Week-4: Manipulating data

NM2207: Computational Media Literacy

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This week

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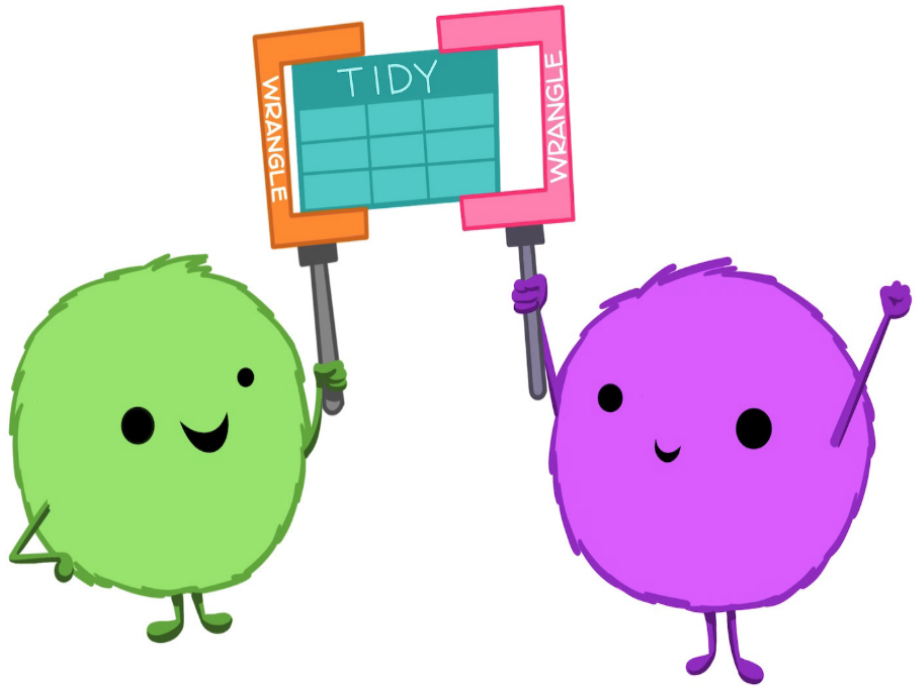
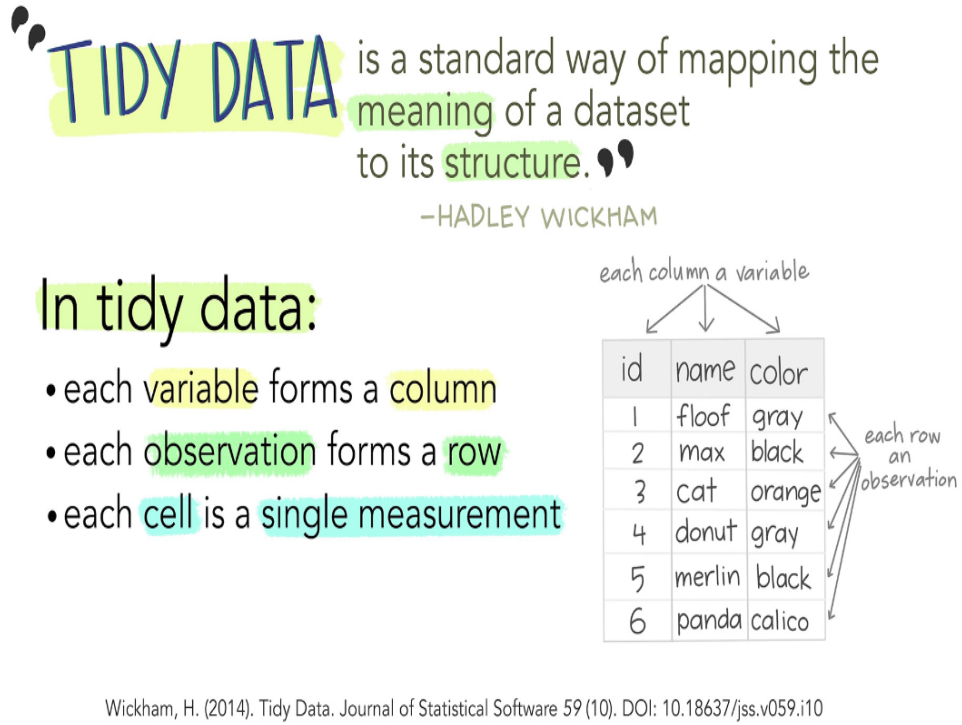


Source: Allison Horst (https://allisonhorst.com/other-r-fun)

I. Tidy data

Tidy data: characteristics

- Every column is a variable
- Every row is an observation
- Each type of observational unit forms a table



Wickham, H. (2014). Tidy Data. Journal of Statistical Software 59 (10). DOI: 10.18637/jss.v059.i10

Source: Allison Horst (https://allisonhorst.com/other-r-fun)

Tidy data: example

country <chr>	year <int>	cases <int>	population <int>
Afghanistan	1999	745	19987071
Afghanistan	2000	2666	20595360
Brazil	1999	37737	172006362
Brazil	2000	80488	174504898
China	1999	212258	1272915272
China	2000	213766	1280428583

6 rows

Observation

Variable

Table

Table 1: Illustration of Tidy Data

Tidy data: what makes data untidy?

Look closely! the table has the same variables as before, but in a different *format*.

country <chr>	year <int>	type <chr>	count <int>
Afghanistan	1999	cases	745
Afghanistan	1999	population	19987071
Afghanistan	2000	cases	2666
Afghanistan	2000	population	20595360
Brazil	1999	cases	37737
Brazil	1999	population	172006362
Brazil	2000	cases	80488
Brazil	2000	population	174504898
China	1999	cases	212258
China	1999	population	1272915272

1-10 of 12 rows Previous 1 2 Next

Table 2: Illustration of data with non-tidy structure

Tidy data: what makes data untidy?

Multiple variables (year, months) in columns!

Airplanes on Hand in the AAF, By Major Type: Jul 1939 to Aug 1945

End of Month	Total	Very Heavy Bombers	Heavy Bombers	Medium Bombers	Light Bombers	Fighters	Recon-naissance	Transports	Trainers	Communi-cations
1939										
Jul	2,402	-	16	400	276	494	356	118	735	7
Aug	2,440	-	18	414	276	492	359	129	745	7
[Germany invades Poland, 1 Sep 1939]										
Sep	2,473	-	22	428	278	489	359	136	754	7
Oct	2,507	-	27	446	277	490	365	137	758	7
Nov	2,536	-	32	458	275	498	375	136	755	7
Dec	2,546	-	39	464	274	492	378	131	761	7
1940										
Jan	2,588	-	45	466	271	464	409	128	798	7
Feb	2,658	-	49	470	271	458	415	128	860	7
Mar	2,709	-	54	468	267	453	415	125	920	7
Apr	2,806	-	54	468	263	451	416	125	1,022	7
May	2,906	-	54	470	259	459	410	124	1,123	7
Jun	2,966	-	54	478	166	477	414	127	1,243	7
[France surrenders to Germany, 25 Jun 1940] [Battle of Britain begins, 10 July 1940]										
Jul	3,102	-	56	483	161	500	410	128	1,357	7
Aug	3,295	-	65	485	158	539	407	128	1,506	7

Table 3: Example of non-tidy dataframe (source: Army Air Forces Statistical Digest, WW II)

Tidy data: what makes data untidy?

Observations are in columns!

	A	AA	AB	AC	AD	AE	AF	AG	AH
1	Estimated HIV Prevalence% - (Ages 15-49)	2004	2005	2006	2007	2008	2009	2010	2011
2	Abkhazia								
3	Afghanistan						0.06	0.06	0.06
4	Akrotiri and Dhekelia								
5	Albania								
6	Algeria	0.1	0.1	0.1	0.1	0.1			
7	American Samoa								
8	Andorra								
9	Angola	1.9	1.9	1.9	1.9	2	2.1	2.1	2.1
10	Anguilla								
11	Antigua and Barbuda								
12	Argentina	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4
13	Armenia	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
14	Aruba								
15	Australia	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
16	Austria	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
17	Azerbaijan	0.06	0.06	0.06	0.1	0.1	0.1	0.1	0.1
18	Bahamas	3	3	3	3.1	3.1	2.9	2.8	2.8

Table 4: Example of non-tidy dataframe (source: Gapminder, Estimated HIV prevalence among 15-49 year olds)

Tidy data: what makes data untidy?

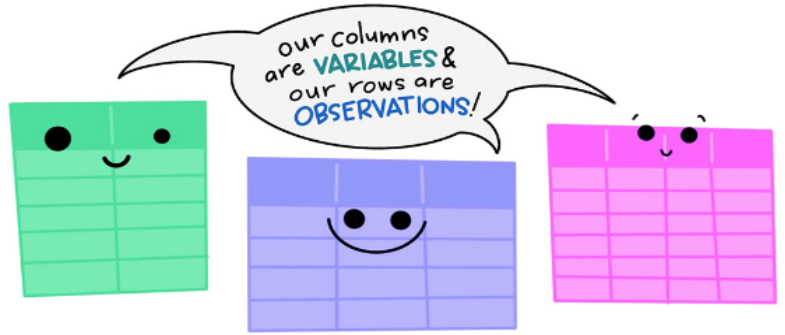
Multiple variables (year, events) in columns!

