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The current COVID-19 pandemic in China: An overview and corona data analysis

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KEYWORDS

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Symptoms;
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Abstract At the end of December 2019, the Wuhan Municipal Health Commission, revealed several cases of pneumonia of unknown etiology. Later, this etiology was called the coronavirus disease 2019 (COVID-19). COVID-19 disease is rapidly spreading around the globe, affected millions of people, compelling governments to take serious actions. Due to this deadly disease, a number of deaths have been occurred and still increasing exponentially. In the practice and application of big data sciences, it is always of interest to provide the best description of the data. In this present article, the event background, symptoms, and preventions from COVID-19 are discussed. The steps were taken by the Chinese government to control the COVID-19 has also been discussed. Up to date, details, and data of daily discovered cases, total discovered cases, daily deaths, and total deaths around the world are presented. Moreover, a new statistical distribution is introduced to provide the best characterization of the survival times of the patients affected by the COVID-19 in China. By analyzing the survival times of the COVID-19 patient's data, it is showed that the new model provides a closer fit to COVID-19 events.

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1. Introduction

The first COVID-19 event was spotted in Wuhan in China, a popular seafood market, where many people coming to buy or sell seafood. On December 31, 2019, the WMHC (Wuhan Municipal Health Commission) reported a total of twenty-seven cases of COVID-19 pneumonia.

The city was closed on January 1, 2020. According to WMHC, samples from a group of people were found to have the novel coronavirus. Cases show symptoms such as a fever, dry cough, headache; radiation exposure displayed the penetration of both lungs; see [1–5].

On January 9, 2020, the CCDCP (Chinese Center for Disease Control and Prevention) reported the discovery of a novel coronavirus. On January 10, 2020, the first sequence of the COVID-19 was made public. Later, on January 11, 2020, the WHO (World Health Organization) named it as severe acute respiratory syndrome coronavirus 2 SARS-CoV-2, a virus that causes COVID-19, for brief details, see [6–9].

On January 20, 2020, more cases were reported from three different countries (Thailand, Japan and South Korea) outside China. All these cases were spread from China. On January 23, 2020, the city of Wuhan was closed (i) prohibited the entry and exit from Wuhan city, and (ii) restricted public moments within the city; see [10,11].

The comparison of the current COVID-19 epidemic between different countries is worth of studies and is of great concern. In this regard, researchers are devoting all of their efforts to make comparison between different countries, and still increasing. For example, modeling of the COVID-19 events in Lebanon is provided in [12]. A case study form Spain has been studied in [13]. Mathematical analysis of the COVID-19 in Mexico is provided in [14]. A case study form Brazil is discussed in [15]. The COVID-19 epidemic situation in Pakistan is studied in [16]. A mathematical model for COVID-19 transmission dynamics in India is provided by [17]. Comparison of COVID-19 events in Asian countries has been carried out in [18]. The comparison between Iran and mainland China has been appeared in [19]. The comparison between Iran and Pakistan is done by [20]. A case of the COVID-19 pandemic in Indonesia has been discussed in [21].

2. What China Did to Control COVID-19

The Chinese government showed serious attention to control the COVID-19. In this regard, the Chinese government was very cautious in the execution of the following course of action.

- They restricted the movement of around 20 million peoples in the vicinity.
- They imposed masks for all (on the threat of arrest).
- Within 10 days, 1200 beds with individual nurses were arranged.
- All the incoming and outgoing international flights were ceased.
- An electronic surveillance machine was assigned to the people associated with health and treatment.

The course of action of China was not only restricted to these steps but many more at various levels during this deadly pandemic dynamic. Due to the implementation of these steps, the report showed about 2331 cases shrank down to 437 cases within a duration of 2 weeks [22].

Table 1 The percentage of the symptoms of the COVID-19.

Symptoms	%	Symptom	%
Sore throat	13.9	Sputum production	33.4
Dry cough	67.7	Muscle pain	14.8
Fever	87.9	Nausea	5.0
Shortness of breath	18.6	Nasal congestion	4.8
Headache	13.6	Haemoptysis	0.9
Fatigue	38.1	Conjunctival congestion	0.8

3. Symptoms of COVID-19

The coronavirus is very similar to the common flu as they are very much similar. The infected person by the COVID-19 starts showing the symptoms from 2–14 days. The symptoms are as follows: sore throat, dry cough, fever, shortness of breath, headache, fatigue, sputum production, muscle or joint pain, nausea or vomiting, nasal congestion, hemoptysis, and conjunctival congestion; see [23]. The percentage of the symptoms are given in Table 1, and displayed graphically in Fig. 1.

4. COVID-19 Cases Toll

So far, on March 30, 2020, 12:00 GMT (Greenwich Mean Time), there are 784794 confirmed cases around the globe. The COVID-19 daily and total confirmed cases are displayed graphically in Figs. 2 and 3, respectively. The latest updates about the daily and total confirmed cases of the current pandemic dynamic around the globe can be found at: https://www.worldometers.info/coronavirus/coronavirus-cases.

5 COVID-19 Deaths Toll

Up to date, 37788 people have died from the outbreak of COVID-19 from March 30, 2020, 12:00 GMT. Daily and total

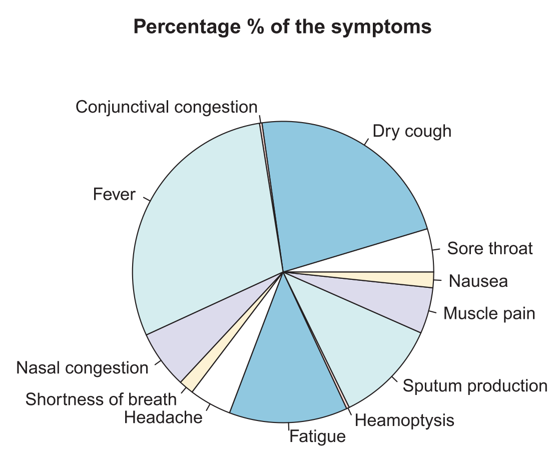

Fig. 1 Graphical display for the percentage of the symptoms of the COVID-19 data.

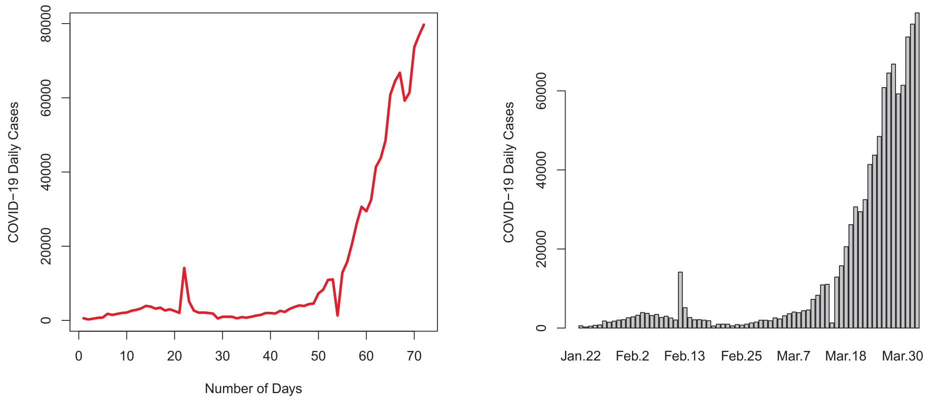

Fig. 2 The COVID-19 daily confirmed cases.

