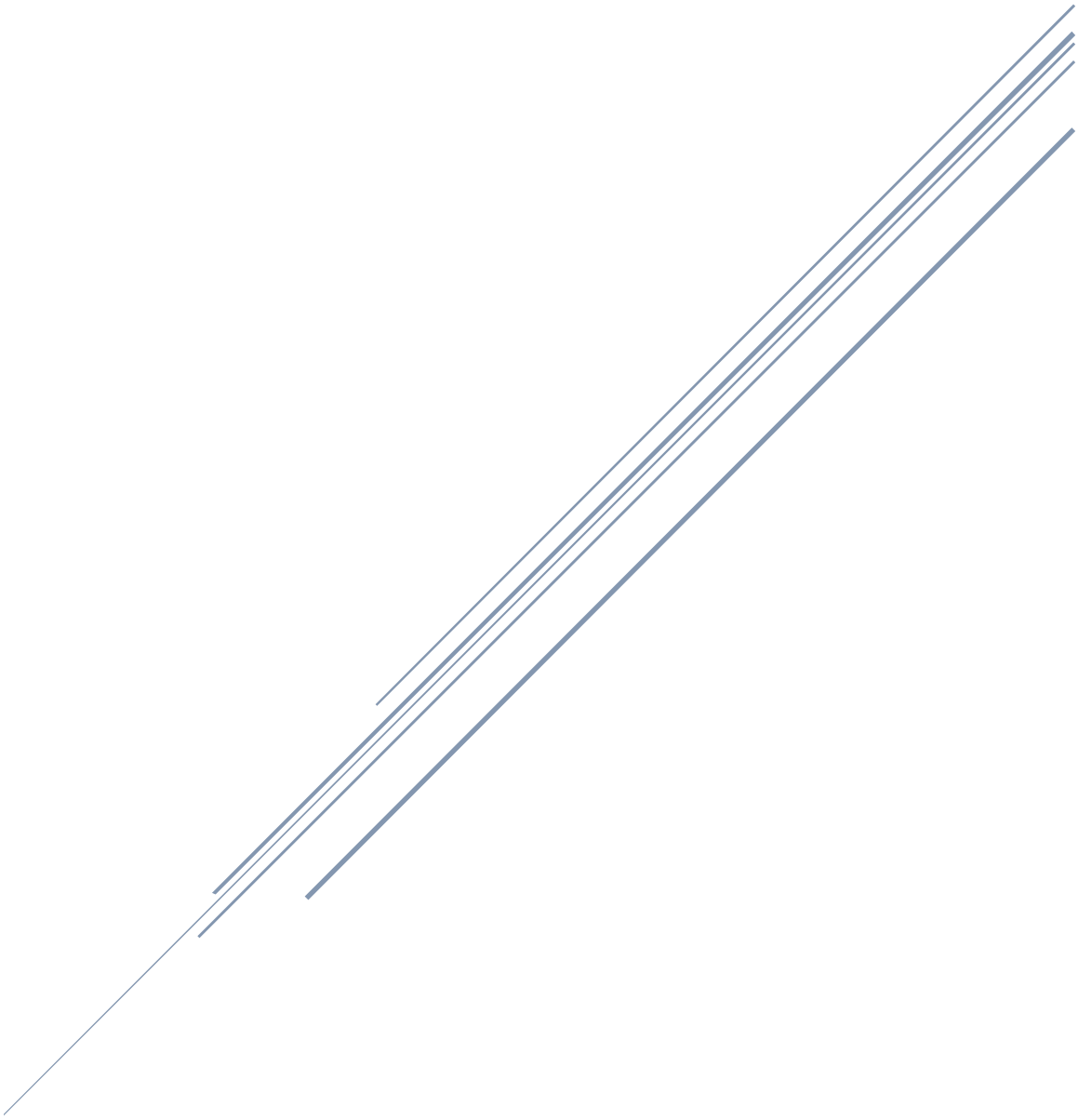
COVID-19: Predictions and Prevention

By: Alexis Castellanos



University of Michigan Dearborn

CIS 306

COVID-19: Predictions and Prevention

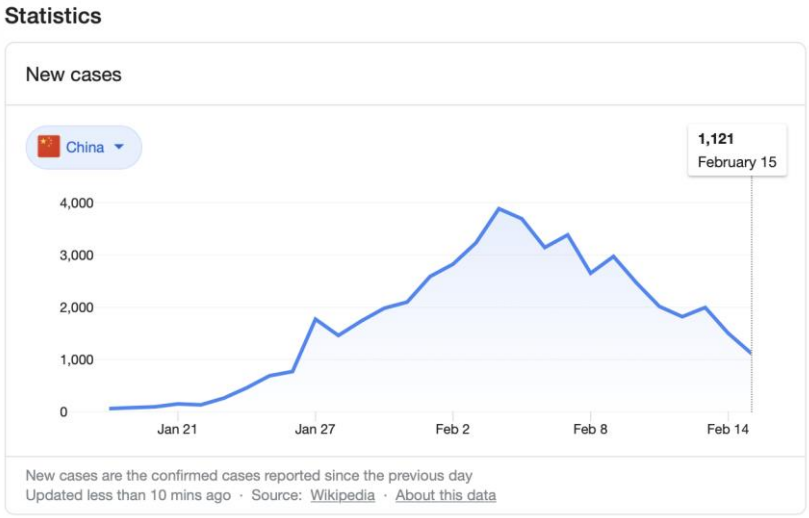
Introduction

Covid-19, more commonly known as Coronavirus, is a newly discovered infectious disease. The virus spreads primarily through bodily fluids, such as coughing or sneezing. Covid-19 is particularly hard to trace because it has a five to seven-day incubation period, yet the host can be contagious during this time while being asymptomatic. Although most people infected will experience moderate flu like symptoms, other groups will be more vulnerable to complications. These vulnerable groups of people include the following categories; over the age of sixty, smokers, diabetes, chronic respiratory disease and cardiovascular disease etc.

Origin

Chinese officials alerted the World Health Organization of an outbreak of some kind of virus on December 31st. By January 7th, Chinese scientists figured out that the virus was the Coronavirus. They discovered the Coronavirus was from the same family as Severe Acute Respiratory Syndrome (SARS), which emerged in China in 2002 and Middle East Respiratory Syndrome (MERS), which infected people in the Middle East in 2012. As of April 15th, there are 82,692 confirmed Coronavirus cases with 4,632 related deaths in China alone. Luckily China has passed the peak of cases in early February and is on its way to recovery.
Source: Google Statistics

