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Optimizing Measurement Methods for Evaluating the Effectiveness of Regulations to Slow Down COVID-19 Spread

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ABSTRACT:*COVID-19 has affected day to day life and slowed down the global economy. Most countries are locking their population and enforcing strict quarantine to control the spread of the havoc of this highly contagious disease. In this article, we propose a model of data analytics to help governmental decision support. Lockdown procedures are regularly reviewed by worldwide governments to enable a reasonable control over the outbreak increase. The model aims to find out the outbreak growth by measuring the exponential tilt angle for predicting any future spike before its occurrence. The prediction chooses small intervals of three to four days. This is essential to closely monitor the sudden outbreak. The model measures the infection stability or instability and enables an appropriate comparison between countries. The model measures any exponential or sigmoid growth of the infection rate.*

KEYWORDS:*COVID-19, Pandemic, Outbreak, Government regulations, spread control*

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I. INTRODUCTION

Three major global pandemic outbreaks have spread in the last few decades, severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and Ebolavirus (EVD). SARS and MERS are both caused by coronaviruses. This group of crown-like viruses can cause liver, neurologic, gastrointestinal, and respiratory disease [1, 2]. SARS first appeared in Southern China in November 2002, caused by the SARS-associated coronavirus (SARS-CoV) with readily transmission through droplets. The incubation period is typically 2 to 7 days. The outbreak is declared to be over by the late July 2003, this global pandemic resulted in a total of 8,098 probable cases with 774 associated deaths [3]. Compared to SARS, new MERS cases were being reported. Since first identified in Saudi Arabia in 2012, a total of 2,519 laboratory-confirmed cases, including 866 associated deaths were reported globally by the end of January 2020 [4]. With 79.6% similarity in sequence identity as SARS-CoV, the newest coronavirus (COVID-19) outbreak first started in Wuhan, China on 12 December 2019 [3]. Considering a rapid spread over the globe and person-to-person transmission capability, the World Health Organization (WHO) declared COVID-19 as a Public Health Emergency of International Concern on 1 February 2020 [2].

Since the lockdown restrictions continue to ease in all countries worldwide, there is a need to avoid another wave of an outbreak that may occur in any place, and at any time [5]. The second wave may not be as high as the first one, but however, it may have a possibility of creating another worldwide break, specially, when reducing restrictions on flights. For this reason, governments need to be more vigilant and should closely monitor any possibility of an outbreak. Predicting the spread of disease globally can foresee the impact of disease and effectively manage the supply chain prior to epidemic secure allocations for critically affected and at-risk countries, therefore reducing the shortage issue for those endangering health workers at the front line [5].

The aim of this paper is highlighting some lockdown factors that may have direct impact on the contagion level. The infection and mortality rates do not depend on the contagion level only, but many other factors such as late response on the start of the pandemic. The lockdown has been applied by most governments worldwide, either as a curfew or as a voluntary. The community lockdown can be statistically defined as maintaining the length of stay at home as long as possible during the 24 hours.

II. EXPERIMENTAL PROCEDURES

This paper presents some suggested methods for measuring the R0 speed on the short run. This is to provide better measurement tools for the governmental body, so they promptly decide in accordance to the spread development. During the past few months, the spread measurements have adapted the value of R0=2.5 [6]. This value was calculated during the initial stages of the pandemic. The calculation method has considered the incubation period of 14 days for the virus. With the time pass, the R0 rate has dramatically dropped down as a reason of the lockdown procedures, self-quarantine, and people's awareness of the disease. Moreover, the uncertainty of giving infection numbers, in the early stages, was high. Currently, the uncertainty percentage rate is lower, and the scan rate of suspected patients is higher. Also, the virus test results period is much shorter than before, which may not exceed few hours. For these reasons, we need to find a faster and more accurate measurement tool that gives governments a better understand to the outbreak growth.

The measurements models in this paper are divided into two types, one for measuring the lockdown procedures and finding out the most appropriate regulation that governments should take. The second measurement model enables a better prediction for the near future diseases spread. Both methods adapt a short period of measurement, which should not exceed four days. This may not look accurate for measuring R0, but however, it can be considered another model of measurement. This is essential to closely monitor the social distancing efficiency.

Governments should have a long-term plan for this outbreak, this includes a continues revision for the lockdown polices restrictions and procedures. The policies should compromise between preventing an over limit outbreak and mitigating economical loss. The limited capacity is defined by the ultimate capacity for intensive care units in the public health system. Governments are concerned about finding the optimal planning response, since they are unable to determine the outbreak spread time, and social activities that cause the highest spread. Future modelling will account for the actions taken by governments, which include restricting travel, isolating people with the virus and their contacts, social distancing, growing health system capacity and others [7].

