Introduction to R

v2.0

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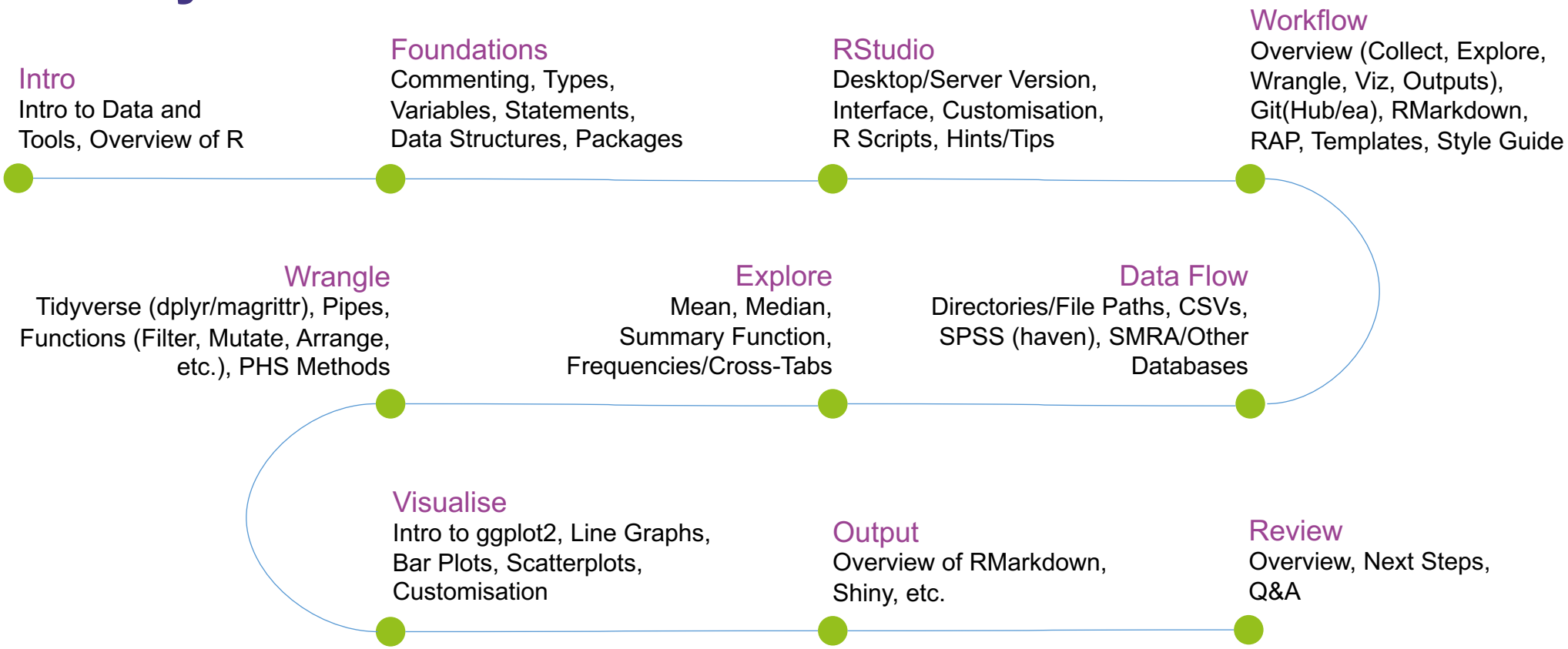
Pathway


Intro
Intro to Data and Tools, Overview of R
Foundations
Commenting, Types, Variables, Statements, Data Structures, Packages
RStudio
Desktop/Server Version, Interface, Customisation, R Scripts, Hints/Tips
Workflow
Overview (Collect, Explore, Wrangle, Viz, Outputs), Git(Hub/ea), RMarkdown, RAP, Templates, Style Guide
Data Flow
Directories/File Paths, CSVs, SPSS (haven), SMRA/Other Databases
Explore
Mean, Median, Summary Function, Frequencies/Cross-Tabs
Wrangle
Tidyverse (dplyr/magrittr), Pipes, Functions (Filter, Mutate, Arrange, etc.), PHS Methods
Visualise
Intro to ggplot2, Line Graphs, Bar Plots, Scatterplots, Customisation
Output
Overview of RMarkdown, Shiny, etc.
Review
Overview, Next Steps, Q&A

