Stat 480 - Midterm

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Tracking the Global Outbreak of COVID-19

The coronavirus pandemic has sickened more than 1.4 million people, according to official counts. Here, we will explore both the global and local growth of COVID-19 using data sourced on April 8th, 2020.

Part I: Recovery data

This data set contains information on some of the first fully recovered cases of COVID-19. We will look at the time it took these patients to recover, defined as the number of days between a confirmed test and an official discharge date. The data is available at https://raw.githubusercontent.com/Stat480-at-ISU/Stat480-at-ISU.github.io/master/exams/data/covid19-recovered.csv (https://raw.githubusercontent.com/Stat480-at-ISU/Stat480-at-ISU.github.io/master/exams/data/covid19-recovered.csv)

Question #1: An overview

i. Read the data without downloading the file locally.

```
recovery_data <- readr::read_csv("https://raw.githubusercontent.com/Stat480-at-ISU/Stat480-at-ISU.github.io/master/exams/data/covid19-recovered.csv")
```

ii. A first look:

- What are the dimensions of the data?
- What variables are included and what are their types?

```
dim(recovery_data)
```

```
## [1] 100   6
```

```
str(recovery_data)
```

```
## tibble [100 x 6] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
##  $ confirmed : chr [1:100] "1/23/2020" "1/24/2020" "1/24/2020" "1/25/2020" ...
##  $ discharged: chr [1:100] "2020/2/19" "2020/2/7" "2020/2/21" "2020/2/12" ...
##  $ recovery  : chr [1:100] "27 days" "14 days" "28 days" "18 days" ...
##  $ category  : chr [1:100] "Imported" "Imported" "Imported" "Imported" ...
##  $ age       : num [1:100] 66 53 37 36 56 56 35 56 56 56 ...
##  $ gender    : num [1:100] 1 0 1 1 0 1 1 0 1 1 ...
##  - attr(*, "spec")=
##   .. cols(
##   ..   confirmed = col_character(),
##   ..   discharged = col_character(),
##   ..   recovery = col_character(),
##   ..   category = col_character(),
##   ..   age = col_double(),
##   ..   gender = col_double()
##   .. )
```

Variables:confirmed, discharged, recovery, category, age, gender Variables type:chr,chr,chr,chr,num,num

Question #2: Some wrangling

In order to continue with an analysis of this data, we should make some modifications to it.

i. Use functions from the `tidyverse` package to make the following modifications:
   - Convert the variables `confirmed` and `discharged` into variables of type “date”.

```
library(tidyverse)
library(lubridate)
library(readr)

recovery_data <- recovery_data %>% mutate(confirmed= mdy(confirmed),discharged= ymd(discharged))
str(recovery_data)
```

```
## tibble [100 x 6] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
##  $ confirmed : Date[1:100], format: "2020-01-23" "2020-01-24" ...
##  $ discharged: Date[1:100], format: "2020-02-19" "2020-02-07" ...
##  $ recovery  : chr [1:100] "27 days" "14 days" "28 days" "18 days" ...
##  $ category  : chr [1:100] "Imported" "Imported" "Imported" "Imported" ...
##  $ age       : num [1:100] 66 53 37 36 56 56 35 56 56 56 ...
##  $ gender    : num [1:100] 1 0 1 1 0 1 1 0 1 1 ...
```

```
- Extract the numeric value from the variable `recovery`.
```

```
recovery_data <- recovery_data %>% mutate(recovery= parse_number(recovery))
head(recovery_data)
```

```
## # A tibble: 6 x 6
##   confirmed  discharged recovery category   age gender
##   <date>     <date>        <dbl> <chr>    <dbl>  <dbl>
## 1 2020-01-23 2020-02-19       27 Imported    66      1
## 2 2020-01-24 2020-02-07       14 Imported    53      0
## 3 2020-01-24 2020-02-21       28 Imported    37      1
## 4 2020-01-25 2020-02-12       18 Imported    36      1
## 5 2020-01-27 2020-02-18       22 Imported    56      0
## 6 2020-01-27 2020-02-20       24 Imported    56      1
```

```
- Re-derive the variable `recovery` as the number of days between `confirmed` and `discharged` a
nd save as `recovery_days`.
```

```
recovery_data <- recovery_data %>% mutate(recovery_days= discharged-confirmed)
head(recovery_data)
```

```
## # A tibble: 6 x 7
##   confirmed  discharged recovery category   age gender recovery_days
##   <date>     <date>        <dbl> <chr>    <dbl>  <dbl> <drtn>
## 1 2020-01-23 2020-02-19       27 Imported    66      1 27 days
## 2 2020-01-24 2020-02-07       14 Imported    53      0 14 days
## 3 2020-01-24 2020-02-21       28 Imported    37      1 28 days
## 4 2020-01-25 2020-02-12       18 Imported    36      1 18 days
## 5 2020-01-27 2020-02-18       22 Imported    56      0 22 days
## 6 2020-01-27 2020-02-20       24 Imported    56      1 24 days
```

```
- Convert the variable `category` from type `character` to type `factor`.
- Save this data as `recovered` and use this data for the remaining questions in part I.
```

```
recovered <- recovery_data %>% mutate(category= as.factor(category))
str(recovered)
```

```
## tibble [100 x 7] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
##  $ confirmed    : Date[1:100], format: "2020-01-23" "2020-01-24" ...
##  $ discharged   : Date[1:100], format: "2020-02-19" "2020-02-07" ...
##  $ recovery     : num [1:100] 27 14 28 18 22 24 8 21 25 11 ...
##  $ category     : Factor w/ 2 levels "Imported","Local": 1 1 1 1 1 1 1 1 1 1 ...
##  $ age          : num [1:100] 66 53 37 36 56 56 35 56 56 56 ...
##  $ gender       : num [1:100] 1 0 1 1 0 1 1 0 1 1 ...
##  $ recovery_days: 'difftime' num [1:100] 27 14 28 18 ...
##   ..- attr(*, "units")= chr "days"
```