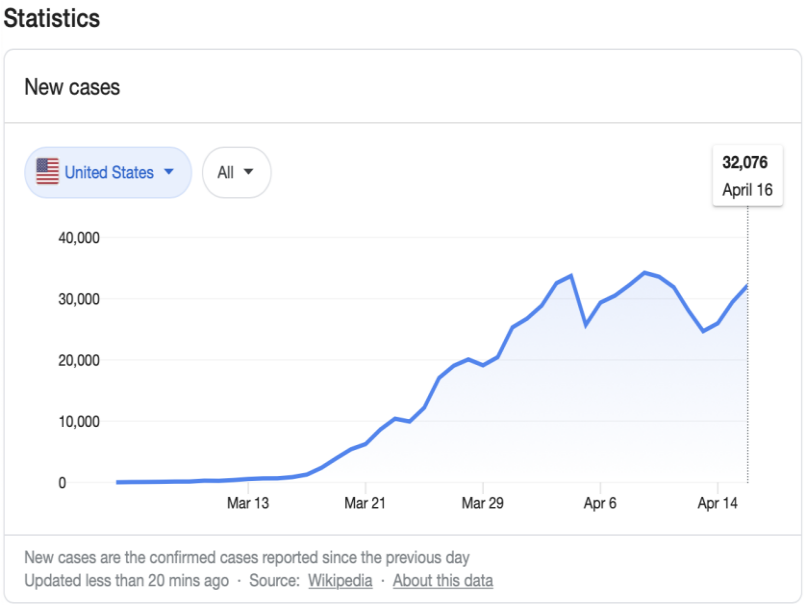
Source: Google Statistics/trends



Impact on The United States

Ever since the initial incident in China, other countries around the world have shut down to prevent the spread of Coronavirus. The United States currently leads the world in both cases and deaths, as represented by the chart below.

Source: Google Statistics/trends



Source: worldometers.info

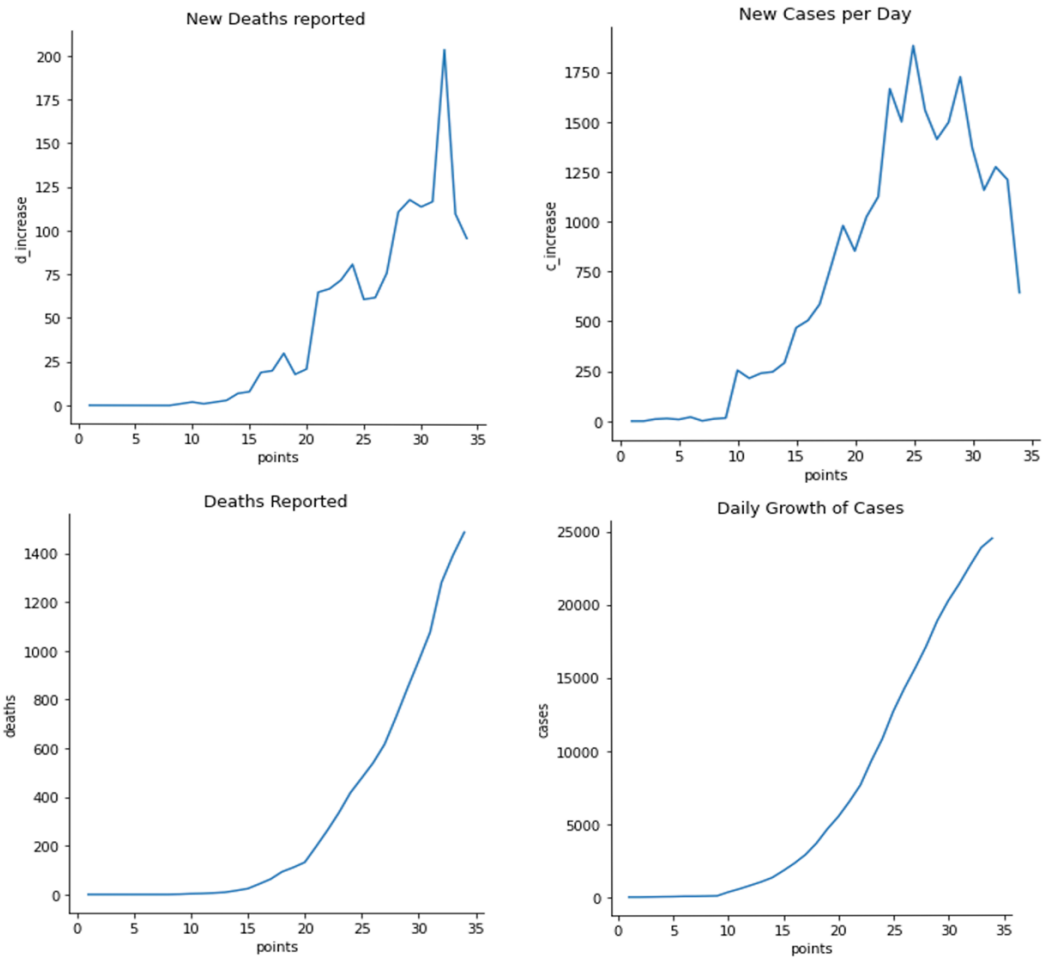
All | Europe | North America | Asia | South America | Africa | Oceania

Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious, Critical
World	2,250,432	+1,568	154,247	+102	571,577	1,524,608	56,960
USA	710,021	+286	37,158	+4	60,510	612,353	13,509
Spain	190,839		20,002		74,797	96,040	7,371
Italy	172,434		22,745		42,727	106,962	2,812
France	147,969		18,681		34,420	94,868	6,027
Germany	141,397		4,352		83,114	53,931	5,013
UK	108,692		14,576		N/A	93,772	1,559
China	82,719	+27	4,632		77,994	93	85

As of March 10th, Michigan started to record and report Covid-19 statistics. The following graph represents the metrics of the virus from 3/10 to 4/12.

Author: Alexis Castellanos
Source of Data: michigan.gov
Key: Dates Points Recorded (3/10 – 4/12) = points
Confirmed Cases = cases
Confirmed Deaths = deaths
New Cases per day = c_increase
New Deaths per day = d_increase

Michigan's Cases and Deaths of Covid-19

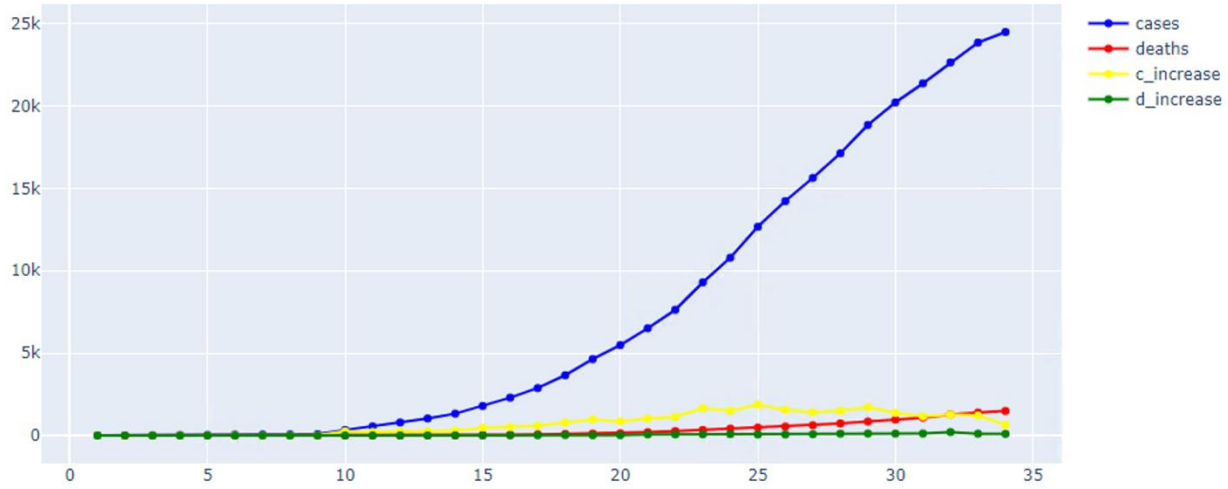


As shown above both total cases and deaths are clearly growing rapidly in the state of Michigan. One could model these cases through exponential growth, as more data is available a possible prediction

Exponential Growth

The following is an interactive graph displaying the exponential growth of the virus's confirmed cases, deaths, new cases and new deaths, for the first 34 recorded dates in Michigan. The graph can be accessed by the source code.

