

Statistical Computing with R

Masters in Data Science 503 (S7)

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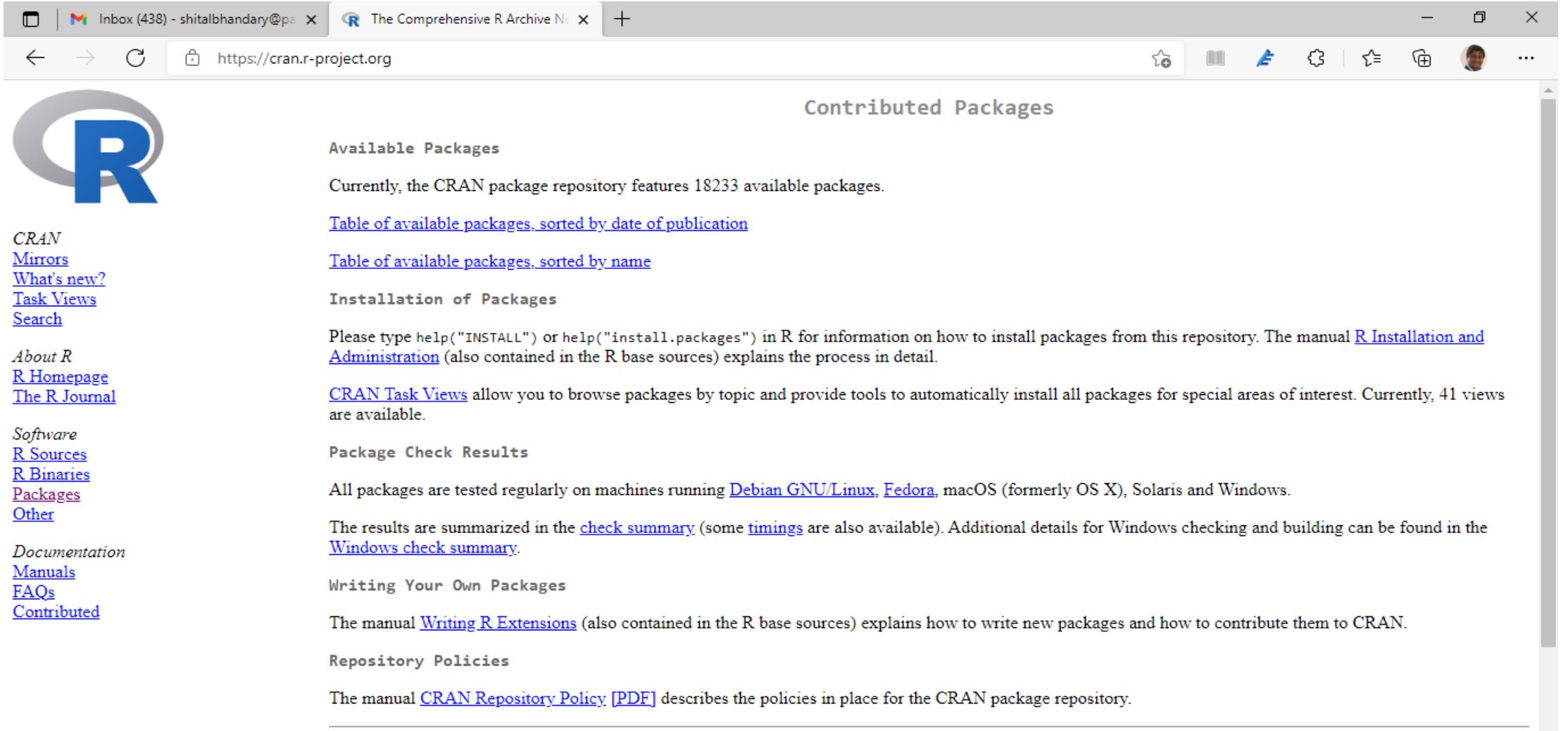
Review Preview (Unit 2, Part 1)

- Package in R
- Using package in R
- Reading data in R
- Reviewing data in R
- Cleaning data in R

What is a “package” in R?