ii. Look at a summary of the variables:

```
summary(recovered)
```

```
##    confirmed            discharged           recovery         category
##  Min.   :2020-01-23   Min.   :2020-02-04   Min.   : 1.00   Imported:23
##  1st Qu.:2020-02-04   1st Qu.:2020-02-18   1st Qu.: 7.00   Local   :77
##  Median :2020-02-12   Median :2020-02-23   Median :11.00
##  Mean   :2020-02-11   Mean   :2020-02-24   Mean   :12.29
##  3rd Qu.:2020-02-17   3rd Qu.:2020-03-02   3rd Qu.:16.25
##  Max.   :2020-03-08   Max.   :2020-03-14   Max.   :31.00
##       age            gender    recovery_days
##  Min.   : 0.50   Min.   :0.0   Length:100
##  1st Qu.:34.75   1st Qu.:0.0   Class :difftime
##  Median :41.50   Median :1.0   Mode  :numeric
##  Mean   :42.53   Mean   :0.6
##  3rd Qu.:54.00   3rd Qu.:1.0
##  Max.   :79.00   Max.   :1.0
```

iii. What was the longest amount of time someone represented in this data took to recover from COVID-19? Which observation was this? Use indexing to print this row of the data frame.

```
#first method
max(recovered$recovery)
```

```
## [1] 31
```

```
which.max(recovered$recovery)
```

```
## [1] 50
```

```
recovered[which.max(recovered$recovery),]
```

```
## # A tibble: 1 x 7
##   confirmed  discharged recovery category   age gender recovery_days
##   <date>     <date>        <dbl> <fct>    <dbl>  <dbl> <drtn>
## 1 2020-02-12 2020-03-14       31 Local       54      1 31 days
```

```
#second method
recovered %>% slice(which.max(recovery))
```

```
## # A tibble: 1 x 7
##   confirmed  discharged recovery category   age gender recovery_days
##   <date>     <date>        <dbl> <fct>    <dbl>  <dbl> <drtn>
## 1 2020-02-12 2020-03-14       31 Local       54      1 31 days
```

31 days. observation 50.

iv. When was the first confirmed case in this data? Which observation is this? Use indexing to print this row of the data frame.

```
#first method
min(recovered$confirmed)
```

```
## [1] "2020-01-23"
```

```
which.min(recovered$confirmed)
```

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

```
recovered[which.min(recovered$confirmed),]
```

```
## # A tibble: 1 x 7
##   confirmed  discharged recovery category   age gender recovery_days
##   <date>     <date>        <dbl> <fct>    <dbl>  <dbl> <drtn>
## 1 2020-01-23 2020-02-19       27 Imported    66      1 27 days
```

```
#second method
recovered %>% slice(which.min(confirmed))
```

```
## # A tibble: 1 x 7
##   confirmed  discharged recovery category   age gender recovery_days
##   <date>     <date>        <dbl> <fct>    <dbl>  <dbl> <drtn>
## 1 2020-01-23 2020-02-19       27 Imported    66      1 27 days
```

