GETTING STARTED WITH R (PART 1)

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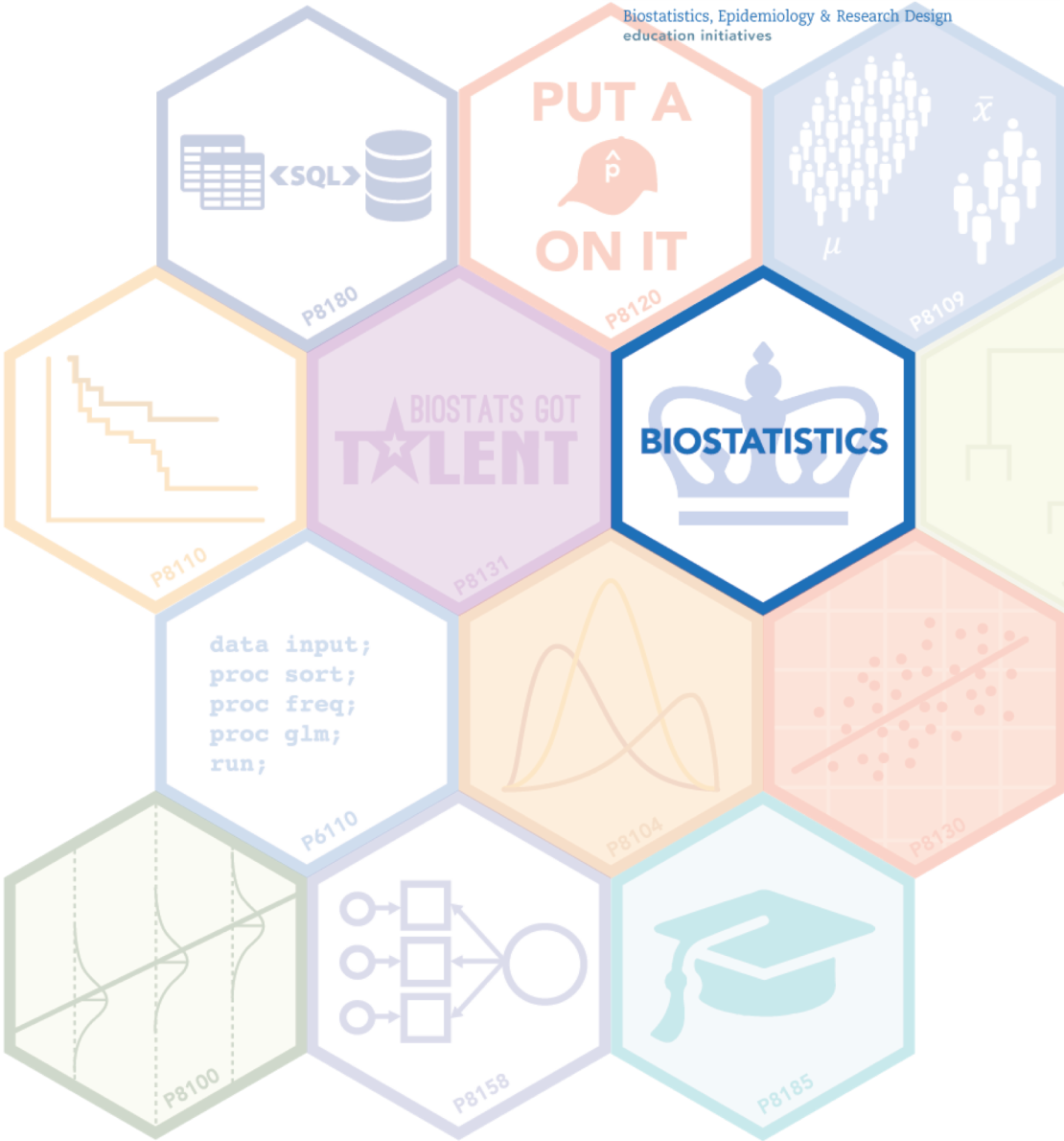
November 19, 2018



About Me

- Assistant Professor, Dpt. Of Biostatistics
- Teaching:
  - ReMA Quantitative Foundations (Fall, MPH Core)
  - Analysis of Categorical Data (Spring)
  - Grant Writing (Summer, CSRI)
- Research: Application of statistics to mental health, psychiatry, and health policy.
  - Diagnosis and Treatment of Complicated Grief
  - Impact of Medical Marijuana Laws on drug use
  - Impact of the Affordable Care Act among those with substance use disorders.
  - Opioid Center

Outline

- Motivating Example
- Overview of R and R Studio
- Importing Data
  - Read CSV files using readr package
- Examining Data Attributes
  - Data structure, type and dimensionality
- Manipulating Data (Data Wrangling)
  - Select, Filter, Mutate, Arrange
  - Stacking and Merging

Application

- A study was conducted to identify risk factors for low infant birth weight using data from 189 live births at Bay State Medical Center in Massachusetts. Low birthweight was defined as a <2500grams.

