Covid-19 Case Fitting Curves.

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Abstract

Based on a linear superposition of hyperbolic tangent functions, a multi-wave analysis is employed to describe Covid-19 case and death data (weekly accumulated) and their growth rates. These curves picture the actual moment of this very serious pandemic in the countries with the highest accumulated cases. Last data update: August 21, 2021.

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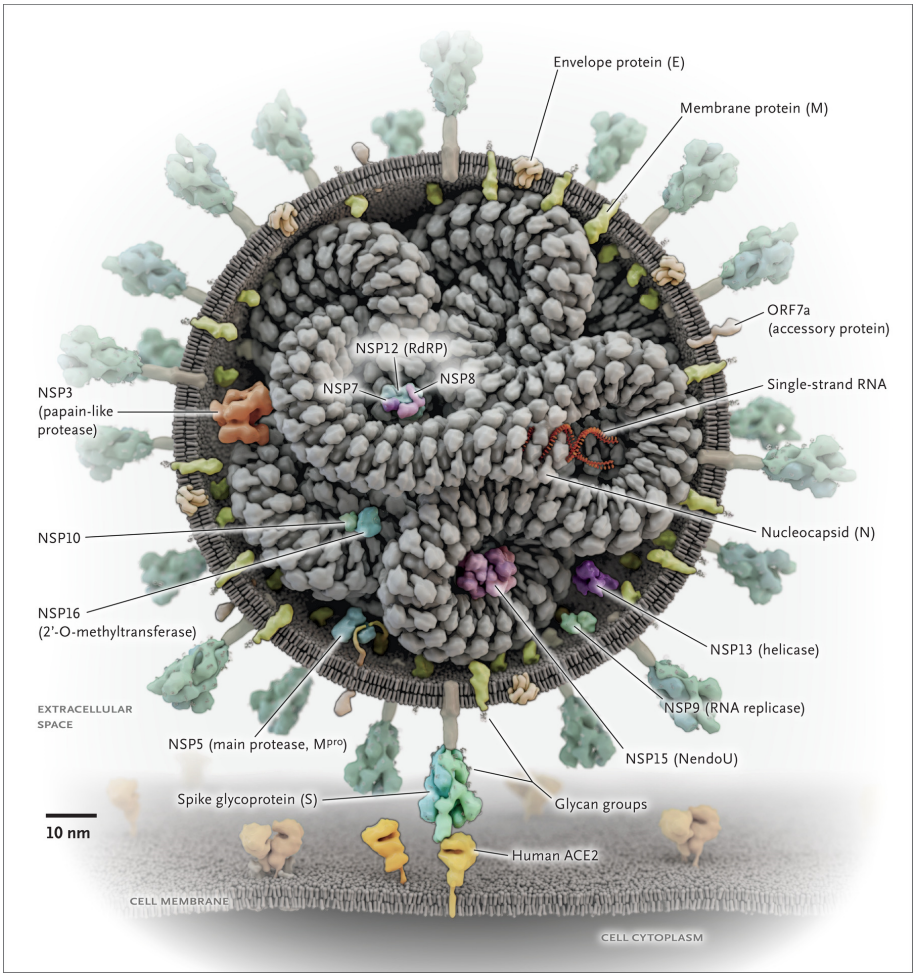

Parks & Smith: The SARS-CoV-2 Virion and Its Proteins.

1 Introduction

More than 212 million people all around the World had Covid-19 and 18 million still have it. The death toll has exceeded the incredible mark of 4.4 million people. Moreover, Covid-19 continues to infect even at higher rates than before. Many countries are facing new waves of contamination by Covid-19. Covid-19's ability to infect people is unprecedented: asymptomatic transmission, the most powerful feature, and airborne transmission.

We present a method to identify the numbers of waves of contamination and death by Covid-19 in a given case data. Each wave is represented by a hyperbolic tangent function. A linear superposition of single waves represents a case data having accumulated cases over N weeks,

$$Z_N(n) = \sum_{i=1}^{l} a_i \tanh(b_i n - c_i) + d. \tag{1}$$

Each smooth curve representing the data is a photography through time. This model function in Eq. 1 has the growth rates

$$V(n) = \frac{dZ}{dn} = \sum_{i=1}^{l} \frac{a_i b_i}{\cosh^2(b_i n - c_i)}, \tag{2a}$$

$$A(n) = \frac{dV}{dn} = -2 \sum_{i=1}^{l} a_i^2 b_i \frac{\sinh(b_i n - c_i)}{\cosh^3(b_i n - c_i)}, \tag{2b}$$

speed and acceleration, respectively.

