Over the past two weeks, utilizing Python and Machine Learning libraries, I have observed patterns in COVID-19 country death rates. Death rate is the number of deaths due to COVID-19, divided by the number of confirmed cases of COVID-19. The figure below (Figure 1.) summarizes these patterns. After describing the death rate pattern below, I will show the pattern present in different countries, describe which stage each country is in, and what happens when a country reacts too late.

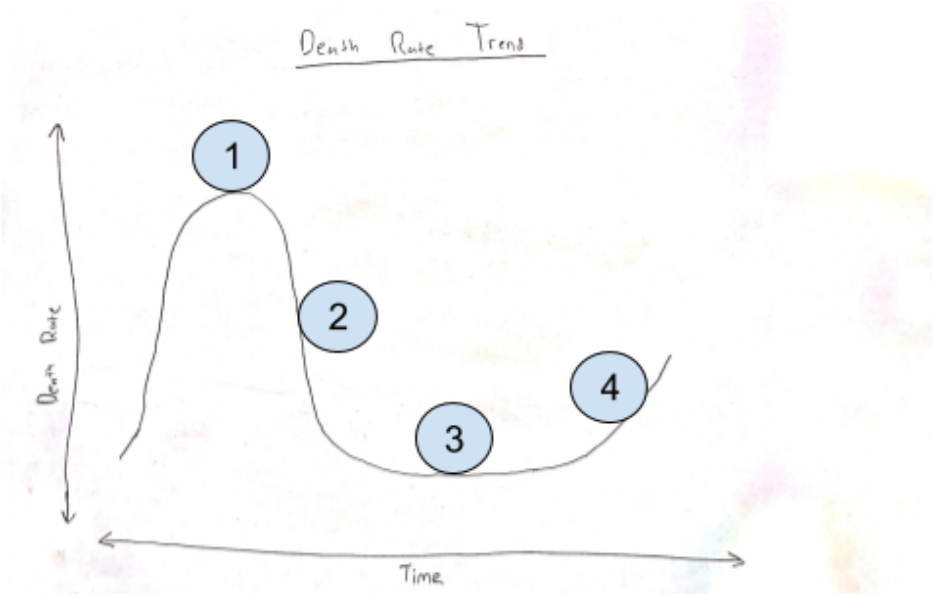

Figure 1. Death Rate Model

Stage 1: Initial spike in death rates

- This occurs due to the lack of testing within a country. This causes the death rate to be artificially high, as testing is only being done in severe cases.

Stage 2: Decrease in country's death rate

- This occurs due to the increase in testing. The more people tested, the higher the number of confirmed cases thus lowering the death rate.

Stage 3: The approximate one to two week plateau

- This plateau in death rate occurs because of the delayed effect of the onset of severe disease and death.

Stage 4: Increase in hospitalization and deaths

- The true destructive impact of COVID-19 is displayed here.
- This is where sick patients start to overload the hospitals, and death rate increases.

After Stage 4: What happens next is dependent on a country's prior methods to soften the impact of COVID-19.

Below I will show all stages as it relates to each country. Italy has gone through all 4 stages already, and they are a prime example of what can happen if the healthcare system becomes overwhelmed.

