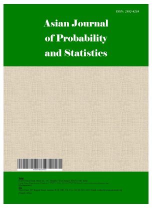

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COVID-19 Pandemic Data Visualization with Moment about Midpoint: Exploratory and Expository Analyses

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Authors' contributions

This work was carried out in collaboration between both authors. Author SOA designed the study and wrote the first draft of the manuscript. Author MIE performed and managed the statistical analysis, wrote the protocol of the study and managed the literature searches. Both authors read and approved the final manuscript.

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Abstract

Aims: To visualize COVID-19 data using Exploratory Data Analysis (EDA) to tell the COVID-19 story expository.
Study Design: The study uses EDA approach to visualize the COVID-19 data. The study uses secondary data collected from World Health Organization (WHO) in a panel form and partition the world using WHO regions. Moment about a midpoint and EDA are jointly used to analyze the data.
Place and Duration of Study: Department of Mathematics & Statistics, Statistical Laboratory, Lagos State Polytechnic and Federal Polytechnic, Ilaro. The data used covered all regions of the world from January 2020 to July 2020.
Methodology: We included 198 countries (cross-sections) partitioned into 7 WHO regions over 7 months (190 days) time period, spanning 3000 datasets. The EDA and moment about a midpoint is used for the analysis. This is a purely descriptive and expository analysis to tell the story of the novel coronavirus disease (COVID-19).

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Results: The total sample points used for this analysis are 30,010, which can be taken as a big data and it is large enough to assume the central limit theorem. The results of the analysis showed that cumulative cases and deaths are increasing but at a slower rate. Some WHO region curves are already flattening.
Conclusion: The study concluded that average number of new cases and new deaths will decrease in coming months but there will be increase in the cumulative cases and deaths but at a slower rate.

Keywords: COVID-19 pandemic; moment about a midpoint; exploratory data analysis; expository report; WHO region.

1 Introduction

COVID-19 pandemic is a global emergency in the health sector, an infectious disease caused by the novel coronavirus, which was detected in Wuhan City, Hubei Province of China in December 2019 and the virus was isolated on 7th January, 2020. China shared the genetic sequence of the novel coronavirus to other laboratories of the world to develop specific diagnostic kits for countries [1]. The first laboratory confirmed case outside China was reported in Thailand (first imported case) on 13th January, 2020. On 20th January, 2020, WHO [2] reported that 282 laboratory confirmed cases of COVID-19 from four countries including 278 cases from China, 2 from Thailand, 1 from Japan and 1 from Republic of Korea; all from the same WHO region. Among the 278 cases confirmed in China, 258 cases were reported from Hubei Province, 14 from Guangdong Province, 5 from Beijing Municipality and 1 from Shanghai Municipality; of the 278 confirmed cases, 51 cases are severely ill, 12 are in critical condition and 6 deaths have been reported from Wuhan City [2]. Cases in Thailand, Japan and Republic of Korea are all imported cases from Wuhan, China [3]. Just in seven months, COVID-19 has claimed more than 600,000 lives. The most common symptoms of COVID-19 include fever, tried cough and tiredness, and other symptoms include aches, pains, sore throat, diarrhea, conjunctivitis, headache, loss of taste or smell, rash on skin, or discolouration of fingers or toes [4].