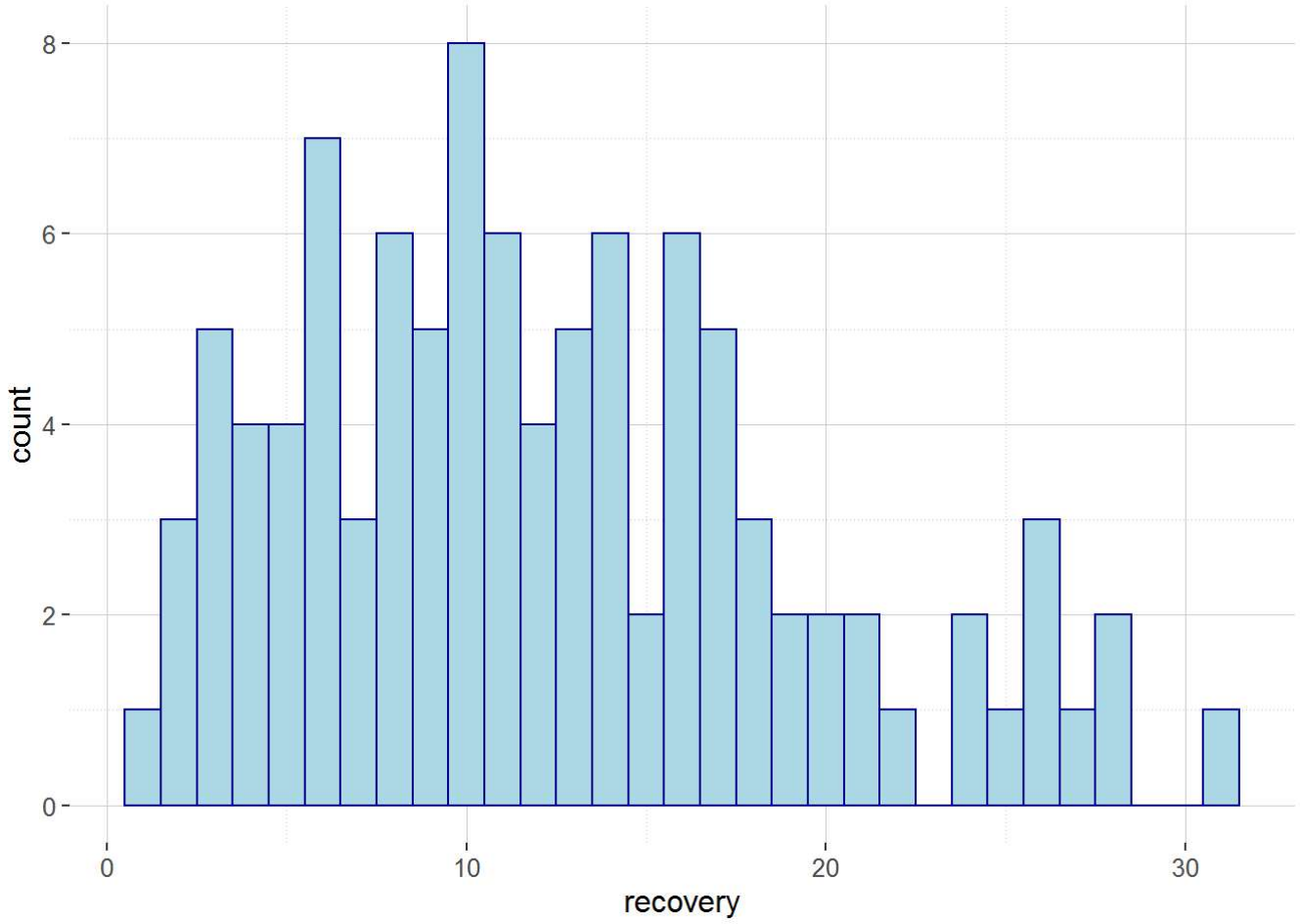
date “2020-01-23” observation 1

Question #4: Time to recovery

If indeed infected, how long would it take for you to be free of the novel coronavirus?

i. Use `ggplot2` to look at the distribution of the variable `recovery` (you may need to adjust the size of the bins).

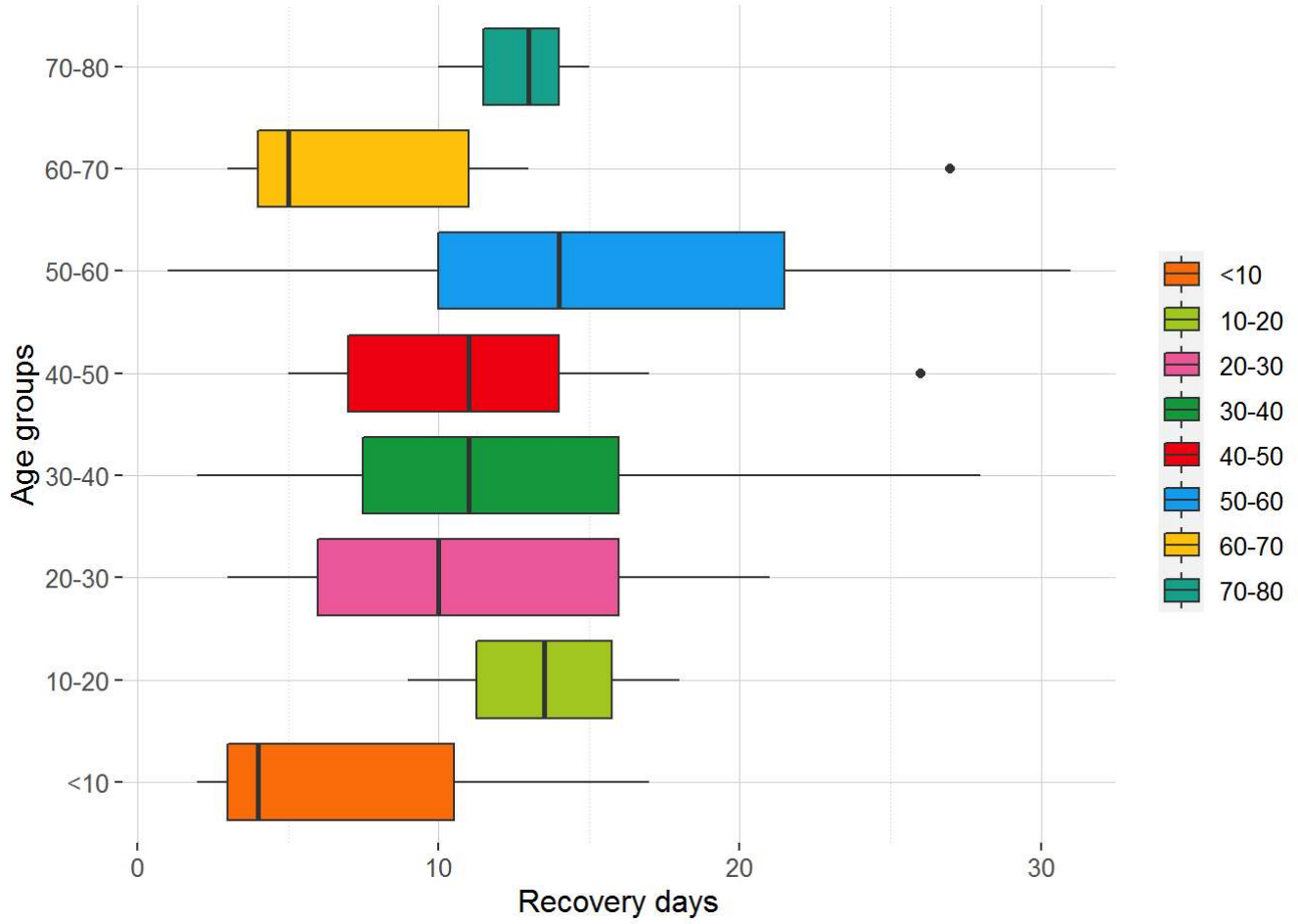
```
recovered %>% ggplot(aes(x = recovery)) +
  geom_histogram(binwidth = 1,color="darkblue", fill="lightblue")
```



ii. Is there a difference in the time it took to recover for different ages?