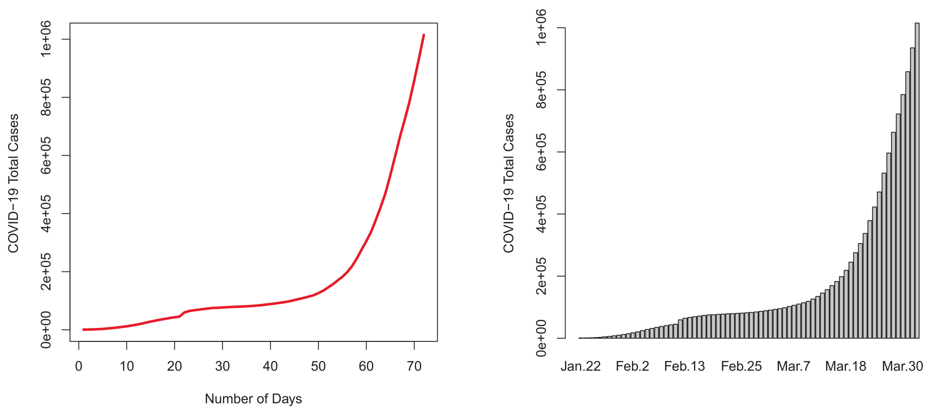

Fig. 3 The COVID-19 total confirmed cases.

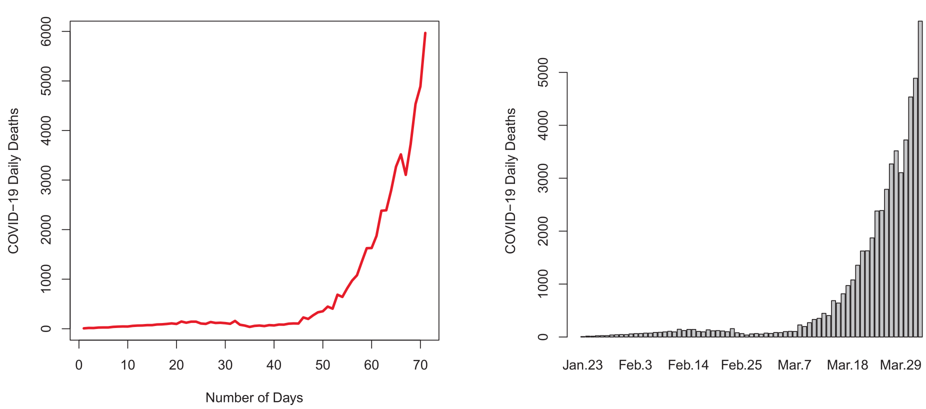

Fig. 4 The COVID-19 daily deaths.

COVID-19 deaths are graphically presented in Figs. 4 and 5, respectively.

The latest updates about the COVID-19 pandemic dynamic daily and total deaths can be found at https://www.worldometers.info/coronavirus/coronavirus-death-toll. The percent changes in daily deaths and daily deaths growth factor are presented in Fig. 6.

5. Countries Got COVID-19

So far, in around 199 countries and territories, a total of 784794 cases have been confirmed due to COVID-19. Out of the confirmed cases, a death toll reached 37788. The information about country-wise confirmed cases and deaths are provided in Tables 2–6.

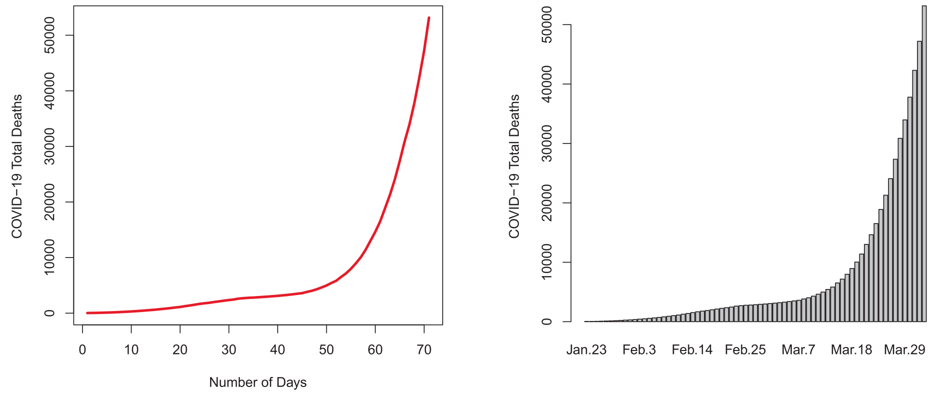

Fig. 5 The COVID-19 total deaths.

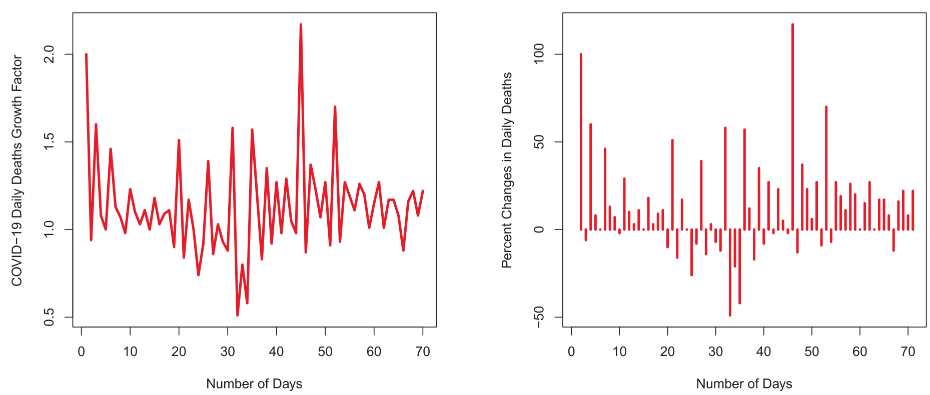

Fig. 6 COVID-19's plots of the daily deaths of (i) percent changes, and (ii) growth factor.

6. Development of the Proposed Family

In this section, we study a new family of statistical models to provide the best fit to COVID-19 events. Alzaatreh et al. [24] proposed the T-X family approach to introducing new distribution families.

Let $p(t)$ be the pdf (probability density function) of a random variable, say T, where $T \in [u_1, u_2]$, $-\infty \leqslant u_1 < u_1 < \infty$, and let $U[F(x)]$ be a function of a cdf (cumulative distribution function) $F(x)$ of a random variable X, satisfying some certain conditions. The cdf and pdf of the T-Xfamily of distributions are given by

$$G(x) = \int_{u_2}^{U[F(x)]} p(t)dt, \qquad x \in \mathbb{R}, \tag{1}$$

and

$$g(x) = \left\{\frac{\partial}{\partial x} U[F(x)]\right\} p\{U[F(x)]\}, \qquad x \in \mathbb{R},$$

respectively.

For the published work based on the concept of the T-X method; see Ahmad et al. [25]. Using the T-X method, one can introduce new statistical distributions of the survival family using the expression given by

$$G(x) = 1 - \int_{u_2}^{W[1-F(x)]} p(x)dt, \qquad x \in \mathbb{R}. \tag{2}$$

Inspired by Eq. (1), we propose a new flexible class of statistical models suitable for modeling data related to COVID-19 deaths. Henceforth, the proposed method may called the alpha power transformed extended-X (APTEx-X) family.