- We have one data set for low birthweight-babies (lowbwt_LOW.csv) and another for normal birthweight babies (lowbwt_Normal.csv).
  - id = ID number of infant
  - smoke = smoking during pregnancy = 1 if yes; 0 if no
  - age = mother's age in years

- We have a separate dataset with data on # of visits (lowbwt_ADMIN.csv).
  - id = ID number of infant
  - visits = number of physician visits during 1st trimester = 0 if none; 1 if one; 2 if two or more

Why R?

- R is a FREE, open-source software used for statistical computing and graphics
- Can be frustrating: a steep learning curve
- Installing R: http://cran.r-project.org/ (for Windows, Mac, Linux)
- Some online resources:

https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf

http://www.mayin.org/ajayshah/KB/R/index.html

R.D., Peng Exploratory Data Analysis With R: https://leanpub.com/exdata

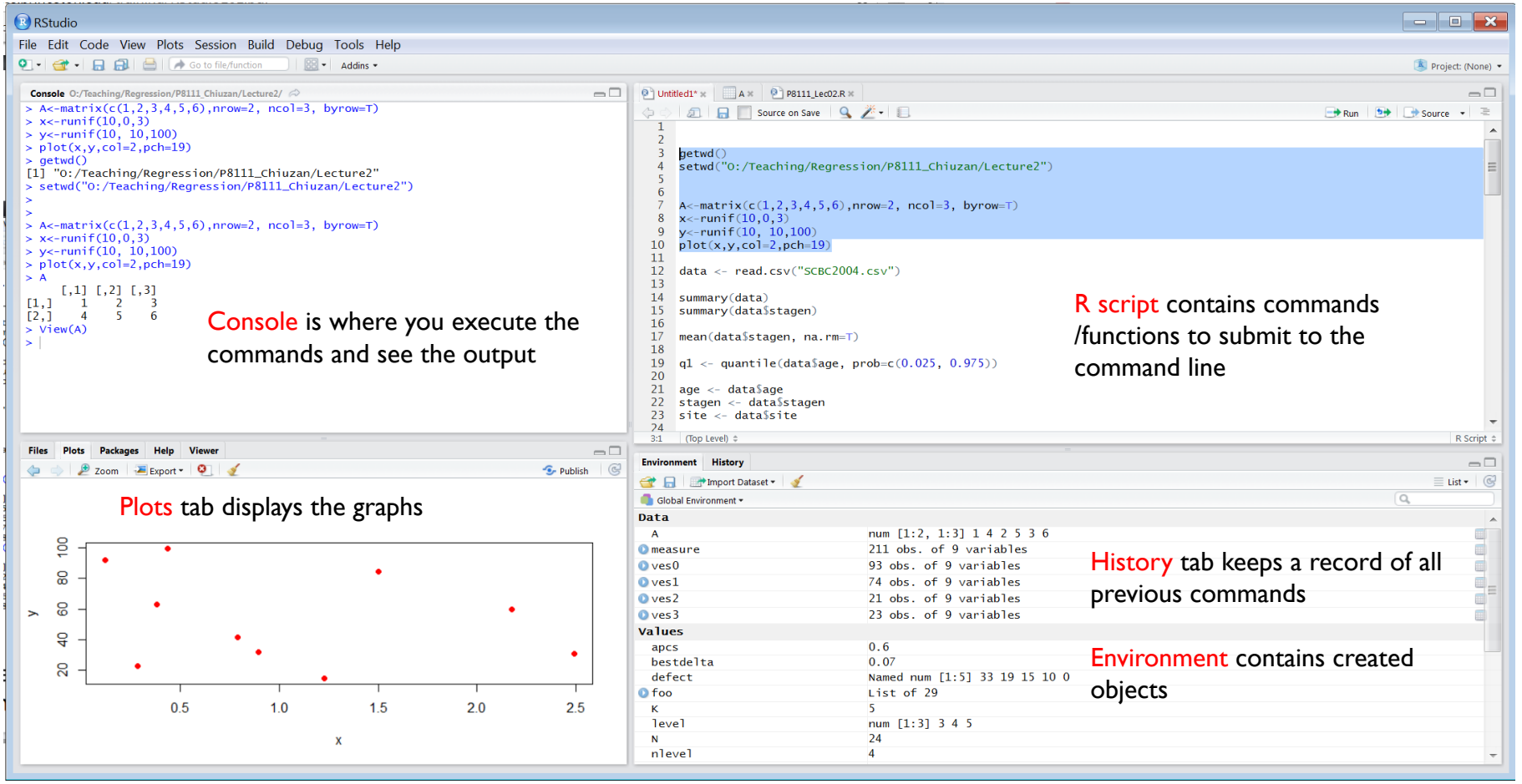
What is RStudio?

