

# COVID-19 Data Analysis with R - Worldwide\*

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# 1 Introduction

This is an analysis report of the Novel Coronavirus (COVID-19) around the world, to demonstrate data processing and visualisation with R, *tidyverse* and *ggplot2*. This report will be updated from time to time, with new data and more analysis. Please find its latest version at <http://www.rdatamining.com/docs/Coronavirus-data-analysis-world.pdf>.

A similar COVID-19 analysis report for China is available at <http://www.rdatamining.com/docs/Coronavirus-data-analysis-china.pdf>, if you are particularly interested what has happened in China.

## 1.1 Data Source

The data source used for this analysis is *the 2019 Novel Coronavirus COVID-19 (2019-nCoV) Data Repository*<sup>1</sup> built by the Center for Systems Science and Engineering, Johns Hopkins University.

## 1.2 R Packages

Below is a list of R packages used for this analysis. Package *magrittr* is for pipe operations like `%>%` and `%<>%` and *lubridate* for date operations. Package *tidyverse* is a collection of R packages for data science, including *dplyr* and *tidyr* for data processing and *ggplot2* for graphics. Package *gridExtra* is for arranging multiple grid-based plots on a page and *kableExtra* works together with `kable()` from *knitr* to build complex HTML or LaTeX tables.

```
library(magrittr) # pipe operations
library(lubridate) # date operations
library(tidyverse) # ggplot2, tidyr, dplyr...
library(gridExtra) # multiple grid-based plots on a page
library(ggforce) # accelerating ggplot2
library(kableExtra) # complex tables
library(leaflet) # map
```

# 2 Loading Data

At first, the datasets, which are three CSV files, are downloaded and saved as local files and then are loaded into R.

```
## source data files
filenames <- c('time_series_covid19_confirmed_global.csv',
               'time_series_covid19_deaths_global.csv',
               'time_series_covid19_recovered_global.csv')
url.path <- paste0('https://raw.githubusercontent.com/CSSEGISandData/COVID-19/',
                  'master/csse_covid_19_data/csse_covid_19_time_series/')

## download files to local
download <- function(filename) {
  url <- file.path(url.path, filename)
  dest <- file.path('./data', filename)
  download.file(url, dest)
}
bin <- lapply(filenames, download)

## load data into R
raw.data.confirmed <- read.csv('./data/time_series_covid19_confirmed_global.csv')
raw.data.deaths <- read.csv('./data/time_series_covid19_deaths_global.csv')
```

<sup>1</sup><https://github.com/CSSEGISandData/COVID-19>

```
raw.data.recovered <- read.csv('./data/time_series_covid19_recovered_global.csv')

dim(raw.data.confirmed)
```

```
## [1] 266 188
```

Each dataset has 266 rows, corresponding to country/region/province/state. It has 188 columns. Starting from column 5, each column corresponds to a single day. Here we have a look at the first 10 rows and the first 10 columns.

```
raw.data.confirmed[1:10, 1:10] %>%
  kable('latex', booktabs=T, caption='Raw Data (Confirmed, First 10 Columns only)') %>%
  kable_styling(font_size=5, latex_options = c('striped', 'hold_position', 'repeat_header'))
```

Table 1: Raw Data (Confirmed, First 10 Columns only)

Province.State	Country.Region	Lat	Long	X1.22.20	X1.23.20	X1.24.20	X1.25.20	X1.26.20	X1.27.20
	Afghanistan	33.93911	67.70995	0	0	0	0	0	0
	Albania	41.15330	20.16830	0	0	0	0	0	0
	Algeria	28.03390	1.65960	0	0	0	0	0	0
	Andorra	42.50630	1.52180	0	0	0	0	0	0
	Angola	-11.20270	17.87390	0	0	0	0	0	0
	Antigua and Barbuda	17.06080	-61.79640	0	0	0	0	0	0
	Argentina	-38.41610	-63.61670	0	0	0	0	0	0
	Armenia	40.06910	45.03820	0	0	0	0	0	0
Australian Capital Territory	Australia	-35.47350	149.01240	0	0	0	0	0	0
New South Wales	Australia	-33.86880	151.20930	0	0	0	0	3	4

Below we check the time frame of the data.

```
n.col <- ncol(raw.data.confirmed)
## get dates from column names
dates <- names(raw.data.confirmed)[5:n.col] %>% substr(2,8) %>% mdy()
range(dates)
```

```
## [1] "2020-01-22" "2020-07-23"
```

```
min.date <- min(dates)
max.date <- max(dates)
min.date.txt <- min.date %>% format('%d %b %Y')
max.date.txt <- max.date %>% format('%d %b %Y') %>% paste('UTC')
```

It shows that the data was last updated on 23 Jul 2020 UTC and all the stats and charts in this report are based on that data.

## 3 Data Preparation

### 3.1 Data Cleaning

The three datasets are converted from wide to long format and then are aggregated by country. After that, they are merged into one single dataset.

```
## data cleaning and transformation
cleanData <- function(data) {
  ## remove some columns
  data %<>% select(-c(Province.State, Lat, Long)) %>% rename(country=Country.Region)
  ## convert from wide to long format
  data %<>% gather(key=date, value=count, -country)
  ## convert from character to date
  data %<>% mutate(date = date %>% substr(2,8) %>% mdy())
```

```

## aggregate by country
data %<>% group_by(country, date) %>% summarise(count=sum(count, na.rm=T)) %>% as.data.frame()
return(data)
}

## clean the three datasets
data.confirmed <- raw.data.confirmed %>% cleanData() %>% rename(confirmed=count)
data.deaths <- raw.data.deaths %>% cleanData() %>% rename(deaths=count)
data.recovered <- raw.data.recovered %>% cleanData() %>% rename(recovered=count)

## merge above 3 datasets into one, by country and date
data <- data.confirmed %>% merge(data.deaths, all=T) %>% merge(data.recovered, all=T)
# data %<>% mutate(recovered = ifelse(is.na(recovered), lag(recovered, 1), recovered))

## countries/regions with confirmed cases, excl. cruise ships
countries <- data %>% pull(country) %>% setdiff('Cruise Ship')

## first 10 records when it first broke out in China
data %>% filter(country=='China') %>% head(10) %>%
  kable('latex', booktabs=T, caption='Raw Data (with first 10 Columns Only)',
        format.args=list(big.mark=',')) %>%
  kable_styling(latex_options = c('striped', 'hold_position', 'repeat_header'))

```

Table 2: Raw Data (with first 10 Columns Only)

country	date	confirmed	deaths	recovered
China	2020-01-22	548	17	28
China	2020-01-23	643	18	30
China	2020-01-24	920	26	36
China	2020-01-25	1,406	42	39
China	2020-01-26	2,075	56	49
China	2020-01-27	2,877	82	58
China	2020-01-28	5,509	131	101
China	2020-01-29	6,087	133	120
China	2020-01-30	8,141	171	135
China	2020-01-31	9,802	213	214

There are 188 countries with confirmed COVID-19 cases, as of 23 Jul 2020 UTC.

## 3.2 Worldwide Cases

The raw data provide the daily number of cases in every country. They are aggregated below to derive the daily stats of the whole world.

```

## counts for the whole world
data.world <- data %>% group_by(date) %>%
  summarise(country='World',
            confirmed = sum(confirmed, na.rm=T),
            deaths = sum(deaths, na.rm=T),
            recovered = sum(recovered, na.rm=T))

data %<>% rbind(data.world)

```

```
## current confirmed cases
data %<>% mutate(current.confirmed = confirmed - deaths - recovered)
```

### 3.3 Daily Increases and Death Rates

After that, the daily increases of death and recovered cases and the death rates are calculated.

`rate.upper` is calculated with the total dead and recovered cases. It is the upper bound of death rate and the reasons are

- 1) there were much more deaths than recovered cases when the coronavirus broke out and when it was not contained, and
- 2) the daily number of death will decrease and that of recovered will increase as it becomes contained and more effective measures and treatments are used.

`rate.lower` is calculated with total dead and confirmed cases. It is a lower bound of death rate, because there are and will be new deaths from the current confirmed cases. The final death rate is expected to be in between of the above two rates.

`rate.daily` is calculated with the daily dead and recovered cases and therefore is more volatile than the above two. However, it can give us a clue of the current situation: whether it is very serious or is getting better.

```
## sort by country and date
data %<>% arrange(country, date)

## daily increases of deaths and recovered cases
## set NA to the increases on day1
n <- nrow(data)
day1 <- min(data$date)
data %<>% mutate(new.confirmed = ifelse(date == day1, NA, confirmed - lag(confirmed, n=1)),
                 new.deaths = ifelse(date == day1, NA, deaths - lag(deaths, n=1)),
                 new.recovered = ifelse(date == day1, NA, recovered - lag(recovered, n=1)))

## change negative number of new cases to zero
data %<>% mutate(new.confirmed = ifelse(new.confirmed < 0, 0, new.confirmed),
                 new.deaths = ifelse(new.deaths < 0, 0, new.deaths),
                 new.recovered = ifelse(new.recovered < 0, 0, new.recovered))

## death rate based on total deaths and recovered cases
data %<>% mutate(rate.upper = (100 * deaths / (deaths + recovered)) %>% round(1))
## lower bound: death rate based on total confirmed cases
data %<>% mutate(rate.lower = (100 * deaths / confirmed) %>% round(1))
## death rate based on the number of death/recovered on every single day
data %<>% mutate(rate.daily = (100 * new.deaths / (new.deaths + new.recovered)) %>% round(1))

## convert from wide to long format, for drawing area plots
data.long <- data %>%
  select(c(country, date, confirmed, current.confirmed, recovered, deaths)) %>%
  gather(key=type, value=count, -c(country, date))
## set factor levels to show them in a desirable order
data.long %<>% mutate(type=recode_factor(type, confirmed='Total Confirmed',
                                         current.confirmed='Current Confirmed',
                                         recovered='Recovered',
```

```

deaths='Deaths'))

## convert from wide to long format, for drawing area plots
rates.long <- data %>%
  # filter(country %in% top.countries) %>%
  select(c(country, date, rate.upper, rate.lower, rate.daily)) %>%
  # mutate(country=factor(country, levels=top.countries)) %>%
  gather(key=type, value=count, -c(country, date))
# set factor levels to show them in a desirable order
rates.long %<>% mutate(type=recode_factor(type, rate.daily='Daily',
                                          rate.lower='Lower bound',
                                          rate.upper='Upper bound'))

```

## 4 Worldwide Cases

After tidying up the data, we visualise it with various charts.

### 4.1 World Map

Below is a world map of vconfirmed cases. An interactive map can be created if running the code in R or RStudio, or knitting it into a HTML file.

```

## select last column, which is the number of latest confirmed cases
x <- raw.data.confirmed
x$confirmed <- x[, ncol(x)]
x %<>% select(c(Country.Region, Province.State, Lat, Long, confirmed)) %>%
  mutate(txt=paste0(Country.Region, ' - ', Province.State, ': ', confirmed))

m <- leaflet(width=1200, height=800) %>% addTiles()
# circle marker (units in pixels)
m %<>% addCircleMarkers(x$Long, x$Lat,
  # radius=2+log2(x$confirmed),
  radius=0.03*sqrt(x$confirmed),
  stroke=F,
  color='red', fillOpacity=0.3,
  popup=x$txt)

# world
m

```

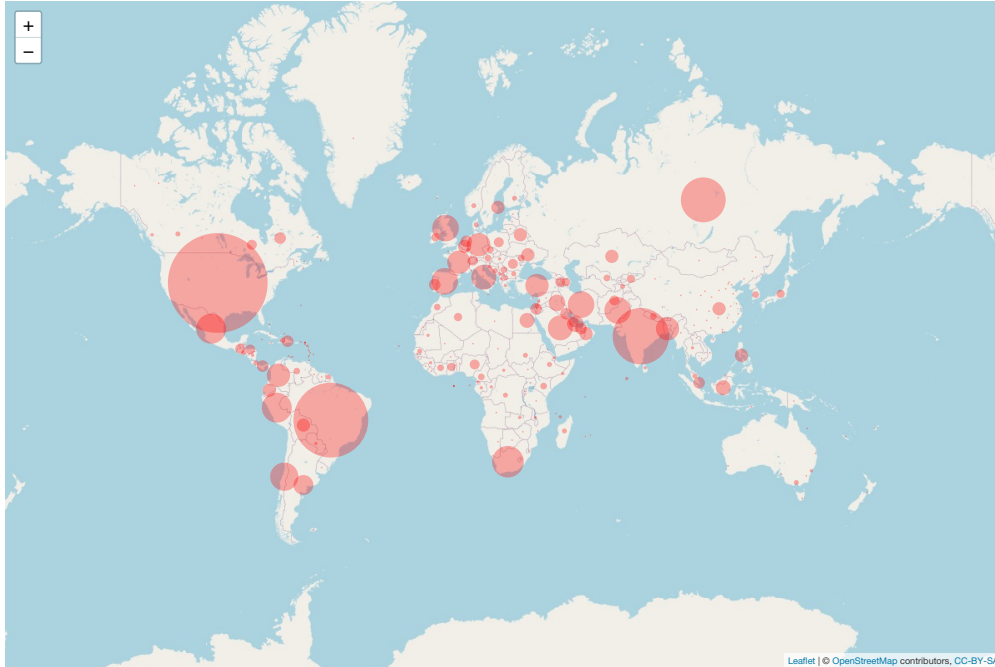


Figure 1: World Map

Views of some specific countries or regions can be produced with the script below.

```
## China
m %>% setView(95, 35, zoom=4)
## Australia and New Zealand
m %>% setView(135, -27, zoom=4)
## US and Canada
m %>% setView(-105, 40, zoom=4)
## Europe
m %>% setView(10, 50, zoom=4)
```

## 4.2 Number of Cases

In the rest of this section, we will focus on the cases worldwide. Similar analysis for a single country can be done by filter the data with the corresponding country name.

```
# data %<>% filter(country=='China')
# data %<>% filter(country=='Australia')
world.long <- data.long %>% filter(country == 'World')

## cases - area plot
plot1 <- world.long %>% filter(type != 'Total Confirmed') %>%
  ggplot(aes(x=date, y=count)) +
  geom_area(aes(fill=type), alpha=0.5) +
  labs(title=paste0('Numbers of Cases Worldwide - ', max.date.txt)) +
  scale_fill_manual(values=c('red', 'green', 'black')) +
  theme(legend.title=element_blank(), legend.position='bottom',
        plot.title = element_text(size=7),
        axis.title.x=element_blank(),
        axis.title.y=element_blank(),
```

```

    legend.key.size=unit(0.2, 'cm'),
    legend.text=element_text(size=6),
    axis.text=element_text(size=7),
    axis.text.x=element_text(angle=45, hjust=1))

plot2 <- world.long %>%
  ggplot(aes(x=date, y=count)) +
  geom_line(aes(color=type)) +
  labs(title=paste0('Numbers of Cases Worldwide (log scale) - ', max.date.txt)) +
  scale_color_manual(values=c('purple', 'red', 'green', 'black')) +
  theme(legend.title=element_blank(), legend.position='bottom',
        plot.title = element_text(size=7),
        axis.title.x=element_blank(),
        axis.title.y=element_blank(),
        legend.key.size=unit(0.2, 'cm'),
        legend.text=element_text(size=6),
        axis.text=element_text(size=7),
        axis.text.x=element_text(angle=45, hjust=1)) +
  scale_y_continuous(trans='log10')
## show two plots side by side
grid.arrange(plot1, plot2, ncol=2)

