# Some Thoughts on the Covid 19 Pandemic

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November 3, 2021

## Contents





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## 1 Introduction

This document contains some hyperlinks that will obviously not function if printed.

We began this excercise in the summer of 2021 trying to make sense of conflicting assertions from mainstream media and for example the Joe Rogan podcast (see https://rumble.com/vrv7k1-dr.-robert-malone-on-joe-rogans-podcast.html). It is well known that the pharmaceutical industry has repeatedly engaged in illegal activity for profit (Rakoff, 2021) personal solution to this problem would be to cover all intellectual property in health care with copyleft licenses.

Our aim is to examine a simple model to determine which policies should be adopted in order to end the pandemic with as few vaccinations as possible.

We weaken the assumptions of the standard model used by epidemiologists to determine the minimum proportion of the population required to be vaccinated to stop the pandemic by not assuming that the reproduction number of the vaccinated is 0. This is obviously the case as vaccinated people can become infected.

This is work in progress. We are soliciting feedback on this work and will update as the information arrives. In particular it is not clear to us why epidemiologists assume the reproduction number of vaccinated individuals to be 0 (also called sterile immunization) when this assumption is obviously false. We suspect that there are standard tools to estimate one global reproduction number as it is related to the rate of change of the number of infections, but that estimating two reproduction numbers in a nonhomogeneous population requires more organization and testing.

We found this video: `https://www.youtube.com/watch?v=oWDGNrOqQfQ` very helpful.

## 2 The Model

We begin with some definitions.

Let $R_0(t)$ be the *reproduction number* of the epidemic at time $t$. More precisely:

$$R_0(t) \stackrel{\text{def}}{=} \text{the average \# of people an infected person will infect at time } t. \tag{1}$$

Though the quantity depends on time, we will drop the $(t)$ to simplify notation. If $R_0 = 1$, then the number of people infected is stable, if $R_0 > 1$, the number of infected is increasing, and if $R_0 < 1$, the number of infected is decreasing. The average is taken over people, not time. We will use $\overline{R_0}$ to denote the average over some undefined time period.

Let us assume that we have an epidemic, thus

$$R_0 > 1. \tag{2}$$

There are 2 possible limits at infinity:

1. $\lim_{t\to\infty} \overline{R_0}(t) = 1$. The pathogen and the host become adapted, mortality is low. The number of infected is roughly constant. This is called well adapted because both the host and the pathogen survive.

2. $\lim_{t\to\infty} R_0(t) = 0$.

(a) The pathogen is eliminated. This can happen, for example, via an effective quarantine.

(b) The pathogen eliminates the host. This is the rarest case. It only occurs in bands of relatively few humans. Neither the host nor pathogen survive.

**Principle 1** *The higher the mortality rate, the lower $R_0$ is.*

The reason for Principle 1 is that in general a high mortality rate means people become sick very quickly and they don't have much time to infect others before becoming bed ridden. High mortality rates in general end up with possibility 2.(a). This is the case with ebola, for example, which has a 50% mortality rate. Usually ebola outbreaks are short lived. Low mortality rates such as that of Covid 19 result in far more deaths because mildly sick people will circulate infecting many others.

We are interested in the effect of vaccinating a percentage of the population with the goal of attaining the above limits more rapidly. To that end, let $v$ be the proportion of the population which is vaccinated. Being vaccinated may change the reproduction number. Let $R_1$ be the reproduction number of the vaccinated subpopulation. We can now define the global reproduction number modified by the vaccination campaign as

$$R_v \stackrel{\text{def}}{=} vR_1 + (1-v)R_0. \tag{3}$$

Equation (3) allows us to define a positive outcome of the vaccine program. Clearly included in the definition of a positive outcome is a stable or decreasing number of infected, thus we are looking for a proportion $v$ that gives

$$R_v \leq 1. \tag{4}$$

It would also be nice to either obtain $R_v(T) = 0$ for some $T \in \mathbb{R}$, or to speed the process of adapting the population to the pathogen so that future vaccine programs would only be necessary for the fragile members of the population. But our main concern is (4).

