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Research Article
Studies on Morbidities and Mortalities from COVID-19: Novel Public Health Practice During Pandemic Periods

Mostafa Essam Eissa

Pharmaceutical and Healthcare Research Facility, Cairo, Egypt

Abstract
Background and Objective: The current human Coronavirus 2019 pandemic has wreaked havoc on the entire world and affected all facets of human life. The morbidities and mortalities that have been reported on a daily basis represent one of the most thorough records for this pandemic. The current study, conducted as part of a series of evaluations for this pandemic in different parts of the world, concentrated on the investigational practice and the outbreak analysis by the ministry of health professional authorities. **Materials and Methods:** The COVID-19-impacted population data were obtained from the South Sudan database. The data was taken from 03 January, 2020 to 13 January, 2023. This work implemented comprehensively detailed new daily cases and deaths-in time order-as valuable public health metrics. The survey would embrace a combination of analytical tools. **Results:** Data visualization showed that almost half of the reported cases could be observed in the winter while 29.0% of the deaths occurred in the summer periods. The attribute control charts showed the appearance of the epidemic waves with mean values between the control windows. The predominant model that was found describing the outbreak-transformed cumulative indices is Morgan-Mercer-Flodin. **Conclusion:** The simple, fast, time-saving and user-friendly epidemiological analysis implemented herein for Coronavirus Disease 2019 could potentially be used by public health authorities to assess, study and measure outbreaks for the sack of containment of the microbial spreading among the affected populations.

Key words: COVID-19, Morgan-Mercer-Flodin model, morbidity, mortality, trending charts

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Corresponding Author: Mostafa Essam Eissa, Pharmaceutical and Healthcare Research Facility, Cairo, Egypt

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The recent viral pandemic brought on by Coronavirus Disease 2019 (COVID-19) has had an impact on the entire planet on large scale and at various levels and in different fields of life[1]. These terrible repercussions are a result of the communities being severely affected by the public health situation[2]. To quantify the disease's dynamic effect and pattern on the populations, two metrics are widely and thoroughly used[3]. These metrics represent cases and deaths that have been recorded based on daily records by official health organizations around the world and they can also be calculated on a cumulative basis.

The incredible ability of infectious agents to adapt and resist known harsh conditions is a critical challenge in the healthcare industry that must be well understood and studied[4]. In the world of accumulating big data, reported morbidities and mortalities could hide more than just recorded numbers of the impacted census[5]. Three-dimensional visualization tools could be used by professionals in public health to examine the pattern and relationship between emerging cases and deaths over the investigation period[6]. Implementation of the Pareto principle would be useful in resources management and prioritization in the presence of many factors and issues facing public health authorities[6]. Process behavior charts which are well-known statistical tools in the industry could be applied usefully in non-industrial sectors to observe the change of specific inspection properties with elapsed time[7]. Finally, mathematical modeling is a critical quantitative tool to be used for investigating the progression of the pandemics through equations that describe the dwelling of the disease within communities[8]. Application of methodologies and techniques like those described are required to be understood from the perspective of public health.

The present study aimed to provide important and practical tools and techniques that would be crucially implemented by official regulatory bodies in the Ministry of the Health of the Community to study, investigate and monitor the behavior and pattern of the epidemics for the sake of risk mitigation and public health safety and security in the outbreak times.

MATERIALS AND METHODS

The current study focused on the investigative practice and outbreak analysis of Severe Acute Respiratory Syndrome Coronavirus 2 by the Ministry of Health professional authorities as part of a series of evaluations for this pandemic in various regions of the world.

Study area: The COVID-19-impacted population data were obtained from the South Sudan database for the daily cases and deaths. The study covered a total number of days of 1107 from the start date 03 January, 2020 till 13 January, 2023 of the observation and monitoring period. This is equivalent to 3 years and 11 days or 36 months and 11 days of continuous daily record.

Public database source: The Human Coronavirus 2019 records were obtained and processed from Humanitarian Data Exchange[9]. The dedicated country's dataset was processed using the Excel functions (Microsoft Office Professional Plus 2010 Version 14.0.726.5000).

Analysis type and metrics: This work used the newly detailed daily cases and fatalities-in chronological sequence-as significant public health measurements[10]. The South Sudan dataset was extracted for the filtered Excel database[11]. The survey would include preliminary 3-D visualization coupled with Pareto analysis, time-series plots employing trending charts and model-fit screening to assess the dynamicity of cumulative morbidities and mortalities, as well as the chronological link between both indices[12].

Software and application: The research was carried out on a commercially available, user-friendly and cost-effective software platform[10-12]. Microsoft office excel-generated database was processed chronologically to yield a daily transformed census of cumulative cases and deaths to be further analyzed using Minitab version 17.1.0 and CurveExpert version 1.40 to produce Contour, 3-D scatter plot associated with Pareto charting and process-behavior charts by the first program and the rational best curve-fitting by the second one.

Statistical analysis: The raw data obtained, including morbidity and mortality populations and their counts, was organized by time, date and season. The proportion of each group was calculated and the total cumulative percent was computed. This would yield a Pareto analysis. Drawing of the trending charts was conducted according to the software manual using Laney modification to correct for data dispersion. Modeling was done using the best curve fitting approach with prioritization selection based on best regression, least error and better residuals, especially after logarithmic conversion to the base ten. One was added to the affected population census before transformation to correct for the presence of zeros without severely distorting the originally recorded report.

