Tools for Reproducible Workflows in R

March, 2023

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# About this Course

Reproducibility of data analyses can be enhanced through the use of tools designed to manage the complexity involved in any data analysis designed to address an important scientific question. We focus on a few software tools that aid in project organization, collaboration, auditability of analyses, and maintaining the integrity of data and code. In this course, we view a data analysis as a complex system with many integrated parts that together produce analytic results. The tools we focus on here allow data analysts to diagnose unexpected results, quickly identify problems with data and code, and provide a basis for managing the dynamic nature of data analysis.

This initiative is funded by the following grant: R25GM141505 from the National Institute of General Medical Sciences (NIGMS). Except where otherwise indicated, the contents of this course are available for use under the Creative Commons Attribution 4.0 license. You are free to adapt and share the work, but you must give appropriate credit, provide a link to the license, and indicate if changes were made. Sample attribution: Tools for Reproducible Workflows in R by Fred Hutchinson Data Science Lab and University of Texas, Austin (CC-BY 4.0). You can download the illustrations by clicking [here](https://docs.google.com/presentation/d/1MNHf8JpolaEP_vQ_kB-1xRBF9wo3haCArRu117hBoHA/edit?usp=sharing).

## 0.1 Available course formats

This course is available in multiple formats which allows you to take it in the way that best suites your needs. You can take it for certificate which can be for free or fee.

* The material for this course can be viewed without login requirement on this [Bookdown website](LINK%20HERE). This format might be most appropriate for you if you rely on screen-reader technology.
* This course can be taken for [free certification through Leanpub](LINK%20HERE).
* This course can be taken on [Coursera for certification here](LINK%20HERE) (but it is not available for free on Coursera).
* Our courses are open source, you can find the [source material for this course on GitHub](LINK%20HERE).

# 1 Introduction

In this course we will explore a variety of tools that can assist with data analysis from a broad range of fields. The tools we will cover may take some time to get used to, but the payoff will be immeasurable. Not only are these skills valuable for career advancement, they will also make your work-life easier. The tools will enhance your ability to reproduce your work across similar projects, stay organized, collaborate with others effectively, and more.

## 1.1 Motivation

Many researchers are self-taught when it comes to computer science. However, data analysis has become a requirement for most researchers. The ability to smoothly work in a reproducible manner not only makes for easier more maintainable workflows, it also improves scientific rigor and transparency.

This course will help learners to use tools that will make their data analytic workflows more organized, more understandable to collaborators (and your future self!), and ultimately more efficient.

## 1.2 Target Audience

This course is intended for people conducting data analyses at the level of a graduate student or higher. The course is designed so that the majority of the material is presented in a high-level manner that should be applicable to researchers working in a broad range of areas. The course is centered around the R programming language, a widely used statistical analysis software package.

## 1.3 Curriculum

The course covers…

## 1.4 Learning Objectives

* Implement basic project organization tools:
* R Studio tips and tricks for efficiency
* R Markdown to create reports
  + Setup and configure RStudio/RStudio projects for data analysis (here package and file structure/paths)
  + Install and configure ProjectTemplate package for formalizing and automating workflows
* Apply the pointblank package for validation of tabular data
* Write functions and package them
* Apply the testthat package for building software unit tests
* Setup and use Git repositories for version control of code
* Interface with GitHub to share Git repositories for collaboration; execute GitHub-based workflows
  + Pull Requests
  + Code review
  + Issues
  + Discussions

References will include Gillespie and Lovelace ([2021](#ref-gillespie_efficient_2021)), Riederer ([2020](#ref-riederer_column_2020)), Timbers, Campbell, and Lee ([2022](#ref-timbers_data_nodate)).

Code review references will include “About Scientific Code Review” ([n.d.](#ref-hutchdatascience_code_review)), Radigan ([n.d.](#ref-radigan_what_nodate)), Parker ([2017](#ref-parker_opinionated_2017)), Bodner ([2018](#ref-bodner_10_2018)).