```

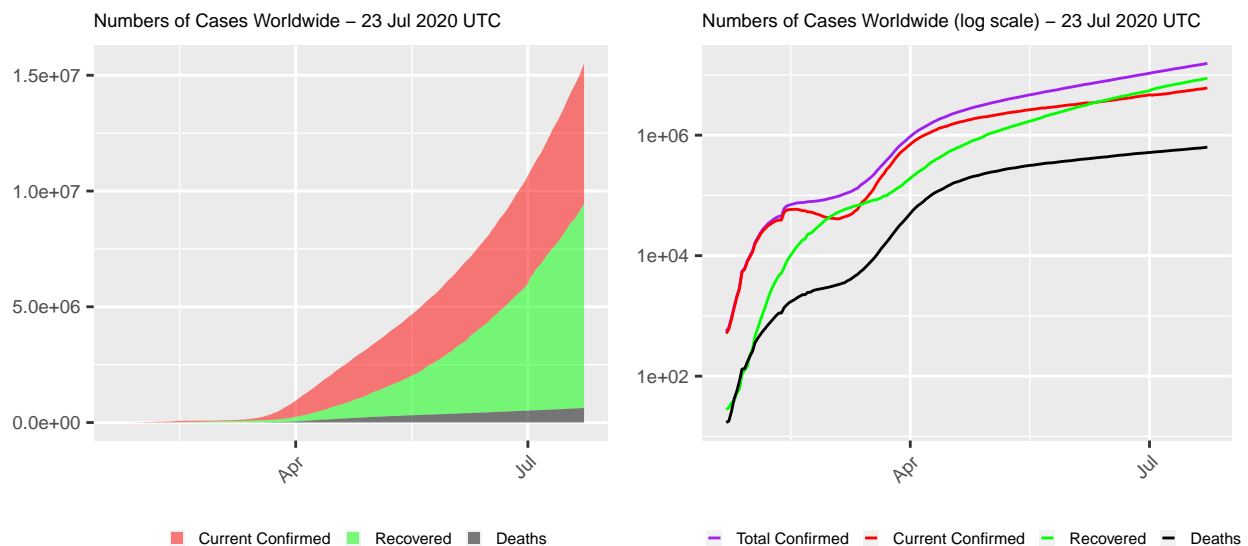


Figure 2: COVID-19 Cases Worldwide

### 4.3 Current Confirmed Cases

```

data.world <- data %>% filter(country=='World')
n <- nrow(data.world)

## current confirmed and daily new confirmed
plot1 <- ggplot(data.world, aes(x=date, y=current.confirmed)) +
  geom_point() + geom_smooth() +
  xlab('') + ylab('Count') + labs(title='Current Confirmed Cases') +
  theme(axis.text.x=element_text(angle=45, hjust=1))
plot2 <- ggplot(data.world, aes(x=date, y=new.confirmed)) +

```



```
geom_point() + geom_smooth() +
xlab('') + ylab('Count') + labs(title='Daily New Confirmed Cases') +
theme(axis.text.x=element_text(angle=45, hjust=1))
## show two plots side by side
grid.arrange(plot1, plot2, ncol=2)
```

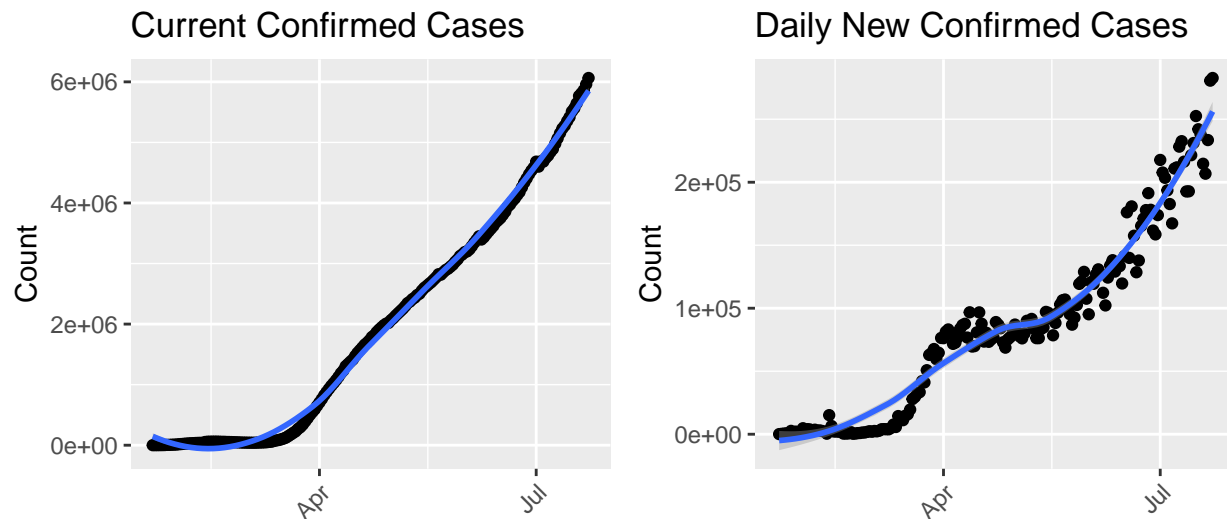


Figure 3: Current Confirmed Cases

Figure 3 shows the numbers of current (see left chart) and new (see right chart) confirmed cases. The blue lines are smoothed conditional means and the grey band around them show the 95% confidence interval.

#### 4.4 Deaths and Recovered Cases

```
## a scatter plot with a smoothed line and vertical x-axis labels
plot1 <- ggplot(data.world, aes(x=date, y=deaths)) +
  geom_point() + geom_smooth() +
  xlab('') + ylab('Count') + labs(title='Accumulative Deaths') +
  theme(axis.text.x=element_text(angle=45, hjust=1))
plot2 <- ggplot(data.world, aes(x=date, y=recovered)) +
  geom_point() + geom_smooth() +
  xlab('') + ylab('Count') + labs(title='Accumulative Recovered Cases') +
  theme(axis.text.x=element_text(angle=45, hjust=1))
plot3 <- ggplot(data.world, aes(x=date, y=new.deaths)) +
  geom_point() + geom_smooth() +
  xlab('') + ylab('Count') + labs(title='New Deaths') +
  theme(axis.text.x=element_text(angle=45, hjust=1))
plot4 <- ggplot(data.world, aes(x=date, y=new.recovered)) +
  geom_point() + geom_smooth() +
  xlab('') + ylab('Count') + labs(title='New Recovered Cases') +
  theme(axis.text.x=element_text(angle=45, hjust=1))
## show four plots together, with 2 plots in each row
grid.arrange(plot1, plot2, plot3, plot4, nrow=2)
```

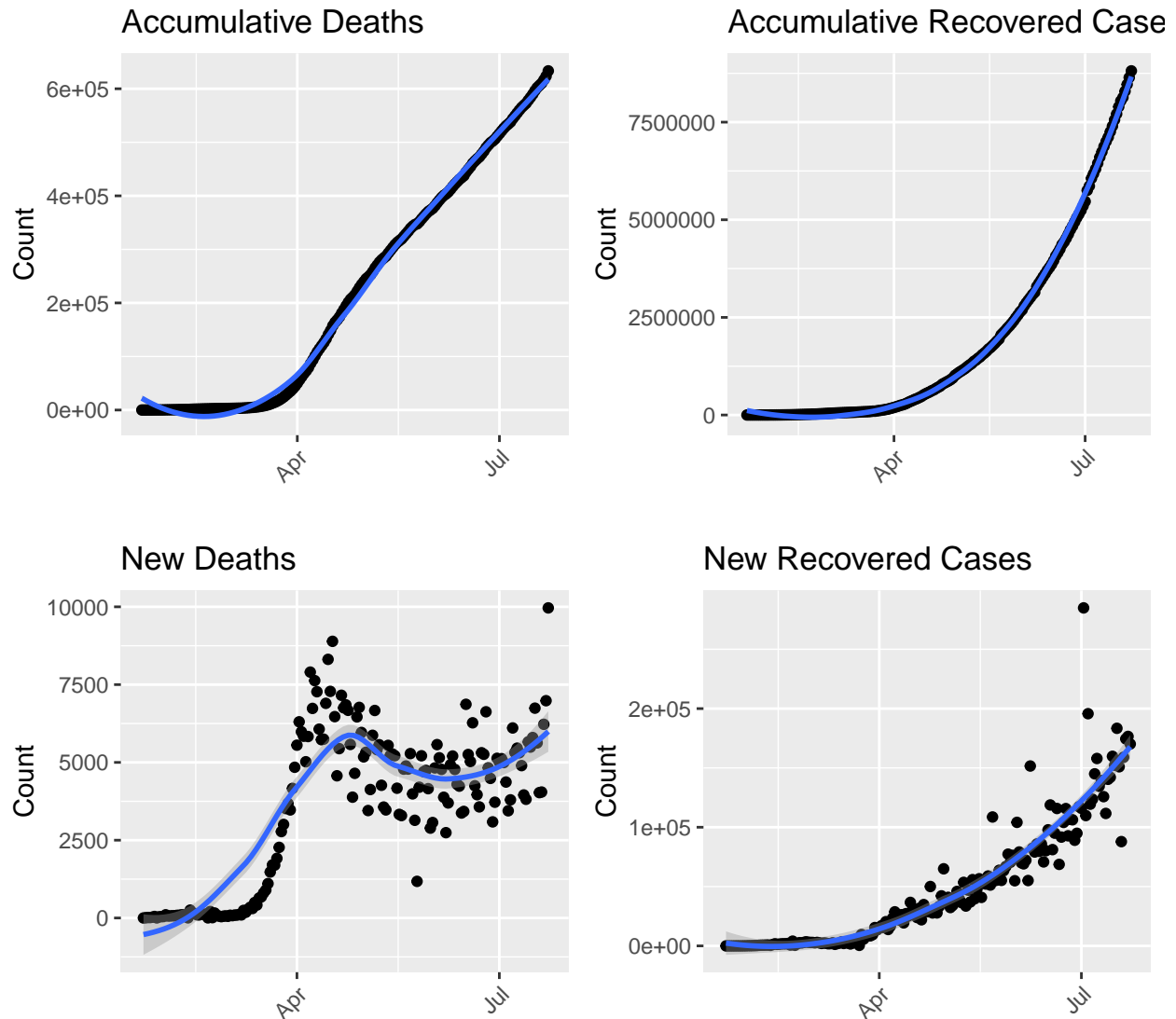


Figure 4: Deaths and Recovered Cases

## 4.5 Death Rates

Figure 5 shows death rates calculated in three different ways (see Section 3.3 for details). The left chart shows the death rates from 22 Jan 2020 to 23 Jul 2020 UTC and the right one is a zoom-in view of the rates in last two weeks.

In the right chart, the upper bound (in blue) is decreasing, as there will be more recovered cases and fewer dead ones daily as time goes on. However, the lower bound (in green) keeps going up, as there are and will be new deaths from the current confirmed cases. Therefore, the final death rate is expected to be in-between of those two rates, and based on the latest data retrieved as of 23 Jul 2020 UTC, it will be between 4.1% and 6.7%.

A surge in the daily death rate (in red) in late March suggests that the situation is changing dramatically (actually, getting worse) and that above lower/upper bounds are likely to increase shortly. A likely reason of that surge is the outbreak of coronavirus in Iran, Europe and US.

```
## three death rates
plot1 <- ggplot(data.world, aes(x=date)) +
```

```

geom_line(aes(y=rate.upper, colour='Upper bound')) +
geom_line(aes(y=rate.lower, colour='Lower bound')) +
geom_line(aes(y=rate.daily, colour='Daily')) +
xlab('') + ylab('Death Rate (%)') + labs(title='Overall') +
theme(legend.position='bottom', legend.title=element_blank(),
      legend.text=element_text(size=8),
      legend.key.size=unit(0.5, 'cm'),
      axis.text.x=element_text(angle=45, hjust=1)) +
ylim(c(0, 99))
## focusing on last 2 weeks
# y.max <- data.world[n-(14:0), ] %>% select(rate.upper, rate.lower, rate.daily) %>% max()
plot2 <- ggplot(data.world[n-(14:0),], aes(x=date)) +
geom_line(aes(y=rate.upper, colour='Upper bound')) +
geom_line(aes(y=rate.lower, colour='Lower bound')) +
geom_line(aes(y=rate.daily, colour='Daily')) +
xlab('') + ylab('Death Rate (%)') + labs(title='Last two weeks') +
theme(legend.position='bottom', legend.title=element_blank(),
      legend.text=element_text(size=8),
      legend.key.size=unit(0.5, 'cm'),
      axis.text.x=element_text(angle=45, hjust=1)) +
ylim(c(0, 20))
grid.arrange(plot1, plot2, ncol=2)

```

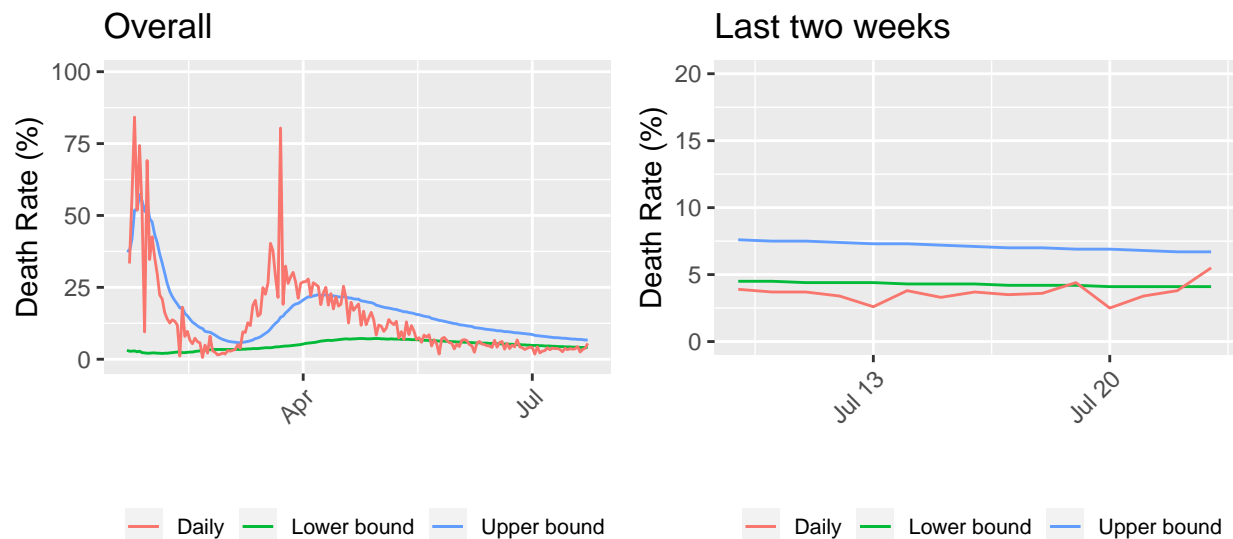


Figure 5: Death Rate

## 5 Top Twenty Countries

Next, we will have a look at the top 20 countries in total confirmed cases.

```

## ranking by confirmed cases
data.latest.all <- data %>% filter(date == max(date)) %>%
  select(country, date,
         confirmed, new.confirmed, current.confirmed,
         recovered, deaths, new.deaths, death.rate=rate.lower) %>%
  mutate(ranking = dense_rank(desc(confirmed)))