- User-friendly development environment for R
- Installing RStudio: http://www.rstudio.com/
- Some online resources:

  http://dss.princeton.edu/training/

  http://libguides.princeton.edu/dss

RStudio Windows

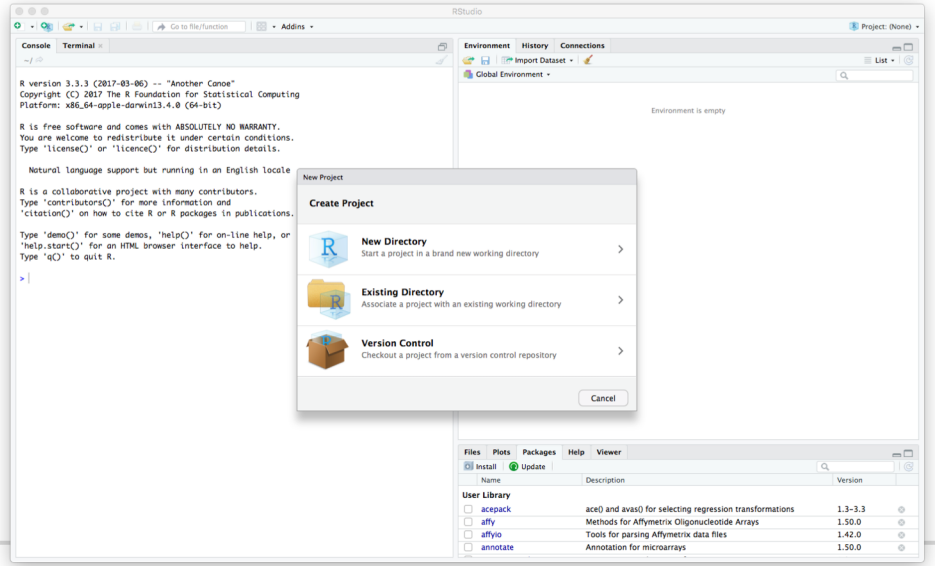


R Workflow

- For every new project, do the following:
  - Create a directory with a reasonable name and path (e.g. ~/Documents/RCourse_Part1/)
- Put an R Project in the directory
  - Create an R Project using File > New Project > Existing Directory and specifying the directory you just created.
- Keep everything related to the analysis – datasets, scripts, reports, output – in there!

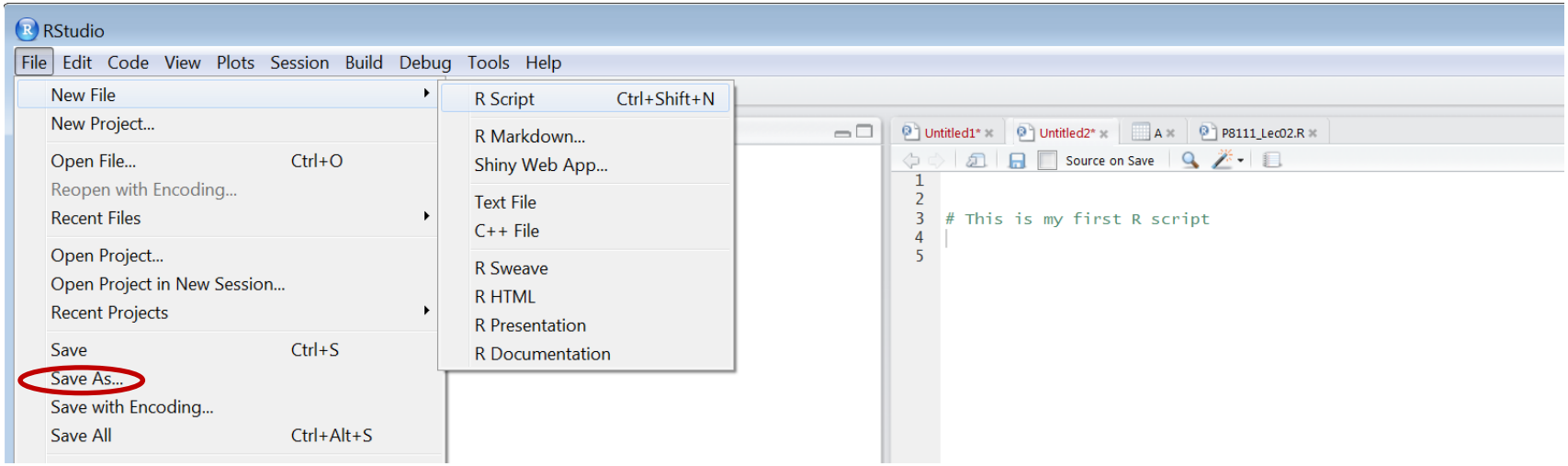
Let's try it!