# 2 R for Reproducibility

## 2.1 Learning Objectives

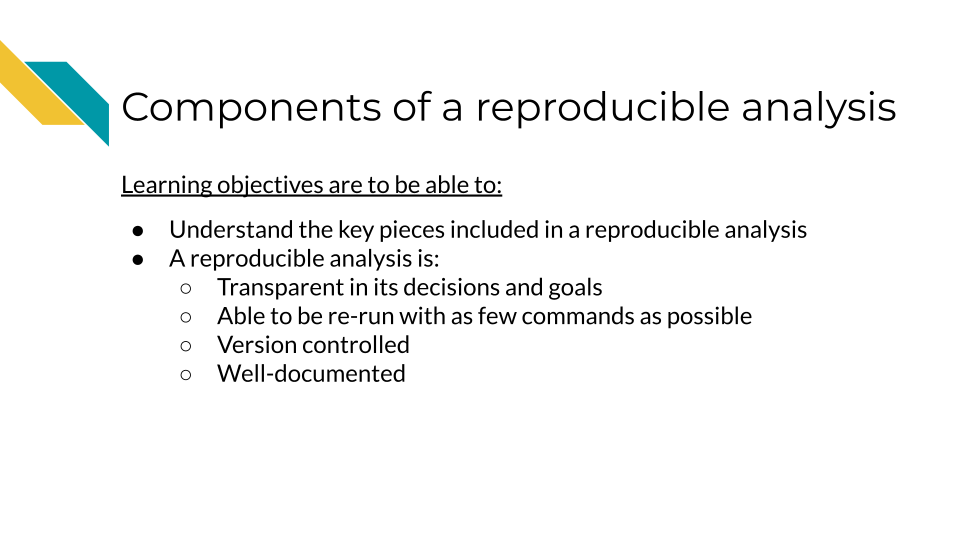
Before we begin to jump into additional tools that R can help us with to be work more efficiently and in a more reproducible manner, it is helpful to first discuss why we should consider R in the first place. After completing this section you will be able to:

* Explain why R can be especially helpful for transparent and reproducibility data analyses
* Recognize that R has a very active and supportive community and locate access points to that community
* Compare R to other similar statistical and data analysis tools and programming languages
* Describe the unique benefits of R

