400,000 Infections per Day

Ty Newell, PhD, PE
Emeritus Professor
Mechanical Science and Engineering
University of Illinois
tynewell@illinois.edu
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Record daily infection numbers in the US have occurred several days over the past week. 30,000, 35,000, and now exceeding 40,000 infections per day are reported. How far will it rise, and what can we do to gain control?

The rise of Covid-19 infection rates in the US, and its control are very predictable, however, garbled messaging and a lack of national coordination of efforts to fight the virus have hindered our ability to take effective actions.

Two weeks ago, I made the following predictions of US daily Covid-19 infections per day (see Figure 1). Three prediction paths shown represent the current path, a path representing "Serious Isolation", and a path representing a realistic goal the US could attain if effective social distancing and decrease of disease transmission efficiency are immediately established.

Unfortunately, we continue following my predicted path, a path headed to disaster. Without noticeable change in our level of social distancing combined with a reduction of disease transmission efficiency, the US will be experiencing 400,000 new cases per day of Covid-19 by August. Figure 2 shows current infection data (as of June 27, 2020) align with the prediction model's path. Figure 3 shows an expanded version of Figure 2 with daily new Covid-19 cases accelerating through the month of July. If no effective action is implemented by the end of July, we will experience an infection tsunami.

Waiting until the end of July to take action against Covid-19 results in growth toward 25,000,000 total infections during the fall, as shown in Figure 4. Immediate action in early July, however, could keep total infections below 5,000,000 and new infections below 50,000 per day, including the impact of a potential "fall wave" as schools and businesses re-open. These are horrific numbers but much better than 400,000 new infections per day. Effective control and management of Covid-19 throughout the US must begin immediately to keep from overwhelming medical personnel and facilities, and to reduce stress on our essential workers.

Covid-19 moves with the momentum of a steamroller. One week of disease incubation followed by a 2 week infectious period pre-ordains the trajectory we are currently following. Action now will require 2 to 3 weeks before we see the impact of our actions. The longer we wait, the more difficult it will be to slow the steamroller down. Infection growth is directly related to the number of current infections, and as active infections increase, the growth of new infection cases increase.

Why the 1918 Influenza Died Out in the Summer and SARS-CoV-2 Continues to Rage

The 1918 Influenza pandemic initially appeared in the spring of 1918, disappeared in the summer, and returned in the fall and again at the end of winter. The fall influenza wave was especially strong and deadly. Many people have been projecting SARS-CoV-2 to have the same behavior, but it does not. There are two reasons why this pandemic is much different in the summer:

1) Influenza viruses tend to have lower survivability outside their host's body during warmer, more humid conditions while SARS-CoV-2 does not show seasonal or climate sensitivity.
2) No one had air conditioning in the summer of 1918 while most in the US in 2020 live and work in air conditioned buildings during the summer.

Without air conditioning in 1918, everyone slept outside, or on "sleeping porches" or with windows and doors wide open during the summer. As hot as it would be outside, indoor environments were even hotter. High levels of fresh air ventilation reduced contagion concentrations to levels that collapsed the uncontrolled spring disease transmission.

Number 2 explains why the virus initially grew rapidly in northern states in the late winter and early spring, while southern states were spared from the initial onslaught. During February and March, when temperatures were still cold, northern states residents were staying in buildings sealed against the cold. Southern state residents were spending time outdoors enjoying spring weather as well as opening windows and increasing building ventilation.

The summer infection surge in the south, with reduced infection spread in the north, can be explained by hot weather forcing southern state residents into insufficiently ventilated, air conditioned buildings. Northern states have been enjoying comfortable May and June weather conditions, with increased outdoor activities and increased fresh air ventilation as windows and doors are opened.

Northern states should not be lulled into feeling they have defeated the spread of Covid-19. In fact, as hot and humid weather conditions move north, the summer infection surge will move north as northern state residents move indoors to avoid hot weather. As average temperatures move above 80F for extended periods in northern regions, accelerated infection growth may occur.