- Create a directory with a reasonable name and path (e.g. ~/Documents/RCourse_Part1/)
- Create an R Project using File > New Project > Existing Directory and specifying the directory you just created.
- Move the three datasets for this assignment to that directory!



RStudio - Essentials

- How to create and save an R script



- Type R commands and run them
  - Note that you can execute commands (e.g. the line with the cursor or highlighted code) in the console from a script using Command+Enter (Mac) or Ctrl+Enter (Windows).

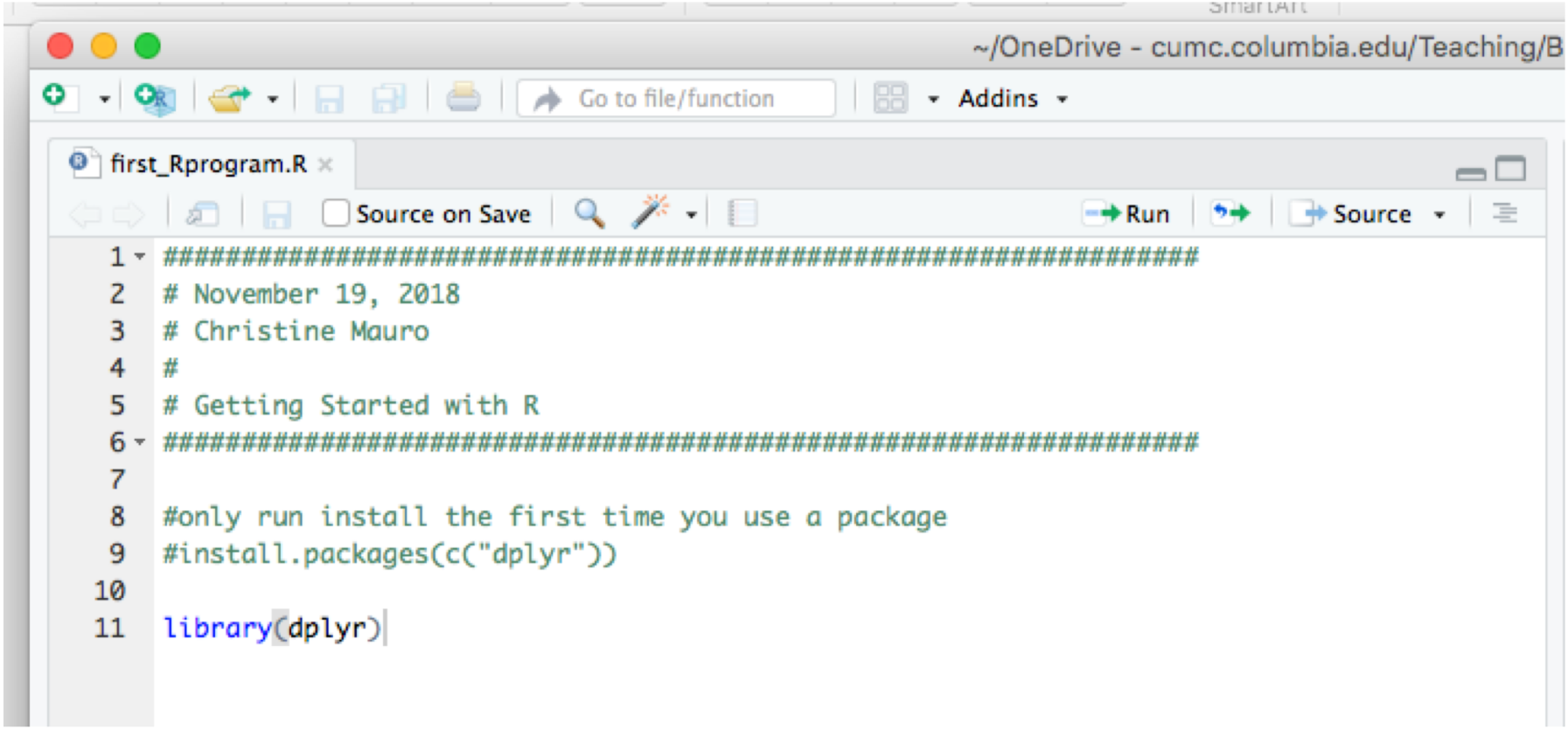
R Packages

- Packages are collections of **R** functions, data, and compiled code in a well-defined format.
- The directory where packages are stored is called the library.
- **R** comes with a standard set of packages. Others are available for download and installation.
  - Only need to install package one time.
- Once installed, they have to be loaded into the session to be used.
  - Once installed, you need to load package every time you use R!