Suppose that the T has the exponential distribution, i.e.,$T \sim \exp(1)$, then its distribution function is given by

$$P(t) = 1 - e^{-t}, \qquad t \geqslant 0, \tag{3}$$

with pdf

$$p(t) = e^{-t}, \qquad t > 0\,. \tag{4}$$

If $p(t)$ follows Eq. (4) and using $U[F(x)] = -\log\left(\frac{\alpha^{\left(1-\frac{1-F(x)}{e^{F(x)}}\right)}-1}{\alpha-1}\right)$ in Eq. (1), we get cdf of the APTEx-Xfamily. A random variable Xhas the APTEx-Xfamily, if its cdf is

$$G(x) = \frac{\alpha^{\left(1-\frac{1-F(x)}{e^{F(x)}}\right)} - 1}{\alpha - 1}, \qquad \alpha > 0,\ \alpha \neq 1,\ x \in \mathbb{R}, \tag{5}$$

with pdf

$$g(x) = \frac{(\log\alpha) f(x)[2 - F(x)]}{(\alpha - 1)e^{F(x)}} \alpha^{\left(1-\frac{1-F(x)}{e^{F(x)}}\right)}, \qquad x \in \mathbb{R}. \tag{6}$$

In the next section, we present a sub-model of the APTEx-X family, called the APTEx-Weibull distribution.

Table 2 Countries-wise and region-wise details of the confirmed case and the death of COVID-19.

Country	Cases	Deaths	Region
Afghanistan	273	6	Asia
Albania	277	16	Europe
Algeria	986	86	Africa
Andorra	428	15	Europe
Angola	8	2	Africa
Anguilla	3	0	North America
Antigua and Barbuda	9	0	North America
Argentina	1265	37	South America
Armenia	663	7	Asia
Aruba	60	0	North America
Australia	5314	28	Australia/Oceania
Austria	11129	158	Europe
Azerbaijan	400	5	Asia
Bahamas	24	1	North America
Bahrain	643	4	Asia
Bangladesh	56	6	Asia
Barbados	46	0	North America
Belarus	304	4	Europe
Belgium	15348	1011	Europe
Belize	3	0	North America
Benin	13	0	Africa
Bermuda	35	0	North America
Bhutan	5	0	Asia
Bolivia	132	9	South America
Bosnia and Herzegovina	533	16	Europe
Botswana	4	1	Africa
Brazil	8066	327	South America
British Virgin Islands	3	0	North America
Brunei	133	1	Asia
Bulgaria	457	10	Europe
Burkina Faso	288	16	Africa
Burundi	3	0	Africa
Cabo Verde	6	1	Africa
Cambodia	114	0	Asia
Cameroon	306	7	Africa
Canada	11283	173	North America
Cayman Islands	28	1	North America
Central African Republic	8	0	Africa
Chad	8	0	Africa

Table 3 Countries-wise and region-wise details of the confirmed case and the death of COVID-19.

Country	Cases	Deaths	Region
Channel Islands	193	3	North America
Chile	3404	8	Europe
China	81620	3322	Asia
Colombia	1161	19	South America
Congo	22	2	Africa
Costa Rica	396	2	North America
Croatia	1011	7	Europe
Cuba	233	6	North America
Curaçao	11	1	North America
Cyprus	356	10	Asia
Czech Republic	3858	44	Europe
Côte d'Ivoire	194	1	Africa
Denmark	3386	123	Europe
Djibouti	40	0	Africa
Dominica	12	0	North America
Dominican Republic	1380	60	North America
DR Congo	134	13	Africa
Ecuador	3163	120	South America
Egypt	865	58	Africa
El Salvador	46	2	North America
Equatorial Guinea	15	0	Africa
Eritrea	22	0	Africa
Estonia	858	11	Europe
Eswatini	9	0	Africa
Ethiopia	29	0	Africa
Faeroe Islands	177	0	Europe
Fiji	7	0	Australia/Oceania
Finland	1518	19	Europe
France	59105	5387	Europe
French Guiana	51	0	South America
French Polynesia	37	0	Australia/Oceania
Gabon	21	1	Europe
Gambia	14	1	Australia/Oceania
Georgia	134	0	Europe
Germany	84794	1107	Europe
Ghana	204	5	South America
Gibraltar	288	0	Australia/Oceania
Greece	1544	53	Australia/Oceania
Greenland	10	0	Europe

7. Special Sub-Model

Let X follow the two-parameter Weibull distribution with cdf represented by $F(x)$ and given by $F(x) = 1 - e^{-\gamma x^{\theta}}$, $x \geqslant 0,\ \theta, \gamma > 0$. Then, the cdf and survival function (sf) of the APTEx-Weibull are given, respectively, bys

$$G(x) = \frac{\alpha^{\left(1 - \frac{e^{-\gamma x^{\theta}}}{e^{\left(1-e^{-\gamma x^{\theta}}\right)}}\right)} - 1}{\alpha - 1}, \qquad x \geqslant 0,\ \alpha, \theta, \gamma > 0,\ \alpha \neq 1, \tag{7}$$

$$S(x) = \frac{\alpha - \alpha^{\left(1 - \frac{e^{-\gamma x^{\theta}}}{e^{\left(1-e^{-\gamma x^{\theta}}\right)}}\right)}}{\alpha - 1}, \qquad x > 0.$$

The pdf corresponding to Eq. (7) is given by

$$g(x) = \frac{(\log\alpha)\,\theta\gamma x^{\theta-1} e^{-\gamma x^{\theta}}\left[1 + e^{-\gamma x^{\theta}}\right]}{(\alpha - 1)\, e^{\left(1-e^{-\gamma x^{\theta}}\right)}} \alpha^{\left(1 - \frac{e^{-\gamma x^{\theta}}}{e^{\left(1-e^{-\gamma x^{\theta}}\right)}}\right)}, \qquad x > 0. \tag{8}$$

Some of the possible pdf plots for the APTEx-Weibull are shown in Fig. 7. These plots are sketched for $\gamma = 1.8, \theta = 0.7, \alpha = 4.2$ (black-color), $\gamma = 1.2, \theta = 1.3, \alpha = 3.8$ (magenta-color), $\gamma = 1, \theta = 1, \alpha = 1.5$ (orange-color), $\gamma = 0.4, \theta = 1, \alpha = 0.9$ (green-color), $\gamma = 1, \theta = 0.8, \alpha = 1.2$ (red-color), $\gamma = 1.2, \theta = 1.3, \alpha = 3.8$ (blue-color), $\gamma = 1$, $\theta = 1.4$, $\alpha = 4.1$ (pink-color), and $\gamma = 1.8, \theta = 1.2, \alpha = 4.5$ (yellow-color),

Whereas, the plots of the hazard rate function (hrf) of the APTEx-Weibull distribution are presented in Fig. 8. These

Table 4 Countries-wise and region-wise details of the confirmed case and the death of COVID-19.

Country	Cases	Deaths	Region
Grenada	10	0	Europe
Guadeloupe	128	6	South America
Guatemala	47	1	Australia/Oceania
Guinea	52	0	Australia/Oceania
Guinea-Bissau	9	0	Australia/Oceania
Guyana	19	4	Australia/Oceania
Haiti	18	0	North America
Holy See	7	0	Europe
Honduras	222	15	North America
Hong Kong	802	4	Asia
Hungary	623	26	Europe
Iceland	1319	4	Europe
India	2567	72	Asia
Indonesia	1790	170	Asia
Iran	50468	3160	Asia
Iraq	772	54	Asia
Ireland	3849	98	Europe
Isle of Man	95	1	Europe
Israel	6857	36	Asia
Italy	115242	13915	Europe
Jamaica	47	3	North America
Japan	3329	74	Asia
Jordan	299	5	Asia
Kazakhstan	444	3	Asia
Kenya	110	3	Africa
Kuwait	342	0	Asia
Kyrgyzstan	125	1	Asia
Laos	10	0	Asia
Latvia	458	0	Europe
Lebanon	494	16	Asia
Liberia	6	0	Africa
Libya	11	1	Africa
Liechtenstein	75	0	Europe
Lithuania	696	9	Europe
Luxembourg	2487	30	Europe
Macao	41	0	Asia
Madagascar	59	0	Africa
Malawi	3	0	Africa
Malaysia	3166	50	Asia
Maldives	19	0	Asia

Table 5 Countries-wise and region-wise details of the confirmed case and the death of COVID-19.

