 author: "Rudradev Sengupta, Bernard Osang'ir & ziv Shmilovich"  
4 date: "01/10/24"  
5 output:  
6 html_document: default  
7 word_document: default  
8 pdf_document: default  
9 params:  
10 snapshot: "lubridate::ymd_hms(\"2015-01-01 12:30:00\")"  
11 start: "lubridate::ymd(\"2015-01-01\")"  
12 ---  
13  
14 ``{r setup, include=FALSE}  
15 knitr::opts_chunk$set(echo = TRUE)  
16 ---  
17  
18 summary(mtcars)  
19 plot(mtcars$wt, mtcars$mpg)  
20 mean(mtcars$mpg)  
21 fit.lm<-lm(mtcars$mpg~mtcars$wt)  
22 summary(fit.lm)
```

22:16 (Top Level) code

Console Terminal Background Jobs

R 4.3.3 · ~/Bernard OSANG'IR/Trainings and workshops/ER-BioStat Kenya 2024/erbiostat/

Min	1Q	Median	3Q	Max
-4.5432	-2.3647	-0.1252	1.4096	6.8727

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	37.2851	1.8776	19.858	< 2e-16 ***
mtcars\$wt	-5.3445	0.5591	-9.559	1.29e-10 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.046 on 30 degrees of freedom
Multiple R-squared: 0.7528, Adjusted R-squared: 0.7446
F-statistic: 91.38 on 1 and 30 DF, p-value: 1.294e-10

> |

Plot Zoom

mtcars\$mpg

mtcars\$wt

The estimated model

Graphical window

Zoom

12:14 2024-10-03

Part 2: Analysis with R markdown

To run the analysis in the example, use the program in R Studio:

R_course_UHasselt_demo_V1.Rmd

Different types of Output

- Two types of output:
 - HTML.
 - PDF.
 - DOCX
- Text and R code in the same document.

Running R in Markdown

- General form:

```
```{r}  
R code
...
```
```

Code chunks for
the analysis.

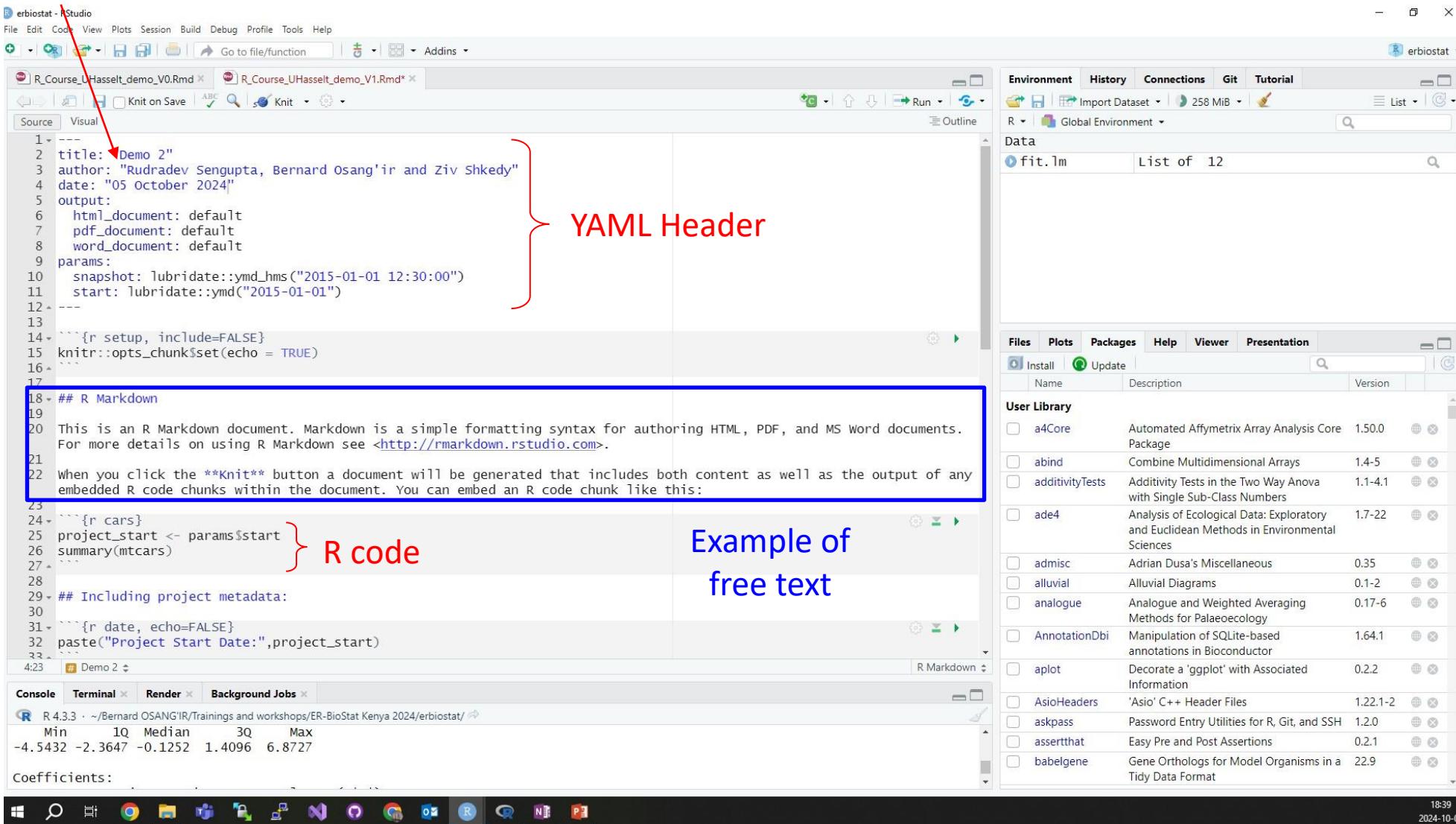
- Example of a scatterplot:

```
```{r}  
plot(x, y)
```
```

Use the function `plot()` to
produce a scatterplot.

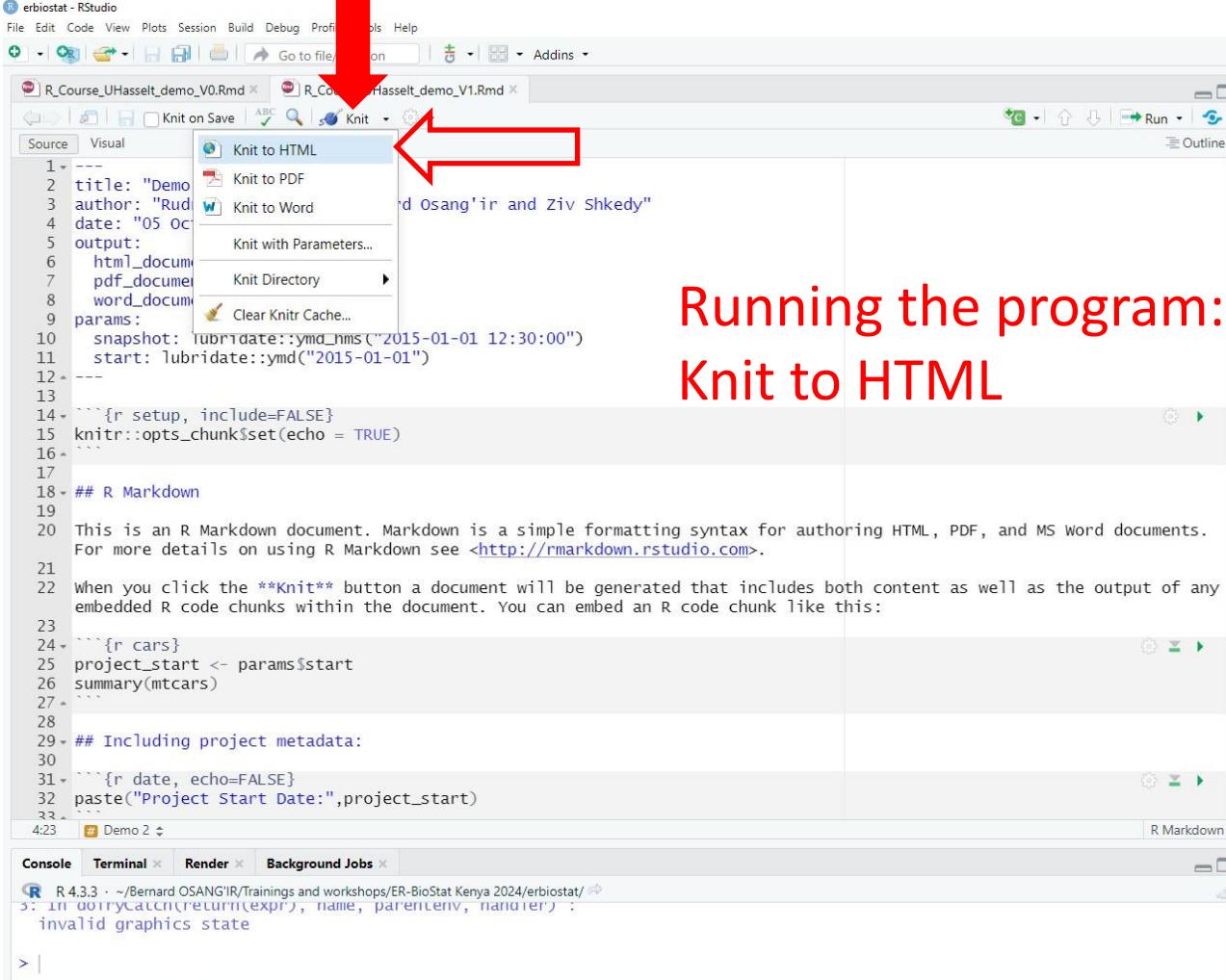
The Rmd program

Title and info.



R course UHasselt demo V1.Rmd

Knit to HTML (how to run the program)



A screenshot of the RStudio interface. The main window shows an R Markdown file named 'R_Course_UHasselt_demo_V0.Rmd'. A red arrow points from the text 'Knit to HTML' in the slide down to the 'Knit' button in the RStudio toolbar. The 'Knit' button has a dropdown menu open, with 'Knit to HTML' highlighted. The RStudio environment includes a sidebar with tabs for Environment, History, Connections, Git, and Tutorial, and a packages tab showing a list of installed packages.

Running the program:
Knit to HTML

```
1 ---  
2 title: "Demo"  
3 author: "Rudolf Hasselt"  
4 date: "05 Oct 2015"  
5 output:  
6 html_document  
7 pdf_document  
8 word_document  
9 params:  
10 snapshot: lubridate::ymd_hms("2015-01-01 12:30:00")  
11 start: lubridate::ymd("2015-01-01")  
12 ---  
13  
14 ``{r setup, include=FALSE}  
15 knitr::opts_chunk$set(echo = TRUE)  
16 ``-  
17  
18 ## R Markdown  
19  
20 This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents.  
For more details on using R Markdown see <http://rmarkdown.rstudio.com>.  
21  
22 When you click the **Knit** button a document will be generated that includes both content as well as the output of any  
embedded R code chunks within the document. You can embed an R code chunk like this:  
23  
24 ``{r cars}  
25 project_start <- params$start  
26 summary(mtcars)  
27 ``-  
28  
29 ## Including project metadata:  
30  
31 ``{r date, echo=FALSE}  
32 paste("Project Start Date:",project_start)  
33 ``-
```

Console Terminal Render Background Jobs

R 4.3.3 · ~/Bernard OSANG'IR/Trainings and workshops/ER-BioStat Kenya 2024/erbiostat/

18:46 2024-10-03

Output: HTML

The screenshot illustrates the R Markdown workflow in RStudio. On the left, the R Markdown source code for "Demo 2" is shown, with a red circle highlighting the line "# R Markdown". A red arrow points from this line to the generated HTML output on the right. The HTML output displays the document title "Demo 2", authors "Rudradev Sengupta, Bernard Osang'ir and Ziv Shkedy", and the date "05 October 2024". The "R Markdown" section is also highlighted with a red box. A red arrow points from the "See page 43" text at the top right to this box. The "The output" text is also highlighted with a red box. The bottom of the screenshot shows the RStudio interface with tabs like "Console", "Terminal", and "Background Jobs", and a status bar indicating the date and time.

See page 43

Demo 2

Rudradev Sengupta, Bernard Osang'ir and Ziv Shkedy

05 October 2024

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
project_start <- params$start  
summary(mtcars)
```

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <<http://rmarkdown.rstudio.com>>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
## {r cars}  
project_start <- params$start  
summary(mtcars)
```

Including project metadata:

```
## [1] "Project Start Date: lubridate::ymd(\"2015-01-01\")"
```

Including Plots

The output

18:51
2024-10-03

The HTML output

RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

HD_Unsupervised_NBA_2017.R Example_prog_2016.R HD_Unsupervised_Examp

Source Visual

Including Plots

You can also embed plots, for example:

```
plot(mtcars$wt,mtcars$mpg)
```

Note that the `echo = FALSE` parameter was added to the code that generated the plot.