Let's try it: Packages

- Start a new R script. Save the script so you have the code for later.
- Type a comment at the beginning of your program.
- Install and Load dplyr package:
  - install.packages(c("dplyr"))
    - This installs dplyr if you haven't used it before
    - Type y in console to any questions about installing dependencies!
  - library(dplyr)
    - This loads the dplyr library – repeat every time you open R!

Let's try it: Packages



Why dplyr?

- Most of what we are going to learn today can be done in base R using other code.
- We are using dplyr which is a part of the tidyverse.
- Why the tidyverse?
  - The tidyverse is a coherent system of packages for data manipulation, exploration and visualization that share a common design philosophy.
  - mostly developed by Hadley Wickham.
  - Tidyverse packages are intended to make statisticians and data scientists more productive by guiding them through workflows that facilitate communication, and result in reproducible work products.

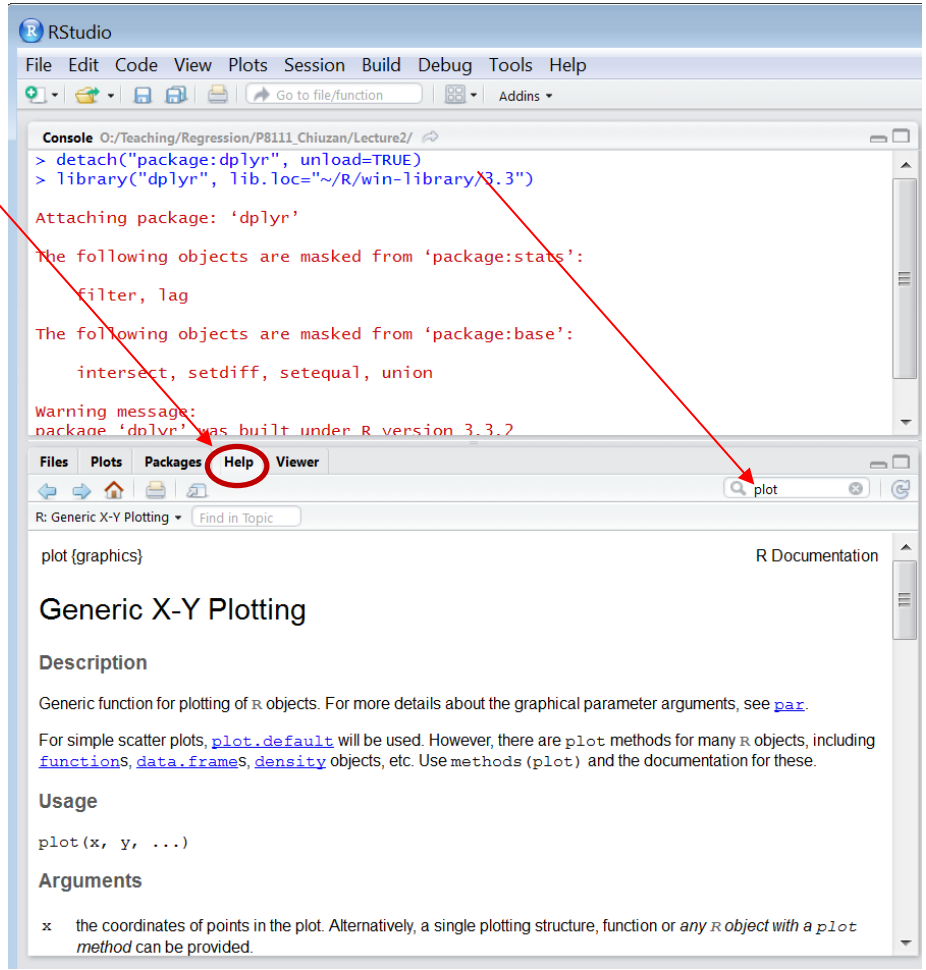
R Help

- Use tab 'Help' to look for a topic

  E.g., look for function 'plot'

- Tab 'Help' has a history of the most recent topics you inquired about

- Or just type help(plot) in the console
  - Or ?plot



R Syntax

- R is an object-oriented programming language
  - If you want to save results, need to store them in an object.
- R is *case sensitive*: 'A' and 'a' are different symbols
- Commands are separated either by (;) or by a new line
  - Commands can be grouped together (in functions) by { and }
- Comments can be inserted almost anywhere
  - Starting with a '#', everything to the end of the line is a comment
  - Use comments to document your code: for YOU and OTHERS!!