Country	Cases	Deaths	Region
Mali	36	3	Africa
Malta	196	0	Europe
Mauritania	6	1	Africa
Mauritius	169	7	Africa
Mayotte	116	1	Africa
Mexico	1510	50	North America
Moldova	505	6	Europe
Monaco	60	1	Europe
Mongolia	14	0	Asia
Montenegro	144	2	Europe
Montserrat	5	0	North America
Morocco	708	44	Africa
Mozambique	10	0	Africa
MS Zaandam	9	2	Africa
Myanmar	20	1	Asia
Namibia	14	0	Africa
Nepal	6	0	Asia
Netherlands	14697	1339	Europe
New Caledonia	18	0	Australia/Oceania
New Zealand	868	1	Australia/Oceania
Nicaragua	5	1	North America
Niger	98	5	Africa
Nigeria	184	2	Africa
North Macedonia	384	11	Europe
Norway	5218	50	Europe
Oman	231	1	Asia
Pakistan	2421	34	Asia
Panama	1475	37	North America
Papua New Guinea	1	0	Australia/Oceania
Paraguay	92	3	South America
Peru	1414	55	South America
Philippines	2633	107	Asia
Poland	2946	57	Europe
Portugal	9034	209	Europe
Qatar	949	3	Asia
Romania	2738	115	Europe
Russia	3548	30	Europe
Rwanda	84	0	Africa
Réunion	308	0	Africa
Saint Barthelemy	6	0	North America
Saint Lucia	13	0	North America

plots are obtained for $\gamma = 0.6, \theta = 0.9, \alpha = 1.2$ (gold-color), $\gamma = 0.2, \theta = 0.9, \alpha = 0.2$ (grey-color), and $\gamma = 0.9$, $\theta = 0.4$, $\alpha = 1.2$ (purple-color).

8. Maximum Likelihood Estimation

Here, we derive the maximum likelihood estimators (MLEs) of the APTEx-Weibull parameters based on the complete samples only. Let $x_1, x_2, \ldots, x_\tau$ represent the observed values from the APTEx-Weibull distribution with parameters α, θ and γ. Corresponding to (8), the total log-likelihood function $\lambda(\Theta)$ is

$$\lambda(\Theta) = \tau\log(\log\alpha) + \tau\log\theta + \tau\log\gamma + (\theta-1)\sum_{k=1}^{\tau}\log(x_k) - \sum_{k=0}^{\tau}\gamma x_k^{\theta} \tag{9}$$

$$+ \sum_{k=0}^{\tau}\log\left[1+e^{-\gamma x_k^{\theta}}\right] - \tau\log(\alpha-1) - \sum_{k=0}^{\tau}\left(1-e^{-\gamma x_k^{\theta}}\right)$$

$$+ \sum_{k=0}^{\tau}\left(1-\frac{e^{-\gamma x_k^{\theta}}}{e^{\left(1-e^{-\gamma x_k^{\theta}}\right)}}\right)\log(\alpha).$$

The numerical maximization of the expression provided by (9) can be done via differentiating. Corresponding to (9), the partial derivatives are as follows

Table 6 Countries-wise and region-wise details of the confirmed case and the death of COVID-19.

Country	Cases	Deaths	Region
Saint Martin	22	1	North America
San Marino	245	30	Europe
Saudi Arabia	1885	21	Asia
Senegal	195	1	Africa
Serbia	1171	31	Europe
Sierra Leone	2	0	Africa
Singapore	1049	5	Asia
Sint Maarten	18	1	North America
Slovakia	426	1	Europe
Slovenia	897	17	Europe
Somalia	5	0	Africa
South Africa	1462	5	Africa
South Korea	10062	174	Asia
Spain	112065	10348	Europe
Sri Lanka	151	4	Asia
St. Vincent & Grenadines	2	0	North America
State of Palestine	161	1	Asia
Sudan	8	2	Europe
Suriname	10	0	South America
Sweden	5568	308	Europe
Switzerland	18827	536	Europe
Syria	16	2	Asia
Taiwan	339	5	Asia
Tanzania	20	1	Africa
Thailand	1875	15	Asia
Timor-Leste	1	0	Asia
Togo	39	2	Africa
Trinidad and Tobago	97	6	North America
Tunisia	455	14	Africa
Turkey	18135	356	Asia
Turks and Caicos	5	0	North America
Uganda	45	0	Africa
Ukraine	897	22	Europe
United Arab Emirates	1024	8	Asia
United Kingdom	23718	2921	Europe
United States	245341	6095	North America
Uruguay	369	4	South America
Uzbekistan	221	2	Asia
Venezuela	146	5	South America
Vietnam	233	0	Asia
Zambia	39	1	Africa
Zimbabwe	9	1	Africa

$$\frac{\partial}{\partial\alpha}\lambda(\Theta) = \frac{\tau}{\alpha(\log\alpha)} - \frac{\tau}{(\alpha-1)} + \sum_{k=0}^{\tau}\frac{\left(1-\frac{e^{-\gamma x_k^{\theta}}}{e^{\left(1-e^{-\gamma x_k^{\theta}}\right)}}\right)}{\alpha},$$

$$\begin{aligned}\tfrac{\partial}{\partial\theta}\lambda(\Theta) = {} & \tfrac{\tau}{\theta} + \sum_{k=1}^{\tau}\log(x_k) - \sum_{k=0}^{\tau}\gamma\log(x_k)x_k^{\theta} - \gamma\sum_{k=0}^{\tau}\frac{\log(x_k)x_k^{\theta}e^{-\gamma x_k^{\theta}}}{\left[1+e^{-\gamma x_k^{\theta}}\right]} \\ & + \log(\alpha)\sum_{k=0}^{\tau}\frac{\log(x_k)x_k^{\theta}e^{-\gamma x_k^{\theta}}\left(1+e^{-\gamma x_k^{\theta}}\right)}{e^{\left(1-e^{-\gamma x_k^{\theta}}\right)}} \\ & - \sum_{k=0}^{\tau}\log(x_k)x_k^{\theta}e^{-\gamma x_k^{\theta}},\end{aligned}$$

and

$$\begin{aligned}\tfrac{\partial}{\partial\gamma}\lambda(\Theta) = {} & \tfrac{\tau}{\gamma} - \sum_{k=0}^{\tau}x_k^{\theta} - \sum_{k=0}^{\tau}\frac{x_k^{\theta}e^{-\gamma x_k^{\theta}}}{\left[1+e^{-\gamma x_k^{\theta}}\right]} - \sum_{k=0}^{\tau}x_k^{\theta}e^{-\gamma x_k^{\theta}} \\ & + \log(\alpha)\sum_{k=0}^{\tau}\frac{x_k^{\theta}e^{-\gamma x_k^{\theta}}\left(1+e^{-\gamma x_k^{\theta}}\right)}{e^{\left(1-e^{-\gamma x_k^{\theta}}\right)}}.\end{aligned}$$

Setting the above partial derivative expressions to zero, i.e., $\frac{\partial}{\partial\alpha}\lambda(\Theta) = \frac{\partial}{\partial\theta}\lambda(\Theta) = \frac{\partial}{\partial\gamma}\lambda(\Theta) = 0$, and solving them provides the respective MLEs.