```
```{r,echo = FALSE}
plot(mtcars$wt,mtcars$mpg)
````
```

1:1 # Demo 2 ^

Console Terminal Render Background Jobs

R 4.3.2 · C:/Ziv_Temp_2023/Wprkshop_Kenya/Shortcourse/Rmarkdown1/Rmds/

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.

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.

> |

C:/Ziv_Temp_2023/Wprkshop_Kenya/Shortcourse/Rmarkdown1/Rmds/R_Course_UHasselt_demo_V1.html

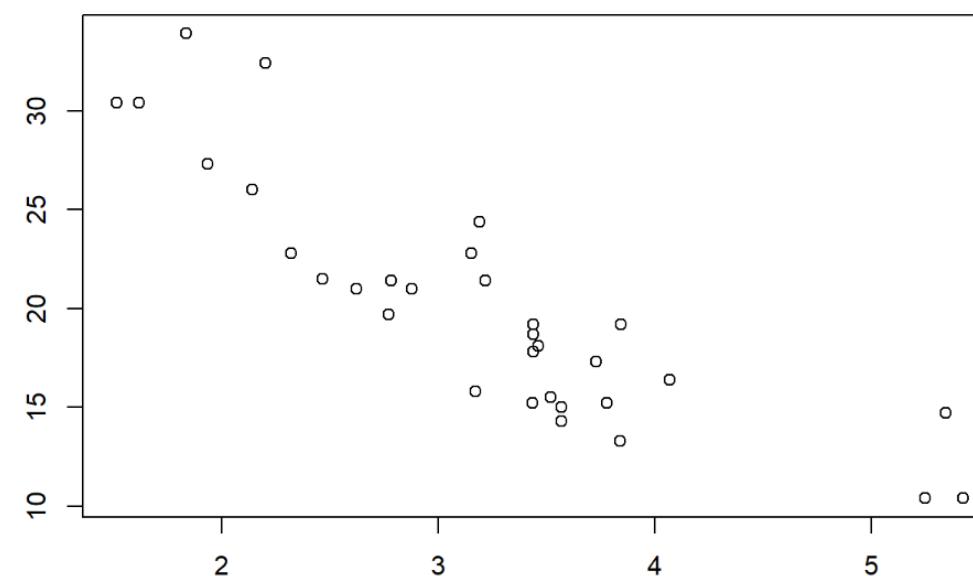
Open in Browser Find

Publish

Including Plots

You can also embed plots, for example:

```
plot(mtcars$wt,mtcars$mpg)
```



A data frame with 15 observations on 2 variables.

8:23 ENG 9/05/2025 47

The HTML output

The screenshot shows the RStudio interface with an R Markdown file open on the left and its generated HTML output on the right.

Left Panel (RStudio Editor):

- File:** HD_Unsupervised_NBA_2017.R, Example_prog_2016.R, HD_Unsupervised_Examp
- Tools:** Go to file/function, Addins
- Code View:** Source (selected), Visual
- Text:** R code including `## Short Analysis` and `## Output for the regression model` sections.
- Console:** Shows the R startup message and basic information about the R environment.

Right Panel (Generated HTML):

- Title:** C:/Ziv_Temp_2023/Wprkshop_Kenya/Shortcourse/Rmarkdown1/Rmds/R_Course_UHasselt_demo_V1.html
- Content:**
 - Short Analysis:** Includes a code block for `mean(mtcars\$mpg)` and its output `## [1] 20.09062`.
 - Output for the regression model:** Includes a code block for `summary(fit.lm)` and its output:

```
## 
## Call:
## lm(formula = mtcars$mpg ~ mtcars$wt)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.5432 -2.3647 -0.1252  1.4096  6.8727
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 37.2851    1.8776 19.858 < 2e-16 ***
## mtcars$wt   -5.3445    0.5591 -9.559 1.29e-10 ***
## ---
```

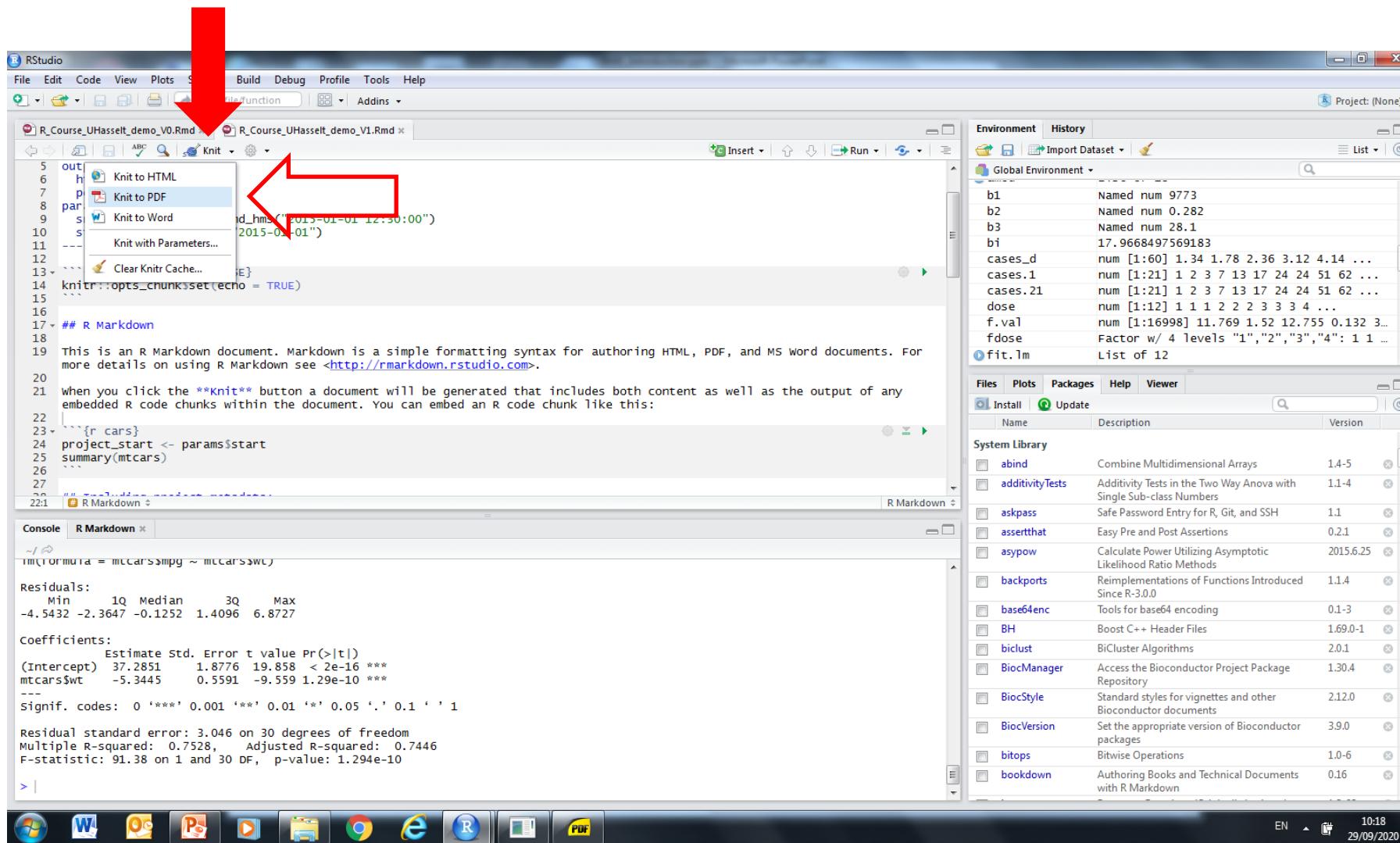
A note at the bottom states: "A data frame with 15 observations on 2 variables."

Bottom: Taskbar showing the Windows Start button, search bar, and various application icons (File Explorer, Google Chrome, Microsoft Word, R). The status bar shows the date and time (8:25 9/05/2025).

The Rmd output

- Output in **ONE** document.
- Text and R output.
- R code can be included.
- Type of document: HTML/PDF.
- **The data analyst designs the output.**

Knit to PDF



The PDF output

A screenshot of the RStudio interface demonstrating the generation of a PDF document from R Markdown code.

Left Panel (RStudio Environment):

- Code Editor:** Shows the R Markdown code for "R_Course_UHasselt_demo_V0.Rmd". It includes code chunks for generating plots and tables, and an R code chunk for a linear regression model on the mtcars dataset.
- Console:** Displays the results of the R code execution, including the regression output and summary statistics for the mtcars dataset.

Right Panel (PDF Preview):

- Title:** The title "Demo 2" is highlighted with a red box and an annotation pointing to it from the text "See page 43 for the title".
- Author:** "Rudradev Sengupta and Ziv Shkedy"
- Date:** "29 September 2020"
- Content:** The PDF includes an R Markdown section explaining how to use R Markdown syntax, an "Including project metadata" section, and an "Including Plots" section.

Annotations: Red arrows point from the RStudio code editor towards the corresponding sections in the PDF preview.

System Status Bar: Shows the system language as EN, the current time as 10:17, and the date as 29/09/2020.

The PDF output

The screenshot shows the RStudio interface with a PDF output window open. The PDF window displays an R Markdown document titled "Demo 2". The document includes code chunks for generating summary statistics and a scatter plot, along with their respective outputs. The RStudio environment shows the code editor, console, and file browser.

R Markdown Document Content:

```
## Median :0.0000 Median :4.0000 Median :2.000
## Mean : 0.4062 Mean :3.688 Mean :2.812
## 3rd Qu.:1.0000 3rd Qu.:4.000 3rd Qu.:4.800
## Max. :1.0000 Max. :5.000 Max. :8.000

Including project metadata:
[1] "Project Start Date: lubridate::ymd(\"2015-01-01\")"

Including Plots
You can also embed plots, for example:
plot(mtcars$wt,mtcars$mpg)
```

Scatter Plot:

A scatter plot showing the relationship between the weight of the car (wt) on the x-axis and its fuel economy (mpg) on the y-axis. The x-axis ranges from approximately 1.6 to 5.4, and the y-axis ranges from 10 to 35. The plot shows a negative correlation, with fuel economy generally decreasing as the weight of the car increases. There are several outliers at higher weights (around 4.5-5.0) and lower fuel economy (around 10-15 mpg).

Note: Note that the echo = FALSE parameter was added to the code chunk to prevent printing of the R code that generated the plot.

RStudio Environment:

- Code Editor:** Shows the R Markdown file "R_Course_UHasselt_demo_V0.Rmd".
- Console:** Shows the R version information and a few commands entered.
- File Browser:** Shows a list of files and packages in the current project.
- Project:** Shows the project structure with files like "bles", "les", "les", and "bles".

The PDF output

The screenshot shows the RStudio interface with a PDF output window open. The PDF contains R code and its output. A red text overlay 'The regression output' is placed over the middle section of the PDF content.

Code in R Markdown:

```
1 ---  
2 title: "Demo 2"  
3 author: "Rudradev Sengupta"  
4 date: "29 September 2020"  
5 output:  
6   pdf_document: default  
7   html_document: default  
8 params:  
9   snapshot: lubridate::ymd  
10  start: lubridate::ymd  
11  ---  
12  ````{r setup, include=FALSE}  
13  knitr::opts_chunk$set(echo = TRUE)  
14  ````  
15    
16    
17  ## R Markdown  
18  This is an R Markdown document.  
19  It is a simple example of how to use R  
20  documents. For more details,  
21  when you click the **Knit** button  
22  of any embedded R code chunk,
```

Console Output:

```
R version 3.6.1 (2019-07-05) -- "Action of the Toad"  
Copyright (C) 2019 The R Foundation for Statistical Computing  
Platform: x86_64-w64-mingw32/x64 (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 more information.  
  
R is a collaborative project with many contributors.  
Type 'contributors()' for more information.  
Type 'citation()' on how to cite R or packages.  
  
Type 'demo()' for some demos,  
'help.start()' for an HTML browser-based help system,  
Type 'q()' to quit R.  
  