Introduction – the why

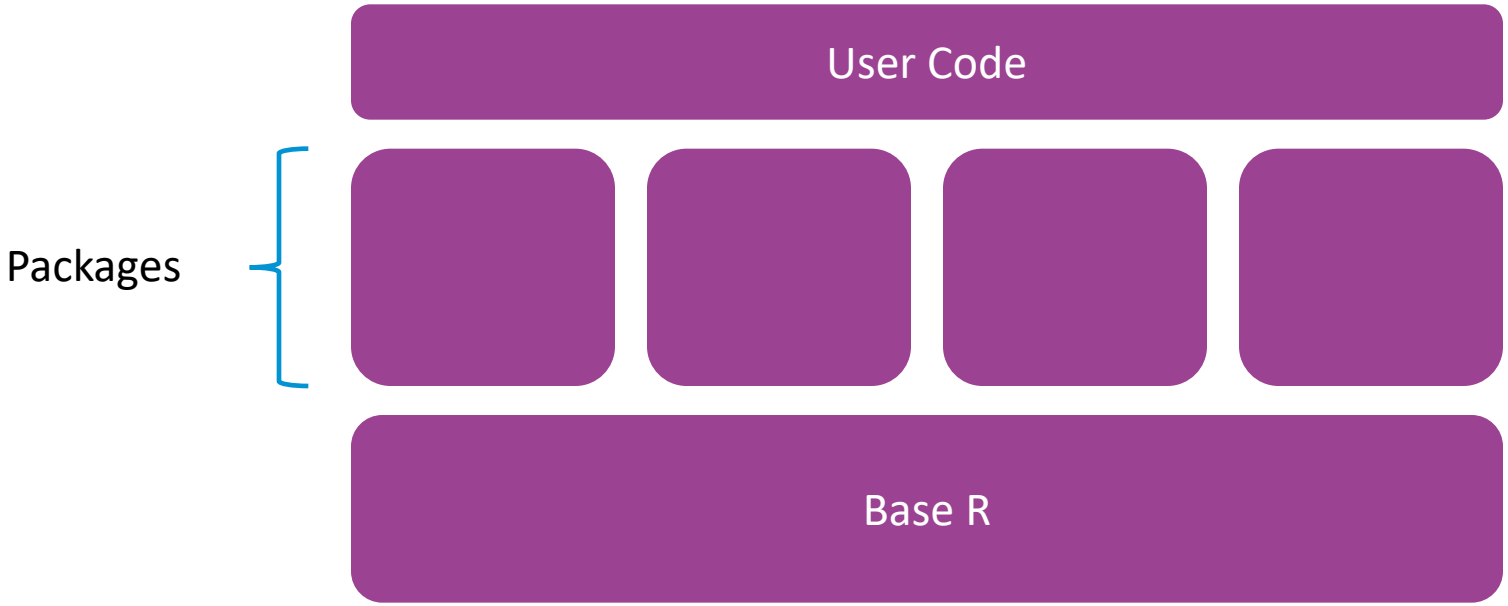
Data

R

- is a **programming language** widely used for *data analysis*, statistics, and *graphics;*
- **is open source**, available on all major operating systems;
- has the functionality to go from raw data to interactive reports and web apps;
- and it's part of the **PHS analytical strategy.**

Foundations – the what

R Structure

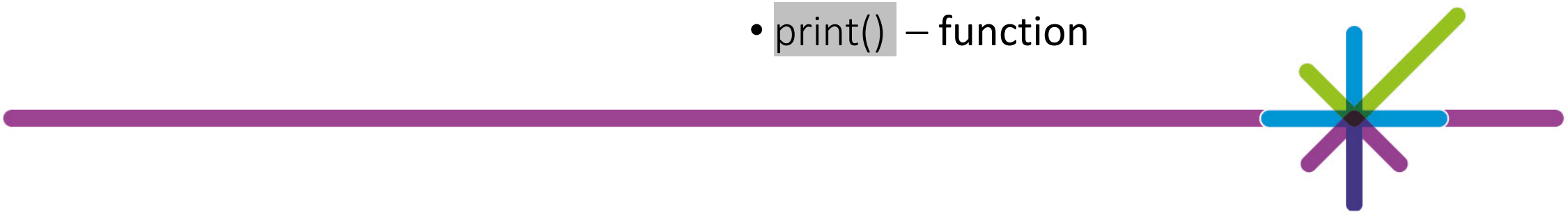


Input

```
# Example 1
hello_world <- "Hello World"
print(hello_world)
```

```
> [1] "Hello World"
```

- `# Example 1` – comment
- `hello_world` – variable
- `<-` – assignment operator (`alt + -`)
- `"Hello World"` – character (" or ')
- print() – function



Basic Data Types

- Character – e.g. `"Hello World!"`
- Numeric (Real) – e.g. `123.5`
- Logical (Boolean) – e.g. `TRUE`

```
typeof("Hello World")
is.numeric(123.5)
print(typeof(TRUE))
```

```
> [1] "character"
> [1] TRUE
> [1] "logical"
```

Type Conversion

`as.<data_type>()`

- `as.character()` conversions tend to succeed without fault
- `as.numeric()` – TRUE and FALSE become 1 and 0, character types needs to be formatted correctly
- `as.logical()` – everything except 0 becomes TRUE for numeric conversions, character can be upper, lower, or proper case versions

```
as.character(123.5)
as.numeric("123.5")
as.logical("False")
```

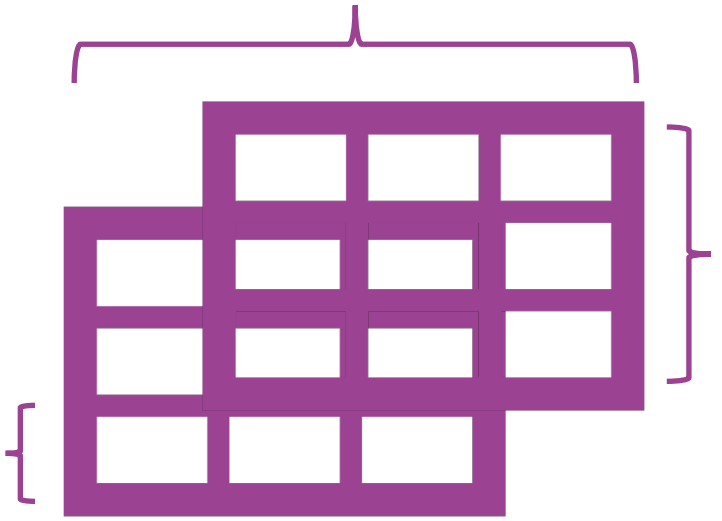
```
> [1] "123.5"
> [1] 123.5
> [1] FALSE
```