9. Simulation Study

Here, we provide a brief Monte Carlo (MC) simulation study to evaluate the MLEs of the APTEx-Weibull parameters. The APTEx-Weibull is easily simulated by inverting the expression (7). The simulation is performed for $\alpha = 0.9, \theta = 1.2$, and $\gamma = 0.7$.

The inverse cdf method is adopted to generate the random numbers. The inverse process and simulation results are obtained via a statistical software R using (rootSolve) library. The sample size selected as $n = 10, 20, \ldots, 500$ and the MC replications was done 500 times. For the maximization of the expression (8), the algorithm $\mathsf{LBFGS-B}$ is used with optim(). For $i = 1, 2, \ldots, 500$, the MLEs are obtained for each set of simulated data. The assessing tools such as biases and mean square errors (MSEs) are considered. These quantities are calculated as follows

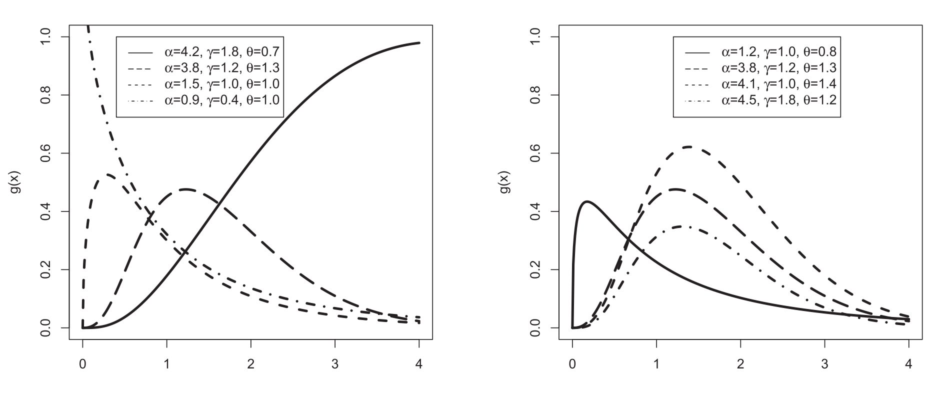

Fig. 7 Different pdf plots of the APTEx-Weibull model.

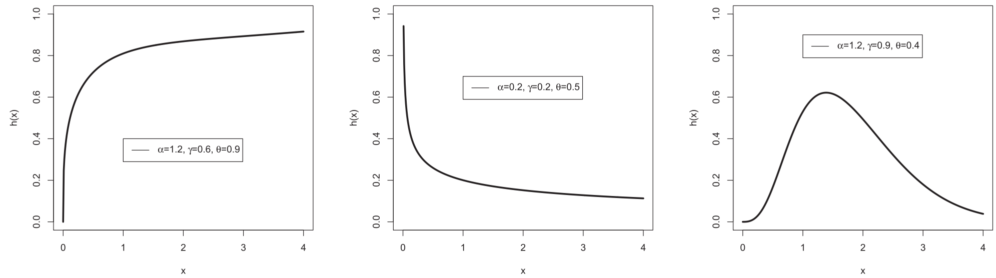

Fig. 8 Different hrf plots of the APTEx-Weibull model.

$$Bias(\Theta) = \frac{1}{500}\sum_{i=1}^{500}\left(\hat{\Theta} - \Theta\right),$$

and

$$MSE(\Theta) = \frac{1}{500}\sum_{i=1}^{500}\left(\hat{\Theta} - \Theta\right)^2,$$

where $\Theta = (\alpha, \theta, \gamma)$.

Corresponding to the simulation results, the plots of MLEs, MSEs, biases and absolute biases are sketched in Fig. 9.

10. Statistical Modeling

Here, we illustrate our model by considering the survival times of patients who suffered due to COVID-19 epidemic in China. The data set representing the survival times of the patients from the admitted time in the hospital (temporary ICU of RHWU East Branch) to death. The data set is given by: 4.01, 5.10, 2.09, 3.01, 4.04, 3.10, 4.04, 5.03, 3.04, 8.05, 6.10, 12.02, 7.05, 9.20, 5.01, 13.02, 6.10, 8.02, 9.01, 8.02, 10.01, 15.02, 14.03, 13.01, 15.05, 17.02, 4.06, 12.01, 1.09, 3.50, 1.20,

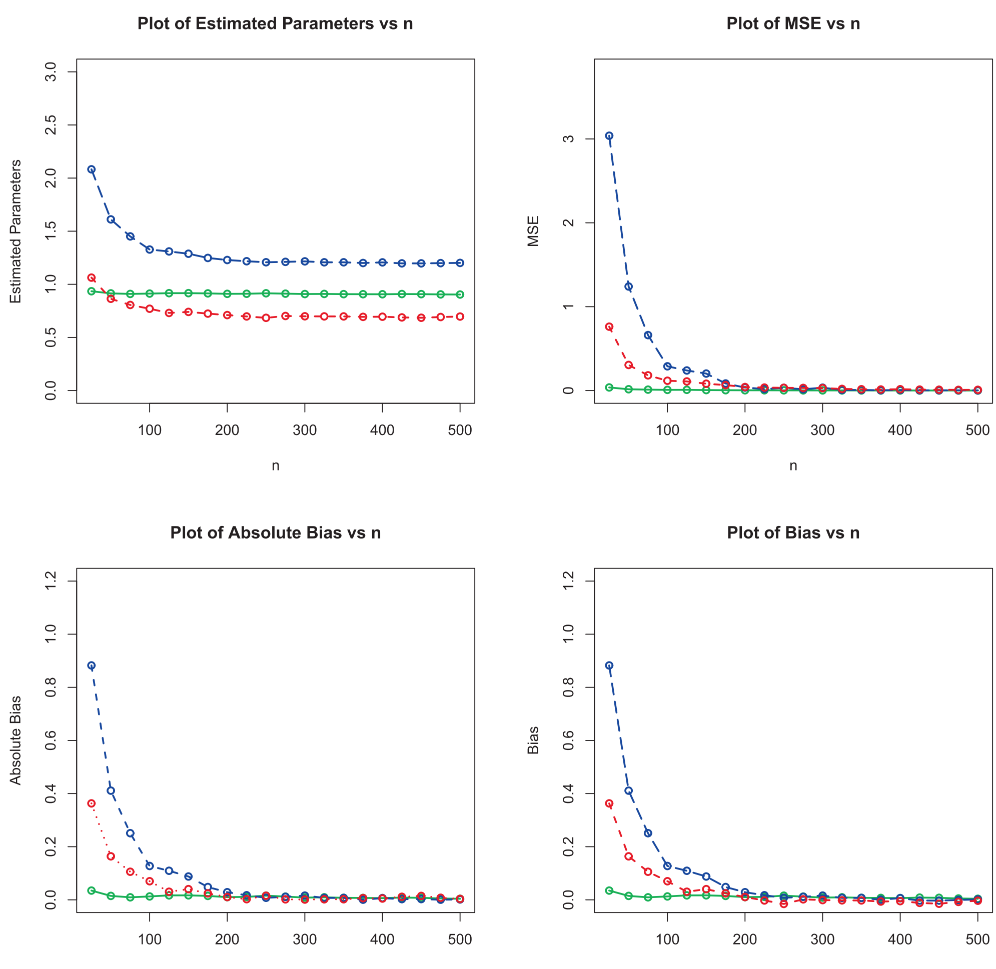

Fig. 9 Plots of the MLEs, MSEs, biases and absolute biases for $\alpha = 0.9$ (green-line), $\theta = 1.2$ (blue-line) and $\gamma = 0.7$ (red-line). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 7 The summary measures of the COVID-19 data.