[workspace loaded from ~/RData]
```

PDF Content:

mtcars\$wt

Short Analysis

```
mean(mtcars$mpg)  
## [1] 20.09062  
fit.lm<-lm(mtcars$mpg~mtcars$wt)
```

Output for the regression model

```
summary(fit.lm)  
  
##  
## Call:  
## lm(formula = mtcars$mpg ~ mtcars$wt)  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max  
## -4.5432 -2.3647 -0.1252  1.4096  6.8727  
##  
## Coefficients:  
##             Estimate Std. Error t value Pr(>|t|)  
## (Intercept) 37.2851    1.8776 19.858 < 2e-16 ***  
## mtcars$wt   -5.3445    0.5591 -9.559 1.29e-10 ***  
  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

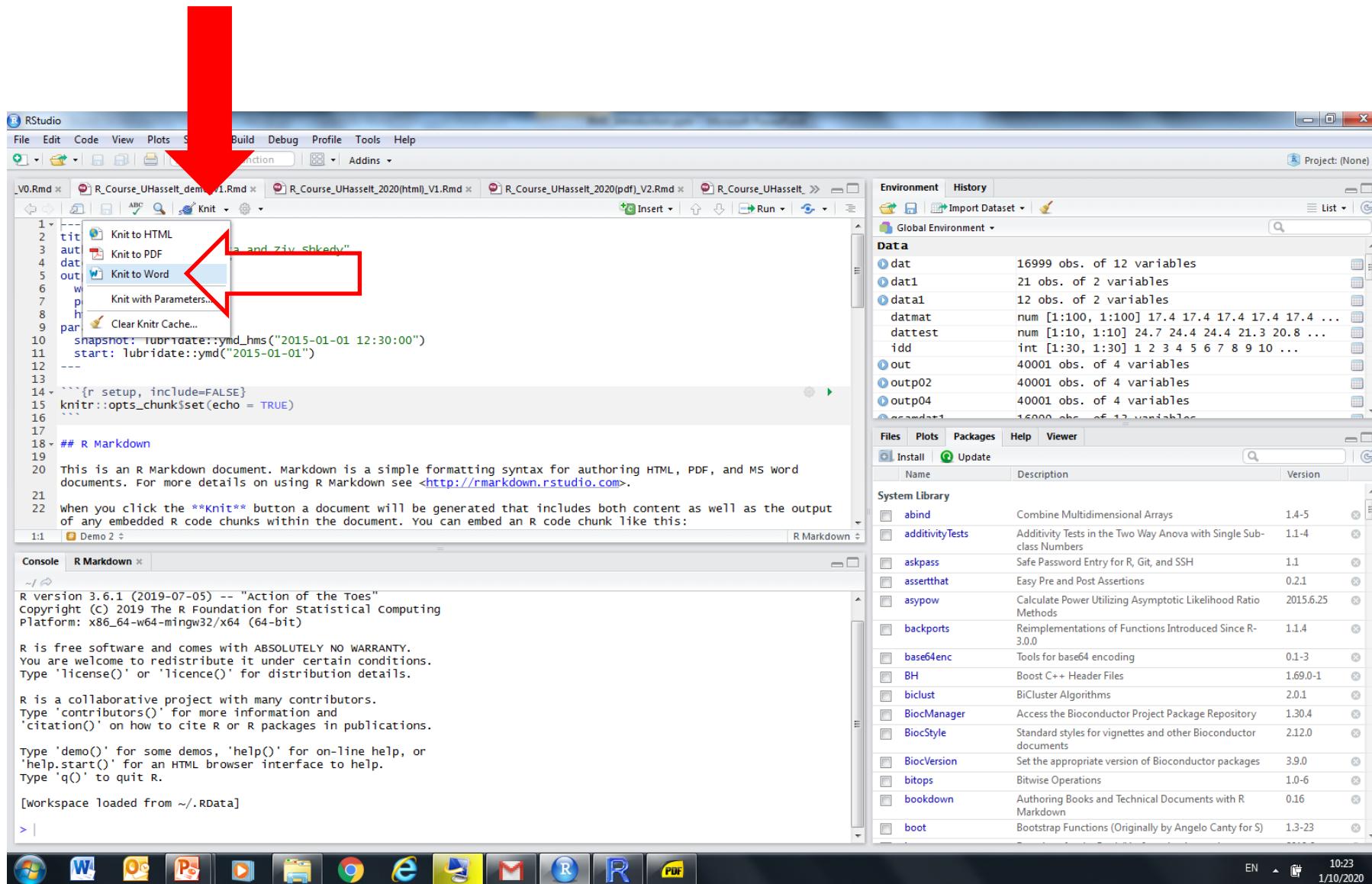
3

The regression output

EN 12:12 30/09/2020

Important: To produce the PDF file, you will need to install [LaTeX](#) or [Tex](#)

Knit to word



The word doc output

A screenshot of Microsoft Word showing an R Markdown document. The document contains a title 'Demo 2', author information 'Rudradev Sengupta and Ziv Shkedy', and a date '29 September 2020'. It also includes an R code chunk for generating a scatter plot of weight vs. miles per gallon, and a summary of the mtcars dataset.

Example 2

Output development

Focus

- How to develop an output document:
 - HTML.
 - PDF/HTML.
- Sections/Subsections.
- R code as a part of the text or not?

The program

- A simple user guide for a document that includes:
 - Free text.
 - R code.
 - Graphical displays.
- To produce the document:
 - run the programs in R Studio.

Development of a **HTML** document

- The output:
 - HTML document.

To run the analysis in the example, use the program in R Studio:

[`R_course_UHasselt_2021\(html\)_V1.Rmd`](#)

The program

R_course_UHasselt_2020(html)_V1.Rmd

YAML Header

```
1 ---  
2 title: "Basic skills in R Markdown"  
3 author:  
4 - name: Ziv Shkedy  
5   affiliation: Hasselt University, Belgium  
6 subtitle: The HTML file (2020)  
7  
8 #institute: UHasselt  
9 date: September, 29, 2020  
10 output:  
11   rmdformats::readthedown:  
12     highlight: kate  
13     use_bookdown: TRUE  
14 vignette: >  
15   %>%vignetteEngine{knitr::rmarkdown}  
16 editor_options:  
17   chunk_output_type: console  
18 categories: ["R"]  
19 bibliography: bibliography.bib  
20 ---  
21  
22  
23 <script type="text/javascript"  
24   src="http://cdn.mathjax.org/mathjax/latest/MathJax.js?config=TeX-AMS-MML_HTMLorMML">  
1:1 Basic Skills in R Markdown
```

R version 3.6.1 (2019-07-05) -- "Action of the Toes"
Copyright (C) 2019 The R Foundation for statistical computing
Platform: x86_64-w64-mingw32/x64 (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.

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.

[workspace loaded from ~/.RData]

> |

Environment History

Data

- dat 16999 obs. of 12 variables
- dat1 21 obs. of 2 variables
- data1 12 obs. of 2 variables
- datmat num [1:100, 1:100] 17.4 17.4 17.4 17.4 ...
- dattest num [1:10, 1:10] 24.7 24.4 24.4 21.3 20.8 ...
- idd int [1:30, 1:30] 1 2 3 4 5 6 7 8 9 10 ...
- out 40001 obs. of 4 variables
- outp02 40001 obs. of 4 variables
- outp04 40001 obs. of 4 variables
- scamdat1 16000 obs. of 12 variables

Files Plots Packages Help Viewer

System Library

- abind Combine Multidimensional Arrays 1.4-5
- additivityTests Additivity Tests in the Two Way Anova with Single Sub-class Numbers 1.1-4
- askpass Safe Password Entry for R, Git, and SSH 1.1
- assertthat Easy Pre and Post Assertions 0.2.1
- asypow Calculate Power Utilizing Asymptotic Likelihood Ratio Methods 2015.6.25
- backports Reimplementations of Functions Introduced Since R-3.0.0 1.1.4
- base64enc Tools for base64 encoding 0.1-3
- BH Boost C++ Header Files 1.69.0-1
- biclust BiCluster Algorithms 2.0.1
- BiocManager Access the Bioconductor Project Package Repository 1.30.4
- BiocStyle Standard styles for vignettes and other Bioconductor documents 2.12.0
- BiocVersion Set the appropriate version of Bioconductor packages 3.9.0
- bitops Bitwise Operations 1.0-6
- bookdown Authoring Books and Technical Documents with R Markdown 0.16
- boot Bootstrap Functions (Originally by Angelo Canty for S) 1.3-23

EN 9:04 6/10/2020

The HTML output

The screenshot shows a Microsoft PowerPoint window with the title bar "RMD Introduction.pptx - Microsoft PowerPoint". The slide content is titled "Basic Skills in R Markdown". The slide contains the following sections:

- 1 Introduction**
- 2 Sections and subsections**
- 3 Including R code**
- 4 Items**
- 5 Use R as a part of your text**
- 6 How to add a link to your document**
- 7 How to create a math formula**
- 8 Just do it**

Below the sections, there is a note: "The HTML file (2020)" followed by two code snippets:

```
## Warning: package 'ggplot2' was built under R version 3.6.3  
  
## Warning: package 'mvtnorm' was built under R version 3.6.2
```

On the right side of the slide, there is a red annotation box with the text: "Very basic guide how to produce a markdown document".

The left side of the image shows the PowerPoint ribbon and the slide navigation pane. The navigation pane lists slides 57, 58, 59, and 60. Slides 57 and 60 show screenshots of RStudio. Slide 59 is highlighted with a yellow border.

The program

An example how to create section/subsection/subsubsection...

Free text

RStudio interface showing R Markdown code and R console output.

Code Editor:

```
49 This document provides basic tools to produce a html file using R markdown. The best way to use this document is  
50 to run the file in R studio and then read the <tt>.Rmd</tt> file to see how the output was created. The file can  
be used to produce a very basic html document an you can add later more components to you document.  
51 # Sections and subsections  
52 This is a an example of a R markdown file that produces htnl output. This is a section in the document.  
53 ## Subsection  
54 This text apears in a subsection  
55 ### Subsubsection  
56 This text is a part of a subsection.  
57  
58 # Including R code  
59  
60 ## Print R code and output  
61  
62 This is an example how to include R code and output in the document. we use the <tt>airquality</tt> data as an  
63  
64  
65  
66  
67  
68  
69  
70 This is an example how to include R code and output in the document. we use the <tt>airquality</tt> data as an  
16:17 Basic Skills in R Markdown
```

Console:

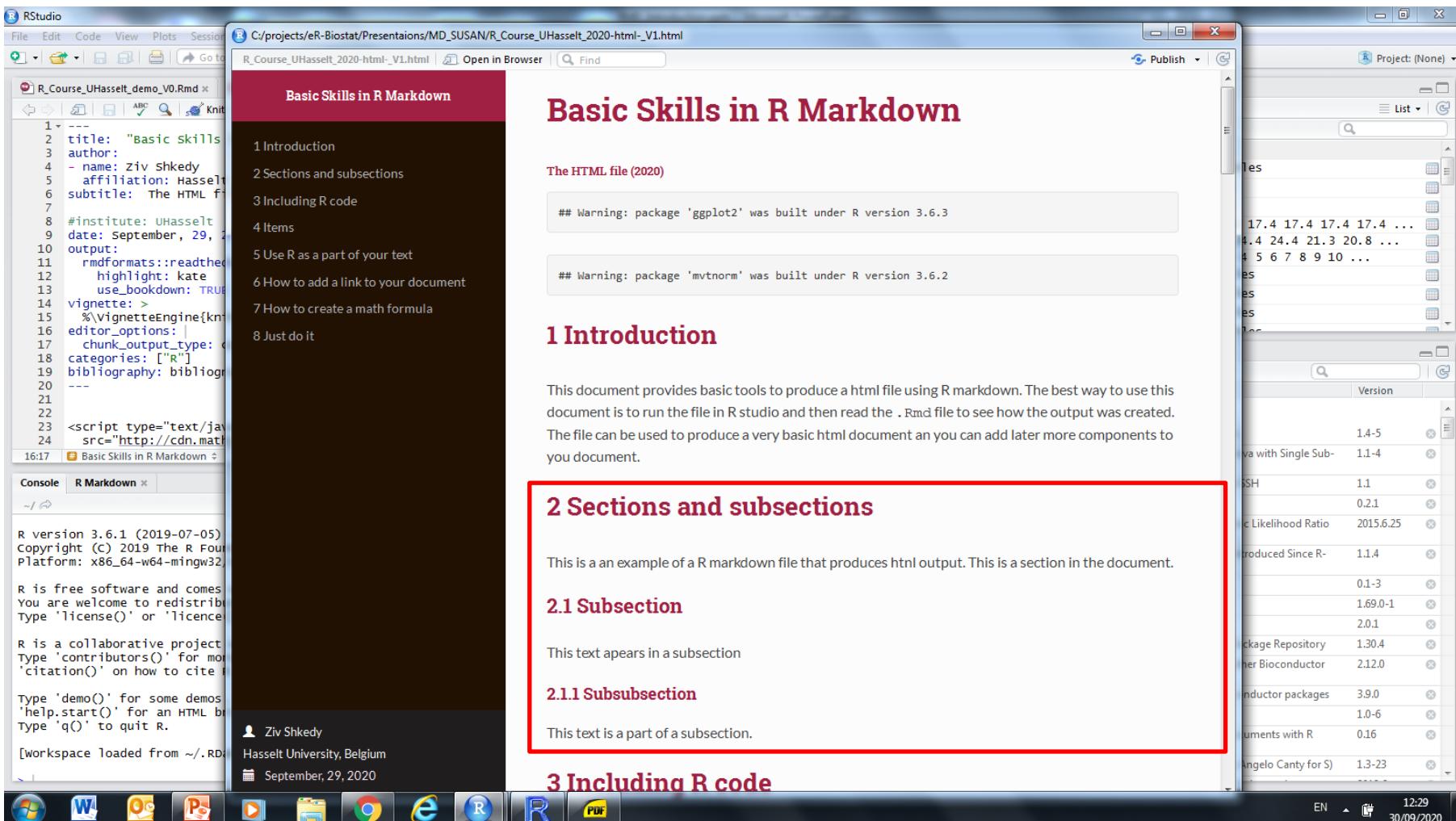
```
R version 3.6.1 (2019-07-05) -- "Action of the Toes"  
Copyright (C) 2019 The R Foundation for Statistical computing  
Platform: x86_64-w64-mingw32/x64 (64-bit)  
  
R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.  
  
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.  
  
[workspace loaded from ~/RData]
```