Operators

Precedence	Operator	Description
1	^	Exponentiation (right to left evaluation)
2	%%	Modulus
3	* /	Multiplication, Division
4	+ −	Addition, Subtraction
5	< > <= >= == !=	Comparison Operators (Less Than, More Than, Less Than or Equal To, More Than or Equal To, Equal To, Not Equal To)
6	!	Logical NOT
7	& &&	Logical AND
8	| ||	Logical OR

Data Structures

- Vectors
- Lists
- Factors
- Matrices
- Data Frame



- `str()` provides an overview and description of the data structure

Vectors

- contain objects of the *same* basic class
- Create: `c(...)` or `vector(<type>, <length>)`
- Access: `<vector>[<index>]`

```
vector("logical", 4)
c("a", "c", "f", "b")[1]
c(2, 5, 1, "abc")[2]
```

```
> [1] FALSE FALSE FALSE FALSE
> [1] "a"
> [1] "5"
```

Lists

- are a special type of vector that can contain objects of *different* classes, including other lists
- Create: `list(...)`
- Sub-list: `<list>[<index>]`
- Access: `<list>[[<index>]]`

```
list("abc", 4, FALSE)[1:2]
list(list(2, 3), "abc")[[2]]
```

```
> [[1]]
> [1] "abc"
> [[2]]
> [1] 4
```

```
> [1] "abc"
```

Naming List Elements

- can be done during or after creation.
- At creation:
  `list("<name>", = <item>)`
- After:
  `names(<list>) <- c("<name>")`

```
x <- list("Ch" = "a", "Nm" = 2)
names(x) <- c("Char", "Num")
x$Char
```

```
> [1] "a"
```

Factors

- are used to represent categorical data
- Create: `factor(c(...))`
- Levels: `factor(c(...), levels = c(...))`

```
x <- factor(c("M", "F", "M"),
     levels = c("F", "M"))
x
```

```
> [1] M F M
Levels: F M
```

Matrices

- expand our dimensions with a `nrow` and `ncol` arguments, constructed column-wise
- Create: `matrix(<data>, nrow = <int>, ncol = <int>)`
- Access: `<matrix>[<row>, <col>]`

```
x <- matrix(1:6, 2, 3)
x
x[2, 3]
```

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

```
> [1] 6
```

Data Frames

- are used to store tabular data, each column contains one variable, each row contains an observation
- Create: `data.frame("<name>" = <element(s)>)`
- Subset: `[]`
- Access: `[[]]` or `$`

```
data.frame(name = c("Harry",
                    "Sarah"),
           score = c(62, 91))
```

```
>     name  score
>  1  Harry     62
>  2  Sarah     91
```

Packages

- are used to expand the functionality of R with additional functions

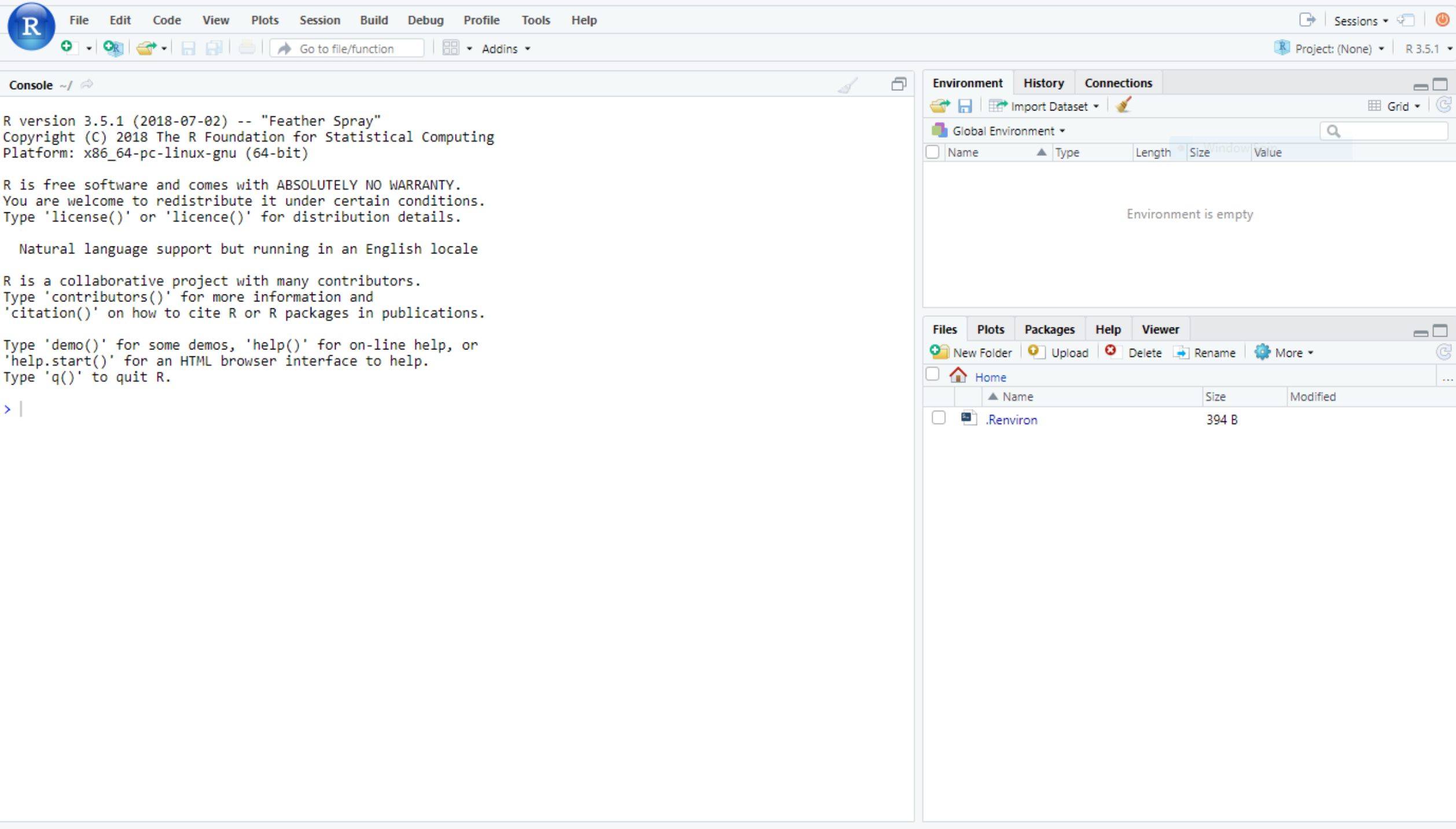
- Install: `install.packages("<package>")`