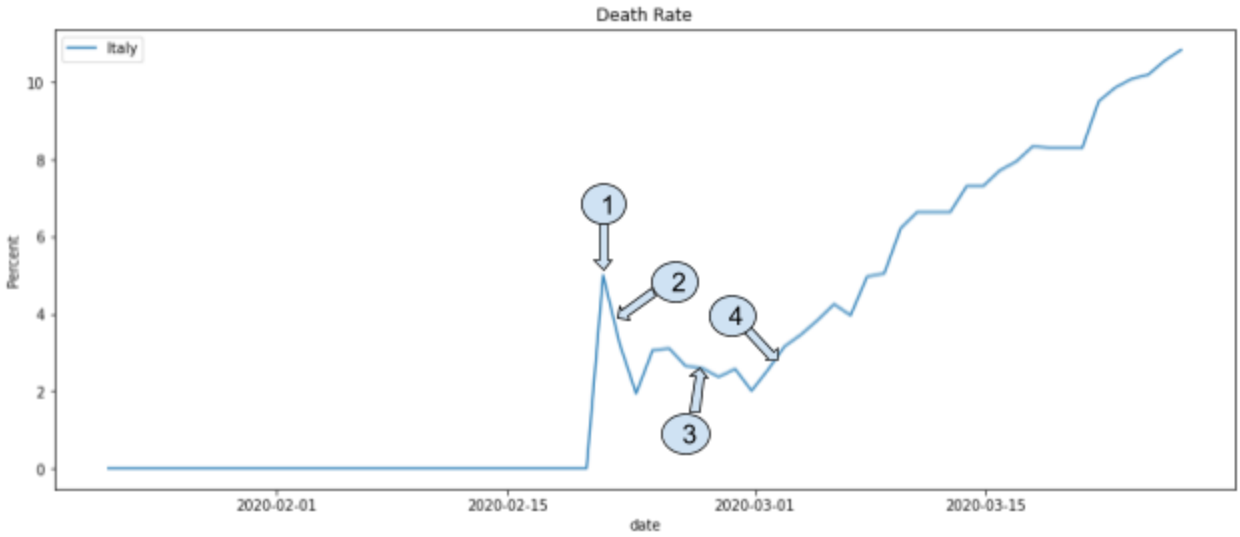

Figure 2. Italy's Death Rate

Italy's death rate in stages

Stage 1: Initial spike in Italy's death rate

- Italy's graph shows an initial spike in death rates.

Stage 2: Decrease in Italy's death rate

- In figure 2, it is clear that after the initial spike, the death rate in Italy has a sharp decline toward stage 3.

Stage 3: There is a two week plateau in Italy's death rate

- Figure 2 shows an approximate two week period in which the death rate remains around the same, with little variance.
- Most parts of Italy were not under quarantine yet, which started around February 24th in some parts, and around March 9th in others.

Stage 4: Italy sees a sharp increase in death rate

- This increase is around 2.3 percent during a three day period
- The majority of Italy is on lockdown (March 9th)

Due to a late start on the lockdown (during stage 4), Italy's hospitals and healthcare system became overwhelmed with the amount of COVID-19 patients coming in. This contributes to the death rate due to a decrease in available resources.

