Modeling the USA Winter 2021 CoVID-19 Resurgence

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Abstract

The current USA 2021 CoVID-19 Winter Resurgence is modeled here with the same function used for analyzing prior USA CoVID-19 waves:

$$N(t) \approx \max\{N_o \exp\langle + \tfrac{t}{[t_R(1+\alpha_S\, t)]} \exp[-\delta_o t]\,\rangle\}\,.$$

Here, $N(t)$ gives the total number of CoVID-19 cases above the previous baseline, and t_R sets the initial $t_{dbl} = t_R\,(\ln 2)$ pandemic t_{dbl} doubling time. Larger α_S values indicate that uninfected people are improving their pandemic mitigation efforts, such as *Social Distancing* and *vaccinations*; while $\delta_o > 0$ accelerates the post-peak $\frac{d}{dt}N(t)$ *tail-off*, and is empirically associated with *mask-wearing*. The pandemic wave end is when $N(t)$ no longer increases.

The USA Summer 2021 resurgence results from our prior *medrxiv.org* preprints* were used as a baseline. By 11/15/2021, an additional $N_o^{2021} \approx 107,000$ cases above baseline were found, signaling the USA Winter 2021 resurgence. This CoVID-19 wave is still in its *initial* stages. Presently, our analysis indicates that this CoVID-19 wave can infect virtually all susceptible persons; just like the *initial* stage of the USA Summer 2021 resurgence. Data up through 12/30/2021 gives these paremeter values:

$$t_R \approx 8.05\, days\,;\ \alpha_S \approx 0.011\,/\,day\,.$$

These values are identical to the prior 2020 USA Winter Resurgence results. Also, the $N_o^{2021}(11/15/2021)$ and the $N_o^{2020}(9/25/2020) = 89,900$ values are similar. However, while the Winter 2020 Resurgence showed a significant *mask-wearing* effect $[\delta_o^{2020} = 1.748 \times 10^{-3}\,/\,day]$, this *initial* USA Winter 2021 Resurgence shows practically no *mask-wearing* effects $[\delta_o^{2021} \leq 0.001 \times 10^{-3}\,/\,day]$. If *mask-wearing* were to quickly rise to the Winter 2020 levels, it would give these projected totals:

$$N(t = [1/1/2022]) \approx 54,705,400\ ;$$
$$N(t = [3/21/2022]) \approx 83,371,000\ ;$$
$$N(t = [3/21/2024]) \approx 92,399,000\ .$$

More robust *mask-wearing* and enhanced *Social Distancing* measures could further reduce these values (*with 3 Figures*).

(10.1101_2021.08.16.21262150; 10.1101_2021.10.15.21265078)

1 Introduction

Each new USA CoVID-19 wave usually starts with a sharp rise in the total number $N(t)$ of new cases. The time evolution for each of these waves has been successfully modeled[1−6] using this basic function for $N(t)$:

$$N(t) \approx \max\{N_o \exp\langle + \tfrac{t}{[t_R(1+\alpha_S\, t)]} \exp[-\delta_o t]\,\rangle\}\,. \qquad [1.1]$$

Equation [1.1] represents the USA Winter 2021 CoVID-19 Resurgence cases above a baseline that is set by the USA Summer 2021 Resurgence from our prior *medrxiv.org* preprints[5−6]. The standard **SEIR** (**S**usceptible, **E**xposed, **I**nfected, and **R**ecovered or Removed) epidemiology models all start with an exponential growth ($R_o > 1$) or decay ($R_o < 1$):

$$\tfrac{d}{dt}N(t) = +\,K_R\,(R_o - 1)\,N(t) = [1\,/\,t_R]\,N(t)\,, \qquad [1.2a]$$

$$N(t) = N_o\,\exp[+\,t\,/\,t_R]\,, \qquad [1.2b]$$

$$t_{dbl} = t_R\,(\ln 2)\,, \qquad [1.2c]$$

where $t_R > 0$ sets the initial growth rate, and t_{dbl} sets the initial $N(t)$ doubling-time. Virtually all **SEIR** models are *local* models, with R_o representing the average number of people who will become infected by an ailing person during the course of their illness.