Subject	United States			
	Estimate	Margin of Error	Percent	Percent Margin of Error
EMPLOYMENT STATUS				
Population 16 years and over	255,797,692	+/-17,051	255,797,692	(X)
In labor force	162,184,325	+/-135,158	63.4%	+/-0.1
Civilian labor force	161,159,470	+/-127,501	63.0%	+/-0.1
Employed	150,599,165	+/-138,066	58.9%	+/-0.1
Unemployed	10,560,305	+/-27,385	4.1%	+/-0.1
Armed Forces	1,024,855	+/-10,363	0.4%	+/-0.1
Not in labor force	93,613,367	+/-126,007	36.6%	+/-0.1
Civilian labor force	161,159,470	+/-127,501	161,159,470	(X)
Unemployment Rate	(X)	(X)	6.6%	+/-0.1
Females 16 years and over	131,092,196	+/-11,187	131,092,196	(X)
In labor force	76,493,327	+/-75,824	58.4%	+/-0.1
Civilian labor force	76,350,498	+/-75,238	58.2%	+/-0.1
Employed	71,451,559	+/-79,007	54.5%	+/-0.1
Own children of the householder under 6 years	22,939,897	+/-14,240	22,939,897	(X)
All parents in family in labor force	14,957,537	+/-36,506	65.2%	+/-0.1
Own children of the householder 6 to 17 years	47,007,147	+/-19,644	47,007,147	(X)
All parents in family in labor force	33,238,793	+/-49,036	70.7%	+/-0.1

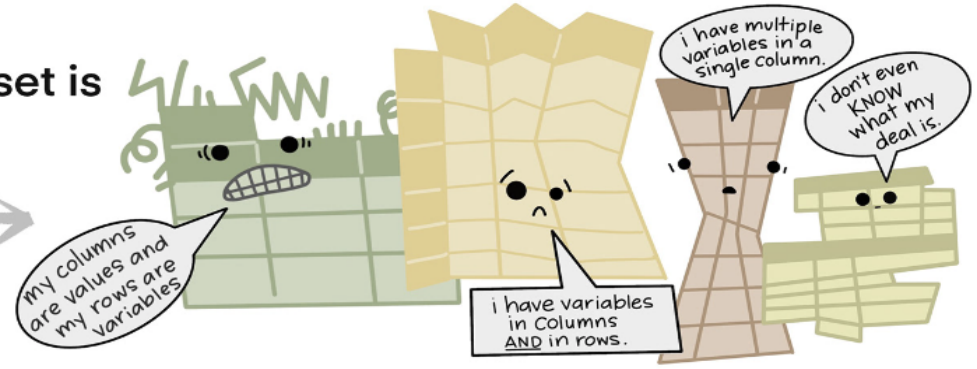
Figure: Example of non-tidy dataframe (Source: GUS Census Fact Finder, General Economic Characteristics, ACS 2017)

Tidy data: what makes data untidy?

The standard structure of tidy data means that "tidy datasets are all alike..."



"...but every messy dataset is messy in its own way."
–HADLEY WICKHAM



Source: Allison Horst (https://allisonhorst.com/other-r-fun)

Ease of manipulation: Tidy vs Non-tidy data

Let us compute the mean number of cases;

- For data in **Tidy** format the code would be,

```
# Tidy data in table1
mean(table1$cases)
```

- For data in **Non-Tidy** format the code would be,

```
# Non-tidy data in table2
mean(table2$count[c(1, 3, 5, 7, 9, 11)])
```

- *Which line of code is easier to write?*
- *Which line could you write if you've only looked at the first row of the data?*

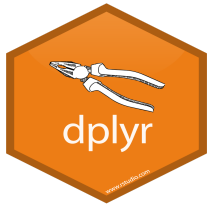
II. Data wrangling

Basics of data wrangling

Once you load data in R, you would want to explore it

- To do so, `dplyr` package is used. It is contained in `tidyverse`
- Some basic functions are,
  - `select()` to pick columns by name
  - `arrange()` to order data
  - `mutate()` to create new columns
  - `filter()` to pick rows matching the criteria

- The first argument (*what goes inside the brackets*) to the functions is always a data-set
- The subsequent arguments indicate operations on the data-set
- The output of the functions is also a data-set
- To store the output, it has to be assigned to a variable



Loading data from files

- **Download** the file with data

- **Create** a folder named data in the same directory as your `.R` file or `.Rmd` file

- We will be using `read_csv()` function to **read** a `.csv` file
  - `.csv` files are text files that can be opened in a text editor
  - They are structured like dataframes or excel sheets with commas separating the values (hence .csv)

Data: hotel booking

- Data of two hotels - a city hotel and a resort
- Each row corresponds to a booking
- It was collected with the aim of developing prediction models to classify a hotel booking's likelihood to be cancelled
    - See: Antonio et al. 2019

```
# Load the package
library(tidyverse)
# Read data from the csv file
hotels <- read_csv("data/hotels.csv")
```

Data: hotel booking

The raw file looks like this (using Notepad on a Windows PC or TextEdit on Mac)

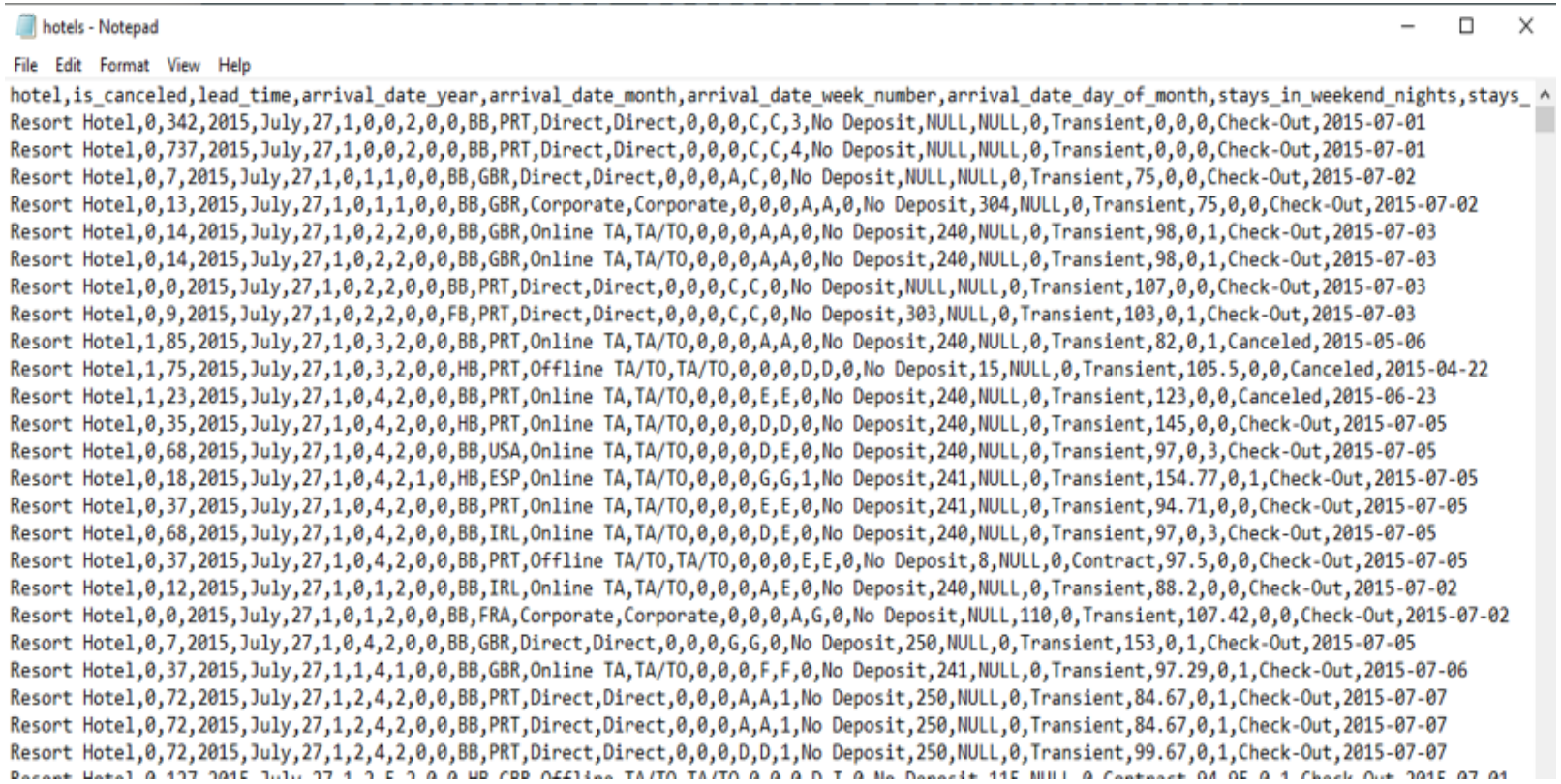
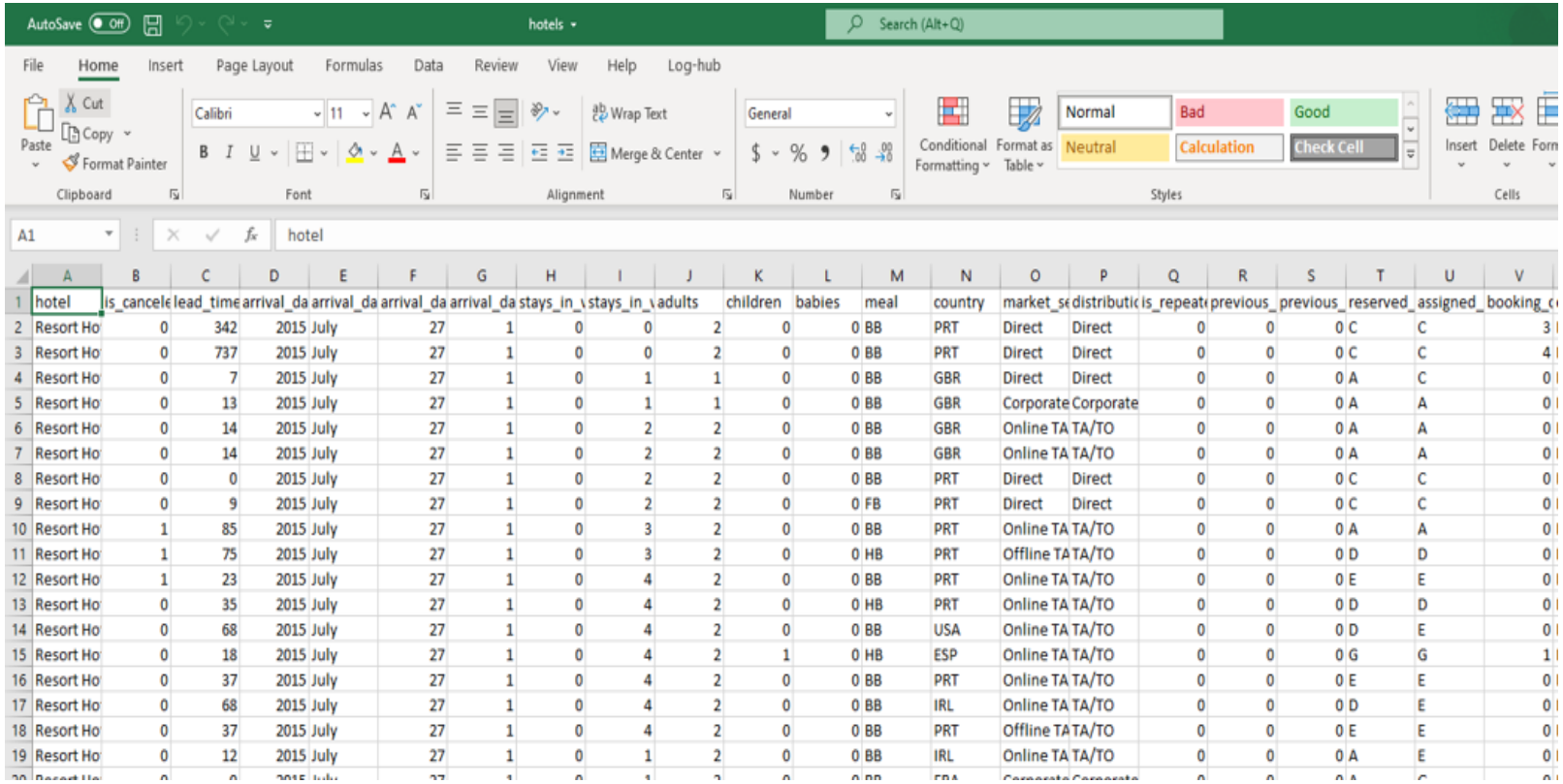