Environment:

| additivityTests | Additivity Tests in the Two Way Anova with Single Sub-class Numbers | 1.1-4 |
|-----------------|---|-----------|
| askpass | Safe Password Entry for R, Git, and SSH | 1.1 |
| assertthat | Easy Pre and Post Assertions | 0.2.1 |
| asypow | Calculate Power Utilizing Asymptotic Likelihood Ratio Methods | 2015.6.25 |
| backports | Reimplementations of Functions Introduced Since R-3.0.0 | 1.1.4 |
| base64enc | Tools for base64 encoding | 0.1-3 |
| BH | Boost C++ Header Files | 1.69.0-1 |
| bclust | BiCluster Algorithms | 2.0.1 |
| BiocManager | Access the Bioconductor Project Package Repository | 1.30.4 |
| BiocStyle | Standard styles for vignettes and other Bioconductor documents | 2.12.0 |
| BiocVersion | Set the appropriate version of Bioconductor packages | 3.9.0 |
| bitops | Bitwise Operations | 1.0-6 |
| bookdown | Authoring Books and Technical Documents with R Markdown | 0.16 |
| boot | Bootstrap Functions (Originally by Angelo Canty for S) | 1.3-23 |

EN 12:30 30/09/2020

The output



R code in the output

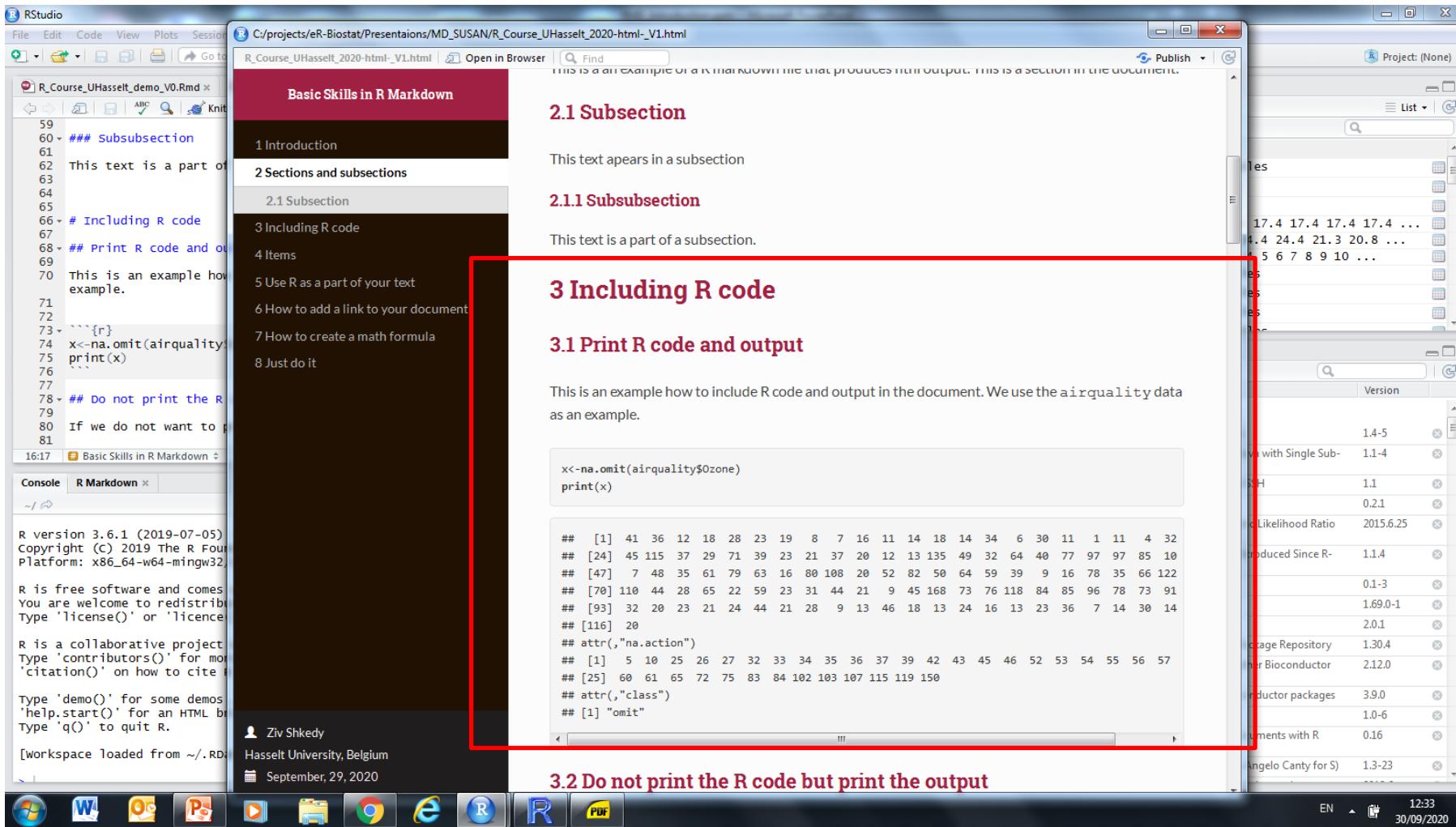
The screenshot shows the RStudio interface with the following components:

- Top Bar:** File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help.
- Project Bar:** Project: (None).
- Left Panel:** Shows three open files: R_Course_UHasselt_demo_V0.Rmd, R_Course_UHasselt_demo_V1.Rmd, and R_Course_UHasselt_2020(html)_V1.Rmd.
- Code Editor:** Displays R code. A red bracket on the right side of the editor highlights the section from line 66 to line 85, which includes a code block and an echo=FALSE option.
- Console:** Shows the R startup message and basic usage instructions.
- Output:** Shows the R code execution results, including the output of the code block and the echo=FALSE example.
- Environment:** Shows the system library with various packages listed.
- Bottom Bar:** Icons for Windows, Word, Excel, Powerpoint, etc., and a status bar showing EN, 12:35, 30/09/2020.

How to include R code and output

```
63
64
65
66 # Including R code
67
68 ## Print R code and output
69
70 This is an example how to include R code and output in the document. We use the <tt>airquality</tt> data as an
example.
71
72
73 ``{r}
74 x<-na.omit(airquality$ozone)
75 print(x)
76
77
78 ## Do not print the R code but print the output
79
80 If we do not want to print the R code, but we want to see the output use the option <tt>echo=FALSE</tt>:
81
82 ``{r,echo=FALSE}
83 x<-na.omit(airquality$ozone)
84 print(x)
85
```

The output



Development of a **PDF/HTML** document

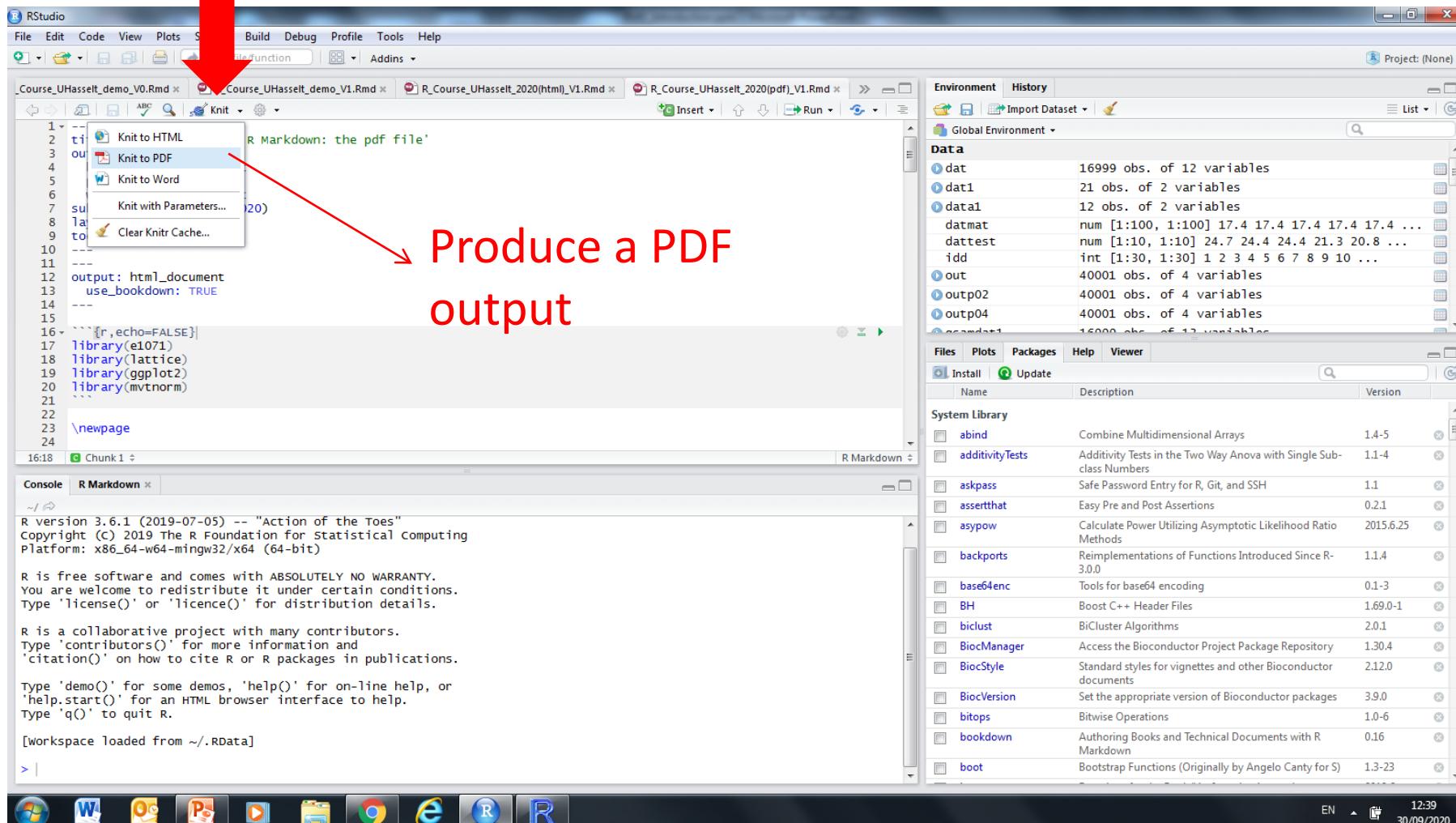
- The output:
 - PDF/HTML document (the user can choose).

To run the analysis in the example, use the program in R Studio:

[`R_course_UHasselt_2021\(pdf\)_V1.Rmd`](#)

The program

R_course_UHasselt_2021(pdf)_V1.Rmd



The PDF output

The image shows a Windows desktop environment with three windows open:

- RStudio:** The leftmost window displays an R Markdown script titled "Basic Skills in R Markdown: the pdf file". It includes code for setting up the document, loading libraries (e1071, lattice, ggplot2, mvtnorm), and creating a new page. The R console below shows the standard R startup message and a warning about ggplot2 being built under R version 3.6.3.
- PDF Viewer:** The middle window shows a PDF document titled "Basic Skills in R Markdown: the pdf file" by Ziv Shkedy (2020). The PDF contains a table of contents with various sections and their page numbers, such as "Introduction" (page 2), "Sections and subsections" (page 2), and "Including R code" (page 2).
- File Explorer:** The rightmost window is a file browser showing a list of files and folders. It includes a search bar and filters for "Dataset" and "List". Some of the files listed are "16999 obs. of 12 variables", "21 obs. of 2 variables", and "12 obs. of 2 variables".