Given a total population of N_{ALL}, the *uninfected population* $U(t)$ is:

$$U(t) = [N_{ALL} - N(t)]\,. \qquad [1.3]$$

Using Eq. [1.1] implicitly assumes that $N(t) << N_{ALL}$ for all times of interest, so that pandemic saturation effects can be ignored. In general, **SEIR** models do not explicitly consider what the $U(t)$ *uninfected population* may be doing in response to the pandemic, prior to becoming infected. In contrast, Eq. [1.1] was developed as a *non-local* extension of **SEIR** models, to explicitly take into account what the *uninfected population*, as a whole, is doing to mitigate pandemic spread.

Since Eq. [1.1] is empirically based, it does not predict when each new CoVID-19 wave will start, or what biological and social circumstances are causing the new wave. As a result, the $t = 0$ point for each wave is usually set by when the resurgence is first easily identified, with $N(t = 0) = N_o$ being the number of cases above baseline at that time. But once the CoVID-19 wave becomes established, Eq. [1.1] appears to successfully predict its time evolution.

As given in our prior preprints[1−6], the parameter α_S measures the combined effect of virtually all large-scale pandemic mitigation efforts. These include *Social Distancing* requirements, such as minimum separation distances and decreased allowable occupancy; along with lockdowns, "stay at home" orders, school closures, and restrictions on business operations; as well as the impact of large-scale vaccination efforts. The $\delta_o > 0$ parameter accelerates the post-peak $\frac{d}{dt}N(t)$ *tail-off*, and our prior work[3−6] shows that it is empirically associated with *mask-wearing*.

The calculated end for each pandemic wave occurs when $N(t)$ in Eq. [1.1] for the total number of cases first stops increasing, which makes the final stages of calculated post-peak $\frac{d}{dt}N(t)$ *tail-off* inaccurate. However, the pandemic wave is substantially over by then, assuming that no follow-on resurgence occurs.

2 The USA Winter 2021 Resurgence

Our CoVID-19 modeling using the same few parameters has been successful at predicting the time evolution of each prior USA CoVID-19 wave[1−6]. This result shows that the **response** of the $U(t)$ *uninfected population* was similar for each wave, even if different dominating factors drove each new resurgence.

Deviations of ˜107,000 extra cases above the USA Summer 2021 baseline were observed by 11/15/2021. Thus, the USA is now in the *initial* stages of a Winter 2021 resurgence, as shown in *Figure 1*. Our calculations indicate that this CoVID-19 wave presently can infect virtually all susceptible people; a result that is similar to the *initial* stage of the USA Summer 2021 wave[5].

In addition, two of the three Eq. [1.1] parameter values, as determined using the data up through 12/30/2021, were found to be identical to the 2020 USA Winter Resurgence values as follows:

$$t_R \approx 8.05\, days\,; \tag{2.1a}$$
$$\alpha_S \approx 0.011\,/\,days\,. \tag{2.1b}$$

Both CoVID-19 Winter Resurgences also have similar N_o values:

$$N_o(\text{Winter 2020},\ 9/25/2020) = 89,900\,; \tag{2.2a}$$
$$N_o(\text{Winter 2021},\ 11/15/2021) = 107,000\,; \tag{2.2b}$$

indicating that both waves started similarly. However, the Winter 2020 Resurgence was associated with a non-negligible amount of *mask-wearing*, as measured by δ_o in Eq. [1.1]. In contrast, this *initial* stage of the USA Winter 2021 wave is associated with having virtually no *mask-wearing* effects:

$$\delta_o(\text{Winter 2020}) = 1.748 \times 10^{-3}\,/\,day\,; \tag{2.3a}$$
$$\delta_o(\text{Winter 2021}) \leq 0.001 \times 10^{-3}\,/\,day\,. \tag{2.3b}$$