Controlling SARS-CoV-2

We can and must control the spread of the SARS-CoV-2 virus, and not stand idly by hoping that an effective vaccine or medical treatment will be found. We are at the beginning of the SARS-CoV-2 pandemic. Allowing the disease to run uncontrolled will result in 60 to 70% of US (200,000,000) becoming infected with enormous number of fatalities and lifelong health difficulties for many afflicted survivors.

Two parameters are important for controlling virus transmission: social distancing and disease transmission efficiency. Social interactions can be characterized with anonymous cell phone and gps data, such as the University of Maryland and Maryland Transportation Institute Social Distance Index (SDI). An SDI=0 represents maximum social interactions and SDI=100 represents perfect isolation. Prior

to the growth of Covid-19 in the US, the SDI was approximately 20. Rapid shutdown throughout the US in late March and April increased the SDI to 60. Since May, the SDI has moved back to an average US level of 30.

The second factor, disease transmission efficiency, represents multiple effects that express the relative transmission of Covid-19 to a reference transmission efficiency of 1.0, representing the apparent average disease transmission in the US as social distancing occurred in March 2020. During the March-April shutdown, changes to interaction habits (eg, wearing masks, 6 ft spacing) had not occurred.

Figures 5 and 6 (expanded view of Figure 5) show the initial trends of IP versus the UMD SDI during the initial shutdown phase in March and April, followed by the current period with decreasing SDI (more social interactions due to re-openings). The initial US IP-SDI trend is used as a reference with an infection transmission efficiency of 1 assigned.

Parametric curves for differing transmission efficiencies are shown in Figures 5 and 6. Wearing masks, maintaining 6ft spacing in public, reduced occupancy density in public buildings, and sanitizing surfaces, for example, could lower disease transmission below 50% at any given SDI. Increased ventilation, improved air filtration (MERV13 filters) and installation of UVGI (Ultraviolet Germicidal Irradiation) can further reduce transmission efficiency.

A boundary exists between infection growth and infection decrease. The boundary between growth and decrease of infections is defined by an Infection Parameter value of 2.72 ("e"). When the Infection Parameter is 2.72, a special condition occurs in which new infections per day are constant and the growth of total infections is linear. The boundary between accelerated infection growth and decline is independent of the current growth rate and number of current infections. The sooner a region moves to an SDI and transmission efficiency level with IP<2.72, the sooner daily infections will decline.

Table 1 shows Infection Parameter values for differing SDI and transmission efficiency (G) values. The yellow arrow shows the path the US followed as it shutdown in March and April. Since April, much of the US was able to decrease SDI (increase social interactions) while keeping IP below 2.72. Many countries, such as South Korea, Norway, Spain, Italy, Germany, and others have successfully held IP well below 2.72, resulting in a significant decay of active Covid-19 cases.

The US has moved back into the accelerated infection growth region. As social distancing was relaxed, sliding from a high of 60 to today's level of 30, other measures such as face masks, 6ft spacing, reduced building occupant density and other measures reduced transmission efficiency to a level of 01. To 0.2. Over the past few weeks, social distancing has remained at an SDI of 30, however, the transmission efficiency has moved above 0.2, resulting in today's IP of 4 (well above the no growth boundary of 2.72).

Two reasons for increased infection transmission efficiency are: re-openings and warm weather in southern states. Vertical movements in Figures 5 and 6 at a given SDI indicate factors impacting Covid-19 transmission efficiency level. For example, one can maintain the same SDI, but as windows and doors are closed and people spend less time outdoors, more efficient infection transmission will occur.

In order to move the US back to a region with decreasing infection transmission, increasing SDI to 40 (less social interaction) and/or reduction of Covid-19 disease transmission efficiency to 0.1 are needed in order to reduce IP below 2.72. Note that a reduction of IP to 1, achieved by either perfect isolation

(SDI=100) or zero transmission efficiency would snuff out the progression of Covid-19 in three weeks as shown in Figure 2 (Serious Isolation case).