Table of contents:
see next slide

The program

A screenshot of the RStudio interface. On the left, the R Markdown editor shows the following code:

```
1 ---  
2 title: 'Basic skills in R Markdown: the pdf file'  
3 output:  
4   pdf_document: default  
5   html_document: default  
6   word_document: default  
7 subtitle: zivishkedy (2020)  
8 layout: page  
9 toc: yes  
10 ---  
11 ---  
12 output: html_document  
13 use_bookdown: TRUE  
14 ---  
15  
16 ```{r, echo=FALSE}  
17 library(e1071)  
18 library(lattice)  
19 library(ggplot2)  
20 library(mvtnorm)  
21 ````  
22  
23 \newpage  
24
```

A red arrow points to the line `toc: yes`. To the right of the code editor, the text "toc: yes Produce the table of contents" is displayed in red. The R Markdown tab is selected in the bottom-left corner of the editor.

The right side of the interface shows the Environment pane, which lists various objects and their details. The Data section shows:

| Object | Description |
|---------|---|
| dat | 16999 obs. of 12 variables |
| dat1 | 21 obs. of 2 variables |
| data1 | 12 obs. of 2 variables |
| datmat | num [1:100, 1:100] 17.4 17.4 17.4 17.4 17.4 ... |
| dattest | num [1:10, 1:10] 24.7 24.4 24.4 21.3 20.8 ... |
| idd | int [1:30, 1:30] 1 2 3 4 5 6 7 8 9 10 ... |
| out | 40001 obs. of 4 variables |
| outp02 | 40001 obs. of 4 variables |
| outp04 | 40001 obs. of 4 variables |
| outp06 | 16000 obs. of 12 variables |

The System Library pane lists numerous R packages with their versions. Some examples include abind (1.4-5), additivityTests (1.1-4), askpass (1.1), assertthat (0.2.1), asympow (2015.6.25), backports (1.1.4), base64enc (0.1-3), BH (1.69.0-1), biclust (2.0.1), BiocManager (1.30.4), BiocStyle (2.12.0), BiocVersion (3.9.0), bitops (1.0-6), bookdown (0.16), and boot (1.3-23).

The bottom of the screen shows the Windows taskbar with icons for various applications like Word, Excel, and R. The system tray indicates the date as 30/09/2020 and the time as 12:40.

The program

A section that explains how to include a figure in the document.

90 var(x)
91
92 ## Graphical displays in the document
93 A histogram for the ozone level can be produced using the function <t
"histogram"></tt>:
94
95 ``{r}
96 Ozone.R<-data.frame(x)
97 qplot(x, data = Ozone.R, geom = "histogram", binwidth = 0.1)
98
99 To add a caption to the figure we use <tt>[r figchp1,fig.cap="Sepal length (III)"]</tt>.
100
101 102
103 To add a caption to the figure we use <tt>[r figchp1,fig.cap="Sepal length (III)"]</tt>.
104
105 ``{r figchp1,fig.cap="Sepal length (III)"}
106 Ozone.R<-data.frame(x)
107 qplot(x, data = Ozone.R, geom = "histogram", binwidth = 0.1)
108
109
110 We can refer to the figure from the text in the document. For example, Figure \@ref(fig:figchp2) presents a
histogram that was produced using the function <tt>qplot()</tt> function.
111
20:17 | Chunk 1 | R Markdown |
Console | R Markdown |
R version 3.6.1 (2019-07-05) -- "Action of the Toes"
Copyright (c) 2019 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

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You are welcome to redistribute it under certain conditions.
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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.

[workspace loaded from ~/RData]
> |

99 obs. of 12 variables
obs. of 2 variables
obs. of 2 variables
[1:100, 1:100] 17.4 17.4 17.4 17.4 17.4 ...
[1:10, 1:10] 24.7 24.4 24.4 21.3 20.8 ...
int [1:30, 1:30] 1 2 3 4 5 6 7 8 9 10 ...
idd
out
outp02
outp04
scandat1
40001 obs. of 4 variables
40001 obs. of 4 variables
40001 obs. of 4 variables
16000 obs. of 12 variables

Files Plots Packages Help Viewer
Install Update
Name Description Version
System Library
abind Combine Multidimensional Arrays 1.4-5
additivityTests Additivity Tests in the Two Way Anova with Single Sub-class Numbers 1.1-4
askpass Safe Password Entry for R, Git, and SSH 1.1
assertthat Easy Pre and Post Assertions 0.2.1
asypow Calculate Power Utilizing Asymptotic Likelihood Ratio Methods 2015.6.25
backports Reimplementations of Functions Introduced Since R-3.0.0 1.1.4
base64enc Tools for base64 encoding 0.1-3
BH Boost C++ Header Files 1.69.0-1
biclust BiCluster Algorithms 2.0.1
BiocManager Access the Bioconductor Project Package Repository 1.30.4
BiocStyle Standard styles for vignettes and other Bioconductor documents 2.12.0
BiocVersion Set the appropriate version of Bioconductor packages 3.9.0
bitops Bitwise Operations 1.0-6
bookdown Authoring Books and Technical Documents with R Markdown 0.16
boot Bootstrap Functions (Originally by Angelo Canty for S) 1.3-23

The PDF output

A screenshot of the RStudio interface illustrating the creation of a PDF document. On the left, the R Markdown editor shows two files: `_Course_UHasselt_demo_V0.Rmd` and `R_Course_UHasselt_demo_V1.Rmd`. The V1 file contains R code demonstrating how to include a figure in a document. A red annotation highlights a section of the code: "Graphical displays in the document". The code uses the `qplot` function with the `geom = "histogram"` option to create a histogram. The right side of the interface shows the generated PDF output titled "R_Course_UHasselt_2020-pdf-V1.pdf". The PDF page displays the highlighted text and a histogram. The histogram has a y-axis ranging from 0 to 6 and an x-axis with several bins. Below the histogram, a red annotation reads: "A section that explains how to include a figure in the document." The bottom status bar shows the date and time: "EN 12:42 30/09/2020".

Graphical displays in the document

A histogram for the Ozone level can be produced using the function qplot with the option geom = "histogram":

```
Ozone.R<-data.frame(x)
qplot(x, data = Ozone.R, geom = "histogram", binwidth = 0.1)
```

A section that explains how to include a figure in the document.

6
4
2

Example 3

Very simple analysis

To run the analysis in the example, use the program in R Studio:

[R_course_UHasselt_2021\(pdf\)_V2.Rmd](#)

Produce a report for an analysis

- How to use Rmd to produce a report about an analysis ?
- Why this is important ?
- Example: the old faithful dataset.
 - Part 1: the analysis.
 - Part 2: the analysis + report using Rmd (you need to run the program
 - [R_course_UHasselt_2020\(pdf\)_V2.Rmd](#)

Exploratory analysis of the Old Faithful dataset

- Old Faithful is a geyser that is found in Yellowstone National Park, in Wyoming.
- It is one of the most famous attractions at Yellowstone National Park.
- Old Faithful is unique because of how long and how often it erupts.



Exploratory analysis of the Old Faithful dataset

- Our aim is to explore the association between the time between eruptions (waiting time) and the duration of the eruption.
- For the analysis we use **basic graphical R functions** and **functions to calculate descriptive statistics** for the data.
- Output: PDF format.

The data in R

```
>head(faithful)
```

The name of the data in R

```
## eruptions waiting
## 1 3.600 79
## 2 1.800 54
## 3 3.333 74
## 4 2.283 62
## 5 4.533 85
## 6 2.883 55
```

A data frame with two variables:
eruption and waiting time.

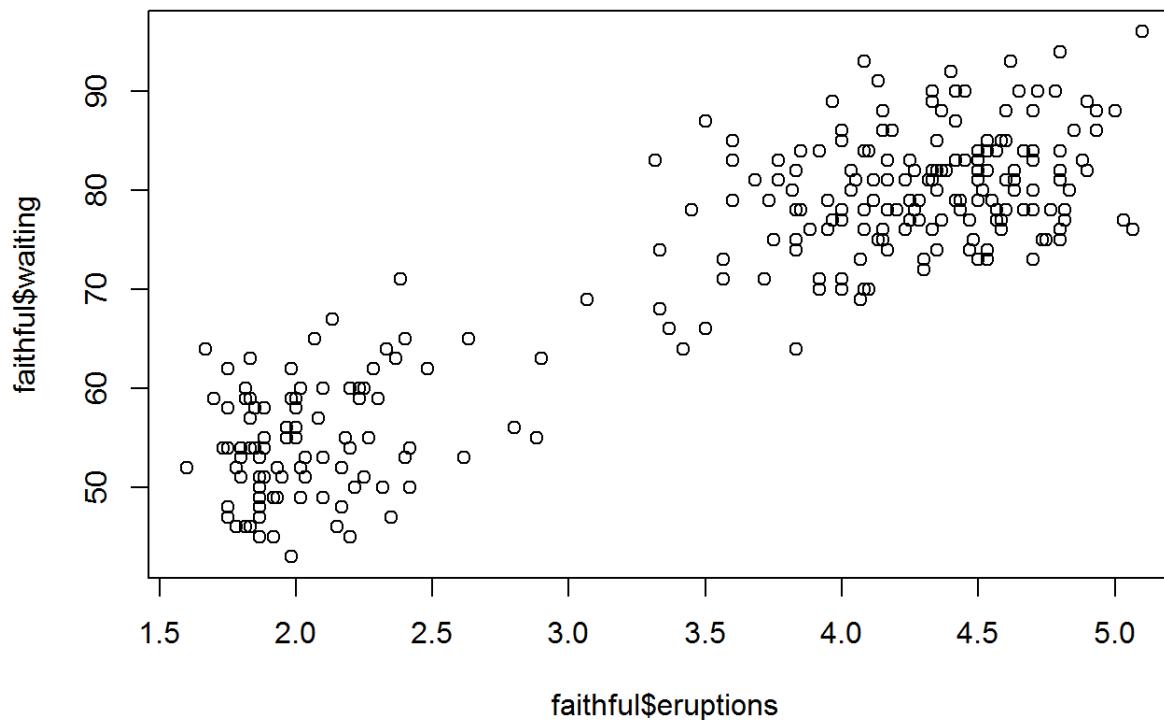
Eruption time and waiting time

```
plot(faithful$eruptions, faithful$waiting)
```