For approximate evaluation, we built a naïve model that may support decision making. The model should provide a short period of reading the exponential spread of the diseases. A period of four days is defined as a short time to re-review the public health policy. The governments respond should act promptly according the resulted output.

1 Measuring the Outbreak Growth

The aim of this tool is measuring the growth angle of the exponential diagram. This is to compare between countries without considering the accumulative number of infections. Moreover, governments recognized that the actual number of infections is inaccurate on a daily basis. The infection number is based on the number of COVID-19 tests performed in every country. A larger test rate may result a larger infection rate. For this reason, zero infection that sometimes was recorded in some countries may not reflect the actual values. For this reason, we ignored the zero infections that appear within few consecutive days, by removing the repeated infection numbers. Any other number of infections, whether low or high, are considered in the exponential equation.

Moreover, the exponential increase of infection rate is unsteady, then the prediction error rate remains high. It is essential to closely monitor the changes that occur on the exponential growth. The related number of accumulated infections Y per day dY/dt, or based on newly informed cases, is necessary to avoid any undesired outbreak. The general growth of dY/dt for COVID-19 usually follows a skewed pattern. In general, any rapid growth usually follows three different patterns, linear, sigmoid, or exponential. The sigmoid pattern occurs when the growth stops or reduces to the minimal [8]. The new lockdown policies and producers made it hard for scientists to predict a correct model. Various models were proposed to predict the future growth of infections, death toll and recovered, such as Susceptible-Infected-Recovered (SIR) model [9]. Other models focused on finding the number of probable infections only such as Generalized Richard Model (GRM) [10]. Nevertheless, the aim is not only predicting the number of infections, but also finding a mechanism of early alerting governmental body before another wave of outbreak starts.

The outbreak wave should count the number of infections during the last few days, so the model can describe a possible growth of infected numbers in a curve-fitting approach. This approach tends to smoothen the natural exponential growth of infections [11]. This model only considers the number of daily infections regardless the death toll or number of recovered cases. In this paper we introduce a naïve model based on basic exponential equation to predict the number of infections Y as follow:

$$Y = \alpha \times \beta^N \quad (5)$$

where α denotes a magnitude that presents the growth stability rate, while β presents the decline rate.

This simple presentation of the exponential equation provides an exponential smoothing for the number of infection cases. The exponential function is attributed to Poisson as an extension of a numerical analysis technique [12]. Exponential smoothing is essential to avoid rough increase or decrease of infection cases on a daily basis. The zigzag line may not provide an accurate reading for the previous, current, and future growth. In exponential graphs, several smoothing models were proposed such as General Exponential Smoothing [13], seasonal exponential smoothing, least-square fitting [14], Broydon method [15], Newton method [16] and others.

We implemented Broydon method to smoothen a small interval of four days counting the number of infections. Broydon's method is chosen since it is recommended for small and medium numbers. It is clear that the number of infections did not exceed seven million cases for any country, therefore; it is reasonable to use this method to smoothen the exponential curve. Equation 5 presents two main values of α and β, while N presents the number of days. The predicted number of infections Y is calculated after removing the repeated values. Variable α presents the stability or non-stability growth. In every small interval, there is one unique value of α and β. These two values may look like linear, curvy, or fixed. The curvy line may show a curve with a high, medium, or low speed. Variable β is highly stable.

The value of α and β were calculated based on Broydon method. They are valid for four consecutive days with ignoring the repeated numbers. Suppose that the predicted Y of the four days interval is Y={Y1, Y2, Y3, Y4}, hence the growth distance (D) between the fourth day and the first day is given by this equation:

$$D = Y_4 - Y_1 \tag{6}$$

The value of D is essential for measuring the variance of the infection rate between the fourth and first days. This equation provides a simple comparison tool between countries and may build a simple graph for each country's expected growth in the future. The D value was multiplied by 100 to avoid the small decimal numbers for a better comparison rate.

III. RESULTS AND DISCUSSION

The results of the calculated D value for many countries show a stable D after the lockdown polices around the world. Most countries gained a value of $D \approx 110$. We built our dataset based on the statistical numbers of COVID-19 data [7]. We merged country's states and converted dates to numbers. Next, we built Python scripts to calculate the values of α and β [17]. Table 3 illustrates the method of calculating the distance D value by abstracting Y4 from Y1. Fig. 3 to Fig. 10 show the values of α and D for several countries within the period between 22/01/2020 and 11/04/2020. The data visualization may show that value of α may shape the exponential, linear or sigmoid. This is essential to determine the future of the infection rate. For instance, Australia shows a sigmoid shape, while Spain and Italy are about to move to sigmoid. Brazil presents a linear increase, while Egypt and Russia present an exponential increase.