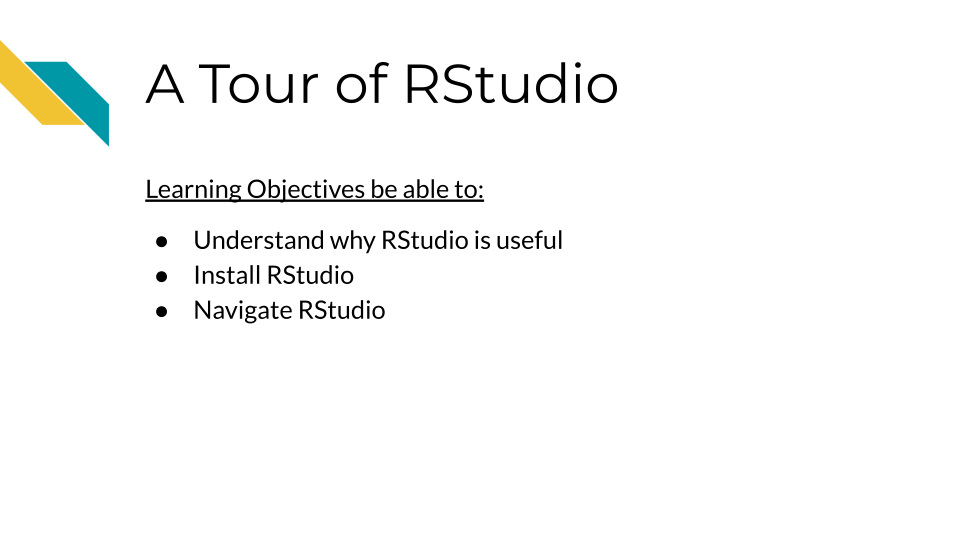
## 2.2 Why R



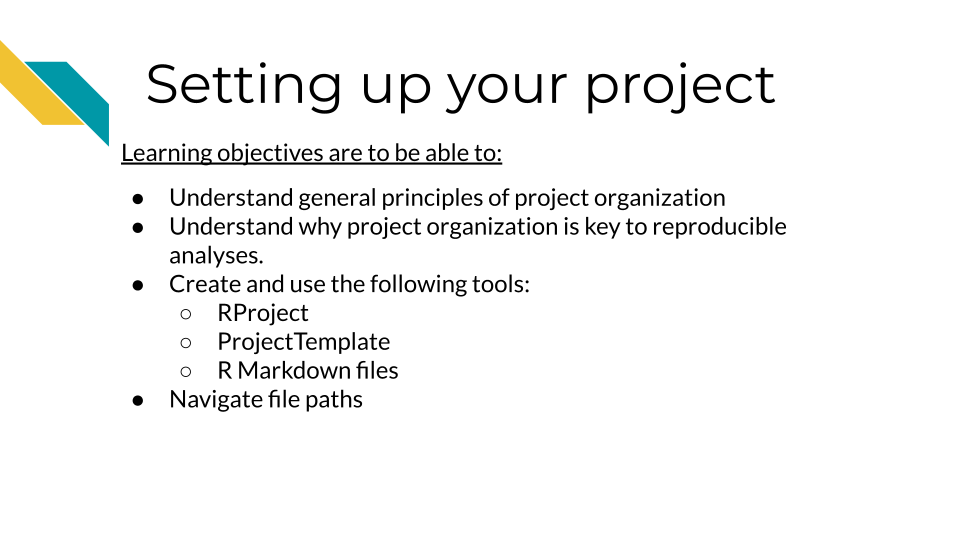
# 3 Components of a reproducible analysis



