Psychology and Strategy for Getting to Zero

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There are challenges to getting to zero. What should be done to ensure extinction? Here we discuss: Risk psychology, and Counting cases.

I. Risk and psychology of a few cases in a country

Imagine a country that has reduced their number of cases dramatically to only a few, say 5 infectious individuals, in a population of 5 million. A person might say: "The likelihood of getting infected today is only about 1 in a million. That is so unlikely that I won't take precautions." And no precautions would be taken by that individual on that day. If everyone follows that rule, then someone will be infected. The number of infected individuals will go up. Each of the infectious people over a few days infects 3-5 others, they infect a few others, and we are off to the races with more and more cases. By the end of the first week there are about 50 cases, 500 after two weeks, 5,000 after three weeks. By then the odds have changed from 1 in 1 million, to 1 in 100,000, to 1 in 10,000, to 1 in 1,000. When do people decide to take precautions? At some point drastic action is necessary. Then the cases go down. At some point the country gets to the situation where people say, "OK now there is only one in a million chance of being infected." Again the infections will grow. How do we stop this cyclic process? There is a need for three actions:

- **Patience**—People in general have to recognize that the only way to stop is to get to zero so that everyone takes some precautions until there are zero cases. Getting to zero takes another week or two, depending on the strength of actions taken.
- **Early case detection with contact tracing**—Everyone has to participate by quickly identifying early symptoms. Contact tracing teams identify likely contacts, they quarantine and test both symptomatic and asymptomatic contacts (of order 100 of them).
- **Green Zone strategy**—precautions are taken where cases are, and not in areas where they aren't. The relaxation of restrictions goes by geographical region, not by business type or profession. This requires restrictions on non-essential travel between zones, so that individuals don't transfer infections from one zone to another. Areas where the disease is found have a higher chance of infection, so people naturally take strong action, while in areas without cases people don't need to follow restrictions. Because of zoning, the number of cases is taken relative to the local population instead of the national population. Take, for example, 5 cases in a county of 50,000 in a nation of 5M population. Instead of 5M people being concerned only a little (5/5M), we have 50K alert people with (5/50K = 1 in 10,000) and 4.950M people living an almost ordinary life (including normal economic activity), but following zone travel restrictions until the last zone is cleared.

II. Counting cases

For countries where the number of cases is low, counting the cases is very important. Since the difference between zero cases and 1 or 2 cases matters, we need to focus our attention on counting them correctly. The risk that the country faces depends on the cases for which transmission can occur. Some cases have a low risk of transmission. There are three important categories for which transmission is under control that we shouldn't count.

Travelers: If there are travelers that come to the country and on arrival are quarantined for 14 days in an effective way, they are not contagious during that time and if they become sick, they can be cared for in isolation without leading to new cases. There are several key statements that are essential and should be noted:

1) arrival takes place without opportunity to infect anyone
2) quarantine is carefully done by authorities, if they are responsible
3) quarantine is carefully adhered to by the individual, if the individual is self-isolating
4) reporting of symptoms is carefully made

This is sufficient if there are a few cases that arrive. This is not enough if many individuals are arriving because of lower probability events: Cases where symptoms arise in more than 14 days, and cases that are asymptomatic. These two types of cases are, in effect, similar. A truly asymptomatic carrier is not manifestly different from someone who becomes symptomatic after an extended period of time. A discussion of additional precautions is given in the Appendix.

Individuals quarantined due to contact tracing: When an individual is diagnosed and their contacts are quarantined, the purpose of that quarantine is to prevent further infections and to minimize undesirable consequences of uncertainty. Some of those individuals then may become sick but if the quarantine is properly done those cases are not able to infect others. We term them pre-quarantined due to contact tracing. The conditions for this are:

1) they have to be a long enough time in quarantine before showing symptoms (several days)
2) they have to strictly follow the quarantine whether by authorities or in self-quarantine
3) if the conditions of the quarantine are insufficient, other individuals may have to be quarantined that were exposed to them.

If so they are not counted as transmission risks.

Mitigation of risk by contact tracing: The central objective of contact tracing is to prevent further infections from those infected by a known case. If completely successful, then the known case can be removed from the set of cases that transmit the disease.

