Mathematical Models for the Coronavirus Disease (Covid-19) Pandemic

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Abstract- This paper presents mathematical models on the growth of the number of cases infected by the Covid-19 virus and the number of deaths caused by the Covid-19 virus. Four models are being considered, the linear, quadratic, cubic and the exponential. Analysis shows that the exponential function is the appropriate model for this pandemic. Forecasted results are very alarming. This can result to human extinction. Moreover, we recommend our humble tangible solutions for the control and to minimize the number of incidents.

Index Terms- Mathematical Models, COVID-19, Linear Function, Quadratic Function, Cubic Function, Exponential Function and Curve Estimation

I. INTRODUCTION

The sporadic increase of the number of cases and deaths caused by the Coronavirus Disease or the Covid-19 is very alarming. As of this writing there is no cure, drug or vaccine which has been discovered. We tried our best in pondering why we have not discovered this solution despite of the very high level of the state of the art, science and technology that we have at present.

Different countries all over the world are in a panic situation. Panics in storing and buying necessary goods and supplies for the purpose of saving and securing lives are the immediate solutions to these crises. One possible solution we come out in our minds is to come out with a mathematical model on the number of cases and deaths caused by this virus. At this very stage, this is considered to be pandemic. Almost all countries in the world are affected.

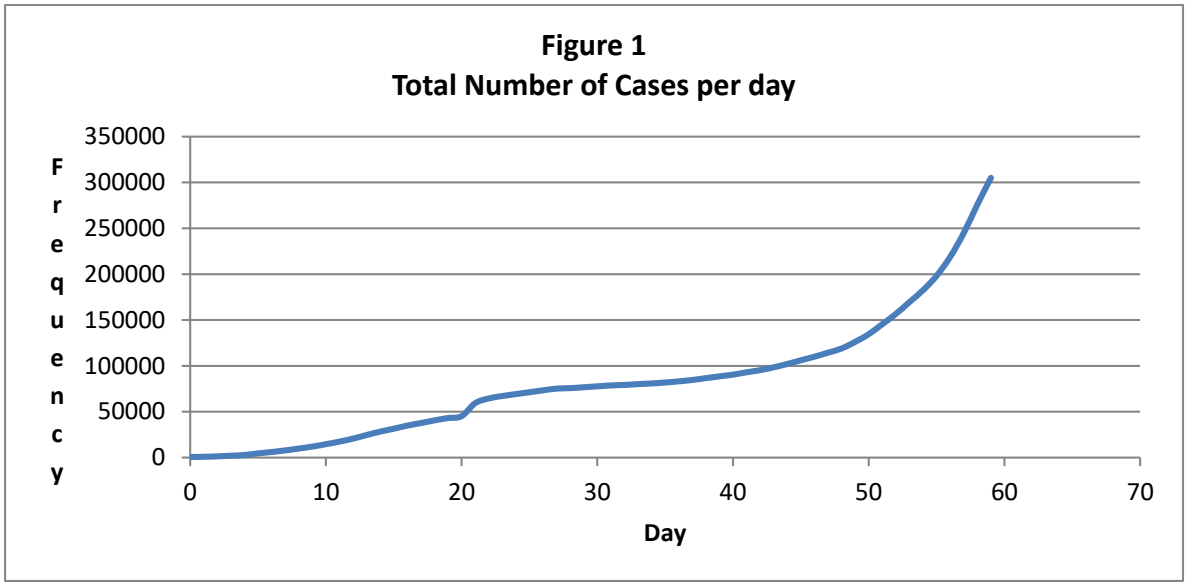
In this paper we present appropriate mathematical models for the guidance of everyone especially the persons in authority and power.

II. THE MATHEMATICAL MODELS

In this paper, we present two mathematical scenarios. One scene is on the number of cases and the other scene is on the number of deaths. The source of our data is from the website (worldometers.info/coronavirus). We started with day 0 for January 22, 2020. Our cut-off day is 59 and this is March 21, 2020. For each scenario, we consider four possible models, the linear, quadratic, cubic and the exponential functions.