Figure: Hotel booking data

Data: hotel booking

You can open the file in excel too



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	hotel	is_cancele	lead_time	arrival_da	arrival_da	arrival_da	arrival_da	stays_in_v	stays_in_v	adults	children	babies	meal	country	market_se	distributi	is_repeate	previous_	previous_	reserved_	assigned_	booking_c
2	Resort Ho	0	342	2015	July	27	1	0	0	2	0	0	BB	PRT	Direct	Direct	0	0	0	C	C	3
3	Resort Ho	0	737	2015	July	27	1	0	0	2	0	0	BB	PRT	Direct	Direct	0	0	0	C	C	4
4	Resort Ho	0	7	2015	July	27	1	0	1	1	0	0	BB	GBR	Direct	Direct	0	0	0	A	C	0
5	Resort Ho	0	13	2015	July	27	1	0	1	1	0	0	BB	GBR	Corporate	Corporate	0	0	0	A	A	0
6	Resort Ho	0	14	2015	July	27	1	0	2	2	0	0	BB	GBR	Online TA	TA/TO	0	0	0	A	A	0
7	Resort Ho	0	14	2015	July	27	1	0	2	2	0	0	BB	GBR	Online TA	TA/TO	0	0	0	A	A	0
8	Resort Ho	0	0	2015	July	27	1	0	2	2	0	0	BB	PRT	Direct	Direct	0	0	0	C	C	0
9	Resort Ho	0	9	2015	July	27	1	0	2	2	0	0	FB	PRT	Direct	Direct	0	0	0	C	C	0
10	Resort Ho	1	85	2015	July	27	1	0	3	2	0	0	BB	PRT	Online TA	TA/TO	0	0	0	A	A	0
11	Resort Ho	1	75	2015	July	27	1	0	3	2	0	0	HB	PRT	Offline TA	TA/TO	0	0	0	D	D	0
12	Resort Ho	1	23	2015	July	27	1	0	4	2	0	0	BB	PRT	Online TA	TA/TO	0	0	0	E	E	0
13	Resort Ho	0	35	2015	July	27	1	0	4	2	0	0	HB	PRT	Online TA	TA/TO	0	0	0	D	D	0
14	Resort Ho	0	68	2015	July	27	1	0	4	2	0	0	BB	USA	Online TA	TA/TO	0	0	0	D	E	0
15	Resort Ho	0	18	2015	July	27	1	0	4	2	1	0	HB	ESP	Online TA	TA/TO	0	0	0	G	G	1
16	Resort Ho	0	37	2015	July	27	1	0	4	2	0	0	BB	PRT	Online TA	TA/TO	0	0	0	E	E	0
17	Resort Ho	0	68	2015	July	27	1	0	4	2	0	0	BB	IRL	Online TA	TA/TO	0	0	0	D	E	0
18	Resort Ho	0	37	2015	July	27	1	0	4	2	0	0	BB	PRT	Offline TA	TA/TO	0	0	0	E	E	0
19	Resort Ho	0	12	2015	July	27	1	0	1	2	0	0	BB	IRL	Online TA	TA/TO	0	0	0	A	E	0

Figure: Hotel booking data

Hotel booking: look at the variables

- `names()` is a function
- `hotels` is the argument

```
names(hotels)
```

```
##  [1] "hotel"                          "is_canceled"
##  [3] "lead_time"                      "arrival_date_year"
##  [5] "arrival_date_month"             "arrival_date_week_number"
##  [7] "arrival_date_day_of_month"      "stays_in_weekend_nights"
##  [9] "stays_in_week_nights"           "adults"
## [11] "children"                       "babies"
## [13] "meal"                           "country"
## [15] "market_segment"                 "distribution_channel"
## [17] "is_repeated_guest"              "previous_cancellations"
## [19] "previous_bookings_not_canceled" "reserved_room_type"
## [21] "assigned_room_type"             "booking_changes"
## [23] "deposit_type"                   "agent"
## [25] "company"                        "days_in_waiting_list"
## [27] "customer_type"                  "adr"
## [29] "required_car_parking_spaces"    "total_of_special_requests"
## [31] "reservation_status"             "reservation_status_date"
```

Hotel booking: data overview

```
glimpse(hotels)
```

```
## Rows: 119,390
## Columns: 32
## $ hotel                         <chr> "Resort Hotel", "Resort Hotel", "Resort…
## $ is_canceled                   <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, …
## $ lead_time                     <dbl> 342, 737, 7, 13, 14, 14, 0, 9, 85, 75, …
## $ arrival_date_year             <dbl> 2015, 2015, 2015, 2015, 2015, 2015, 201…
## $ arrival_date_month            <chr> "July", "July", "July", "July", "July",…
## $ arrival_date_week_number      <dbl> 27, 27, 27, 27, 27, 27, 27, 27, 27, 27,…
## $ arrival_date_day_of_month     <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, …
## $ stays_in_weekend_nights       <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
## $ stays_in_week_nights          <dbl> 0, 0, 1, 1, 2, 2, 2, 2, 3, 3, 4, 4, 4, …
## $ adults                        <dbl> 2, 2, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, …
## $ children                      <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
## $ babies                        <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
## $ meal                          <chr> "BB", "BB", "BB", "BB", "BB", "BB", "BB…
## $ country                       <chr> "PRT", "PRT", "GBR", "GBR", "GBR", "GBR…
## $ market_segment                <chr> "Direct", "Direct", "Direct", "Corporat…
## $ distribution_channel          <chr> "Direct", "Direct", "Direct", "Corporat…
## $ is_repeated_guest             <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
## $ previous_cancellations        <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
## $ previous_bookings_not_canceled <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
```