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1.030	4.293	7.030	7.884	12.010	18.070

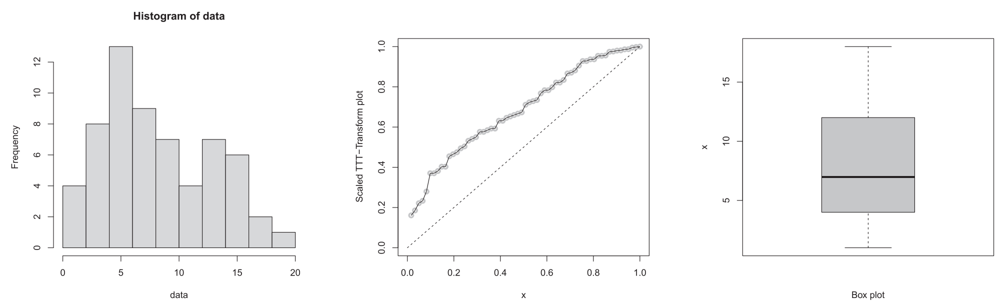

Fig. 10 The Histogram, TTT and box plots of the COVID-19 data.

4.03, 13.01, 5.02, 1.03, 3.10, 11.04, 10.12, 12.01, 14.10, 5.20, 6.09, 7.02, 14.01, 16.09, 18.07, 14.05, 7.04, 8.03, 9.16, 7.08, 6.09, 10.01, 12.09, 4.70, 5.02, 6.23, 4.37, 3.09, 5.10. Among the data, 42 patients (70%) were men and 19 women (31.66%). 45 patients (75%) were diagnosed with chronic diseases, especially including high blood pressure, heart disease, and diabetes. 58 patients (96%) had common clinical symptoms of the flu, 48 patients (80%) were coughing, 36 (60%) were short of breath, and 30 patients (50%) had fatigue. 57 (95%) patients had bilateral pneumonia showed by the chest computed tomographic scans.

The summary measures of the COVID-19 data are presented in Table 7. Whereas, the histogram, total time test (TTT) and box plots are provided in Fig. 10.

The APTEx-Weibull distribution is applied to model the survival times of the COVID-19 patients in China, and the its comparison is made with the exponentiated Weibull (EW), alpha power transformed Weibull (APTW), and Marshall-Olkin Weibull (MOW) distributions. The survival functions of the competing distributions are given by.

- EW

$$S(x) = \left(1 - e^{-\gamma x^{\theta}}\right)^{a}, \qquad x, a, \gamma, \theta > 0.$$

- APTW

$$S(x) = 1 - \left(\frac{\alpha^{1-e^{-\gamma x^{\theta}}} - 1}{\alpha - 1}\right), \qquad x, \alpha, \theta, \gamma > 0, \alpha \neq 1.$$

- MOW

$$S(x) = \frac{\sigma e^{-\gamma x^{\theta}}}{1 - (1-\sigma)e^{-\gamma x^{\theta}}}, \qquad x, \theta, \gamma, \sigma > 0.$$

To decide abut the best fitting of the competing distributions, certain criterion are considered. These criterion are given by.

- The Anderson–Darling (AD) test

$$AD = -n - \frac{1}{n}\sum_{k=1}^{n}(2k-1)[\log F(x_k) + \log\{1 - F(x_{n-k+1})\}],$$

Table 8 The analytical measures of the fitted models.

Model	α	γ	θ	σ	a
APTEx-Weibull	1.6768	0.0086	2.0141	-	-
MOW	-	0.1007	1.3558	3.9583	-
EW	-	0.0212	1.7874	-	1.0264
APTW	1.0063	0.0170	1.8804	-	-

Table 9 The analytical measures of the fitted models.

Model	CM	AD	KS	p-value
APTEx-Weibull	0.0790	0.5166	0.1034	0.5418
MOW	0.1252	0.7294	0.1166	0.3881
EW	0.0797	0.5494	0.1052	0.5093
APTW	0.0845	0.5226	0.1050	0.5226

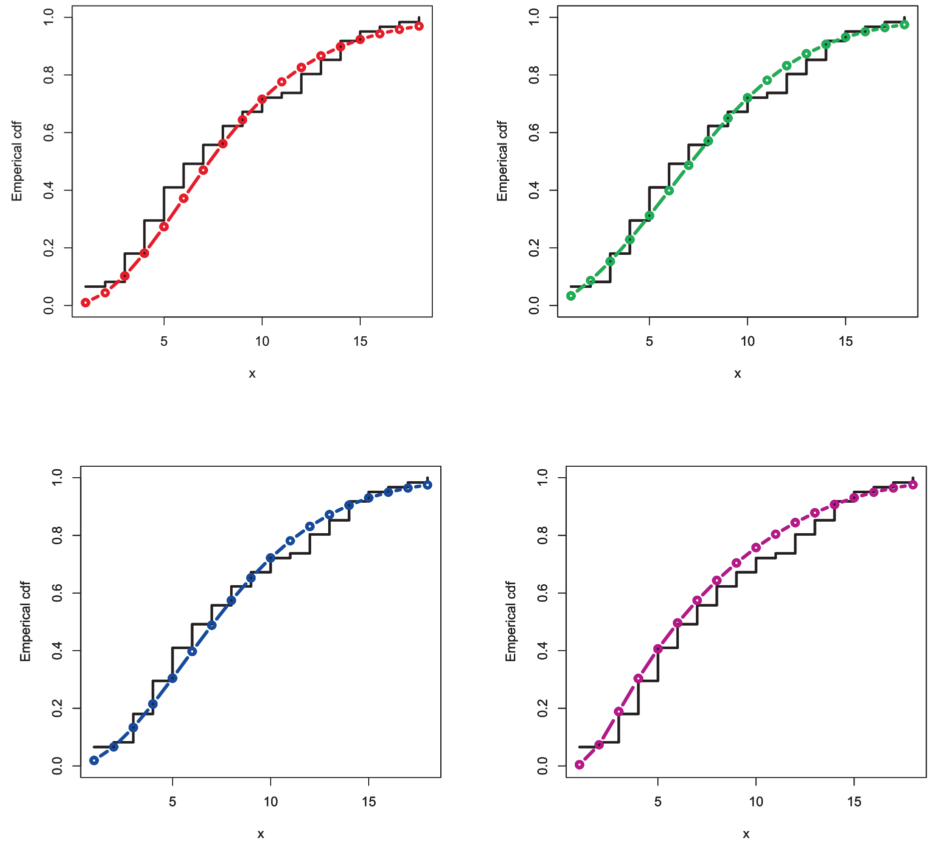

Fig. 11 The fitted cdf plots of the competing distributions.