In *Figure 2*, the $\{N_o;\, t_R;\, \alpha_S;\, \delta_o\}$ parameter values for this Winter 2021 Resurgence are compared to each of the prior USA CoVID-19 waves. If *mask-wearing* were now to quickly rise to the Winter 2020 levels, without changing the other Winter 2021 Resurgence parameters, the total number of projected USA CoVID-19 cases would be:

$$N(t = [1/1/2022]) \approx 54,705,400\ ; \tag{2.4a}$$
$$N(t = [3/21/2022]) \approx 83,371,000\ ; \tag{2.4b}$$
$$N(t = [3/21/2024]) \approx 92,399,000\ . \tag{2.4c}$$

Without *mask-wearing* [$\delta_o \approx 0$], the 3/21/2022 projection would change to:

$$N(t = [1/1/2022]) \approx 54,705,400\ ; \tag{2.5a}$$
$$N(t = [3/21/2022]) \approx 126,463,000\ ; \tag{2.5b}$$

with the calculated $N(t)$ for [3/21/2024] substantially exceeding the N_{ALL} total US population. At that point the Eq. [1.1] assumption that N_{ALL} is large enough so that $N(t) << N_{ALL}$ for all times of interest, would no longer be valid. The USA would be in a pandemic saturation stage, where practically everybody is or was infected.

Figure 3 shows our model predictions vs CoVID-19 data for the entire pandemic, from March 2020 through January 2022. Whenever the pandemic appeared to be beaten down, restrictions were relaxed, CoVID-19 cases increased, new CoVID-19 variants appeared, and the pandemic rose up again, almost with every season.

The daily number of new cases $dN(t)\,/\,dt$ in *Figure 3* has peaks for the initial Spring 2020 pandemic; a Summer 2020 resurgence; the long Winter 2020 Resurgence; a small uptick in Spring 2021; the USA Summer 2021 Resurgence; and now the USA Winter 2021 Resurgence.

In addition, *Figure 3* shows Winter 2021 Resurgence projections for two different δ_o-values. One projection is the best datafit to date (12/30/2021), and uses $\delta_o \leq 0.001 \times 10^{-3}\,/\,day$. The other projection is how the Winter 2021 Resurgence would progress, if δ_o were to suddenly increase to the prior Winter 2020 Resurgence value of $\delta_o = 1.748 \times 10^{-3}\,/\,day$.

3 Summary

It is January 2022, and the USA is in the midst of the *initial stages* of a CoVID-19 Winter 2021 Resurgence. Using the USA CoVID-19 Summer 2021 Resurgence as a baseline[5−6], the latest CoVID-19 wave was modeled using:

$$N(t) \approx \max\{N_o \exp\langle + \tfrac{t}{[t_R(1+\alpha_S\, t)]} \exp[-\delta_o t]\,\rangle\}\,, \qquad [3.1]$$

with those results shown in *Figure 1*. This function was used to analyze each previous USA CoVID-19 wave[1−6]. Since the same few parameters successfully apply to all these USA CoVID-19 waves, with only different $t = 0$ starting points and $\{N_o; t_R; \alpha_S; \delta_o\}$ parameter values allowed, it shows that the **response** of the $U(t)$ *uninfected population* has been similar for each CoVID-19 wave, even if different factors were driving each new resurgence.

This effect is best seen by comparing the parameters derived for this *initial stage* of the USA CoVID-19 Winter 2021 Resurgence to the prior USA CoVID-19 Winter 2020 Resurgence, as shown in *Figure 2*. Both have similar $\{N_o; t_R; \alpha_S\}$ parameter values, indicating the USA population is in a similar position with respect to CoVID-19 in both cases. No doubt, the large number of Winter 2021 CoVID-19 Resurgence cases is being driven by infections from the most recent *Omicron* CoVID-19 variant.

However, back on Jan. 7, 2021, during the Winter 2020 Resurgence, only about $\sim$ 3% of the USA population had received any vaccinations, with only ˜0.3% being fully vaccinated. At that time, the $U(t)$ *uninfected population* was substantially unvaccinated. In contrast, by Jan. 2022, a substantial fraction of the $U(t)$ *uninfected population* was considered fully vaccinated.