The world had experienced similar pandemics that had claimed lives in the past, with some having similar symptoms and mode of transmission, just to mention some to the best of our knowledge. The earliest recorded pandemic in history happened in 430 B.C., during the Peloponnesian War and was named Athens. The Athens disease passed through Libya, Ethiopia and Egypt and crossed the Athenian walls as the Spartans laid siege with 40% mortality rate. The symptoms included fever, thirst, bloody throat and tongue, red skin and lesions [5]. The Antonine plague (165 A.D. – 180 A.D.) started with Huns with early appearance of smallpox, who infected the Germans with the plague. The Germans passed it to the Romans, and was later spread throughout the Roman empire. The symptoms included diarrhea, sore throat, fever and probably pus-filled sores. The Antonine plague claimed the life of Emperor Marcus Aurelius Antoninus [6]. Cyprian plague (250 A.D. – 444 A.D.) index case was Christian bishop of Carthage in Ethiopia named Cyprian. The symptoms included diarrhea, vomiting, throat ulcers, fever and gangrenous hands and feet. In trying to escape infections, City dwellers fled to the country but instead spread the disease further from Ethiopia to Rome, then to Egypt and northward. Recurring outbreak of the disease lasted over three centuries and hit Britain in 444 A.D. [7,8]. Justinian plague (541 A.D.) first appeared in Egypt and spread through Palestine and the Byzantine Empire, and then throughout the Mediterranean. Justinian plague squelched Emperor Justinian's plans to unite the Roman Empire and causing economic hardship. Recurrences over the next two centuries eventually killed about 50 million people (26% of the world population then) [9]. The Black Death (1347-1352) in Europe claimed 60% lives in UK. In the summer of 1348, the disease had reached English ports from continental Europe and begun to ravage its way toward the capital. The plague caused painful and frightening symptoms, including fever, vomiting, coughing up blood, black pustules on the skin, and swollen lymph nodes. Death usually came within 3 days. In 1349, the Black Death killed about half of all Londoners; from 1347 to 1351, it killed between 30% and 60% of all Europeans and specifically, France lost about half its population [10,11].

Another deadly wave of pandemic was the Columbia Exchange, which was as a result of arrival of the Spanish in Caribbean, which included smallpox, measles and bubonic plague [12]. Smallpox (1588) was endemic to Europe, Asia and Arabia with a mortality rate of 30%. In America region, it killed up to 90% or 95% of the indigenous American. However, smallpox was the first virus epidemic to be ended by a vaccine by a British doctor named Edward Jenner. The smallpox lasted over centuries. In 1529, a similar plague, measles outbreak in Cuba killed more 60% of those natives who had previously survived smallpox. Two years later, measles was responsible for the deaths of 50% of Honduras population, and it had ravaged Mexico, Central America, and the Inca civilization [13]. Around 1855 and 2005, measles had killed about 200 million people globally [14,15,16]. Measles is caused by the measles virus, a single-stranded, negative-sense, enveloped RNA virus of the genus Morbillivirus within the family Paramyxoviridae [17]. Measles is highly contagious (90% infectious contact rate) and it is the most contagious virus known to date, and is spread by coughing and sneezing via close personal contact or direct contact with secretions. It remains infective for up to two hours in that airspace or nearby surfaces. Humans are the only natural hosts of the virus, and no other animal reservoirs are known to exist [18]. Bubonic plague is one of three types of plague caused by bacterium Yersinia pestis, a flu-like symptoms, which include fever, headaches, vomiting, swollen and painful lymph nodes occur in the area closest to where the bacteria entered the skin. Treatment of bubonic plague include aminoglycosides such as streptomycin and gentamicin, tetracyclines, and the fluoroquinolone ciprofloxacin. Mortality rate is 15% and 60% associated with treated cases and untreated cases respectively. Preventive drugs include prophylactic antibiotics. Using the broad-based antibiotic streptomycin has proven to be dramatically successful against the bubonic plague within 12 hours of infection [19,20,21]. From 1629 to 1631, Plague in Northern Italy claimed a lot of lives. Around 1656 to 1657 was the Plague in Southern Italy. In 1665, the Great Plague of London surfaced in another devastating appearance, the bubonic plague led to the deaths of 20% of London’s population.