Basic graphical
function in R

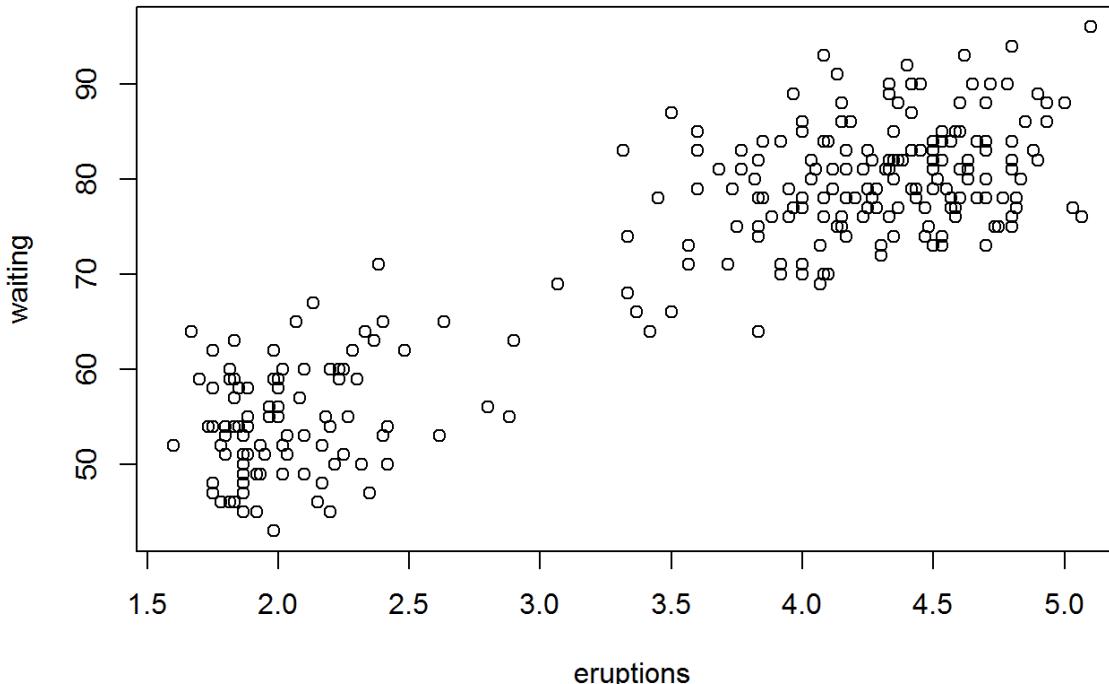
```
plot(x, y)
```



Eruption time and waiting time

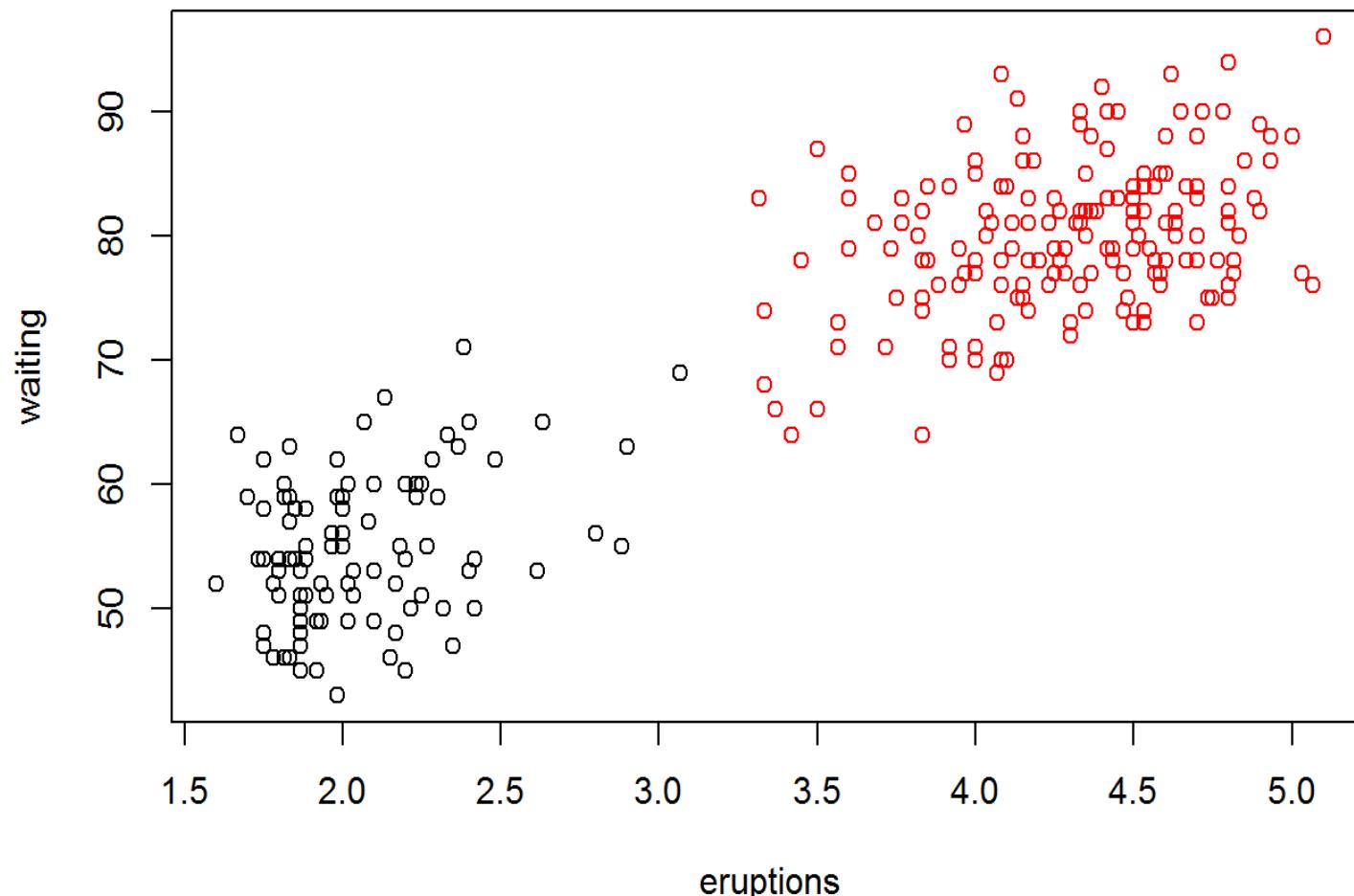
```
plot(faithful$eruptions, faithful$waiting,  
      xlab="eruptions", ylab="waiting")  
  
title("The old faithful data")
```

Adding title and text
for the labels.



Two clusters ?

The old faithful data



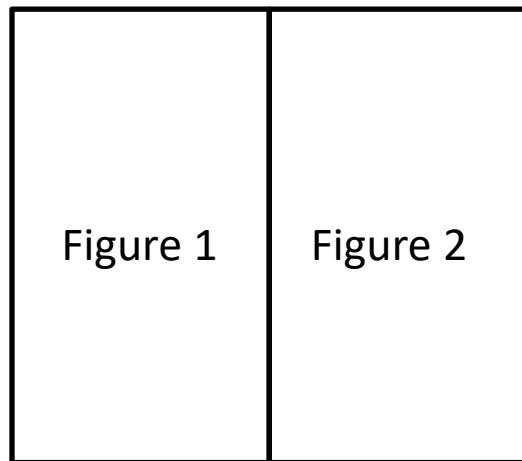
Distribution of eruption time

```
par(mfrow=c(1, 2))
```

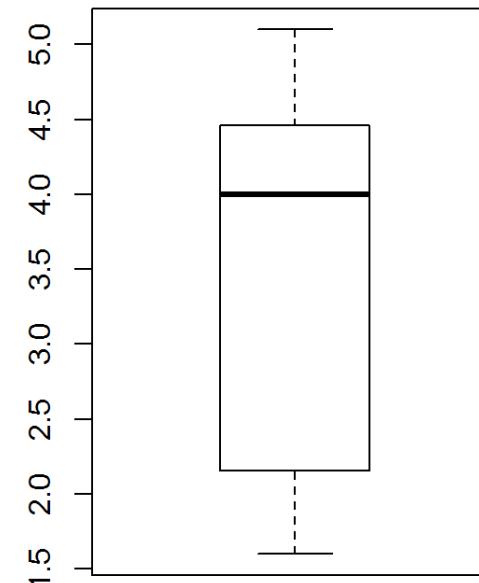
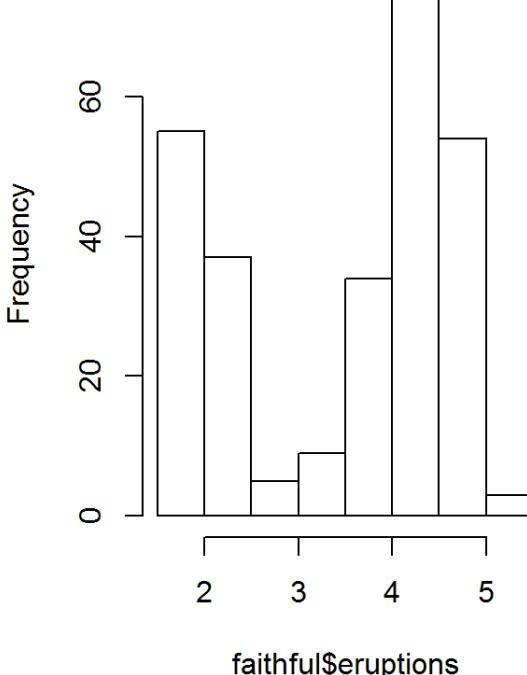
Split the graphical window

```
hist(faithful$eruptions)  
boxplot(faithful$eruptions)
```

Split the graphical window



Histogram of faithful\$eruptions

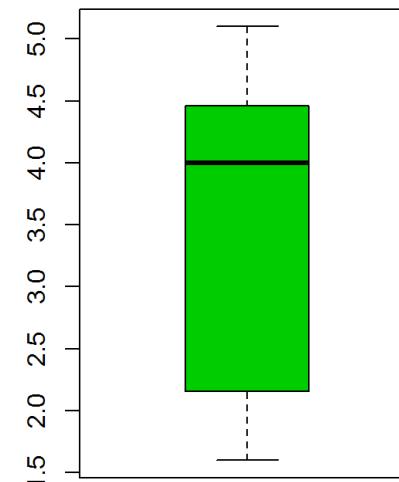
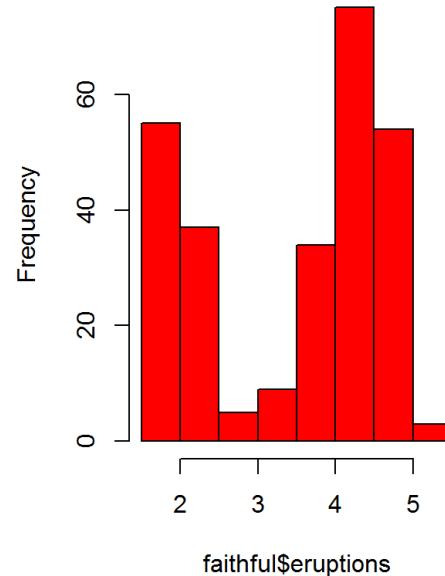


Distribution of eruption time

```
par(mfrow=c(1, 2))  
hist(faithful$eruptions, col=2)  
boxplot(faithful$eruptions, col=3)
```

Change plot settings.

Histogram of faithful\$eruptions

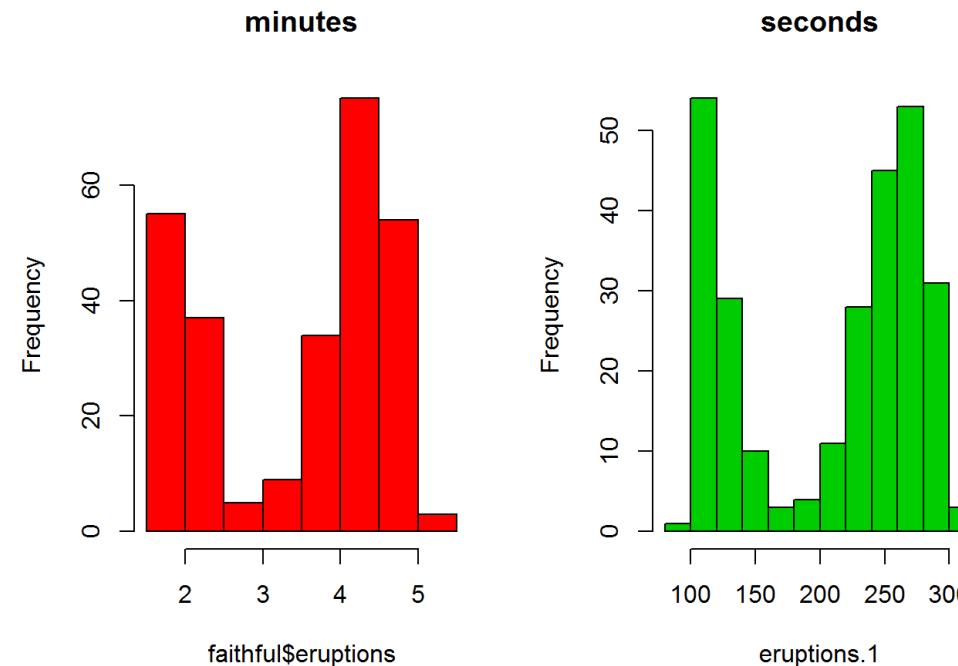


Distribution of eruption time in seconds

```
eruptions.1<-faithful$eruptions*60  
par(mfrow=c(1,2))  
hist(faithful$eruptions, col=2,main="minutes")  
hist(eruptions.1, col=3,main="seconds")
```

Create a new object:

eruptions.1



The Rmd program

- Repeat the analysis above.
- Produce a report for the analysis.
- Output: PDF format.
- Run the analysis in your own laptop to see the report.
- Rmd program:

R_course_UHasselt_2021(pdf)_V2.Rmd

The R markdown program & PDF output

R_course_UHasselt_2021(pdf)_V2.Rmd

The screenshot shows the RStudio interface with two panes. The left pane displays an R Markdown file named `R_course_UHasselt_2021(pdf)_V2.Rmd`. The right pane shows the generated PDF output titled `R.Course_UHasselt_2020-pdf_-V2.pdf`.

Code (Left Pane):

```
25 # Introduction
26 
27 Old Faithful is a geyser that is found in Yellowstone National Park, in Wyoming. It is one of the most famous attractions at Yellowstone National Park. Old Faithful is unique because of how long and how often it erupts. Our aim is to explore the time between eruptions and the duration of the eruption. For the analysis we use basic graphical R functions and functions to calculate descriptive statistics for the data.
28 
29 # The data
30 
31 Data recorded from 1990 measured the time between eruptions and the duration of the eruptions in minutes. This data set was based on 272 observations of Old Faithful's eruptions. The variables are: eruption time in mins and waiting time to next eruption (in mins). Both variables are numeric.
32 
33 `r` head(faithful)
34 
35 # Analysis of the old faithful data
36 
37 ## Eruption time and waiting time
```

PDF Output (Right Pane):

Introduction

Old Faithful is a geyser that is found in Yellowstone National Park, in Wyoming. It is one of the most famous attractions at Yellowstone National Park. Old Faithful is unique because of how long and how often it erupts. Our aim is to explore the time between eruptions and the duration of the eruption. For the analysis we use basic graphical R functions and functions to calculate descriptive statistics for the data.