- Create a new variable `age_blks` from `age` that introduces age categories that groups the ages of the patients into intervals: < 10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, and >80. (see ?cut).
- Create side-by-side boxplots of the number of days to recovery for the different age groups.
- Flip the coordinates and map the variable `age_blks` to the fill aesthetic.

```
recovered%>% mutate(age_blks=cut(age, c(0,10,20,30,40,50,60,70,80,200),
              labels = c('<10','10-20','20-30','30-40','40-50','50-60','60-70','70-80','>80')))
 %>% group_by(age_blks) %>% ggplot(aes(x=as.factor(age_blks),y=recovery,fill=as.factor(age_blk
s))) +
  geom_boxplot() +
  coord_flip()+
  labs(x ="Age groups", y = "Recovery days")
```

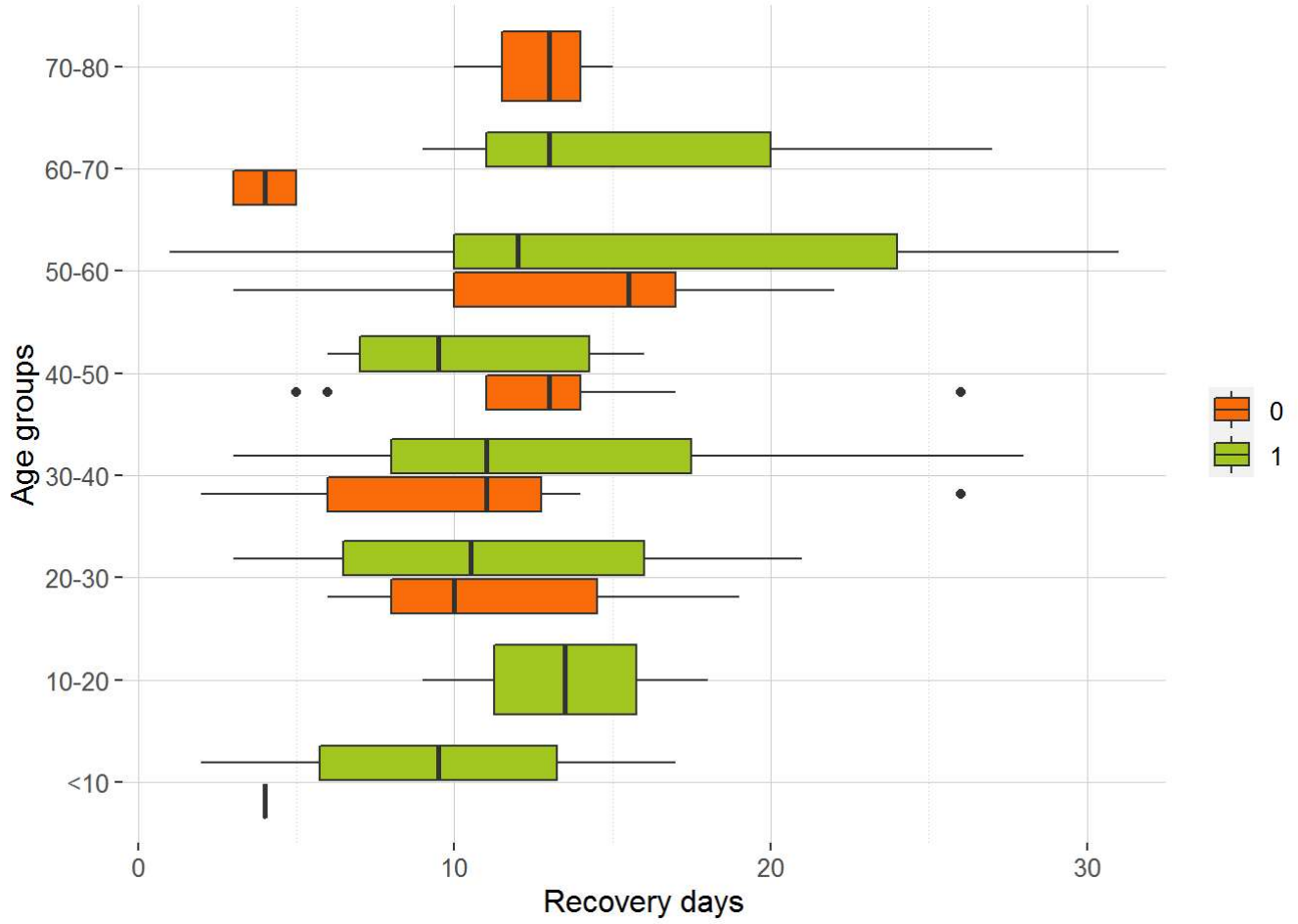


It seems age group <10 recover sooner but we can not conclud it certainly because there is a a small number of data points in this group. Also, for other age group there is no spesific pattern to makea conclusion.

iii. Is there a difference between the genders in the time it took to recover for any of the groups?