Guidelines for Re-Opening while Controlling Covid-19

The following guidelines are recommended for home and public spaces for controlling the spread of Covid-19. These guidelines are based on studies that have demonstrated the reduction of viral contagions in buildings. Note that measuring carbon dioxide concentration is easy and ensures that a building has fresh air ventilation levels that reduce contagion concentrations. Additional background information can be found here.

For homes, business, and public gathering places:

1) Increase fresh air ventilation until indoor carbon dioxide concentration is kept below 800ppm
2) Recirculate indoor air through a MERV 13 or greater filter (85% viral particle filtration)
3) Consider adding UVGI (ultraviolet germicidal irradiation) to recirculation air stream for additional protection (0.02Watts-UV per cfm of airflow for 85% kill efficiency)

For businesses and public gathering places:

4) Consider UVGI surface sanitization in addition to standard disinfectant washing and spraying
5) Encourage staff, customers, visitors, and others to wear face masks
6) Stay away (much more than 6 feet) from anyone not wearing a face mask in public

Table 1 Infection Parameter (IP) table for varying Social Distance Index (SDI) and Covid-19 transmission efficiency (G) values. IP values above 2.72 result in accelerated disease growth and IP values below 2.72 result in decrease of daily infections. An IP value of 2.72 has linear total infection growth (constant new infection cases per day). The yellow line shows the infection path the US has followed.

	G=1.0	G=0.6	G=0.3	G=0.2	G=0.1
SDI	G*IP	G*IP	G*IP	G*IP	G*IP
20	60.89	36.93	18.97	12.98	6.99
25	29.71	18.22	9.61	6.74	3.87
30	16.74	10.45	5.72	4.15	2.57
35	10.47	6.68	3.84	2.89	1.95
40	7.10	4.66	2.83	2.22	1.61
60	2.60	1.96	1.48	1.32	1.16
80	1.62	1.37	1.19	1.12	1.06