```

```

k <- 20
## top 20 countries: 21 incl. 'World'
top.countries <- data.latest.all %>% filter(ranking <= k + 1) %>%
  arrange(ranking) %>% pull(country) %>% as.character()
top.countries %>% setdiff('World') %>% print()

## [1] "US"          "Brazil"      "India"       "Russia"
## [5] "South Africa" "Peru"        "Mexico"      "Chile"
## [9] "United Kingdom" "Iran"       "Pakistan"    "Spain"
## [13] "Saudi Arabia" "Italy"       "Colombia"    "Turkey"
## [17] "France"      "Bangladesh" "Germany"     "Argentina"

## add 'Others'
# top.countries %<>% c('Others')
## put all others in a single group of 'Others'
data.latest <- data.latest.all %>% filter(!is.na(country)) %>%
  mutate(country=ifelse(ranking <= k + 1, as.character(country), 'Others')) %>%
  mutate(country=country %>% factor(levels=c(top.countries, 'Others'))))
data.latest %<>% group_by(country) %>%
  summarise(confirmed=sum(confirmed), new.confirmed=sum(new.confirmed),
    current.confirmed=sum(current.confirmed),
    recovered=sum(recovered), deaths=sum(deaths), new.deaths=sum(new.deaths)) %>%
  mutate(death.rate=(100 * deaths/confirmed) %>% round(1))
data.latest %<>% select(c(country, confirmed, deaths, death.rate,
  new.confirmed, new.deaths, current.confirmed))

data.latest %>% mutate(death.rate=death.rate %>% format(nsmall=1) %>% paste0('%')) %>%
  kable('latex', booktabs=T, row.names=T, align=c('l', rep('r', 6)),
    caption=paste0('Cases in Top 20 Countries - ', max.date.txt,
    '. See a complete list of all infected countries at the end of this report.'),
    format.args=list(big.mark=',')) %>%
  kable_styling(font_size=7, latex_options=c('striped', 'hold_position', 'repeat_header'))

## convert from wide to long format, for drawing area plots
data.latest.long <- data.latest %>% filter(country!='World') %>%
  gather(key=type, value=count, -country)
## set factor levels to show them with proper text and in a desirable order
data.latest.long %<>% mutate(type=recode_factor(type,
  confirmed='Total Confirmed',
  deaths='Total Deaths',
  death.rate='Death Rate (%)',
  new.confirmed='New Confirmed (compared with one day before)',
  new.deaths='New Deaths (compared with one day before)',
  current.confirmed='Current Confirmed'))

## bar chart
data.latest.long %>% ggplot(aes(x=country, y=count, fill=country, group=country)) +
  geom_bar(stat='identity') +
  geom_text(aes(label=count, y=count), size=2, vjust=0) +
  xlab('') + ylab('') +
  labs(title=paste0('Top 20 Countries with Most Confirmed Cases - ', max.date.txt)) +
  scale_fill_discrete(name='Country', labels=aes(count)) +
  theme(legend.title=element_blank(),
    legend.position='none',
    plot.title=element_text(size=11),

```

Table 3: Cases in Top 20 Countries - 23 Jul 2020 UTC. See a complete list of all infected countries at the end of this report.

	country	confirmed	deaths	death.rate	new.confirmed	new.deaths	current.confirmed
1	World	15,511,157	633,396	4.1%	282,724	9,966	6,063,875
2	US	4,038,748	144,304	3.6%	68,663	1,114	2,661,175
3	Brazil	2,287,475	84,082	3.7%	59,961	1,311	583,080
4	India	1,288,108	30,601	2.4%	49,310	740	440,298
5	Russia	793,720	12,873	1.6%	5,830	147	201,552
6	South Africa	408,052	6,093	1.5%	13,104	153	165,699
7	Peru	371,096	17,654	4.8%	4,546	3,887	97,497
8	Mexico	370,712	41,908	11.3%	8,438	718	53,350
9	Chile	338,759	8,838	2.6%	2,357	116	18,490
10	United Kingdom	298,731	45,639	15.3%	779	53	251,667
11	Iran	284,034	15,074	5.3%	2,621	221	21,730
12	Pakistan	270,400	5,763	2.1%	1,209	54	44,854
13	Spain	270,166	28,429	10.5%	2,615	3	91,361
14	Saudi Arabia	260,394	2,635	1.0%	2,238	34	44,269
15	Italy	245,338	35,092	14.3%	306	10	12,404
16	Colombia	226,373	7,688	3.4%	7,945	315	110,734
17	Turkey	223,315	5,563	2.5%	913	18	11,387
18	France	216,667	30,185	13.9%	1,062	10	105,882
19	Bangladesh	216,110	2,801	1.3%	2,856	50	94,101
20	Germany	204,881	9,110	4.4%	605	8	6,631
21	Argentina	148,027	2,702	1.8%	6,127	114	82,510
22	Others	2,750,051	96,362	3.5%	41,239	890	965,204

```
axis.text=element_text(size=7),
axis.text.x=element_text(angle=45, hjust=1)) +
facet_wrap(~type, ncol=1, scales='free_y')
```

Top 20 Countries with Most Confirmed Cases – 23 Jul 2020 UTC

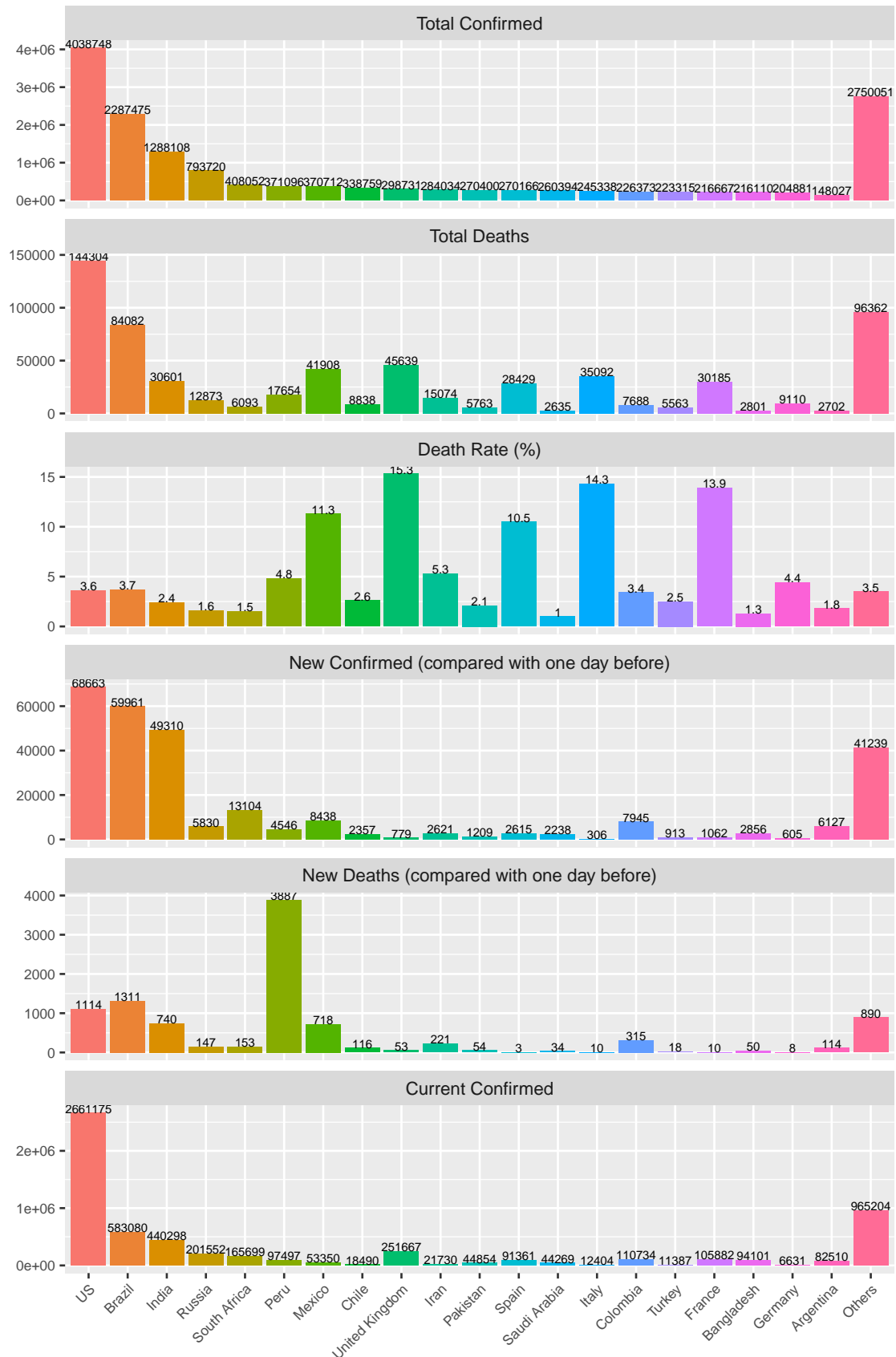
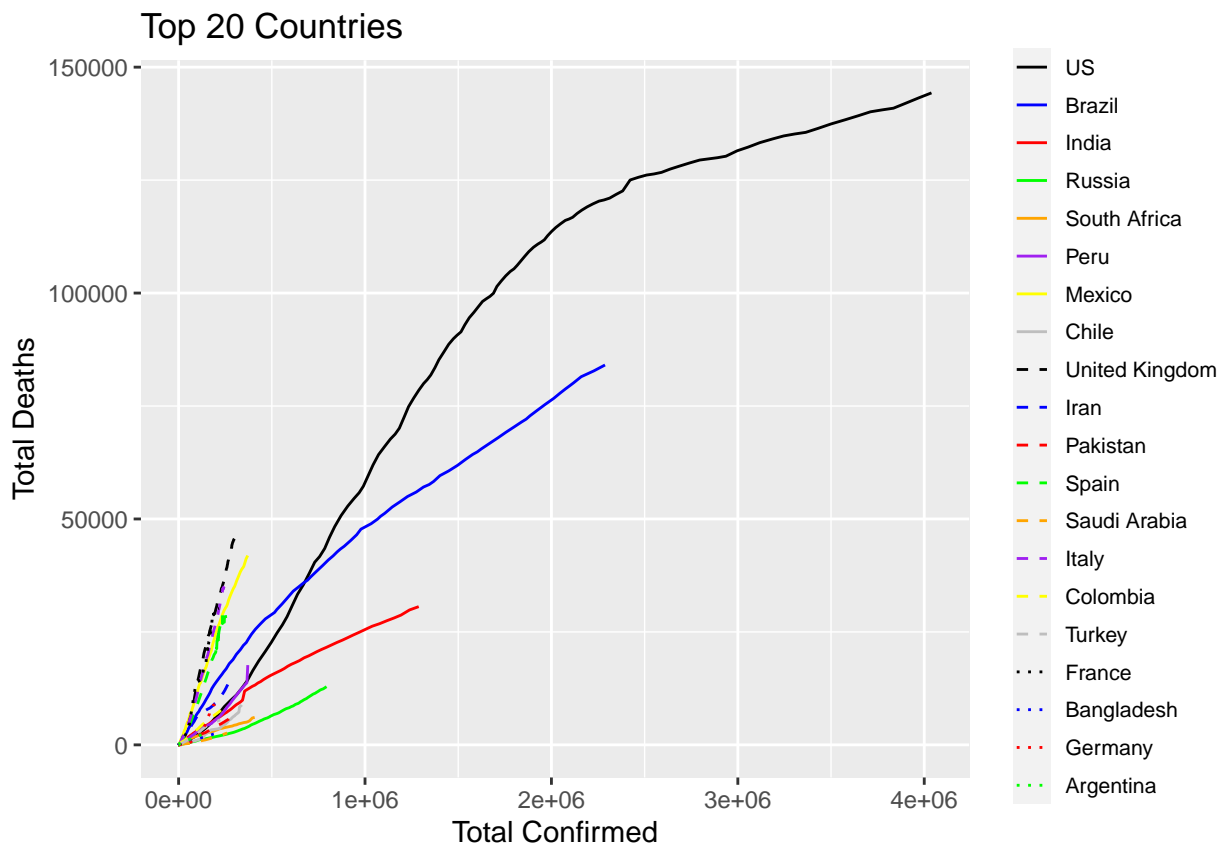


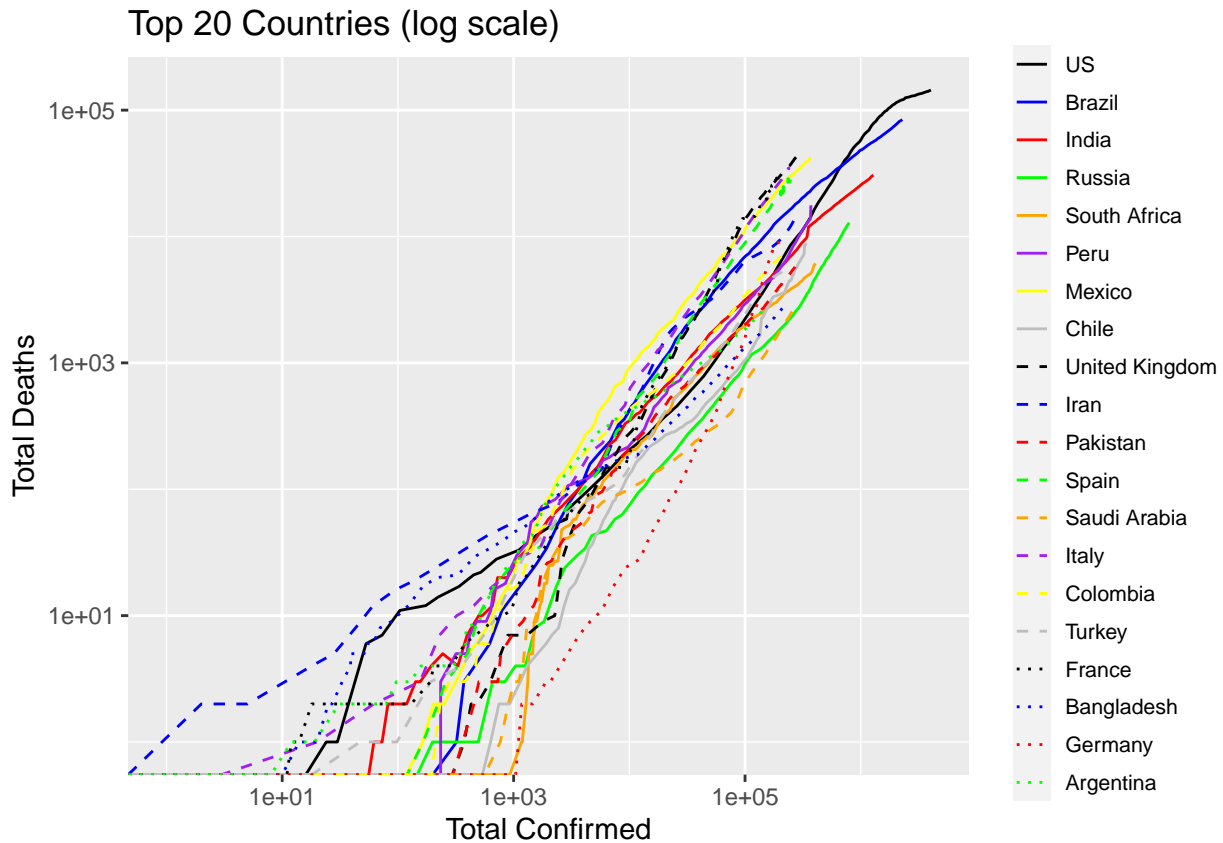
Figure 6: Top 20 Countries with Most Confirmed Cases