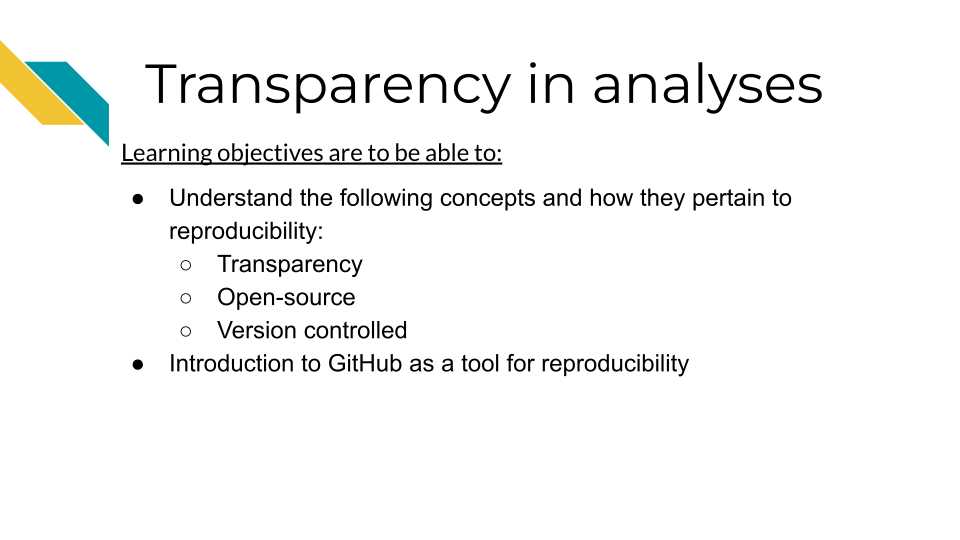
# 4 A Tour of RStudio



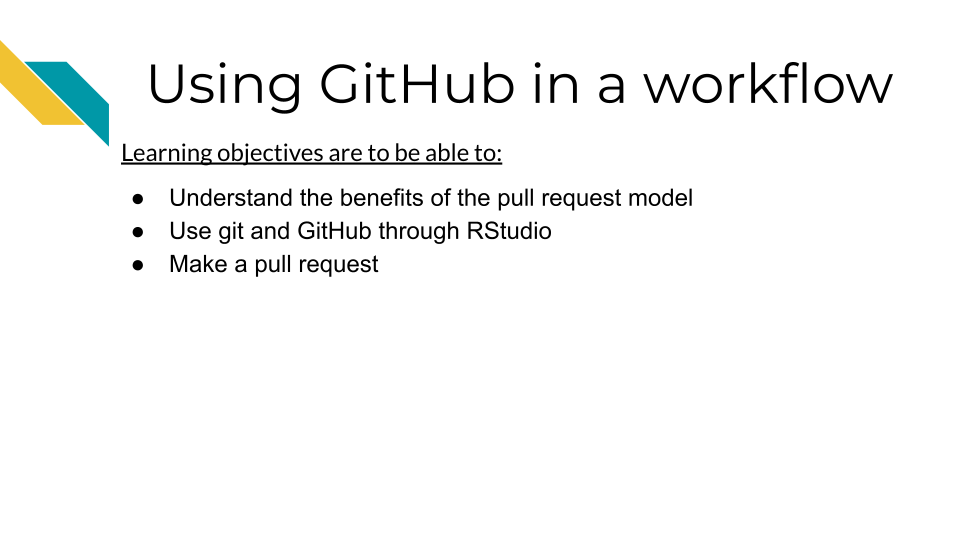
# 5 Setting up your project



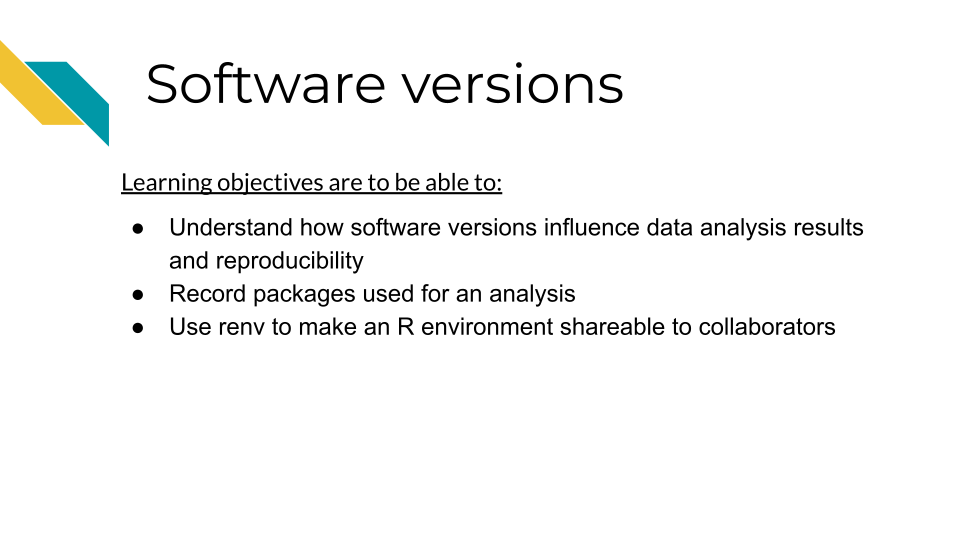
# 6 Transparency in Analyses



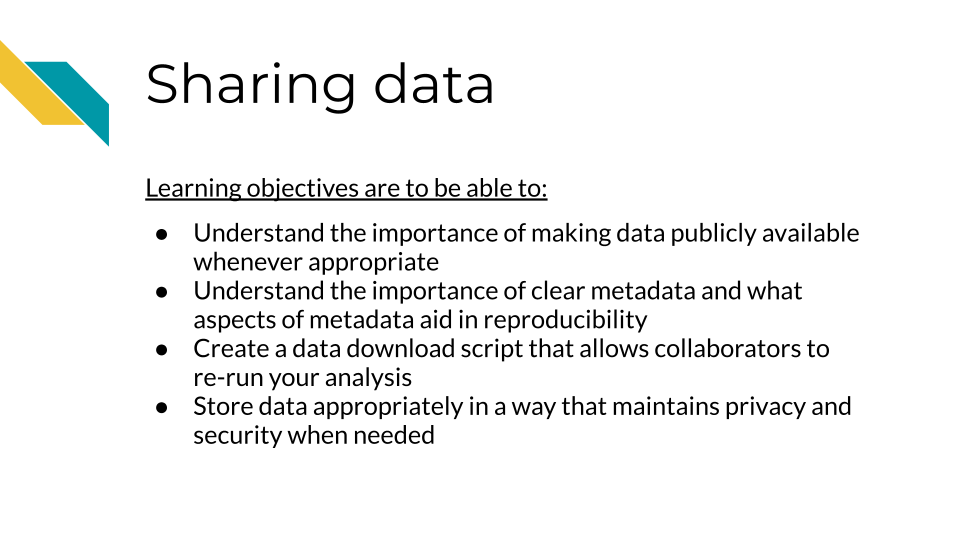
# 7 Using GitHub in a workflow



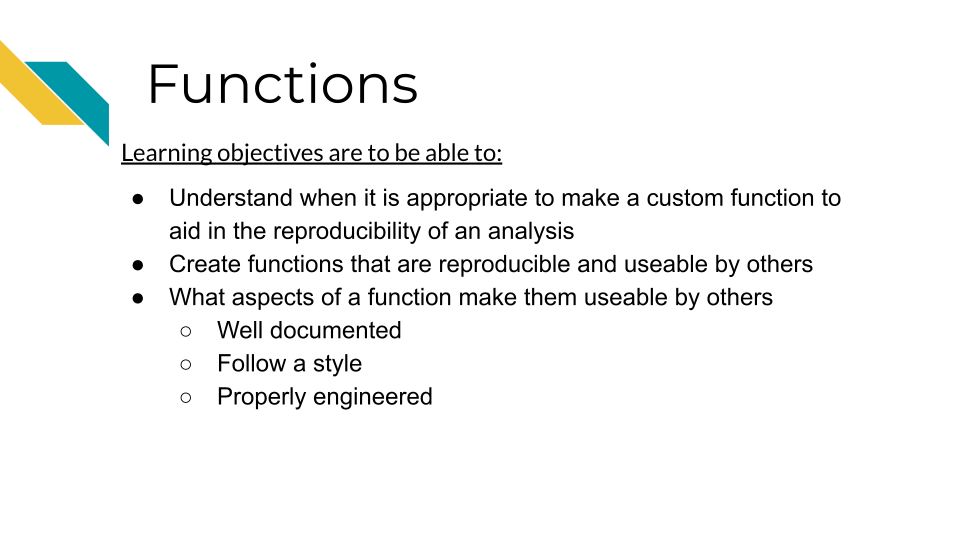