We try to employ the graphical method in modeling. According to Lee, Elisa t. (1992) graphical methods have long been used for display and interpretation of data because they are simple and effective. Moreover, (Lee, 1992) emphasized that graphical methods are often used in placed of or in conjunction with numerical analysis, a plot of data simultaneously serves as a number of purpose that no numerical method can.

Walpole (1992) commented that if the set of data can be represented by a nonlinear regression curve, we must then try to determine the form of the curve and estimate the parameters.



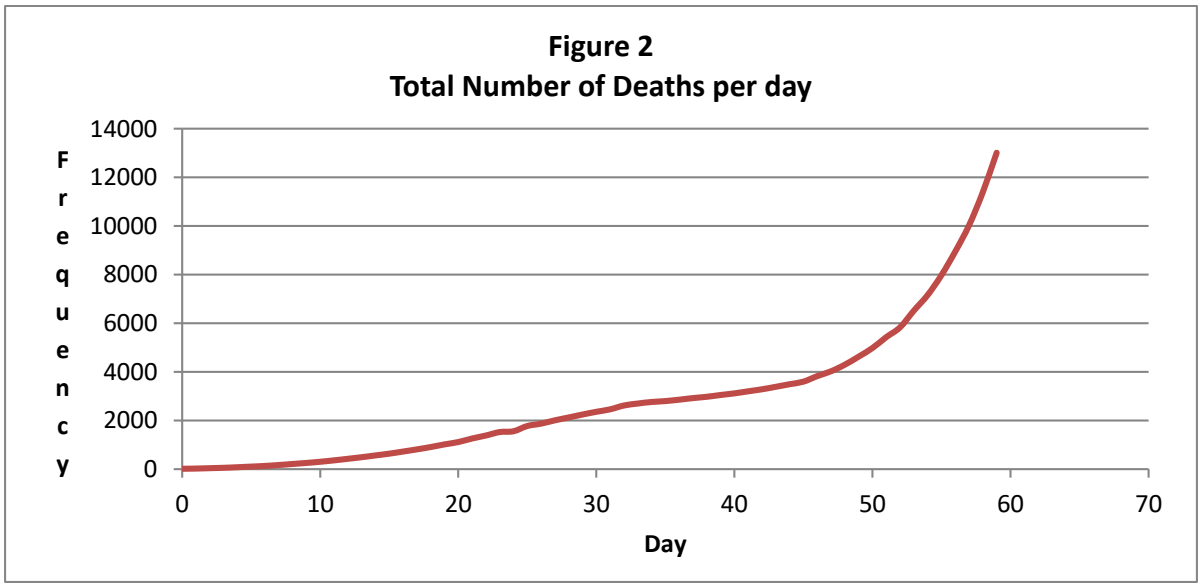


Figure 1 is all about the total number of cases per day, while Figure 2 is all about the total number of deaths per day. It is interesting to note that both graphs are in the increasing pattern. From day 0 to day 50, the graphs have the linear trend, however from day 51 to day 59 an exponential or a power function can be seen.

Table 1
Curve Estimation for the Total Number of Cases

Dependent	*Model*	*Rsq*	*d.f.*	*F*	*Sigf*	*b0*	*b1*	*b2*	*b3*
CASES	*LIN*	*.837*	*58*	*298.08*	*.000*	*-23310*	*3573.09*		
CASES	*QUA*	*.901*	*57*	*260.07*	*.000*	*13116.8*	*-195.20*	*63.8693*	
CASES	*CUB*	*.960*	*56*	*445.81*	*.000*	*-26067*	*8125.84*	*-291.70*	*4.0177*
CASES	*EXP*	*.783*	*58*	*209.05*	*.000*	*5511.41*	*.0721*		

From Table 1, we can see that the linear, quadratic, cubic and exponential functions are appropriate models for the growth of the total number of cases due to COVID 19. Below are their equations, where y is the total number of cases and t is the number of days:

$$y = -23310 + 3537t \quad (1)$$

$$y = 13116.8 - 195.2t + 63.8693t^2 \quad (2)$$

$$y = -26067 + 8125.84t - 291.70t^2 + 4.0177t^3 \quad (3)$$

$$y = 5511.41e^{0.0721t} \quad (4)$$

Of the four models the cubic function shows the best fit with the highest f value. As can be seen also in the graphs in Figure 3, the cubic function has the best fit. However by further analysis and by using forecasting as reflected in Table 2.