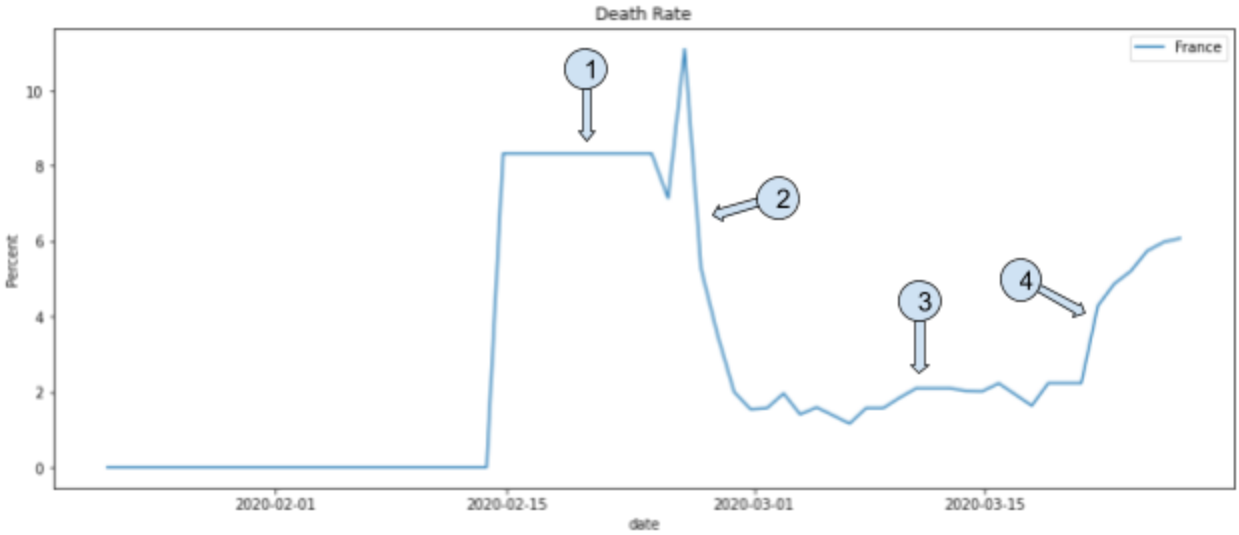

Figure 3. France's Death Rate

France's death rate in stages

Stage 1: Initial spike in France's death rate

- France's graph shows an initial spike in death rate.

Stage 2: Decrease in France's death rate

- In figure 3, it is clear that after the initial spike, the death rate in France has a sharp decline toward stage 3.

Stage 3: There is a two week plateau in France's death rate

- Figure 3 shows an approximate two week period in which the death rate remains around the same, with little variance.
- Most parts of France were not under quarantine yet.

Stage 4: France sees a sharp increase in death rate

- This increase is around 3.25 percent during a three day period
- France announced a lockdown (March 16th)

France started their lockdown in stage 4, just like Italy. Since they have recently entered stage 4, we do not have the data yet to observe if their lockdown effective in keeping their healthcare system intact.

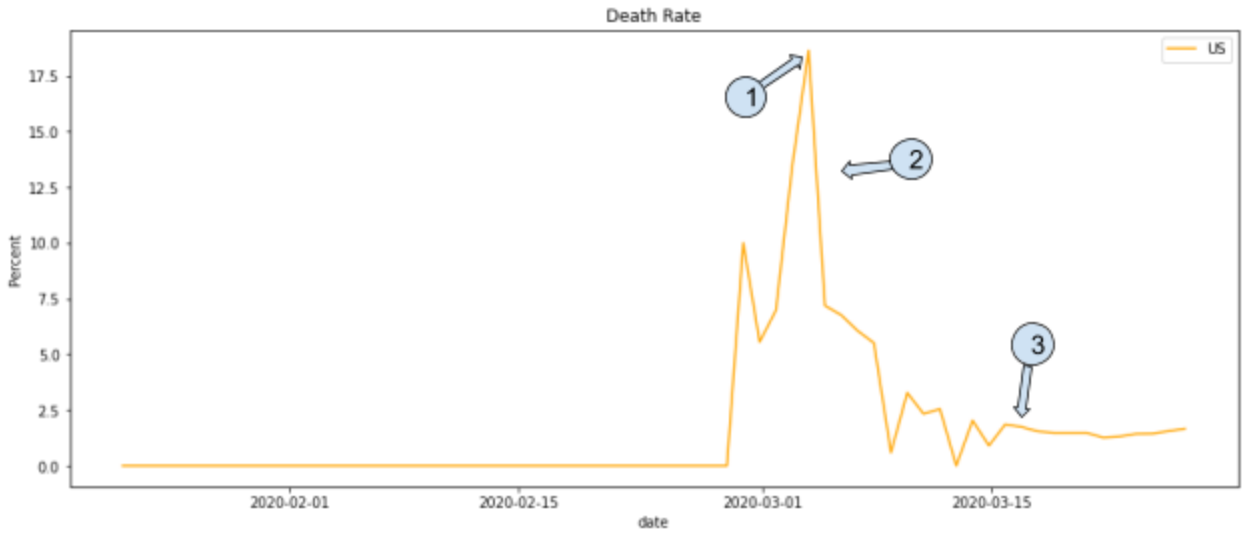

Figure 4. US Death Rate

US death rate in stages

Stage 1: Initial spike in US death rate

- The US graph shows an initial spike in death rates.

Stage 2: Decrease in the US death rate

- In figure 4, it is clear that after the initial spike, the death rate in the US has a sharp decline toward stage 3.

Stage 3: The approximate two week plateau in the US death rate

- The US is currently in this stage, and seems to be one to two weeks behind France.
- The US hasn't had a nationwide lockdown, or nationwide shelter in place order yet.
- There are cities around the US that are closing all non-essential work.
- The majority of states are urging their citizens to stay at home, with some even going as far as a shelter in place order.