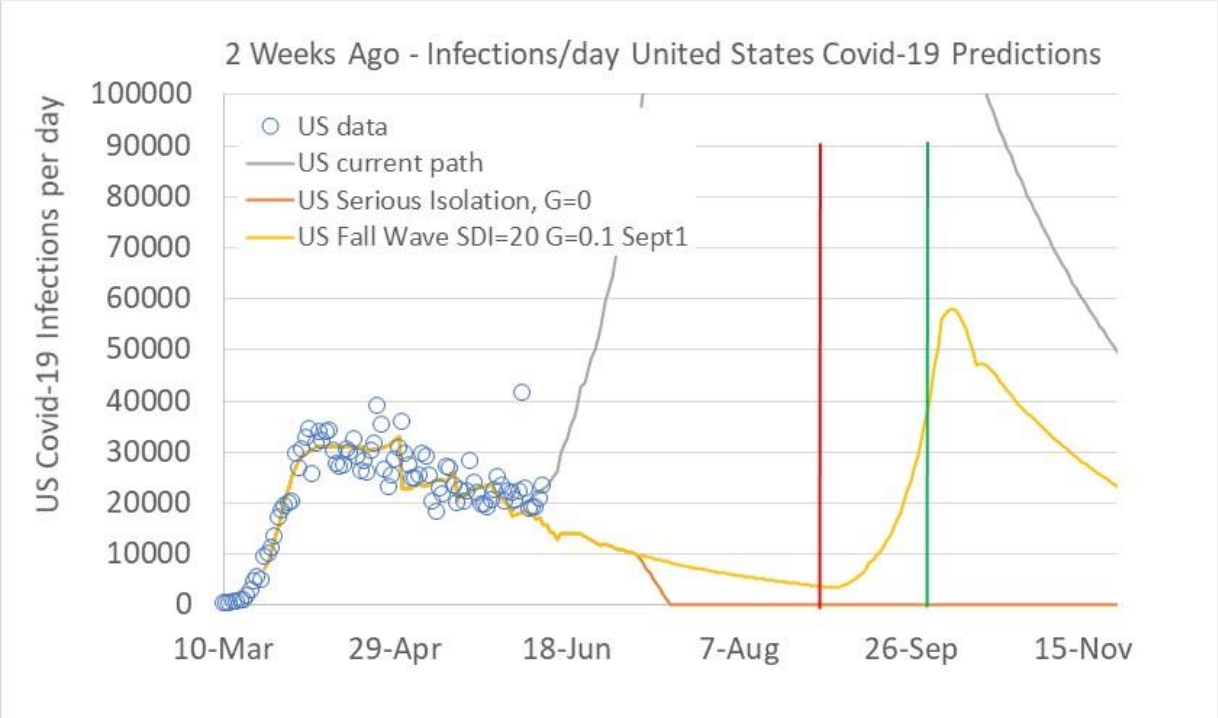

Figure 1 Predicted Covid-19 new cases per day predictions with data as of June 11, 2020.

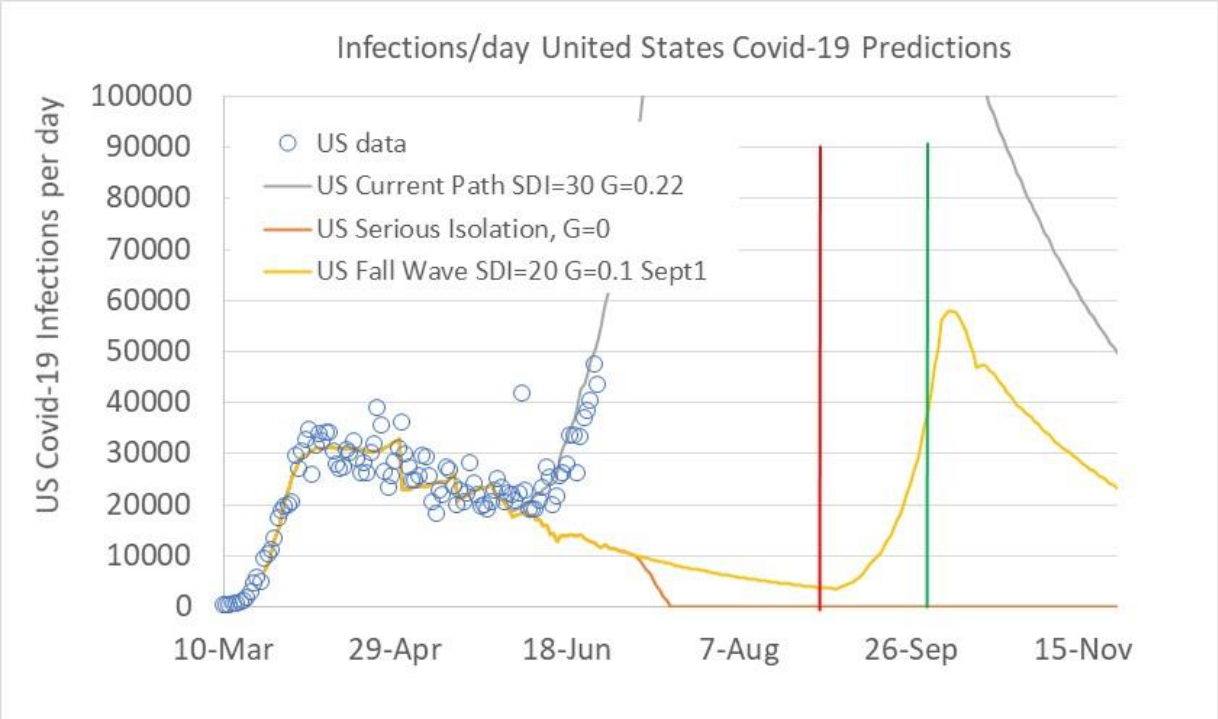

Figure 2 Current (as of June 27, 2020) comparison of daily Covid-19 infections and predicted infection paths.