Figure 3 Graphs of the Appropriate Models for Total Number of Cases

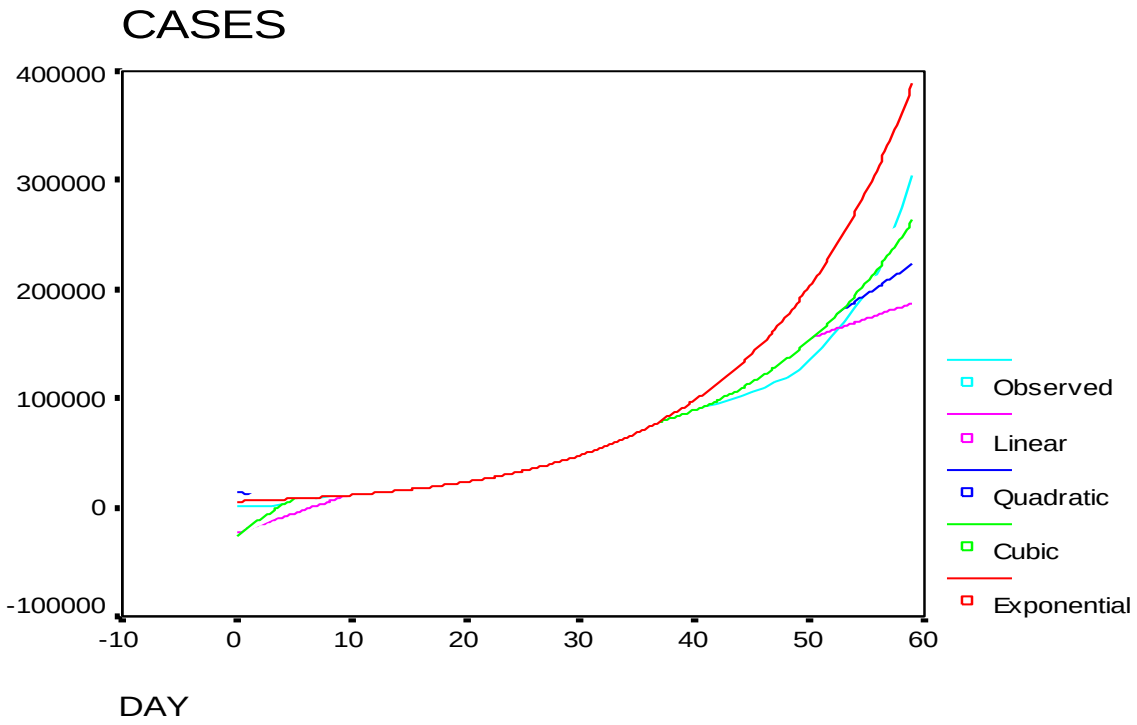


Table 2 can validate the four models by considering Day 67. On day 67, March29, 2020, the website (worldometers.info/coronavirus) records 683,563 cases which is almost near to 690,504 cases, the forecasted value by the exponential model. It is amazing and noteworthy that the total number of cases behaves to be exponential. By day 100 (May 1, 2020) the total number of cases rises to 7.45 million and by day 200 (August 9, 2020), the total sums up to 10.1 billion. As of March 30, 2020, the world has a population of 7.77 billion people (worldometers.info). Thus, it is expected that by day 197 (August 6, 2020), the entire population of the world will be infected by this virus, granting that there is no cure that has been discovered.

