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Conversations With Individuals on the Fence about CV-19 Vaccination: Analysis of Lives Saved by Vaccine vs. Natural Infection Mortality and Other Reflections

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Abstract

As of June 15, 2021, from 672,000 to 912,000 deaths have been averted through vaccination of 48% of the US population. Because 52% remain unvaccinated, 728,000 to 988,000 lives remain at risk. These deaths can be spared, and the pandemic stopped in its tracks provided a final national vaccination rate of 84% is achieved. We aim to demonstrate in our analysis the number of lives saved that can be attributed to CV-19 vaccination vs the mortality rate of natural infection seen in unvaccinated individuals. However, time is short given the recent exponential rise of the highly contagious SARS-CoV-2 Delta variant. Delta infection results in a thousand-fold increase in viral load and a transmissibility 2.25x that of the original SARS-CoV-2 strain. Predominance of the Delta variant has already resulted in Covid-19 surges in area with low vaccination rates. An aggressive and timely vaccination campaign is being attempted. We hope our analysis helps convince individuals 'on the fence' that vaccination is essential if the pandemic is to be ended in the United States.

Keywords: Covid-19 vaccination, Vaccination rates, 7-day Covid-19 positivity rates, Covid-19 variants of concern, Delta variant

1. Introduction

From the beginning of the Covid-19 (CV-19) pandemic through 7/19/2021, 190 million cases and 4.09 million deaths have been reported worldwide. Statistics for the United States are 34 million cases and 608,000 deaths. Advances in treatment for CV-19 may have ameliorated mortality by 25% but definitive primary preventive treatment appears to be CV-19 vaccination which results in a high percentage of protection. Here we aim to demonstrate the magnitude of the effect of vaccination on CV-19 mortality, the threshold needed to stop the pandemic and the reason we are witnessing a surge in CV-19 cases and deaths. Data on the SARS-CoV-2 Delta variant, which as of this writing has

supplanted all remaining strains, are particularly alarming and discussed below.

2. Methods

Seven-day average CV-19 positivity rates were obtained from Johns Hopkins data as of 6/15/21: (<https://www.coronavirus.jhu.edu>testing>individual-states>). Apparently, Florida was not reporting that week (nor for several days after) as their rate was quoted as "0%"—a rate not obtained by any other state and inconsistent with their previous 30-day running average. Thus only 49 states were included in the analysis. State data on % of the population fully vaccinated were obtained from Beckers Hospital Review: (<https://>

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beckershospitalreview.com>public-health) as of the same date. Data on the US population were obtained from Census Bureau records: (<https://www.census.gov/topics/population>). Data on the range of vaccination in New York State were obtained from the site <https://www.covid19vaccine.health.ny.gov/vaccination-rates-zip-code>. Data on prevalence of strains in Washington State were obtained from Washington State Department of Health¹

3. Results

3.1. Predictions of CV-19 mortality without vaccination

As of 6/15/2021 there have been approximately 600,000 deaths in US owing to SARS-CoV-2 infection. During that time 33,060,171 individuals, clinically diagnosed, have survived infection. As the US census is currently 331 million, the natural immunity for this group is 10%. There is also a group of individuals who survived infection but were never formally diagnosed, presumably owing to an asymptomatic or minimally symptomatic infection. They were not included in the “known” cases because they never presented for formal diagnosis. Their presence and quantification have been provided by measuring the proportion of the US population that has antibodies to SARS-CoV-2. This number stood at 22.1% as measured for the last two weeks of May 2021.¹⁷

Most experts predict herd immunity and a stop to the pandemic once an immunity rate of 70% is achieved. This translates into an additional 1.9 million deaths to attain herd immunity ($600,000 \times 70\% / 22.1\%$) or a final toll of 2.5 million deaths had the pandemic been allowed to take its natural course.