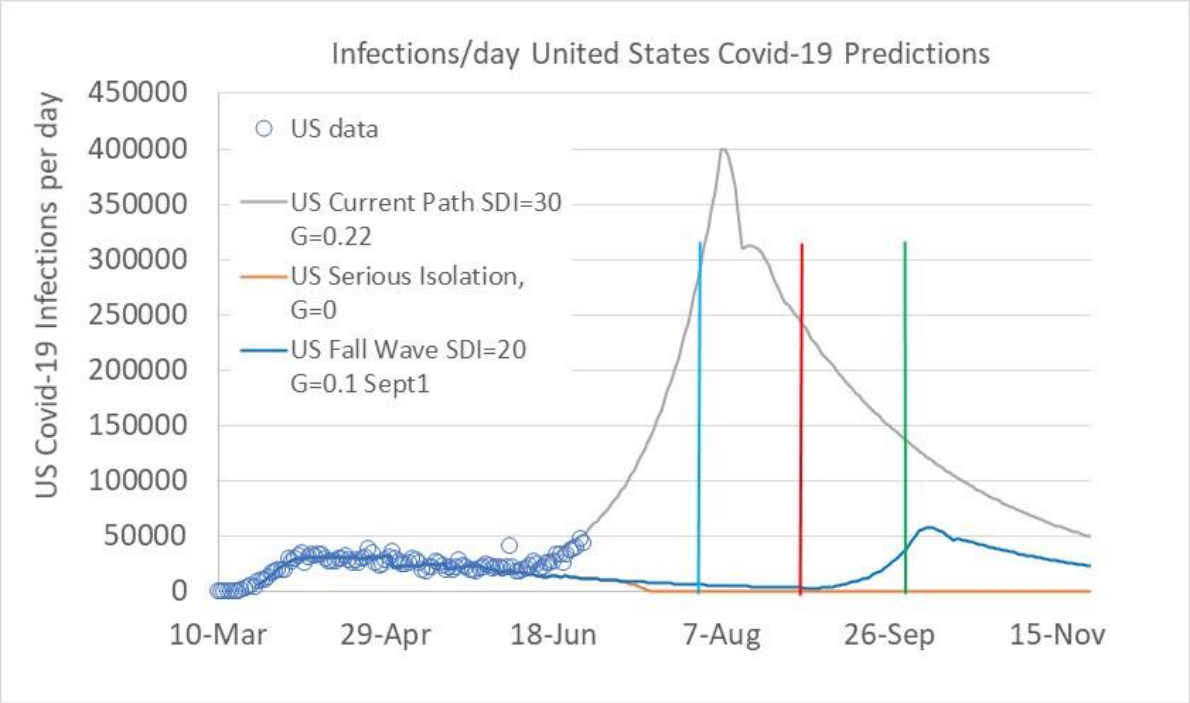

Figure 3 Expanded view of Figure 2 daily showing 400,000 new infections per day without change to our current infection growth path.