RESULTS

The outbreak showed the 3D pattern in Fig. 1. The appearance demonstrated higher density in the middle of the investigation period, with a relatively lower census of morbidities and mortalities at the beginning of the investigation period and expressing the lowest magnitude at the end. A detailed examination was performed using the Pareto principle of 80% major contribution could be visualized in Fig. 2 and 3. From these figures, simplified Table 1 that has been created to demonstrate a focus group that details the most important times of the epidemic for morbidity and mortality counts in terms of seasons, years and months.

Exploratory process-behavior charts were used to track and show the pattern of the disease progression (Fig. 4). Time-series of the census illustrated several successive waves of the outbreak that appeared as peaks and clusters made of groups from adjacent sporadic aberrant counts. The death chart is correlated with the reported cases graph except for the last wave in morbidity which was not accompanied by the corresponding peak in the mortality graph.

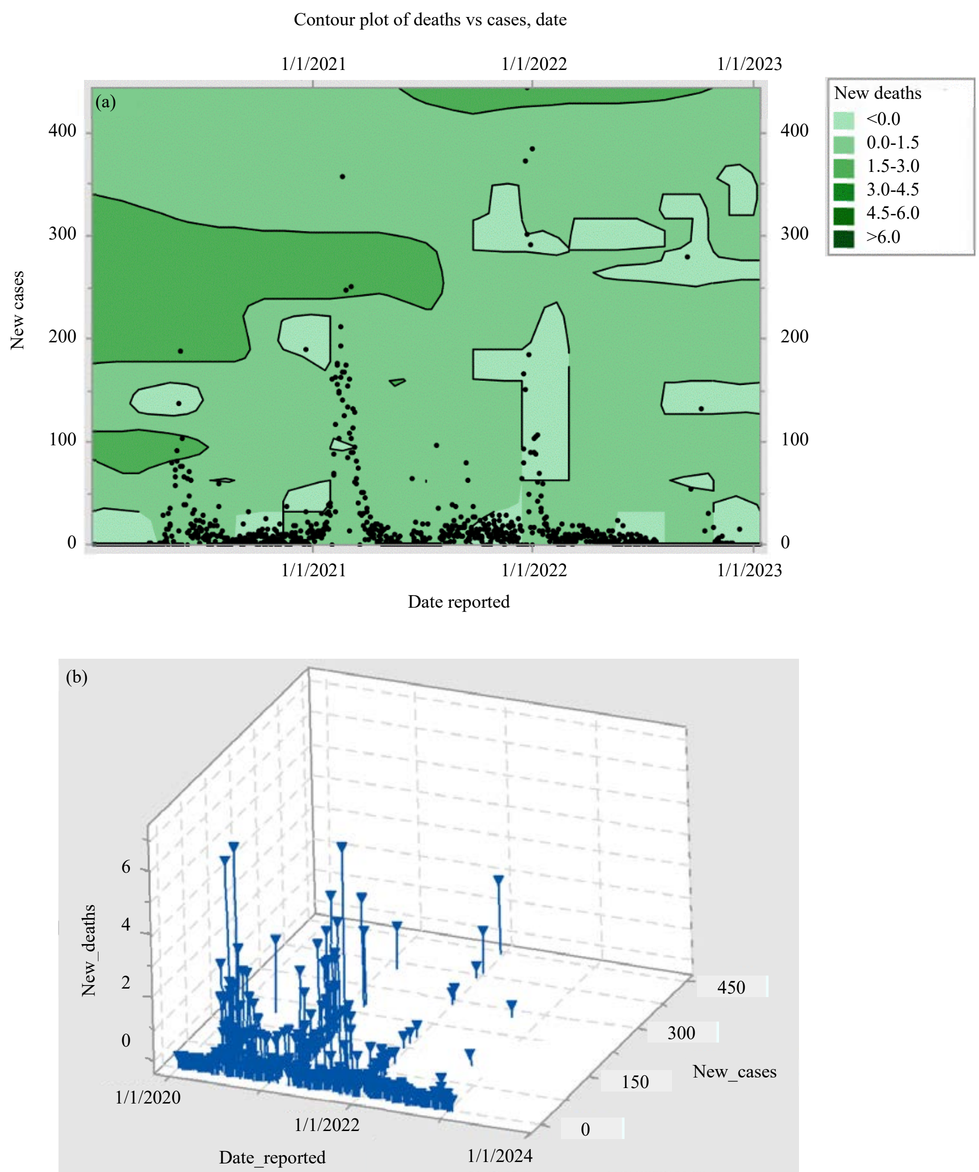
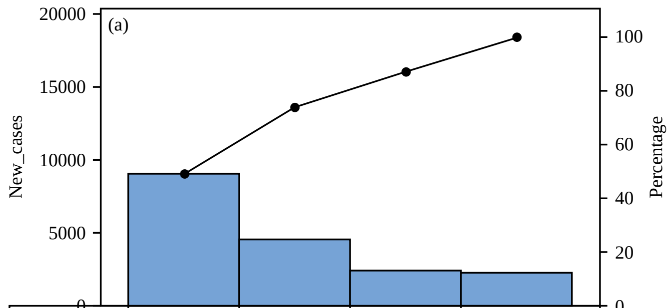
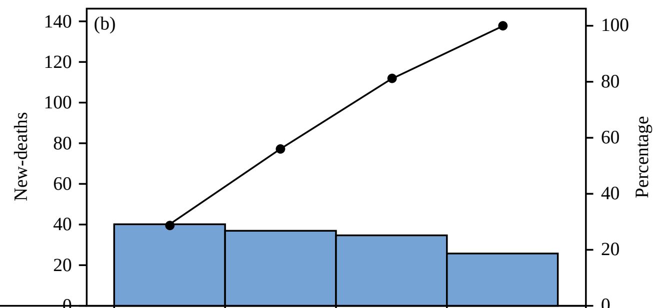