Table 1. **Method of calculating Y and D values**

α	β	N	Y	D=(Y4-Y1) ×100
1.504609	1.143343	1	Y1=1.720284	85.08797
1.504609	1.143343	2	Y2=1.966875	
1.504609	1.143343	3	Y3=2.248812	
1.504609	1.143343	4	Y4=2.571164	
19.07286	1.019324	5	Y1=20.98829	124.0394
19.07286	1.019324	6	Y2=21.39386	
19.07286	1.019324	7	Y3=21.80728	
19.07286	1.019324	8	Y4=22.22868	
24.61267	1.014774	9	Y1=28.08543	126.3248
24.61267	1.014774	10	Y2=28.50036	
24.61267	1.014774	11	Y3=28.92141	
24.61267	1.014774	12	Y4=29.34868	

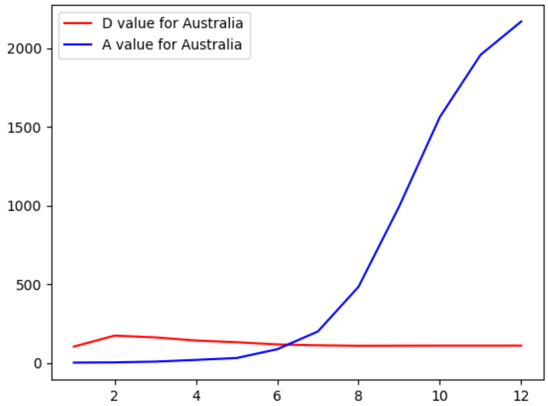

Fig. 1. Australia D and α values

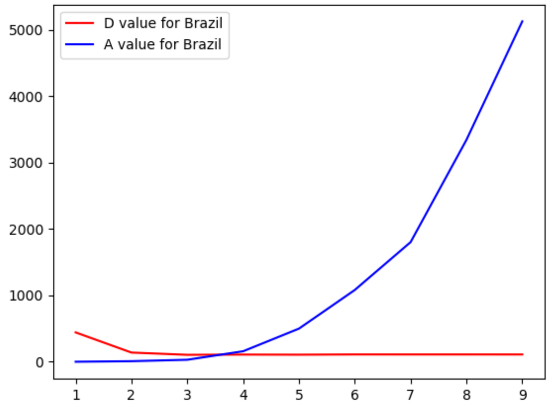

Fig. 2. Brazil D and α values

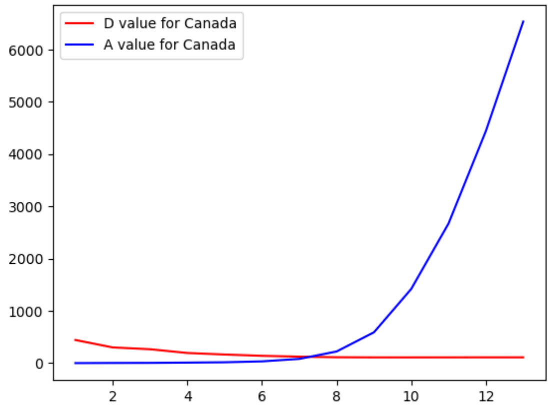

Fig. 5. Canada D and α values

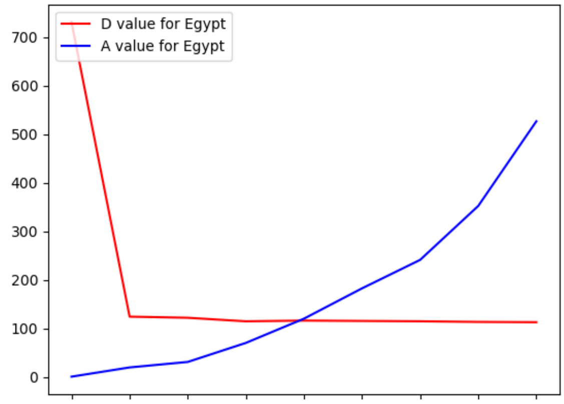

Fig. 6. Egypt D and α values

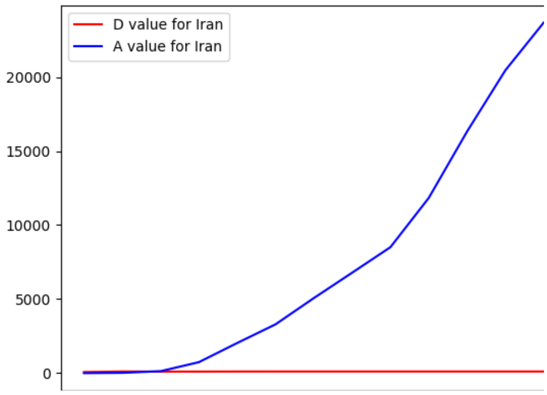

Fig. 7. Iran D and α values

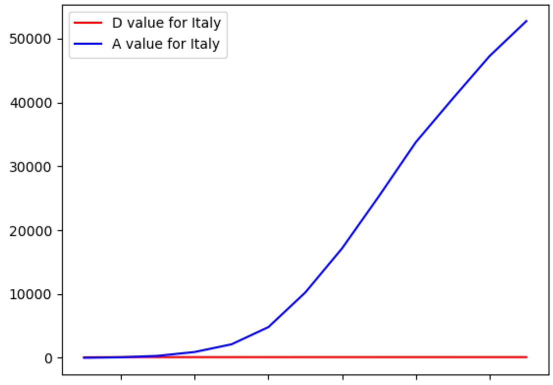

Fig. 8. Italy D and α values

This method enables an easier comparison between countries. Here are some examples that show the comparison between various countries. Fig. 11 illustrates a comparison between five countries Canada, France, Spain, Germany, and Australia. It is clear that Canada had the highest tilt of the exponential increase. This indicates a sharp growth of infection cases, which may describe a high rate of R0 as well. However, the line graph shows a stable value after day 8 with a Y value around 110. The graph was calculated using Table 3, where each four days present one increment in x-axis. The y-axis presents the variance that occurred between then fourth day and the first day.