- In R, the fundamental unit of shareable code/function is the package.
- A package bundles together code, data, documentation, and tests, and is easy to share with others.
- As of June 2019, there were over 14,000 packages available on the **Comprehensive R Archive Network**, or CRAN, the public clearing house for R packages.
- This huge variety of packages is one of the reasons that R is so successful: the chances are that someone has already solved a problem that you’re working on, and you can benefit from their work by downloading their package.

Available “packages” from CRAN:



The screenshot shows a web browser window with the title bar "Inbox (438) - shitalbhandary@pa" and "The Comprehensive R Archive Net". The address bar displays "https://cran.r-project.org". The main content area is titled "Contributed Packages".

Available Packages
Currently, the CRAN package repository features 18233 available packages.
[Table of available packages, sorted by date of publication](#)
[Table of available packages, sorted by name](#)

Installation of Packages
Please type `help("INSTALL")` or `help("install.packages")` in R for information on how to install packages from this repository. The manual [R Installation and Administration](#) (also contained in the R base sources) explains the process in detail.

CRAN Task Views allow you to browse packages by topic and provide tools to automatically install all packages for special areas of interest. Currently, 41 views are available.

Package Check Results
All packages are tested regularly on machines running [Debian GNU/Linux](#), [Fedora](#), macOS (formerly OS X), Solaris and Windows.
The results are summarized in the [check summary](#) (some [timings](#) are also available). Additional details for Windows checking and building can be found in the [Windows check summary](#).

Writing Your Own Packages
The manual [Writing R Extensions](#) (also contained in the R base sources) explains how to write new packages and how to contribute them to CRAN.

Repository Policies
The manual [CRAN Repository Policy \[PDF\]](#) describes the policies in place for the CRAN package repository.

“Packages” details at CRAN:

[Related Directories](#)

[Archive](#)

Previous versions of the packages listed above, and other packages formerly available.

[Orphaned](#)

Packages with no active maintainer, see the corresponding [README](#).

[bin/windows/contrib](#)

Windows binaries of contributed packages

[bin/macosx/contrib](#)

macOS High Sierra binaries of contributed packages

[bin/macosx/el-capitan/contrib](#)

OS X El Capitan binaries of contributed packages

How to install, use and get help about any package from CRAN?

- We can install packages of CRAN in R using:

```
install.packages("packagename")
```

e.g. `install.packages("dplyr")`

- We can then use the installed packages in R using:

```
library(packagename)
```

i.e. `library(dplyr)`

- We can get help on the installed packages in R using:

```
?packagement or help(package = "packagement")
```

e.g. `?dplyr` OR `help(package = "dplyr")`

“Packages” from Bioconductor repository: To work with Bioinformatics!

The screenshot shows the Bioconductor website with a teal header bar. The header includes a logo, navigation links for Home, Install, Help, Developers, and About, and a search bar. The main content area has four sections: 'About Bioconductor', 'Install >', 'Learn >', 'Use >', and 'Develop >'. Each section contains a list of links related to its topic.

About Bioconductor

Bioconductor provides tools for the analysis and comprehension of high-throughput genomic data. Bioconductor uses the R statistical programming language, and is open source and open development. It has two releases each year, and an active user community. Bioconductor is also available as an [AMI](#) (Amazon Machine Image) and [Docker](#) images.

News

- Bioconductor [3.14](#) release schedule announced. Please view for important deadlines.
- Bioconductor [Bioc 3.13](#) Released.
- Bioconductor [browsable code base](#) now available.
- See our [google calendar](#) for events, conferences, meetings, forums, etc. Add your event with email to events at bioconductor.org.
- Bioconductor [F1000 Research Channel](#) is available.
- Orchestrating single-cell analysis with Bioconductor ([abstract](#); [website](#)) and other [recent literature](#).

Install >

- Discover [2042 software packages](#) available in Bioconductor release 3.13.