More generally, contact tracing helps to identify the sequence of disease transmission, both precursor and successor cases of an identified case. This may include individuals who live together, work together, or more generally are part of the same immediate geographic area or social network. Since there are mildly symptomatic or asymptomatic individuals that may be part of the transmission chain, contacts of contacts should be included as high-risk individuals. A target number

of individuals to be considered is 10-100. In some circumstances there is clear distinction between high-risk and low-risk individuals due to behavioral clarity of the individual or stay-at-home conditions.

Individuals identified as contacts have to be tested and/or quarantined. Often both. It is important to test all individuals who might be the source of the infection to narrow the search across potential other transmission routes. Testing all possible contacts, symptomatic or non-symptomatic, increases the likelihood of identifying the transmission channel and tracking it through the population. Since an individual who was the source of transmission may no longer be a carrier serological tests should be used (in addition to RT-PCR tests) as they determine with some degree of accuracy whether a person has been sick in the past. If all individuals that are transmission risks are identified and quarantined, then there are no uncontrolled transmission risks. Even if they become sick, their quarantine guarantees that the chain of transmission will be stopped.

Community transmission: Omitting the travelers, pre-quarantined, and fully contact-traced individuals, the remainder of the cases are known as "community transmission." For these individuals we don't have clear identification of the limits of transmission. We know that there are prior individuals in the chain of transmission, perhaps unknown, and individuals that may have been infected subsequently.

Summary for counting cases: We need to count the number of cases in the past 14 days that may lead to further infections. This is the number of community transmissions, which is given by

$$N_x = N_c - N_t - N_q - N_p \tag{1}$$

where N_c is the number of new cases in 14 days, N_t is the number of quarantined arriving travelers that are new cases, N_q the number of contact tracing based quarantined new cases, N_p is the number of new cases that through complete contact tracing cannot infect any non-quarantined individuals. Any of the cases for which certainty of prevention of transmission is not complete should not be subtracted. To the extent it is possible to quantify risk reduction fractional counts may be considered. For example, if someone is quarantined and they subsequently become symptomatic or test positive, there is a risk factor associated with the timing of their quarantine. If the timing is not sufficiently early, a fractional multiplier for risk may be considered. Risks should be conservatively evaluated. Finally, some care can also be used in distinguishing the timing of reporting of cases from the timing of their infectious periods. The key is to ensure that individuals are counted if the period of infectiousness overlaps the most recent 14 day period.

Green zones: Zones with no community transmissions, $N_x = 0$ even with $N_c > 0$, can be regarded as green zones. Governments and individuals living in green zones can relax restrictions given that contact tracing and quarantine measures are expected to be sufficient to prevent transmission. Still, everyone should be be ready to roll back quickly into restrictions if new community transmissions emerge. In this circumstance, it is important to actively trace cases to determine which part was not done sufficiently identifying which of the N_t, N_q, N_p was not properly accounted for so this can be avoided in the future.

Appendix: Additional steps when many travelers are arriving

When there are many travelers and the probability of infection is not very low the likelihood that some are asymptomatic carriers must be addressed by additional precautions that impose significantly larger burden:

1) It is known that in a few cases the incubation period is longer than 14 days. This is the tail of the incubation period distribution and happens in a small proportion of cases. If the number of travelers is large, this will happen sufficiently many times that additional precautions are needed. This includes a longer quarantine period of perhaps 18 or 20 days. The larger number of travelers, the higher the chance that the travelers are infected, the longer the quarantine period should be. The precise number of days has to be calibrated to have a low probability of a new outbreak.
2) Instead of a full quarantine extension, a longer period of partial quarantine might be used. Taking this period to be an additional week, this might include one or more of the following during an additional third week: Only participating in a specific social event, engaging in social distancing at any event, only seeing a few designated individuals, not going to events with more than a few individuals, not going to high density or large number of people events. It should be noted that these restrictions don't prevent all transmission, only the risk of a large outbreak. Moreover, if one other person is infected, and that person participates in large events, even superspreader events are not fully prevented by this approach. Early detection is essential.
3) In order to prevent transmission by asymptomatic individuals testing that detects infected asymptomatic individuals with some probability may be used. This includes nasal swab tests, anal swab tests, and CT scans. Due to false negatives, multiple tests may be needed to rule out infection.