- Use the age blocks created in the last question.
- Create side-by-side boxplots for males and females (1's and 0's, respectively) for each of the age groups.
- Fill your boxplots by mapping the variable `gender` to the aesthetic `fill` .

```
recovered%>% mutate(age_blks=cut(age, c(0,10,20,30,40,50,60,70,80,200),
              labels = c('<10','10-20','20-30','30-40','40-50','50-60','60-70','70-80','>80')))
 %>% group_by(age_blks,gender) %>% ggplot(aes(x=as.factor(age_blks),y=recovery,fill=as.factor(ge
nder))) +
  geom_boxplot() +
  coord_flip()+
  labs(x ="Age groups", y = "Recovery days")
```



It seems that women recover sooner than men.

Part II: Global Data

Question #1: First Overview

i. Read the data from https://raw.githubusercontent.com/Stat480-at-ISU/Stat480-at-ISU.github.io/master/exams/data/covid19-global.csv (https://raw.githubusercontent.com/Stat480-at-ISU/Stat480-at-ISU.github.io/master/exams/data/covid19-global.csv) without downloading the file locally. Each line of the file contains daily counts for Province/State-County/Region pair.

```
global_data <- readr::read_csv("https://raw.githubusercontent.com/Stat480-at-ISU/Stat480-at-ISU.github.io/master/exams/data/covid19-global.csv")
```

ii. How many rows and columns does the data have?

```
dim(global_data)
```

```
## [1] 263  81
```

rows=263 cols=81

iii. What are the variables called?

```
colnames(global_data)
```

```
##  [1] "Province/State" "Country/Region" "Lat"           "Long"
##  [5] "1/22/20"        "1/23/20"        "1/24/20"        "1/25/20"
##  [9] "1/26/20"        "1/27/20"        "1/28/20"        "1/29/20"
## [13] "1/30/20"        "1/31/20"        "2/1/20"         "2/2/20"
## [17] "2/3/20"         "2/4/20"         "2/5/20"         "2/6/20"
## [21] "2/7/20"         "2/8/20"         "2/9/20"         "2/10/20"
## [25] "2/11/20"        "2/12/20"        "2/13/20"        "2/14/20"
## [29] "2/15/20"        "2/16/20"        "2/17/20"        "2/18/20"
## [33] "2/19/20"        "2/20/20"        "2/21/20"        "2/22/20"
## [37] "2/23/20"        "2/24/20"        "2/25/20"        "2/26/20"
## [41] "2/27/20"        "2/28/20"        "2/29/20"        "3/1/20"
## [45] "3/2/20"         "3/3/20"         "3/4/20"         "3/5/20"
## [49] "3/6/20"         "3/7/20"         "3/8/20"         "3/9/20"
## [53] "3/10/20"        "3/11/20"        "3/12/20"        "3/13/20"
## [57] "3/14/20"        "3/15/20"        "3/16/20"        "3/17/20"
## [61] "3/18/20"        "3/19/20"        "3/20/20"        "3/21/20"
## [65] "3/22/20"        "3/23/20"        "3/24/20"        "3/25/20"
## [69] "3/26/20"        "3/27/20"        "3/28/20"        "3/29/20"
## [73] "3/30/20"        "3/31/20"        "4/1/20"         "4/2/20"
## [77] "4/3/20"         "4/4/20"         "4/5/20"         "4/6/20"
## [81] "4/7/20"
```

iv. Rename the variables `Province/State`, `Country/Region`, `Lat`, and `Long` to be `province`, `country`, `lat`, and `long`, respectively.

```
colnames(global_data)[1:4] <-c('province','country','lat','long')
colnames(global_data)
```

```
##  [1] "province" "country"  "lat"      "long"     "1/22/20"  "1/23/20"
##  [7] "1/24/20"  "1/25/20"  "1/26/20"  "1/27/20"  "1/28/20"  "1/29/20"
## [13] "1/30/20"  "1/31/20"  "2/1/20"   "2/2/20"   "2/3/20"   "2/4/20"
## [19] "2/5/20"   "2/6/20"   "2/7/20"   "2/8/20"   "2/9/20"   "2/10/20"
## [25] "2/11/20"  "2/12/20"  "2/13/20"  "2/14/20"  "2/15/20"  "2/16/20"
## [31] "2/17/20"  "2/18/20"  "2/19/20"  "2/20/20"  "2/21/20"  "2/22/20"
## [37] "2/23/20"  "2/24/20"  "2/25/20"  "2/26/20"  "2/27/20"  "2/28/20"
## [43] "2/29/20"  "3/1/20"   "3/2/20"   "3/3/20"   "3/4/20"   "3/5/20"
## [49] "3/6/20"   "3/7/20"   "3/8/20"   "3/9/20"   "3/10/20"  "3/11/20"
## [55] "3/12/20"  "3/13/20"  "3/14/20"  "3/15/20"  "3/16/20"  "3/17/20"
## [61] "3/18/20"  "3/19/20"  "3/20/20"  "3/21/20"  "3/22/20"  "3/23/20"
## [67] "3/24/20"  "3/25/20"  "3/26/20"  "3/27/20"  "3/28/20"  "3/29/20"
## [73] "3/30/20"  "3/31/20"  "4/1/20"   "4/2/20"   "4/3/20"   "4/4/20"
## [79] "4/5/20"   "4/6/20"   "4/7/20"
```

v. Each row contains data for one province-country pair. How many countries are represented in this data set?

```
length(unique(global_data$country))
```

```
## [1] 184
```

vi. For each country represented, how many provinces are recorded? Print a table for the five countries with the largest number of provinces recorded.

```
global_data %>% group_by(country) %>% summarise(n_province=length(unique(province[!is.na(provinc
e)]))) %>% arrange(desc(n_province)) %>% top_n(n_province,n=5)
```

```
## # A tibble: 5 x 2
##   country        n_province
##   <chr>               <int>
## 1 China                  33
## 2 Canada                 15
## 3 France                 10
## 4 United Kingdom         10
## 5 Australia               8
```

vii. How many countries do not have any provinces recorded in this data?

```
countries<-global_data %>% group_by(country) %>% summarise(n_province=length(unique(province[!i
s.na(province)])))

n_zero_province<-sum(countries$n_province==0)
n_zero_province
```

```
## [1] 177
```