Exponential Growth of Covid-19 in Michigan



Starting from the first Michigan COVID-19 recorded date, March 10th, to the next date involves multiplying by some constant in our data. The number of cases tends to be a multiple of 1.18 to 1.25 (outside the outliers) of the cases reported in the previous day. Therefore, we can represent this epidemic as an example of exponential growth. To further understand our graph, we label the following variables.

$$\Delta N_d = E * p * N_d$$

ΔN_d = Change per day

N_d = Quantity of cases on current day

E = Average number of people in contact with an infected person on current day

p= Probability of becoming infected

When the number of new cases each day is proportional to the number of existing cases it you must multiply by some constant:

$$\Delta N_d = E * p * N_d$$

$$N_{d+1} = (1 + E * p)N_d$$

$$\text{While } N_d = (1 + E * p)^d * N_0$$

Theoretically this can go on to infinity, yet we are bound by E and p, that will eventually decrease. Limited amount of population would result in our probability being the following:

$$p = 1 - \frac{N_d}{U}$$

$$U = Size\ of\ Population$$

Due to our limited population size, our exponential curve can become a Logistic Equation as the following:

$$\frac{dN}{dt} = p * c * N$$

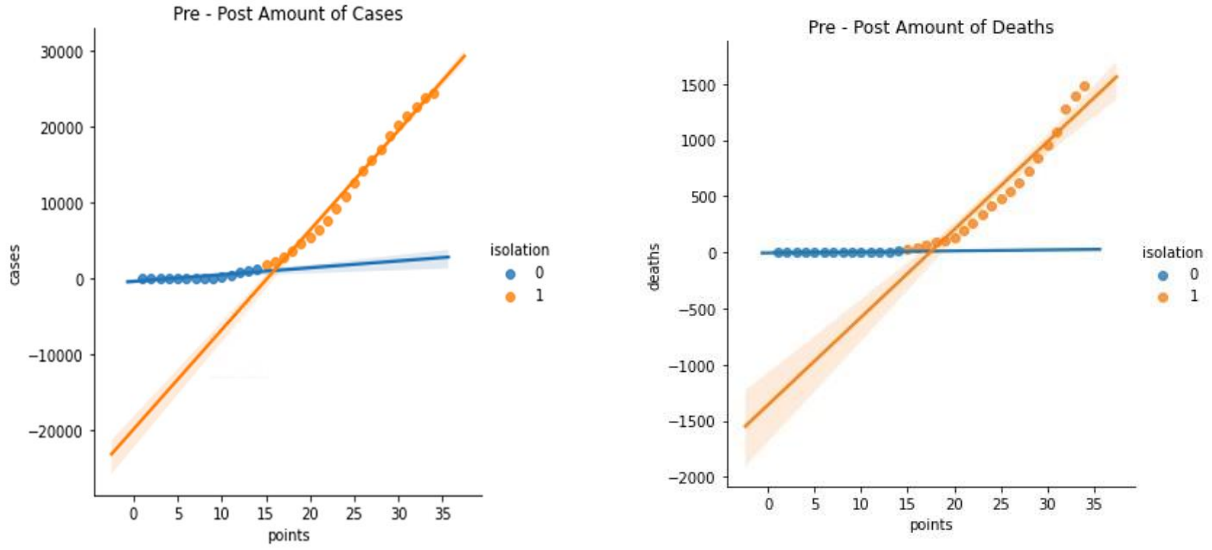
To correctly analyze our data, we must account for the rate of growth. The rate of growth can be represented by the following:

$$G = \frac{\Delta N_d}{\Delta N_{d-1}}$$

As our variable G approaches, the numeric value of one can be a great sign of our exponential growth becoming a logistic equation. The point of G is equal to one is known as the inflection point. When the inflection point is reached, we can estimate the maximum number of cases to be the value of this instant's cases multiplied by a factor of two (considering all factors to stay constant).Fortunately, reaching the capacity of population is not the only factor to end this pandemic. Other efforts can be made to reach this inflection point such as social distancing and precautionary measures (gloves, mask, etc.). Governor Whitmer ordering social distancing on March 25th reveals the following information shown below.

