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CASE STUDY

COVID-19 KINETICS BASED ON REPORTED DAILY INCIDENCE IN HIGHLY DEVASTATED GEOGRAPHICAL REGION: A UNIQUE ANALYSIS APPROACH OF EPIDEMIC

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Abstract

The recent outbreak of COVID-19 has impacted the whole globe in various facets of life. Most challenges stem from the public health effect with morbidities and mortalities extensively and comprehensively recorded and reported. The present case provides a unique analysis of the database of the observed cases and deaths of the corona virus pandemic. The focus was on one of the most devastating geographical locations in the world. The dataset of the USA was extracted and arranged chronologically over 106 weeks. The kinetics of mortality and morbidity were analyzed using three-dimensional graphs and control charts. Modeling of the cumulative dataset after logarithmic transformation was executed and the model was analyzed for fitting in terms of regression and error. A strong correlation existed between the number of reported cases and deaths over the study period with noticeable signs of six overlapping waves. Logarithmic transformation (to the base ten) showed improvement in data fitting with an appreciable reduction in standard error and residual parameters. The best-fitted model was an exponential association that could be used to evaluate the severity and frequency of the epidemic in terms of cumulative daily cases and deaths. The provided examination highlights the importance of the new statistical techniques for public health assessment and confrontation of the outbreaks by practitioners and professionals for community protection by providing measurable metrics for the evaluation of the health effect of the disease in the community.
Keywords: Control chart, correlation coefficient, COVID-19, exponential association, morbidity, mortality.

INTRODUCTION

The viral pandemic that has impacted the globe recently due to COVID-19 has affected the whole world at various levels and in different fields[1]. These devastating effects are the consequences of the catastrophic public health influence that hits the communities[2]. Two metrics are extensively and comprehensively used to measure the disease dynamic effect and pattern on the populations[3]. These measures are the reported cases and deaths based on the daily records by the official health organizations worldwide as could be also calculated on the cumulative basis.

In previous work, cumulative data records were analyzed following the Pareto principle showed that the USA is one of the major geographical areas influenced by morbidity and mortality cases with cumulative cases accounting for a fifth of the record and cumulative deaths of about 16.4%[4]. This analysis will make use of the same data source as in later research work[5]. The following investigation would demonstrate a new perspective quantitative examination using morbidities and mortalities as indicators by focusing on the USA case over long-term monitoring for more than two years and showing 0.7322 Spearman correlation (95%) at $p<0.001$ between new daily emerging cases and deaths.

The present case herein provides a unique descriptive statistical analysis for investigation of the daily dynamic pattern of the epidemic using COVID-19 in the USA as a model example with insight into the disease kinetic in the affected population within a finite geographical region. The aim of this work is to provide a useful and simple means for the healthcare practitioner to evaluate and assess the microbial outbreak quantitatively within the affected herd.

CASE STUDY

An analysis-driven Excel database was conducted from "The official portal for European data" at https://data.europa.eu/en. The USA dataset was filtered and extracted with the recorded daily cases and deaths arranged chronologically. Cumulative data and logarithmic transformation of the affected census (to the base ten adding one to compensate for days with zeros i.e., no individuals pertaining to COVID-19 infection were reported) were calculated. The obtained processed observations were subjected to statistical examination using a commercial software package.

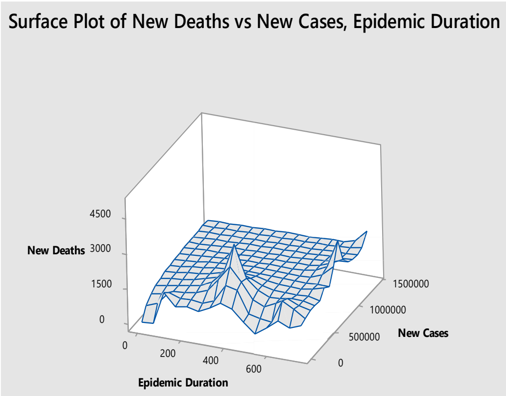

Figure 1: Three-dimensional trend monitoring of the reported sickness cases and deaths attributed to COVID-19 over more than two years.

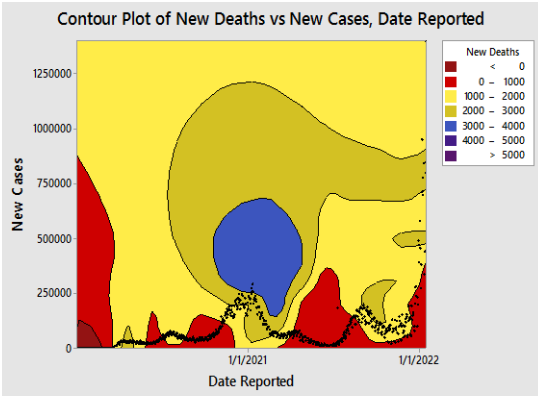

Figure 2: Contour plot for trend monitoring of the reported sickness cases and deaths attributed to COVID-19 over more than two years.

