The mechanics of suppression by TTSI

Key concepts

Several key concepts drive the effectiveness of contact tracing.

Trace Time Suppose we give a test to person A and start the clock. We send this test out, get the test results back, person A has tested positive, we mobilize a trace team, they talk to A, they find a list of exposed people, they contact people on this list and get a test out to them. We give them a test. We stop the clock when the at risk individuals have been given a test. All of this is the "trace time". *This process needs to move fast* — any delays to check and confirm will likely lead to more deaths than it saves. A trace time beyond 3 days has little value in controlling the epidemic while a trace time of 1 day is plausibly typically effective. See here: here, particularly figure 3 which expresses this.

Achieving a 1 day trace time appears possible, although it requires an optimized process. For example, testing facilities supporting contact tracing must be dispersed across the country to avoid significant transport delays, the tracing process should be ready to go 24 hours a day, and significant organization is required.

Note that there is a role for slower testing systems as well— they can potentialy be used to discover unknown outbreaks through wide scale surveillance of symptomatic individuals. Thus, we envision two 'lanes' here: a fast lane used for "hot pursuit" contact tracing and a slow lane used to discover outbreaks from symptomatic individuals. We plausibly have sufficient slow lane capacity for surveillance across the nation, so our focus as a nation should be on buildout of fast lane capacity. Note here that fast lane tests can be used for slow lane purposes, but not vice versa since by the time slow lane test results come back the disease has already been transmitted to new people.

Community In the context of a virus, a community is a group of people that cannot be easily split apart into two groups that have few chances to infect each other. This is an inexact definition, but it's crucial to understand since you cannot use contact tracing for half of a community to effectively suppress the virus because the other half of the community will constantly keep reinfecting the contact tracing half. Stated another way, treating Manhattan as its own community is not useful since more than half of the people who work there come from off the island.

There are 392 "Metropolitan Statistical Area" (MSA) in the United States which provide a working definition of community for most of the population. There are several thousand smaller urban clusters which may also be good targets for analysis(distribution). These two types of urban regions account for 80% of Americans. For more rural locations a geographic area large enough that most people do not leave it on a daily basis is a community. A plausible unit here is a county. Though communities are defined for social, political and economic reasons, it is a good approximation of the regions we should be dealing with in planning for how to handle a shift from lockdowns to a TTSI strategy.[1]

See table for a selection of communities of different sizes. We have included two cities that are too small to be in the list of MSAs and two example counties that are completely rural and have no urban clusters in them. We can think of each row of the table corresponding to about 10% of Americans, in other words, as the sizes get smaller, their frequency increases.

Every community is currently in some state, either green,

[1]This https://marroninstitute.nyu.edu/uploads/content/The_Coronavirus_and_the_Cities%2C_27_March_data%2 discusses spread through MSAs.

Rank	MSA	Population
1st	NYC	20M
3rd	Chicago	10M
10th	Phoenix	5M
34th	Cleveland	2M
53rd	Tucson	1M
115th	Reno	500k
226th	Bend, OR	200k
356th	Grand Forks, ND	100k
384th	Carson City, NV	50k
NA	Los Alamos, NM	20k
NA	Vernon, TX	13k
(rural)	Sierra County, CA	3k
(rural)	Bristol Bay Borough, AK	1k

Table 1: A sample of various communities. Note: The last four are too small to be MSAs but are included to be representative of some of the smaller cities in the USA. The last two are examples of 100% rural counties.

yellow, or red. Green communities have no known active infections. Yellow communities have known active infections at a small scale which public health authorities are handling. Red communities have an outbreak which public health authorities cannot suppress.

Strategy

The question we are addressing in this document is when should an area open up from lock down? They should do this when they have sufficient TTSI capacity to handle a post-lockdown situation.

Our overwhelming goal is preventing New York-style outbreaks which kill a significant fraction of the population. Given limited but growing resources for a TTSI strategy, this appears best done via an 'outside in' strategy, where we organize to ensure sufficient surveillance in green communities, fully support TTSI in yellow communities, and build capacity towards TTSI in red communities. This strategy protects the most people with limited resources.

Communities are all unique in many different ways. So the plan described below makes the assumption that we have a good idea of what exactly an "open community" should look like. For a large number of jobs the answer has to be yes for it to qualify as open. But, restaurants? Shows? Sports? Masks? Etc. These are questions for which there are good guesses, but we might not trust those guesses for a particular communities. In that case, a good plan is to slow the transition to being open along the TTSI phases so that we have evidence that we haven't opened too much. This will avoid needing to ever lock a community down again since if the number of cases isn't continuing down, we just back up one step rather than all the way to a lockdown.

Plans for communities

Green communities are the easiest to deal with—we just need to allocate sufficient slow lane testing capacity to cover all symptomatic individuals. Since we are headed into summer, seasonal illnesses are declining, so this should be easy. We should also organize to assist green communities in case they transition to yellow so as to efficiently get them back to green. Since many of our green communities are rural, having a mobile testing facilities ready to move there, training local people to do contact tracing as a reserve, and setting up contingent agreements with hotels or motels to support isolation make sense. With these preparations, green communities can end lockdowns and when outbreaks occur, they can suppress them by TTSI rather than further lockdowns.

Stabilizing yellow communities requires active investment into fast-lane testing. Many of these communities are doing contact tracing right now, but they are either bordering on overwhelmed or not working with sufficient alacrity. Beefing up the contact tracing corps in these communities with both personel and fast systems or procedures is necessary to get the tracing time under 1 day. Finally, supported isolation locations such as hotels dedicated to the purpose need to be put into active use. Many people going to such hotels (or isolating in their house) are not infected—they are simply contacts of someone who is infected isolating to protect family, friends, and community. The precise criteria for who is a contact should be driven by data, but a conservative approach suggests people who have been within 2 meters of infected individual for the last two weeks. If all contacts isolate for two weeks, are tested immediately using a fast lane, and have followup fast lane tests if they become symptomatic, then the number of active infections should rapidly decline in yellow communities. Once we have sufficient capacity to execute TTSI with a trace time of ¡1 day, we should be able to move up at least one phase in the TTSI plan and possibly more.