- Load: `library(<package>)` or `require(<package>)`

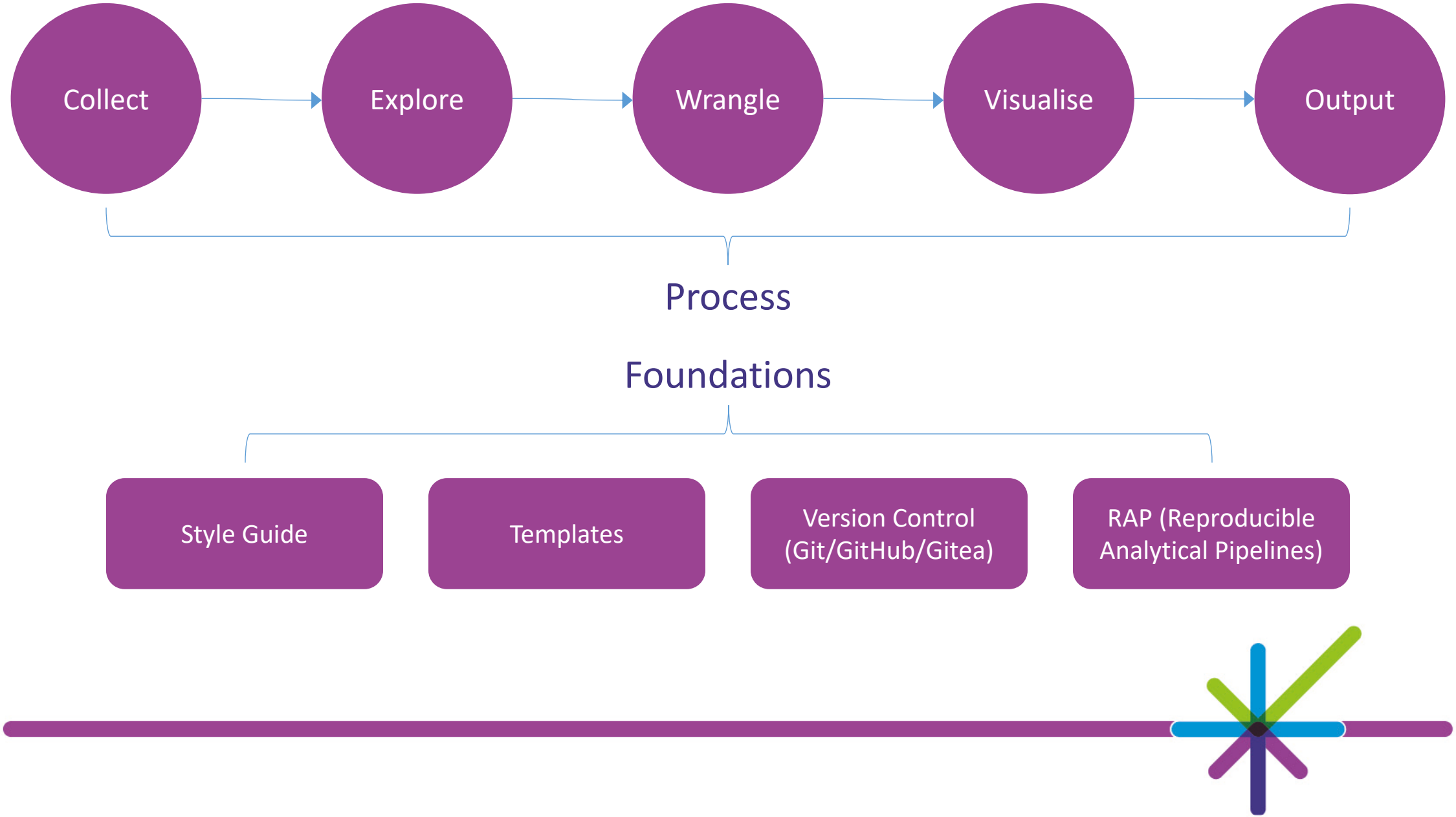
```
install.packages("tidyverse")
library(tidyverse)
```

- output varies by package, warnings (not errors) are normal. An example would be where a function 'masks' that of another R function.