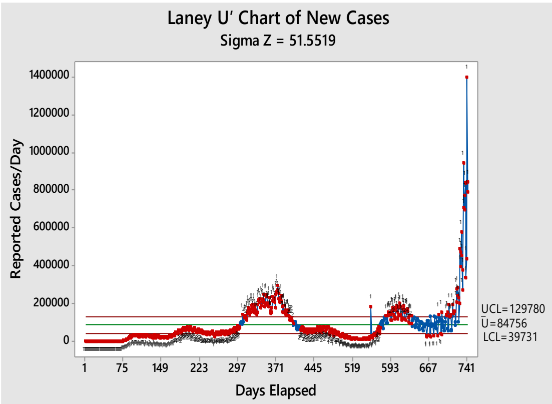

Figure 3: Process-behavior chart of the Laney type showing the pattern of Corona virus disease waves and magnitude in terms of morbidities on daily basis over 743 days. (red marks are indicative of aberrant numbers either high or low)**.**

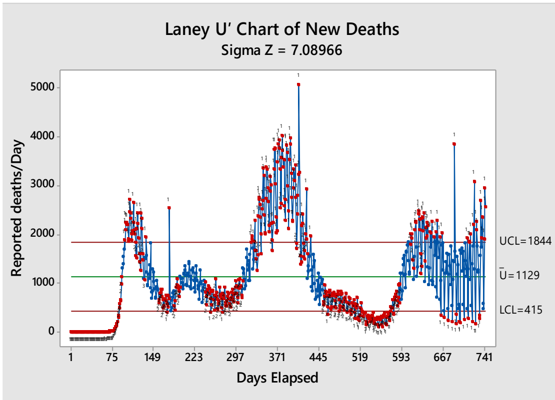

Figure 4: Process-behavior chart of the Laney type showing the pattern of Corona virus disease waves and magnitude in terms of mortalities on daily basis over 743 days (red marks are indicative of aberrant numbers either high or low)**.**

The analysis involved three-dimensional visualization of the association between morbidity and mortality with time. Then, they were separated into trending charts to monitor the behavior of the daily cases and deaths of COVID-19 infection. Data modeling was investigated for the cumulative daily transformed records and the regressions, standard errors and residuals were calculated with a comparison with raw data of one of the outbreak markers, namely cases. The program platform used embraces Microsoft Excel 365, Minitab version 17 and Curve Expert Basic version 2.2.3.

DISCUSSION

Monitoring of daily reported cases and deaths over 743 days between 03 January 2020 and 14 January 2022 is shown as a three-dimensional relationship through two perspectives in Figure 1, in addition to Contour plot (Figure 2) for zones visualization. The surface plot shows the side while the contour plot illustrates the top view showing the visual association between morbidity and mortality, confirming the correlation result. The 3D-chatting was segregated into 2D-trending graphs where Laney attribute charts were selected to provide an advantage to look into pattern and incident behavior[6-8]. There is an insight into six waves of morbidity cases associated with the same number of mortality incidents that follow the first chronologically after 42 days of the lag period (Figure 3 and Figure 4). The process-behavior charts demonstrate observable excursions in count either high or low by red dots which might be due to excessive counts or potential shifting in the trend mean.

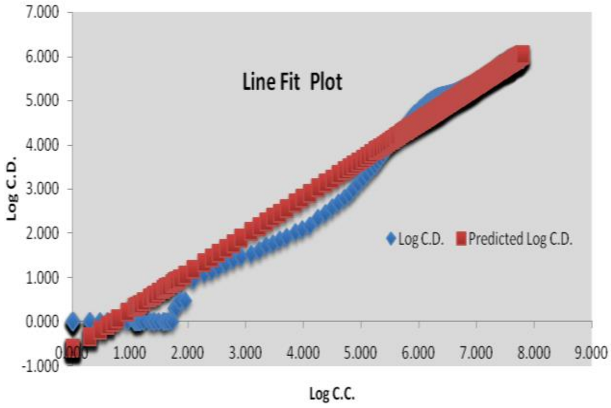

Figure 5: Correlation between reported cumulative daily cases and deaths after logarithmic transformation
(C.C.: Cumulative Cases and C.D: Cumulative Deaths).