Stabilizing red communities is similar to stabilizing yellow communities with some additional complications. The first complication is just that it will simply take longer to build up suffiicent TTSI capacity. Fortunately, lockdowns also suppress the virus, so while TTSI capacity is being built up, the number of active infections is also declining. Engaging the TTSI strategy for a fraction of cases before these lines cross will provide valuable experience, information, and further suppress the virus beyond what the lockdown alone achieves. After these lines cross, all active cases will be a part of the TTSI strategy and we should see a rapid decrease in new infections every week. More caution is required in opening up the economy here because of the large number of active infections, so we recommend taking this week by week with every week of significant decline leading to another phase in the TTSI plan. Note here that the amount of contact tracing work is only modestly related to economic activity—it's much more strongly related to the number of infections. Given this, we expect the exponential decline in active cases to rapidly decrease the need for active contact tracing. That's good—these trained contact tracers can get back to their normal jobs and form a reserve corps in case of further outbreaks.

Testing and tracing needs

{**SK:** *Rural areas: we should give numbers here and strategy.*}

Initial resources needed to reopen various MSAs

region	**Pop**	$\frac{\textbf{Deaths}}{\textbf{day}}$	$\frac{\textbf{new infections}}{\textbf{day}}$	$\frac{\textbf{Test}}{\textbf{day}}$	$\frac{\textbf{Tracers}}{\textbf{day}}$
MSA (total deaths)	P	D	$N \approx D/\,\text{IFR}$ $\approx 100D$	$T = cN$ $\approx 30N$	VN $\approx 5N$
NYC (12k)	20M	200[a]	20k	600k	100k
Chicago (1300)	10M	40[b]	4k	120k	20k
Phoenix (122)	5M	5[b]	500	15k	2500
Cleveland (96)	2M	5[b]	500	15k	2500
Tucson (76)	1M	2[b]	200	6000	1000
Reno (219)	500k	15[b]	1500	50k	7k
Bend (0)	200k	.1[c]	10	300	50
Grand Forks (0)	100k	.1[c]	10	300	50
Carson City (219)	50k	10[b]	1000	30k	5k
Los Alamos, NM (0)	20k	0	≤ 1	1	5
Vernon, TX	13k	0	≤ 1	1	5
Sierra County, CA	3k	0	≤ 1	1	5
Bristol Bay Borough, AK	1k	0	≤ 1	1	5

[a] Seven day average.

[b] Estimated as total deaths divided by 10.

[c] We will take about one per week as our minimum daily death rate for computing the number of tests and tracers.

Table 2: Estimating D = total/30 except for NYC.

region	**Pop**	**tests need in**		
		month 1	**month 2**	**month 3**
NYC	20M	10M	2M	500k
Chicago	10M	2M	500k	100k
Phoenix	5M	250k	50k	10k
Cleveland	2M	250k	50k	10k
Tucson	1M	120k	30k	10k
Reno	500k	500k	100k	25k
Bend	200k	20	20	20
Grand Forks	100k	10	10	10
Carson City	50k	500k	100k	25
Los Alamos, NM	20k	10	10	10
Vernon, TX	13k	≤ 10	≤ 10	≤ 10
Sierra County, CA	3k	≤ 10	≤ 10	≤ 10
Bristol Bay Borough, AK	1k	≤ 10	≤ 10	≤ 10

Table 3: Estimated number of tests needed in the first few months. Notice it is mostly a function of the number of initial infections and not the population. {**dpf:** *We need to fill this in for all MSAs.*}

APPENDIX

Parameters

MSA data:

D = number of deaths per day in the MSA at the start

N = number of new infections a day the MSA at the start

P = population of MSA

Assumed parameters:

V = Total tests done per per positive test result (30 to 50)

IFR = Infection Fatality Rate = 1/100 to 1/50

H = Typical duration of overkill phase (half life = 15 days)

m = rate of new infections during maintence (= 1/5 million estimated from SK){**dpf:** *Can we get a higher number from Daegu SK, Soul SK? Can we estimate how many people move across MSA boundaries?*}

c = trace team in days of effort = 5

Key result variables:

initial estimate of N = $D/\,\mathrm{IFR}$

initial tests per day = VN

Q = Tests needed during overkill phase = $2VHN$

q = Tests needed (per day) during maintenance $= PmV/(1-R)$[2]

T = number of tracers initially $= Nc = cD/\,\mathrm{IFR}$

t = number of tracers needed during maintenance $= Pmc$

total tests needed = for MSA in first year $= 2HVN + 365 \times mP$

Before we are testing a total of VN per day, we will likely be missing lots of new infections. So a good rule for estimating N is simply $1/\,\mathrm{IFR}$ times the number of Deaths. So, we start with an initial guess of $N = D/\,\mathrm{IFR}$ or about $50 \times D$ to $100 \times D$. Each new infection needs a contact team to focus on it as soon as it is discovered. Most of the effort of that team should be on that new discovery and as rapidly as possible tracing the infection to other people. Assuming a contact team spends a full day on each case and consists of c members, then, we need T = cN. So, before we are testing at $20 \times N$, we will start with a guess of $T = cD/\,\mathrm{IFR}$ or about $250 \times D$. This is the number of initial tracers we should start with in a MSA.

[2] {**dpf:** *Add/delete an R? $PmV/(1-R)$.*}