RStudio


File Edit Code View Plots Session Build Debug Profile Tools Help
Sessions
Go to file/function
Addins
Project: (None)
R 3.5.1
Console ~/
R version 3.5.1 (2018-07-02) -- "Feather Spray"
Copyright (C) 2018 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.
Natural language support but running in an English locale
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
>
Environment History Connections
Import Dataset
Grid
Global Environment
Name Type Length Size Value
Environment is empty
Files Plots Packages Help Viewer
New Folder Upload Delete Rename More
Home
Name Size Modified
.Renviron 394 B

Workflow


Collect
Explore
Wrangle
Visualise
Output
Process
Foundations
Style Guide
Templates
Version Control (Git/GitHub/Gitea)
RAP (Reproducible Analytical Pipelines)

Data Flow

Working Directory

- Current: `getwd()`
- Set new: `setwd(<filepath>)`
- We can also use the `here` package, with `here()`
- RStudio also provides options through the user interface for navigating directories.

```
setwd("/home/learnr01/intro_R")
getwd()
here()
```

```
> [1] "/home/learnr01/intro_R"
> [1] "/home/learnr01/intro_R"
```

Read CSV

Package: `readr`

1. Load package, `library(readr)`
2. `read_csv(<filepath>)`
3. Check output

```
library(readr)
borders_csv <-
    read_csv("data/Borders.csv")
View(borders_csv)
```

Read SPSS

Package: `haven`

1. Load package, `library(haven)`
2. `read_sav(<filepath>)`
3. Check output

```
library(haven)
borders_spss <-
    read_sav("data/Borders.sav")
View(borders_spss)
```

Read Web

The packages/functions used will vary depending on the structure of the data. This example uses a CSV so the process to follow is the same as before.

Package: `readr`

1. Load package, `library(readr)`
2. `read_csv(<filepath>)`
3. Check output

```
library(readr)
hospital_codes <- read_csv("
    https://www.opendata.nhs.scot/dataset/[...].csv")
View(hospital_codes)
```

Database (SMRA)

Package: `odbc`

1. Load package, `library(odbc)`
2. Connect:
```
smra_connection <- dbConnect(drv = odbc(),
                             dsn = "SMRA",
                             uid = .rs.askForPassword("SMRA Username:"),
                             pwd = .rs.askForPassword("SMRA Password:"))
```
3. Extract:
```
smr01 <- dbGetQuery(smra_connection,
                    paste("<sql>"))
```
4. Check output

RDS

Read

1. `readRDS(<filepath>)`
2. Check output

Write

1. `saveRDS(<object>, <filepath>)`
2. Check output

```
borders_RDS <-
     readRDS("data/borders.rds")


saveRDS(borders,
     "data/borders.rds")
```

Write CSV

Package: `readr`

1. Load package, `library(readr)`
2. `write_csv(<object>, <filepath>)`
3. Check output

```
library(readr)
write_csv(borders,
          "data/borders.csv")
```

Explore

Mean/Median & Summary

- `mean()` and `median()` are passed arrays of values (usually from a data frame) to return the mean and median value

- `summary()` returns all summary statistics based on a given array (usually from a data frame)

- We access columns using `[[]]` or `$`

```
mean(borders[["LengthOfStay"]])
summary(borders$LengthOfStay)
```

```
> [1] 4.297008
>   Min. 1st Qu. Median    Mean  3rd Qu.   Max
  0.000   0.000   1.000  4.297   4.000   458
```

Frequencies & Crosstabs

- Frequency: `table(<df>$<col>)`
- Crosstab: `table(<df>$<col1>, <df>$<col2>)`
- To add column and row totals, the function `addmargins()` can be used

```
addmargins(table(borders$HospitalCode, borders$Sex))
```

```
          1     2    3    Sum
A210H     1     0    0      1
B102H    56   100    0    156
B103H    50   108    0    158
...
Sum   11947 13340    2  25289
```

Exercise 1

1. Read in "`Borders.csv`" (giving the data frame an appropriate name)
2. What are the **mean, median, and max** values from the `LengthOfStay` variable? Can you do this in one step?
3. Produce a **frequency table** to check the `sex` variable, save this as an object with an appropriate name
4. Export the frequency table as a **csv** file

Wrangle

Tidyverse

- is a suite of packages for data exploration, manipulation, and visualisation; it's best practice to utilise these where possible;

- functions have a consistent format, i.e. `function(data, task)`;

- gives us the package `dplyr`

dplyr

`library(dplyr)`

- is a grammar of data manipulation, providing a set of "*verbs*" to help solve most data manipulation challenges

- `filter()`
- `mutate()`
- `arrange()`
- `select()`
- `group_by()`
- `summarise()`
- `count()`
- `rename()`
- `recode()`

Pipe Operator

- `%>%` is used to link functions together, passing the previous to the next
- Using the pipe operator makes R code more readable and prevents extensive parenthesis building up with multiple function calls
- Readable as "and then"
- Shortcut: (`ctrl` + `shift` + `M`)

```
arrange(filter(borders,
     HospitalCode == "B102H"), Dateofbirth)
```

```
borders %>%
     filter(HospitalCode == "B102H") %>%
     arrange(Dateofbirth)
```

Filter

`filter(<data>, <logical expression>)`

- picks cases based on their values

```
# all cases with E12 specialty
borders %>%
     filter(Specialty == "E12")

# B120H cases more than 10 days
borders %>%
     filter(HospitalCode ==
                "B120H" &
            LengthOfStay > 10)
```