The data

Data recorded from 1990 measured the time between eruptions and the duration of the eruption, both taken in minutes. This data set was based on 272 observations of Old Faithful's eruptions and consists of 2 variables: eruption time in mins and waiting time to next eruption (in mins). Both variables are numeric.

Analysis of the old faithful data

Eruption time and waiting time

By looking at the scatter plot, we can see a visual representation of the data.

```
plot(faithful$eruptions,faithful$waiting)
```

Console (Bottom Left):

```
ordinary text without R code
|.....| 91%
1label: unnamed-chunk-15 | 94%
ordinary text without R code
|.....| 97%
1label: unnamed-chunk-16 | 100%
ordinary text without R code

"C:/Program Files/RStudio/bin/pandoc/pandoc" +RTS -K512m -RTS R.Course_UHasselt_2020
markdown+autolink_bare_uris+ascii_identifiers+tex_math_single_backslash --output R_
template "C:/PROGRA~1/R/R-3.6.1/library/RMARKD-1/rmd/latex/DEFAULT3.TEX" --highlight_
x --variable graphics=yes --variable "geometry:margin=1in" --variable "compact-titl
output file: R.Course_UHasselt_2020-pdf_-V2.knit.md

pandoc.exe: Could not parse YAML header: mapping values are not allowed in this con
Output created: R.Course_UHasselt_2020-pdf_-V2.pdf
```

Taskbar (Bottom):

EN 14:57
30/09/2020

The R markdown program & PDF output

RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

_Course_UHasselt_demo_V0.Rmd x R_Course_UHasselt_demo_V1.Rmd x R_Course_UHasselt_2020(html)_V1.Rmd x

```
76  
77  
78 ~ ``{r}  
79 min(faithful$eruptions)  
80  
81  
82 Let us look once again in the scatterplot. we can add labels name and title  
83  
84  
85 ~ ``{r}  
86 plot(faithful$eruptions,faithful$waiting,  
87 xlab="eruptions",ylab="waiting")  
88 title("The old faithful data")  
89  
90  
91 In the next figure we use different colors for the two clusters.  
92  
93 ~ ``{r}  
94 plot(faithful$eruptions,faithful$waiting,  
95 xlab="eruptions",ylab="waiting")  
96 points(faithful$eruptions[faithful$eruptions>3.2],faithful$waiting[faithful$eruptions>3.2])  
97 title("The old faithful data")  
98  
99
```

31:11 The data

Console R Markdown x

.../MD_SUSAN/R_Course_UHasselt_2020(pdf)_V2.Rmd

ordinary text without R code

|.....| 91%
label: unnamed-chunk-15
|.....| 94%
ordinary text without R code
|.....| 97%
label: unnamed-chunk-16
|.....| 100%
ordinary text without R code

```
"C:/Program Files/RStudio/bin/pandoc/pandoc" +RTS -K512m -RTS R_Course_UHasselt_2020.Rmd --output R_Course_UHasselt_2020.pdf --highlight-style tango --mathjax --variable graphics=yes --variable "geometry:margin=1in" --variable "compact-title"  
pandoc.exe: Could not parse YAML header: mapping values are not allowed in this context  
output created: R_Course_UHasselt_2020-pdf_V2.pdf
```

R_Course_UHasselt_2020-pdf_V2.pdf

Page: 4 / 13

R code as a part of your text in the output

```
## [1] 96  
and the minimum eruption time is  
min(faithful$eruptions)  
## [1] 1.6  
Let us look once again in the scatterplot. We can add labels name and title  
plot(faithful$eruptions,faithful$waiting,  
xlab="eruptions",ylab="waiting")  
title("The old faithful data")
```

The old faithful data

The output

In the next figure we use different colors for the two clusters.

```
plot(faithful$eruptions,faithful$waiting,  
xlab="eruptions",ylab="waiting")
```

EN 14:59 30/09/2020

What did we see today ?

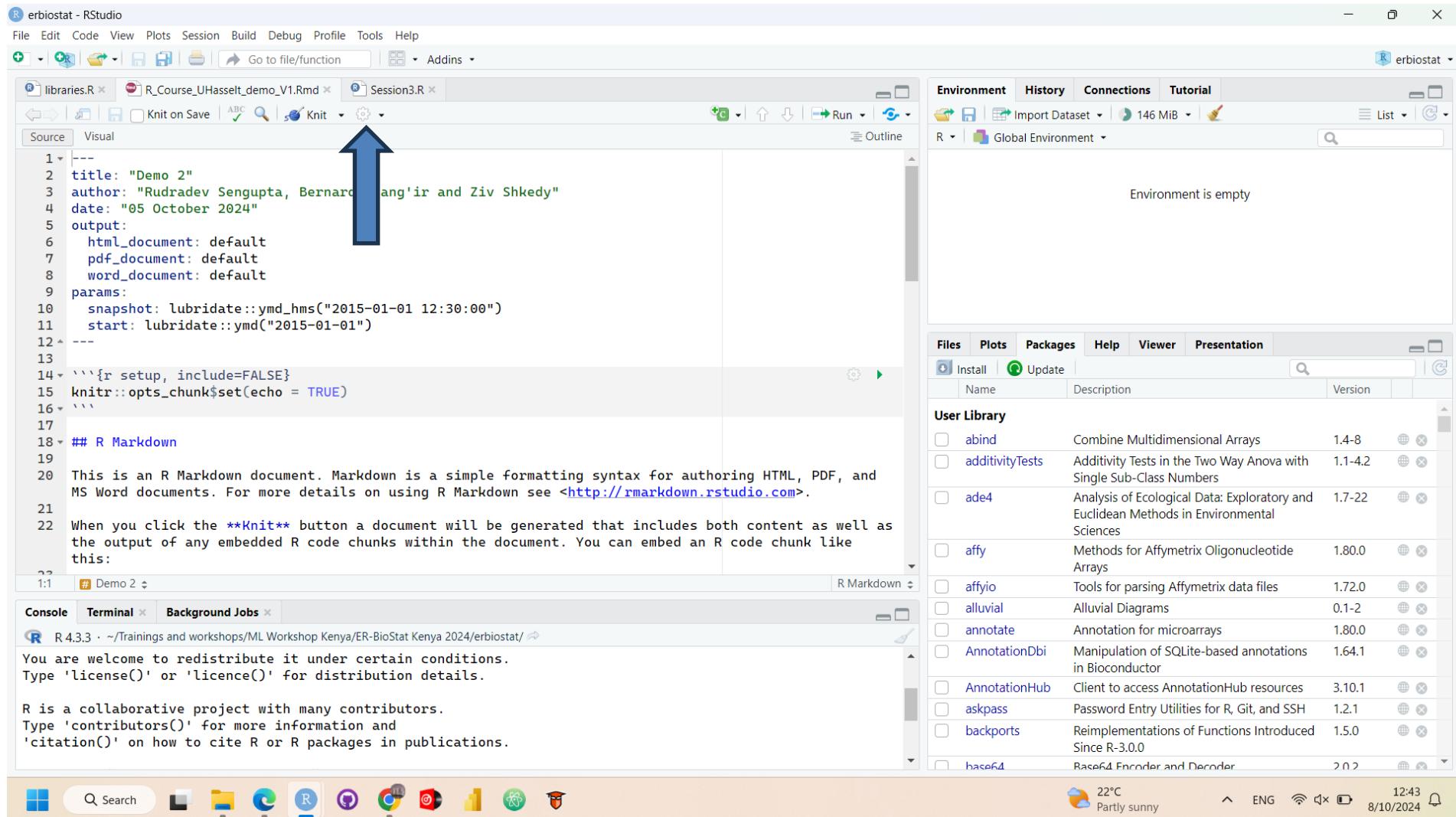
- R Studio.
- R markdown + output.
- Basic graphical functions in R and how to control the figure (title, colors etc).
- Do the analysis in the file:

R_course_UHasselt_2021 (pdf) _v2 .Rmd

Extra sildes

Source vs Visual Editor

Source vs Visual Editor



Source vs Visual Editor

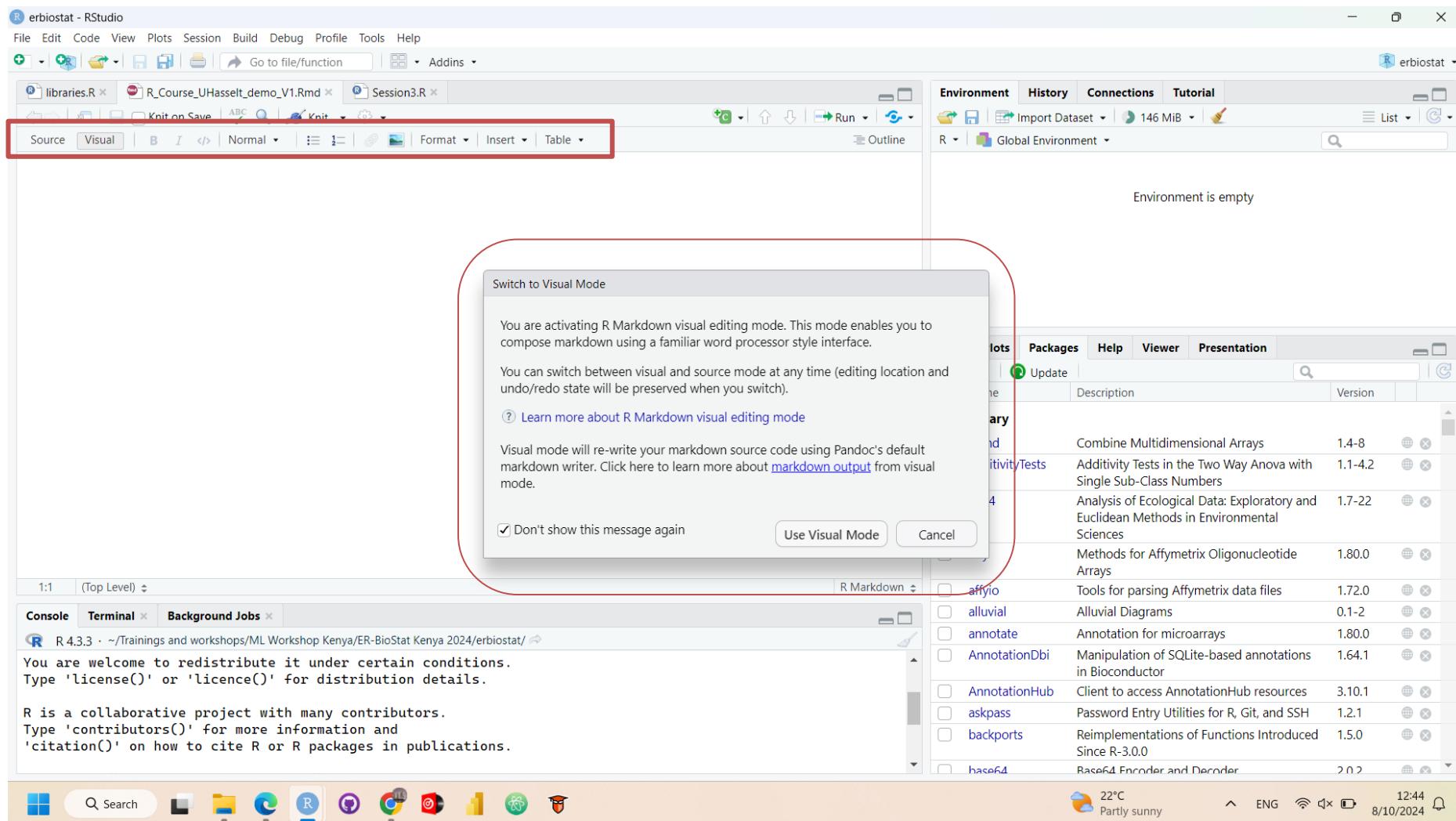
The screenshot shows the RStudio interface with the title bar "erbiostat - RStudio". The main area displays an R Markdown file named "R_Course_UHasselt_demo_V1.Rmd". The left pane shows the "Source" editor with the following code:

```
1 ---  
2 title: "Demo 2"  
3 author: "Rudradev Sengupta, Bernar  
4 date: "05 October 2024"  
5 output:  
6   html_document: default  
7   pdf_document: default  
8   word_document: default  
9 params:  
10  snapshot: lubridate::ymd_hms("2024-10-05T00:00:00")  
11  start: lubridate::ymd("2015-01-01")  
12  ---  
13  
14  ```{r setup, include=FALSE}  
15  knitr::opts_chunk$set(echo = TRUE)  
16  ```  
17  
18  ## R Markdown  
19  
20 This is an R Markdown document. It is intended to be used as  
MS Word documents. For more detail... http://rmarkdown.rstudio.com.  
21  
22 When you click the Knit button a document will be generated that includes both content as well as  
the output of any embedded R code chunks within the document. You can embed an R code chunk like  
this:  
23  
1:1 # Demo 2
```

The right pane shows the "Visual" editor with a context menu open over the code. A blue arrow points to the "Use Visual Editor" option in the menu. The menu also includes options like "Preview in Window", "Preview Images and Equations", "Show Previews Inline", "Chunk Output Inline", "Expand All Output", "Collapse All Output", "Clear Output", "Clear All Output", and "Output Options...". Below the menu, a tooltip provides syntax information for R Markdown.