Question #2: Data wrangling

In order to continue with an analysis of this data, we should reshape it.

i. Use functions from the `tidyverse` package to modify the shape and form of the data:
   - Use a function from `dplyr` to remove the `lat` and `long` variables from the `cases` data.
   - Then use a function from the `tidyr` package to move from wide format into long format where each row represents the number of confirmed cases on a particular date for each country-province pair.
   - Lastly, use a function from `lubridate` to convert the variable `date` from a string into an object of type `date`.
   - Save the resulting data frame as `cases_long`.

```
library(tidyr)
library(lubridate)

cases_long <- global_data %>% select (-c(lat, long)) %>%
pivot_longer(cols = -c('country','province'),
             names_to = "date_",
             values_to = "confirmed")  %>% mutate(date=mdy(date_)) %>% select(c('country','provi
nce','date','confirmed'))
```

ii. Identify the nine countries with the largest number of confirmed cases and save these in a data frame named `cases_by_country`. Plan of attack:
   - Begin with the data frame `cases_long`.
   - Calculate the number of confirmed cases for each country on each date.
   - Find the rank of the countries by current number of confirmed cases for each country.
   - Filter the top nine countries.
   - Save this data frame as `cases_by_country`.

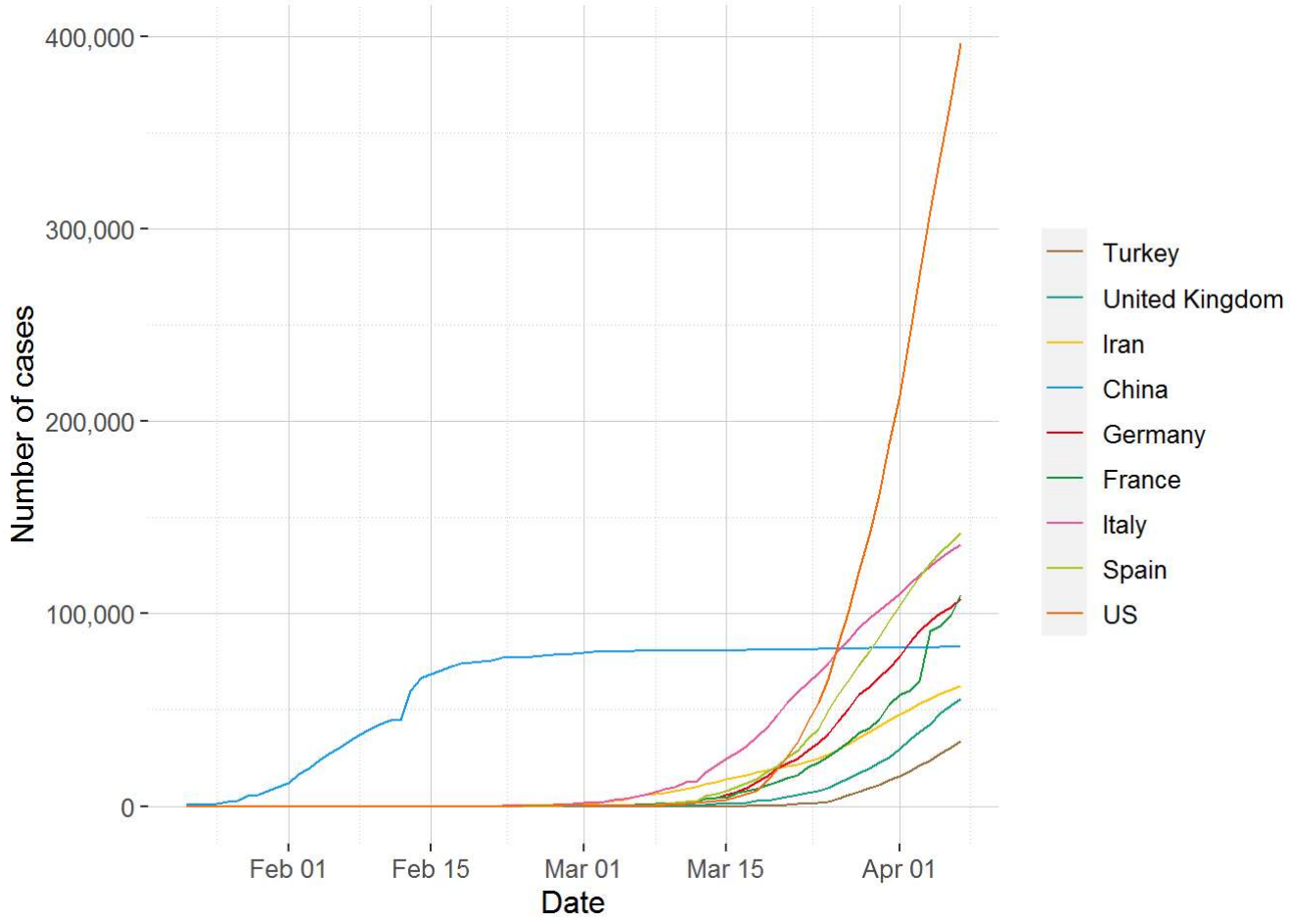
```
temp_data <-cases_long %>% group_by(country,date) %>% summarise(n_cases=sum(confirmed)) %>% ungr
oup()
top_nine_countries<-temp_data %>% filter(date=='2020-04-07') %>% arrange(desc(n_cases)) %>% slic
e(1:9)
names<-top_nine_countries$country
cases_by_country<- temp_data %>% filter(country %in% names)
```

Question #3: Growth over time

i. Let's look at how the number confirmed cases for these nine countries grew over time.