Given the known capacity for the *Omicron* CoVID-19 variant to infect *fully vaccinated* persons, the similarity in the $\{N_o; t_R; \alpha_S\}$ parameters between these two USA Winter Resurgences, shows that the USA *vaccinated population* is in a similar position to the USA *unvaccinated population* a year ago. Such a result brings CoVID-19 infection closer to becoming *endemic*. The 'silver lining' to this dour cloud is that those who are vaccinated appear to have much less severe CoVID-19 infection impacts.

One significant difference between this *initial stage* of the USA CoVID-19 Winter 2021 Resurgence and the prior USA CoVID-19 Winter 2020 Resurgence is that the δ_o-parameter associated with *mask-wearing* was significantly higher

in 2020, compared to this *initial stage* of the USA CoVID-19 Winter 2021 Resurgence, which showed a $\delta_o \approx 0$ result.

If $\delta_o \approx 0$ persists, along with the present $\{N_o; t_R; \alpha_S\}$ values, this CoVID-19 Winter 2021 Resurgence will have the capacity to infect nearly everyone who is not practicing the strictest CoVID-19 prevention protocols, with the resulting $N(t)$ projections for $\delta_o \approx 0$ given in the prior section. Significantly increased *mask-wearing* and enhanced *Social Distancing* measures are needed to prevent these high levels of USA CoVID-19 projected cases from actually occurring.

4 List of Figures

5 References

1. *https: //medrxiv.org/cgi/content/short/2020.05.04.20091207v1*
"Initial Model for the Impact of Social Distancing on CoVID-19 Spread"
2. *https: //medrxiv.org/cgi/content/short/2020.06.30.20143149v1*
"Orthogonal Functions for Evaluating
Social Distancing Impact on CoVID-19 Spread"
3. *https: //medrxiv.org/cgi/content/short/2020.08.07.20169904*
"Model to Describe Fast Shutoff of CoVID-19 Pandemic Spread"
4. *https: //medrxiv.org/cgi/content/short/2020.09.16.20196063*
"Initial Model for USA CoVID-19 Resurgence"
5. *https: //medrxiv.org/cgi/content/short/2021.08.16.21262150*
"The *IHME* vs Me: Modeling USA CoVID-19 Spread,
Early Data to the *Fifth Wave*"
6. *https: //medrxiv.org/cgi/content/short/2021.10.15.21265078*
"Updated Model for the USA Summer 2021 CoVID-19 Resurgence"