Get started with Bioconductor

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- [Get support](#)
- [Latest newsletter](#)
- [Follow us on twitter](#)
- [Install R](#)

Learn >

Master Bioconductor tools

- [Courses](#)
- [Support site](#)
- [Package vignettes](#)
- [Literature citations](#)
- [Common work flows](#)
- [FAQ](#)
- [Community resources](#)
- [Videos](#)

Use >

Create bioinformatic solutions with Bioconductor

- [Software](#), [Annotation](#), and [Experiment](#) packages
- [Docker](#) and [Amazon](#) machine images
- [Latest release announcement](#)
- Use Bioconductor in the [AnVIL](#). See our [project updates](#).
- [Community Slack](#) sign-up
- [Support site](#)
- [Events calendar](#); [email events at](#)

Develop >

Contribute to Bioconductor

- [Developer resources](#)
- [Use Bioc 'devel'](#)
- 'Devel' packages
- [Package guidelines](#)
- [New package submission](#)
- [Git source control](#)
- [Build reports](#)
- [Browsable code base](#)

How to develop a package in R?

<https://hilaryparker.com/2014/04/29/writing-an-r-package-from-scratch/>

- Step 0: Packages you will need
- Step 1: Creating your package directory
- Step 2: Add functions
- Step 3: Add documentation
- Step 4: Process your documentation
- Step 5: Install
- Step 6: Make a package GitHub repo (Bonus!)
- Step 7: Infinity- Iterate

You do not need to create package in R for this course but it is required to know how to do it so that you can do it if required.

Reading (Import) data in R/R Studio:

- Text files: R base, readr etc. #Already covered in Unit 1
- Excel files: readXL, openxls etc. #Already covered in Unit 1
- SPSS, Stata, SAS files: foreign, haven etc. #Already covered in Unit 1

Reading data in R/R Studio:

- JSON files: rjson, jsonlite, RJSONIO etc.

Where, **JSON = JavaScript Object Notation**, used a lot in websites!

Creating a JSON file using a Text Editor (Notepad):

https://www.tutorialspoint.com/r/r_json_files.htm

- Example of a JavaScript Object Notation (JSON) file:

```
{  
  "ID": ["1", "2", "3", "4", "5", "6", "7", "8"],  
  "Name": ["Rick", "Dan", "Michelle", "Ryan", "Gary", "Nina", "Simon", "Guru"],  
  "Salary": [623.3, 515.2, 611, 729, 843.25, 578, 632.8, 722.5],  
  "StartDate": ["1/1/2012", "9/23/2013", "11/15/2014", "5/11/2014", "3/27/2015", "5/2  
  1/2013", "7/30/2013", "6/17/2014"],  
  "Dept": ["IT", "Operations", "IT", "HR", "Finance", "IT", "Operations", "Finance"]  
}
```

- It can be typed in text editor and saved with .json extension e.g. jason_data.json
- `Install.packages("rjson")`

Read the created JSON file in R and Convert it as data.frame for further manipulation in R:

- library("rjson")
- data <- fromJSON(file = "jason_data.json")
 # jason_data.json must be in the working directory of R!
- print(data)

- Covert to data frame:
- jason_data_frame <- as.data.frame(data)
- print(jason_data_frame) #Get summary, histogram of salary,
 # Average salary by department
 #Frequency distribution of all variables

Reading data in R/R Studio: Web Scrapping

- JSON files: rjson, jsonlite, RJSONIO etc.
- HTML page: rvest package (from R Studio)
- Use “rvest” package to extract HTML <table>

Reading JSON file from URL: Web API

<https://www.geeksforgeeks.org/working-with-json-files-in-r-programming/>

- `install.packages("jsonlite")` #Package “RJSONIO” also works!
- `library(jsonlite)`
- `Raw <- fromJSON("https://data.ny.gov/api/views/9a8c-vfzj/rows.json?accessType=DOWNLOAD")` #Large list!
- `food_market <- Raw[['data']]`
- `str(food_market)` #Large Matrix, 28472 rows and 24 columns!
- `head(food_market)`
- `Names <- food_market[,14]` #Large characters, Col 14 only!
- `heads(Names)` #Few names from Column 14!