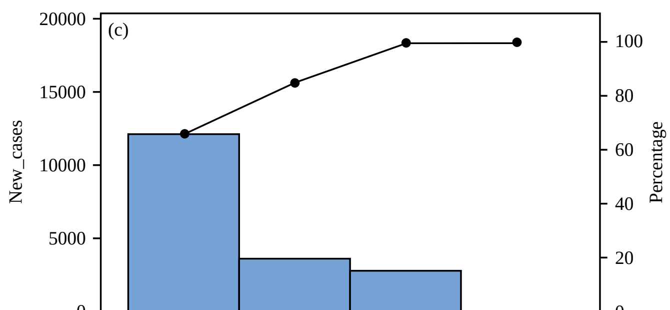
Fig. 1(a-b): 3D visualization of the daily reported cases and fatalities from COVID-19 in South Sudan using (a) Contour plot and (b) 3D scatter plot (generated using Minitab version 17.1.0)



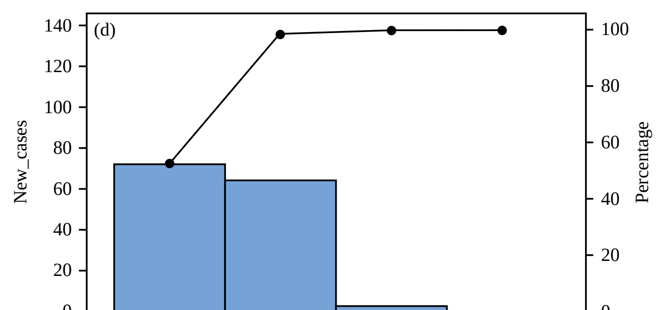
Season	Winter	Spring	Autumn	Summer
New_cases	9059	4542	2476	2291
Percentage	49.3	24.7	13.5	12.5
Cum (%)	49.3	74.0	87.5	100.0



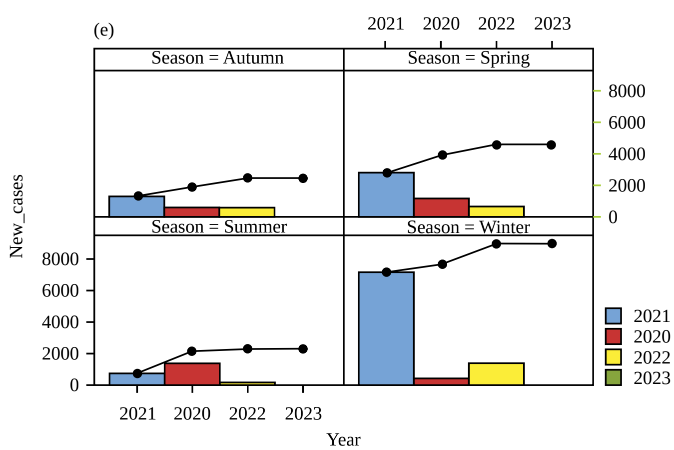
Season	Summer	Spring	Winter	Autumn
New_deaths	40.0	37.0	35.0	26.0
Percentage	29.0	26.8	25.4	18.8
Cum (%)	29.0	26.8	81.2	100.0



Year	2021	2020	2022	2023
New-cases	12086	3540	2742	0
Percentage	65.8	19.3	14.9	0.0
Cum (%)	65.8	85.1	100.0	100.0



Year	2021	2020	2022	2023
New-cases	72.0	64.0	2.0	0
Percentage	52.2	46.4	1.4	0.0
Cum (%)	52.2	98.6	100.0	100.0



