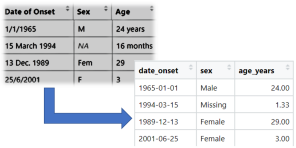
Core Data Functions

> Extended Materials
>
> You can find the original, extended version of this chapter here.



This week we are going to learn how to use R to manipulate data. This will include learning about core functions for manipulating and summarizing data, as well as using conditional statements to create subsets.

Key operators, functions, and constants

An **operators** is a symbol or set of symbols representing some mathematical or logical operation. They are essentially equivalent to functions. R has a number of built-in operators, and libraries may add additional operators (such as the `%>%` operator used in Tidyverse packages). Some examples of operators are:

- Definitional operators
- Relational operators (less than, equal too..)
- Logical operators (and, or…)
- Handling missing values
- Mathematical operators and functions (+/-, >, sum(), median(), …)
- The `%in%` operator

R also has some built-in **constants**, which have the same meaning in programming as in mathematics and statistics. Examples of constants in R include:

- `pi` which in base R equals `3.141593`
- `Inf` and `-Inf` for positive and negative infinity
- `NaN` for not a number (such as the result of `0/0`)
- `NA` for missing data

Assignment operators

`<-`

The basic assignment operator in R is `<-`. Such that `object_name <- value`.
This assignment operator can also be written as `=`. We advise use of `<-` for general R use.
We also advise surrounding such operators with spaces, for readability.

Relational and logical operators

Relational operators compare values and are often used when defining new variables and subsets of datasets. Here are the common relational operators in R:

Meaning	Operator	Example	Example Result
Equal to	`==`	`"A" == "a"`	`FALSE` (because R is case sensitive) *Note that == (double equals) is different from = (single equals), which acts like the assignment operator* `<-`
Not equal to	`!=`	`2 != 0`	`TRUE`
Greater than	`>`	`4 > 2`	`TRUE`
Less than	`<`	`4 < 2`	`FALSE`
Greater than or equal to	`>=`	`6 >= 4`	`TRUE`
Less than or equal to	`<=`	`6 <= 4`	`FALSE`
Value is missing	`is.na()`	`is.na(7)`	`FALSE`
Value is not missing	`!is.na()`	`!is.na(7)`	`TRUE`

Logical operators, such as AND and OR, are often used to connect relational operators and create more complicated criteria. Complex statements might require parentheses ( ) for grouping and order of application.

Meaning	Operator
AND	`&`
OR	`|` (vertical bar)
Parentheses	`( )` Used to group criteria together and clarify order of operations

For example, below, we have a linelist with two variables we want to use to create our case definition, `hep_e_rdt`, a test result and `other_cases_in_hh`, which will tell us if there are other cases in the household. The command below uses the function `case_when()` to create the new variable `case_def` such that:

```
linelist_cleaned <- linelist %>%
  mutate(case_def = case_when(
    is.na(rdt_result) & is.na(other_case_in_home)            ~ NA_character_,
    rdt_result == "Positive"                                 ~ "Confirmed",
    rdt_result != "Positive" & other_cases_in_home == "Yes"  ~ "Probable",
    TRUE                                                     ~ "Suspected"
  ))
```

Criteria in example above	Resulting value in new variable "case_def"
If the value for variables `rdt_result` and `other_cases_in_home` are missing	`NA` (missing)
If the value in `rdt_result` is "Positive"	"Confirmed"
If the value in `rdt_result` is NOT "Positive" AND the value in `other_cases_in_home` is "Yes"	"Probable"
If one of the above criteria are not met	"Suspected"

Note that R is case-sensitive, so "Positive" is different than "positive"…

Missing values

In R, missing values are represented by the special value `NA` (a "reserved" value) (capital letters N and A - not in quotation marks). **To test whether a value is `NA`, use the special function `is.na()`**, which returns `TRUE` or `FALSE`.

```
rdt_result <- c("Positive", "Suspected", "Positive", NA)   # two positive cases, one suspe
is.na(rdt_result)  # Tests whether the value of rdt_result is NA
```

```
[1] FALSE FALSE FALSE  TRUE
```

We will be learning more about how to deal with missing data in future weeks.

Mathematics and statistics

All the operators and functions in this page are automatically available using **base** R.

Mathematical operators

These are often used to perform addition, division, to create new columns, etc. Below are common mathematical operators in R. Whether you put spaces around the operators is not important.

Purpose	Example in R
addition	2 + 3
subtraction	2 - 3
multiplication	2 * 3
division	30 / 5
exponent	2^3
order of operations	( )

Mathematical functions

Purpose	Function
rounding	round(x, digits = n)
rounding	janitor::round_half_up(x, digits = n)
ceiling (round up)	ceiling(x)
floor (round down)	floor(x)
absolute value	abs(x)
square root	sqrt(x)
exponent	exponent(x)
natural logarithm	log(x)
log base 10	log10(x)
log base 2	log2(x)

Note: for `round()` the `digits =` specifies the number of decimal placed. Use `signif()` to round to a number of significant figures.