R Errors

- Syntax errors - generated by misspelling or forgetting to close a bracket
- Semantic errors – correct code, but the outcome is NOT what you expected
- Logic errors – worst case! The mistake is not in the code, but the logic of execution

IMPORTING DATA

Reading Data into R

- First, you need to save your data onto your computer
  - Excel, SPSS, or some other type of file
  - Datasets need to be in the "*PROJECT*" folder we created earlier
- Some useful tips:
  - Reserve the first row for headers (variable/column names)
  - First column is used to identify sampling units
  - Avoid named or fields with blank spaces; put a '_' instead.
  - Delete comments from Excel
  - Missing values should be noted with ' .' or 'NA'
  - Avoid symbols such as: ' #, ?, *, <, /, -, }'

Reading Data into R

- Read CSV files – if you have a '.csv' file (comma separated file)

  read_csv("./Data.csv") You need to load the readr package first!

first_Rprogram.R*

Source on Save

```
1  ######################################################################
2  # November 19, 2018
3  # Christine Mauro
4  #
5  # Getting Started with R
6  ######################################################################
7
8  #only run install the first time you use a package
9  #install.packages(c("dplyr", "tidyr"))
10
11
12 library(dplyr)
13 library(readr)
14
15 lowbwt_data = read_csv(file = "./lowbwt_Low.csv")
16 names(lowbwt_data)
17 lowbwt_data
18
```

DATA ATTRIBUTES

Data Description

Before running any analysis, make sure you examine your data!!!

Number of variables and their types, number of observations, dates of creation, etc.

- Check variable names

  R: names(mydata)

- Check data dimensions: (#rows) by (# columns)
- Look at the 'top' and 'bottom' of the data

  R: head(mydata), tail(mydata)

- Check "structure"

  R: str(mydata)

- Check for missing data

  R: anyNA(mydata)

Let's try it!

```
18
19  #Viewing data
20  View(lowbwt_data)
21  head(lowbwt_data)
22  tail(lowbwt_data)
23  str(lowbwt_data)
24  anyNA(lowbwt_data)
25
```

```
> head(lowbwt_data)
# A tibble: 6 x 3
     id smoke   age
  <int> <int> <int>
1    31     0    20
2    76     0    20
3    44     1    20
4    68     1    17
5    23     1    19
6    45     1    17
> tail(lowbwt_data)
# A tibble: 6 x 3
     id smoke   age
  <int> <int> <int>
1    19     0    24
2    11     1    34
3    56     1    31
4    65     1    30
5    10     0    29
6    22     1    32
> str(lowbwt_data)
Classes 'tbl_df', 'tbl' and 'data.frame':       59 obs. of  3 variables:
 $ id   : int  31 76 44 68 23 45 51 49 71 83 ...
 $ smoke: int  0 0 1 1 1 1 1 0 0 0 ...
 $ age  : int  20 20 20 17 19 17 20 18 17 17 ...
 - attr(*, "spec")=List of 2
  ..$ cols   :List of 3
  .. ..$ id   : list()
```

Data Description: Examples

- Tabulate your data
  R function: table(mydata)
- Symbol '$' is used to select a specific column from your dataset

Example: tabulate variable 'smoke' from data 'low_birth'

```
> table(lowbwt_data$smoke)

 0  1
29 30
> table(lowbwt_data$age)

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 34
 2  2  1  5  2  3  8  5  2  5  5  6  4  2  2  1  1  1  1  1
```

- In data 'low_birth' there are 30 subjects identified as 'smokers' and 29 subjects that are 'non-smokers'.

DATA MANIPULATION

Operators in R

Logical comparisons

< for less than
> for greater than
<= for less than or equal to
>= for greater than or equal to
== for equal to each other
!= not equal to each other
is.na() is NA
!is.na() is not NA.

Logical operators

value == 2|3; value equal 2 or (|) 3
&; means and. For example smoke == "0" & age > 25

Data Transformations: R Math

>*log()* – natural logarithm

>*sqrt()* – square root

>*x^n* – exponent

Matrix Operations:

>*A%*%B* - matrix multiplication

>*t(A)* – matrix transpose

>*det(A)* – determinant of A

>*diag(A)* – diagonal of A

>*solve(A)* – matrix inverse

Data Manipulation (or Wrangling)

- From this point forward we will use library(dplyr) for data selection and manipulation
- Main Functions for data manipulation in dplyr:
  1. Select
  2. Filter
  3. Mutate
  4. Arrange

Select

- From this point forward we will use library(dplyr) for data selection and manipulation
- Select only certain columns (or variables in a dataset)

  R function: select(mydata, col_name)

Examples:

- select only one column
- select several columns
- select all columns but one

Let's try it: SELECT

```
31  ######## Data Manipulation
32  #Select
33  select(lowbwt_data, id, smoke)
34  lowbwt_data_subsetA = select(lowbwt_data, id, smoke)
35
36  select(lowbwt_data, -smoke)
37
```

```
> select(lowbwt_data, id, smoke)
# A tibble: 59 x 2
      id smoke
   <int> <int>
 1    31     0
 2    76     0
 3    44     1
 4    68     1
 5    23     1
 6    45     1
 7    51     1
 8    49     0
 9    71     0
10    83     0
# ... with 49 more rows
> select(lowbwt_data, -smoke)
# A tibble: 59 x 2
      id   age
   <int> <int>
 1    31    20
 2    76    20
 3    44    20
 4    68    17
 5    23    19
 6    45    17
 7    51    20
 8    49    18
 9    71    17
10    83    17
# ... with 49 more rows
>
```