III. Choosing rows or columns

Selecting columns

- `select()` let's us select specific columns from a data-set

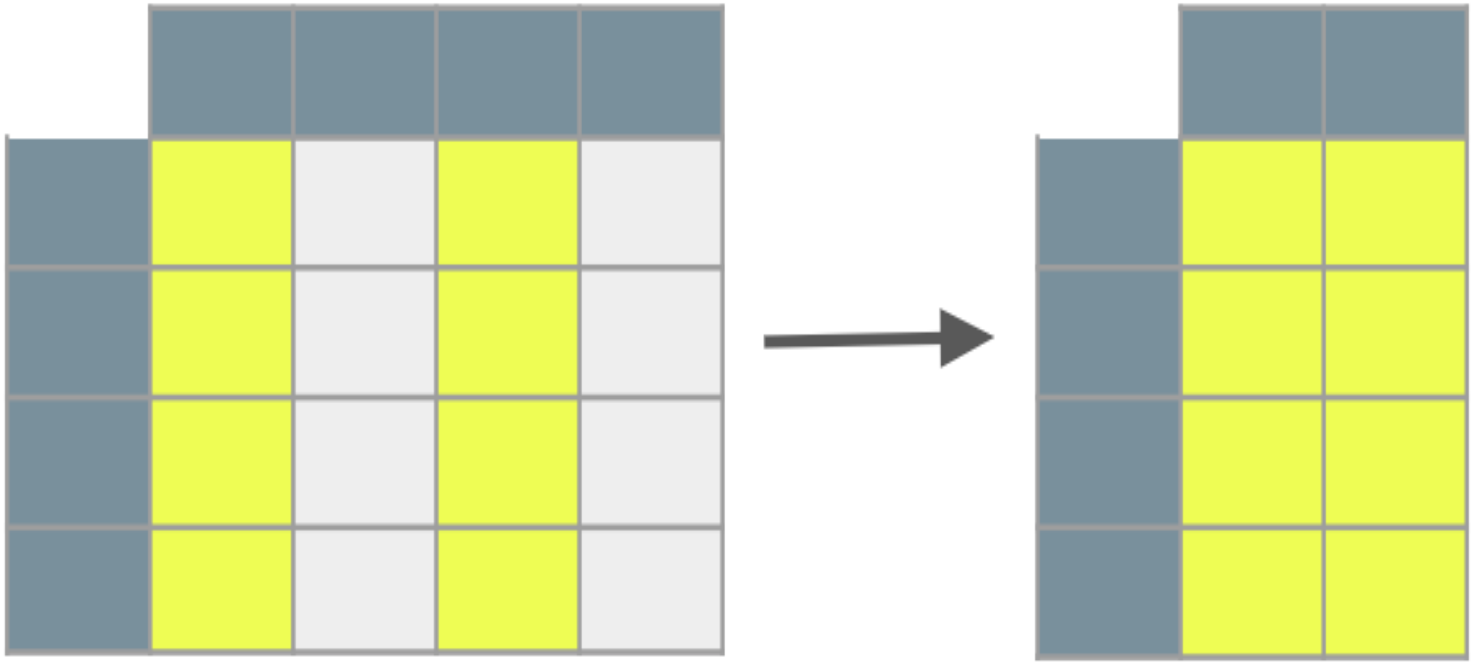


Figure: Selecting columns

Hotel booking: select a single column

- Start with the verb

```
select(              # <-- verb
        hotels,
         lead_time
            )
```

- First argument is the data-set

```
select(
        hotels,     # <-- data-set
         lead_time
            )
```

- Second argument is the column we want to select

```
select(
       hotels,
          lead_time    # <-- chosen column/variable
            )
```

Hotel booking: select a single column

- View only `lead_time` (number of days between booking and arrival)

```
select(hotels, lead_time)
```

```
## # A tibble: 119,390 × 1
##    lead_time
##        <dbl>
##  1       342
##  2       737
##  3         7
##  4        13
##  5        14
##  6        14
##  7         0
##  8         9
##  9        85
## 10        75
## # … with 119,380 more rows
```

- **Remember:** `dplyr` functions always expect a dataframe and the output is also a dataframe

Hotel booking: selecting multiple columns

- View `lead_time`, `agent` and `market_segment`

```
select(hotels, lead_time,agent,market_segment)
```

```
## # A tibble: 119,390 × 3
##    lead_time agent market_segment
##        <dbl> <chr> <chr>
##  1       342 NULL  Direct
##  2       737 NULL  Direct
##  3         7 NULL  Direct
##  4        13 304   Corporate
##  5        14 240   Online TA
##  6        14 240   Online TA
##  7         0 NULL  Direct
##  8         9 303   Direct
##  9        85 240   Online TA
## 10        75 15    Offline TA/TO
## # … with 119,380 more rows
```

- **Note:** you can use `-c("column_names")` to remove specific columns

Arranging columns

`arrange()` let's us reorder data

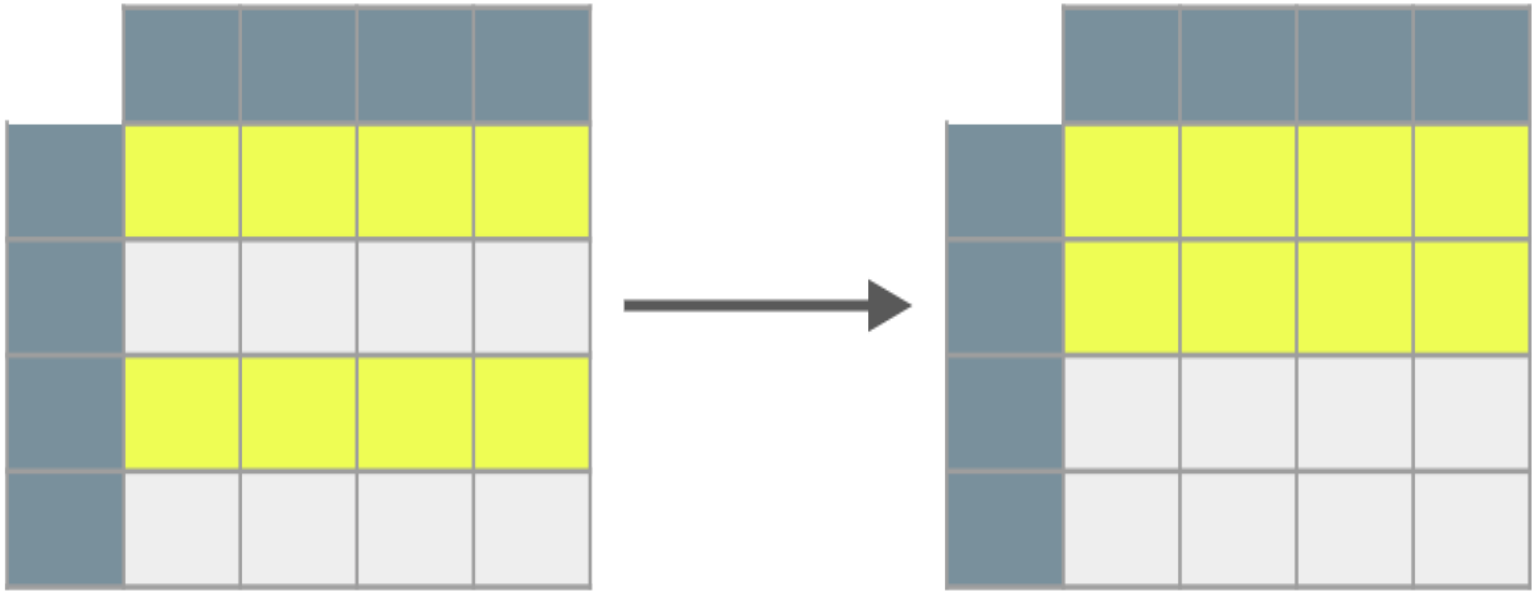


Figure: Arranging columns

Hotel booking: arrange

Let us try reordering entries of the column `lead_time`

- Start with the verb

```
arrange(             # <-- verb
          hotels,
           lead_time
              )
```

- First argument is the data-set

```
arrange(
         hotels,     # <-- data-set
           lead_time
              )
```

- Second argument is the column whose entries we want to reorder

```
arrange(
        hotels,
           lead_time    # <-- chosen column/variable
              )
```