Table 2
Forecasted Number of Cases

Model	Day 67	Day 100	Day 200	Day 300	Day 400	Day 500	Day1000
Linear	239,168	357,077	714,377	1,071,677	1,428,977	1,786,277	3,572,777
Quadratic	286,746	632,287	2,528,837	5,702,767	10,154,077	15,882,767	63,686,917
Cubic	417,298	1,887,217	22,072,701	84,636,585	213,685,069	433,324,353	3.73E+9
Exponential	690,594	7,456,703	1.01E+10	1.36E+13	1.85E+16	2.50E+19	1.13E+35

Table 3
Possible Models for the Total Number of Deaths

Dependent	*Model*	*Rsq*	*d.f.*	*F*	*Sigf*	*b0*	*b1*	*b2*	*b3*
DEATHS	*LIN*	*.777*	*58*	*202.51*	*.000*	*-1475.0*	*145.981*		
DEATHS	*QUA*	*.904*	*57*	*268.91*	*.000*	*696.821*	*-78.695*	*3.8081*	
DEATHS	*CUB*	*.956*	*56*	*407.33*	*.000*	*-868.54*	*253.728*	*-10.397*	*.1605*
DEATHS	*EXP*	*.872*	*58*	*395.81*	*.000*	*114.678*	*.0835*		

From Table 3, we can see that the linear, quadratic, cubic and exponential functions are appropriate models for the growth of the number of deaths due to COVID 19. Below are their equations, where y is the total number of deaths and t is the number of days:

$$y = -1475 + 145.981t \quad (5)$$

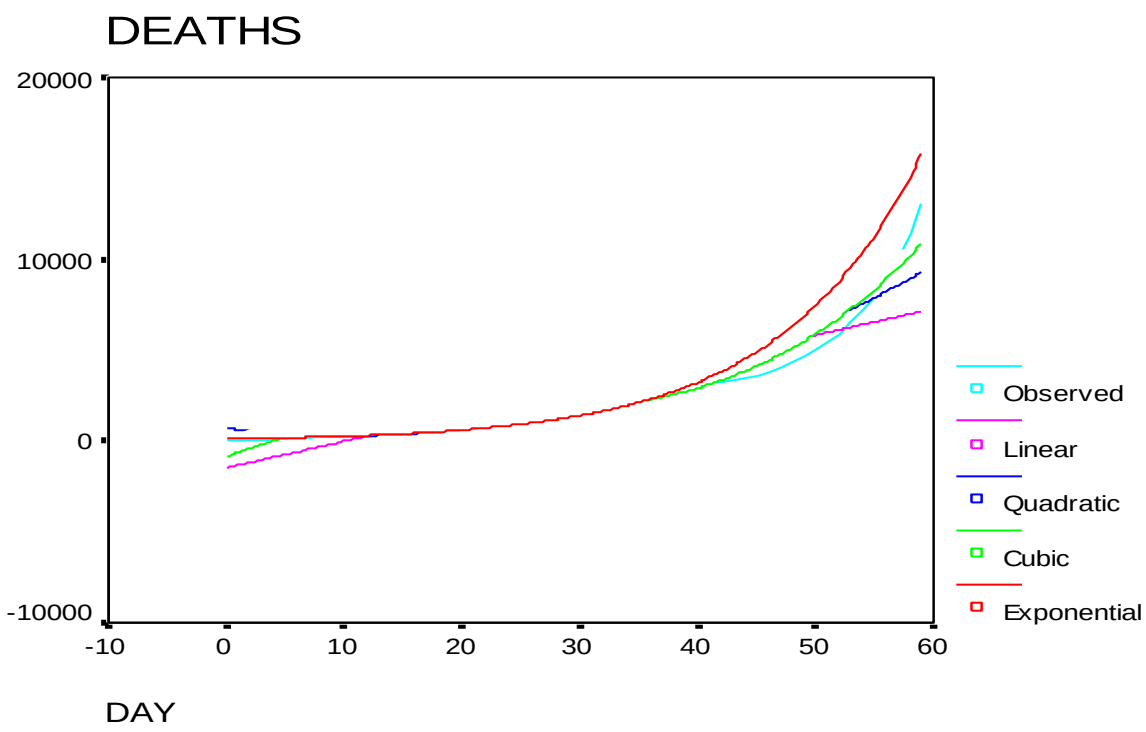
$$y = 696.821 - 78.695t + 3.8081t^2 \quad (6)$$

$$y = -868.54 + 253.728t - 10.397t^2 + .0160t^3 \quad (7)$$

$$y = 114.678e^{0.0835t} \quad (8)$$

Of the four models the cubic function shows the best fit with the highest f value. As can be seen also in the graphs in Figure 4, the cubic function has the best fit.