From Equations (2) and (3) it is immediate that we cannot satisfy (4) if $R_1 \geq 1$ because

$$\begin{aligned} R_v &= vR_1 + (1-v)R_0 \\ &\geq v + (1-v)R_0 \\ &= 1 + (R_0 - 1)(1-v) \\ &> 1. \end{aligned}$$

In other words, if $R_1 \geq 1$ then even a 100% vaccination rate does not end the pandemic. We therefore assume

$$R_1 < 1. \tag{5}$$

**Remark 1** *It is now clear that mixing two nonhomogeneous populations and a pathogen, one population adjusted to or vaccinated with respect to the pathogen (and $R_1 \geq 1$), the other with a high mortality rate from the pathogen will cause a large number of deaths. The relative immunity of one population allows them to become super spreaders and eventually the entire vulnerable population comes in contact with the disease. This is why, in the 17th century, when Europeans arrived in the Americas 90% of the indigenous population died from diseases that had jumped from domesticated European animals to humans (Diamond, 1998).*

Let

$$\lambda \stackrel{\text{def}}{=} R_1/R_0 < 1. \tag{6}$$

We now calculate the vaccination rate which satisfies (4):

$$\begin{aligned}
& R_v = R_1 v + (1-v)R_0 \leq 1 \\
\iff & v(R_1 - R_0) + R_0 \leq 1 \\
\iff & v(\lambda - 1) + 1 \leq 1/R_0 \\
\iff & v(\lambda - 1) \leq -1 + 1/R_0 \\
\iff & v \geq \frac{1 - 1/R_0}{1 - \lambda} & (7) \\
\iff & v \geq \frac{R_0 - 1}{R_0 - R_1}. & (8)
\end{aligned}$$

# 3 Conclusions

If $R_1 = 0$, the vaccination rate that stops the pandemic is given by $R_v = 1 - 1/R_0$. Note that the smaller $R_1$ is the larger the denominator in (7) and thus the lower the proportion of vaccinated people we must have to stop the epidemic. From (3) we see that the higher the percentage of vaccinated individuals, the more important it is to reduce $R_1$. It follows that those who are vaccinated should be taking all measures to avoid infecting others such as wearing masks, social distancing, and frequent testing. Indeed, it is more important for them than for the unvaccinated because of Principle 1. In particular, testing requirements of the unvaccinated should also be required of those vaccinated.

The 85% of the population that are resistant to the Corona virus can be grouped with the vaccinated. Thus school children should be masked.

It can probably be shown that the fewer the number vaccinated, the sooner the pathogen and host will adapt to each other. In (Marya and Patel, 2021) the authors argue that our food system favors pandemics and that a diverse microbiota is an important element in adapting to pathogens.

Vaccination is just one tool to fight the pandemic. Unless all tools are used, the pandemic will last.

It is troubling that collecting data on $R_1$ is not a priority of the U.S. Center for Disease Control. Data from the Wisconsin Department of Public Health indicates that the $R_1 \approx R_0/3$ (giving $\lambda = 1/3$): `https://www.statista.com/chart/25589/covid-19-infections-vaccinated-unvaccinated/?utm_source=Statista+Newsletters&utm_campaign=d29e4f9c73-All_InfographTicker_daily_COM_AM_KW33_2021_Fr&utm_medium=email&utm_term=0_662f7ed75e-d29e4f9c73-314851633`

Examples:

| $R_0$ | $R_1$ | stop $v$ |
|---|---|---|
| 2 | 0 | 50% |
| 2 | .5 | 67% |
| 2 | .25 | 57% |
| 3 | 0 | 67% |
| 3 | .5 | 80% |

## 4 Acknowledgements

The author would like to thank Jacqueline Fleckinger for her helpful comments and suggestions.

## References

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