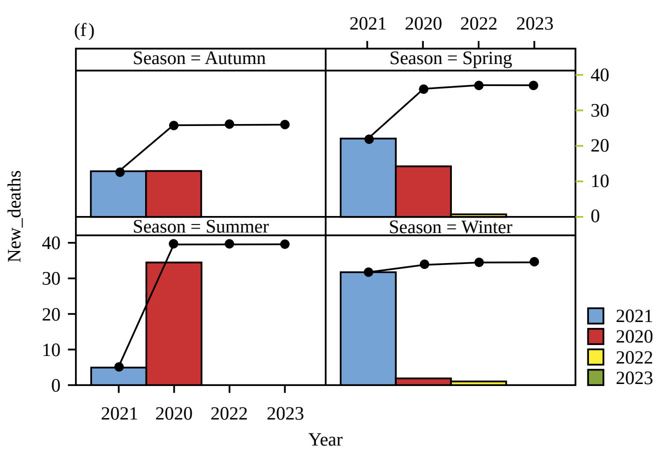


Fig. 2(a-h): Continue

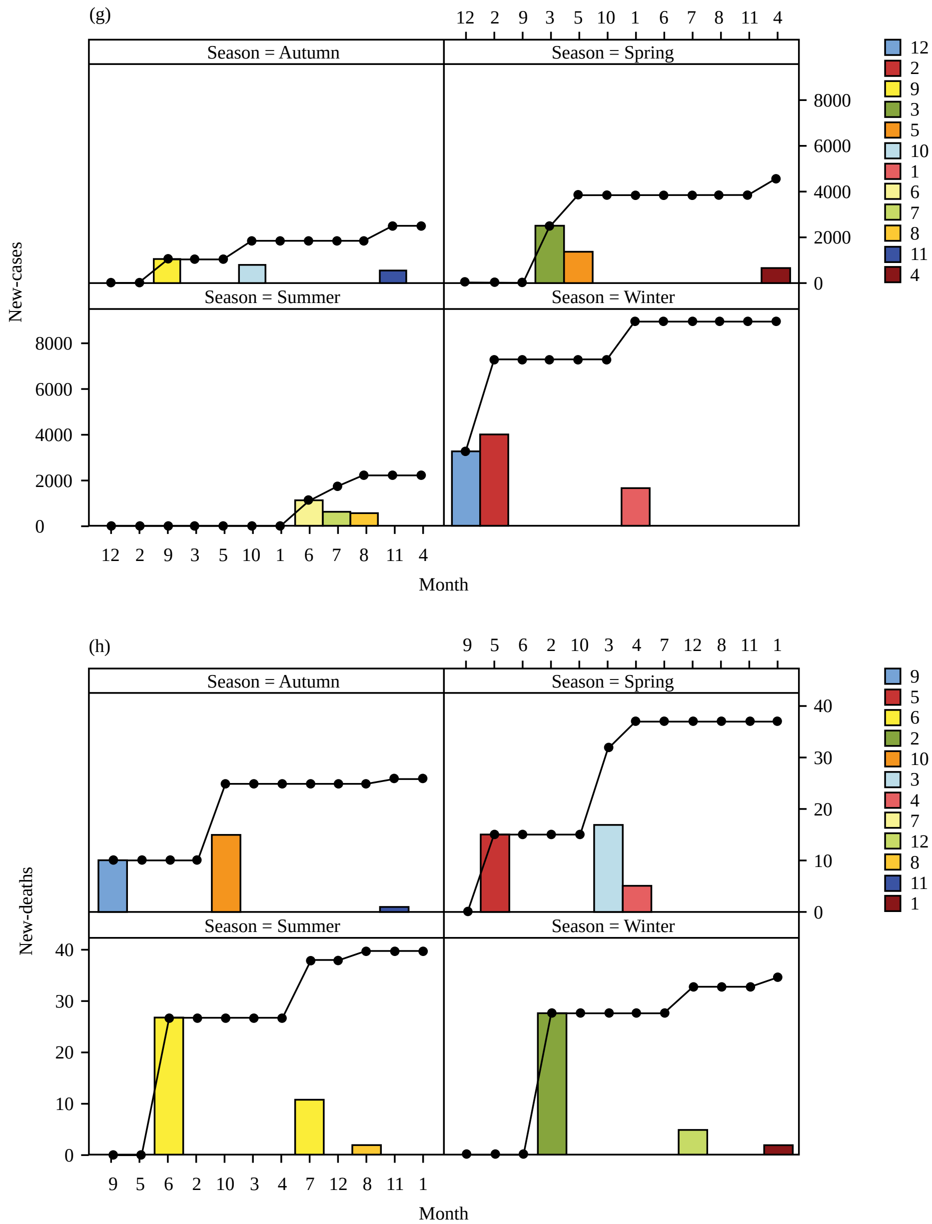


Fig. 2(a-h): Pareto diagrams showing the main contributing periods in cases and deaths of COVID-19 in terms of seasons, years and months, (a) Cases by seasons, (b) Deaths by seasons, (c) Cases by years, (d) Deaths by years, (e) Cases of years by seasons, (f) Deaths of years by seasons, (g) Cases of months by seasons and (h) Deaths of months by seasons (generated using Minitab version 17.1.0)

The kinetics of the cumulative daily cases and deaths-in the transformed form-showed a significant pattern of the Morgan-mercer-flodin (MMF) model after screening for the best non-linear regression of the best curve fitting. Also, the MMF model showed an acceptable fit when used to describe the relationship between the two parameters of the epidemic. Figure 5 illustrated this curve fitting behavior and Table 2 showed the parameters of MMF equation:

$$y = \frac{a \times b + c \times x^{d}}{b + x^{d}}$$

where, a, b, c and d are coefficient data, x is the time in days and x is the census of cases or deaths.

