Introduction to R

Session 1 – Introduction

Statistical Consulting Centre

consulting@stat.auckland.ac.nz
The Department of Statistics
The University of Auckland

19 July, 2017

Wednesday

Each session comprises two parts: lecture and practice.

Session	Time	Session
1	09:00am - 10:30am	Introduction
	10:30am - 10:50am	Break
2	10:50am - 01:00pm	Data manipulation
	01:00pm - 02:00pm	Lunch break
3	02:00pm - 03:00pm	Data exploration
	03:00pm - 03:20pm	Break
4	03:20pm - 04:30pm	Data Wrangling (with dplyr and tidyr)

Thursday

Each session comprises two parts: lecture and practice.

Session	Time	Session
1	09:00am - 10:30am	Graphics
	10:30am - 10:50am	Break
2	10:50am - 01:00pm	Advanced Graphics (ggplot2)
	01:00pm - 02:00pm	Lunch break
3	02:00pm - 03:00pm	Simple analysis
	03:00pm - 03:20pm	Break
4	03:20pm - 04:30pm	R Markdown

R and UoA's Department of Statistics

- R was initially written by Robert Gentleman and Ross Ihaka *R & R* of the **Department of Statistics, University of Auckland**.
- Three members of the *R Development Core Team* are in UoA's Department of Statistics.

THE UNIVERSITY OF
AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

SCIENCE
DEPARTMENT OF STATISTICS

R and UoA's Department of Statistics

Ross Ihaka and Robert Gentleman

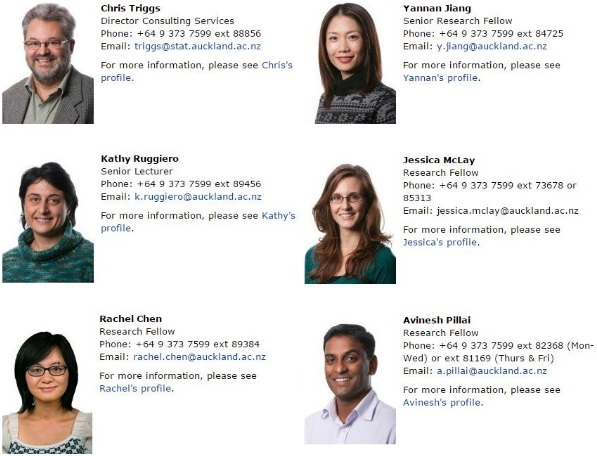
R and UoA's Department of Statistics

Paul Murrell and Thomas Lumley

R and UoA's Department of Statistics

What does this mean?

If you want to learn R, you are talking to the right people!



Chris Triggs
Director Consulting Services
Phone: +64 9 373 7599 ext 88856
Email: triggs@stat.auckland.ac.nz

For more information, please see Chris's profile.

Yannan Jiang
Senior Research Fellow
Phone: +64 9 373 7599 ext 84725
Email: y.jiang@auckland.ac.nz

For more information, please see Yannan's profile.

Kathy Ruggiero
Senior Lecturer
Phone: +64 9 373 7599 ext 89456
Email: k.ruggiero@auckland.ac.nz

For more information, please see Kathy's profile.

Jessica McLay
Research Fellow
Phone: +64 9 373 7599 ext 73678 or 85313
Email: jessica.mclay@auckland.ac.nz

For more information, please see Jessica's profile.

Rachel Chen
Research Fellow
Phone: +64 9 373 7599 ext 89384
Email: rachel.chen@auckland.ac.nz

For more information, please see Rachel's profile.

Avinesh Pillai
Research Fellow
Phone: +64 9 373 7599 ext 82368 (Mon-Wed) or ext 81169 (Thurs & Fri)
Email: a.pillai@auckland.ac.nz

For more information, please see Avinesh's profile.

Statistical Consulting Centre

The School of Biological Sciences (SBS) has a contract with the Statistical Consulting Centre (SCC) to provide statistical support to staff and postgraduate students of SBS.

`https://www.stat.auckland.ac.nz/consulting/meet-us/any1_uoa/appointment_scheduler_kevin`

What is 'R'?