At the inflection points i_p, by definition, the acceleration $A(i_p)$ is null (and about to become negative), and the speed $V(i_p)$ is at a local maximum. Each inflection point belongs to one wave. Since the acceleration becomes negative after the inflection point, the speed diminishes and the stabilization can be reached if a new wave is not on the way. When both velocity and acceleration are practically zero on both sides of the inflection point, a wave is called complete. In order to have multiple waves in play, the acceleration must be zero at the points connecting them and the velocity must be at a local minimum.

Parameters $\{a, b, c, d\}$ appearing in the model function (1) were obtained by a (local) non-linear fitting minimizing the root mean square (rms) deviations. All case data points are equally weighted. Case data are available at Our World in Data.

2 United States of America

2.1 Contamination

The last four fitted $Z_N(n)$ curves describing the weekly (n) accumulated case data of infections by Covid-19 in United States of America are shown in Figure 1, where the inset shows the root mean square (rms) deviations for the latest curve. Growth rates (2) from the latest curve are shown in Figure 2. Five waves were used.

2.2 Deaths

The last four fitted $Z_N(n)$ curves describing the weekly (n) accumulated case data of deaths by Covid-19 in United States of America are shown in Figure 3, where the inset shows the root mean square (rms) deviations for the latest curve. Growth rates (2) from the latest curve are shown in Figure 4. Five waves were used.

3 Brazil

3.1 Contamination

The last four fitted $Z_N(n)$ curves describing the weekly (n) accumulated case data of infections by Covid-19 in Brazil are shown in Figure 5, where the inset shows the root mean square (rms) deviations for the latest curve. Growth rates (2) from the latest curve are shown in Figure 6. At least three waves were needed. The last wave is still growing very fast.

3.2 Deaths

The last four fitted $Z_N(n)$ curves describing the weekly (n) accumulated case data of deaths by Covid-19 in Brazil are shown in Figure 7, where the inset shows the root mean square (rms) deviations for the latest curve. Growth rates (2) from the latest curve are shown in Figure 8. Three waves were used.

References

[1] Jerry M. Parks and Jeremy C. Smith, New England Journal of Medicine 2020, 382:2261-2264. DOI: 10.1056/NEJMcibr2007042.

[2] Monica Gandhi, Deborah S. Yokoe and Diane V. Havlir, New England Journal of Medicine 2020, 382:2158-2160. DOI: 10.1056/NEJMe2009758.

[3] Julian W. Tang, Linsey C. Marr, Yuguo Li and Stephanie J. Dancer, British Medical Journal 2021, 373:n913. DOI: 10.1136/bmj.n913.

[4] Max Roser, Hannah Ritchie, Esteban Ortiz-Ospina and Joe Hasell, Coronavirus Pandemic (COVID-19). Our World in Data (2020).

4 Figures

4.1 USA

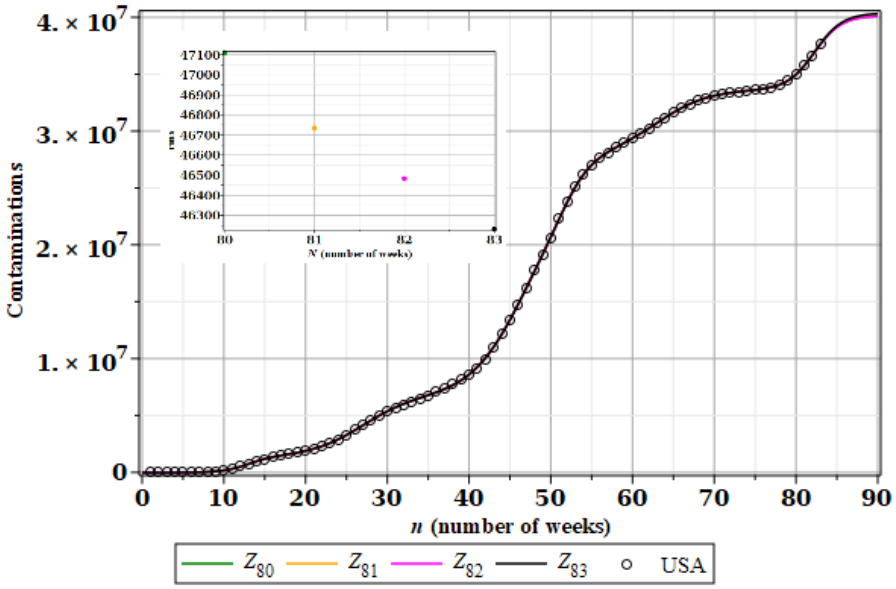

Figure 1: Weekly Covid-19 contamination curves and rms for the data from United Sates of America.