## 5.1 Confirmed vs Deaths

```
# linetypes <- rep(c("dotted", "dashed", "solid"), each=8)
# colors <- rep(c('grey', 'yellow', 'purple', 'orange', 'green', 'red', 'blue', 'black'), 3)
linetypes <- rep(c("solid", "dashed", "dotted"), each=8)
colors <- rep(c('black', 'blue', 'red', 'green', 'orange', 'purple', 'yellow', 'grey'), 3)
df <- data %>% filter(country %in% setdiff(top.countries, c('World'))) %>%
  mutate(country=country %>% factor(levels=c(top.countries)))
p <- df %>% ggplot(aes(x=confirmed, y=deaths, group=country)) +
  geom_line(aes(color=country, linetype=country)) +
  xlab('Total Confirmed') + ylab('Total Deaths') +
  scale_linetype_manual(values=linetypes) +
  scale_color_manual(values=colors) +
  theme(legend.title=element_blank(),
        legend.text=element_text(size=8),
        legend.key.size=unit(0.5, 'cm'))
p + labs(title=paste0('Top 20 Countries'))
```



```
p + scale_x_log10() + scale_y_log10() +
  labs(title=paste0('Top 20 Countries (log scale)'))
```



The two figures below show the numbers of confirmed cases and deaths of top 20 countries, as well as the death rates up to 23 Jul 2020 UTC.

```
df <- data.latest %>% filter(country %in% setdiff(top.countries, 'World'))
## breaks for circle size in legend; needs to be adjusted accordingly when the number of total confirmed
breaks.confirmed <- c(5e3, 1e4, 2e4, 5e4, 1e5, 2e5, 5e5, 1e6, 2e6, 5e6, 1e7)

plot1 <- df %>% ggplot(aes(x=confirmed, y=deaths, col=death.rate, size=current.confirmed)) +
  scale_size(name='Current Confirmed', trans='log2', breaks=breaks.confirmed) +
  geom_text(aes(label=country), size=2.5, check_overlap=T, vjust=-1.6) +
  geom_point() +
  xlab('Total Confirmed') + ylab('Total Deaths') +
  labs(col="Death Rate (%)") +
  scale_color_gradient(low='#56B1F7', high='#132B43') +
  scale_x_log10() + scale_y_log10() +
  labs(title=paste0('Top 20 Countries - Confirmed vs Deaths (log scale)'))

plot2 <- df %>% ggplot(aes(x=new.confirmed, y=new.deaths, col=death.rate, size=current.confirmed)) +
  scale_size(name='Current Confirmed', trans='log2', breaks=breaks.confirmed) +
  geom_text(aes(label=country), size=2.5, check_overlap=T, vjust=-1.6) +
  geom_point() +
  xlab('New Confirmed') + ylab('New Deaths') +
  labs(col="Death Rate (%)") +
  scale_color_gradient(low='#56B1F7', high='#132B43') +
  scale_x_log10() + scale_y_log10() +
  labs(title=paste0('Top 20 Countries - New Confirmed vs New Deaths (log scale)'))
```



```
grid.arrange(plot1, plot2, ncol=1)
```

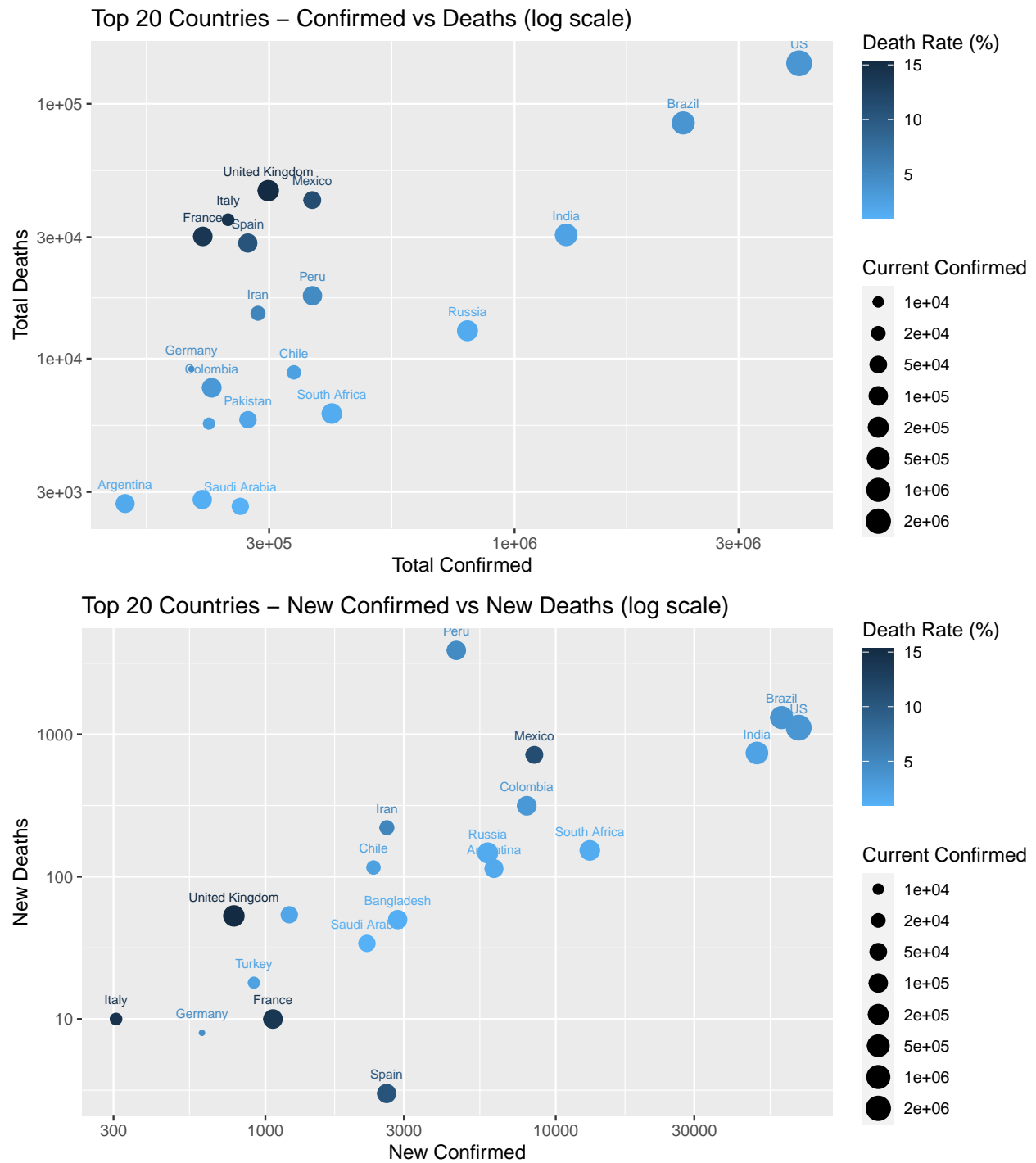


Figure 7: Top 20 Countries

## 5.2 Comparison across Countries

The area plots blow show the numbers of dead, recovered, total and current confirmed cases. Note that, in the area plot, the total number of total confirmed cases is represented by the total areas of current confirmed,

recovered and dead.

```
## plot: cases by type
df <- data.long %>% filter(country %in% top.countries) %<>%
  mutate(country=country %>% factor(levels=c(top.countries)))

p <- df %>% filter(country != 'World') %>%
  ggplot(aes(x=date, y=count)) + xlab('') + ylab('Count') +
  theme(legend.title=element_blank(),
        legend.text=element_text(size=8),
        legend.key.size=unit(0.5, 'cm'),
        plot.title=element_text(size=11),
        axis.text.x=element_text(angle=45, hjust=1)) +
  facet_wrap(~type, ncol=2, scales='free_y')

## area plot
plot1 <- p + geom_area(aes(fill=country)) +
  labs(title=paste0('Cases around the World - ', max.date.txt))

## line plot and in log scale
# linetypes <- rep(c("solid", "dashed", "dotted"), each=8)
# colors <- rep(c('black', 'blue', 'red', 'green', 'orange', 'purple', 'yellow', 'grey'), 3)
plot2 <- p + geom_line(aes(color=country, linetype=country)) +
  scale_linetype_manual(values=linetypes) +
  scale_color_manual(values=colors) +
  labs(title=paste0('Cases around the World - Log Scale - ', max.date.txt)) +
  scale_y_continuous(trans='log10')

grid.arrange(plot1, plot2, ncol=1)
```

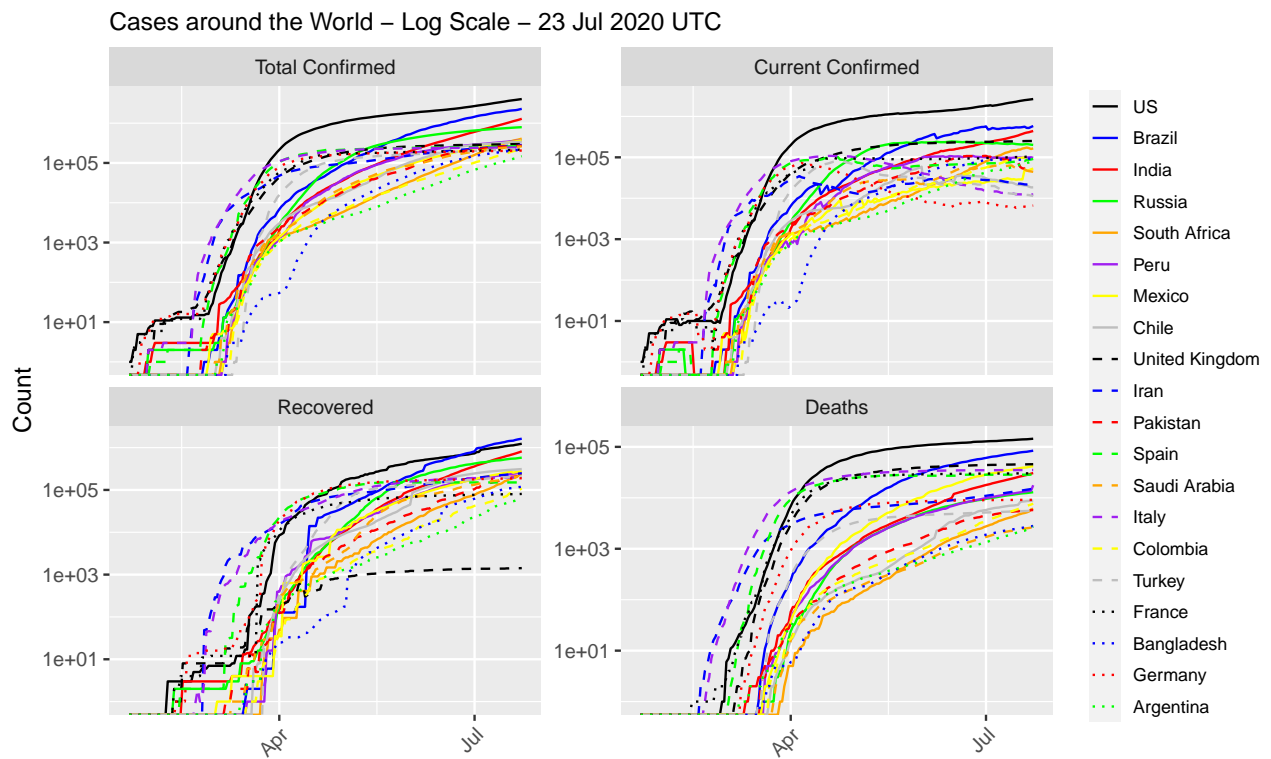
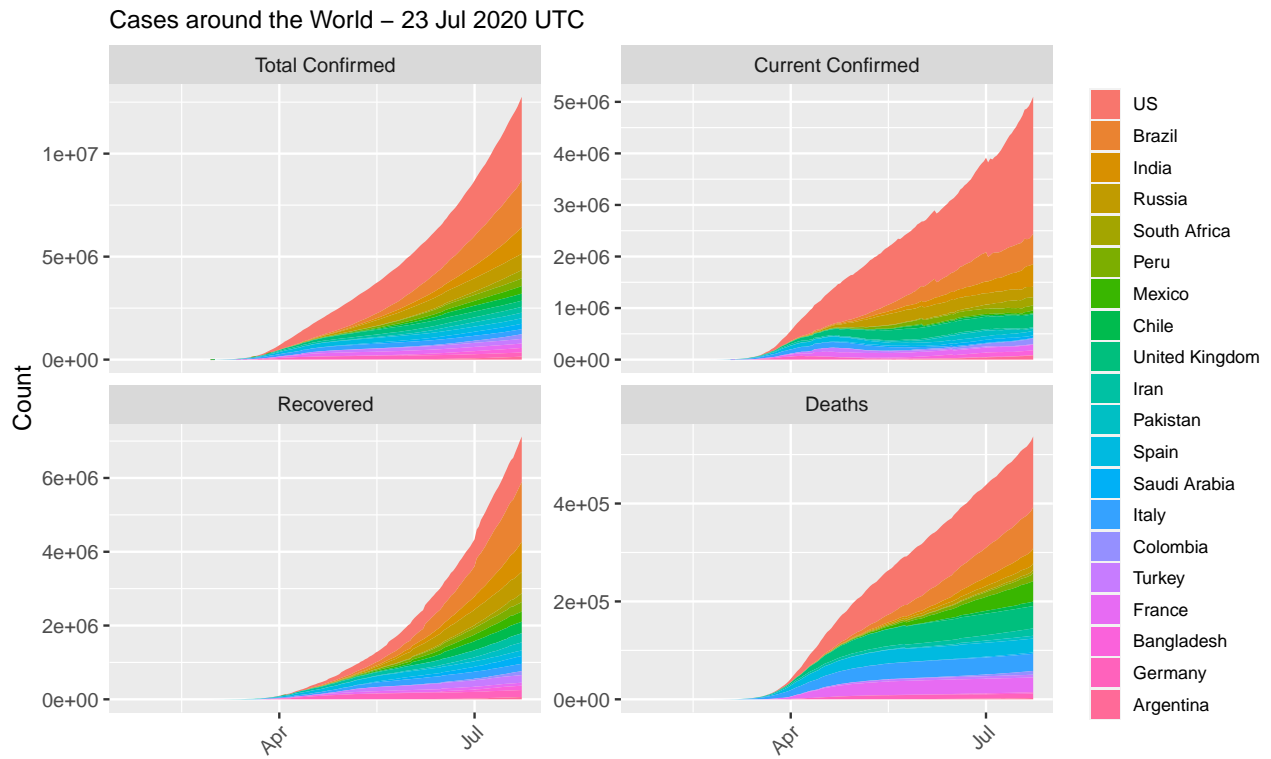


Figure 8: Cases around the World

```
## plot: excluding China
p <- df %>% filter(!(country %in% c('World', 'China')))
```

```

ggplot(aes(x=date, y=count)) + xlab('') + ylab('Count') +
  theme(legend.title=element_blank(),
        legend.text=element_text(size=8),
        legend.key.size=unit(0.5, 'cm'),
        plot.title=element_text(size=11),
        axis.text.x=element_text(angle=45, hjust=1)) +
  facet_wrap(~type, ncol=2, scales='free_y')
p + geom_area(aes(fill=country)) +
  labs(title=paste0('Cases around the World (excl. China) - ', max.date.txt))