- Start with the data frame `cases_by_country`.
- Use `ggplot2` to plot the number of confirmed cases for each of the nine countries over time.
- Map the variable `country` to color and use the function `fct_reorder2()` from the `forcats` package to align the colors of the lines with the colors in the legend.
- Optional: to make the y-axis labels more readable, add the layer `+ scale_y_continuous(labels = scales::comma)`.

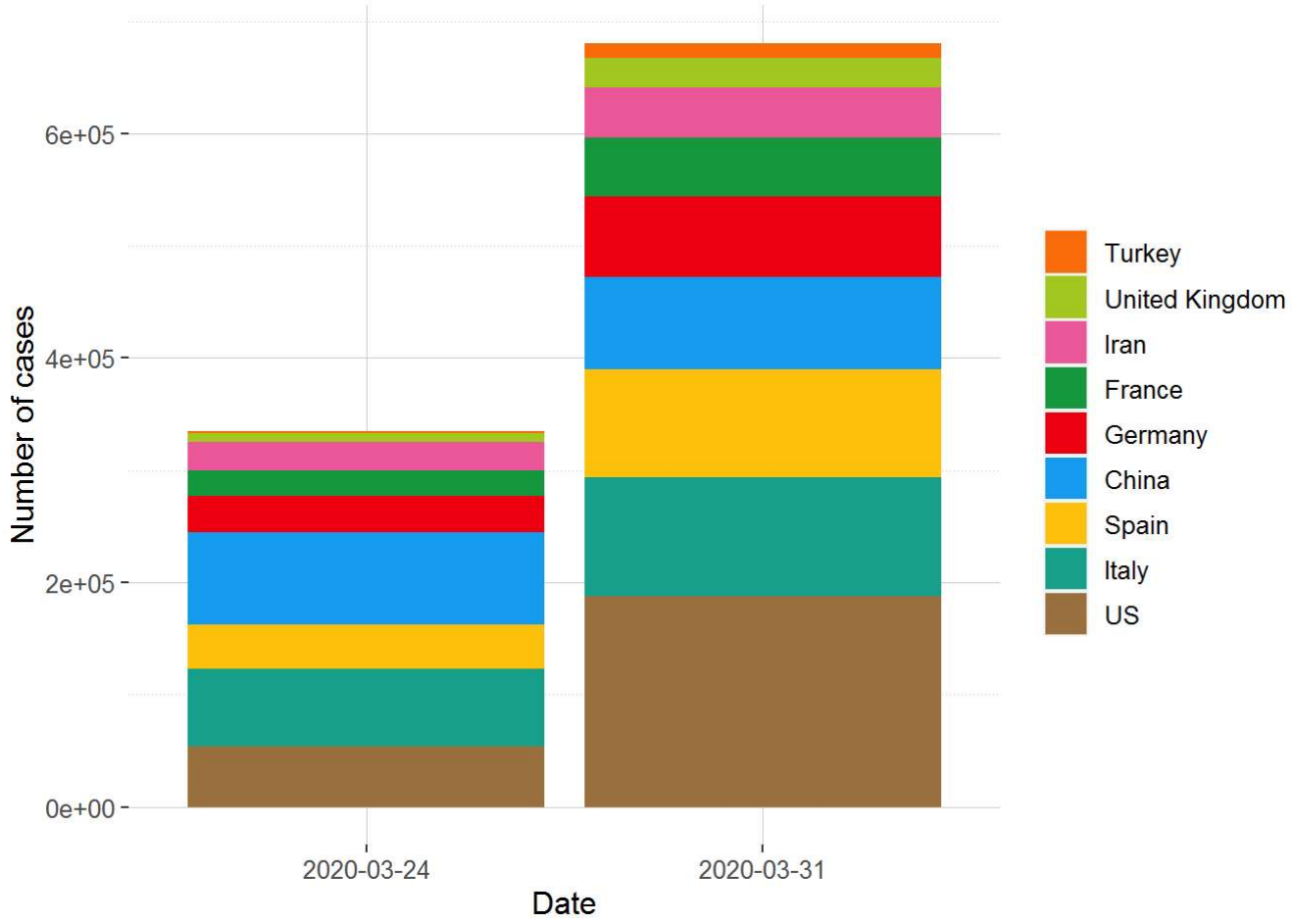
```
library(forcats)
cases_by_country %>% ggplot(aes(x=date,y=n_cases,color=fct_reorder(country,n_cases,.fun="max")))
+
  geom_line() +
  scale_y_continuous(labels = scales::comma)+
  labs(y="Number of cases",x="Date")
```



ii. Let's next look at the difference the last week of March made (Mar 24 vs. Mar 31).