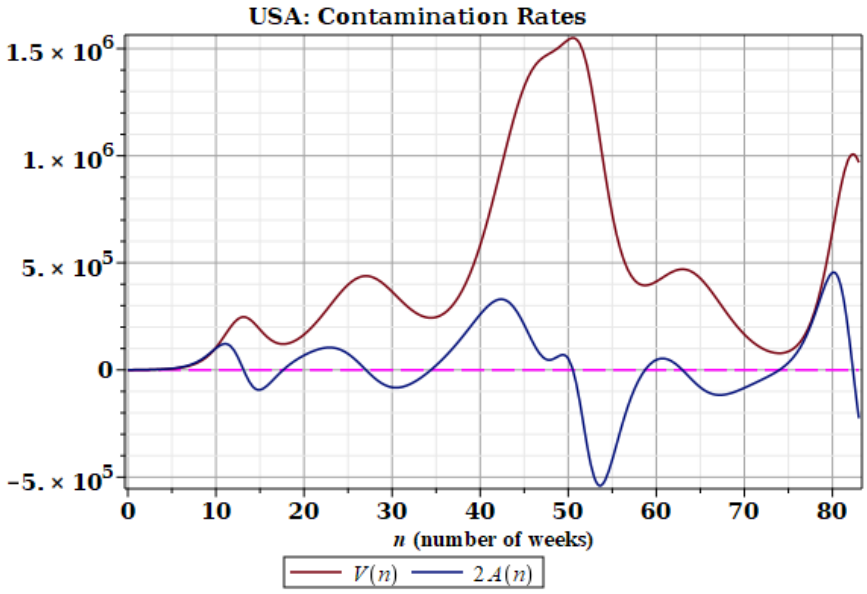

Figure 2: Weekly growth rates (speed V and acceleration A) from the last fitted case curve.

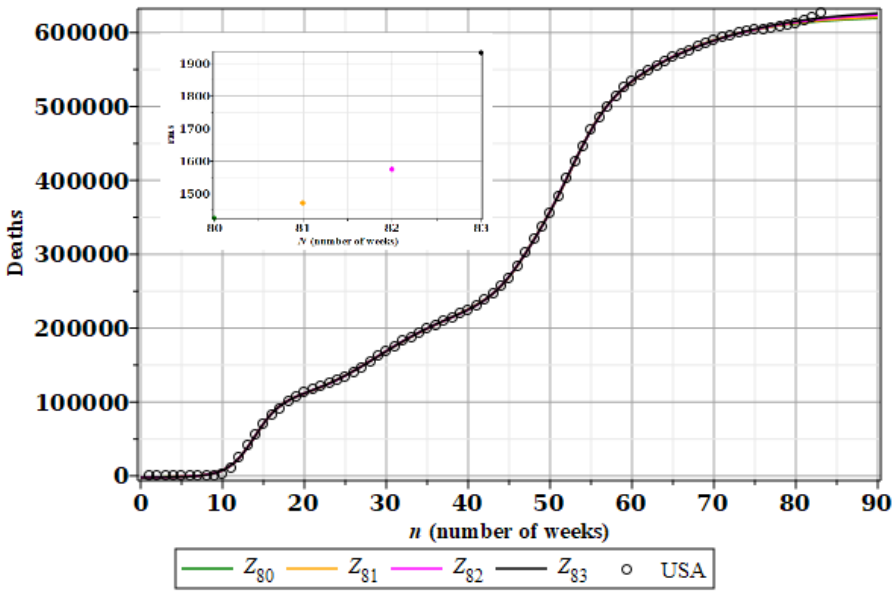

Figure 3: Weekly Covid-19 death curves and rms for the data from United Sates of America.