Hotel booking: arrange

- View the rearranged entries of `lead_time`

```
arrange(hotels, lead_time)
```

```
## # A tibble: 119,390 × 32
##    hotel  is_ca…¹ lead_…² arriv…³ arriv…⁴ arriv…⁵ arriv…⁶ stays…⁷ stays…⁸ adults
##    <chr>    <dbl>   <dbl>   <dbl> <chr>     <dbl>   <dbl>   <dbl>   <dbl>  <dbl>
##  1 Resor…       0       0    2015 July         27       1       0       2      2
##  2 Resor…       0       0    2015 July         27       1       0       1      2
##  3 Resor…       0       0    2015 July         27       2       0       1      2
##  4 Resor…       0       0    2015 July         27       2       0       1      2
##  5 Resor…       0       0    2015 July         27       2       0       1      2
##  6 Resor…       0       0    2015 July         28       5       1       0      2
##  7 Resor…       0       0    2015 July         28       6       0       0      1
##  8 Resor…       0       0    2015 July         28       7       0       1      1
##  9 Resor…       0       0    2015 July         28       7       0       1      3
## 10 Resor…       0       0    2015 July         28       7       0       1      1
## # … with 119,380 more rows, 22 more variables: children <dbl>, babies <dbl>,
## #   meal <chr>, country <chr>, market_segment <chr>,
## #   distribution_channel <chr>, is_repeated_guest <dbl>,
## #   previous_cancellations <dbl>, previous_bookings_not_canceled <dbl>,
## #   reserved_room_type <chr>, assigned_room_type <chr>, booking_changes <dbl>,
## #   deposit_type <chr>, agent <chr>, company <chr>, days_in_waiting_list <dbl>,
```

Hotel booking: arrange

- Original order of the entries of `lead_time`

```
hotels
```

```
## # A tibble: 119,390 × 32
##    hotel  is_ca…¹ lead_…² arriv…³ arriv…⁴ arriv…⁵ arriv…⁶ stays…⁷ stays…⁸ adults
##    <chr>    <dbl>   <dbl>   <dbl> <chr>     <dbl>   <dbl>   <dbl>   <dbl>  <dbl>
##  1 Resor…       0     342    2015 July         27       1       0       0       2
##  2 Resor…       0     737    2015 July         27       1       0       0       2
##  3 Resor…       0       7    2015 July         27       1       0       1       1
##  4 Resor…       0      13    2015 July         27       1       0       1       1
##  5 Resor…       0      14    2015 July         27       1       0       2       2
##  6 Resor…       0      14    2015 July         27       1       0       2       2
##  7 Resor…       0       0    2015 July         27       1       0       2       2
##  8 Resor…       0       9    2015 July         27       1       0       2       2
##  9 Resor…       1      85    2015 July         27       1       0       3       2
## 10 Resor…       1      75    2015 July         27       1       0       3       2
## # … with 119,380 more rows, 22 more variables: children <dbl>, babies <dbl>,
## #   meal <chr>, country <chr>, market_segment <chr>,
## #   distribution_channel <chr>, is_repeated_guest <dbl>,
## #   previous_cancellations <dbl>, previous_bookings_not_canceled <dbl>,
## #   reserved_room_type <chr>, assigned_room_type <chr>, booking_changes <dbl>,
## #   deposit_type <chr>, agent <chr>, company <chr>, days_in_waiting_list <dbl>,
```

Hotel booking: arrange

- By default, `arrange()` arranges the entries of the chosen column in the **increasing** order
- Re-arranging applies to the entire row and not just the entries of the column
- In other words, the observation (rows) get rearranged so that the entries of `lead_time` are in the ascending order
- To rearrange entries in the descending order, use `desc()`

```
arrange(hotels, desc(lead_time))
```

Hotel booking: select + arrange

- After picking the column/variable `lead_time`, let us say we want to rearrange its entries in the decreasing order

- Step-1 is to pick the desired column, `select(hotels, lead_time)`

```
  select(hotels, lead_time)
```

- Step-2 is to rearrange the output of `select(hotels, lead_time)`

```
  arrange(       # <-- start with the verb
  select(hotels, lead_time), # <-- first argument is the dataframe *
   desc(lead_time) # <--- second argument is the how you want arrange
)                 # i.e. decreasing order of lead_time
```

* *in this case, it is the output of the* `select` *operation.*

Hotel booking: select + arrange

```
select(hotels, lead_time)
```

```
## # A tibble: 119,390 × 1
##    lead_time
##        <dbl>
##  1       342
##  2       737
##  3         7
##  4        13
##  5        14
##  6        14
##  7         0
##  8         9
##  9        85
## 10        75
## # … with 119,380 more rows
```

```
arrange(
  select(hotels, lead_time),
desc(lead_time)
)
```

```
## # A tibble: 119,390 × 1
##    lead_time
##        <dbl>
##  1       737
##  2       709
##  3       629
##  4       629
##  5       629
##  6       629
##  7       629
##  8       629
##  9       629
## 10       629
## # … with 119,380 more rows
```

Hotel booking: select + arrange

- Did you notice how many functions we used to arrive at a rearranged column?
- A function(s) within another function(s) is called a ***nested function***
- Now, imagine having to do more than ten operations on a data-frame
- How confusing could it get to have functions inside another??!
- You think not? Read on.

```
arrange(                        # <-- Function 1
  select(hotels, lead_time), # <-- Function 2
desc(lead_time) # <-- Function 3
)
```

IV. Combining two or more operations

Nesting operations

- Think of the activities that you might be doing every morning
    - find keys, unlock car, start car, drive to work, park

- As R functions, this would hypothetically look like:

```
park(drive(start_car(find("keys")), to = "work"))
```

- This is very confusing to read, given that the first thing you write, is the last thing you do,
    - `park` then `drive` then `start_car` then `find(keys)`, and then the `to` argument again refers to `drive`, not what is right next to it (i.e. `find`)

- Is there an easier way to tackle this?? **Pipes**

Pipes

- We have already used this operator earlier in our course
- They are a part of `magrittr` package that is automatically loaded when you load `tidyverse`
- `%>%` operator takes the left-hand side and passes it as an input to the right-hand side
- It makes the code easier to read and write
- Let us apply it to the hypothetical scenario from earlier

```
"keys" %>%
  find() %>%
    start_car() %>%
      drive(to = "work") %>%
        park()
```

- *Isn't it easier to read and follow?*

Hotel booking: select + arrange using pipes

```
arrange(
  select(hotels, lead_time),
  desc(lead_time)
)
```

```
## # A tibble: 119,390 × 1
##    lead_time
##        <dbl>
##  1       737
##  2       709
##  3       629
##  4       629
##  5       629
##  6       629
##  7       629
##  8       629
##  9       629
## 10       629
## # … with 119,380 more rows
```

```
hotels %>%
  select(lead_time) %>%
  arrange(desc(lead_time))
```

```
## # A tibble: 119,390 × 1
##    lead_time
##        <dbl>
##  1       737
##  2       709
##  3       629
##  4       629
##  5       629
##  6       629
##  7       629
##  8       629
##  9       629
## 10       629
## # … with 119,380 more rows
```

Hotel booking: select + arrange using pipes

- **Notice** how the results remain the same
- Also note how the pipe operator passes the output of the function on the left-hand side as the input to the function on the right-hand side

Piping versus Layering

- Let us recall visualization using `ggplot2`
  - we created the plot in layers, separated by `+`
- Layering works differently from pipelines of `dplyr`
  - As noted in earlier slides, the output of the previous line of code serves as the input to the next

Piping in `dplyr`

This is incorrect

```
hotels +
  select(hotel,lead_time)
```

```
## Error in select(hotel, lead_time): object 'l
```

This is correct

```
hotels %>%
select(hotel,lead_time)
```

```
## # A tibble: 119,390 × 2
##    hotel        lead_time
##    <chr>            <dbl>
##  1 Resort Hotel       342
##  2 Resort Hotel       737
##  3 Resort Hotel         7
##  4 Resort Hotel        13
##  5 Resort Hotel        14
##  6 Resort Hotel        14
##  7 Resort Hotel         0
##  8 Resort Hotel         9
##  9 Resort Hotel        85
## 10 Resort Hotel        75
## # … with 119,380 more rows
```

Layering in `ggplot2`

- This is incorrect

```
ggplot(hotels, aes(x = hotel, fill = deposit_type)) %>%
  geom_bar()
```