In 1817, the first of seven cholera pandemics, the small intestine infection originated in Russia, where one million people died. It spreads through feces-infected water and food. The bacterium passed through British soldiers who brought it to India where millions more died. The British Empire navy spread cholera to Spain, Africa, Indonesia, China, Japan, Italy, Germany and America, where it killed 150,000 people. A vaccine was created in 1885, but pandemics continued. In 1855, the Third Plague Pandemic starting in China and moving to India and Hong Kong, the bubonic plague claimed 15 million victims. Initially spread by fleas during a mining boom in Yunnan, the plague is considered a factor in the Parthay rebellion and the Taiping rebellion [22,23]. Fiji Measles Pandemic outbreak (1875) started after Fiji was ceded to the British Empire and claimed 40,000 lives. Russian Flu (1889 - 1890) was the first significant flu pandemic, which started in Siberia and Kazakhstan, and spread through Moscow to Finland, Poland, and then entire Europe. A year later, Russian Flu crossed the ocean and infected North America and Africa, recording 360,000 deaths. Spanish Flu (1918 - 1919), an avian-borne flu that resulted in 50 million deaths globally, was first observed in Madrid (Europe), the United States and parts of Asia before spreading fast around the globe. Hundreds of thousands of Americans died same year as a result of the flu, but the pandemic stopped in the summer of 1919, when there was no new case and the closed cases either recovered from the flu and developed immunities or died [22,23]. Asian flu (1957) index case was detected in Hong Kong and spread throughout China and then into the United States claiming 14,000 lives in England and its second wave in early 1958 caused an estimated deaths of 1.1 million globally, with 116,000 deaths in the United States alone. A vaccine was developed to contain the pandemic effectively. In 1981, HIV/AIDS was first identified, a disease which destroys a person’s immune system, resulting in eventual death by diseases that the body would usually fight off. Those infected by the HIV virus encounter fever, headache, and enlarged lymph nodes upon infection. When symptoms subside, carriers become highly infectious through blood and genital fluid, and the disease destroys t-cells. AIDS was first observed in American gay communities but is believed to have developed from a chimpanzee virus from West Africa in the 1920s. The disease, which spreads through certain body fluids, moved to Haiti in the 1960s, and then New York and San Francisco in the 1970s [22,23]. In 2003, Severe Acute Respiratory Syndrome (SARS) was first identified after several months of cases, SARS is believed to have possibly started with bats, spread to cats and then to humans in China, followed by 26 other countries, infecting 8,096 people, with 774 deaths. SARS is characterized by respiratory problems, dry cough, fever and head and body aches and is spread through respiratory droplets from coughs and sneezes. Quarantine efforts proved effective and by July, the virus was contained and has not reappeared since. China was criticized for trying to suppress information about the virus at the beginning of the outbreak. SARS was seen by global health professionals as a wake-up call to improve outbreak responses, and lessons from the pandemic were used to keep diseases like H1N1, Ebola and Zika under control [22,23].

From the victory over H1N1, Ebola and Zika, one would have been made to believe so much in the medical system globally, but COVID-19 caught the whole world unguarded. World Health Organization (WHO) on 11th March, 2020 officially declared COVID-19 a pandemic after infecting 114 countries within three months with over 118,000 cases. COVID-19 is caused by a novel coronavirus strain that has not been previously diagnosed in human. COVID-19 symptoms include respiratory problems, fever, cough, probably pneumonia and possibly death. It spreads through droplets from sneezes like SARS. The index case was detected in China on 17th November, 2019, in Wuhan, Hubei Province of China, but went unrecognized with 8 new cases in December 2019 by unknown cause. COVID-19 became popular when ophthalmologist Dr. Li Wenliang, a Chinese doctor, went against government orders and released vital information on the existence of the novel coronavirus and how to manage the virus to fellow doctors around the globe and was immediately charge by China government with a crime. Immediately after he released the information, China informed WHO about the existence of COVID-19. A month later, Li died from COVID-19. The virus spread from Chinese to other part of the globe affecting more than 163 countries in mid-March, 2020. On 11th February, 2020, SARS-CoV-2 was officially named COVID-19. It is not the first coronavirus disease in history. Coronaviruses were first identified in the mid-1960s and were known to infect humans and a variety of animals, including birds and mammals. The first coronavirus outbreak was SARS-CoV in 2002, where infected animals passed it to humans (Betacoronavirus, subgenus Sarbecovirus), and in 2012, another coronavirus called MERS-CoV (Betacoronavirus, subgenus Merbecovirus) [24] spread through the entire Arabian Peninsula inside the Middle East. In 2002–2003, SARS-CoV affected 8,096 people, causing severe pulmonary infections and 774 deaths, leading to 10% case fatality ratio [24,25]. Coronavirus is likely to originate from bats, then spread to Himalayan palm civets, Chinese ferret badgers and raccoon dogs sold for food at the wet markets of Guangdong, China. The virus that causes COVID-19 was first isolated in December 2019 from three patients with pneumonia, connected to the cluster of acute respiratory illness cases from Wuhan, China. Genetic analysis shows that the novel coronavirus is related to SARS-CoV and genetically clusters within the genus Betacoronavirus, forming a distinct clade in lineage B of the subgenus Sarbecovirus together with two bat-derived SARS-like strains (zoonotic in origin) [26]. Similar to SARS-CoV, a recent study confirmed that Angiotensin Converting Enzyme 2 (ACE 2), a membrane exopeptidase, is the receptor used by 2019-nCoV for entry into the human cells. The virus was initially isolated in bronchoalveolar lavage fluid samples [26,27]. RNA of the virus was detected in blood samples in six out of 41 cases in a study of the clinical features of the infection [28].