Figure 4 Graphs of the Appropriate Models for the total number of deaths



In a similar fashion with the total number of cases, the model for the total number of deaths can be validated in Table 4 by looking at Day 67 (March 29, 2020). As recorded by the website (worldometers.info/coronavirus), reaches 32,144 deaths. The total number of deaths as forecasted by means of the exponential function is 30,843. This is the closest value with respect to the four models. By day 216 (August 25, 2020), human population will be terminated, assuming at this point of time there is no vaccine and no cure being discovered. This is very terrible and horrifying, no one will be left in the world, and this is the total termination of human beings.

Table 4
Forecasted Number of Deaths

Model	Day 67	Day 100	Day 200	Day 300	Day 400	Day 500	Day1000
Linear	8,294	13,106	27,687	42,268	56,849	71,430	144,335
Quadratic	12,519	30,908	137,282	319,817	578,515	913,374	3,730,102
Cubic	17,581	80,534	913,997	3,459,520	8,677,103	17,526,745	149,855,859
Exponential	30,843	485,136	2.05E+9	8.68E+12	3.67E+16	1.55E+20	2.11E+38

III. CONCLUDING REMARKS

A mathematical model is an abstraction from the realities. According to George E. P. Box (1979), “Models, of course, are never true, but fortunately it is only necessary that they be useful”. There is no such perfect model that will really give a true picture of a certain reality. This is due to the primary basis that models were formulated with various assumptions. We hope that with this output, we can be of help to be guided by this model.

The exponential function provides a very alarming forecast. This can result to human extinction. In this time that neither cure nor vaccine is being discovered we humbly recommend the following:

1. Establishing checkpoints in the heavy traffic highways and streets for the purpose of checking body temperatures is not an appropriate measure. This will just complicate the problem of traffic flows and management. Congestion in the checkpoints can expedite the transmission of the virus due to the closer contacts of individuals. The very good move is a house to house check-up. Those who will be considered to be positive should be advised for self-quarantine or be housed in emergency quarantine housing. Segregation of Persons under Investigation and Persons under Monitoring away from their respective family members is highly recommended.

2. Establishing of an emergency housing for those persons who are considered persons under observations or persons under monitoring. This housing will serve as the quarantine hostel for these people. Hospitals at this time are totally congested. Sports facilities such as gymnasiums, astrodomes and coliseums are good accommodations. Dormitories of State Universities and Colleges can also be used if they have. School buildings and classrooms can be utilized. Build a quarantine area with a hospital settings, facilities and health workers to attend the needs of the COVID patients. Categorize them by color coding such as severity or priority, critical, high chance of survival or recovery, low chance of recovery, old and young patients.

3. Set up an isolated island that will cater patients with infectious disease for in case in the future we might encounter this pandemic. We are one step ahead of preparation in this campaign.

4. It is suggested that classes should be temporarily suspended until a cure or vaccine has been discovered.

5. The best method and procedure for the burial of deaths in these cases is cremation. If possible there should be a mass cremation for a big number of deaths.

6. Minimize the usage of currency bills and coins. This is a good medium for the transmission of the virus.

7. Establish a mobile grocery store or mobile market. This will reduce dense and congested traffic flow in terms of human and goods.

8. Government should provide an emergency funding for this health crisis. We request that authorities should be sincere and committed in applying the protocol as provided by the orders of the highest official in the country. We advised them not to corrupt the process. Remember that corrupted money will just go to the hospital. At this very critical moment it is necessary to love one another.

9. Obey and respect the official authorities in your respective countries, cities, municipalities and barrios.

10. Eliminate and prohibit mass gatherings, forums, conferences and conventions.

11. Conduct survival analysis studies on this COVID-19 pandemic.

12. The best move and action is the prayer. Prayer for the immediate recovery of the infected persons and for the discovery of vaccine and drug that can terminate this virus. Prayer for the officials and authorities so that they will be given wisdom in making the appropriate decisions.

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