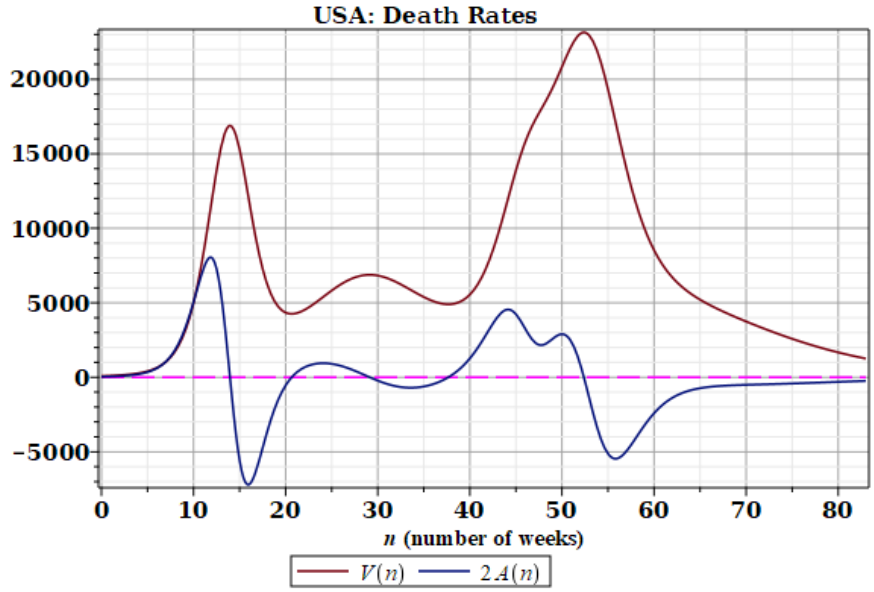

Figure 4: Weekly growth rates (speed V and acceleration A) from the last fitted death curve.

4.2 Brazil

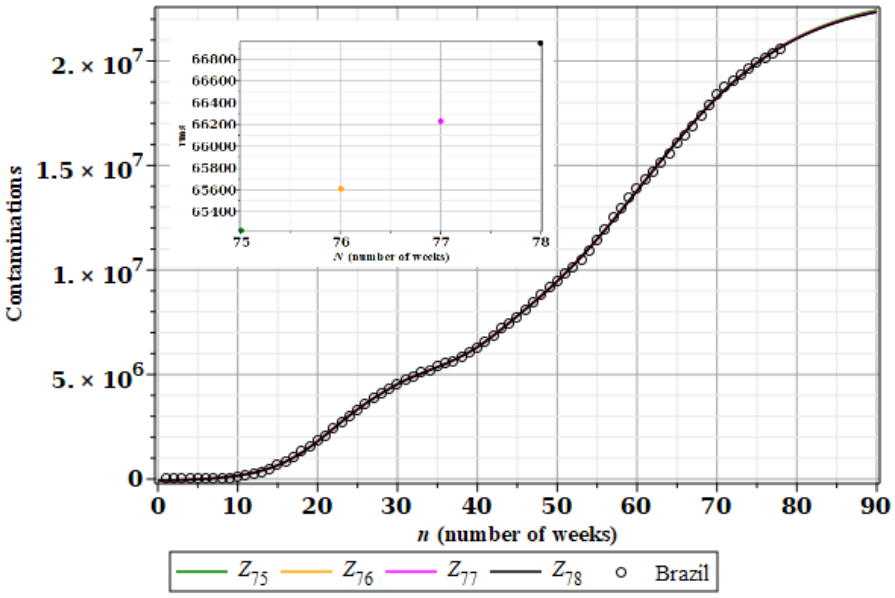

Figure 5: Weekly Covid-19 contamination curves and rms for the data from Brazil.