Might advances in CV-19 therapy with Remdesivir, dexamethasone and tocilizumab affect the above estimate? Remdesivir has been shown to hasten recovery in hospitalized patients but to date has not demonstrated any statistically significant effect on CV-19 mortality.² Dexamethasone, in one large meta-analysis, was associated with a decrease in CV-19 mortality of 28%³ although another large meta-analysis failed to demonstrate any difference.⁴ Perhaps the most optimistic and authoritative analysis is the RECOVERY Collaborative Group study which randomized 2104 patients to dexamethasone and 4321 to usual care. For patients requiring mechanical ventilatory support, mortality was decreased 36%; for patients requiring oxygen

18%; for patients with no requirement for supplemental oxygen mortality was higher than without this intervention.⁵

An early Italian observational study demonstrated the benefit of tocilizumab in CV-19 patients.⁶ Subsequently, two randomized trials found higher mortality in the tocilizumab arm than in the placebo arm.^{7,8} The RECOVERY Collaborative Group found that tocilizumab effects a 15% reduction in Covid-19 mortality when coupled with dexamethasone therapy.⁹

Although it is difficult to translate these finding into a firm estimate of the total net effect of therapy on CV-19 mortality, a reasonable assumption may be a 25% overall reduction in mortality. This modifies the above estimate to an additional 1.4 million (1.9×0.75) or 2.0 million total deaths.

3.2. Lives saved, lives still at peril

As of 6/15/21, 48% of the population had been fully vaccinated preventing between 672,000–912,000 deaths: $0.48 \times (1.4–1.9 \text{ million})$. 52% of lives are still in jeopardy since they are not vaccinated. This works out to $0.52 \times (1.4–1.9 \text{ million})$ or an additional 728,000–988,000 deaths that might be spared through Covid-19 vaccination.

3.3. Relationship between state CV 19 vaccination rates and seven-day average positivity rates

An analysis of data for 41 inlier states reveals a logarithmic relationship between vaccination rates and average seven-day CV-19 positivity rates (see Fig. 1). Eight states are high outliers-also conforming to a logarithmic relationship but with a higher average weekly positivity level. High outliers will be discussed in a separate section.

Once positivity becomes lower than 1%, person-to-person CV-19 transmission rates are hampered and by 0.5% should naturally extinguish. As per the curve, a positivity rate of 0.42% is achieved at a vaccination rate of 60%.

No state has yet to reach a 0% seven-day positivity rate. This is explained by heterogeneity in vaccination rates. For example, for New York State, average vaccination as of 6/15 was 50.3%. However, a Zip code by Zip code analysis shows that regional vaccination rates vary from 0 to 99+%. Pockets of low vaccination rates continue to serve as breeding grounds and reservoirs for CV-19, thus preventing total eradication.