What more can you do with the food_market data?

- Try: `table(Names)`
- Try: `table(V19)` #Why error?
- Try: `table(food_market$V19)` #What is “atomic vector”?
- Try: `table(food_market[,19])` #What do you get?
- Convert the food_market data to `data.frame` and get summary, create plots of all the “useful” variables and compute appropriate averages too!

HTML scrapping: Inspect in Google Chrome

<https://dataquestio.github.io/web-scraping-pages/simple.html>

The screenshot shows a Google Chrome window with the title bar "A simple example page" and the address bar "dataquestio.github.io/web-scraping-pages/simple.html". The main content area displays the text "Here is some simple content for this page." A yellow callout box on the left contains the question "What is ==\$0 in Chrome Developer Tool?". The callout box also contains the following text: "It's the last selected DOM (Document Object Model) node index. Chrome assigns an index to each DOM node you select. So \$0 will always point to the last node you selected, while \$1 will point to the node you selected before that." Below this text is a link: "<https://stackoverflow.com/questions/36999739/what-does-0-double-equals-dollar-zero-mean-in-chrome-developer-tools>". On the right side of the screenshot, the Chrome developer tools are open, specifically the "Elements" tab. The DOM tree shows the structure of the page, with the body node expanded to show the content "Here is some simple content for this page.". The node "body" is highlighted with a blue selection bar. The "Styles" tab is active in the developer tools, showing the CSS rules applied to the body element.

Web scrapping in R: A Simple (barebones) Example

<https://www.dataquest.io/blog/web-scraping-in-r-rvest>

- The recommended package for web scrapping in R is “rvest”
- `install.packages("rvest")`
- `library(rvest)`
- `simple <- read_html("https://dataquestio.github.io/web-scraping-pages/simple.html")`
- `simple %>%`
 `html_nodes("p") %>%`
 `html_text()`

`<p>This is some text in a paragraph.</p>`
It is embedded in `<body>`

rvest package: `html_node()` or `html_nodes()` find HTML tags (nodes) using CSS selectors or XPath expressions

A simple HTML Table node with <table> and <td>:

https://www.w3schools.com/html/html_tables.asp

Company	Contact	Country
Alfreds Futterkiste	Maria Anders	Germany
Centro comercial Moctezuma	Francisco Chang	Mexico
Ernst Handel	Roland Mendel	Austria
Island Trading	Helen Bennett	UK
Laughing Bacchus Winecellars	Yoshi Tannamuri	Canada
Magazzini Alimentari Riuniti	Giovanni Rovelli	Italy

- <table>
 <tr>
 <th>Company</th>
 <th>Contact</th>
 <th>Country</th>
 </tr>
 <tr>
 <td>Alfreds Futterkiste</td>
 <td>Maria Anders</td>
 <td>Germany</td>
 </tr>
 <tr>
 <td>Centro comercial Moctezuma</td>
 <td>Francisco Chang</td>
 <td>Mexico</td>
 </tr>
</table>

How to do web scrapping of this page? Inspect the HTML elements!

The COVID-19 pandemic in Nepal is part of the worldwide pandemic of coronavirus disease 2019 (COVID-19). The first case in Nepal was confirmed on 23 January 2020. The country has since experienced a significant outbreak, with over 783,910 confirmed cases and nearly 12,000 deaths as of September 2020.

COVID-19 pandemic in Nepal	
Disease	COVID-19
Virus strain	SARS-CoV-2
Location	Nepal
First outbreak	Wuhan, Hubei, China
Index case	Kathmandu, Bagmati Province
Arrival date	9 January 2020 (1 year, 7 months, 4 weeks and 1 day)
Date	23 January 2020
Confirmed cases	783,910 (18 September) ^[1]
Active cases	▲ 25,082 (18 September) ^[1]
Recovered	747,800 (18 September) ^[1]
Deaths	11,028 (18 September) ^[1]

What to do now?