The spread of COVID-19 is believed to be geographically associated, but with uncertainty. Human-to-human transmission of COVID-19 has been established, such as through respiratory droplets, and there is also a suspicion of asymptomatic infection. Infected individuals recover without requiring special treatment. Older people who immune system have been compromised with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more vulnerable to develop serious illness and eventually die. The mode of transmission of the COVID-19 virus is primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. Some sources believe that it is only symptomatic carriers could spread the virus, while some believe that both symptomatic and asymptomatic carriers could spread the virus. Qian [29] reported a family cluster spread of COVID-19 by a pre-symptomatic carrier in China. The study showed that out of 8 laboratory-confirmed cases, 2 were asymptomatic. The pre-symptomatic carries are probably those in their incubation period but might still show symptoms later. The work observed and concluded that pre-symptomatic carriers, asymptomatic carriers and those in incubation period could spread the virus. Studies that supported this fact include [30,31,32]. However, recently, in June 2020, WHO has retracted her statement within a day that said asymptomatic carriers cannot spread the virus. Studies have shown that symptomatic carriers have higher probability of spreading the virus than asymptomatic carriers because of sneezing and coughing by the former producing droplets on surfaces [33]. At the moment, there are no specific vaccines or treatments for COVID-19. Studies have shown that asymptomatic carriers would recover from the coronavirus with or without taking antiviral drugs, but there is possibility of recovered individuals to test positive again even after the nucleic acid tested negative [34,35]. The following recommendations are made by WHO and Centre for Disease Control (CDC) to reduce the general risk of transmission of COVID-19, they include keeping physical distance of at least 1 metre apart, frequent hand-washing, especially after direct contact with infected people or their environment or surfaces, keep away from farm or wild animals, except you are protected, practicing cough etiquette by people with symptoms of acute respiratory infection, emergency unit in hospitals should enhance standard infection prevention and control practices and staying at home when no pressing need to go out. There is no specific vaccine yet for COVID-19 globally. However, there are many ongoing clinical research on various potential antiviral drugs. Currently, some countries have been able to manage cases with high rate of recovery, while the body's immune system fights the illness. Some studies and interviews with some medical practitioners recently, have shown that the combination of hydroxychloroquine, azithromycin, Zinc sulphate and vitamin C have been proved effective both as preventive and curative measures for COVID-19 [36,37]. Also see [38,39,40] on conclusions on hydroxychloroquine and other drugs therapies in treating COVID-19.

Many authors have developed different types of models, deterministic, probabilistic, static and dynamic models on COVID-19, only few authors have considered telling the story of COVID-19 using visualization. EDA is used for revealing the hidden features in a dataset, what the data can tell us beyond the formal modeling or hypothesis testing task. EDA was promoted by John Tukey to encourage statisticians to explore the data, and possibly formulate hypotheses that could lead to new data collection and experiments. Adeniyi et al. [4] combined dynamic model with EDA, [41] analyzed COVID-19 using EDA approach, [42] also worked on data visualization and analyzation of COVID-19 with modelling. Aroro et al. [43] applied EDA in analyzing the current perspective of COVID-19 in South Korea and containment of the pandemic. In this research, descriptive statistics is mainly used in an expository manner. The moment about a midpoint is introduced as a descriptive measure of data analysis. The midpoint analysis is different from mean and median. It is a focus point on the data so that 50% of the weight the dataset will turn the data clockwise and the other 50% weight will balance it anticlockwise. This will help us to detect outliers in the dataset and help to determine if the data is skewed.