Author: Alexis Castellanos
(March 25th is depicted as the 15th point in the following graph)

Social Distancing Efforts



The illustrations above could be misinterpreted as social distancing being ineffective. However, this is not the case; the extreme rise of confirmed cases was a result of increased testing throughout the state. Many hospitals and clinics started offering Coronavirus testing soon after the social distancing policy was enforced in Michigan. Towards the end of recorded dates (data points) we start to see a slight decrease in the rate of confirmed cases per day. Starting from April 6th (point 28) we can see our rate of growth 'G' start approaching one. Shown below is our rate of growth for the last week of this report.

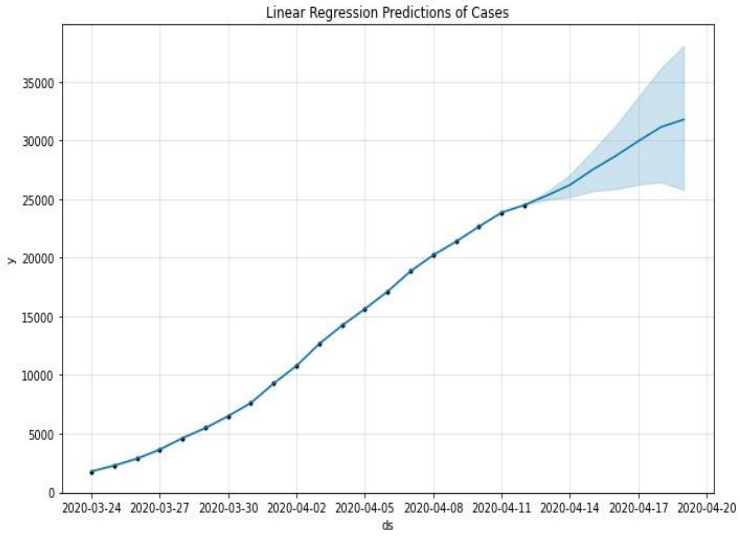
Unfortunately, social distancing alone will not be sufficient enough to halt the rapid spread and fatality of the Coronavirus. Current data cannot justify our last week's average as a definite inflection point. The following graphs provide a forecast of the next five day's new confirmed cases and deaths.

Date	$G = \frac{\Delta N_d}{\Delta N_{d-1}}$
4/6/2020	1.46
4/7/2020	1.06
4/8/2020	0.97
4/9/2020	1.02
4/10/2020	1.74
4/11/2020	0.54
4/12/2020	0.87

Predictions for Michigan

Using linear regression at a 95% confidence interval we can make a good prediction of confirmed Covid-19 cases and deaths for the following five days.

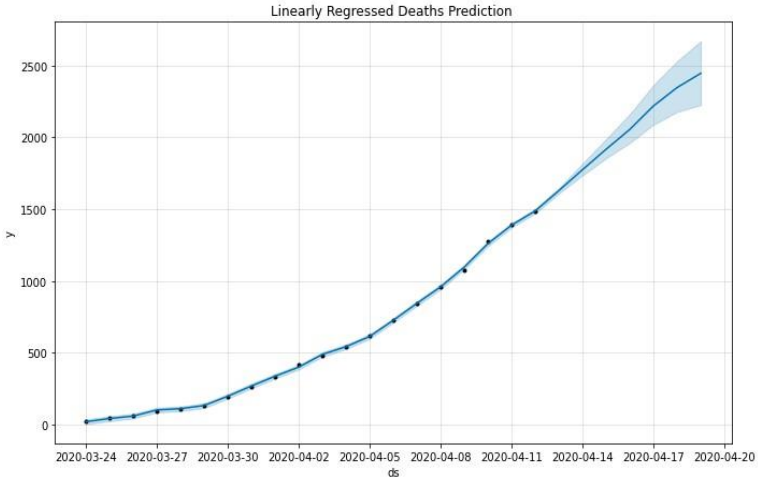
Covid-19 Confirmed Cases Forecast



	ds	yhat	yhat_lower	yhat_upper
22	2020-04-15	27506.112186	25676.982868	29126.029809
23	2020-04-16	28661.112186	25857.014096	31233.176642
24	2020-04-17	29932.112186	26227.587110	33707.754143
25	2020-04-18	31139.112186	26437.189870	36149.541132
26	2020-04-19	31780.112186	25796.939315	38060.660365