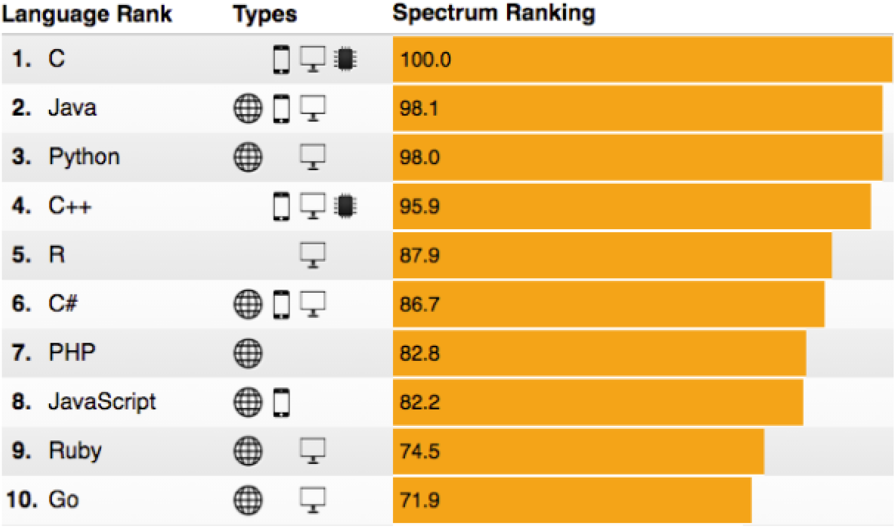
What does this mean?

R is a free software environment for statistical computing and graphics"

Key words:

- FREE!
- Statistical computing
- Graphics (much more flexible than SAS, SPSS, JMP, etc.)
- Support from communities of different fields, i.e. R packages. https://cran.r-project.org/web/views/.
- Even Microsoft is in it: Microsoft R Open. https://mran.microsoft.com/open/.
- https://www.slideshare.net/RevolutionAnalytics/r-then-and-now

What is R? (IEEE Spectrum's ranking 2016)



Language Rank	Types	Spectrum Ranking
1. C	📱 🖥 ▪	100.0
2. Java	🌐 📱 🖥	98.1
3. Python	🌐 🖥	98.0
4. C++	📱 🖥 ▪	95.9
5. R	🖥	87.9
6. C#	🌐 📱 🖥	86.7
7. PHP	🌐	82.8
8. JavaScript	🌐 📱	82.2
9. Ruby	🌐 🖥	74.5
10. Go	🌐 🖥	71.9

What is 'R'?

What does this mean?

R is a free software environment for statistical computing and graphics"

R and the biological sciences:

- Many *applications of statistical methods to biological datasets are implemented in R*
- These R *packages* are publically available on the web for immediate download and use.
- Bioconductor) https://www.bioconductor.org/.
- E.g. Next Generation Sequencing, Genomics.

How to download and install R

1. Go to the CRAN (Comprehensive R Archive Network) `cran.stat.auckland.ac.nz`.
2. Download the relevant version for Linux/Mac/Windows.
    - We will only look at R in the Windows environment today.
3. Install it on your computer (for Windows only):
    - Choose "Yes (customized startup)" in Startup options.
    - Choose "SDI (separate windows) "in Display mode.
    - Choose "HTML help" in Help .

Using the R editor

- The R GUI is not menu driven.
- Commands can be typed at the console.
    - OK for simple calculations requiring few lines of code
    - Painful for anything more!
- We *strongly* recommend using an R editor
    - Great for reproducible analyses and research.
    - Best editor for you depends on whether you are a(n)...
        1. Beginner: Built-in R editor,
        2. Advanced user: Rstudio, Tinn-R, Notepad++, and many others.
        3. R geek: Emacs

Rstudio

- integrated development environment, or IDE, for R programming.
- Download and install it from `http://www.rstudio.com/download`.

Reasons to use it

- Writing better R code.
- Producing reports (R markdown).
- Producing interactive reports/tools (Shiny).
- Developing R packages.

Using R as a calculator

```r
1 + 2
```

```
## [1] 3
```

```r
1 + 3^2
```

```
## [1] 10
```

```r
log(15) - sqrt(3.4)
```

```
## [1] 0.8641413
```

```r
pnorm(1.96)
```

```
## [1] 0.9750021
```

Variable assignment

- `<-` is the "assign to" operator, made up of `<` and `-` without a space.
- E.g., `x <- 2` is read as "The value 2 is assigned to the object `x`".

```
x <- 2
y <- 3
x^2 - 3 * y + 5
```

```
## [1] 0
```

- `<-` has a direction, from right to left, `x <- 2` means assigning 2 to `x`,

Variable assignment

- `->` operates from left to right, assigning `x` to 2.
  - 2 is a real value so you can not do that.

```
2 <- x
```

```
## Error in 2 <- x: invalid (do_set) left-hand side to assignm
```

- `=` has no direction and can be confusing sometimes.
- It is good programming practice to use `<-`.
- The most important thing is to keep consistent.