Mutate

```
mutate(<data>, <new_col> =
<expression>)
```

- adds new variables that are functions of existing variables

```
# length of stay divided by 2
borders %>%
    mutate(los_div2 =
        LengthOfStay / 2)
```

Arrange

`arrange(<data>, <variables>)`

- changes the ordering of rows

- `desc()` to sort in descending order

```
# sort by Hospital Code
borders %>%
    arrange(HospitalCode)
```

Select

`select(<data>, <expression>)`

- picks variables based on their names
- prepend "–" to a variable to remove

```
# remove Postcode
borders %>%
    select(-Postcode)
```

Exercise 2

1. Read in "`Borders.csv`" (giving the data frame an appropriate name)
2. What patients had a `LengthOfStay` of between 2 and 10 days?
3. Which of these patients were under `Specialty` E12 or C8?
4. Remove all columns other than `URI`, `Specialty`, and `LengthOfStay`
5. Store this data in an appropriately named data frame ordered by `LengthOfStay`

Group By

```
group_by(<data>,
<col_name>)
```

- groups variables to perform operations

- This doesn't visibly affect the data, but we can see the output shows the grouping. We can then perform other operations on the groups.

```
# sort by Hospital Code
borders %>%
    group_by(HospitalCode)
```

```
> ...
# Groups: HospitalCode [48]
...
```

Summarise

```
summarise(<data>, <name> = <expression>)
```

- reduced multiple values down to a single summary

```
# avg length of stay by hospital
borders %>%
    group_by(HospitalCode) %>%
    summarise(mean_los =
        mean(LengthOfStay))
```

Count

`count(<data>, <variables>)`

- useful for running frequencies, this calls group_by() and produces counts for a specified column

- sort by descending order using `sort = TRUE` as an argument

```
# counts of specialty
borders %>%
     count(Specialty, sort = TRUE)
```

Exercise 3

1. Read in "`Borders.csv`" (giving the data frame an appropriate name)
2. What is the earliest admission date by specialty?
3. What is the latest discharge date by specialty?
4. What are the number of admissions per hospital, per specialty?

Rename

```
rename(<data>, <new_name> = <existing_name>)
```

- renaming specific columns in a data frame

```
# rename Date of Birth column
borders %>%
    rename(date_of_birth = Dateofbirth)
```

Recode

```
mutate(<col> = recode(<col>,
<existing_code> =
<new_code>))
```

- for changing values within a column
- works best when used with `mutate()`

```
# change hospital code
borders %>%
    mutate(HospitalCode =
        recode(HospitalCode,
            "B120V" = "B120H"))
```

Exercise 4

1. Select the `URI`, `Specialty`, and `Dateofbirth` columns from the borders data and save to a new data frame.
2. Arrange this new data in ascending order by `Specialty` and check the results.
3. Extract the records with a missing `Dateofbirth` (hint: `?filter`)
4. Finally, recode `Specialty` "A1" to be "General Medicine"

Joining Tables

```
<type>_join(<data1>,
<data2>, by =
<common_variable>)
```

- for merging data by matching together using common variable(s)

```
# merge baby data
baby5 <- read_csv("data/Baby5.csv")
baby6 <- read_csv("data/Baby6.csv")
baby_joined %>%
     left_join(baby5, baby6, by =
          c("FAMILYID", "DOB"))
```

