How Long Should Social Distancing Last?
Predicting Time to Moderation, Control, and Containment of COVID-19

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Abstract

Lockdowns and stay-at-home orders in response to the Covid-19 pandemic have raised an urgent question in peoples' minds, "How long must these restrictions last?" We propose two metrics of the spread of disease to answer this question: **daily growth rate** and **time to double** cumulative cases. These metrics enable three simple, intuitive, and actionable benchmarks to target: **Moderation, Control, and Containment** (growth < 10%, 1%, and 0.1% respectively). In addition, we define action or intervention as massive testing and quarantine, stay-at-home orders, or lockdowns.

An analysis of top 36 countries and 50 states of the US affected by the epidemic as of end-March yield the following results. Any moderation or slowdown has so far been due only to aggressive intervention. Countries take an average of about three weeks to act. However, even aggressive intervention does not show immediate results. Countries take an average of about three weeks to moderate, four weeks to control, and over 6 weeks to contain the spread of the disease, after aggressive intervention. Substantial differences exist between large and small and Asian and European countries in time to act. Using these findings, we predict the likely dates of moderation and control for specific countries and States of the US.

In the absence of a vaccine, cure, or massive testing and quarantine, lockdowns and stay-at-home orders will need to last for months. However, the US faces a unique challenge because only half the states have adopted aggressive intervention, and done so at varying times. Even if these states achieve control or containment, they may be vulnerable to contagion from other states that were late to do so.

Keywords: Coronavirus; COVID-19; restrictions; lockdown; metrics; prediction;

JEL classifications: I1, I18

Main Article

With governments' growing enforcement of stay-at-home orders, lockdowns, and quarantines against COVID-19, the topmost question on people's mind is, "For how long?" The widespread reporting about new and cumulative infections fail to shed light on this question. Based on our extensive prior research[1] on diffusion of innovations, we propose two metrics and three benchmarks to help answer this critical questions.

Two metrics of the spread of disease that are simple, intuitive, and generalizable are **daily growth rate** and **time to double** cumulative cases. Daily growth rate is the percentage increase in cumulative cases. Time to double, or doubling time, is the number of days for cumulative cases to double at the current growth rate (approximately 70 divided by growth).[2] Time to double in disease spread is the opposite of half-life in drug metabolism. Besides their simplicity and intuitive appeal, these metrics are not dependent on calendar time, country, or type of disease. This feature enables comparisons across time and country.

For example, when New York reported 1,008 new cases on March 18th on a base of 1,374 total cases on March 17th, its growth rate was 73% and its doubling time was 1.25 days. At that rate, the number of victims would have grown to about 22,000 in five days. Had Governor Cuomo not intervened and allowed the disease to spread uncontrolled, the disease would have infected 585,000 victims as of March 29th.

Using these two metrics, we define three measurable benchmarks for analysts and public health managers to target:

- **Moderation**: when growth rate stays below 10% and doubling time stays above 7 days.
- **Control**: when growth rate stays below 1% and doubling time stays above 70 days.
- **Containment**: when growth rate stays below 0.1% and doubling time stays above 700 days.

Note, just like the metrics, these benchmarks are also independent of country, calendar time, or type of disease. This new model with its two metrics and three benchmarks allows us to compare across regions (countries, states, or cities) stricken by COVID-19, infer important patterns, and draw actionable lessons.

To do so, we record the start of the disease in each region (**first incidence**) and the start of **aggressive intervention** (**action**). We define the latter as, 1) Stay-at-home or lock down orders (e.g., China, California, Italy) or 2) Massive smart-testing and quarantine (e.g. Singapore, S. Korea, Japan). We then compute the time it takes for a region to adopt aggressive intervention and the time from then to moderation, control, and containment. We compute these statistics

for 36 countries of the world and 50 states of the USA, for which we could assemble data, as of March 29th.

Using this model on the data collected, we compute the mean times for these events by region, either large Asian countries, large European countries, small countries, or states of the USA. Table 1 presents the results.

