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The Current COVID-19 Pandemic in China: An Overview and Corona Data Analysis

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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 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] and [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].

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 Figure 1.

| Symptoms             | %  |
|----------------------|----|
| Sore throat          | 13.9 |
| Dry cough            | 67.7 |
| Fever                | 87.9 |
| Shortness of breath  | 18.6 |
| Headache             | 13.6 |
| Fatigue              | 38.1 |

| Symptom              | %  |
|----------------------|----|
| Sputum production    | 33.4 |
| Muscle pain          | 14.8 |
| Nausea               | 5.0  |
| Nasal congestion     | 4.8  |
| Haemoptysis          | 0.9  |
| Conjunctival congestion | 0.8 |
Sore throat
Dry cough
Conjunctival congestion
Fever
Nasal congestion
Shortness of breath
Headache
Muscle pain
Nausea
Fatigue
Heamoptysis
Sputum production
Muscle pain
Nausea
Fever
Conjunctival congestion
Dry cough
Figure 1: Graphical display for the percentage of the symptoms of the COVID-19 data.

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 Figures 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.

Figure 2: The COVID-19 daily confirmed cases
Figure 3: The COVID-19 total confirmed 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 COVID-19 deaths are graphically presented in Figures 4 and 5, respectively.

Figure 4: The COVID-19 daily deaths.
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 Figure 6.

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

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.
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      |
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 |
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        |
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 \( T \in [u_1, u_2] \), \( -\infty \leq u_1 < u_2 < \infty \), 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-X family of distributions are given by

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

(1)

and

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

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

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

(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

\[
P(t) = 1 - e^{-t}, \quad t \geq 0,
\]

(3)

with pdf

\[
p(t) = e^{-t}, \quad t > 0.
\]

(4)

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

\[
G(x) = \frac{\alpha (1 - \frac{1-F(x)}{e^{F(x)}}) - 1}{\alpha - 1}, \quad \alpha > 0, \; \alpha \neq 1, \; x \in \mathbb{R},
\]

(5)

with pdf

\[
g(x) = \frac{(\log \alpha) f(x) [2 - F(x)]}{(\alpha - 1) e^{F(x)}} \alpha (1 - \frac{1-F(x)}{e^{F(x)}}), \quad x \in \mathbb{R}.
\]

(6)

In the next section, we present a sub-model of the APTEX-X family, called the APTEX-Weibull distribution.
7 Special Sub-Model

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

\[
G(x) = \frac{\alpha}{\alpha - 1} \left( 1 - \frac{1 - e^{-\gamma x^\theta}}{e^{(1 - e^{-\gamma x^\theta})}} \right), \quad x \geq 0, \ \alpha, \theta, \gamma > 0, \ \alpha \neq 1, \quad (7)
\]

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

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

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

Some of the possible pdf plots for the APTEx-Weibull are shown in Figure 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 Figure 8. These 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).

![Figure 7: Different pdf plots of the APTEx-Weibull model.](image-url)
8 Maximum Likelihood Estimation

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

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

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

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

and

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

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 \(\alpha = 0.9, \theta = 1.2, \gamma = 0.7\).

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 \(n = 10, 20, ..., 500\) and the MC replications was done 500 times. For the maximization of the expression (8), the algorithm “LBFGS – B” is used with optim(). For \(i = 1, 2, ..., 500\), 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

\[Bias(\Theta) = \frac{1}{500} \sum_{i=1}^{500} (\hat{\Theta} - \Theta),\]

and

\[MSE(\Theta) = \frac{1}{500} \sum_{i=1}^{500} (\hat{\Theta} - \Theta)^2,\]
where $\Theta = (\alpha, \theta, \gamma)$.

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

![Plots of Estimated Parameters vs n](image1)

![Plot of MSE vs n](image2)

![Plot of Absolute Bias vs n](image3)

![Plot of Bias vs n](image4)

Figure 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).

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, 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 Figure 10.

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|

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**
  \[
  S(x) = \left(1 - e^{-\gamma x^\theta}\right)^a, \quad x, a, \gamma, \theta > 0.
  \]

- **APTW**
  \[
  S(x) = 1 - \left(\frac{\alpha^{-e^{-\gamma x^\theta}} - 1}{\alpha - 1}\right), \quad x, \alpha, \theta, \gamma > 0, \alpha \neq 1.
  \]

- **MOW**
  \[
  S(x) = \frac{\sigma e^{-\gamma x^\theta}}{1 - (1 - \sigma)e^{-\gamma x^\theta}}, \quad x, \theta, \gamma, \sigma > 0.
  \]
To decide about the best fitting of the competing distributions, certain criterion are considered. These criterion are given by

- The Anderson-Darling (AD) test
\[
AD = -n - \frac{1}{n} \sum_{k=1}^{n} (2k - 1) \left[ \log F(x_k) + \log \left\{ 1 - F(x_{n-k+1}) \right\} \right],
\]
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
\[
KS = \sup_{x} \left| F_n(x) - F(x) \right|.
\]

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

### Table 8: The analytical measures of the fitted models.

| Model       | \( \alpha \) | \( \gamma \) | \( \theta \) | \( \sigma \) | \( a \) |
|-------------|--------------|--------------|--------------|-------------|-----|
| 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  |

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 Figure 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 Figure 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 Figure 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 Figure 14.

Figure 11: The fitted cdf plots of the competing distributions.
Figure 12: The Kaplan-Meier survival plots of the competing distributions.
Figure 13: The PP plots of the competing distributions.
Figure 14: The QQ plots of the competing distributions.

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.
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