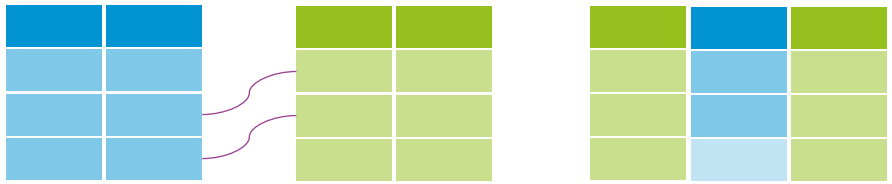
Join Types

`left_join()`

`all rows from the 'left', any matches from the 'right'`

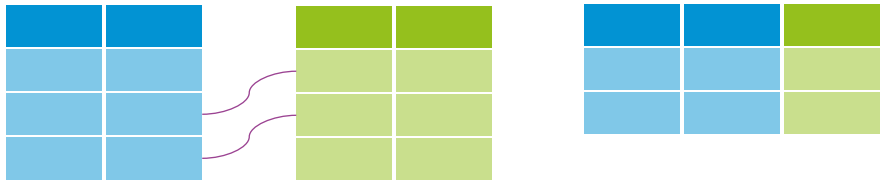
`right_join()`

`all rows from the 'right', any matches from the 'left'`



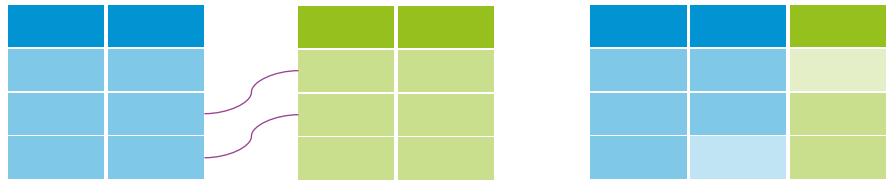
`inner_join()`

`rows of matched fields from data sets`



`full_join()`

`all rows, na for non-matched fields`



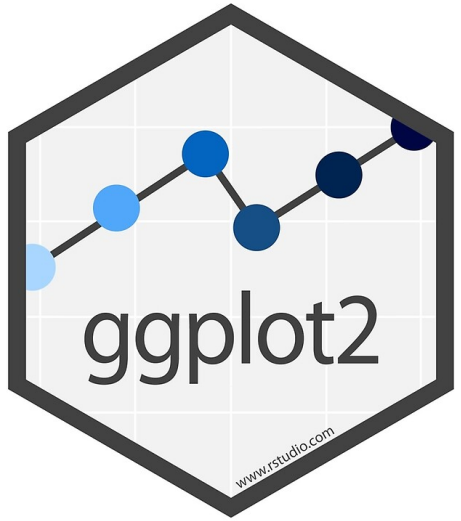
Visualise

ggplot2

`library(ggplot2)`

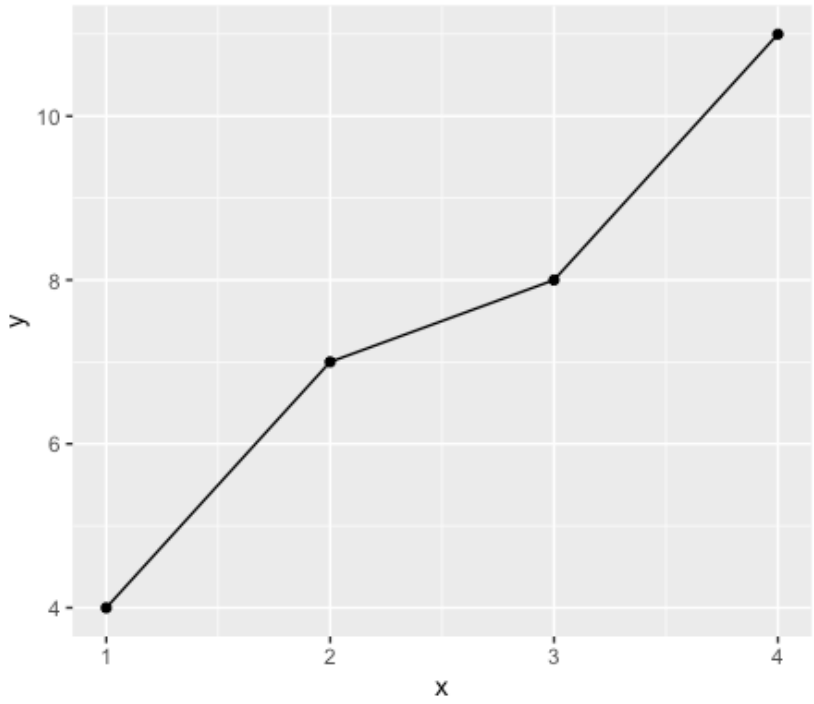
- is a system for creating graphics to visualise data

- Begin with a call to `ggplot()`, supplying the data and aesthetic mappings using `aes()`
- Then add `layers`, `scales`, `coords`, and `facets` with `+`



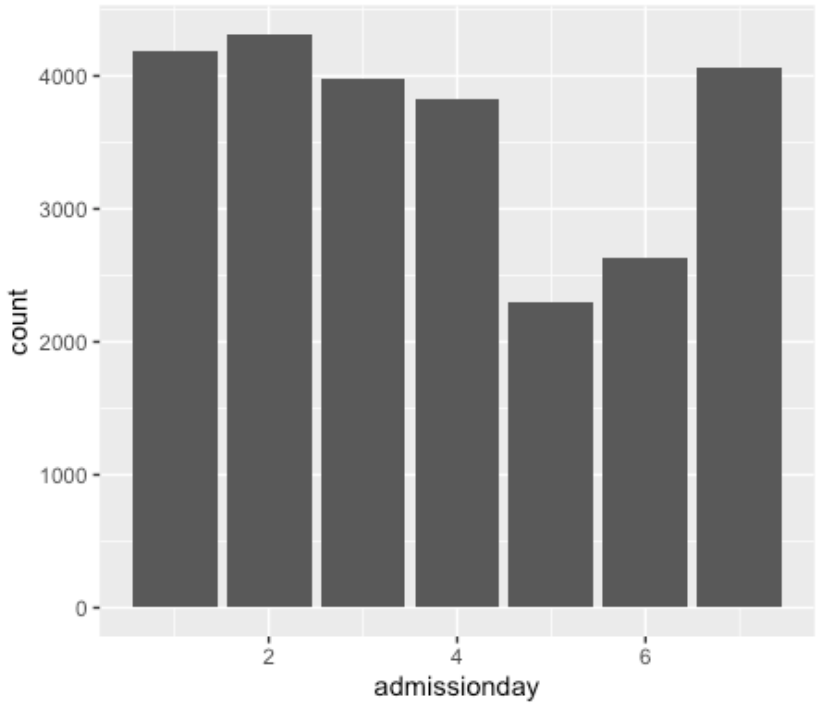
Line Graph

```
# Define data
data <- data.frame(
          x = c(1, 3, 2, 4),
          y = c(4, 8, 7, 11))


# Plot the data
line_plot <- ggplot(data,
                    aes(x, y)) +
     geom_line() +
     geom_point()
```