Inbox (58) - shitalbhandary@gmail.com x COVID-19 pandemic in Nepal - V en.wikipedia.org/wiki/COVID-19_pandemic_in_Nepal +

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1 The tidy text format | Text Mining with R https://www.tidytextmining.com/tidytext.html

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COVID-19 pandemic in Nepal

From Wikipedia, the free encyclopedia

This article needs to be **updated**. The reason given is: Almost everything except the stat in the infobox is outdated.. Please help update this to reflect recent events or newly available information. (September 2021)

The **COVID-19 pandemic in Nepal** is part of the worldwide pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first case in Nepal was confirmed on 23 January 2020 when a 31-year-old student, who had returned to Kathmandu from Wuhan on 9 January, tested positive for the disease.^[2] It was also the first recorded case of COVID-19 in South Asia.^[3] Nepal's first case of local transmission was confirmed on 4 April in Kailali District. The first death occurred on 14 May. A country-wide lockdown came into effect on 24 March 2020, and ended on 21 July 2020.^[4] As of 18 September 2021, the Ministry of Health and Population

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1 The tidy text format | Text Mining with R https://www.tidytextmining.com/tidytext.html

html.client-js.ve-available lang="en" dir="ltr">
body class="mediawiki ltr sitedir-ltr mw-hide-empty-elt ns-0 ns-subject mw-editable page-COVID-19_pandemic_in_Nepal rootpage-COVID-19_pandemic_in_Nepal skin-vector action-view skin-vector-legacy">

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COVID-19 pandemic in Nepal

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We/you need to scrap this data (table) in R: And create plots, get summaries etc.

Inbox (58) - shitalbhandary@gmail.com × COVID-19 pandemic in Nepal - Wikipedia

en.wikipedia.org/wiki/COVID-19_pandemic_in_Nepal

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Data [edit]

This article needs to be **updated**. Please help update this article to reflect recent events or newly available information. (July 2021)

The table below documents the daily growth and change of laboratory-confirmed COVID-19 cases, deaths, and recoveries and real-time RT-qPCR tests in Nepal, since the first confirmed case on 23 January 2020:

Date	Confirmed cases			Recoveries		Deaths		RT-PCR tests		TPR	RR	CFR	Ref.
	Total	New	Active	Total	New	Total	New	Total	New				
23 Jan	1	+1	1	0	0	0	0			0%	0%	[170]	
24 Jan	1	0	1	0	0	0	0			0%	0%		
25 Jan	1	0	1	0	0	0	0			0%	0%		
26 Jan	1	0	1	0	0	0	0			0%	0%		
27 Jan	1	0	1	0	0	0	0			0%	0%		
28 Jan	1	0	1	0	0	0	0	3		33.33%	0%	[171]	
29 Jan	1	0	0	1	+1	0	0	4	+1	25%	100%	0% [172][173]	
30 Jan	1	0	0	1	0	0	0	5	+1	20%	100%	0% [174]	
31 Jan	1	0	0	1	0	0	0	5	0	20%	100%	0% [175]	
1 Feb	1	0	0	1	0	0	0			100%	0%		
2 Feb	1	0	0	1	0	0	0	5		20%	100%	0% [176]	
3 Feb	1	0	0	1	0	0	0			100%	0%		
4 Feb	1	0	0	1	0	0	0	14		7.14%	100%	0% [177]	

Inspect the page and find the html (table) node representing this table.