Thus, in this research, we explored the COVID-19 data using descriptive statistics, which included a novel moment about a midpoint, expository analysis and EDA. Data on daily COVID-19 laboratory confirmed cases, cumulative cases, daily deaths and cumulative deaths were collected from WHO situation reports from January to July 2020. All the countries of the world with COVID-19 are included in the data but are partitioned into seven WHO regions (not continent).

2 Materials and Methods

In this section, the data used would be described, expository data analysis, exploratory data analysis and moment about midpoint would be used in descriptive capacity and outlined for future research. R, SPSS and MS Excel are used for the data analysis to bring out the best results for the data visualization.

2.1 Data description

The data is a secondary data downloaded from WHO situation reports of 27th July 2020. The data was compiled from 11th January, 2020 to 27th July 2020, spanning 7 months, comprising 216 countries and territories of the world, partitioned into 7 WHO regions. The data is arranged in an unbalanced panel data form, in that, all the countries do not have equal time interval. A country's data start from when the index case is reported in the country. This will help to eliminate the number of zero cumulative cases. Data on cases, cumulative cases, deaths and cumulative deaths were collected. The cases are the new COVID-19 confirmed laboratory cases reported every day (every 24 hours), while the cumulative cases are the confirmed cases recorded from the index case to the day of reference. It is the total individuals that have been infected with the virus. The variable deaths are the new COVID-19 induced deaths recorded daily (with 24 hours) while the cumulative deaths are all the deaths recorded due to COVID-19 in that country. Other variables such as COVID-19 mortality rate per 1000 infected cases and time between two successive deaths in a country are derived from the collected data.

2.2 Expository data analysis

Expository data analysis should not be confused with exploratory data analysis (EDA). In expository data analysis, an analyst set up a specific point of view or argument about an occurrence of a phenomenon and often writes directly to the viewer, emphasizing the relationship between the data visualization presented and expository explanation. So, a documentary is a form of expository data analysis. This is a form of analyzing data by telling a story about the data. The EDA is very much important in telling this story. A mass-communicator or a linguistic can use expository data analysis to tell a story concerning a phenomenon using dataset of such phenomena and visualization. The story is told in a hierarchical order or chronological order from the date of inception to a reference future date. This will help readers to see how it all started and where we are. Sometimes, preambles can be given to trace the source of such occurrence and after the story, possible trend can be generated to see what the future holds concerning such occurrence. In this study, we have given good background of the disease and other deadly disease that breakout in time past. In the result, the story of COVID-19 is told with some visualizations to aid understanding of the story.

2.3 Exploratory data analysis

The concept of EDA was made popular by John Tukey in 1961 to encourage statisticians to explore data, and possibly formulate hypotheses that could lead to new data collection and experiments. In statistics, exploratory data analysis (EDA) is an approach to analyzing data sets to summarize their main characteristics, often with visualizations. A statistical model can be used or not, but primarily EDA is for seeing what the data can tell us beyond the formal modelling or hypothesis testing task. EDA is different from initial data analysis (IDA), [44] which focuses more narrowly on checking assumptions required for model fitting and hypothesis testing, and handling missing values and making transformations of variables as needed. EDA involves IDA. Tukey defined data analysis in 1961 as procedures for analysing data, techniques for interpreting the results of such procedures, ways of planning the gathering of data to make its analysis easier, more precise or more accurate, and all the machinery and results of (mathematical) statistics which apply to analysing data [45].

Tukey's championing of EDA encouraged the development of statistical computing packages, especially S programming language, S-PLUS and R. This family of statistical-computing environments featured vastly improved dynamic visualization capabilities, which allowed statisticians to identify outliers, trends and patterns in data that merited further study. Tukey's EDA was related to two other developments in statistical theory, both of which tried to reduce the sensitivity of statistical inferences to errors in formulating statistical models. Tukey promoted the use of five number summary of numerical data, the two extremes, maximum and minimum, median, 1^{st} and 3^{rd} quartiles, because these median and quartiles are functions of the empirical distribution and are defined for all distributions, unlike the mean. Moreover, the quartiles and median are more robust to skewed or heavy-tailed distributions than mean. The packages S, S-PLUS, and R included routines using resampling statistics, such as Quenouille and Tukey's jackknife and Efron's bootstrap, which are nonparametric and robust (for many problems). The EDA used for data visualization in this research include the novel moment about a midpoint, tables, graphs, charts, pictures and diagrams [46].