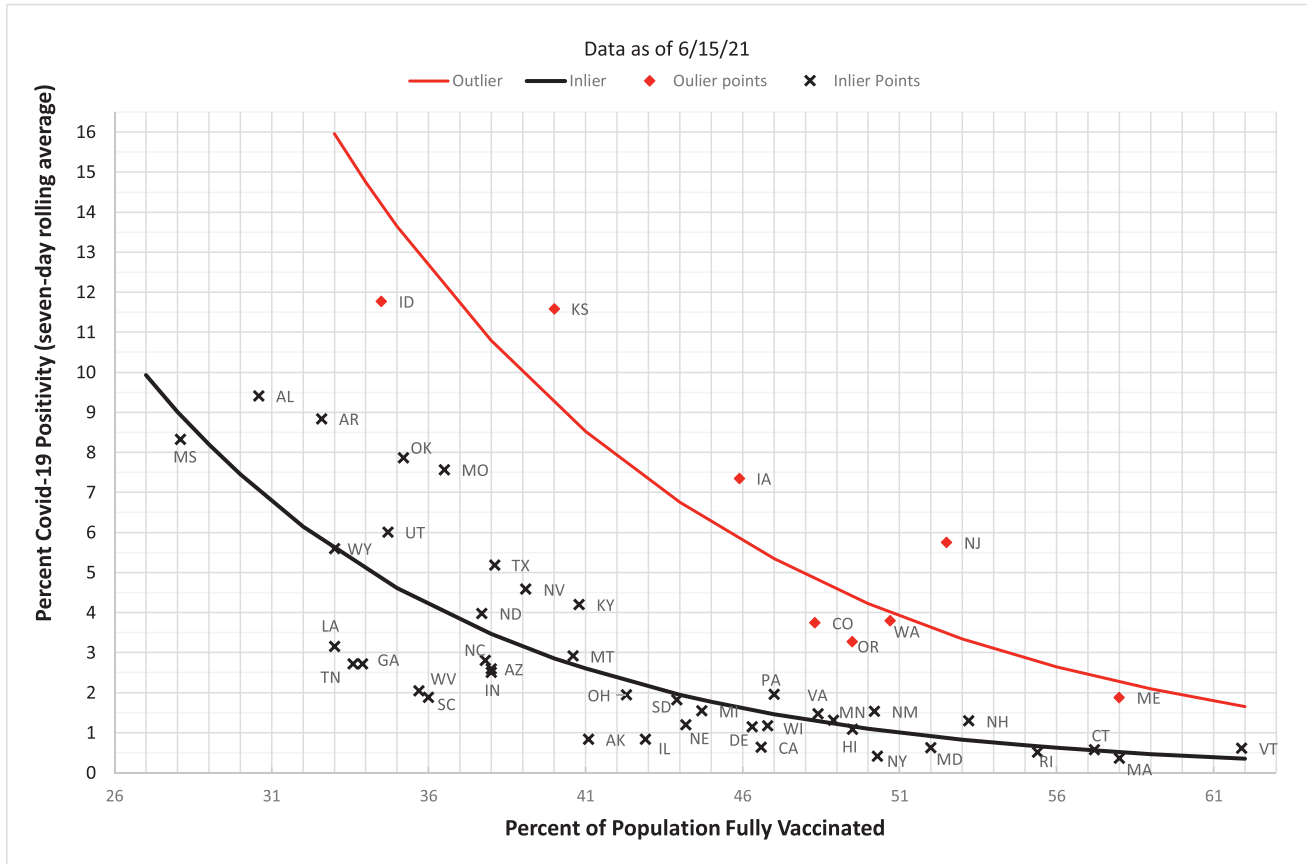


Fig. 1. Percent of total population fully vaccinated against COVID-19 versus seven-day average COVID-19 positivity rate.

Table 1. Percent total population vaccinated against CV-19 versus seven-day average CV-19 positivity rate (Data as of 6/15/21).

| State | % Vaccinated | 7d Positivity % |
|-------------------|--------------|-----------------|
| Mississippi | 28.1 | 8.33 |
| Alabama | 30.6 | 9.41 |
| Arkansas | 32.6 | 8.84 |
| Louisiana | 33 | 3.15 |
| Wyoming | 33 | 5.6 |
| Tennessee | 33.6 | 2.72 |
| Georgia | 33.9 | 2.72 |
| Idaho | 34.5 | 11.77 |
| Utah | 34.7 | 6.01 |
| Oklahoma | 35.2 | 7.86 |
| W. Virginia | 35.7 | 2.04 |
| S. Carolina | 36 | 1.88 |
| Missouri | 36.5 | 7.57 |
| N. Dakota | 37.7 | 3.98 |
| N. Carolina | 37.8 | 2.81 |
| Arizona | 38 | 2.59 |
| Indiana | 38 | 2.50 |
| Texas | 38.1 | 5.19 |
| Nevada | 39.1 | 4.58 |
| Kansas | 40 | 11.59 |
| Montana | 40.6 | 2.91 |
| Kentucky | 40.8 | 4.20 |
| Alaska | 41.1 | 0.83 |
| Ohio | 42.3 | 1.94 |
| Illinois | 42.9 | 0.83 |
| S Dakota | 43.9 | 1.82 |
| Nebraska | 44.2 | 1.19 |
| Michigan | 44.7 | 1.54 |
| Iowa | 45.9 | 7.35 |
| Delaware | 46.3 | 1.15 |
| California | 46.6 | 0.63 |
| Wisconsin | 46.8 | 1.17 |
| Pennsylvania | 47.0 | 1.96 |
| Colorado | 48.3 | 3.74 |
| Virginia | 48.4 | 1.47 |
| Minnesota | 48.9 | 1.31 |
| Hawaii | 49.5 | 1.09 |
| Oregon | 49.5 | 3.27 |
| New Mexico | 50.2 | 1.53 |
| New York | 50.3 | 0.41 |
| Washington | 50.7 | 3.80 |
| Maryland | 52 | 0.62 |
| New Jersey | 52.5 | 5.75 |
| New Hamp. | 53.2 | 1.29 |
| Rhode Island | 55.4 | 0.51 |
| Connecticut | 57.2 | 0.57 |
| Maine | 58 | 1.88 |
| Massachusetts | 58 | 0.36 |
| Vermont | 61.9 | 0.61 |