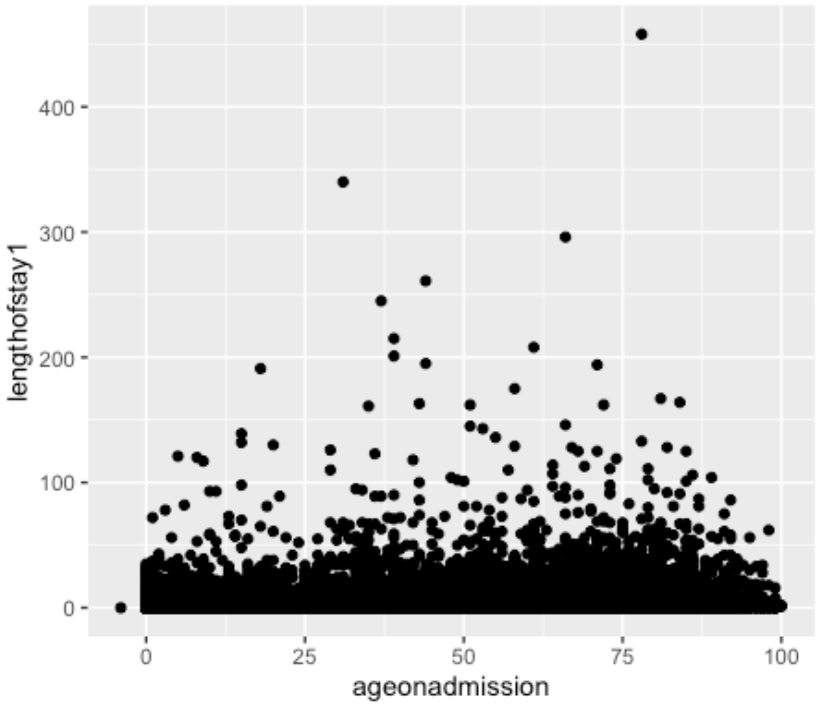
Bar Plot

```
# Define data
data <- read_csv("
 data/Borders.csv")


# Plot the data
bar_plot <- ggplot(data) +
     geom_bar(aes(x =
                  admissionday))
```



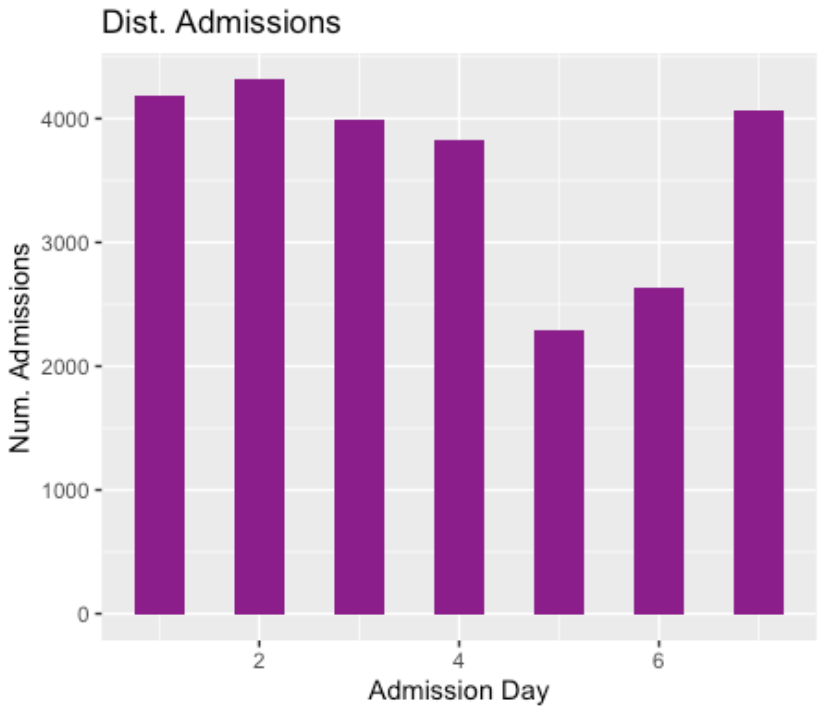
Scatter Plot

```
# Define data
data <- read_csv("
 data/BORDERS (inc Age).csv")


# Plot the data
scatter_plot <-
 ggplot(data, aes(x =
     ageonadmission,
     y = lengthofstay1)) +
  geom_point()
```



Customisation

```
# bar_plot colour and width
bar_plot <- ggplot(data) +
     geom_bar(aes(x =
      admissionday),
      fill = "magenta4",
      width = 0.5) +
# add titles
     xlab("Admission Day") +
     ylab("Num. Admissions") +
     ggtitle("Dist. Admissions")
```



Exercise 5

1. Read in "`Borders.csv`" (giving the data frame an appropriate name)
2. Filter data to show only records from `HospitalCode` "B109H"
3. Create a histogram for patient's `LengthOfStay`, check the output
4. Add axis labels and a title to your histogram
5. Save the plot (as a PNG) to the plots folder in your working directory

Output

rmarkdown

- allows for the production of fully reproducible documents, with R (and other language) ‘chunks’ included

- supports many static and dynamic outputs, including PDF, MS Word, HTML, books, presentations, etc.

- is used in RAP publications, infographics, and more within PHS

shiny

- is for building interactive web apps through R;
- it provides an interactive approach to sharing data and analyses and can be hosted online or embedded in RMarkdown documents
- is used for some PHS publications and in development for more

Review

Getting Help

- Vignettes (Help) / `` `?<function>` ``
- Google / Stack Overflow
  tag queries "[r]"
- R User Group Teams – Technical Queries
- Transforming Publishing

Next Steps

- Embed your new knowledge and skills!
- Expand your knowledge and skills with related technologies (e.g. git)
- Take R Further - look at other training opportunities (`phsmethods`)