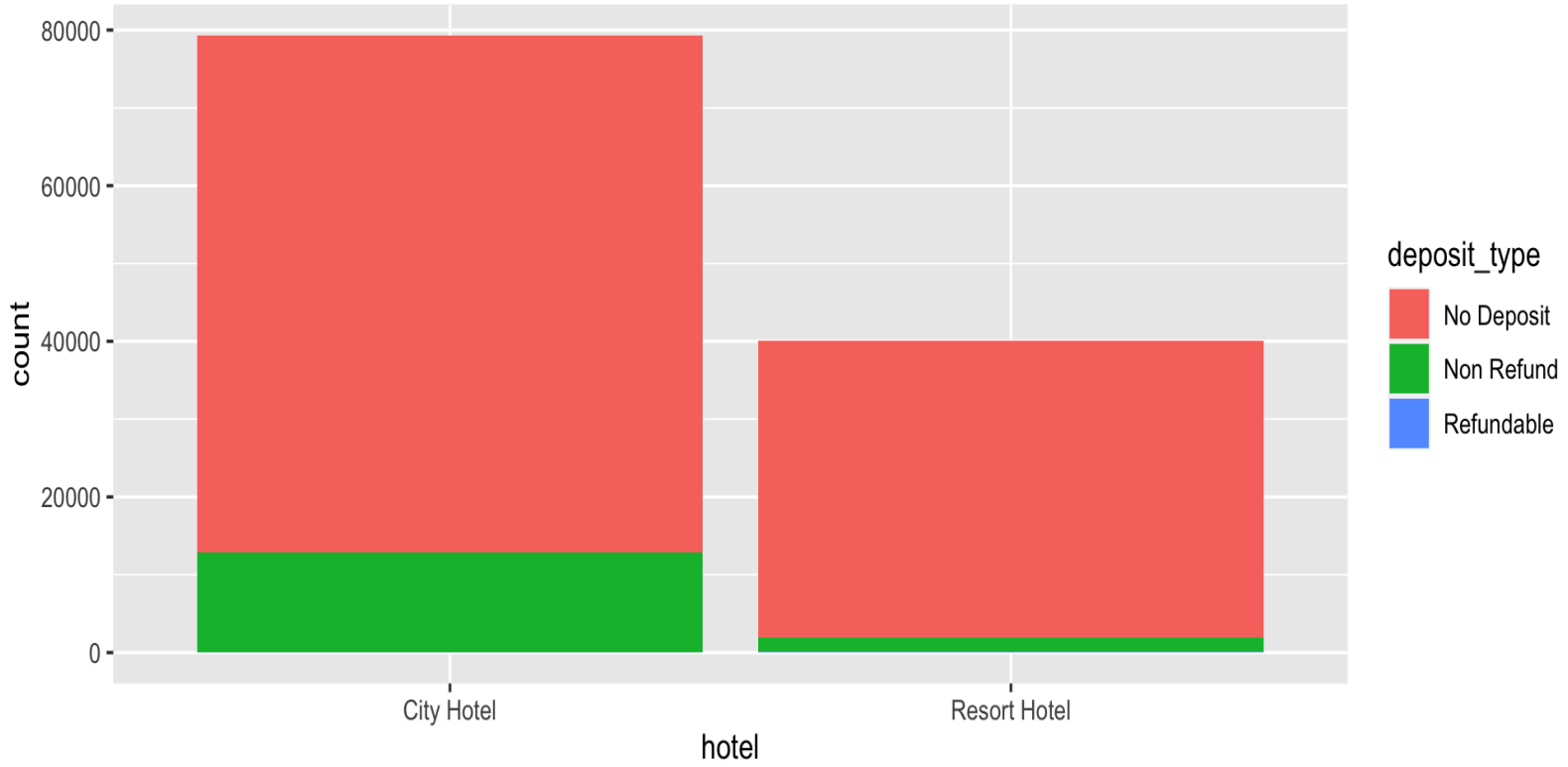
```
## Error in `geom_bar()`:
## ! `mapping` must be created by `aes()`
## ℹ Did you use `%>%` or `|>` instead of `+`?
```

- This is correct

```
ggplot(hotels, aes(x = hotel, fill = deposit_type)) +
  geom_bar()
```

Layering in `ggplot2`

```
ggplot(hotels, aes(x = hotel, fill = deposit_type)) +
  geom_bar()
```



background-image: url(images/logo_all.png) background-position: 98% 1% background-size: 5%

Hotel Booking: Pick rows matching a condition using `filter()`

- Start with the verb

```
hotels %>%
   filter(                          # <-- verb 1
    children >= 1
      ) %>%
         select(hotel, children)  # <-- verb 2
```

- Pass the condition, the column/variable on the left of the conditional operator

```
hotels %>%
  filter(
     children >= 1                # <-- condition
      ) %>%
       select(hotel, children)
```

Hotel Booking: Pick rows matching a condition using `filter()`

```
hotels %>%
  filter(children >= 1) %>%
       select(hotel, children)
```

```
## # A tibble: 8,590 × 2
##    hotel        children
##    <chr>           <dbl>
##  1 Resort Hotel        1
##  2 Resort Hotel        2
##  3 Resort Hotel        2
##  4 Resort Hotel        2
##  5 Resort Hotel        1
##  6 Resort Hotel        1
##  7 Resort Hotel        2
##  8 Resort Hotel        2
##  9 Resort Hotel        1
## 10 Resort Hotel        2
## # … with 8,580 more rows
```

Hotel Booking: Pick rows matching more than one condition using `filter()`

- Start with the verb

```
hotels %>%
   filter(                          # <-- verb 1
    children >= 1
      ) %>%
         select(hotel, children)   # <-- verb 2
```

- Pass the conditions, separated by `,`

```
hotels %>%
  filter(
    children >= 1,                 # <-- condition 1
    hotel == "City Hotel"          # <-- condition 2
      ) %>%
       select(hotel, children)
```

Hotel Booking: Pick rows matching a condition using `filter()`

```
hotels %>%
  filter(children >= 1,hotel == "City Hotel") %>%
       select(hotel, children)
```

```
## # A tibble: 5,106 × 2
##    hotel      children
##    <chr>         <dbl>
##  1 City Hotel        1
##  2 City Hotel        2
##  3 City Hotel        1
##  4 City Hotel        1
##  5 City Hotel        1
##  6 City Hotel        1
##  7 City Hotel        1
##  8 City Hotel        1
##  9 City Hotel        1
## 10 City Hotel        1
## # … with 5,096 more rows
```

Pick rows using `slice()`: No conditional selection

> Choose certain rows/observations without conditions using `slice()`

- Quick recap
  - Choose certain variables/columns using `select()`
  - Conditionally pick rows or observations using `filter()`

Pick rows using `slice()`: No conditional selection

- Start with the verb

```
hotels %>%
  slice(          #<-- verb
        1:5
       )
```

- Pass the indices or the range of indices of the rows to be picked

```
hotels %>%
  slice(
        1:5    #<-- indices
       )
```

Pick rows using `slice()`: No conditional selection

- Using a sequence of indices

```
hotels %>% slice(1:5)
```

```
## # A tibble: 5 × 32
##   hotel   is_ca…¹ lead_…² arriv…³ arriv…⁴ arriv…⁵ arriv…⁶ stays…⁷ stays…⁸ adults
##   <chr>     <dbl>   <dbl>   <dbl> <chr>     <dbl>   <dbl>   <dbl>   <dbl>  <dbl>
## 1 Resort…       0     342    2015 July         27       1       0       0       2
## 2 Resort…       0     737    2015 July         27       1       0       0       2
## 3 Resort…       0       7    2015 July         27       1       0       1       1
## 4 Resort…       0      13    2015 July         27       1       0       1       1
## 5 Resort…       0      14    2015 July         27       1       0       2       2
## # … with 22 more variables: children <dbl>, babies <dbl>, meal <chr>,
## #   country <chr>, market_segment <chr>, distribution_channel <chr>,
## #   is_repeated_guest <dbl>, previous_cancellations <dbl>,
## #   previous_bookings_not_canceled <dbl>, reserved_room_type <chr>,
## #   assigned_room_type <chr>, booking_changes <dbl>, deposit_type <chr>,
## #   agent <chr>, company <chr>, days_in_waiting_list <dbl>,
## #   customer_type <chr>, adr <dbl>, required_car_parking_spaces <dbl>, …
```

Pick rows using `slice()`: No conditional selection

- Using specific indices

```
hotels %>%
  slice(1,3,5)
```

```
## # A tibble: 3 × 32
##   hotel   is_ca…¹ lead_…² arriv…³ arriv…⁴ arriv…⁵ arriv…⁶ stays…⁷ stays…⁸ adults
##   <chr>     <dbl>   <dbl>   <dbl> <chr>     <dbl>   <dbl>   <dbl>   <dbl>  <dbl>
## 1 Resort…       0     342    2015 July         27       1       0       0      2
## 2 Resort…       0       7    2015 July         27       1       0       1      1
## 3 Resort…       0      14    2015 July         27       1       0       2      2
## # … with 22 more variables: children <dbl>, babies <dbl>, meal <chr>,
## #   country <chr>, market_segment <chr>, distribution_channel <chr>,
## #   is_repeated_guest <dbl>, previous_cancellations <dbl>,
## #   previous_bookings_not_canceled <dbl>, reserved_room_type <chr>,
## #   assigned_room_type <chr>, booking_changes <dbl>, deposit_type <chr>,
## #   agent <chr>, company <chr>, days_in_waiting_list <dbl>,
## #   customer_type <chr>, adr <dbl>, required_car_parking_spaces <dbl>, …
```

Pick unique rows using `distinct()`

- Start with the verb

```
distinct(          #<-- verb
          hotels,
            hotel)
```

- Pass the dataframe

```
distinct(
        hotels,    #<-- data-set
          hotel)
```

- Pass the column or variable whose unique entries are to to be picked

```
distinct(
         hotels,
          hotel) #<-- column/variable
```

- The output is a dataframe with only those rows with the unique entries of `hotel`