- Use `ggplot2` to create a barchart of the number of cases for the top nine countries for the two dates, sorted according to the total number of cases in that country.
- Make sure the labels of the bars are readable and fill by country.

```
cases_by_country %>% filter((date == "2020-03-24") | (date == "2020-03-31")) %>%
   ggplot(aes(x=as.factor(date),y=n_cases,fill=fct_reorder(country,n_cases,.fun="max"))) +geom_b
ar(stat="identity")+
    labs(y="Number of cases",x="Date")
```



Question #4: Some summaries

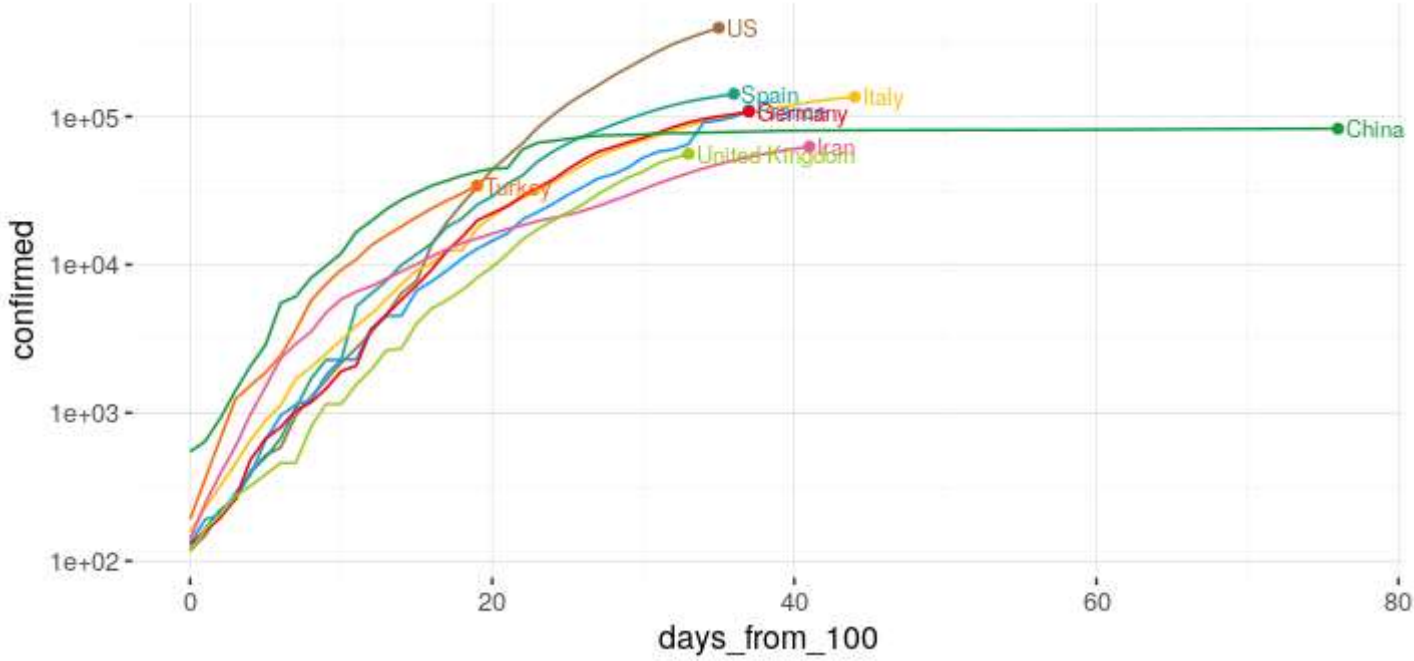
i. How many days did it take for each of the nine countries to go from their 500th case to their 20,000th case?

```
cases_by_country %>% mutate(case_blks=cut(n_cases, c(-1,500,20000,400000), labels = c('<500','50
0-20k','>20k'))) %>% group_by(case_blks) %>% filter(case_blks=="500-20k") %>% group_by(country)
 %>%
  summarise(date_of_500=min(date),date_of_20k=max(date),duration=max(date)-min(date))
```

```
## # A tibble: 9 x 4
##   country        date_of_500 date_of_20k duration
##   <chr>          <date>      <date>      <drtn>
## 1 China          2020-01-22  2020-02-03  12 days
## 2 France         2020-03-06  2020-03-22  16 days
## 3 Germany        2020-03-06  2020-03-20  14 days
## 4 Iran           2020-02-29  2020-03-20  20 days
## 5 Italy          2020-02-27  2020-03-13  15 days
## 6 Spain          2020-03-08  2020-03-19  11 days
## 7 Turkey         2020-03-21  2020-04-02  12 days
## 8 United Kingdom 2020-03-13  2020-03-29  16 days
## 9 US             2020-03-08  2020-03-20  12 days
```

ii. Let's take another look at how the number of cases has grown. This time, though, let's look at the growth for each country starting at their 100th case.

- For each country, calculate the first date that the country had 100 or more cases.
- Introduce a new variable that transforms the date variable into the number of days since the 100th case.
- Save this data frame as `cases100`.
- Create a subset of the `cases100` that contains only the last date and save as `cases100_last`.
- Extra credit: Using `cases100` and `cases100_last`, recreate the visualization below.




```
cases100 <- cases_by_country %>% mutate(case_blks=cut(n_cases, c(-1,100,400000), labels = c('<10
0','>100'))) %>% group_by(case_blks) %>% filter(case_blks==">100") %>% group_by(country) %>% sum
marise(date_of_100=min(date),last_date=max(date),days_Since_100=max(date)-min(date))

cases100_last<- cases100 %>% select(last_date)
```

```
library(directlabels)


cases_by_country %>% left_join(cases100,by="country") %>% mutate(date_diff=date-date_of_100) %>%
filter(date_diff>0) %>% ggplot(aes(x=date_diff,y=n_cases,color=fct_reorder(country,n_cases,.fun=
"max")))+
  geom_line()+
  theme(legend.position="none")+
  geom_dl(aes(label = fct_reorder(country,n_cases,.fun="max")), method = list(dl.combine("last.p
oints"), cex = 0.6)) +
    labs(y="confirmed",x="days_from_100")
```