Table 1: Mean Time to Act, Moderate, and Control by Region^

Country/State	Time to Act	Time to Moderate	Time to Control	Time to Containment
Large Asian (n = 4)	22	18	31*	45*
Small Asian (n = 7)	16	15	Pending	Pending
Large European (n = 2)	31	17	Pending	Pending
Small European (n = 2)	21	5	Pending	Pending
US States Jan-Feb 27 1st case	50	Pending	Pending	Pending
US States Feb 17-Mar 1st Case	10	Pending	Pending	Pending

* Only China has achieved control or containment at this stage

^ These predictions are based on as of March 29th, 2020

Here are the important points to note about Time to Act.

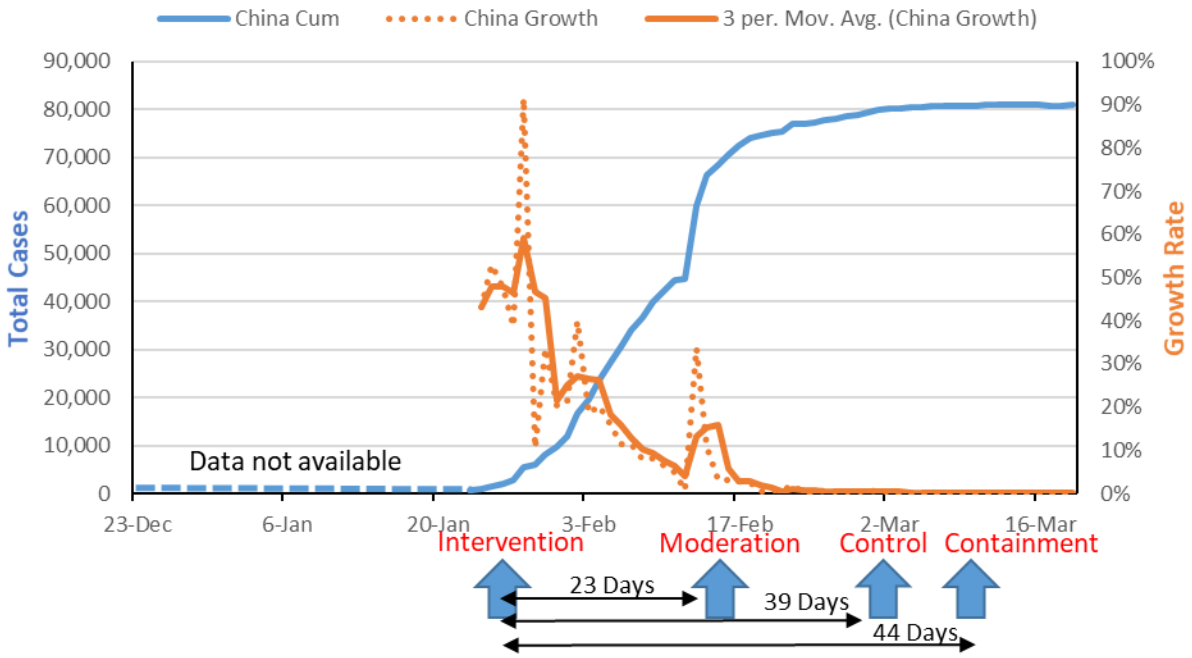
- First, countries took, on average, about three weeks to act. This is a huge time interval, especially given the high cost of delay in terms of people falling sick, being hospitalized, and dying.
- Second, a large difference exists in time to act between Asian (19 days) and European (26 days) countries. The relatively shorter times to act for Asian countries could be due to their previous experience with similar viral epidemics (e.g., SARS).
- Third, across Asia and Europe, small countries act faster (18 days) than large ones (26 days), perhaps because small countries can achieve consensus among disparate coalitions faster than big countries.
- Fourth, the longest time to act is for US States that had the first case before Feb 27th (50 days). The probable reason is that the US had not been hit by a pandemic for decades. So, people were in disbelief that the pandemic would spread too rapidly in the US, with its premier medical system, physical separation from Europe and Asia, and long tradition of hygiene and fighting disease.
- Fifth, now that US states have seen the terrible consequences of delayed action in California and especially New York, they are acting one third as fast as the states that had the first case before Feb 27th and nearly as fast as small Asian countries.

Here are the important points to note about time to moderate.

- First, large Asian countries take slightly less than three weeks to moderate. Small Asian countries take about fifteen days to moderate. The small difference may be due to more stringent implementation or compliance of orders in small Asian countries.
- Second, it's too early to see a pattern between time to act and time to moderate, though we suspect that such a pattern will emerge.