```

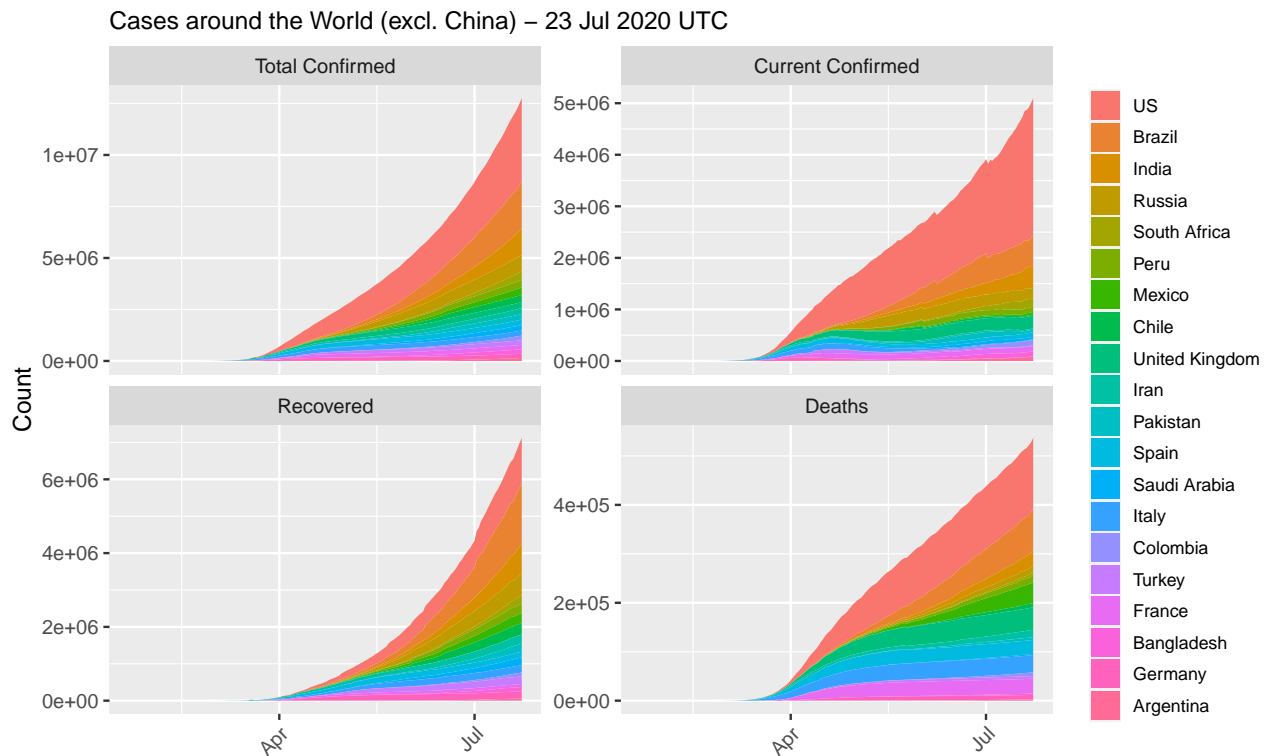


Figure 9: Cases around the World (excl. China)

```

## remove 'Others'
top.countries %<>% setdiff('Others')
## if China or Australia not in top 20, add them in
if(!('China' %in% top.countries)) {
  top.countries %<>% c('China')
}
if(!('Australia' %in% top.countries)) {
  top.countries %<>% c('Australia')
}
df <- data.long %>% filter(country %in% top.countries) %<>%
  mutate(country=country %>% factor(levels=c(top.countries)))

## cases by country - area plot
df %>% filter(country != 'World' & type != 'Total Confirmed') %>%
  ggplot(aes(x=date, y=count, fill=type)) +
  geom_area(alpha=0.5) +

```

```

# xlab('') + ylab('') +
labs(title=paste0('Numbers of COVID-19 Cases in Top 20 Countries - ',
                  max.date.txt)) +
scale_fill_manual(values=c('red', 'green', 'black')) +
theme(legend.title=element_blank(), legend.position='bottom',
      plot.title = element_text(size=12),
      axis.title.x=element_blank(),
      axis.title.y=element_blank(),
      legend.key.size=unit(0.4, 'cm'),
      # legend.text=element_text(size=7),
      strip.text.x=element_text(size=7),
      axis.text=element_text(size=7),
      axis.text.x=element_text(angle=45, hjust=1)) +
facet_wrap(~country, ncol=4, scales='free_y')

```

Numbers of COVID-19 Cases in Top 20 Countries – 23 Jul 2020 UTC

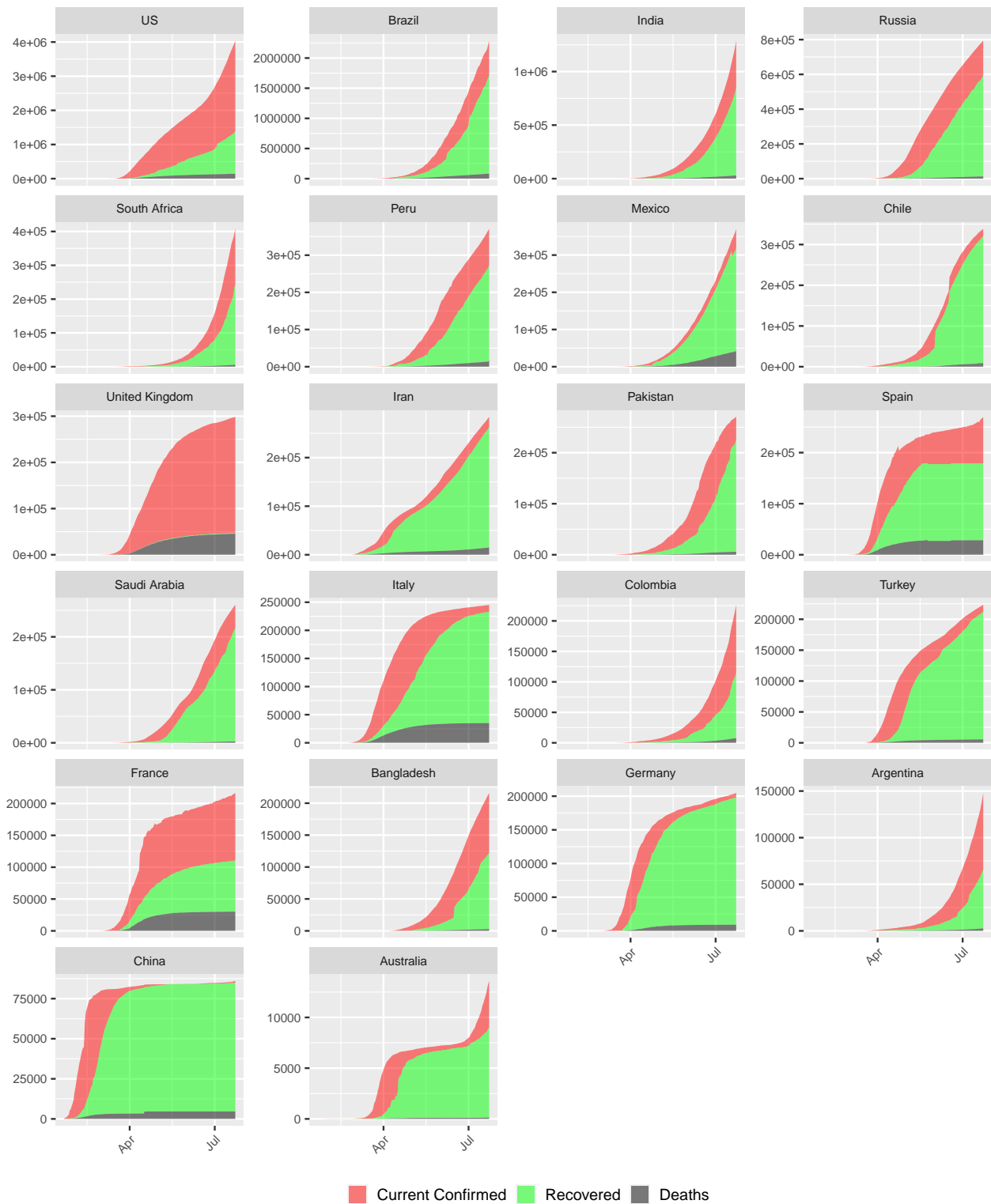


Figure 10: COVID-19 Cases in Top 20 Countries. Ordered descendingly by number of confirmed cases.

```

## cases by country - line plot - log scale
p <- df %>% filter(country != 'World') %>%
  ggplot(aes(x=date, y=count, color=type)) +
  geom_line() +
  labs(title=paste0('Numbers of COVID-19 Cases in Top 20 Countries (log scale) - ',
                    max.date.txt)) +
  scale_color_manual(values=c('purple', 'red', 'green', 'black')) +
  theme(legend.title=element_blank(), legend.position='bottom',
        plot.title = element_text(size=12),
        axis.title.x=element_blank(),
        axis.title.y=element_blank(),
        legend.key.size=unit(0.4, 'cm'),
        # legend.text=element_text(size=7),
        strip.text.x=element_text(size=7),
        axis.text=element_text(size=7),
        axis.text.x=element_text(angle=45, hjust=1)) +
  scale_y_continuous(trans='log10')
p + facet_wrap(~country, ncol=4, scales='free_y')

```

Numbers of COVID-19 Cases in Top 20 Countries (log scale) – 23 Jul 2020 UTC

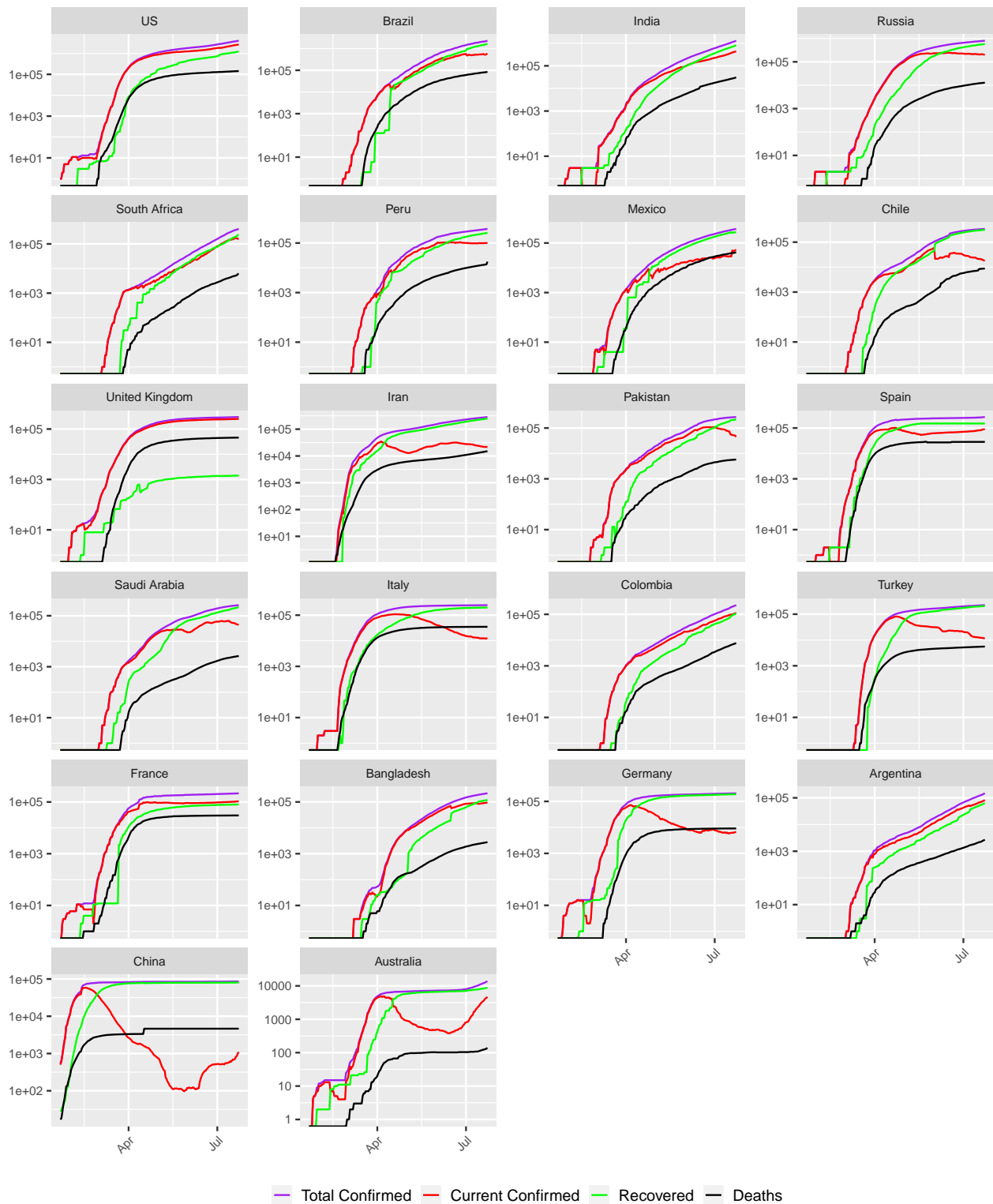


Figure 11: COVID-19 Cases Top 20 Countries (log scale). Ordered descendingly by number of confirmed cases.



```
## plot over multiple pages
# p + facet_wrap_paginate(~country, nrow=4, ncol=3, page=1, scales='free_y')
# p + facet_wrap_paginate(~country, nrow=4, ncol=3, page=2, scales='free_y')
```

Figures 10 and 11 show that China has entered a post-epidemic phase, followed by Australia and Germany, with an increase of recovered cases (in green) every day and a shrinking of the current confirmed cases (in red). In contrast, there are sharp surges in Russia, South America (incl. Brazil, Peru, Chile and Mexico) and West/South Asia (incl. Saudi Arabia, India and Pakistan), which suggests that the virus spread is accelerating there.