We can do as follows in R/R Studio:

- library(rvest)
 - wiki_link <- "https://en.wikipedia.org/wiki/COVID-19_pandemic_in_Nepal"
 - wiki_page <- read_html(wiki_link) **#rvest package**
 - str(wiki_page)
 - wiki_page %>% html_nodes("table") **#to get tables with index**
- #Get the desired table using “div class”:
- covid_table <- wiki_page %>%
 html_element("div.COVID19_pandemic_data_Nepal_medical_cases")%>%
 html_nodes("table") %>% html_table()%>% .[[1]]
 - str(covid_table) **#tibble [496 x 14]; tibble = fast data frame!**

Data wrangling: Part I

Column names of covid_table

#Changing names of the columns by adding values of first row

- `names(covid_table) <- paste(names(covid_table), covid_table[1,], sep = "_")`

#Removing the first row thereafter

- `covid_table <- covid_table[-1,]`

#Check the structure of data again

- `str(covid_table)`

Data wrangling: Part II

Now do as follows in R for “covid-table” data:

- Change “Date_Date” variable as “Date”
- Change “Confirmed cases_Total” variable as “Confirmed_Cases_Total”
- Change “Confirmed cases_New” variable as “Confirmed_Cases_New”
- Change “Confirmed cases_Active” variable as “Confirmed_Cases_Active”
- Change “RT-PCR tests_Total” variable as “RT-PCR_tests_Total”
- Change “RT-PCR tests_New” variable as “RT-PCR_tests_New”
- Change “TPR_TPR” variable as “TPR”
- Change “RR_RR” variable as “RR”
- Change “CFR_CFR” variable as “CFR”
- Change “Ref._Ref.” variable as “Ref”

Data wrangling: Part I

You can use other method too!

- Check if this works or not!
- ```
colnames(covid_table) <- c("Date", "Confirmed_Cases_Total",
 "Confirmed_Cases_New", "Confirmed_Cases_Active",
 "Recoveries_Total", "Recoveries_New", "Deaths_Total",
 "Deaths_New", "PCR_Total", "PCR_New", "TPR", "RR", "CFR", "Ref")
```
- ```
str(covid_table)
```

OR, will this also work?

```
15 colnames(covid_table)
16 names(covid_table)[names(covid_table) == "Date_Date"] = "Date"
17 names(covid_table)[names(covid_table) == "Confirmed cases_Total"] = "Confirmed_Cases_Tot
18 names(covid_table)[names(covid_table) == "Confirmed cases_New"] = "Confirmed_Cases_New"
19 names(covid_table)[names(covid_table) == "Confirmed cases_Active"] = "Confirmed_Cases_Active"
20 names(covid_table)[names(covid_table) == "RT-PCR tests_Total"] = "PCR_Total"
21 names(covid_table)[names(covid_table) == "RT-PCR tests_New"] = "PCR_New"
22 names(covid_table)[names(covid_table) == "TPR_TPR"] = "TPR"
23 names(covid_table)[names(covid_table) == "RR_RR"] = "RR"
24 names(covid_table)[names(covid_table) == "CFR_CFR"] = "CFR"
25 names(covid_table)[names(covid_table) == "Ref._Ref."] = "Ref"
26 colnames(covid_table)
```

Data wrangling: Part III

Removing “+” and “%” from variables:

#Removing + from four variables

- covid_table\$Confirmed_Cases_New <- gsub('[+]', "", covid_table\$Confirmed_Cases_New)
- covid_table\$Recoveries_New <- gsub('[+]', "", covid_table\$Recoveries_New)
- covid_table\$Deaths_New <- gsub('[+]', "", covid_table\$Deaths_New)
- covid_table\$PCR_New <- gsub('[+]', "", covid_table\$PCR_New)

#Removing % from three variables

- covid_table\$TPR <- gsub('[%]', "", covid_table\$TPR)
- covid_table\$RR <- gsub('[%]', "", covid_table\$RR)
- covid_table\$CFR <- gsub('[%]', "", covid_table\$CFR)

