

# Communicating Science using R Markown

W. Evan Johnson, Ph.D.  
Professor, Division of Infectious Disease  
Director, Center for Data Science  
Rutgers University – New Jersey Medical School

2024-05-23

Effective science communicators educate non-specialist audiences about scientific topics, issues, and debates in ways that are informative, accessible, and empowering. \vskip .1in

Science communicators should be able to answer the following questions:

- Who is my audience?
- What is my message for my audience?
- What medium am I going to use to communicate my message to my audience?

The **lay public** is made up of all the people who are not experts in a specific field. When addressing the lay public:

- Keep the story simple and front-load exciting aspects
- Make the story relevant to your audience
- Use analogies and visuals
- Front-load the story
- Avoid jargon - simple language but don't oversimplify
- Include the people and the process (challenges, successes, collaborations, etc.)

# Communicating Science

The **media** is a “mediator” between scientists and the public. Note the media is not a homogenous group. \vskip .1in

Describing your process, challenges, successes, and collaborations are important for writing an informative and engaging press release. Read a few popular science articles to get a sense of how your research might eventually appear in the news and magazines. \vskip .1in

Articles about your work should include visuals—videos or photos—that will draw readers’ attention to the article and help them grasp the gist of the piece.

Scientists can share their knowledge with **policy makers** through meetings, testimonies, and open presentations. Suggestions for communicating with policy makers:

- Know what issues policy makers are currently discussing and debating
- Keep your explanations simple and relevant
- Think of some actionable solutions to the problem
- Think about the problem and solution in the context of the policy maker's constituency
- Be confident in yourself and what you know
- Approach a meeting as a conversation, not a presentation
- Create a one-pager with your message and key points

Visuals make the data supporting your message clear and accessible to your audience. Science visualizations include:

- 1 Graphs, tables, and infographics
- 2 Conceptual diagrams
- 3 Maps, Satellite photos
- 4 Photographs

Keep the following points in mind:

- 1 Use a consistent style and format
- 2 Use colors with purpose
- 3 Use high-resolution graphics
- 4 Format your graphics and include labels, legends, and captions

# Reproducible Reports (R markdown)

The final product of a data analysis project is often a report: scientific publications, news articles, an analysis report for your company, or lecture notes for a class. \vskip .1 in

Now imagine after you are done you realize you:

- had the wrong dataset
- have a new dataset for the same analysis
- made a mistake and fix the error, or
- your boss or someone you are training wants to see the code and be able to reproduce the results \vskip .1in

Situations like these are common for a data scientist.

R markdown is a format for **literate programming** documents. Literate programming weaves instructions, documentation, equations, and detailed comments among executable code.

It is based on **markdown**, a markup language that is widely used to generate html pages. You can learn more about markdown with the following tutorial: **[click here](#)**



You can start an R markdown document in RStudio by clicking on **File, New File**, then **R markdown**. You will then be asked for a title and author.

Once you gain experience with R markdown, you will be able to do this without the template and can simply start from a blank template.

As a convention, we use the `.Rmd` suffix for R markdown files

# Compiling the document using knitr

With R markdown, you need to **compile** the document into the final report. We use the `knitr` package to do this. The specific function used to compile is the `knit` function, which takes a filename as input.

RStudio provides a `Knit` button that makes it easy and convenient to compile the document.

# The Header

At the top of the document is the R markdown header:

```
---  
title: "Nanostring Analysis"  
author: "Evan Johnson"  
date: "12/5/2019"  
output: html_document  
---
```

R markdown reports can be to be in HTML, PDF, Microsoft Word, or presentation formats. By changing the output to, for example `pdf_document` or `word_document`, we can control the type of output that is produced.

# The Header

Other output options include code folding, themes, etc.:

```
---  
title: "Nanostring Analysis"  
author: "Evan Johnson"  
date: "12/5/2019"  
output:  
  html_document:  
    code_folding: hide  
    toc: true  
    toc_float: true  
    theme: "flatly"  
editor_options:  
  chunk_output_type: console  
---
```

In various places in the document, we see something like this:

```
```${r}  
summary(pressure)  
```
```

These are the **code chunks**. When you compile the document, the R code inside the chunk, in this case `summary(pressure)`, will be evaluated and the result included in that position in the final document.

To add your own R chunks, you can type the characters above quickly with the key binding `command-option-I` on the Mac and `Ctrl-Alt-I` on Windows.