For the 41 inlier states the logarithmic relationship predicts 5% positivity at 34.1% vaccination rate; 4% at 36.5; 3% at 36.5; 2% at 43.7; 1% at 51.0; 0.5% at 58.2.

For the 8 high-outlier states (in bold) the logarithmic relationship predicts 5% positivity at 48.6% vaccination rate; 4% at 51.7; 3% at 55.8; 2% at 61.7; 1% at 71.6; 0.5% at 81.6.

3.4. CV-19 variants of concern

Eight states, although they fit a similar logarithmic curve, have much higher CV-19 seven-day average positivity rates for any given level of total vaccination

(Fig. 1 and Table 1). Although adherence to masking, social distancing, hand hygiene and avoidance of crowded gatherings may be in part responsible, there is the possibility that these states were infected by strains of CV-19 with higher person-to-person transmissibility. The best documentation of prevalence of “variants of concern” comes from the Washington State Department of Health.

As of the end of June, the B.1.1.7 alpha (UK) strain, with 1.5 time the transmissibility of the wild-type strain¹⁰ was responsible for 55% of CV-19 infections in the state. Also on the rise, is the P.1 gamma (Brazilian) strain with twice the transmissibility¹¹ at 16.3% of all CV-19 infections.¹

A comparison of the slopes of the inlier versus outlier states suggest that, if the difference in the two is owing to strains with higher transmissibility, the CV-19 variants infecting these states were, on average, 1.23-fold more transmissible.

3.5. The SARS-CoV-2 delta variant has supplanted all other strains in the US

The Delta variant of CV-19 is 1.5-fold more transmissible than the B.1.1.7 Alpha (UK) strain¹². The Alpha strain is already 1.5-fold more contagious than the original wild type 19A/19B strain¹⁰. Thus, Delta is 2.25 x more transmissible overall. A study of 167 Chinese individuals with the Delta strain revealed viral loads approximately 1000 times those seen for wild type 19A/19B.¹³

This enhanced transmissibility has allowed this variant to eclipse all other SARS-CoV-2 strains in a span of just six weeks. Two-week prevalence of the Delta variant in new CV-19 cases increased eight-fold in this short period of time: June 5–10.1%; June 19–30.4%; July 3–51.7%; July 17–83%.¹⁴ Concomitant with the rise in prevalence of the Delta variant, the national 7-day CV-19 average positivity rate has doubled from 2 to 4% in just one month (6/15-7/16).