### 5.3 Death Rates

```
## three death rates
rate.max <- rates.long$count %>% max(na.rm=T)
df <- rates.long %>% filter(country %in% setdiff(top.countries, 'World')) %>%
  mutate(country=factor(country, levels=top.countries))
df %>% ggplot(aes(x=date, y=count, color=type)) +
  geom_line() +
  xlab('') + ylab('Death Rate (%)') +
  theme(legend.position='bottom', legend.title=element_blank(),
        legend.text=element_text(size=8),
        legend.key.size=unit(0.5, 'cm'),
        axis.text.x=element_text(angle=45, hjust=1)) +
  ylim(c(0, 99)) +
  facet_wrap(~country, ncol=4)
```

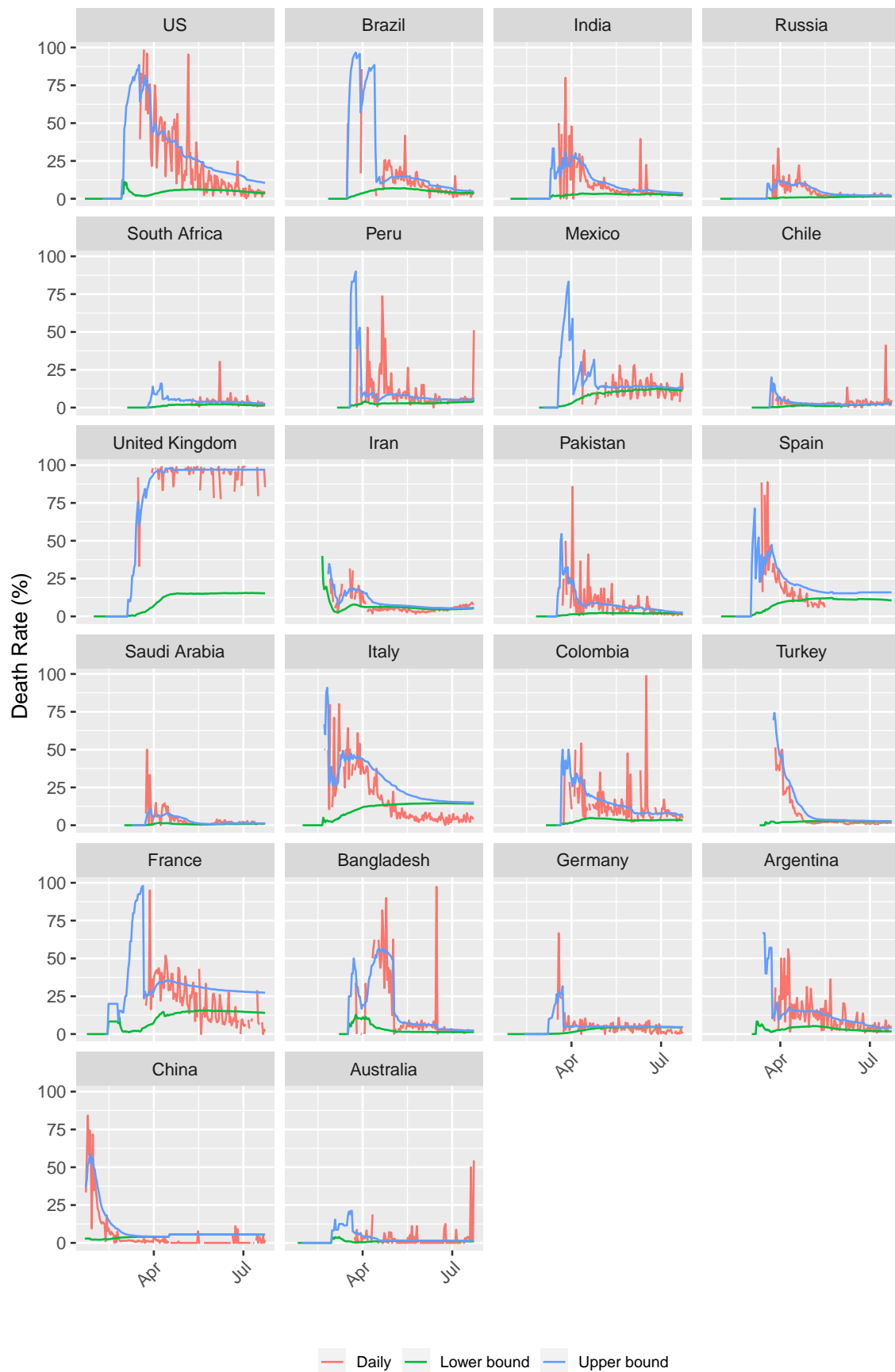


Figure 12: Death Rates  
26

## 5.4 Countries with Highest Death Rates

Below are a list of top 20 countries with the highest death rates out of countries having 2000+ confirmed cases.

```
## sort the latest data by death rate, and if tie, by confirmed
df <- data %>% filter(date == max(date) & country != 'World' & confirmed >= 2000) %>%
  select(country, confirmed, new.confirmed, current.confirmed,
         recovered, deaths, new.deaths, death.rate=rate.lower) %>%
  arrange(desc(death.rate, confirmed))

df %>% head(20) %>%
  mutate(death.rate=death.rate %>% format(nsmall=1) %>% paste0('%')) %>%
  kable('latex', booktabs=T, row.names=T, align=c('l', rep('r', 7)),
        caption=paste0('Top 20 Countries with Highest Death Rates - ', max.date.txt),
        format.args=list(big.mark=',')) %>%
  kable_styling(font_size=7, latex_options=c('striped', 'hold_position', 'repeat_header'))
```

Table 4: Top 20 Countries with Highest Death Rates - 23 Jul 2020 UTC

	country	confirmed	new.confirmed	current.confirmed	recovered	deaths	new.deaths	death.rate
1	United Kingdom	298,731	779	251,667	1,425	45,639	53	15.3%
2	Belgium	64,847	220	37,666	17,369	9,812	4	15.1%
3	Italy	245,338	306	12,404	197,842	35,092	10	14.3%
4	France	216,667	1,062	105,882	80,600	30,185	10	13.9%
5	Hungary	4,380	14	484	3,300	596	0	13.6%
6	Netherlands	52,640	165	46,287	195	6,158	0	11.7%
7	Mexico	370,712	8,438	53,350	275,454	41,908	718	11.3%
8	Spain	270,166	2,615	91,361	150,376	28,429	3	10.5%
9	Canada	114,398	608	5,542	99,937	8,919	6	7.8%
10	Sweden	78,763	259	73,087	0	5,676	9	7.2%
11	Ecuador	78,148	891	39,254	33,455	5,439	21	7.0%
12	Ireland	25,826	7	699	23,364	1,763	9	6.8%
13	Sudan	11,237	0	4,694	5,835	708	0	6.3%
14	Switzerland	34,000	117	1,525	30,500	1,975	3	5.8%
15	Slovenia	2,033	27	257	1,661	115	0	5.7%
16	China	86,045	139	1,099	80,297	4,649	1	5.4%
17	Iran	284,034	2,621	21,730	247,230	15,074	221	5.3%
18	Romania	41,275	1,112	14,287	24,862	2,126	25	5.2%
19	Egypt	90,413	668	54,867	31,066	4,480	40	5.0%
20	Greece	4,110	33	2,535	1,374	201	1	4.9%

## 6 Conclusions

As of 23 Jul 2020 UTC, there are 188 countries with confirmed COVID-19 cases. It seems to be contained in China, but starts to break out in rest of the world. The current death rate is in between 4.1% and 6.7%, but it is likely to change dramatically with the breakout in many countries, such as European countries.

## Appendix A. Processed Data

Blow is the processed data for this analysis.

### Appendix A.1 COVID-19 Cases Worldwide

```
## sort by date descendingly and re-order columns
data.world %<>% arrange(desc(date)) %>%
```

```

select(c(date, confirmed, deaths, recovered, current.confirmed,
        new.confirmed, new.deaths, new.recovered, rate.lower, rate.upper, rate.daily))
## output as a table
data.world %>%
  mutate(rate.upper = rate.upper %>% format(nsmall=1) %>% paste0('\\%'),
         rate.lower = rate.lower %>% format(nsmall=1) %>% paste0('\\%'),
         rate.daily = rate.daily %>% format(nsmall=1) %>% paste0('\\%')) %>%
  kable('latex', escape=F, booktabs=T, longtable=T,
        caption='Cases in the Whole World',
        format.args=list(big.mark=','),
        align=c('l', rep('r', 10))) %>%
  kable_styling(font_size=4, latex_options=c('striped', 'hold_position', 'repeat_header'))

```

Table 5: Cases in the Whole World

date	confirmed	deaths	recovered	current.confirmed	new.confirmed	new.deaths	new.recovered	rate.lower	rate.upper	rate.daily
2020-07-23	15,511,157	633,396	8,813,886	6,063,875	282,724	9,966	170,164	4.1%	6.7%	5.5%
2020-07-22	15,228,433	623,430	8,643,722	5,961,281	280,611	6,983	176,544	4.1%	6.7%	3.8%
2020-07-21	14,947,822	616,447	8,467,178	5,864,197	233,455	6,224	174,490	4.1%	6.8%	3.4%
2020-07-20	14,714,367	610,223	8,292,688	5,811,456	206,778	4,048	158,996	4.1%	6.9%	2.5%
2020-07-19	14,507,589	606,175	8,133,692	5,767,722	214,647	4,029	87,877	4.2%	6.9%	4.4%
2020-07-18	14,292,942	602,146	8,045,815	5,644,981	237,635	5,627	150,957	4.2%	7.0%	3.6%
2020-07-17	14,055,307	596,519	7,894,858	5,563,930	242,039	6,743	183,393	4.2%	7.0%	3.5%
2020-07-16	13,813,268	589,776	7,711,465	5,512,027	252,541	5,799	152,287	4.3%	7.1%	3.7%
2020-07-15	13,560,727	583,977	7,559,178	5,417,572	231,119	5,493	159,781	4.3%	7.2%	3.3%
2020-07-14	13,329,608	578,484	7,399,397	5,351,727	221,452	5,660	142,097	4.3%	7.3%	3.8%
2020-07-13	13,108,156	572,824	7,257,300	5,278,032	192,779	3,815	140,407	4.4%	7.3%	2.6%
2020-07-12	12,915,377	569,009	7,116,893	5,229,475	192,668	3,954	111,648	4.4%	7.4%	3.4%
2020-07-11	12,722,709	565,055	7,005,245	5,152,409	216,328	4,897	125,780	4.4%	7.5%	3.7%
2020-07-10	12,506,381	560,158	6,879,465	5,066,758	232,577	5,311	139,392	4.5%	7.5%	3.7%
2020-07-09	12,273,804	554,847	6,740,073	4,978,884	228,227	5,458	134,514	4.5%	7.6%	3.9%
2020-07-08	12,045,577	549,389	6,605,559	4,890,629	211,802	5,319	157,949	4.6%	7.7%	3.3%
2020-07-07	11,833,775	544,070	6,447,610	4,842,095	210,844	6,107	145,025	4.6%	7.8%	4.0%
2020-07-06	11,622,931	537,963	6,302,585	4,782,383	3,797	5,797	123,612	4.6%	7.9%	3.0%
2020-07-05	11,455,588	534,166	6,178,973	4,742,449	182,695	3,445	119,439	4.7%	8.0%	2.8%
2020-07-04	11,272,893	530,721	6,059,534	4,682,638	193,567	4,369	195,716	4.7%	8.1%	2.2%
2020-07-03	11,079,326	526,352	5,863,818	4,689,156	203,494	4,995	109,837	4.8%	8.2%	4.3%
2020-07-02	10,875,832	521,357	5,753,981	4,600,494	207,705	5,120	284,873	4.8%	8.3%	1.8%
2020-07-01	10,668,127	516,237	5,469,108	4,682,782	217,689	5,011	115,922	4.8%	8.6%	4.1%
2020-06-30	10,450,438	511,226	5,353,186	4,586,026	173,898	5,132	117,393	4.9%	8.7%	4.2%
2020-06-29	10,276,540	506,094	5,235,793	4,534,653	158,572	3,721	94,913	4.9%	8.8%	3.8%
2020-06-28	10,117,968	502,373	5,140,880	4,474,715	161,630	3,089	89,033	5.0%	8.9%	3.4%
2020-06-27	9,956,338	499,284	5,051,847	4,405,207	178,110	4,486	106,304	5.0%	9.0%	4.0%
2020-06-26	9,778,228	494,798	4,945,543	4,337,887	191,346	4,827	106,639	5.1%	9.1%	4.3%
2020-06-25	9,586,882	489,971	4,838,904	4,258,007	177,887	6,627	92,793	5.1%	9.2%	6.7%
2020-06-24	9,408,995	483,344	4,746,111	4,179,540	171,183	5,261	115,721	5.1%	9.2%	4.3%
2020-06-23	9,237,812	478,083	4,630,390	4,129,339	165,338	5,311	104,053	5.2%	9.4%	4.9%
2020-06-22	9,072,474	472,772	4,526,337	4,073,365	137,858	3,571	91,691	5.2%	9.5%	3.7%
2020-06-21	8,934,616	469,201	4,434,646	4,030,769	128,539	3,963	68,699	5.3%	9.6%	5.5%
2020-06-20	8,806,077	465,238	4,365,947	3,974,892	157,552	4,249	115,818	5.3%	9.6%	3.5%
2020-06-19	8,648,525	460,989	4,250,129	3,937,407	180,806	6,273	95,010	5.3%	9.8%	6.2%
2020-06-18	8,467,719	454,716	4,155,119	3,857,884	139,928	5,029	81,142	5.4%	9.9%	5.8%
2020-06-17	8,327,791	449,687	4,073,977	3,804,127	176,132	5,255	118,782	5.4%	9.9%	4.2%
2020-06-16	8,151,659	444,432	3,955,195	3,752,032	141,403	6,867	97,830	5.5%	10.1%	6.6%
2020-06-15	8,010,256	437,565	3,857,365	3,715,326	119,638	3,425	80,208	5.5%	10.2%	4.1%
2020-06-14	7,890,618	434,140	3,777,157	3,679,321	133,421	3,374	70,778	5.5%	10.3%	4.6%
2020-06-13	7,757,197	430,766	3,706,379	3,620,052	134,337	4,238	85,941	5.6%	10.4%	4.7%
2020-06-12	7,622,860	426,528	3,620,438	3,575,894	129,094	4,297	79,716	5.6%	10.5%	5.1%
2020-06-11	7,493,766	422,231	3,540,722	3,530,813	138,114	4,774	85,889	5.6%	10.7%	5.3%
2020-06-10	7,355,652	417,457	3,454,833	3,483,362	134,025	5,205	79,139	5.7%	10.8%	6.2%
2020-06-09	7,221,627	412,252	3,375,694	3,433,681	124,342	4,922	82,260	5.7%	10.9%	5.6%
2020-06-08	7,097,285	407,330	3,293,434	3,396,521	102,225	3,697	151,598	5.7%	11.0%	2.4%
2020-06-07	6,995,060	403,633	3,141,836	3,449,591	112,259	2,742	55,093	5.8%	11.4%	4.7%
2020-06-06	6,882,801	400,891	3,086,743	3,395,167	127,198	3,881	72,202	5.8%	11.5%	5.1%
2020-06-05	6,755,603	397,010	3,014,541	3,344,052	130,863	4,776	69,156	5.9%	11.6%	6.5%
2020-06-04	6,624,740	392,234	2,945,385	3,287,121	126,937	5,149	70,029	5.9%	11.8%	6.8%
2020-06-03	6,497,803	387,085	2,875,356	3,235,362	119,388	5,572	79,142	6.0%	11.9%	6.6%
2020-06-02	6,378,415	381,513	2,796,214	3,200,688	120,810	4,823	104,123	6.0%	12.0%	4.4%
2020-06-01	6,257,605	376,690	2,728,824	3,188,824	95,196	3,068	54,895	6.0%	12.3%	5.3%
2020-05-31	6,162,409	373,622	2,637,196	3,151,591	107,552	2,888	76,308	6.1%	12.4%	3.6%
2020-05-30	6,054,857	370,734	2,560,888	3,123,235	128,865	4,156	70,472	6.1%	12.6%	5.6%
2020-05-29	5,925,992	366,578	2,490,416	3,068,998	121,167	4,742	77,327	6.2%	12.8%	5.8%
2020-05-28	5,804,825	361,836	2,413,089	3,029,900	119,314	4,701	66,857	6.2%	13.0%	6.6%
2020-05-27	5,685,511	357,135	2,346,232	2,982,144	102,600	5,213	63,393	6.3%	13.2%	7.6%
2020-05-26	5,582,911	351,922	2,282,839	2,948,150	92,522	4,203	55,214	6.3%	13.4%	7.1%
2020-05-25	5,490,389	347,719	2,227,625	2,915,045	86,963	1,178	63,723	6.3%	13.5%	1.8%
2020-05-24	5,403,426	346,541	2,163,902	2,892,983	95,326	3,140	55,440	6.4%	13.8%	5.4%
2020-05-23	5,308,100	343,401	2,108,462	2,856,237	98,983	3,989	54,971	6.5%	14.0%	6.8%
2020-05-22	5,209,117	339,412	2,053,491	2,816,214	106,900	5,284	108,651	6.5%	14.2%	4.6%
2020-05-21	5,102,217	334,128	1,944,840	2,823,249	106,334	4,786	51,265	6.5%	14.7%	8.5%
2020-05-20	4,995,883	329,342	1,893,575	2,772,966	103,028	4,885	58,913	6.6%	14.8%	7.7%
2020-05-19	4,892,855	324,457	1,834,662	2,733,736	96,424	4,784	52,165	6.6%	15.0%	8.4%