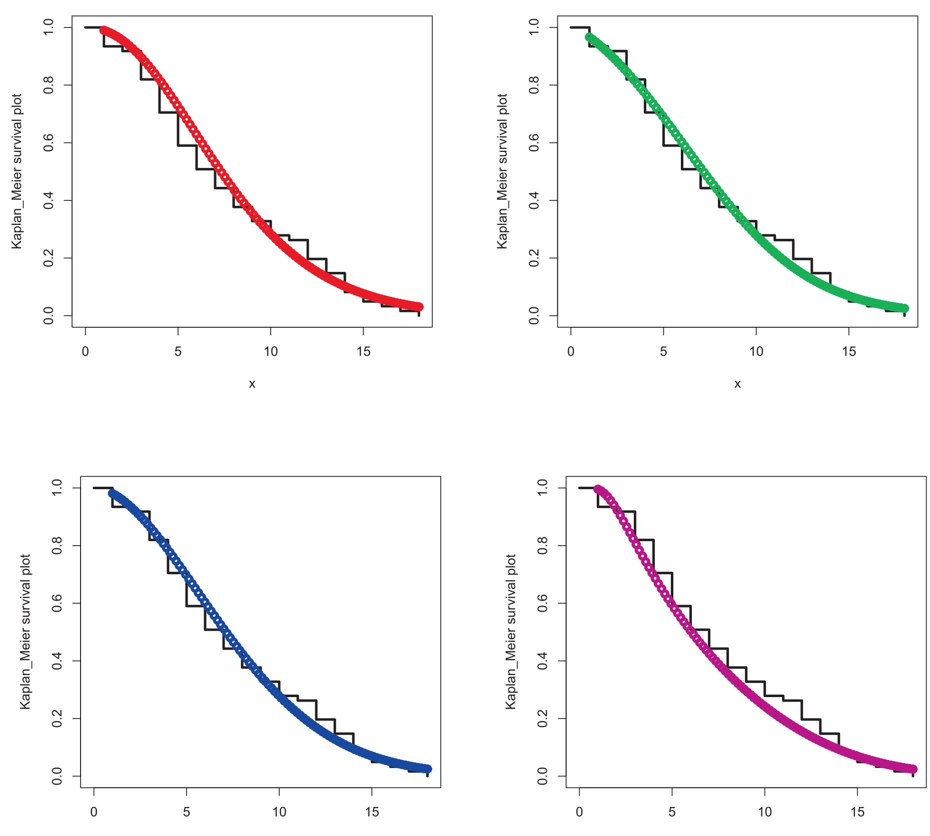

Fig. 12 The Kaplan–Meier survival plots of the competing distributions.

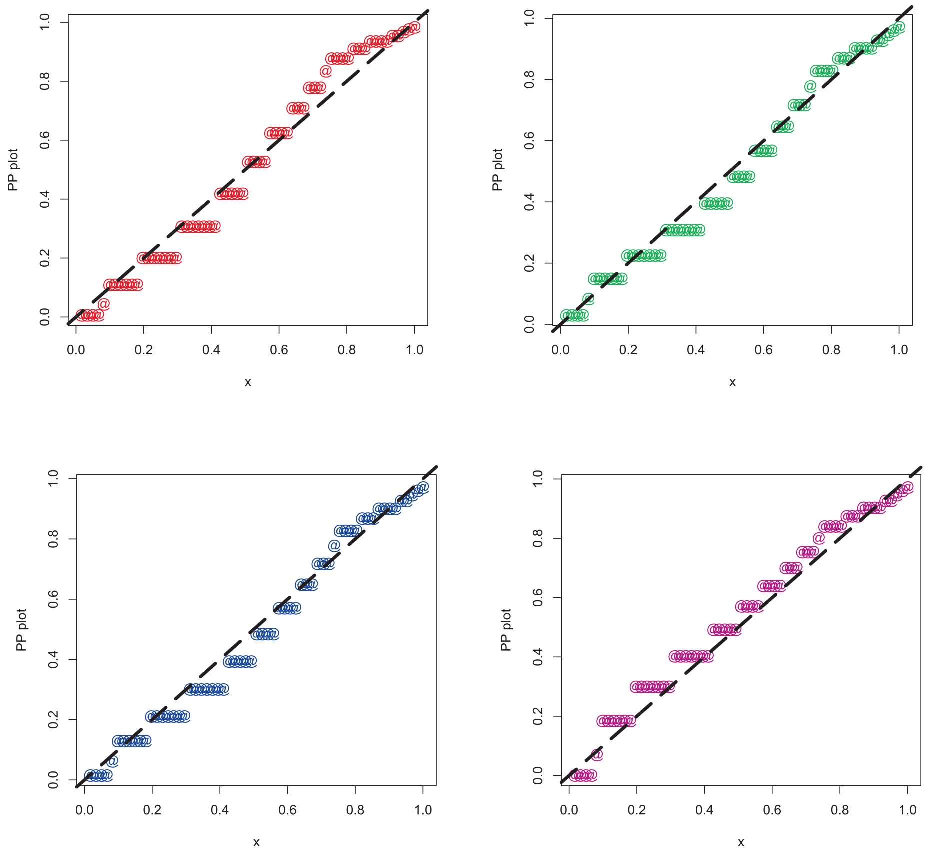

Fig. 13 The PP plots of the competing distributions.

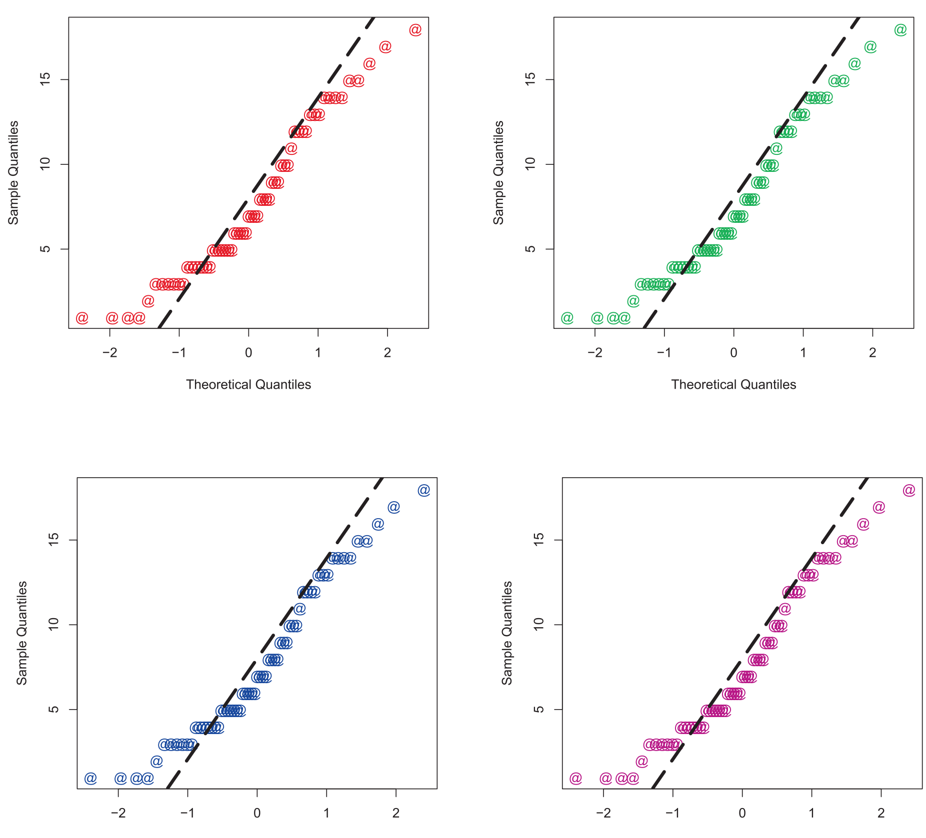

Fig. 14 The QQ plots of the competing distributions.

where x_k is the k^{th} observation in the sample size n.