The bottom status bar shows system icons for search, file, browser, and other applications, along with the date and time (8/10/2024) and battery level (22%).

Source vs Visual Editor



Source vs Visual Editor

The screenshot shows the RStudio interface with the 'Source' tab selected in the top-left panel. The main code editor displays R Markdown code:

```
---  
title: "Demo 2"  
author: "Rudradev Sengupta, Bernard Osang'ir and Ziv Shkedy"  
date: "05 October 2024"  
output:  
  html_document: default  
  pdf_document: default  
  word_document: default  
params:  
  snapshot: lubridate::ymd_hms("2015-01-01 12:30:00")  
  start: lubridate::ymd("2015-01-01")  
---|  
  
{r setup, include=FALSE}  
knitr::opts_chunk$set(echo = TRUE)
```

The 'Visual' tab is also visible in the top-left panel. Below the code editor, there's an 'R Markdown' preview section with the heading 'R Markdown'. The preview text reads:

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

The bottom-left panel shows the 'Console' tab active, displaying R version information and a welcome message about redistribution conditions.

The right side of the interface includes the 'Environment' pane (which is currently empty), the 'Packages' pane (listing various packages like abind, additivityTests, ade4, affy, etc.), and a system status bar at the bottom showing weather, language, battery level, and date.

Source vs Visual Editor

The screenshot shows the RStudio interface with two main panes. The left pane is the 'Source' editor, which displays R Markdown code. The right pane is the 'Visual' editor, which displays the generated HTML output. A red box highlights the 'Visual' tab in the Source editor's toolbar. A blue arrow points from the 'Knit' button in the Source editor to the 'Knit' button in the Visual editor. Another blue arrow points from the 'R Markdown' section in the Source editor to the 'R Markdown' section in the Visual editor.

Demo 2
Rudradev Sengupta, Bernard Osang'ir and Ziv Shkedy
05 October 2024

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the Knit button a document will be generated that includes both content as well as the output of any **embedded R code** chunks within the document. You can embed an R code chunk like this:

```
project_start <- params$start
summary(mtcars)
```

| ## | mpg | cyl | disp | hp |
|------------|--------|---------------|---------------|----------------|
| ## Min. | 10.40 | Min. :4.000 | Min. :71.1 | Min. :52.0 |
| ## 1st Qu. | 15.43 | 1st Qu.:4.000 | 1st Qu.:120.8 | 1st Qu.:96.5 |
| ## Median | 19.20 | Median :6.000 | Median :196.3 | Median :123.0 |
| ## Mean | 20.09 | Mean :6.188 | Mean :230.7 | Mean :146.7 |
| ## 3rd Qu. | 22.80 | 3rd Qu.:8.000 | 3rd Qu.:326.0 | 3rd Qu.:180.0 |
| ## Max. | 33.90 | Max. :8.000 | Max. :472.0 | Max. :335.0 |
| ## | drat | wt | qsec | vs |
| ## Min. | 2.760 | Min. :1.513 | Min. :14.50 | Min. :0.0000 |
| ## 1st Qu. | 3.080 | 1st Qu.:2.581 | 1st Qu.:16.89 | 1st Qu.:0.0000 |
| ## Median | 3.695 | Median :3.325 | Median :17.71 | Median :0.0000 |
| ## Mean | 3.597 | Mean :3.217 | Mean :17.85 | Mean :0.4375 |
| ## 3rd Qu. | 3.920 | 3rd Qu.:3.610 | 3rd Qu.:18.90 | 3rd Qu.:1.0000 |
| ## Max. | 4.930 | Max. :5.424 | Max. :22.90 | Max. :1.0000 |
| ## | am | gear | carb | |
| ## Min. | 0.0000 | Min. :2.000 | Min. :1.000 | |

Including project metadata:

```
# R Markdown
# Project: erbiostat - RStudio
# Author: Rudradev Sengupta, Bernard Osang'ir and Ziv Shkedy
# Date: 05 October 2024
# Version: 1.4.8
# R version: 4.3.3
```

R 4.3.3 · ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/R_Course_UHasselt_demo_V1.html

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

[Workspace loaded from ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/R_Course_UHasselt_demo_V1.html]

22°C Partly sunny 12:46 8/10/2024

Source vs Visual Editor

The screenshot shows the RStudio interface with a large blue arrow pointing from the Source Editor on the left to the Visual Editor on the right.

Source Editor (Left):

- File menu: File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help.
- Toolbar icons: New, Open, Save, Run, Knit, Addins.
- Project navigation: libraries.R, R_Course_UHasselt_demo_V1.Rmd*, Session3.R.
- File tabs: Go to file/function, Addins.
- Text area:
 - R Markdown**
 - This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.
 - When you click the **Knit** button a document will be generated that includes output of any **embedded R code** chunks within the document. You can
 - Code chunk:

```
{r cars}
project_start <- params$start
summary(mtcars)
```
- Console tab: R Markdown, Console, Terminal, Render, Background Jobs.
- Console output:

```
R 4.3.3 · ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/
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.
[Workspace loaded from ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/.RData]
```

Visual Editor (Right):

- Environment tab: Environment, History, Connections, Tutorial.
- Environment pane: Import Dataset, 149 MiB, List, Global Environment (empty).
- Packages tab: Install, Update, Packages, Help, Viewer, Presentation.
- Packages pane: User Library (list of packages).
- System status bar: 22°C, Partly sunny, ENG, 12:47, 8/10/2024.

Source vs Visual Editor

The screenshot shows the RStudio interface with two main panes. The left pane, titled 'R Markdown', displays a table with columns 'Column', 'Report', and 'P-value'. A blue arrow points upwards from the table towards the title 'R Markdown'. The text 'Direct editing' is overlaid on the table area. Below the table, the text 'Demonstration for visual' is followed by a note about knitting. The right pane shows the 'Environment' and 'Global Environment' tabs, both indicating an empty environment. At the bottom, the R console shows the R version 4.3.3 startup message and the Windows taskbar is visible.

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

| Column | Report | P-value |
|--------|--------|---------|
| | | |
| | | |
| | | |

Direct editing

Demonstration for visual

When you click the **Knit** button a document will be generated that includes both content as well as the output of any **embedded R code** chunks within the document. You can embed an R code chunk like this:

```
fr cars
```

11

Console Terminal × Render × Background Jobs ×

R 4.3.3 · ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/ ↗

R version 4.3.3 (2024-02-29 ucrt) -- "Angel Food Cake"
Copyright (C) 2024 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.

Environment History Connections Tutorial

Import Dataset 149 MiB List

Global Environment

Environment is empty

Files Plots Packages Help Viewer Presentation

Install Update

| Name | Description | Version |
|-----------------|--|---------|
| abind | Combine Multidimensional Arrays | 1.4-8 |
| additivityTests | Additivity Tests in the Two Way Anova with Single Sub-Class Numbers | 1.1-4.2 |
| ade4 | Analysis of Ecological Data: Exploratory and Euclidean Methods in Environmental Sciences | 1.7-22 |
| affy | Methods for Affymetrix Oligonucleotide Arrays | 1.80.0 |
| affyio | Tools for parsing Affymetrix data files | 1.72.0 |
| alluvial | Alluvial Diagrams | 0.1-2 |
| annotate | Annotation for microarrays | 1.80.0 |
| AnnotationDbi | Manipulation of SQLite-based annotations in Bioconductor | 1.64.1 |
| AnnotationHub | Client to access AnnotationHub resources | 3.10.1 |
| askpass | Password Entry Utilities for R, Git, and SSH | 1.2.1 |
| backports | Reimplementations of Functions Introduced Since R-3.0.0 | 1.5.0 |
| base64 | Base64 Encoder and Decoder | 202 |

22°C Partly sunny 12:47 8/10/2024

Source vs Visual Editor

The screenshot shows the RStudio interface with two panes demonstrating the difference between Source and Visual editors.

Left Pane (Source Editor):

- Header:** erbiostat - RStudio
- Menu Bar:** File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, Help
- Toolbar:** Go to file/function, Addins
- File List:** libraries.R, R_Course_UHasselt_demo_V1.Rmd, Session3.R
- Editor:** Displays R Markdown code with a red arrow pointing to the "Report" column header of a table.
- Console:** Shows R code and output related to the mtcars dataset.

Right Pane (Visual Editor):

- Title Bar:** ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/R_Course_UHasselt... R_Course_UHasselt_demo_V1.html
- Toolbar:** Publish, Find
- Content Area:**
 - ## Demo 2
 - Rudradev Sengupta, Bernard Osang'ir and Ziv Shkedy
 - 05 October 2024
 - ## R Markdown
 - This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.
 - Demonstration for visual**
 - A table with columns: Column, Report, P-value.
 - Text explaining that clicking Knit generates a document including both content and R code output.
 - An R code block:

```
project_start <- params$start  
summary(mtcars)
```
 - The output of the R code:

```
##      mpg          cyl          disp          hp  
## Min. :10.40    Min. :4.000    Min. : 71.1   Min. : 52.0  
## 1st Qu.:15.43   1st Qu.:4.000   1st Qu.:120.8  1st Qu.: 96.5  
## Median :19.20   Median :6.000   Median :196.3  Median :123.0  
## Mean   :20.09   Mean   :6.188   Mean   :230.7  Mean   :146.7  
## 3rd Qu.:22.80   3rd Qu.:8.000   3rd Qu.:326.0  3rd Qu.:180.0  
## Max.  :33.90   Max.  :8.000   Max.  :472.0  Max.  :335.0
```

Source vs Visual Editor

The screenshot shows the RStudio interface with two main panes: the Source Editor and the Visual Editor.

Source Editor: This pane displays R Markdown code. A red box highlights a table chunk:

| Column | Report | P-value |
|--------|--------|---------|
| | | |
| | | |

Below the table, another red box highlights the text: "When you click the **Knit** button a document will be generated that includes both content as well as the output of any **embedded R code** chunks within the document. You can embed an R code chunk like this:"

Visual Editor: This pane shows the rendered output of the R Markdown code. It includes a sidebar with a dropdown menu for "R Markdown" options like "Including project ...", "Including Plots", etc. The main area displays the rendered content, which includes the table and the explanatory text. A message "Environment is empty" is shown in the top right corner.

Console: The bottom left shows the R console output:

```
R 4.3.3 · ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/ 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. [Workspace loaded from ~/Trainings and workshops/ML Workshop Kenya/ER-BioStat Kenya 2024/erbiostat/.RData]
```

File Explorer: The bottom right shows the file explorer with a list of packages in the "User Library".

| Name | Description | Version |
|-----------------|--|---------|
| abind | Combine Multidimensional Arrays | 1.4-8 |
| additivityTests | Additivity Tests in the Two Way Anova with Single Sub-Class Numbers | 1.1-4.2 |
| ade4 | Analysis of Ecological Data: Exploratory and Euclidean Methods in Environmental Sciences | 1.7-22 |
| affy | Methods for Affymetrix Oligonucleotide Arrays | 1.80.0 |
| affyio | Tools for parsing Affymetrix data files | 1.72.0 |
| alluvial | Alluvial Diagrams | 0.1-2 |
| annotate | Annotation for microarrays | 1.80.0 |
| AnnotationDbi | Manipulation of SQLite-based annotations in Bioconductor | 1.64.1 |
| AnnotationHub | Client to access AnnotationHub resources | 3.10.1 |
| askpass | Password Entry Utilities for R, Git, and SSH | 1.2.1 |
| backports | Reimplementations of Functions Introduced Since R-3.0.0 | 1.5.0 |
| base64 | Base64 Encoder and Decoder | 2.0.2 |

System Tray: The bottom right shows the system tray with icons for search, file, browser, and other system status.

What did we see today ?

- R Studio.
- R markdown + output.
- Basic graphical functions in R and how to control the figure (title, colors etc).
- Do the analysis in the file:
 - [**R_course_UHasselt_2021\(pdf\)_V2.Rmd**](#)
- Explore use of Source and Visual Editor