2.4 Moment about midpoint and midpoint theory

The concept of moment in physics is derived from the mathematical concept of moments [47]. The principle of moments is derived from Archimedes' discovery of the operating principle of the lever. In the lever one applies a force, F, often human muscle, to an arm, a beam of some sort. Archimedes noted that the amount of force applied to the object, the moment of force, is defined as $M = Fx$, where x is the distance from the applied force to the support. In physics, a moment is an expression involving the product of a distance and another physical quantity, and in this way it accounts for how the physical quantity is located or arranged. Moments are usually defined with respect to a fixed reference point and deal with physical quantities measured at some distance relative to that reference point. For example, the moment of force acting on an object, often called torque, is the product of the force and the distance to the object from the reference point.

In principle, any physical quantity can be multiplied by a distance to produce a moment. Commonly used quantities include forces, masses, areas, and electric charge distributions.

The Principle of Moments postulates that when a body is in equilibrium, the total clockwise moment about a point is equalled to the total anticlockwise moment about the same point. Fig. 1 shows two forces F_1 and F_2 in either side of a support placed at the centre of the data. Based on the principle of moment, $F_1x_1 = F_2x_2$ should hold. If this does not hold, it means that the data is not uniformly distributed. Then the fulcrum should be shifted away from the initial midpoint calculated (empirical midpoint) to a theoretical midpoint so that there is a balance.

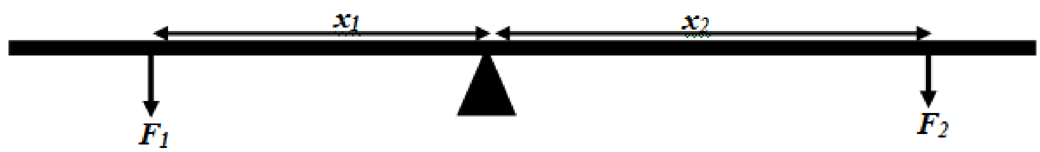

Fig. 1. Moment about a midpoint

The magnitude of the moment of a force acting about a point is directly proportional to the distance of the force from the point. It is defined as the product of the force (F) and the perpendicular distance (x) between the line of action of the force and the centre of moments. It is given by

$$M = F\dot{x} \tag{1}$$

where F is the weight of the data and x is the absolute difference between the fulcrum and F. In statistics, it is referred to as the absolute deviation. The centre of moment here is the midpoint of the data, which is different from arithmetic mean or median. The midpoint between two points x_1 and x_n, in coordinate geometry is calculated as

$$\dot{x} = \frac{x_1+x_n}{2} \tag{2}$$

where x_1 and x_n are two extreme values, minimum and maximum values. Equation (2) can be inserted in (1) for practical purpose. The entire dataset is divided into two weight of 50% each to the left and to the right, so that the sum of clockwise moment is equal to the sum of the anticlockwise moment. This midpoint theorem has application in Inventory Control of Operations Research, where the average inventory is calculated as (maximum inventory + minimum inventory)/2. Thus, the midpoint can be used as a measure of central tendency, especially when the mean is not feasible.

A clockwise rotation about the centre of moments will be considered a positive moment; while a counter-clockwise rotation about the centre of moments will be considered negative. A positive moment can be taken as positive skewness and negative moment as negative skewness. In its most simple and basic form, a moment is the product of the distance to some point, x, raised to some power r, and some physical quantity such as the force, charge, etc, denoted by p(x) at that point, and it is given by.