Table 1: Pareto concept implementation showing major contribution periods in the outbreak count of the reported cases and deaths during time-bound investigation

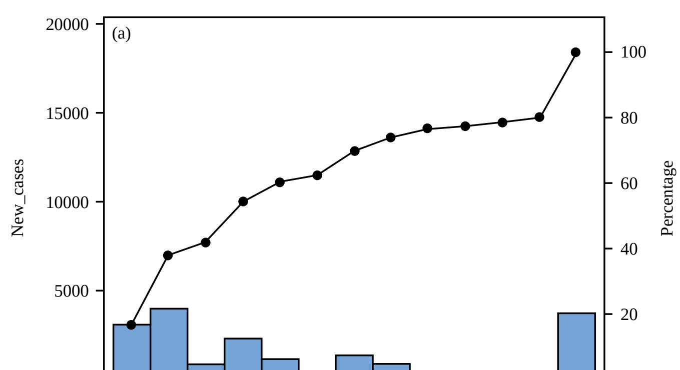
Year contribution order by season for cases**		Year contribution order by season for deaths**	
Autumn	2021>2020≈2022	Autumn	2021≈2020>2022
Spring	2021>2020>2022	Spring	2021>2020>2022
Summer	2020>2021>2022	Summer	2020>2021>2022
Winter	2021>2020>2022	Winter	2021>2020>2022
**Cases (month/year) (season)	*Contribution from total (%)	**Deaths (month/year) (season)	*Contribution from total (%)
Feb-21 (Winter)	21	Jun-20 (Summer)	18
Dec-21 (Winter)	15	Feb-21 (Winter)	15
Mar-21 (spring)	12	May-20 (Spring)	10
May-20 (spring)	6	Oct-20 (Autumn)	7
Jan-22 (Winter)	6	Mar-21 (Spring)	7
		Jul-20 (Summer)	7
**Cases (month) (season)	*Contribution from total (%)	**Deaths (month) (season)	*Contribution from total (%)
Feb (Winter)	21	Jun (Summer)	18
Dec (Winter)	17	Feb (Winter)	15
Mar (spring)	12	May (Summer)	10
Jan (Winter)	7	Oct (Autumn)	10
May (spring)	6	Sep (Autumn)	7
		Mar (spring)	7
**Cases (season)	*Contribution from total (%)	**Deaths (season)	*Contribution from total (%)
Winter	49.3	Summer	29.0
Spring	24.7	Spring	26.8
		Winter	25.4
**Cases (year)	*Contribution from total (%)	**Deaths (year)	*Contribution from total (%)
2021	65.8	2021	52.2
		2020	46.4

*Refer to the sum contribution of ≥60% from the total 100% of the calculated parameter and **Pareto results extracted from Minitab version 17.1.0

Table 2: MMF model parameters for the transformed cumulative morbidity and mortality from COVID-19

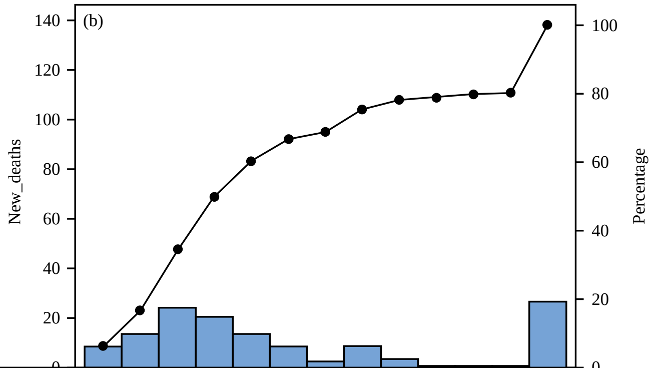
Curve fitting[£]	C.C.[∂] vs. C.D.	C.C. vs. time	C.D.[¥] vs. time
Coefficient data			
A	-2.60119987236E-002	-6.55197765393E-001	5.77425386857E-002
B	1.43969173506E+003	1.43483485078E+001	3.82074974014E+000
C	2.31774974777E+000	4.57031682536E+000	2.73876159203E+000
D	6.76725203770E+000	7.87666924247E-001	3.92742151420E-001
Standard Error	0.0418816	0.1506189	0.0500987
Correlation Coefficient	0.9956382	0.9734399	0.9778271

[∂]C.C.: Cumulative Cases [¥] C.D.: Cumulative Deaths and [£] CurveExpert version 1.40