# 8 Software versions



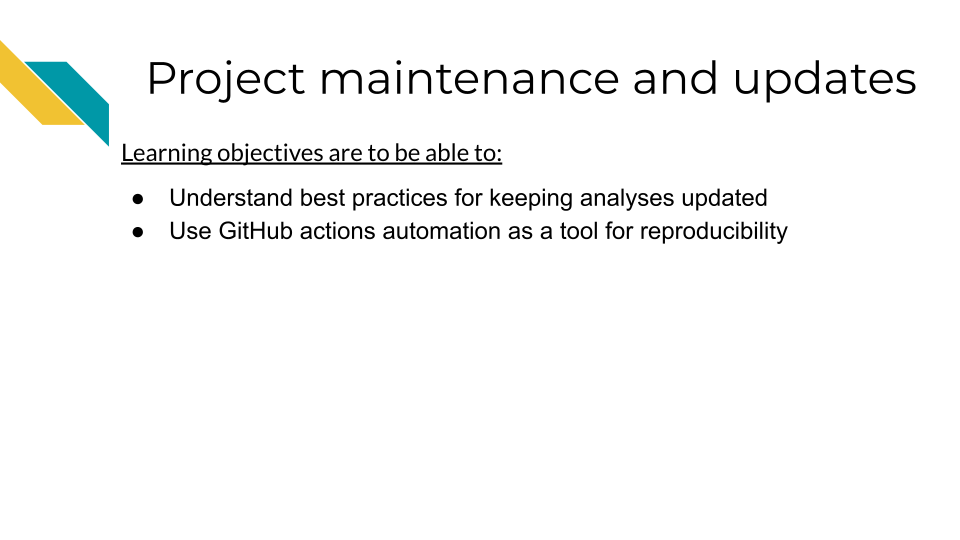
# 9 Sharing Data



# 10 Functions



# 11 Project maintenance and updates



# 12 Collaborations through GitHub



# About the Authors

These credits are based on our [course contributors table guidelines](https://www.ottrproject.org/more_features.html#giving-credits-to-contributors).