$$\mu_r = \int_{-\infty}^{\infty} x^r p(x)dx \tag{3}$$

where p is the distribution of the density of charge, mass, or whatever quantity is being considered. This implies that there are multiple moments (one for each value of r) and that the moment generally depends on the reference point from which the distance x is measured. Each value of r corresponds to a different moment in equation (3). The 1st moment corresponds to $r = 1$; the 2nd moment to $r = 2$, etc. The 0th moment ($r = 0$) is sometimes called the monopole moment; the 1st moment (r = 1) is sometimes called the dipole moment, and the 2nd moment (r = 2) is sometimes called the quadrupole moment, especially in the context of electric charge distributions. For example, the moment of force, or torque, is a first moment τ = Fx. The total mass is the zeroth moment of mass. The centre of mass is the 1st moment of mass normalized by total mass. For a collection of point masses, we have (4)

$$R = \frac{1}{N}\sum_{i=1}^{N} x_i m_i \quad (4)$$

while for an object with density f(x), we have (5)

$$R = \frac{1}{N}\int_{-\infty}^{\infty} xp(x)\, d^3x \quad (5)$$

The moment of inertia is the 2nd moment of mass. The collection of point masses is given in (6)

$$R = \sum_{i=1}^{N} x_i^2 m_i \quad (6)$$

while for an object with density f(x) is given in (7)

$$R = \int_{-\infty}^{\infty} x^2 p(x)\, d^3x \quad (7)$$

Note that the centre of mass is often taken as the reference point, which in this study is the midpoint.

3 Results and Discussion

3.1 Application of moment about midpoint

The data used for the moment include data on cases and mortality rate per 1000 infected individuals. Table 1 shows that WHO AMRO region has the highest daily average of COVID-19 reported cases, WHO other region has the lowest. In this data, there are two extreme values, 74,354 at the top and 99 at the bottom. Among the valid listed WHO region, EMRO has the least daily COVID-19 reported cases per country on the average. The WHO AMRO region has the highest deaths per day for a country within the region, while WHO other region has the lowest average daily death per country. The WHO EURO region has the highest mortality rate per 1000 cases, while WHO others region has the lowest mortality rate per 1000 cases. WHO EMRO region has the lowest mortality rate among the valid WHO regions.

Table 1. New and cumulative cases and deaths of COVID-19 by WHO region

	WHO region	New cases	New deaths	Mortality rate
Americas	AMRO	74,354	6,409	86.2
South-East Asia	SEARO	49,931	2,003	40.1
Western Pacific	WPRO	15,152	1,290	85.1
Africa	AFRO	13,944	572	41.0
Europe	EURO	12,559	2,003	159.5
Eastern Mediterranean	EMRO	6,884	229	33.3
Others	Other	99	2	20.2

Fig. 2 depicts that the clockwise moment is greater than the anticlockwise moment making a positive turn, which shows the data is positively skewed. The empirical midpoint is (74,354 + 99)/2 = 37,226.5. The fulcrum is placed at the point 37,225.5. The new cases here are the average new cases of COVID-19 per day. There are 31,010 data point, which was used for the computation of the mean, which is then calculated for each region. Some region has more data point than others. For example, the WHO AMRO region has 74,354 cases per day on the average for a country. Note that this is not the total per day for each region but the average a country within a region can report for the period under review.