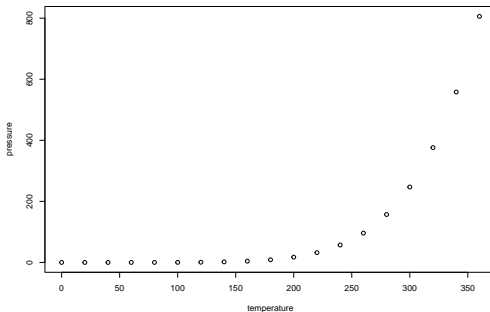
Its a good habit to adding a label to the R code chunks. This will be very useful when debugging, among other situations. You do this by adding a descriptive word like this:

```
```{r pressure-summary}  
summary(pressure)  
```
```

# R Code Chunks

We can also add plots to our report:

```
```{r, out.width = '60%', fig.align = 'center'}  
plot(pressure)  
```
```



The chunk options (comma sparated) `out.width` and `fig.align` adjust the size and loction of the figure

By default, the code will show up as well. To avoid having the code show up, you can use an argument. To avoid this, you can use the argument `echo=FALSE`. For example:

```
```{r, echo=FALSE}  
summary(pressure)  
```
```

If you want to include the code in the document, but not run the code and/or include results, you can use the argument `eval=FALSE`:

```
```{r, eval=FALSE}  
# You can install the tidyverse using:  
install.packages(tidyverse)  
```
```



# R Code Chunks (global knitr options)

One of the R chunks may contain a complex looking call:

```
```${r setup, include=FALSE}  
knitr::opts_chunk$set(echo = TRUE)  
```
```

The `include=FALSE` option in the chunk call will tell the system to run the R code, but not include it in the html/pdf/word report.

The R code in the chunk sets the `knitr` default to `echo=TRUE` in the call for any R chunks following this one.

knitr can execute code in many languages besides R:

```
```{python}
x = [2, 1, 3]
print(x[0], "Hello Python!")
```
```

## 2 Hello Python!

Some of the available language engines include: Python, SQL, Bash, Rcpp, Stan, JavaScript, and CSS.

One exciting feature about R markdown is that it allows you to include L<sup>A</sup>T<sub>E</sub>X equations to be rendered in html, pdf, or Word.

For example, to show the probability under the normal curve in the interval  $(a, b)$ , you can use the L<sup>A</sup>T<sub>E</sub>X code:

```
\mbox{Pr}(a < x < b) =  
  \int_a^b \frac{1}{\sqrt{2\pi}\sigma}  
  e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \, dx
```

This will be rendered by knitr as:

$$\Pr(a < x < b) = \int_a^b \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} dx$$

## Other Options (tabsets)

One very useful tool in Markdown is to add tabs to the html document:

```
## This is a header {.tabset}
### This is Tab 1
### This is Tab 2
## This is a new header (not in the tabs)
```

The `{.tabset}` option will make all lower level subheadings tabs in the html. The next same or higher level header will break out of the tabset.

# Other Options (tabsets)

**Pro tip:** tabs can be generated dynamically:

```
## My Header {.tabset}
```${r, results = 'asis'}
n <- 10
for (i in 1:n){
  cat("###" , "Tab", i, "\n")
  print(i)
  cat("\n\n")
}
```
```

We will explore other R markdown options: headers, tabsets, and  $\text{\LaTeX}$  equations in class and in your Exercises. `\vskip .2` in Note:  
From now on, all R-based Exercises should preferably be done using an R markdown document. Your document should include headers, descriptive text, equations, R code, and plots/figures!

There is a lot more you can do with R markdown. We highly recommend you continue learning as you gain more experience writing reports in R. There are many free resources on the internet including:

- 1 RStudio's tutorial: <https://rmarkdown.rstudio.com>
- 2 The cheat sheet: <https://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf>
- 3 The knitR book: <https://yihui.name/knitr/>

R markdown is a powerful tool for literate programming. To gain more practice, recreate the .Rmd file for the example file: “Rmarkdown\_example.html.”



# Session info

```
sessionInfo()
```

```
## R version 4.4.0 (2024-04-24)
## Platform: aarch64-apple-darwin20
## Running under: macOS Sonoma 14.2.1
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRlapack.dylib; LAPACK version 3.12.0
##
## locale:
##  [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/Denver
## tzcode source: internal
##
## attached base packages:
## [1] stats      graphics  grDevices  utils      datasets  methods   base
##
## loaded via a namespace (and not attached):
##  [1] digest_0.6.35    fastmap_1.1.1    xfun_0.43        Matrix_1.7-0
##  [5] lattice_0.22-6   reticulate_1.36.1 knitr_1.46        htmltools_0.5.8.1
##  [9] png_0.1-8        rmarkdown_2.26   tinytex_0.50     cli_3.6.2
## [13] grid_4.4.0       compiler_4.4.0   rprojroot_2.0.4  here_1.0.1
## [17] rstudioapi_0.16.0 tools_4.4.0      evaluate_0.23    Rcpp_1.0.12
## [21] yaml_2.3.8       jsonlite_1.8.8   rlang_1.1.3
```