Renaming Variables

- Renaming a variable in a dataset can be done with:

  R function: rename(mydata, new_name_var = old_name_var)

Example: Rename variable 'smoke' to 'smoking_status'

```
> rename(lowbwt_data, smoke_status=smoke)
# A tibble: 59 x 3
      id smoke_status   age
   <int>        <int> <int>
 1    31            0    20
 2    76            0    20
 3    44            1    20
 4    68            1    17
 5    23            1    19
 6    45            1    17
 7    51            1    20
 8    49            0    18
 9    71            0    17
10    83            0    17
# ... with 49 more rows
>
```

Filter

- Filter
  - Some data tables will include rows you don't need for your current analysis.
  - You should filter rows based on logical expressions using the filter function.
  - You will often filter using comparison operators (>, >=, <, <=, ==, and !=).

- Example: Suppose we only want to include mothers under 20 years of age.

Let's try it: FILTER

```
> filter(lowbwt_data, age < 20)
# A tibble: 15 x 3
      id smoke   age
   <int> <int> <int>
 1    68     1    17
 2    23     1    19
 3    45     1    17
 4    49     0    18
 5    71     0    17
 6    83     0    17
 7    50     1    18
 8    33     0    19
 9    78     1    14
10    37     1    17
11    34     1    19
12    57     0    15
13    62     0    15
14    25     0    16
15    81     0    14
```

More examples: FILTER

- What if we want moms < 20 and non-smokers??
  - filter(lowbwt_data, age < 20 & smoke==0)
  - filter(lowbwt_data, age < 20, smoke==0)

- What if we want moms < 20 OR non-smokers
  - filter(lowbwt_data, age < 20 | smoke==0)

MUTATE

- Sometimes you need to change columns or create new ones.
  - You can do this using mutate.
  - NOTE: columns = variables in your data set; rows = observations in data set

- Example: apply a log transformation to skewed variables

  R function: mutate(mydata, new_name_var = transform_old_var)

Let's try it: Mutate

- Sometimes you want to create new variables derived from existing ones
  - E.g., apply a log transformation to skewed variables

R function: mutate(mydata, new_name_var = transform_old_var)

Example:

Let's take the log of 'age'

```
> lowbwt_data2 = mutate(lowbwt_data, log_age=log(age))
> lowbwt_data2
# A tibble: 59 x 4
      id smoke   age log_age
   <int> <int> <int>   <dbl>
 1    31     0    20    3.00
 2    76     0    20    3.00
 3    44     1    20    3.00
 4    68     1    17    2.83
 5    23     1    19    2.94
 6    45     1    17    2.83
 7    51     1    20    3.00
 8    49     0    18    2.89
 9    71     0    17    2.83
10    83     0    17    2.83
# ... with 49 more rows
```

Mutate Example 2

- What if we wanted to create a new binary variable to indicate age < 20?
- Need if_else function. General syntax:
  - if_else (condition, value if true, value if false)
- Let's try it!

Missing Data??

```
> lowbwt_data2 = mutate(lowbwt_data, ageless20 = if_else(age<20, 1, 0))
> lowbwt_data2
# A tibble: 59 x 5
      id smoke   age bwt   ageless20
   <int> <int> <int> <chr>     <dbl>
 1    31     0    20 low           0
 2    76     0    20 low           0
 3    44     1    20 low           0
 4    68     1    17 low           1
 5    23     1    19 low           1
 6    45     1    17 low           1
 7    51     1    20 low           0
 8    49     0    18 low           1
 9    71     0    17 low           1
10    83     0    17 low           1
# ... with 49 more rows
> |
```

ARRANGE

- Order rows of a data according to one of the variables

  R function: arrange(mydata, ordering_variable)

Example: order data by 'id'

- Use function desc() to arrange in descending order
- See R code for ordering by multiple variables/columns

```
> #Arrange to sort data
> arrange(lowbwt_data, id)
# A tibble: 59 x 3
      id smoke   age
   <int> <int> <int>
 1     4     1    28
 2    10     0    29
 3    11     1    34
 4    13     0    25
 5    15     0    25
 6    16     0    27
 7    17     0    23
 8    18     0    24
 9    19     0    24
10    20     1    21
# ... with 49 more rows
```

COMBINING DATASETS

Combining Datasets (Stacking)

- Combine datasets that have the same variables but different observations
- Combine by Rows:

data 1
ID
1
4
6

data 2
ID
2
5
7

combined
ID
1
4
6
2
5
7

Missing Variables?