Stage 4: A look into the future (the US is not currently here yet)

- If the US follows the current pattern described in figure 1, expect a rise in death rates in the coming 1 to 2 weeks (as of 03/26/2020).

As the data indicates the US is at a critical stage. **It is vital that we all listen to our state governments and practice social distancing**. Without strong steps now, we are bound to fall into a stage of explosive growth in the death rate of COVID-19.

Figure 5 below shows a few other countries that are also going through the stages of the COVID-19 death rates. It is too early to say how accurate this model is, because a lot of countries do not have reliable data, as they are just entering the fight against COVID-19. I will keep researching and updating my models.

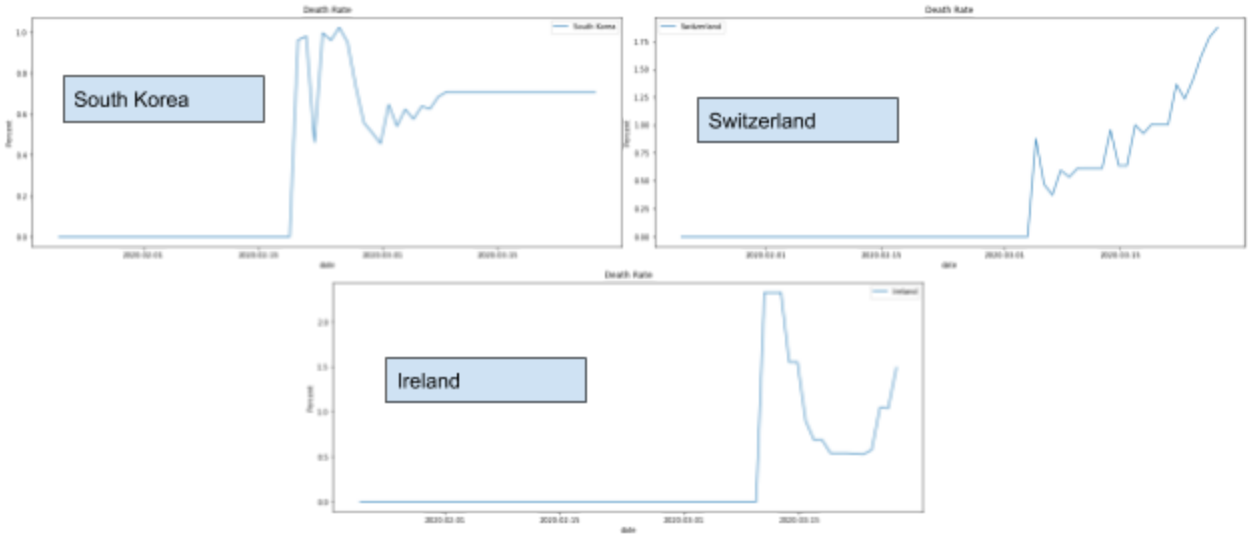

Figure 5. South Korea, Ireland, Switzerland's Death Rate

South Korea had a lockdown which can be seen as successful as they never entered stage 4, and successfully "flattened the curve" of new cases per day.

In summary, we must slow the spread as much as possible. In Italy they started their main lockdown toward the end of stage 4, which was too late and caused their healthcare system to become overwhelmed. France started their nationwide 15-day lockdown at the start of stage 4, and we will soon see how their efforts paid off. In the US we are nearing the end of stage 3, so it is vital we stay inside, so that hopefully we can soften the impact of COVID-19.

References

1. All of the data used in my algorithm is taken from JHU and pulled from this github repository: https://github.com/CSSEGISandData/COVID-19
2. List of US states and their current precautions: https://www.nytimes.com/interactive/2020/us/coronavirus-stay-at-home-order.html?auth=login-email&login=email
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5. Fox breakdown of COVID-19's impact on Italy's healthcare system:https://www.youtube.com/watch?v=W6ZaHOVMM-U