V. Creating new columns or rows

Creating columns with `mutate()`

- Use `mutate()` to create new columns using existing columns

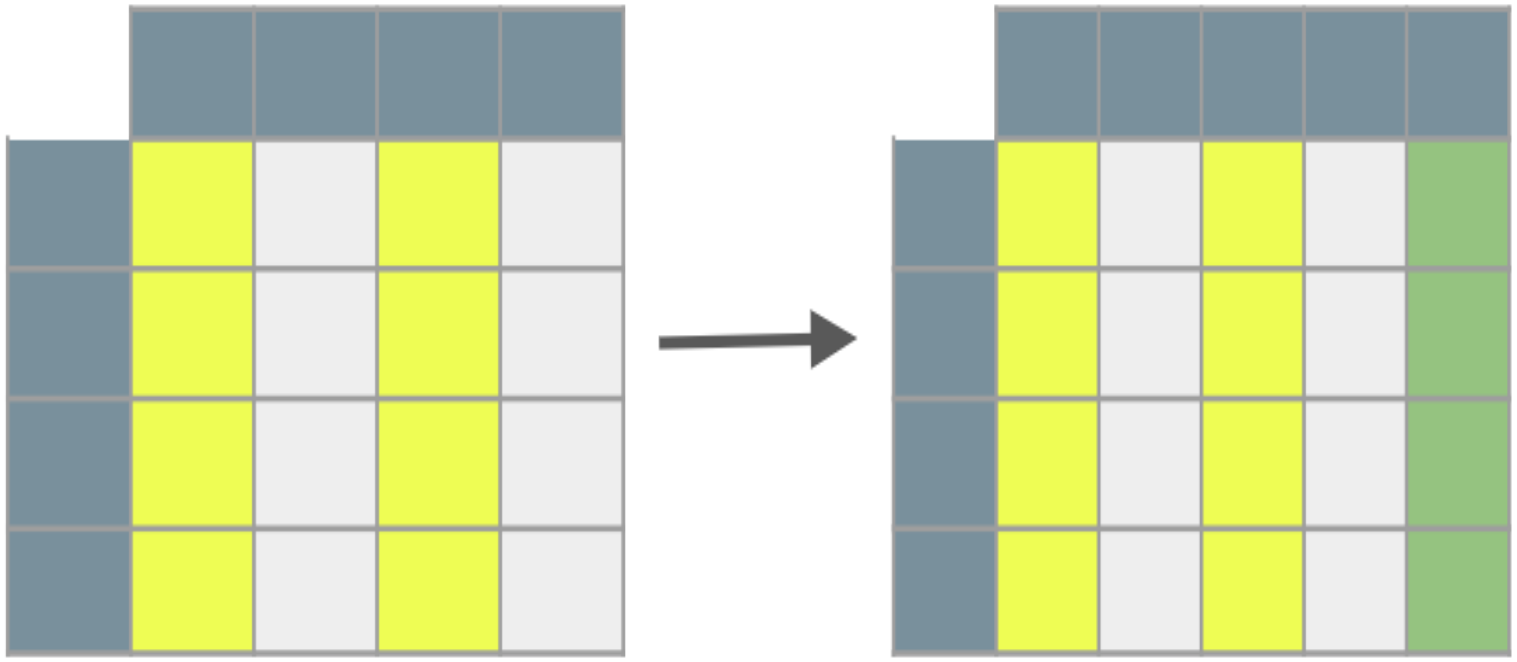


Figure: Create new columns

Creating a single column with `mutate()`

- To create a new column, on the left side of `=` is the name of the new column
- On the right of `=` are the operations on existing columns

```
hotels %>%
   mutate(little_ones = children + babies) %>% #<-- Look here!
    select(hotel, little_ones,children,babies)
```

Creating a single column with `mutate()`

```
hotels %>%
  mutate(little_ones = children + babies) %>%
    select(hotel, little_ones,children,babies)
```

```
## # A tibble: 119,390 × 4
##    hotel        little_ones children babies
##    <chr>              <dbl>    <dbl>  <dbl>
##  1 Resort Hotel           0        0      0
##  2 Resort Hotel           0        0      0
##  3 Resort Hotel           0        0      0
##  4 Resort Hotel           0        0      0
##  5 Resort Hotel           0        0      0
##  6 Resort Hotel           0        0      0
##  7 Resort Hotel           0        0      0
##  8 Resort Hotel           0        0      0
##  9 Resort Hotel           0        0      0
## 10 Resort Hotel           0        0      0
## # … with 119,380 more rows
```

Creating multiple columns with `mutate()`

- To create a new column, on the left side of `=` is the name of the new column
- On the right of `=` are the operations on existing columns
- The columns are separated by `,`
- The newer columns can even use a newly created column(s)

```
hotels %>%
  mutate(little_ones = children + babies,                  #<-- New column 1
         average_little_ones = mean(little_ones)) %>%      #<-- New column 2
    select(hotel, little_ones,children,babies)
```

Creating multiple columns with `mutate()`

```
hotels %>%
  mutate(little_ones = children + babies,
         average_little_ones = mean(little_ones)) %>%
    select(hotel, little_ones,children,babies, average_little_ones)
```

```
## # A tibble: 119,390 × 5
##    hotel        little_ones children babies average_little_ones
##    <chr>              <dbl>    <dbl>  <dbl>                <dbl>
##  1 Resort Hotel           0        0      0                   NA
##  2 Resort Hotel           0        0      0                   NA
##  3 Resort Hotel           0        0      0                   NA
##  4 Resort Hotel           0        0      0                   NA
##  5 Resort Hotel           0        0      0                   NA
##  6 Resort Hotel           0        0      0                   NA
##  7 Resort Hotel           0        0      0                   NA
##  8 Resort Hotel           0        0      0                   NA
##  9 Resort Hotel           0        0      0                   NA
## 10 Resort Hotel           0        0      0                   NA
## # … with 119,380 more rows
```

VI. More operations with examples

`count()` to get frequencies (counts)

```
hotels %>%
  count(market_segment)
```

```
## # A tibble: 8 × 2
##   market_segment     n
##   <chr>          <int>
## 1 Aviation         237
## 2 Complementary    743
## 3 Corporate       5295
## 4 Direct         12606
## 5 Groups         19811
## 6 Offline TA/TO  24219
## 7 Online TA      56477
## 8 Undefined          2
```

- **Note** that count automatically arranges in alphabetical order

`count()` to get frequencies (counts)

```
hotels %>%
  count(market_segment, sort = TRUE) # <-- decreasing order of counts
```

```
## # A tibble: 8 × 2
##   market_segment     n
##   <chr>          <int>
## 1 Online TA      56477
## 2 Offline TA/TO  24219
## 3 Groups         19811
## 4 Direct         12606
## 5 Corporate       5295
## 6 Complementary    743
## 7 Aviation         237
## 8 Undefined          2
```

`count()` multiple variables

```
hotels %>%
  count(hotel, market_segment)
```

```
## # A tibble: 14 × 3
##    hotel        market_segment     n
##    <chr>        <chr>          <int>
##  1 City Hotel   Aviation         237
##  2 City Hotel   Complementary    542
##  3 City Hotel   Corporate       2986
##  4 City Hotel   Direct          6093
##  5 City Hotel   Groups         13975
##  6 City Hotel   Offline TA/TO  16747
##  7 City Hotel   Online TA      38748
##  8 City Hotel   Undefined          2
##  9 Resort Hotel Complementary    201
## 10 Resort Hotel Corporate       2309
## 11 Resort Hotel Direct          6513
## 12 Resort Hotel Groups          5836
## 13 Resort Hotel Offline TA/TO   7472
## 14 Resort Hotel Online TA      17729
```

`summarise()` for summary statistics

> `summarise()` collapses the dataframe down to a single summary statistic

```
# mean average daily rate for all bookings
hotels %>%
  summarise(mean_adr = mean(adr))
```

```
## # A tibble: 1 × 1
##   mean_adr
##      <dbl>
## 1     102.
```

`summarise()` by variable using `group_by()`

```
# mean average daily rate for all booking at city and resort hotels
hotels %>%
  group_by(hotel) %>%
  summarise(mean_adr = mean(adr))
```

```
## # A tibble: 2 × 2
##   hotel        mean_adr
##   <chr>           <dbl>
## 1 City Hotel      105.
## 2 Resort Hotel     95.0
```

`summarise()` by variable using `group_by()`

```
# mean average daily rate for all booking at city and resort hotels
hotels %>%
  group_by(hotel) %>%
  summarise(count = n())
```

```
## # A tibble: 2 × 2
##   hotel        count
##   <chr>        <int>
## 1 City Hotel   79330
## 2 Resort Hotel 40060
```

Calculating frequencies

- These two give the same results

```
hotels %>%
  group_by(hotel) %>%
  summarise(count = n())
```

```
## # A tibble: 2 × 2
##   hotel        count
##   <chr>        <int>
## 1 City Hotel   79330
## 2 Resort Hotel 40060
```

```
hotels %>%
  count(hotel)
```

```
## # A tibble: 2 × 2
##   hotel             n
##   <chr>         <int>
## 1 City Hotel    79330
## 2 Resort Hotel 40060
```

`summarise()` for multiple summary statistics

```
hotels %>%
  summarise(
    min_adr = min(adr),
    mean_adr = mean(adr),
    median_adr = median(adr),
    max_adr = max(adr)
  )
```

```
## # A tibble: 1 × 4
##   min_adr mean_adr median_adr max_adr
##     <dbl>    <dbl>      <dbl>   <dbl>
## 1   -6.38     102.       94.6    5400
```