Table 5: Cases in the Whole World (continued)

date	confirmed	deaths	recovered	current.confirmed	new.confirmed	new.deaths	new.recovered	rate.lower	rate.upper	rate.daily
2020-05-18	4,796,431	319,673	1,782,497	2,694,261	88,284	3,291	52,898	6.7%	15.2%	5.9%
2020-05-17	4,708,147	316,382	1,729,599	2,662,166	78,509	3,329	40,886	6.7%	15.5%	7.5%
2020-05-16	4,629,638	313,053	1,688,713	2,627,872	91,813	4,171	56,591	6.8%	15.6%	6.9%
2020-05-15	4,537,825	308,882	1,632,122	2,596,821	96,349	5,215	47,989	6.8%	15.9%	9.8%
2020-05-14	4,441,476	303,667	1,584,133	2,553,676	97,105	5,268	39,735	6.8%	16.1%	11.7%
2020-05-13	4,344,371	298,399	1,544,398	2,501,574	84,752	5,228	55,842	6.9%	16.2%	8.6%
2020-05-12	4,259,619	293,171	1,488,556	2,477,892	83,599	5,547	37,035	6.9%	16.5%	13.0%
2020-05-11	4,176,020	287,624	1,451,521	2,436,875	76,241	3,473	46,994	6.9%	16.5%	6.9%
2020-05-10	4,099,779	284,151	1,404,527	2,411,101	76,246	3,566	33,594	6.9%	16.8%	9.6%
2020-05-09	4,023,533	280,585	1,370,933	2,372,015	83,635	4,265	53,549	7.0%	17.0%	7.4%
2020-05-08	3,939,898	276,320	1,317,384	2,346,194	91,517	5,568	36,522	7.0%	17.3%	13.2%
2020-05-07	3,848,381	270,752	1,280,862	2,296,767	89,086	5,409	39,497	7.0%	17.4%	12.0%
2020-05-06	3,759,295	265,343	1,241,365	2,252,587	90,022	6,669	45,919	7.1%	17.6%	12.7%
2020-05-05	3,669,273	258,674	1,195,446	2,215,153	79,989	5,871	36,605	7.0%	17.8%	13.8%
2020-05-04	3,589,284	252,803	1,158,841	2,177,640	76,077	4,128	34,064	7.0%	17.9%	10.8%
2020-05-03	3,513,207	248,675	1,124,777	2,139,755	77,636	3,453	32,323	7.1%	18.1%	9.7%
2020-05-02	3,435,571	245,222	1,092,454	2,097,895	80,587	5,325	40,917	7.1%	18.3%	11.5%
2020-05-01	3,354,984	239,897	1,051,537	2,063,550	87,048	5,177	38,231	7.2%	18.6%	11.9%
2020-04-30	3,267,936	234,720	1,013,306	2,019,910	83,681	5,962	64,971	7.2%	18.8%	8.4%
2020-04-29	3,184,255	228,758	948,335	2,007,162	77,046	6,768	42,168	7.2%	19.4%	13.8%
2020-04-28	3,107,209	221,990	906,167	1,979,052	75,299	6,463	33,267	7.1%	19.7%	16.3%
2020-04-27	3,031,910	215,527	872,900	1,943,483	68,704	4,649	27,803	7.1%	19.8%	14.3%
2020-04-26	2,963,206	210,878	845,097	1,907,231	72,947	3,883	28,603	7.1%	20.0%	12.0%
2020-04-25	2,890,259	206,995	816,494	1,866,770	84,121	5,578	27,779	7.2%	20.2%	16.7%
2020-04-24	2,806,138	201,417	788,715	1,816,006	86,940	6,674	50,033	7.2%	20.3%	11.8%
2020-04-23	2,719,198	194,743	738,682	1,785,773	89,013	6,850	28,791	7.2%	20.9%	19.2%
2020-04-22	2,630,185	187,893	709,891	1,732,401	76,806	6,755	30,430	7.1%	20.9%	18.2%
2020-04-21	2,553,379	181,138	679,461	1,692,780	75,250	7,157	34,827	7.1%	21.0%	17.0%
2020-04-20	2,478,129	173,981	644,634	1,659,514	73,339	5,443	22,002	7.0%	21.3%	19.8%
2020-04-19	2,404,790	168,538	622,632	1,613,620	80,525	4,570	31,655	7.0%	21.3%	12.6%
2020-04-18	2,324,265	163,968	590,977	1,569,320	73,528	6,471	23,923	7.1%	21.7%	21.3%
2020-04-17	2,250,737	157,497	567,054	1,526,186	87,724	8,891	26,120	7.0%	21.7%	25.4%
2020-04-16	2,163,013	148,606	540,934	1,473,473	96,712	7,283	30,828	6.9%	21.6%	19.1%
2020-04-15	2,066,301	141,323	510,106	1,414,872	80,829	8,312	36,667	6.8%	21.7%	18.5%
2020-04-14	1,985,472	133,011	473,439	1,379,022	69,927	6,899	25,093	6.7%	21.9%	21.6%
2020-04-13	1,915,545	126,112	448,346	1,341,087	69,594	5,747	27,166	6.6%	22.0%	17.5%
2020-04-12	1,845,951	120,365	421,180	1,304,406	96,782	5,731	19,408	6.5%	22.2%	22.8%
2020-04-11	1,749,169	114,634	401,772	1,232,763	76,720	6,069	26,249	6.6%	22.2%	18.8%
2020-04-10	1,672,449	108,565	375,523	1,188,361	87,658	7,272	21,823	6.5%	22.4%	25.0%
2020-04-09	1,584,791	101,293	353,700	1,129,798	86,625	7,629	25,341	6.4%	22.3%	23.1%
2020-04-08	1,498,166	93,664	328,359	1,076,143	83,775	6,735	28,716	6.3%	22.2%	19.0%
2020-04-07	1,414,391	86,929	299,643	1,027,819	76,873	7,902	23,391	6.1%	22.5%	25.3%
2020-04-06	1,337,518	79,027	276,252	982,239	72,672	5,832	16,580	5.9%	22.2%	26.0%
2020-04-05	1,264,846	73,195	259,672	931,979	71,718	5,021	13,840	5.8%	22.0%	26.6%
2020-04-04	1,193,128	68,174	245,832	879,122	80,375	5,841	20,417	5.7%	21.7%	22.2%
2020-04-03	1,112,753	62,333	225,415	825,005	83,155	5,985	15,448	5.6%	21.7%	27.9%
2020-04-02	1,029,598	56,348	209,967	763,283	81,401	6,305	17,045	5.5%	21.2%	27.0%
2020-04-01	948,197	50,043	192,922	705,232	76,221	5,554	15,092	5.3%	20.6%	26.9%
2020-03-31	871,976	44,489	177,830	649,657	76,416	4,844	13,493	5.1%	20.0%	26.4%
2020-03-30	795,560	39,645	164,337	591,578	64,639	4,164	15,446	5.0%	19.4%	21.2%
2020-03-29	730,921	35,481	148,891	546,549	59,577	3,473	9,467	4.9%	19.2%	26.8%
2020-03-28	671,344	32,008	139,424	499,912	67,608	3,679	8,503	4.8%	18.7%	30.2%
2020-03-27	603,736	28,329	130,921	444,486	64,400	3,518	8,776	4.7%	17.8%	28.6%
2020-03-26	539,336	24,811	122,145	392,380	62,960	3,007	8,370	4.6%	16.9%	26.4%
2020-03-25	476,376	21,804	113,775	340,797	50,817	2,777	5,783	4.6%	16.1%	32.4%
2020-03-24	425,559	19,027	107,992	298,540	41,139	2,270	9,641	4.5%	15.0%	19.1%
2020-03-23	384,420	16,757	98,351	269,312	42,165	1,917	466	4.4%	14.6%	80.4%
2020-03-22	342,255	14,840	97,885	229,530	33,413	1,698	6,215	4.3%	13.2%	21.5%
2020-03-21	308,842	13,142	91,670	204,030	32,278	1,706	4,267	4.3%	12.5%	28.6%
2020-03-20	276,564	11,436	87,403	177,725	29,609	1,478	2,445	4.1%	11.6%	37.7%
2020-03-19	246,955	9,958	84,958	152,039	27,918	1,106	1,637	4.0%	10.5%	40.3%
2020-03-18	219,037	8,852	83,321	126,864	19,593	897	2,483	4.0%	9.6%	26.5%
2020-03-17	199,444	7,955	80,838	110,651	15,844	804	2,752	4.0%	9.0%	22.6%
2020-03-16	183,600	7,151	78,086	98,363	14,659	680	2,054	3.9%	8.4%	24.9%
2020-03-15	168,941	6,471	76,032	86,438	11,146	641	3,410	3.8%	7.8%	15.8%
2020-03-14	157,795	5,830	72,622	79,343	11,091	417	2,371	3.7%	7.4%	15.0%
2020-03-13	146,704	5,413	70,251	71,040	14,407	497	1,927	3.7%	7.2%	20.5%
2020-03-12	132,297	4,916	68,324	59,057	5,750	305	1,322	3.7%	6.7%	18.7%
2020-03-11	126,547	4,611	67,002	54,934	7,663	345	2,598	3.6%	6.4%	11.7%
2020-03-10	118,884	4,266	64,404	50,214	5,024	279	1,911	3.6%	6.2%	12.7%
2020-03-09	113,860	3,987	62,493	47,380	3,900	184	1,799	3.5%	6.0%	9.3%
2020-03-08	109,960	3,803	60,694	45,463	3,951	244	2,335	3.5%	5.9%	9.5%
2020-03-07	106,009	3,559	58,359	44,091	4,038	99	2,494	3.4%	5.7%	3.8%
2020-03-06	101,971	3,460	55,865	42,646	3,943	112	2,069	3.4%	5.8%	5.1%
2020-03-05	98,028	3,348	53,796	40,884	2,791	93	2,626	3.4%	5.9%	3.4%
2020-03-04	95,237	3,255	51,170	40,812	2,299	95	2,942	3.4%	6.0%	3.1%
2020-03-03	92,938	3,160	48,228	41,550	2,578	75	2,626	3.4%	6.1%	2.8%
2020-03-02	90,360	3,085	45,602	41,673	1,974	89	2,886	3.4%	6.3%	3.0%
2020-03-01	88,386	2,996	42,716	42,674	2,377	54	2,934	3.4%	6.6%	1.8%
2020-02-29	86,009	2,942	39,782	43,285	1,895	69	3,071	3.4%	6.9%	2.2%
2020-02-28	84,114	2,873	36,711	44,530	1,377	59	3,434	3.4%	7.3%	1.7%
2020-02-27	82,737	2,814	33,277	46,646	1,364	43	2,893	3.4%	7.8%	1.5%
2020-02-26	81,373	2,771	30,384	48,218	977	61	2,479	3.4%	8.4%	2.4%
2020-02-25	80,396	2,710	27,905	49,781	853	80	2,678	3.4%	8.9%	2.9%
2020-02-24	79,543	2,630	25,227	51,686	564	160	1,833	3.3%	9.4%	8.0%
2020-02-23	78,979	2,470	23,394	53,115	378	11	508	3.3%	9.5%	2.1%
2020-02-22	78,601	2,459	22,886	53,256	1,761	207	3,996	3.1%	9.7%	4.9%
2020-02-21	76,840	2,252	18,890	55,698	629	4	713	2.9%	10.7%	0.6%
2020-02-20	76,211	2,248	18,177	55,786	560	125	2,056	2.9%	11.0%	5.7%

Table 5: Cases in the Whole World (continued)

date	confirmed	deaths	recovered	current.confirmed	new.confirmed	new.deaths	new.recovered	rate.lower	rate.upper	rate.daily
2020-02-19	75,651	2,123	16,121	57,407	500	115	1,769	2.8%	11.6%	6.1%
2020-02-18	75,151	2,008	14,352	58,791	1,882	140	1,769	2.7%	12.3%	7.3%
2020-02-17	73,269	1,868	12,583	58,818	2,035	98	1,718	2.5%	12.9%	5.4%
2020-02-16	71,234	1,770	10,865	58,599	2,184	104	1,470	2.5%	14.0%	6.6%
2020-02-15	69,050	1,666	9,395	57,989	2,142	143	1,337	2.4%	15.1%	9.7%
2020-02-14	66,908	1,523	8,058	57,327	6,527	152	1,763	2.3%	15.9%	7.9%
2020-02-13	60,381	1,371	6,295	52,715	15,153	253	1,145	2.3%	17.9%	18.1%
2020-02-12	45,228	1,118	5,150	38,960	418	5	467	2.5%	17.8%	1.1%
2020-02-11	44,810	1,113	4,683	39,014	2,042	100	737	2.5%	19.2%	11.9%
2020-02-10	42,768	1,013	3,946	37,809	2,609	107	702	2.4%	20.4%	13.2%
2020-02-09	40,159	906	3,244	36,009	3,030	100	628	2.3%	21.8%	13.7%
2020-02-08	37,129	806	2,616	33,707	2,734	87	605	2.2%	23.6%	12.6%
2020-02-07	34,395	719	2,011	31,665	3,593	85	524	2.1%	26.3%	14.0%
2020-02-06	30,802	634	1,487	28,681	3,159	70	363	2.1%	29.9%	16.2%
2020-02-05	27,643	564	1,124	25,955	3,745	72	272	2.0%	33.4%	20.9%
2020-02-04	23,898	492	852	22,554	4,011	66	229	2.1%	36.6%	22.4%
2020-02-03	19,887	426	623	18,838	3,100	64	151	2.1%	40.6%	29.8%
2020-02-02	16,787	362	472	15,953	4,749	103	188	2.2%	43.4%	35.4%
2020-02-01	12,038	259	284	11,495	2,111	46	62	2.2%	47.7%	42.6%
2020-01-31	9,927	213	222	9,492	1,693	42	79	2.1%	49.0%	34.7%
2020-01-30	8,234	171	143	7,920	2,068	38	17	2.1%	54.5%	69.1%
2020-01-29	6,166	133	126	5,907	588	2	19	2.2%	51.4%	9.5%
2020-01-28	5,578	131	107	5,340	2,651	49	46	2.3%	55.0%	51.6%
2020-01-27	2,927	82	61	2,784	809	26	9	2.8%	57.3%	74.3%
2020-01-26	2,118	56	52	2,010	684	14	13	2.6%	51.9%	51.9%
2020-01-25	1,434	42	39	1,353	493	16	3	2.9%	51.9%	84.2%
2020-01-24	941	26	36	879	287	8	6	2.8%	41.9%	57.1%
2020-01-23	654	18	30	606	99	1	2	2.8%	37.5%	33.3%
2020-01-22	555	17	28	510				3.1%	37.8%	NA%