- The Cramer-von Mises (CM) test

$$CM = \frac{1}{12n} + \sum_{k=1}^{n}\left[\frac{2k-1}{2n} - F(x_k)\right]^2.$$

- The Kolmogorov–Smirnov (KS) test

$$KS = sup_x[F_n(x) - F(x)].$$

The MLEs and goodness of fit measures of the competing models are provided in Tables 8 and 9, respectively.

Furthermore, the fitted cdf plots of the APTEx-Weibull (red-line), MOW (green-line), EW (blue-line) and FW (Magenta-line) distributions are presented in Fig. 11. The Kaplan–Meier survival plots of the APTEx-Weibull (red-line), MOW (green-line), EW (blue-line) and FW (Magenta-line) distribution are sketched in Fig. 12. The PP (probability-probability) plots of the APTEx-Weibull (red-line), MOW (green-line), EW (blue-line) and FW (Magenta-line) distributions are provided in Fig. 13. The QQ (quantile–quantile) plots of the APTEx-Weibull (red-line), MOW (green-line), EW (blue-line) and FW (Magenta-line) distributions are displayed in Fig. 14.

11. Concluding remarks

The current COVID-19 is one of the deadliest viruses in the world. The COVID-19 situation in the Asian region is very threatening. In this study, a brief overview of the background of the COVID-19 pandemic is provided. Its symptoms are discussed and some useful tips are provided to prevent this virus. To update the peoples, a detail of confirmed cases and the death toll of the COVID-19 are provided. Finally, a new distribution family is proposed to use it for modeling the COVID-19 pandemic events. A sub-model of the APTEx-X family is considered in detail. The approach of the maximum likelihood estimation is utilized to obtain the estimates of the APTEx-Weibull parameters. The usefulness of the APTEx-Weibull model is demonstrated by fitting the survival times of the COVID-19 patients in China, and it is found that the new model may give the best fit to the current pandemic dynamic events.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] W. Shatanawi, A. Raza, M.S. Arif, K. Abodayeh, M. Rafiq, M. Bibi, An effective numerical method for the solution of a stochastic coronavirus (2019-nCovid) pandemic model, Computers, Materials, & Continua 66 (2) (2020).
[2] R.A. Al-Falluji, Z.D. Katheeth, B. Alathari, Automatic Detection of COVID-19 Using Chest X-Ray Images and Modified ResNet18-Based Convolution Neural Networks, Computers, Materials, & Continua 66 (2) (2021) 1301–1313.
[3] A. Abdallah Ali, How Can Lean Manufacturing Lead the Manufacturing Sector during Health Pandemics Such as COVID 19: A Multi Response Optimization Framework, Computers, Materials, & Continua 66 (2) (2021) 1397–1410.
[4] H.G. Hong, Y. Li, Estimation of time-varying reproduction numbers underlying epidemiological processes: a new statistical tool for the COVID-19 pandemic, PloS One 15 (2020) 1–18.
[5] I. Nesteruk, Statistics-based predictions of coronavirus epidemic spreading in mainland China, Innovative Biosystems and Bioengineering 4 (2020) 3–18.
[6] Y. Liu, A.A. Gayle, A. Wilder-Smith, J. Rocklv, The reproductive number of COVID-19 is higher compared to SARS coronavirus, Journal of travel medicine 27 (2020) 1–16.
[7] E. El-Shafeiy, A.E. Hassanien, K.M. Sallam, A.A. Abohany, Approach for training quantum neural network to predict severity of COVID-19 in patients, Computers, Materials, & Continua 66 (2) (2020) 1745–1755.
[8] M. Zuo, S.K. Khosa, Z. Ahmad, Z. Almaspoor, Comparison of COVID-19 pandemic dynamics in Asian countries with statistical modeling, Computational and mathematical methods in medicine 2020 (2020) 1–16.
[9] M.A. Khan, A. Atangana, Modeling the dynamics of novel coronavirus (2019-nCov) with fractional derivative, Alexandria Engineering Journal 59 (4) (2020) 2379–2389.
[10] Z. Du, L. Wang, S. Cauchemez, X. Xu, X. Wang, B.J. Cowling, L.A. Meyers, Risk for transportation of coronavirus disease from Wuhan to other cities in China, Emerging infectious diseases 26 (5) (2020) 10–49.
[11] V. Surveillances, The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) China, 2020, China CDC weekly 2 (8) (2020) 113–122.
[12] S.A. Kharroubi, Modeling the spread of COVID-19 in Lebanon: A Bayesian perspective, Frontiers in Applied Mathematics and Statistics 6 (2020) 1–40.
[13] A.S. Ahmar, E.B. Del Val, SutteARIMA: Short-term forecasting method, a case: Covid-19 and stock market in Spain, Science of The Total Environment 729 (2020) 138883.
[14] U.A.P. de Len, G. Prez, E. Avila-Vales, An SEIARD epidemic model for COVID-19 in Mexico: mathematical analysis and state-level forecast, Chaos, Solitons & Fractals 140 (2020) 110–165.
[15] A. de Paula Lobo, A.C. Cardoso-dos-Santos, M.S. Rocha, R.S. Pinheiro, J.M. Bremm, E.M. Macrio, G.V.A. de Frana, COVID-19 epidemic in Brazil: Where are we at?, International Journal of Infectious Diseases 97 (2020) 382–385
[16] K. Abid, Y.A. Bari, M. Younas, S. Tahir Javaid, A. Imran, Progress of COVID-19 Epidemic in Pakistan, Asia Pacific Journal of Public Health 32 (4) (2020) 154–156.

[17] P. Samui, J. Mondal, S. Khajanchi, A mathematical model for COVID-19 transmission dynamics with a case study of India, Chaos, Solitons & Fractals 140 (110–173) (2020) 110173.

[18] M. Zuo, S.K. Khosa, Z. Ahmad, Z. Almaspoor, Comparison of COVID-19 pandemic dynamics in Asian countries with statistical modeling, Computational and mathematical methods in medicine 2020 (2020) 1–18.

[19] J. Zhao, Z. Ahmad, Z. Almaspoor, Modeling the covid-19 pandemic dynamics in iran and china, Computers, Materials & Continua 67 (2) (2021) 2111–2122.

[20] J. Zhao, Z. Ahmad, Z. Almaspoor, M. El-Morshedy, A.Z. Afify, Modeling COVID-19 Pandemic Dynamics in Two Asian Countries, Computers, Materials & Continua 67 (1) (2020) 965–977.

[21] M. Abdy, S. Side, S. Annas, W. Nur, W. Sanusi, An SIR epidemic model for COVID-19 spread with fuzzy parameter: the case of Indonesia, Advances in Difference Equations 2021 (1) (2021) 1–17.

[22] S.A. Cheema, T. Kifayat, A.R. Rahman, U. Khan, A. Zaib, I. Khan, K.S. Nisar, Is Social Distancing, and Quarantine Effective in Restricting COVID-19 Outbreak? Statistical Evidences from Wuhan, China, Computers, Materials, & Continua 66 (2) (2020) 1977–1985.

[23] M. Miller, Novel Coronavirus (COVID-19) Data Repository, Bulletin-Association of Canadian Map Libraries and Archives 164 (2019) 47–51.

[24] A. Alzaatreh, C. Lee, F. Famoye, A new method for generating families of continuous distributions, Metron 71 (1) (2013) 63–79.

[25] Z. Ahmad, G.G. Hamedani, N.S. Butt, Recent developments in distribution theory: a brief survey and some new generalized classes of distributions, Pakistan Journal of Statistics and Operation Research 15 (1) (2019) 87–110.