Thus, across this sample, size of region, prior exposure to epidemics, prior challenges of neighboring states, and misunderstanding, may play a role in time to act and time to moderate the spread of the disease. The figure below shows dates of intervention, moderation, control, and containment in China, which is the only country that has gone through all four events.

Figure: Total Cases & Daily Growth in China



These results yield the following important implications.

The spread of the disease has not been slowing down due to penetrating the whole population. (It has penetrated less than 0.3% of the populations in most countries). Nor as yet does it have a cure or vaccine. So, any moderation or slowdown has been due only to aggressive intervention. Such actions are essential to achieve moderation and control in the near future.

However, even aggressive intervention does not show immediate results (due partly to the incubation period of the virus). Moderation alone takes about three weeks for large countries. Moreover, longer time to act does not shorten the time to moderate. Thus, there is no advantage in delaying intervention.

From the experience of some East Asian countries, early lifting of lockdowns and stay at home orders may not be productive. For example, Singapore suffered a relapse in growth near the end of March, possibly because they lowered their aggressive intervention in early-March 2020.

Using this model, we can assess the merit of the stay-at-home orders of US states. Are they required? Yes. Lockdown and stringent quarantine are the only way China got moderation and control. As an alternative to a complete lockdown, Singapore, South Korea, Japan, and Hong Kong used smart identification, massive testing, and selective quarantine. With these strategies, these countries got moderation and may get control.

Using our model on the data we collected, Table 2 (below) gives the tentative predicted time to moderation and control for select regions of the world.

Table 2: Times to Predicted Moderation and Control for a Select Countries and US States

Region	Date - First Incidence	Action Day	Days to Act	Days to Moderate	Date of Moderation	Predicted Date of Control*
China	23-Dec	23-Jan	31	16	8-Feb	23-Feb
Japan	23-Jan	3-Feb	11	14	17-Feb	(>29-Mar)
South Korea	23-Jan	12-Feb	20	21	4-Mar	(>29-Mar)
Italy	31-Jan	6-Mar	35	17	23-Mar	(>14-Apr)
Washington	21-Jan	12-Mar	51	Pending	(>01-Apr)	(>12-Apr)
Illinois	24-Jan	21-Mar	57	Pending	(>04-Apr)	(>21-Apr)
California	26-Jan	19-Mar	53	Pending	(>02-Apr)	(>19-Apr)
Germany	27-Jan	22-Mar	55	Pending	(>05-Apr)	(>22-Apr)
Massachusetts	1-Feb	24-Mar	52	Pending	(>07-Apr)	(>24-Apr)
Spain	1-Feb	14-Mar	42	Pending	(>01-Apr)	(>14-Apr)
New York	1-Mar	22-Mar	21	Pending	(>05-Apr)	(>22-Apr)

There is considerable political and economic pressure, especially in the US, to lift lockdowns after two weeks. Will two weeks be enough time? No. It takes about three weeks for moderation and more than six weeks to get containment (see Table 1). Are there alternatives to stay-at-home and lockdown orders? Yes, if done well. Smart identification, massive testing, and quarantine can reduce the need or extent of blunt and economically disrupting stay-at-home or lock down measures. However, all restrictions should be removed cautiously because regions may relapse. In particular, the US faces a unique challenge because only half the states adopted aggressive intervention, and done so at varying times. Even if these states achieve control or containment, they may be vulnerable to contagion from other states that were late to do so.

Some important assumptions qualify these preliminary findings. First, the data reported by the various countries and regions within countries are honest and not fudged. The rate of detection is similar across countries, albeit we know that the rates of testing differ vastly. We have not yet explicitly controlled for other potential drivers like humidity and temperature,[3] geographical latitude,[4] density of population, enforcement of the control, cultural greetings (e.g., bowing vs. handshaking vs. kissing), personal hygiene, etc. in our predictions, which would require detailed data. When available, such data will enable more sophisticated models, which may give more precise estimates than ours. In the absence of such data and models, the estimates in the table above give some guidance to public health managers and the public about the progression of the disease and the imperative for action.

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Endnotes

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[2] For a constant growth rate of r% within time t, the doubling time Td is given by $T_d = t\frac{\ln(2)}{\ln(1+\frac{r}{100})}$

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