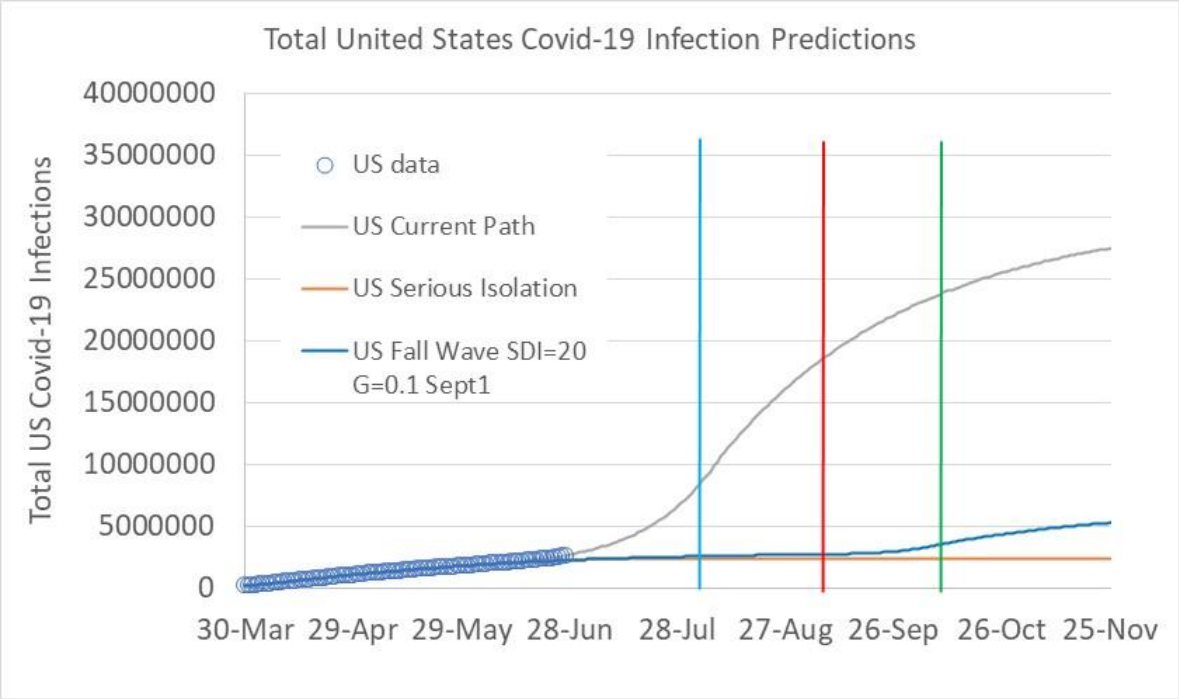

Figure 4 Total US Covid-19 infections for the 3 prediction paths in comparison to infection data.