## Appendix A.2 Latest Cases by Country

```
## highlight high death rates (if >= 5%) for those countries with 2000+ confirmed cases
data.latest.all %>% arrange(desc(confirmed)) %>% select(-c(date, ranking)) %>%
  mutate(death.rate=ifelse(confirmed >= 2000 & death.rate >= 5,
    cell_spec(format(death.rate, big.mark=',') %>% paste0('%'),
      "latex", color="red", bold=T),
    cell_spec(format(death.rate, big.mark=',') %>% paste0('%'),
      "latex", color="black", bold=F))) %>%
  kable(format='latex', escape=F, booktabs=T, longtable=T, row.names=T,
    caption=paste0('Cases by Country (', max.date.txt, ')'),
    format.args=list(big.mark=','),
    align=c('l', rep('r', 7))) %>%
  kable_styling(font_size=6, latex_options=c('striped', 'hold_position', 'repeat_header'))
```

Table 6: Cases by Country (23 Jul 2020 UTC)

	country	confirmed	new.confirmed	current.confirmed	recovered	deaths	new.deaths	death.rate
1	World	15,511,157	282,724	6,063,875	8,813,886	633,396	9,966	4.1%
2	US	4,038,748	68,663	2,661,175	1,233,269	144,304	1,114	3.6%
3	Brazil	2,287,475	59,961	583,080	1,620,313	84,082	1,311	3.7%
4	India	1,288,108	49,310	440,298	817,209	30,601	740	2.4%
5	Russia	793,720	5,830	201,552	579,295	12,873	147	1.6%
6	South Africa	408,052	13,104	165,699	236,260	6,093	153	1.5%
7	Peru	371,096	4,546	97,497	255,945	17,654	3,887	4.8%
8	Mexico	370,712	8,438	53,350	275,454	41,908	718	<b>11.3%</b>
9	Chile	338,759	2,357	18,490	311,431	8,838	116	2.6%
10	United Kingdom	298,731	779	251,667	1,425	45,639	53	<b>15.3%</b>
11	Iran	284,034	2,621	21,730	247,230	15,074	221	<b>5.3%</b>
12	Pakistan	270,400	1,209	44,854	219,783	5,763	54	2.1%
13	Spain	270,166	2,615	91,361	150,376	28,429	3	<b>10.5%</b>
14	Saudi Arabia	260,394	2,238	44,269	213,490	2,635	34	1.0%
15	Italy	245,338	306	12,404	197,842	35,092	10	<b>14.3%</b>
16	Colombia	226,373	7,945	110,734	107,951	7,688	315	3.4%
17	Turkey	223,315	913	11,387	206,365	5,563	18	2.5%
18	France	216,667	1,062	105,882	80,600	30,185	10	<b>13.9%</b>
19	Bangladesh	216,110	2,856	94,101	119,208	2,801	50	1.3%
20	Germany	204,881	605	6,631	189,140	9,110	8	4.4%

Table 6: Cases by Country (23 Jul 2020 UTC) (continued)

	country	confirmed	new.confirmed	current.confirmed	recovered	deaths	new.deaths	death.rate
21	Argentina	148,027	6,127	82,510	62,815	2,702	114	1.8%
22	Canada	114,398	608	5,542	99,937	8,919	6	7.8%
23	Qatar	108,244	373	3,062	105,018	164	1	0.2%
24	Iraq	102,226	2,361	28,699	69,405	4,122	80	4.0%
25	Indonesia	93,657	1,906	36,917	52,164	4,576	117	4.9%
26	Egypt	90,413	668	54,867	31,066	4,480	40	5.0%
27	China	86,045	139	1,099	80,297	4,649	1	5.4%
28	Sweden	78,763	259	73,087	0	5,676	9	7.2%
29	Kazakhstan	78,486	3,333	28,413	49,488	585	0	0.7%
30	Ecuador	78,148	891	39,254	33,455	5,439	21	7.0%
31	Philippines	74,390	2,121	48,136	24,383	1,871	28	2.5%
32	Oman	72,646	1,099	20,942	51,349	355	6	0.5%
33	Belarus	66,688	167	6,730	59,439	519	6	0.8%
34	Bolivia	65,252	1,117	42,815	20,030	2,407	79	3.7%
35	Belgium	64,847	220	37,666	17,369	9,812	4	15.1%
36	Ukraine	63,169	874	26,564	35,035	1,570	17	2.5%
37	Kuwait	61,872	687	9,204	52,247	421	4	0.7%
38	United Arab Emirates	57,988	254	6,798	50,848	342	0	0.6%
39	Israel	57,982	1,897	33,496	24,044	442	12	0.8%
40	Dominican Republic	57,615	1,572	29,704	26,905	1,006	1	1.7%
41	Panama	56,817	911	23,780	31,828	1,209	29	2.1%
42	Netherlands	52,640	165	46,287	195	6,158	0	11.7%
43	Portugal	49,379	229	13,305	34,369	1,705	3	3.5%
44	Singapore	49,098	354	4,056	45,015	27	0	0.1%
45	Guatemala	42,192	1,057	11,704	28,856	1,632	59	3.9%
46	Poland	41,580	418	8,388	31,541	1,651	9	4.0%
47	Romania	41,275	1,112	14,287	24,862	2,126	25	5.2%
48	Nigeria	38,948	604	22,054	16,061	833	20	2.1%
49	Bahrain	37,996	359	3,450	34,412	134	4	0.4%
50	Honduras	36,902	800	31,443	4,448	1,011	5	2.7%
51	Armenia	36,162	469	10,230	25,244	688	10	1.9%
52	Afghanistan	35,928	201	10,167	24,550	1,211	21	3.4%
53	Switzerland	34,000	117	1,525	30,500	1,975	3	5.8%
54	Kyrgyzstan	31,247	2,267	11,998	18,038	1,211	100	3.9%
55	Ghana	29,672	0	3,429	26,090	153	0	0.5%
56	Azerbaijan	28,980	347	7,615	20,974	391	6	1.3%
57	Japan	28,114	978	6,244	20,878	992	2	3.5%
58	Ireland	25,826	7	699	23,364	1,763	9	6.8%
59	Algeria	25,484	612	6,991	17,369	1,124	13	4.4%
60	Serbia	22,443	412	21,935	0	508	9	2.3%
61	Moldova	22,105	307	6,212	15,174	719	7	3.3%
62	Austria	20,099	170	1,445	17,943	711	0	3.5%
63	Uzbekistan	18,986	607	8,734	10,149	103	5	0.5%
64	Morocco	18,264	302	2,100	15,872	292	7	1.6%
65	Nepal	18,241	147	5,358	12,840	43	1	0.2%
66	Cameroon	16,522	0	2,412	13,728	382	0	2.3%
67	Kenya	15,601	796	8,203	7,135	263	3	1.7%
68	Cote d'Ivoire	15,001	268	5,626	9,282	93	0	0.6%
69	Czechia	14,800	230	5,107	9,328	365	1	2.5%
70	Korea, South	13,979	41	864	12,817	298	1	2.1%
71	Venezuela	13,613	449	5,732	7,752	129	5	0.9%
72	Australia	13,595	293	4,681	8,775	139	6	1.0%
73	Denmark	13,594	40	482	12,500	612	1	4.5%
74	El Salvador	13,377	402	5,729	7,276	372	9	2.8%
75	Costa Rica	13,129	768	9,601	3,448	80	9	0.6%
76	Ethiopia	11,933	409	6,091	5,645	197	9	1.7%
77	Sudan	11,237	0	4,694	5,835	708	0	6.3%
78	Bulgaria	9,853	269	4,493	5,031	329	8	3.3%
79	West Bank and Gaza	9,744	346	6,957	2,720	67	1	0.7%
80	North Macedonia	9,669	122	4,153	5,071	445	3	4.6%
81	Bosnia and Herzegovina	9,462	347	4,821	4,367	274	6	2.9%
82	Senegal	9,266	145	2,918	6,170	178	1	1.9%
83	Norway	9,085	26	156	8,674	255	0	2.8%
84	Malaysia	8,840	9	143	8,574	123	0	1.4%
85	Congo (Kinshasa)	8,720	94	3,414	5,105	201	4	2.3%
86	Madagascar	8,381	219	3,151	5,160	70	1	0.8%
87	Finland	7,372	10	124	6,920	328	0	4.4%
88	Haiti	7,197	30	2,807	4,236	154	0	2.1%

Table 6: Cases by Country (23 Jul 2020 UTC) (continued)

	country	confirmed	new.confirmed	current.confirmed	recovered	deaths	new.deaths	death.rate
89	Tajikistan	7,060	45	1,209	5,793	58	0	0.8%
90	Guinea	6,806	59	765	5,999	42	1	0.6%
91	Gabon	6,588	0	2,306	4,235	47	0	0.7%
92	Kosovo	6,467	181	2,804	3,505	158	8	2.4%
93	Mauritania	6,067	40	1,825	4,086	156	1	2.6%
94	Luxembourg	5,952	98	1,249	4,591	112	1	1.9%
95	Djibouti	5,031	1	46	4,927	58	0	1.2%
96	Croatia	4,634	104	1,112	3,394	128	3	2.8%
97	Central African Republic	4,590	16	3,080	1,452	58	1	1.3%
98	Albania	4,466	108	1,820	2,523	123	3	2.8%
99	Hungary	4,380	14	484	3,300	596	0	13.6%
100	Paraguay	4,113	113	1,590	2,487	36	0	0.9%
101	Greece	4,110	33	2,535	1,374	201	1	4.9%
102	Zambia	3,789	206	1,978	1,677	134	6	3.5%
103	Nicaragua	3,439	0	839	2,492	108	0	3.1%
104	Malawi	3,302	0	1,944	1,282	76	0	2.3%
105	Thailand	3,279	18	114	3,107	58	0	1.8%
106	Lebanon	3,260	156	1,598	1,619	43	0	1.3%
107	Somalia	3,171	10	1,579	1,499	93	0	2.9%
108	Maldives	3,120	17	677	2,428	15	0	0.5%
109	Equatorial Guinea	3,071	0	2,178	842	51	0	1.7%
110	Congo (Brazzaville)	2,851	0	2,135	666	50	0	1.8%
111	Sri Lanka	2,753	1	665	2,077	11	0	0.4%
112	Montenegro	2,569	97	1,991	538	40	1	1.6%
113	Mali	2,494	0	482	1,889	123	0	4.9%
114	Cuba	2,466	4	40	2,339	87	0	3.5%
115	Libya	2,314	138	1,757	501	56	3	2.4%
116	South Sudan	2,239	28	1,019	1,175	45	0	2.0%
117	Cabo Verde	2,190	36	1,019	1,150	21	0	1.0%
118	Zimbabwe	2,124	90	1,586	510	28	2	1.3%
119	Slovakia	2,089	31	505	1,556	28	0	1.3%
120	Slovenia	2,033	27	257	1,661	115	0	5.7%
121	Estonia	2,027	2	46	1,912	69	0	3.4%
122	Eswatini	2,021	83	1,111	882	28	3	1.4%
123	Lithuania	1,960	9	269	1,611	80	0	4.1%
124	Guinea-Bissau	1,954	0	1,125	803	26	0	1.3%
125	Iceland	1,841	1	8	1,823	10	0	0.5%
126	Sierra Leone	1,752	21	394	1,292	66	0	3.8%
127	Rwanda	1,710	21	816	889	5	0	0.3%
128	Benin	1,694	4	742	918	34	0	2.0%
129	Yemen	1,654	14	431	762	461	3	27.9%
130	Mozambique	1,582	25	1,043	528	11	0	0.7%
131	New Zealand	1,556	1	21	1,513	22	0	1.4%
132	Namibia	1,522	120	1,446	69	7	0	0.5%
133	Tunisia	1,406	12	238	1,118	50	0	3.6%
134	Suriname	1,234	58	437	774	23	2	1.9%
135	Latvia	1,203	6	127	1,045	31	0	2.6%
136	Uruguay	1,141	24	167	940	34	0	3.0%
137	Jordan	1,131	11	85	1,035	11	0	1.0%
138	Niger	1,124	2	33	1,022	69	0	6.1%
139	Liberia	1,117	3	433	613	71	1	6.4%
140	Georgia	1,085	12	158	911	16	0	1.5%
141	Uganda	1,079	4	108	971	0	0	0.0%
142	Burkina Faso	1,070	4	98	919	53	0	5.0%
143	Cyprus	1,045	5	179	847	19	0	1.8%
144	Chad	915	26	35	805	75	0	8.2%
145	Andorra	889	0	34	803	52	0	5.8%
146	Angola	851	39	582	236	33	0	3.9%
147	Togo	828	22	228	584	16	0	1.9%
148	Jamaica	821	5	100	711	10	0	1.2%
149	Sao Tome and Principe	749	2	131	604	14	0	1.9%
150	Diamond Princess	712	0	48	651	13	0	1.8%
151	San Marino	699	0	1	656	42	0	6.0%
152	Malta	680	1	6	665	9	0	1.3%
153	Botswana	592	70	543	48	1	0	0.2%
154	Syria	584	23	375	174	35	3	6.0%
155	Tanzania	509	0	305	183	21	0	4.1%
156	Taiwan*	455	0	8	440	7	0	1.5%



Table 6: Cases by Country (23 Jul 2020 UTC) (*continued*)

	country	confirmed	new.confirmed	current.confirmed	recovered	deaths	new.deaths	death.rate
157	Vietnam	412	4	47	365	0	0	0.0%
158	Lesotho	359	0	284	69	6	0	1.7%
159	Guyana	351	1	156	176	19	0	5.4%
160	Burundi	345	17	74	270	1	0	0.3%
161	Burma	343	0	57	280	6	0	1.7%
162	Mauritius	343	0	1	332	10	0	2.9%
163	Comoros	340	3	9	324	7	0	2.1%
164	Mongolia	288	1	71	217	0	0	0.0%
165	Bahamas	274	55	172	91	11	0	4.0%
166	Eritrea	261	10	72	189	0	0	0.0%
167	Cambodia	202	4	60	142	0	0	0.0%
168	Gambia	170	24	107	58	5	0	2.9%
169	Brunei	141	0	0	138	3	0	2.1%
170	Trinidad and Tobago	141	0	5	128	8	0	5.7%
171	Monaco	114	2	10	100	4	0	3.5%
172	Seychelles	108	0	81	27	0	0	0.0%
173	Barbados	106	0	5	94	7	0	6.6%
174	Bhutan	92	0	9	83	0	0	0.0%
175	Liechtenstein	86	0	4	81	1	0	1.2%
176	Antigua and Barbuda	76	0	15	58	3	0	3.9%
177	Saint Vincent and the Grenadines	52	0	15	37	0	0	0.0%
178	Belize	47	4	20	25	2	0	4.3%
179	Papua New Guinea	31	1	20	11	0	0	0.0%
180	Fiji	27	0	9	18	0	0	0.0%
181	Saint Lucia	24	1	2	22	0	0	0.0%
182	Timor-Leste	24	0	0	24	0	0	0.0%
183	Grenada	23	0	0	23	0	0	0.0%
184	Laos	19	0	0	19	0	0	0.0%
185	Dominica	18	0	0	18	0	0	0.0%
186	Saint Kitts and Nevis	17	0	2	15	0	0	0.0%
187	Holy See	12	0	0	12	0	0	0.0%
188	Western Sahara	10	0	1	8	1	0	10.0%
189	MS Zaandam	9	0	7	0	2	0	22.2%

## Appendix B. How to Cite This Work

### Citation

Yanchang Zhao, COVID-19 Data Analysis with R – Worldwide. RDataMining.com, 2020. URL: <http://www.rdatamining.com/docs/Coronavirus-data-analysis-world.pdf>.

### BibTex

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  Author = {Yanchang Zhao},
  Institution = {RDataMining.com},
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## Appendix C. Contact

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Comments and suggestions and welcome. Thanks!