Statistical functions

> **Warning**
>
> The functions below will by default include missing values in calculations. Missing values will result in an output of `NA`, unless the argument `na.rm = TRUE` is specified. This can be written shorthand as `na.rm = T`.

Objective	Function
mean (average)	mean(x, na.rm=T)
median	median(x, na.rm=T)
standard deviation	sd(x, na.rm=T)
quantiles*	quantile(x, probs)
sum	sum(x, na.rm=T)
minimum value	min(x, na.rm=T)
maximum value	max(x, na.rm=T)
range of numeric values	range(x, na.rm=T)
summary**	summary(x)

Notes:

- `*quantile()`: `x` is the numeric vector to examine, and `probs =` is a numeric vector with probabilities within 0 and 1.0, e.g `c(0.5, 0.8, 0.85)`
- `**summary()`: gives a summary on a numeric vector including mean, median, and common percentiles

> **Warning**
>
> If providing a vector of numbers to one of the above functions, be sure to wrap the numbers within `c()` .}

```
# If supplying raw numbers to a function, wrap them in c()
mean(1, 6, 12, 10, 5, 0)    # !!! INCORRECT !!!
```

```
[1] 1
```

```
mean(c(1, 6, 12, 10, 5, 0)) # CORRECT
```

```
[1] 5.666667
```

Other useful functions

Objective	Function	Example
create a sequence	seq(from, to, by)	`seq(1, 10, 2)`
repeat x, n times	rep(x, ntimes)	`rep(1:3, 2)` or `rep(c("a", "b", "c"), 3)`

Objective	Function	Example
subdivide a numeric vector	cut(x, n)	`cut(linelist$age, 5)`
take a random sample	sample(x, size)	`sample(linelist$id, size = 5, replace = TRUE)`

%in%

A very useful operator for matching values, and for quickly assessing if a value is within a vector or dataframe.

```
my_vector <- c("a", "b", "c", "d")
```

```
"a" %in% my_vector
```

```
[1] TRUE
```

```
"h" %in% my_vector
```

```
[1] FALSE
```

To ask if a value is **not** `%in%` a vector, put an exclamation mark (!) **in front** of the logic statement:

```
# to negate, put an exclamation in front
!"a" %in% my_vector
```

```
[1] FALSE
```

```
!"h" %in% my_vector
```

```
[1] TRUE
```

`%in%` is very useful when using the **dplyr** function `case_when()`. You can define a vector previously, and then reference it later. For example:

```r
affirmative <- c("1", "Yes", "YES", "yes", "y", "Y", "oui", "Oui", "Si")

linelist <- linelist %>%
  mutate(child_hospitaled = case_when(
    hospitalized %in% affirmative & age < 18 ~ "Hospitalized Child",
    TRUE                                     ~ "Not"))
```

Tidyverse functions

We will be emphasizing use of the functions from the **tidyverse** family of R packages. The functions we will be learning about are listed below.

Many of these functions belong to the **dplyr** R package, which provides "verb" functions to solve data manipulation challenges (the name is a reference to a "data frame-plier. **dplyr** is part of the **tidyverse** family of R packages (which also includes **ggplot2**, **tidyr**, **stringr**, **tibble**, **purrr**, **magrittr**, and **forcats** among others).

Function	Utility	Package
`%>%`	"pipe" (pass) data from one function to the next	**magrittr**
`mutate()`	create, transform, and re-define columns	**dplyr**
`select()`	keep, remove, select, or re-name columns	**dplyr**
`rename()`	rename columns	**dplyr**
`clean_names()`	standardize the syntax of column names	**janitor**
`as.character()`, `as.numeric()`, `as.Date()`, etc.	convert the class of a column	**base** R
`across()`	transform multiple columns at one time	**dplyr**
tidyselect functions	use logic to select columns	**tidyselect**
`filter()`	keep certain rows	**dplyr**
`distinct()`	de-duplicate rows	**dplyr**
`rowwise()`	operations by/within each row	**dplyr**
`add_row()`	add rows manually	**tibble**
`arrange()`	sort rows	**dplyr**
`recode()`	re-code values in a column	**dplyr**
`case_when()`	re-code values in a column using more complex logical criteria	**dplyr**

Function	Utility	Package
`replace_na()`, `na_if()`, `coalesce()`	special functions for re-coding	**tidyr**
`age_categories()` and `cut()`	create categorical groups from a numeric column	**epikit** and **base** R
`match_df()`	re-code/clean values using a data dictionary	**matchmaker**
`which()`	apply logical criteria; return indices	**base** R