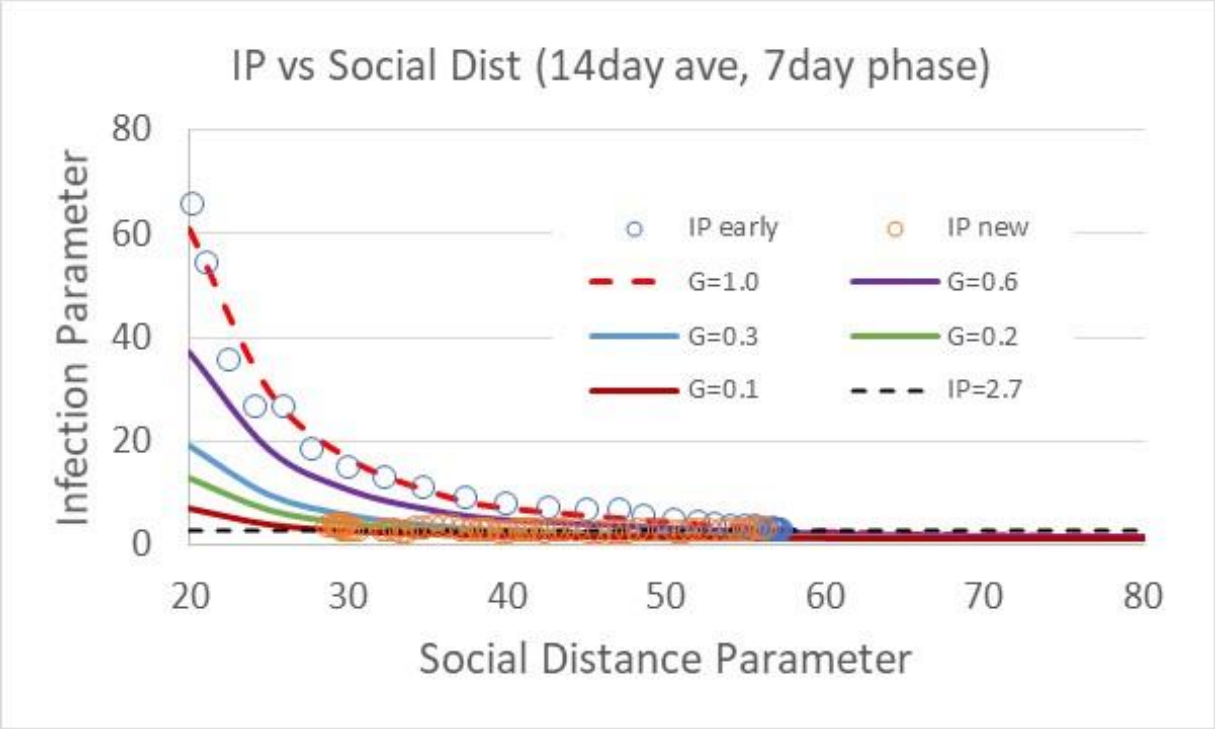

Figure 5 Infection Parameter as a function of the UMD Social Distance Index and Covid-19 disease transmission efficiency (G).

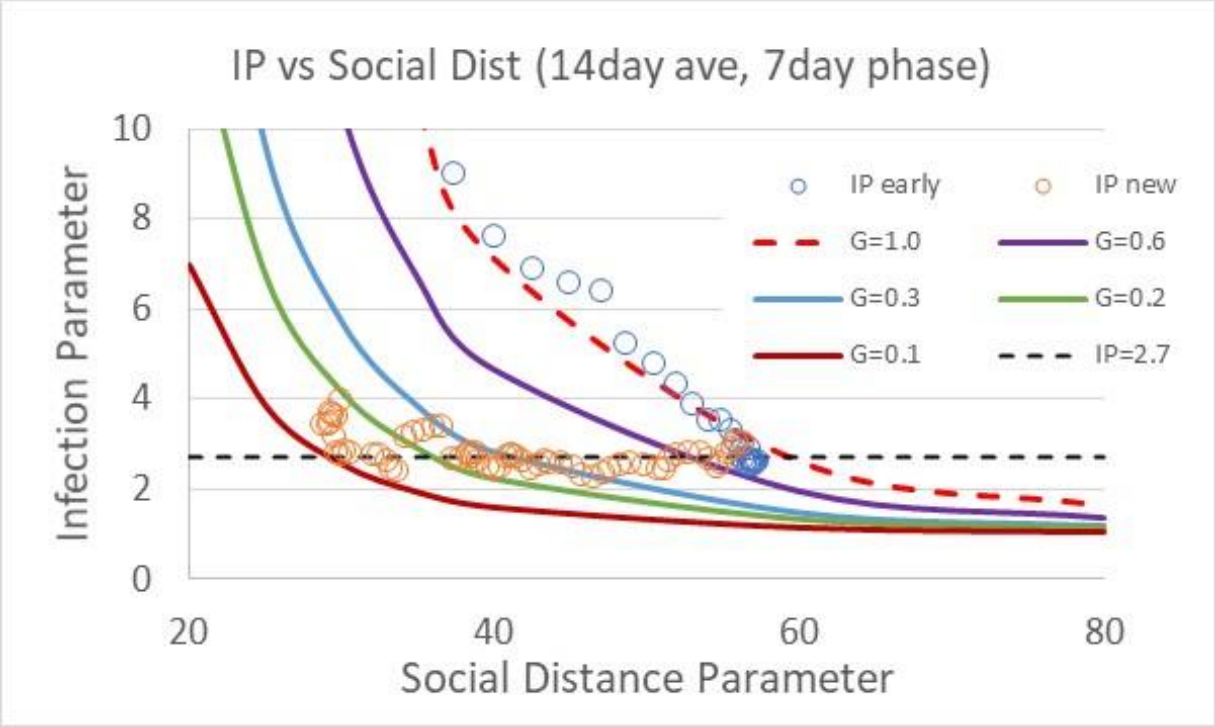

Figure 6 Expanded view of Infection Parameter versus Social Distance and Covid-19 transmission efficiency parameters.