Fig. 1: The USA CoVID-19 Winter 2021 Resurgence, By Itself

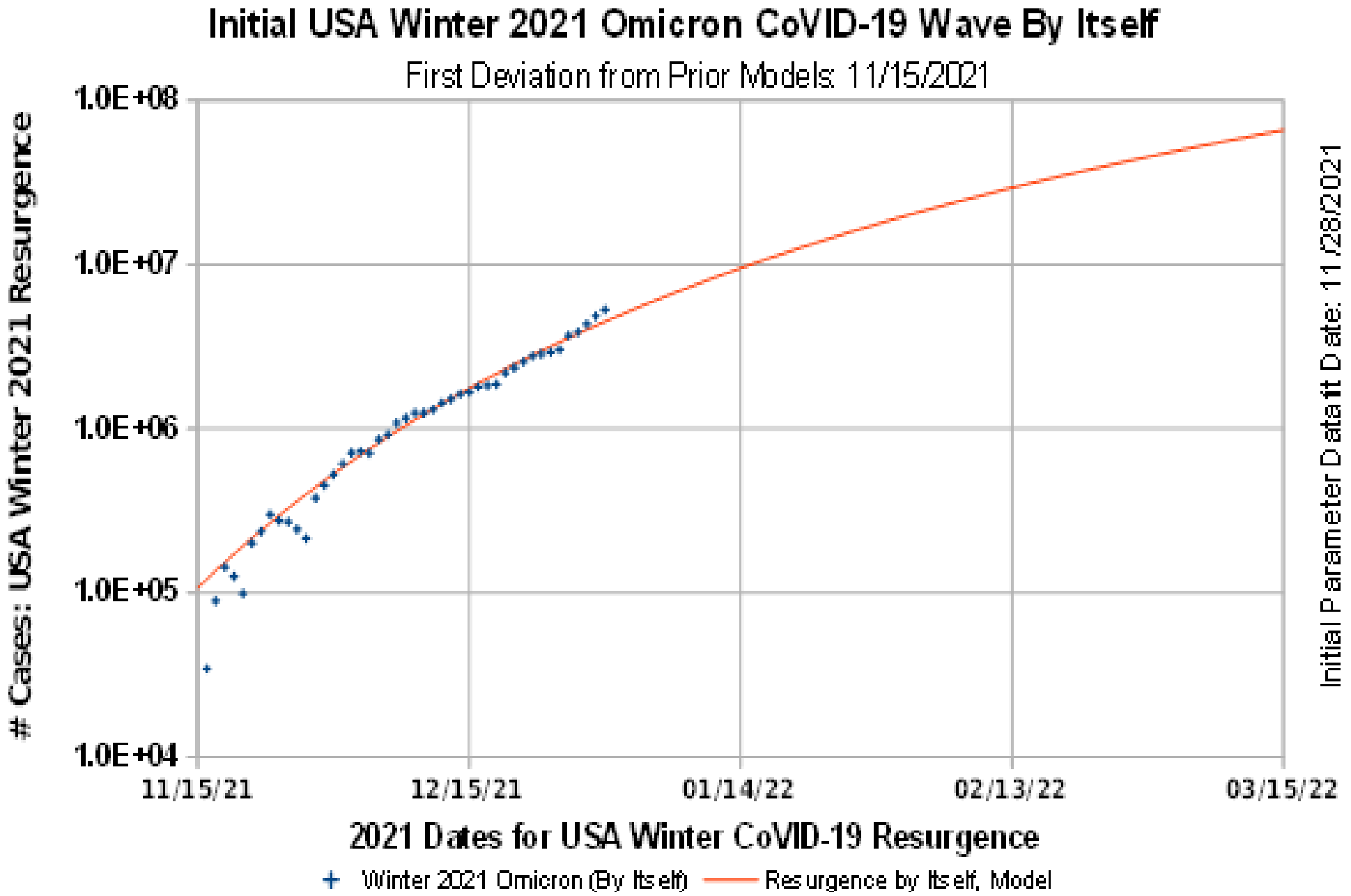

Fig. 2: **Summary of CoVID-19 Model and Parameter Values**

Index	U.S.A. CoVID-19 Stage	*No, (Initial t=0 Value)*	*t=0 Date*	*t/dbl days, at t=0*	t_R value	α_S value	δ_o value
1	Ini.Model 6/7/20 Update	23,710	03/21/2020	1.99657	2.88044	0.06618	0.00000
2	1st Resurgence Summer 2020 =>	15,650	06/07/2020	2.88000	4.15496	0.058__	0.0108_
3	Winter 2020 Resurgence =>	88,900	09/25/2020	5.57983	8.05__	0.011__	0.001748
4	Small Spring 2021 Resurgence =>	146,000	03/19/2021	5.57983	8.05__	0.00128	0.01365
5	Inital Portion, Summer 2021 Resurgence =>	41,000	06/07/2021	9.08924	13.113_	0.0030_	0.00000
6	Latter Portion, Summer 2021 Resurgence =>	3,200,000	08/13/2021	14.44339	20.83740	0.019999	0.000489
7	Initial Portion, Winter 2021 Resurgence =>	107,000	11/15/2021	5.57983	8.05__	0.011__	0.000001
8	Winter 2021 Extrapolation using Winter 2020 δ_o value =>	107,000	11/15/2021	5.57983	8.05__	0.011__	0.001748

Fig. 3: **USA CoVID-19 Totals: Data 3/21/2020 through 12/30/2021**