An analysis from Scotland reveals that 70% of those infected with the Delta variant have no relevant comorbidities. Infections were more severe in that the hospitalization rate for Delta was approximately double that seen for those infected with the Alpha variant. Lethality of this strain has yet to be determined in that deaths lag significantly behind hospitalizations. CV-19 vaccination still provides adequate levels of protection against the Delta variant.¹⁵

Owing to its high level of transmissibility, the Delta strain has caused a CV-19 surge in areas with low vaccination rates. These surges, in turn, will likely lead to poorer CV-19 survival rates. Data from

558 US hospitals reveal that during surge months mortality rates can increase up to two-fold.¹⁶

The Delta variant threatens to compress the time for vaccine intervention from years to just months. This mandates post-haste persuasion of another 36% of the population to accept vaccination (see below).

3.6. Vaccination levels required to defeat the pandemic

Experts have predicted an end to the CV-19 pandemic once herd immunity of 70% is achieved. The nation met this threshold on June 15 with 22% natural and 48% vaccine immunity. Why, then, have we since witnessed an increase in CV-19 cases, hospitalizations and deaths rather than an end to the pandemic? The answer is two-fold.

First, owing to the wide disparity in CV-19 vaccination rates, the populace has been divided into two distinct silos. Half are protected through vaccination while the other half remains vulnerable and provides fertile ground for the continued propagation of SARS-CoV-2 virus.

Second, the Delta virus has eclipsed all other strains in the United States. Its greatly enhanced transmissibility has raised the entire nation (not just eight states) from inlier to a status exceeding the outlier curve. On June 15, the national vaccination rate was 48% and the seven-day average CV-19 positivity rate stood at 2%. Correspondingly, the logarithmic curves (see Fig. 1 and Table 1) predicted a 1.98% positivity rate: (41 inlier states x predicted 1.324% plus 8 outlier states x predicted 5.309%—all divided by 49).

Just one month later, the national positivity rate had risen to 4% with a 49% vaccination rate. The outlier curve at this point predicted a rate of 4.9%. As of this writing (July 27, 2021), the seven-day average is at 5.8% with a 49.7% vaccination rate—a value exceeding that predicted from the outlier curve by more than 1% (a 4.6% prediction). Extrapolation of the outlier curve predicts a 1% positivity at 72% total vaccination. It reaches 0.5% (a rate at which the spread of Covid-19 should naturally extinguish—see above) once 82% of the population has been vaccinated. Again, as of the end of July the expectations of the outlier curve have been exceeded.

A much simpler and straight forward analysis, that yields a comparable answer, is to find the level of vaccination needed to bring the remaining 52% of the unvaccinated population to 70% immunity. This works out to be an additional 52% x 0.7 or 36% of the

total population. A final figure to end the pandemic is thus 48 + 36 or an 84% total vaccination rate.

4. Discussion

Left to its natural course, the CV-19 pandemic would, over a three to four-year span of time, have resulted in a US death toll of 2.0–2.5 million lives. Covid-19 vaccination has already prevented 672–912 thousand deaths. If an additional 728 to 988 thousand deaths are to be averted, a vaccination rate of 84% of the nation's population must be achieved (36% in addition to the present 48%). Because the extremely transmissible Delta variant has compressed the time course of the pandemic from years-long to perhaps 6 months, time is of the essence in vaccinating the remainder of the US population at risk.

Conflict of interest

The authors report no conflicts of interest.

Addendum

Subsequent to the Delta variant dominance (discussed in this article) the Omicron variant has appeared and is quickly supplanting Delta as the dominant SARS-CoV-2 strain in the United States (1).

The 36 amino acid substitutions in the Omicron Spike (S) protein have rendered it more resistant to vaccine-induced immunity.

Analysis of the recent London accelerated outbreak of SARS-CoV-2 infections, reported by the Imperial College of London, suggests that “fully vaccinated” (2-dose of Pfizer/Moderna) individuals are protected from severe illness (hospitalization) only in the range of 0–20% (2) while those who received their third, booster dose are protected at the 80% level (95% confidence level 76.3–83.2%). Though not as high as the booster effect on Delta (96.5% protection with 95% CL 96.1–96.8%), vaccination remains the intervention most likely to end the CV-19 pandemic (3).

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