Getting help

- Google!!!!
  e.g. How to calculate the mean in `R`? The search results tell you that the function `mean()` would be helpful.
- Quick-R: `http://www.statmethods.net/`
- R-bloggers: `https://www.r-bloggers.com/`

Getting help

- `?`

  e.g. `?mean` brings up the help file for this function. It will tell you (almost) everything you need to know to use `mean()`.
- `??`

  e.g. `??mean` searches for everything related to mean in your computer.
- `RSiteSearch(" ")`

  Searches everything on CRAN as well as your computer.

Data, files, statisticians and R

- Statisticians prefer (read: ***want***) rectangular data files
    - Each case in its own row
    - Data collected on each variable in its own column
    - Variable names in the first row of each column
    - No blanks, e.g. fill with NA, *, 99999, anything but a blank!
- R likes (read: ***needs***) this too!
- R prefers to read data files in Comma Separated Value (CSV) format.
- This does not mean R only reads files stored in csv format.

Getting data into R

Try your best to save your data in a `csv` or `txt` format.

- Most datasets are saved in an Excel spreadsheet.
- Do as much data cleaning as you can in Excel. No comments, no formatting, no colours, no fancy fonts.
- Convert it into `csv` by clicking on `Save As`. Change the `Save as type` from `xlsx` or `xls` into `CSV (Comma Delimited)`.
- `CSV` can have one worksheet only. If you have multiple worksheets, it saves the active worksheet.

Read and Check

- Always set a working directory using `setwd()`, this can be a directory where you store the data and/or outputing the results.
- Use `read.csv` to read a CSV file into `R`.
- `dim()`: Returns the number of observations (rows) and variables (columns).
- `head()`/`tail()`: Returns the first/last few rows of a data set.
- `str()`: Returns the structure of the dataset, e.g., dimension, column names, type of data object, first few values of each variable.
- `names()`: Returns the names of the variables contained in a dataset.

Patient.df

Seven variables:

- ID: Identifcation Number.
- Age: in years
- Sex: 0 = Female, 1 = Male
- Race: 1 = Caucasian, 2 = African, 3 = Other
- Weight: in pounds
- Height: in inches
- Smoke: 1 = Yes, 2 = No

Cholesterol.df

Serum Cholesterol level, mg/100ml, measured on:

- Day1
- Day5
- Day10

Reading data into R

```r
setwd("your working directory")
Patient.df <- read.csv("Patient.csv")
head(Patient.df)
```

```
##   Patient.ID Age    Sex Race Weight Height Smoke
## 1          3  21   Male    1  179.5   70.4    NA
## 2          4  32 Female    1     NA   63.9    NA
## 3          9  48 Female    1  149.7   61.8     2
## 4         10  35   Male    1  203.5   69.8    NA
## 5         11  48   Male    1  155.3     NA     2
## 6         19  44   Male    2  189.6   70.2     1
```

names(Patient.df)

```r
# Names of the variables
names(Patient.df)
```

```
## [1] "Patient.ID" "Age"        "Sex"
## [4] "Race"       "Weight"     "Height"
## [7] "Smoke"
```

- Anything following the # symbol is treated as a comment and ignored by R.
- Writing comments is a very good habit to develop!

dim() and str()

```
dim(Patient.df)
```

```
## [1] 17030     7
```

```
str(Patient.df)
```

```
## 'data.frame':    17030 obs. of  7 variables:
##  $ Patient.ID: int  3 4 9 10 11 19 34 44 45 48 ...
##  $ Age       : int  21 32 48 35 48 44 42 24 67 56 ...
##  $ Sex       : Factor w/ 2 levels "Female","Male": 2 1 1 2
##  $ Race      : int  1 1 1 1 1 2 2 1 2 1 ...
##  $ Weight    : num  180 NA 150 204 155 ...
##  $ Height    : num  70.4 63.9 61.8 69.8 NA 70.2 62.6 64.4 6
##  $ Smoke     : int  NA NA 2 NA 2 1 1 1 NA 2 ...
```

Note that **character** vector, Sex, is automatically converted to **factor**.

`factor`

What is a factor?