`select()`, `slice()`, and `arrange()`

```
hotels %>%
  select(hotel, lead_time) %>%
  slice(1:5) %>%
  arrange(lead_time)
```

```
## # A tibble: 5 × 2
##   hotel        lead_time
##   <chr>            <dbl>
## 1 Resort Hotel         7
## 2 Resort Hotel        13
## 3 Resort Hotel        14
## 4 Resort Hotel       342
## 5 Resort Hotel       737
```

`select()`, `arrange()`, and `slice()`

- How is that different from?

```
hotels %>%
  select(hotel, lead_time) %>%
  arrange(lead_time) %>%
  slice(1:5)
```

`select()`, `arrange()`, and `slice()`

- How is that different from?

```
hotels %>%
  select(hotel, lead_time) %>%
  arrange(lead_time) %>%
  slice(1:5)
```

```
## # A tibble: 5 × 2
##   hotel        lead_time
##   <chr>            <dbl>
## 1 Resort Hotel         0
## 2 Resort Hotel         0
## 3 Resort Hotel         0
## 4 Resort Hotel         0
## 5 Resort Hotel         0
```

- the **order of the piping** matters!

as ignored code or comments

```
hotels %>%
  # slice the first five rows  # this line is a comment
  #select(hotel) %>%          # this one doesn't run
  slice(1:5)                  # this line runs
```

```
## # A tibble: 5 × 32
##   hotel   is_ca…¹ lead_…² arriv…³ arriv…⁴ arriv…⁵ arriv…⁶ stays…⁷ stays…⁸ adults
##   <chr>     <dbl>   <dbl>   <dbl> <chr>     <dbl>   <dbl>   <dbl>   <dbl>  <dbl>
## 1 Resort…       0     342    2015 July         27       1       0       0       2
## 2 Resort…       0     737    2015 July         27       1       0       0       2
## 3 Resort…       0       7    2015 July         27       1       0       1       1
## 4 Resort…       0      13    2015 July         27       1       0       1       1
## 5 Resort…       0      14    2015 July         27       1       0       2       2
## # … with 22 more variables: children <dbl>, babies <dbl>, meal <chr>,
## #   country <chr>, market_segment <chr>, distribution_channel <chr>,
## #   is_repeated_guest <dbl>, previous_cancellations <dbl>,
## #   previous_bookings_not_canceled <dbl>, reserved_room_type <chr>,
## #   assigned_room_type <chr>, booking_changes <dbl>, deposit_type <chr>,
## #   agent <chr>, company <chr>, days_in_waiting_list <dbl>,
## #   customer_type <chr>, adr <dbl>, required_car_parking_spaces <dbl>, …
```

`filter()` to select rows based on conditions

- get all rows where `hotel` is "City Hotel" (note the use of `==` as opposed to `=`)

```
# bookings in City Hotels
hotels %>%
  filter(hotel == "City Hotel")
```

```
## # A tibble: 79,330 × 32
##    hotel  is_ca…¹ lead_…² arriv…³ arriv…⁴ arriv…⁵ arriv…⁶ stays…⁷ stays…⁸ adults
##    <chr>    <dbl>   <dbl>   <dbl> <chr>     <dbl>   <dbl>   <dbl>   <dbl>  <dbl>
##  1 City …       0       6    2015 July         27       1       0       2       1
##  2 City …       1      88    2015 July         27       1       0       4       2
##  3 City …       1      65    2015 July         27       1       0       4       1
##  4 City …       1      92    2015 July         27       1       2       4       2
##  5 City …       1     100    2015 July         27       2       0       2       2
##  6 City …       1      79    2015 July         27       2       0       3       2
##  7 City …       0       3    2015 July         27       2       0       3       1
##  8 City …       1      63    2015 July         27       2       1       3       1
##  9 City …       1      62    2015 July         27       2       2       3       2
## 10 City …       1      62    2015 July         27       2       2       3       2
## # … with 79,320 more rows, 22 more variables: children <dbl>, babies <dbl>,
## #   meal <chr>, country <chr>, market_segment <chr>,
## #   distribution_channel <chr>, is_repeated_guest <dbl>,
## #   previous_cancellations <dbl>, previous_bookings_not_canceled <dbl>,
```

`filter()` to select rows based on conditions

- get all rows where adults is 0 and children is greater than or equal to 1

```
hotels %>%
  filter(
    adults == 0,
    children >= 1
    ) %>%
  select(adults, babies, children)
```

```
## # A tibble: 223 × 3
##    adults babies children
##     <dbl>  <dbl>    <dbl>
##  1      0      0        3
##  2      0      0        2
##  3      0      0        2
##  4      0      0        2
##  5      0      0        2
##  6      0      0        3
##  7      0      1        2
##  8      0      0        2
##  9      0      0        2
## 10      0      0        2
## # … with 213 more rows
```

`filter()` to select rows based on (complex) conditions

- get all rows where adults is 1 and children is greater than or equal to 1 or babies is greater than or equal to 1

```
hotels %>%
  filter( adults == 1,
    children >= 1 | babies >=1) %>%    # | means OR
  select(adults, babies, children)
```

```
## # A tibble: 450 × 3
##    adults babies children
##     <dbl>  <dbl>    <dbl>
##  1      1      0        2
##  2      1      0        2
##  3      1      0        1
##  4      1      1        0
##  5      1      0        1
##  6      1      0        1
##  7      1      0        2
##  8      1      0        2
##  9      1      0        1
## 10      1      0        1
```

Logical operators in R

Operator	Definition
<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
==	exactly equal to
!=	not equal to
x & y	x AND y
x | y	x OR y
is.na(x)	test if x is NA
!is.na(x)	test if x is not NA
x %in% y	test if x is in y
!(x %in% y)	test if x is not in y
!x	not x

`count()` and `arrange()` instead

```
hotels %>%
  count(market_segment) %>%
  arrange(desc(n)) # <-- decreasing order of counts
```

```
## # A tibble: 8 × 2
##   market_segment     n
##   <chr>          <int>
## 1 Online TA      56477
## 2 Offline TA/TO  24219
## 3 Groups         19811
## 4 Direct         12606
## 5 Corporate       5295
## 6 Complementary    743
## 7 Aviation         237
## 8 Undefined          2
```

`mutate()` to add new variables

```
hotels %>%
  mutate(little_ones = children + babies) %>% # <---
  select(children, babies, little_ones) %>%
  arrange(desc(little_ones))
```

```
## # A tibble: 119,390 × 3
##    children babies little_ones
##       <dbl>  <dbl>       <dbl>
##  1       10      0          10
##  2        0     10          10
##  3        0      9           9
##  4        2      1           3
##  5        2      1           3
##  6        2      1           3
##  7        3      0           3
##  8        2      1           3
##  9        2      1           3
## 10        3      0           3
## # … with 119,380 more rows
```

`mutate()` and `filter()` using new columns

```
hotels %>%
  mutate(little_ones = children + babies) %>%
  filter(
    little_ones >= 1,
    hotel == "Resort Hotel"
    ) %>%
  select(hotel, little_ones)
```

```
hotels %>%
  mutate(little_ones = children + babies) %>%
  filter(
    little_ones >= 1,
    hotel == "City Hotel"
    )  %>%
  select(hotel, little_ones)
```

`mutate()` and `filter()` using new columns

```
hotels %>%
  mutate(little_ones = children + babies) %>%
  filter(
    little_ones >= 1,
    hotel == "Resort Hotel"
    ) %>%
  select(hotel, little_ones)
```

```
## # A tibble: 3,929 × 2
##    hotel        little_ones
##    <chr>              <dbl>
##  1 Resort Hotel           1
##  2 Resort Hotel           2
##  3 Resort Hotel           2
##  4 Resort Hotel           2
##  5 Resort Hotel           1
##  6 Resort Hotel           1
##  7 Resort Hotel           2
##  8 Resort Hotel           2
##  9 Resort Hotel           1
## 10 Resort Hotel           1
## #   with 3,919 more rows
```

```
hotels %>%
  mutate(little_ones = children + babies) %>%
  filter(
    little_ones >= 1,
    hotel == "City Hotel"
    )  %>%
  select(hotel, little_ones)
```

```
## # A tibble: 5,403 × 2
##    hotel      little_ones
##    <chr>            <dbl>
##  1 City Hotel           1
##  2 City Hotel           1
##  3 City Hotel           2
##  4 City Hotel           1
##  5 City Hotel           1
##  6 City Hotel           1
##  7 City Hotel           1
##  8 City Hotel           1
##  9 City Hotel           1
## 10 City Hotel           1
## #   with 5,393 more rows
```

Recap

We have learned,

a. How to use some functions in `dplyr` package to manipulate data. This included,

- `select()` to pick columns
- `arrange()` to order data
- `mutate()` to create new columns
- `filter()` to extract rows matching some criteria
- `count()` to determine frequency of occurrence
- `summarise()` for summary statistics
- `slice()` for non-conditional selection

b. Use of logical operators

c. Piping operators

Thanks!

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gadenbuie/xaringanthemer.

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