| Credits | Names |
| --- | --- |
| **Pedagogy** |  |
| Lead Content Instructor(s) | [FirstName LastName](link%20to%20personal%20website) |
| Lecturer(s) (include chapter name/link in parentheses if only for specific chapters) - make new line if more than one chapter involved | Delivered the course in some way - video or audio |
| Content Author(s) (include chapter name/link in parentheses if only for specific chapters) - make new line if more than one chapter involved | If any other authors besides lead instructor |
| Content Contributor(s) (include section name/link in parentheses) - make new line if more than one section involved | Wrote less than a chapter |
| Content Editor(s)/Reviewer(s) | Checked your content |
| Content Director(s) | Helped guide the content direction |
| Content Consultants (include chapter name/link in parentheses or word “General”) - make new line if more than one chapter involved | Gave high level advice on content |
| Acknowledgments | Gave small assistance to content but not to the level of consulting |
| **Production** |  |
| Content Publisher(s) | Helped with publishing platform |
| Content Publishing Reviewer(s) | Reviewed overall content and aesthetics on publishing platform |
| **Technical** |  |
| Course Publishing Engineer(s) | Helped with the code for the technical aspects related to the specific course generation |
| Template Publishing Engineers | [Candace Savonen](https://www.cansavvy.com/), [Carrie Wright](https://carriewright11.github.io/) |
| Publishing Maintenance Engineer | [Candace Savonen](https://www.cansavvy.com/) |
| Technical Publishing Stylists | [Carrie Wright](https://carriewright11.github.io/), [Candace Savonen](https://www.cansavvy.com/) |
| Package Developers ([ottrpal](https://github.com/jhudsl/ottrpal)) [Candace Savonen](https://www.cansavvy.com/), [John Muschelli](https://johnmuschelli.com/), [Carrie Wright](https://carriewright11.github.io/) |  |
| **Art and Design** |  |
| Illustrator(s) | Created graphics for the course |
| Figure Artist(s) | Created figures/plots for course |
| Videographer(s) | Filmed videos |
| Videography Editor(s) | Edited film |
| Audiographer(s) | Recorded audio |
| Audiography Editor(s) | Edited audio recordings |
| **Funding** |  |
| Funder(s) | Institution/individual who funded course including grant number |
| Funding Staff | Staff members who help with funding |

## ─ Session info ───────────────────────────────────────────────────────────────  
## setting value   
## version R version 4.0.2 (2020-06-22)  
## os Ubuntu 20.04.5 LTS   
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## ui X11   
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## ctype en\_US.UTF-8   
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##   
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## cachem 1.0.7 2023-02-24 [1] CRAN (R 4.0.2)   
## callr 3.5.0 2020-10-08 [1] RSPM (R 4.0.2)   
## cli 3.6.0 2023-01-09 [1] CRAN (R 4.0.2)   
## crayon 1.3.4 2017-09-16 [1] RSPM (R 4.0.0)   
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## devtools 2.3.2 2020-09-18 [1] RSPM (R 4.0.3)   
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## ellipsis 0.3.1 2020-05-15 [1] RSPM (R 4.0.3)   
## evaluate 0.20 2023-01-17 [1] CRAN (R 4.0.2)   
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## fs 1.5.0 2020-07-31 [1] RSPM (R 4.0.3)   
## glue 1.4.2 2020-08-27 [1] RSPM (R 4.0.5)   
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## stringi 1.5.3 2020-09-09 [1] RSPM (R 4.0.3)   
## stringr 1.4.0 2019-02-10 [1] RSPM (R 4.0.3)   
## testthat 3.0.1 2023-03-10 [1] Github (R-lib/testthat@e99155a)   
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## withr 2.3.0 2020-09-22 [1] RSPM (R 4.0.2)   
## xfun 0.26 2023-03-10 [1] Github (yihui/xfun@74c2a66)   
## yaml 2.2.1 2020-02-01 [1] RSPM (R 4.0.3)   
##   
## [1] /usr/local/lib/R/site-library  
## [2] /usr/local/lib/R/library

# 13 References

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