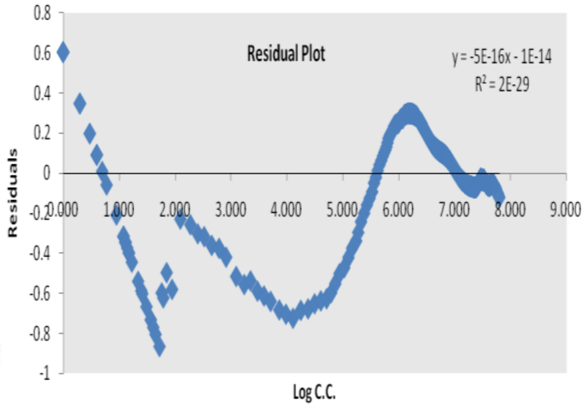

Figure 6: Residual plot for the reported cumulative daily cases and deaths after Logarithmic transformation.

Table 1: Regression analysis between transformed cumulative daily cases and deaths.

Regression Statistics		Statistics	df	SS	MS	F	Significance F
Multiple R	0.9921	Regression	1	1991.267	1991.267	46543.14	0
R Square	0.9843	Residual	741	31.702	0.042783		
Adjusted R Square	0.9843	Total	742	2022.969			
Standard Error	0.2068	Regression equation: $y = 0.8526x - 0.607$					
Observations	743						

Control charts show exploratory Upper Control Limit (UCL), Lower Control Limit and the average($\bar{U}$). The mortality rate – expressed as percentage – from the total emerged cases has a lower limit of 1.04%, center value of 1.33% and upper boundary of 1.42%.

The proposed analysis herein provides an examination of the cumulative cases and deaths after the logarithmic transformation of data plus one (to compensate for zero values without distorting the dataset)[9,10]. The logarithmic transformation has shown previous improvements in reducing the scattering of the record points minimizing outliers and mitigating extreme values[11]. Figure 5 shows the correlation between the recorded cases and deaths of COVID-19 during the investigation period of the outbreak, in addition to the residual plot in Figure 6. There was a linear relationship with good regression and low standard error. The associated Table 1 shows the numerical analysis of the regression statistics. The threshold of the mortality count of zero reported deaths is one for emerging infection cases at the x-axis intercept. Residuals did not show systematic or fixed bias with the increasing number of the affected individuals.

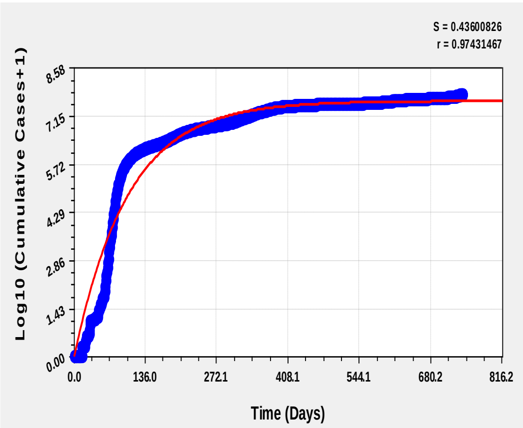

Figure 7: Modeling of daily cumulative morbidity cases of COVID-19 based on the logarithmic transformation showing the standard error of the regression (S) and correlation coefficient (r).

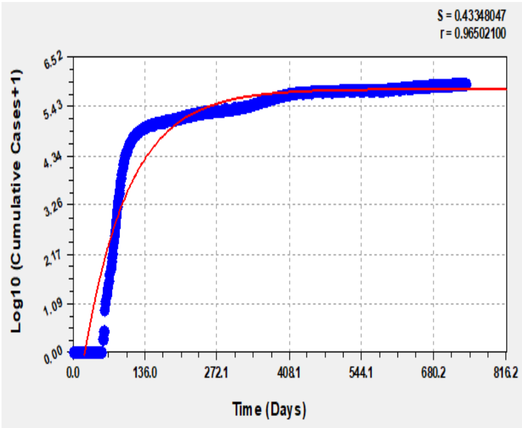

Figure 8: Modeling of daily cumulative mortality cases of COVID-19 based on the logarithmic transformation showing the standard error of the regression (S) and correlation coefficient (r).

Polynomial fitting was excluded from modeling where over fitting might occur due to response to excessive noise that occur normally in natural data that would complicate the outcome with multiple order polynomial that could be more than 10th order[12]. Study the kinetics of morbidity and mortality as daily cumulative numbers of the untransformed data showed Morgan-Mercer-Flodin (MMF) Model: $y=(a*b+c*x^d)/(b+x^d)$ as a best fit with good correlation coefficient of 0.9870977 but high standard error of

2821207.2882689 when using the raw dataset of the reported cases as an example[13,14]. The iteration count of 100 was exceeded. The fit failed to converge to tolerance of 0.000001 (CHI2 at 5881856606338862.000000) and no weighting was used according to report generated by software[15]. However, using the logarithmic transformation demonstrated reasonably low error value without significant decrease in the regression as could be seen in Figure 6 and Figure 8. This transformation was favored in previous instances[16]. The modified results showed fitting to the exponential association: *y=a(1-exp(-bx)* for cases and *y=a(b-exp(-cx))*for deaths[17-19]. The fit converged to a tolerance of 1e-006 in 5 and 7 iterations and no weighting was used for morbidity and mortality, respectively[20]. Figure 9 demonstrates the difference between the residuals between both original (cases are only shown as an example) and the transformed data.