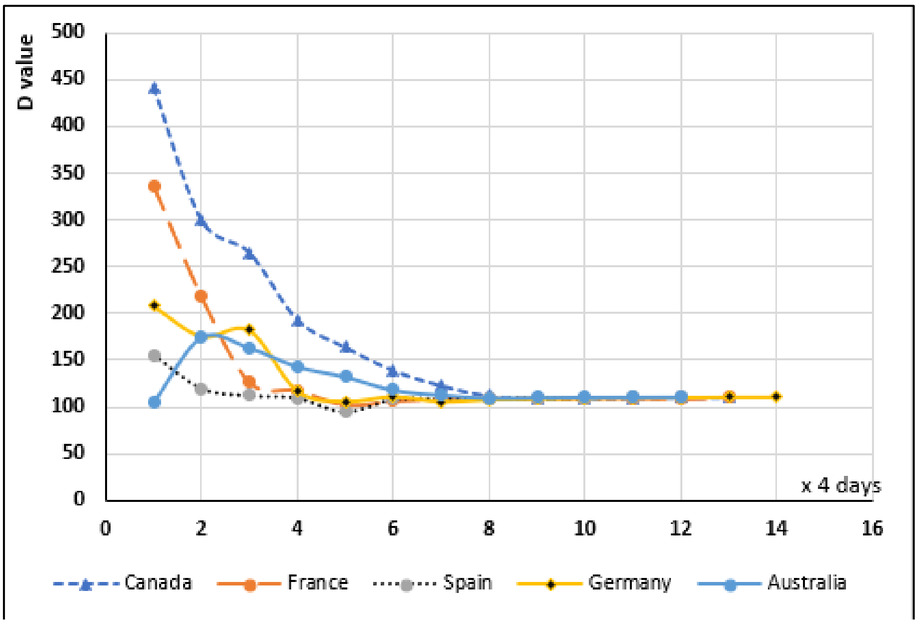

Fig. 11. The distance value of D for five countries, where x-axis presents 4 days for each increment

IV. CONCLUSION

A statistical model is defined in this paper. These calculations may support governmental body plans and decision making. Since this pandemic may last a year or more, then there should be a well-structured plan to bring life to usual activities with a high level of cautious. The model was for measuring the outbreak growth, this can be conducted by measuring the exponential tilt angle for predicting any future spike before its occurrence. A small interval of four days was smoothened using Broydon's method. The predicted smoothed values have measured the exponential equation's variable of α and β. The predicted Y_4 value of the fourth day interval was abstracted from the predicted Y_1 value of the first day to conclude the distance value D. The value D denotes the growth speed of the infection cases rather than measuring the number of infected cases. It is an independent method of calculating and comparing the growth changes. The statistical were applied on various countries and the results show a good agreement between countries' pandemic growth and our results.

Conflict of interest
There is no conflict to disclose

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