Data wrangling: Part III

Converting “chr” variables as integers 1

- covid_table\$Confirmed_Cases_Total <-
as.integer(covid_table\$Confirmed_Cases_Total)
- covid_table\$Confirmed_Cases_New <-
as.integer(covid_table\$Confirmed_Cases_New)
- covid_table\$Confirmed_Cases_Active <-
as.integer(covid_table\$Confirmed_Cases_Active)
- covid_table\$Recoveries_Total <-
as.integer(covid_table\$Recoveries_Total)
- covid_table\$Recoveries_New <-
as.integer(covid_table\$Recoveries_New)

Data wrangling: Part IV

Converting “chr” variables as integers 2

- covid_table\$Deaths_Total <- as.integer(covid_table\$Deaths_Total)
- covid_table\$Deaths_New <- as.integer(covid_table\$Deaths_New)
- covid_table\$PCR_Total <- as.integer(covid_table\$PCR_Total)
- covid_table\$PCR_New <- as.integer(covid_table\$PCR_New)

Data wrangling: Part IV

#Converting “chr” variables as numbers

- covid_table\$TPR <- as.numeric(covid_table\$TPR)
- covid_table\$RR <- as.numeric(covid_table\$RR)
- covid_table\$CFR <- as.numeric(covid_table\$CFR)

How to change “date” variable?

- The date is shown as “23 Jan”, “24 Jan”, “25 Jan” etc.
- You need to use as.Date function
- What is the default Date values to use this function?
- Can you use different format to convert?
- **This is an assignment for you!**

Also see these posts to know more on web scrapping with “rvest” in R:

- <https://kyleake.medium.com/wikipedia-data-scraping-with-r-rvest-in-action-3c419db9af2d>
- <https://www.engineeringbigdata.com/web-scraping-wikipedia-world-population-rvest-r/>
- <https://stackoverflow.com/questions/33360634/how-to-scrape-data-from-wikipedia-using-r>

Collecting Web Data – APIs & Web Scrapping

<https://research.library.gsu.edu/c.php?g=1050939&p=7628916>

- Web scraping is an extremely popular amongst researchers and web developers. The best example may be Google Search.
- When you use Google to find information, you are (in highly over simplified terms) not actually searching the "live" internet, but rather a database of webpages that Google has mapped.
- If Google is allowed to do it, why can't you!?

Collecting Web Data – APIs & Web Scrapping

<https://research.library.gsu.edu/c.php?g=1050939&p=7628916>

1. Research Ethics

- Is the data you are collecting potentially sensitive information?
- If you are scraping user-comments from a social media website, are the users aware that their comments are visible to you or others?
- Are the users fully or partially aware of how their comments and data may be used?
- Do the users have an expectation of anonymity or confidentiality?
- Do the users represent marginalized or at-risk group?
- Does your research pose any form of potential risk to the users who supplied the data you are using?

Collecting Web Data – APIs & Web Scrapping

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2. Public vs. Protected Content

- Are the webpages you are collecting data from freely and publicly visible? OR...
- Are the webpages you are collecting data password-protected, requiring you to log into the website?
- If webpages and content are password-protected, does the website require you to adhere to a "Terms of Service", "Terms of Use" or other type of agreement in order to access and use the website?
 - Often these agreements explicitly forbid systematic web-scraping activities

Collecting Web Data – APIs & Web Scrapping

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3. Copyright & Commercial Activity

- Are you violating copyright as part of your overall web-scraping activities?
- Are you reproducing the data or contents of webpages on your own website or in another medium?
- If you are reproducing or embedding the content in some way, do you have the site owner's permission?

Collecting Web Data – APIs & Web Scrapping

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4. Sustainability

- Are you systematically collecting large volumes of webpages at a high rate from the target website?
- Are you systematically collecting on a repeating schedule at a rapid rate?
- Are you collecting webpages from the website in such a way that poses commercial and/or technical risk to the technical operations of the target website?

More on “ethical issues” with the use of web scrapping/ web APIs are here:

- <https://towardsdatascience.com/ethics-in-web-scraping-b96b18136f01>
- <https://blogs.mulesoft.com/api-integration/strategy/ethics-of-apis/>
- **Self-learning!**

Question/Queries?

Thank you!

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