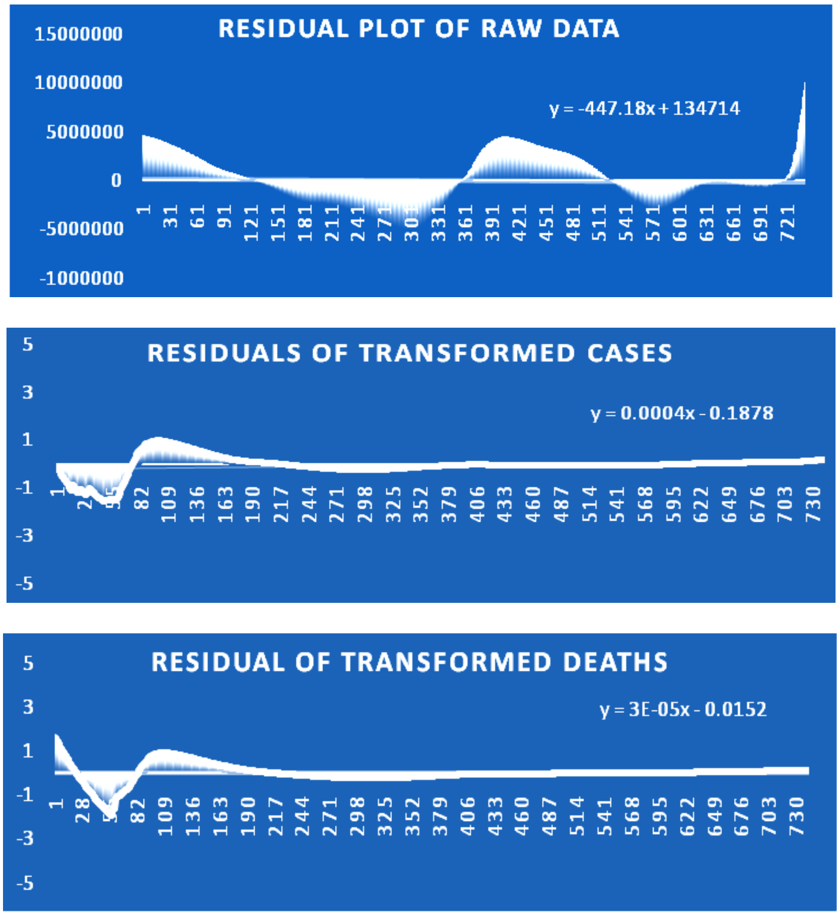

Figure 9: Residual analysis of raw (cases are shown here only as an example) and transformed data demonstration mitigation in the scattering in the values.

CONCLUSIONS

In this letter, a quantitative estimation of the outbreak magnitude and extent could be delivered comprehensively using simple and useful statistical techniques for the sake of public health safety in epidemic times. These fast tools could be used to aid in imposing measures by healthcare professionals, practitioners and officials by understanding the disease pattern and progression. With this regard, it could be concluded that there is a strong association between mortalities and morbidities of the COVID-19 illness, even when it could be observed that the mortality rate is very low, if compared with other catastrophic pandemics over 24.4 months period. Data transformation improved points fitting with low errors and residuals with acceptable regression. Control charts showed signs of multiple overlapping outbreak waves with no signs of recession during the examination period. The exponential association model was the best fit for the cumulative data points of the count of the affected individuals in the morbidity and mortality. It describes the interaction between the population and the virus with elapsed time as a cumulative rate. This model could serve as a quantitative comparison tool for before and after actions to measure enhancement or deterioration, in addition to estimating variations between different geographical regions. From this proposal, this study could be extended to other countries, especially those with high priority in a series of investigational analyses to assess COVID-19 extension and level around the world to be prepared for the worst scenario of the next global pandemic with a risk of more casualties.

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AUTHOR'S CONTRIBUTION

Eissa ME: writing original draft, analysis and interpretation of results. **Rashed ER:** research design, data collection. **Eissa DE:** study conception and design. All authors reviewed the results and approved the final version of the manuscript.

DATA AVAILABILITY

The datasets generated during this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

None to declare.

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