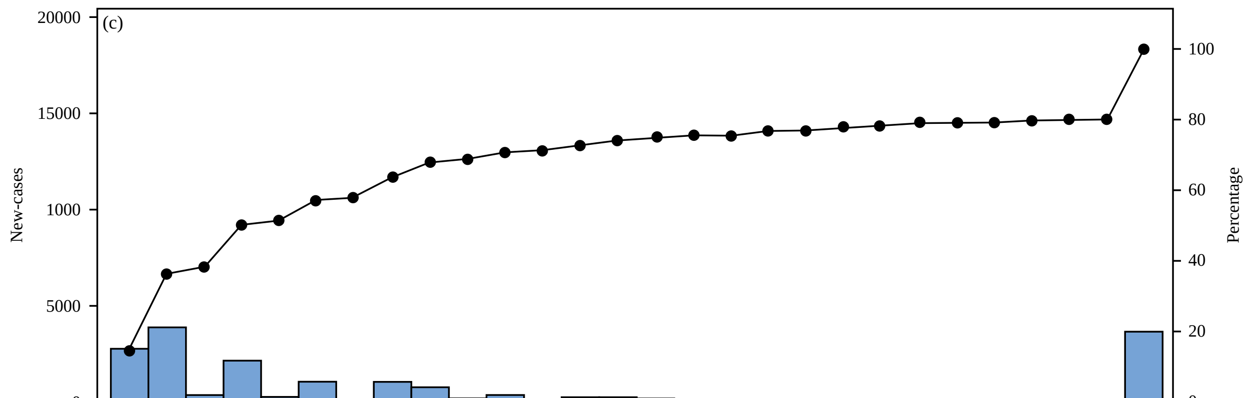


Month	12	2	9	3	5	10	1	6	7	8	11	4	Other
New_cases	3046	3920	778	2267	1089	368	1329	845	399	210	216	241	3660
Percentage	17	21	4	12	6	2	7	5	2	1	1	1	20
Cum (%)	17	38	42	55	60	62	70	74	76	78	79	80	100

Fig. 3(a-d): Continue

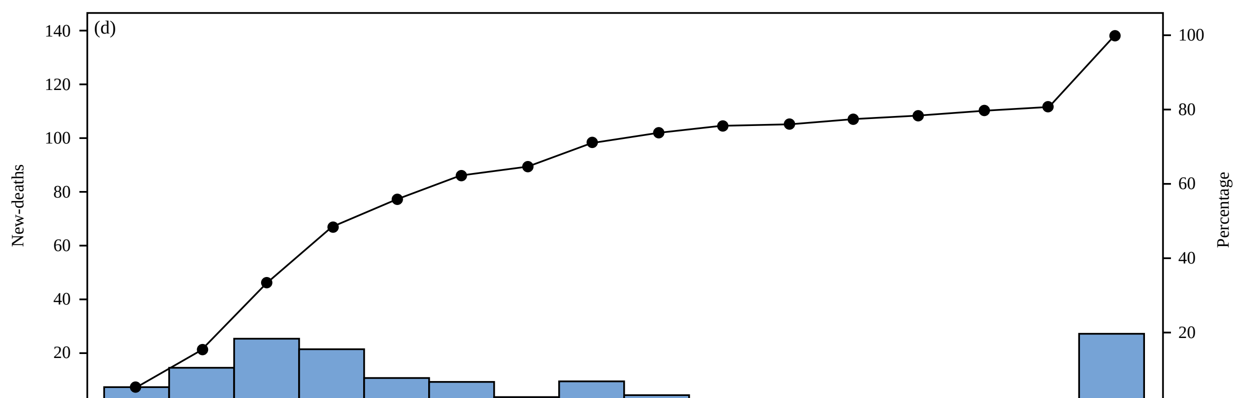


Month	9	5	6	2	10	3	4	7	12	8	11	4	Other
New_cases	9	14	25	21	14	9	3	9	4	1	1	1	27
Percentage	7	10	18	15	10	7	2	7	3	1	1	1	20
Cum (%)	7	17	35	50	60	67	69	75	78	79	80	80	100



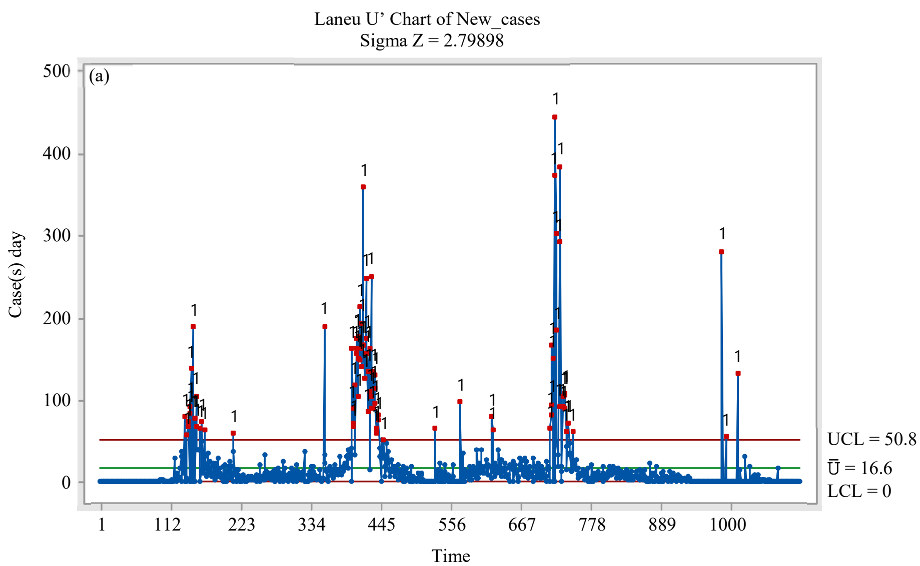
Month/year	Dec-21	Feb-21	Sep-22	Mar-21	Dec-20	May-20	Oct-22	Jan-22	Jun-20	Jul-21	Sep-21	Jun-21	Jul-20	Jan-21
New-cases	2767	3900	335	2194	279	1031	163	1044	758	172	389	87	227	285
Percentage	15	21	2	12	2	6	1	6	4	1	2	0	1	2
Cum (%)	15	36	38	50	52	57	58	64	68	69	71	71	73	74