A variable which takes either qualitative values, ordinal values or a discrete set of quantitative values. The values of a factor are called its levels*.*

Examples of factors:

- `Gender` with 2 *qualitative* levels: `Male` and `Female`.
- `Education` with 6 *ordinal* levels: `None` < `"Primary compl` < `Incpl secondary` < `Secondary compl` < `Incpl university` < `University degree`.
- `Income` has 9 *quantitative* levels when the mid-values of the income ranges are used: 5000, 12500, 17500, 22500, 27500, 35000, 45000, 60000 and 85000.

factor

- R stores two *additional* pieces of information for each factor: (1) the unique set of levels and (2) an integer value, assigned by R, for each unique level.
- The integer values are assigned to factor levels so that they have an order associated with them.
- By default, the unique levels are assigned the values 1, 2,. . . , according to ascending alphabetical order. This is not always appropriate!

```r
typeof(Patient.df$Sex)
```

```
## [1] "integer"
```

```r
levels(Patient.df$Sex)
```

```
## [1] "Female" "Male"
```

Reading data into R

```r
Patient.df <- read.csv("Patient.csv",
                       stringsAsFactors = FALSE)
str(Patient.df)
```

```
## 'data.frame':    17030 obs. of  7 variables:
##  $ Patient.ID: int  3 4 9 10 11 19 34 44 45 48 ...
##  $ Age       : int  21 32 48 35 48 44 42 24 67 56 ...
##  $ Sex       : chr  "Male" "Female" "Female" "Male" ...
##  $ Race      : int  1 1 1 1 1 2 2 1 2 1 ...
##  $ Weight    : num  180 NA 150 204 155 ...
##  $ Height    : num  70.4 63.9 61.8 69.8 NA 70.2 62.6 64.4 6
##  $ Smoke     : int  NA NA 2 NA 2 1 1 1 NA 2 ...
```

`stringsAsFactors`

`stringsAsFactors` argument is set to `FALSE`, so **character** vectors are not converted to **factors**.

Data Type

Everything in R is a vector (but some have only one element).

1. Numeric (same as double), or integer. E.g. Patient.ID, Age, Race, Weight, Height and Smoke
2. String (same as character). E.g. Sex
3. Logical: TRUE or FALSE, e.g.

```
1 == 1
```

```
## [1] TRUE
```

```
2 <= 0
```

```
## [1] FALSE
```

```
3 != 2
```

```
## [1] TRUE
```

Descriptive statistics

Calculate the mean of `Height`:

```
mean(Height)
```

```
## Error in mean(Height): object 'Height' not found
```

You must tell `R` that `Height` is a variable (column) *within* `Patient.df`, i.e.

```
mean(Patient.df$Height)
```

```
## [1] NA
```

You must also tell `R` how to deal with missing values: remove them before calculating the mean, i.e.

```
mean(Patient.df$Height, na.rm = TRUE)
```

```
## [1] 65.43787
```

table of counts

```
# One-way table of counts

table(Patient.df$Sex)
```

```
##
## Female   Male
##   9077   7953
```

table of proportions

```r
# Total count
total <- sum(table(Patient.df$Sex))
total
```

```
## [1] 17030
```

```r
# Proportions of total
table(Patient.df$Sex)/total
```

```
##
##    Female      Male
## 0.5330006 0.4669994
```

One-way tables with less typing

Tired of typing `Patient.df$` over and over again? Use the `with` function.

```
Sex.table <- with(Patient.df, table(Sex))
Sex.table
```

```
## Sex
## Female   Male
##   9077   7953
```

```
total <- sum(Sex.table)
Sex.table/total
```

```
## Sex
##    Female      Male
## 0.5330006 0.4669994
```

One-way tables with less typing

```r
# Convert to percentages
Sex.pct <- 100 * Sex.table/total
Sex.pct
```

```
## Sex
##   Female     Male
## 53.30006 46.69994
```

```r
# Round to 1 decimal place
round(Sex.pct, 1)
```

```
## Sex
## Female   Male
##   53.3   46.7
```

Two-way frequency tables

```r
Sex.Race.tab <- with(Patient.df, table(Sex, Race))
Sex.Race.tab
```

```
##         Race
## Sex         1    2    3
##   Female 6114 2687  274
##   Male   5498 2173  279
```

Two-way frequency tables

```
# Calculate proportion with respect to 'margin'
# total margin = 1 (row total) or 2 (column total)
perc.Sex.Race <- prop.table(Sex.Race.tab, margin = 2)
perc.Sex.Race
```

```
##         Race
## Sex              1         2         3
##   Female 0.5265243 0.5528807 0.4954792
##   Male   0.4734757 0.4471193 0.5045208
```

Two-way frequency tables

```
# Tabulate as percentages
round(100 * perc.Sex.Race, 1)
```

```
##          Race
## Sex          1    2    3
##   Female 52.7 55.3 49.5
##   Male   47.3 44.7 50.5
```

Summary

- Quick introduction to R
- Getting data into R
- Frequency tables