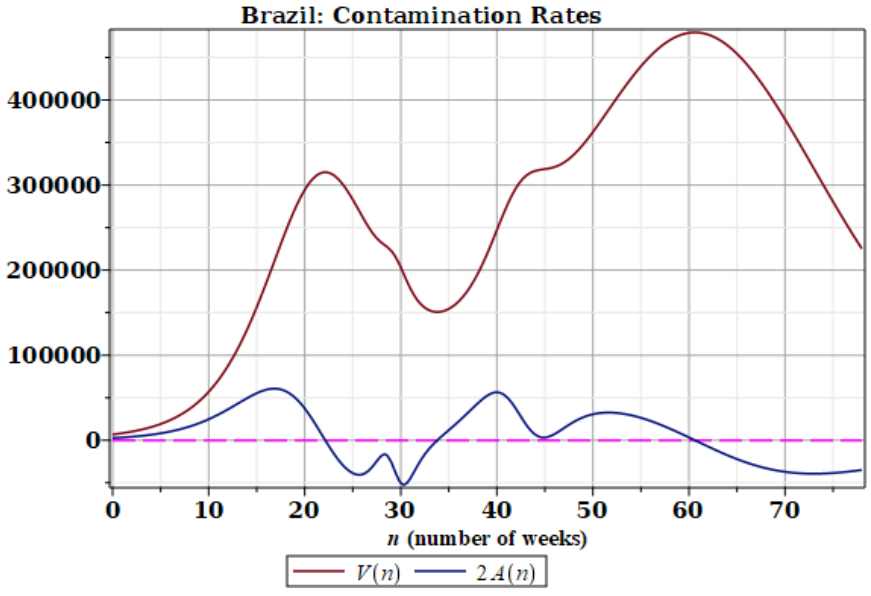

Figure 6: Weekly growth rates (speed V and acceleration A) from the last fitted case curve.

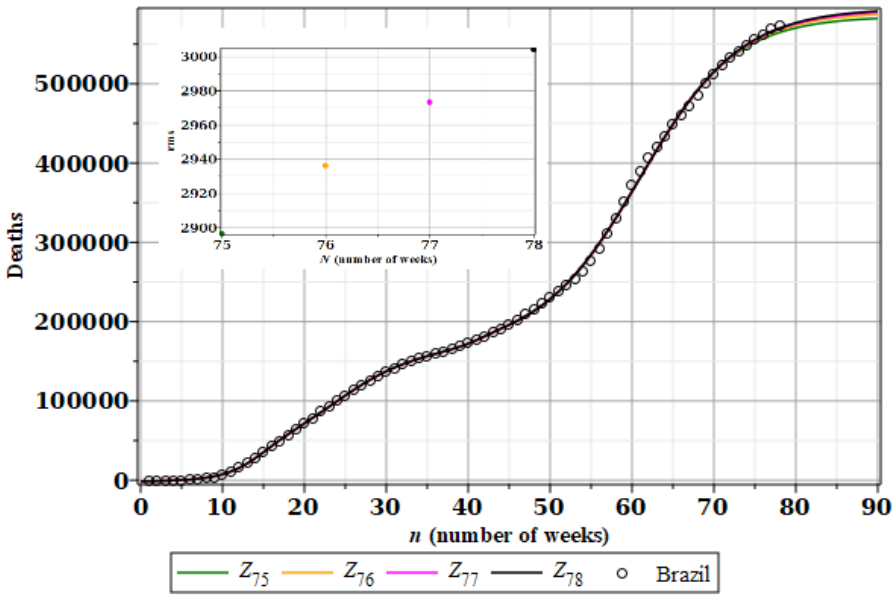

Figure 7: Weekly Covid-19 death curves and rms for the data from Brazil.

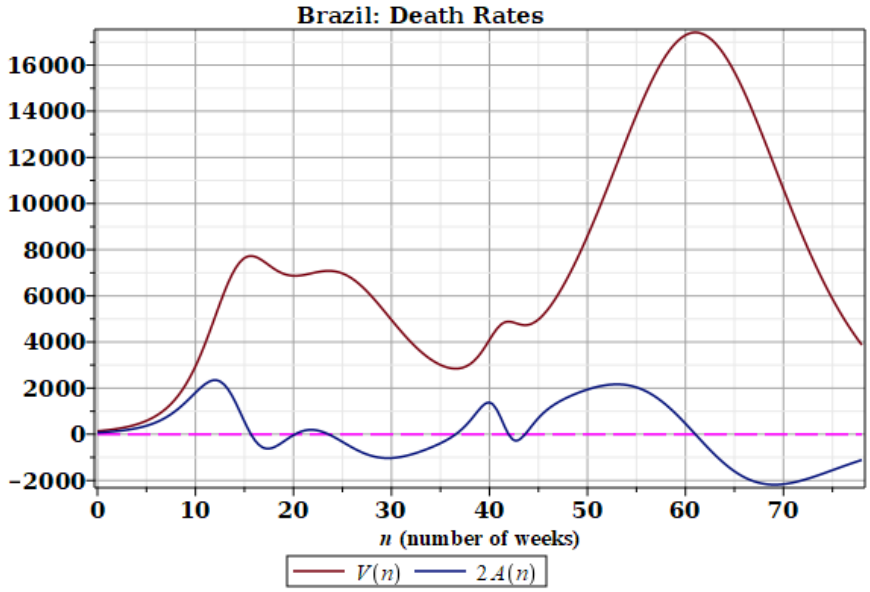

Figure 8: Weekly growth rates (speed V and acceleration A) from the last fitted death curve.