Month/year	Aug-21	Aug-20	Nov-20	Apr-21	Sep-20	Nov-21	Apr-20	Oct-21	Oct-20	May-22	Feb-22	Mar-22	May-21	Other
New-cases	173	37	57	213	54	159	28	180	25	41	20	73	17	3660
Percentage	1	0	0	1	0	0	0	0	0	0	0	0	0	20
Cum (%)	75	75	76	77	77	78	78	79	79	79	80	80	80	100



Month/year	Sep-21	May-20	Jun-20	Feb-21	Oct-20	Mar-21	Apr-21	Jul-20	Oct-21	Dec-21	Aug-20	Sep-20	Nov-20	Dec-20	Jan-21	Other
New-deaths	7	14	25	21	10	9	3	9	4	2	1	2	1	2	1	27
Percentage	5	10	18	15	7	7	2	7	3	1	1	1	1	1	1	20
Cum (%)	5	15	33	49	56	62	64	71	74	75	76	78	78	80	80	100

Fig. 3(a-d): Overall Pareto plots showing main contributing months and months/years in COVID-19 metrics, (a) Cases by months, (b) Deaths by months, (c) Cases by month per year and (d) Deaths by month per year (generated using Minitab version 17.1.0)



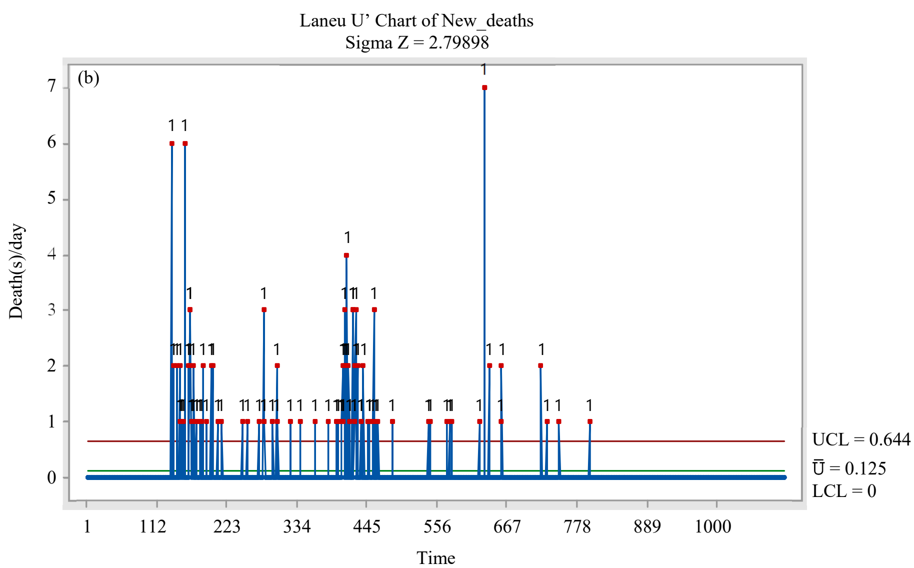


Fig. 4(a-b): Exploratory attribute trending chart showing the pattern and excursions in the daily census of the reported illness and fatalities in South Sudan, (a) Process behavior chart of new cases and (b) Process behavior chart of new deaths (generated using Minitab version 17.1.0)

DISCUSSION

The present study of South Sudan is characterized by a diminishing number of reported death numbers that were attributed to COVID-19. Like other countries, the widely disseminated viral outbreak was accompanied by very low fatality rates[13]. The average rate of mortality from the mean affected population by COVID-19 is very low (0.75%) and the upper bound value is 1.27%. The worst year in the epidemic was 2021 followed by 2020 and 2022 with the worst season in morbidity being the winter while the worst season for mortality was the summer. An exception was found in the summer of 2020 which witnessed the worst level of the seasonal outbreak.

Logarithmic transformation of the datasets was found to be useful in decreasing data spreading and hence, the noise and error factors. Thus, the error factor in the record would be reduced significantly[14]. This was found to be useful in the result interpretation and modeling. Time-series plots could reveal the start time of the outbreak and the presence of low, medium and high-magnitude waves of the mass illness which could be found reasonably correlated for both outbreak indices (i.e., cases and deaths).