Combine by Rows

- General Syntax:
  - combined_data = bind_rows(data1, data2, data3, …)

- Before stacking datasets, it's helpful to create a variable to identify which data source they are coming from!
  - mutate(data1, variable=1)
  - mutate(data2, variable=2)

Let's try it: Stacking Datasets

- Right now we only have data on low birthweights; suppose we want to combine that with data on normal birthweights.

```
59  ############## stacking datasets
60
61  # Read in normal weight data
62  normalbwt_data = read_csv(file = "./lowbwt_Normal.csv")
63
64  #create a variable to identify data source in each file
65  lowbwt_data = mutate(lowbwt_data, bwt="low")
66  normalbwt_data = mutate (normalbwt_data, bwt="normal")
67
68  #combine the data sets by stacking
69  combined_data = bind_rows(lowbwt_data, normalbwt_data)
```

Result

```
> combined_data
# A tibble: 189 x 4
      id smoke   age bwt
   <int> <int> <int> <chr>
 1    31     0    20 low
 2    76     0    20 low
 3    44     1    20 low
 4    68     1    17 low
 5    23     1    19 low
 6    45     1    17 low
 7    51     1    20 low
 8    49     0    18 low
 9    71     0    17 low
10    83     0    17 low
# ... with 179 more rows
>
```

Merging Datasets

- Useful when you need to combine data from different sources, or at different times

data 1

ID	Age
1	15
2	20
3	18

data 2

ID	Age	Weight
1	15	115
2	20	134
6	22	140

combined

ID	Age	Weight
1	15	115
2	20	134
3	18	.
6	22	140

- Merging two datasets require that both have at least one variable in common (either character or numeric).
  - If character, make sure the categories have the same spelling (i.e. country names, etc.).

Merging Datasets in R

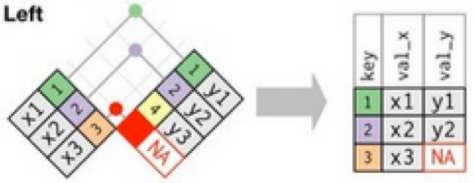
Join types

- Joining datasets x and y

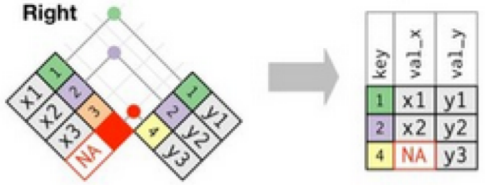
Inner joins

Outer joins

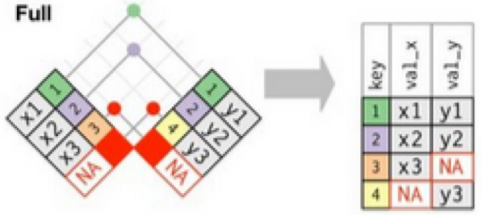
Left



Right



Full



R for Data Science

Inner: keeps data that appear in both x and y
Left: keeps data that appear in x
Right: keeps data that appear in y
Full: keeps data that appear in either x or y

Missing Data??

*_join in R

- General Syntax
  - newdata = inner_join(data1, data2, by = "ID")
  - newdata = left_join(data1, data2, by = "ID")
  - newdata = right_join(data1, data2, by = "ID")
  - newdata = full_join(data1, data2, by = "ID")

Let's try it: Merging datasets

- Suppose we'd like to bring in information on # of visits during the first trimester from another administrative data source.

```
71
72  ######## merging datasets
73
74  #Read in administrative data set
75  admin_data = read_csv(file = "./lowbwt_ADMIN.csv")
76  admin_data
77
78  combined_data
79
80  merged_data = full_join(combined_data, admin_data, by = "id")
81  merged_data
```

Results and write_csv

```
> merged_data
# A tibble: 189 x 5
      id smoke   age bwt   visits
   <int> <int> <int> <chr>  <int>
 1    31     0    20 low        0
 2    76     0    20 low        2
 3    44     1    20 low        0
 4    68     1    17 low        2
 5    23     1    19 low        0
 6    45     1    17 low        0
 7    51     1    20 low        0
 8    49     0    18 low        0
 9    71     0    17 low        2
10    83     0    17 low        0
# ... with 179 more rows
```

```
87
88  ##export merged dataset as csv
89  write_csv(merged_data, "./lowbwt_merged.csv")
90
```

Next Steps

- We now have one data set that includes data on low and normal birthweight babies and includes data on # of visits!
- Next time, we will explore this data.
  - Descriptive Statistics
  - Visualizing Data
  - Basic Hypothesis Testing

Thank you!

Visit our BERD EDU website for additional resources:
http://irvinginstitute.columbia.edu/resources/biostat_educational_initiatives.html

Data Wrangling Cheat Sheet on Dropbox !

Acknowledgements: Jeff Goldsmith (Data Science 1 notes: http://p8105.com/)