Update: 4/15 Actual Cases: 27893
Update: 4/16 Actual Cases: 29119

Covid-19 Fatality Forecast



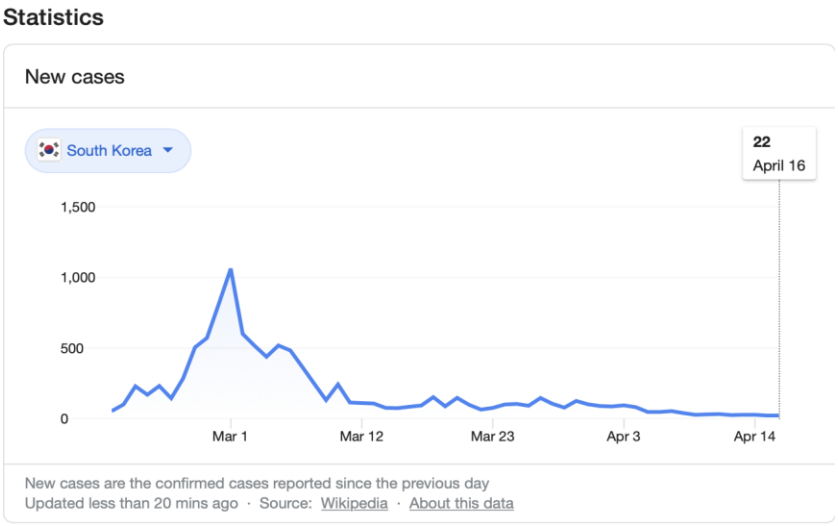
	ds	yhat	yhat_lower	yhat_upper
22	2020-04-15	1917.961031	1854.684515	1989.597040
23	2020-04-16	2055.752382	1961.596507	2162.738710
24	2020-04-17	2219.210308	2088.981133	2365.099122
25	2020-04-18	2347.547671	2177.689085	2531.017855
26	2020-04-19	2446.592432	2225.780208	2671.442901

Update: 4/15 Actual Deaths: 1919
4/16 Actual Deaths 2091

Successful Recovery

South Korea was on the rise reporting some of the highest numbers of confirmed cases in the world. However, South Korea was able to quickly reduce the spread of the virus.

Source: Google Statistics/trends



South Korea managed to contain the spread of the virus early on due to techniques developed previously when they faced a similar viral outbreak, MERS in 2015. Apart from enforcing social distancing they also performed contact tracing which proved very successful. Contact tracing is when authorities trace whom the infected persons came in contact with. Once located they test and monitor them regardless if they show symptoms, if found positive they are quarantined and treated. Apart from human to human transmission, the infected can transmit disease by leaving traces of the virus in public places. This inspired South Korea to change the law, permitting the government to collect an infected persons data and security footage during an outbreak. Additionally, authorities publicly share the recent activity of newly found cases via smartphones. These locations display places and times in radar format. This information allows people to know if they cross paths with an infected person, so that they may be monitored and tested for the virus. South Korea was able to test hundreds of thousands of people more than any other country at the time, making it easier for authorities to see the spread of the virus. Tracing people's every move may seem controversial, but in South Korea they prioritized public health over privacy and saw notably great outcomes from this practice.

In regard to COVID-19, countries like Germany and the UK are starting to implement preemptive testing. On the other hand, the US is scrambling to provide adequate testing displayed by the rising cases in the US. The US can learn from the testing strategies South Korea implemented. Despite the US having a larger population these practices may prove successful.

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