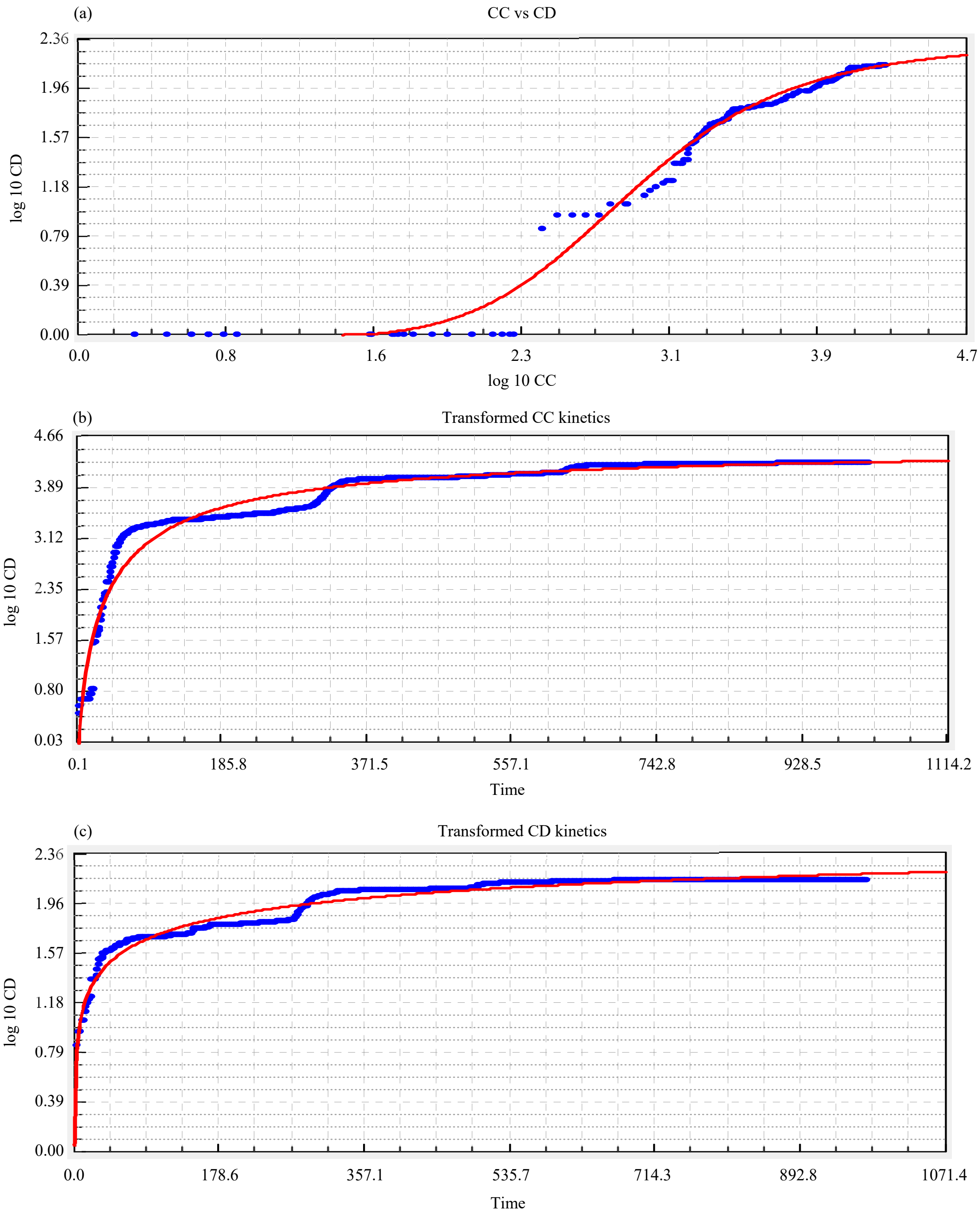


Fig. 5(a-c): Modeling of COVID-19 logarithmically transformed, (a) Cumulative cases (CC) and (b) Cumulative deaths (CD) and (c) Kinetics with elapsed time and against each other(CurveExpert version 1.40)

Best curve fitting showed that the MMF equation was the preferred fit for the transformed disease indices with high regression and low standard error. The MMF model description of the morbidity vs mortality relationship showed that at the initial stage, death is lagging the detected illness[11]. The second stage demonstrates a fast rise in both parameters after inflection point[15,16]. The last stage represents the flattening phase where deaths begin to cease to increase with new cases[17,18]. A similar pattern could be observed when observing the dynamic nature of both morbidity and mortality rates with time as a balanced saturation level could be found after reaching the community capacity based on its pre-existing conditions and actions put in place.

The novel perspective for examination and analysis of the pandemics in the present study is helpful for monitoring and tracking the progression and pattern of the outbreak by the workers in the health governmental authorities. Expanding the perception and knowledge about epidemic containment and resource management for the employees in the ministries of health is inevitable through the support of these complementary methodologies. A future enhancement-through further investigation-would be required to overcome the challenge of the presence of autocorrelation during the modeling of the cumulative counts of the morbidities and mortalities over time.

CONCLUSION

The present work provided novel and useful epidemiological analysis and descriptive study that could be implemented by public health professionals and the Ministry of Health authorities to study, analyze, control and predict the behavior of the outbreaks. This study helps to understand and set measures to contain the microbial disease by tracking and predicting the behavior and the pattern of the outbreak spreading. Further examination would be needed to overcome the challenges that might be confronted due to issues raised due to the potential autocorrelation of the residuals in the proposed model.

SIGNIFICANCE STATEMENT

Despite the limitation that could be encountered by modeling the time-series data, the present investigation provided a useful perspective analysis for health professionals and public health authorities for the study of the pandemics and quantitative evaluation of the disease magnitude and measurable metrics for the health risk to the affected herd within the community.

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