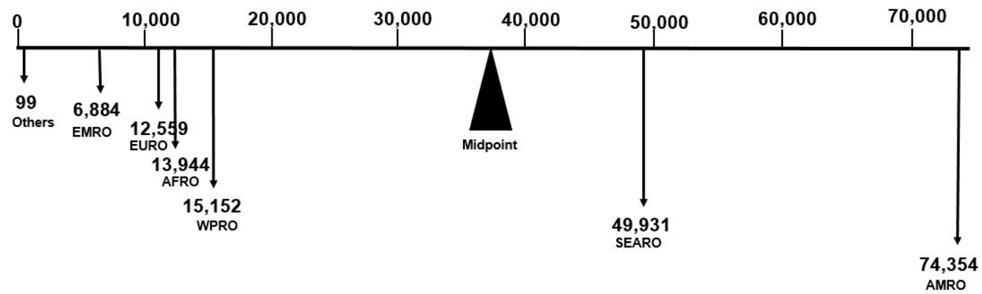

Fig. 2. Moment about empirical midpoint of new COVID-19 cases

Fig. 3 depicts that the clockwise moment is equal to the anticlockwise moment. The fulcrum has been shifted from the empirical midpoint of 37,226.5 to a theoretical midpoint of 50,026.71. WHO SEARO region was on the right of the fulcrum is now on the left of the fulcrum after the fulcrum has been shifted. This adjustment is made so that we can easily see the WHO region that report high cases per day for a country. The WHO AMRO region has the highest daily average of COVID-19 confirmed cases. This implies that if WHO AMRO region reduces the average infected individuals per day, then 50% of COVID-19 cases would have reduced globally. Fig. 4 depicts that the clockwise moment is greater than the anticlockwise moment making a positive turn, which shows the data is positively skewed. The empirical midpoint is (159.5 + 20.2)/2 = 89.8. The fulcrum is placed at the empirical midpoint. The COVID-19 mortality rate per 1000 cases is the number of deaths due to COVID-19 out of 1000 confirmed cases per day.

Fig. 5 depicts that the clockwise moment is now equal to the anticlockwise moment. The fulcrum has been shifted from the empirical midpoint of 89.8 to a theoretical midpoint of 96.516. In this case, all the downward forces remain at their position, only the support if shifted to the right a little to have equilibrium. The WHO EURO region has the highest mortality rate per 1000 COVID-19 confirmed cases. This implies that if WHO EURO region reduces the mortality rate in her region, then 50% of COVID-19 mortality rate would have reduced globally.

3.2 Data visualization with exploratory data analysis

Fig. 6 depicts that January has 2% of COVID-19 cases, February has 3%, March has 5%, April has 13%, May has 16%, June has 24% while July has 37%. Following this trend, it is possible that August will record a higher percentage. These are not cumulative cases; these are average daily cases. It implies that in January 2020, only 59 cases are reported per day on the average, while in July 2020, just six months after, 1,015 cases are reported per day for a country reporting COVID-19 new cases.

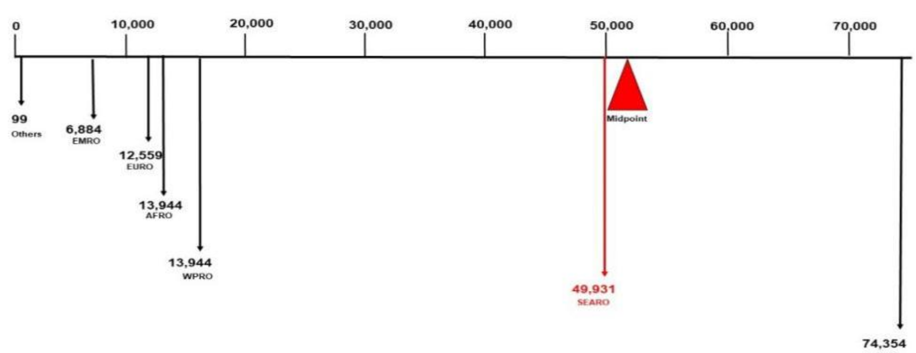

Fig. 3. Moment about theoretical midpoint of new COVID-19 cases

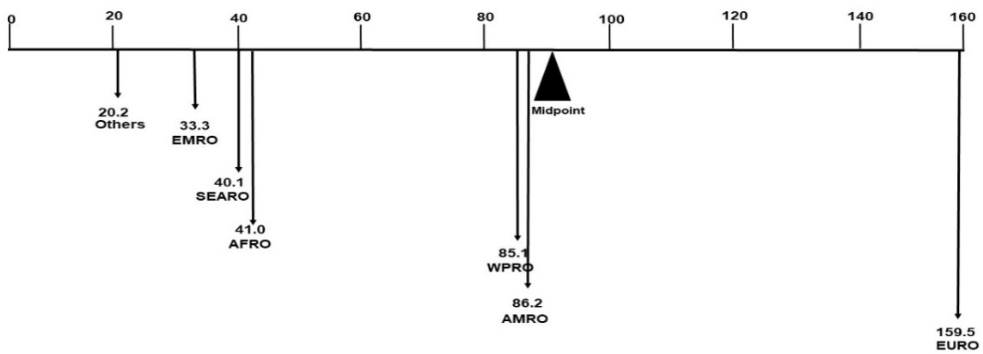

Fig. 4. Moment about empirical midpoint of COVID-19 mortality rate

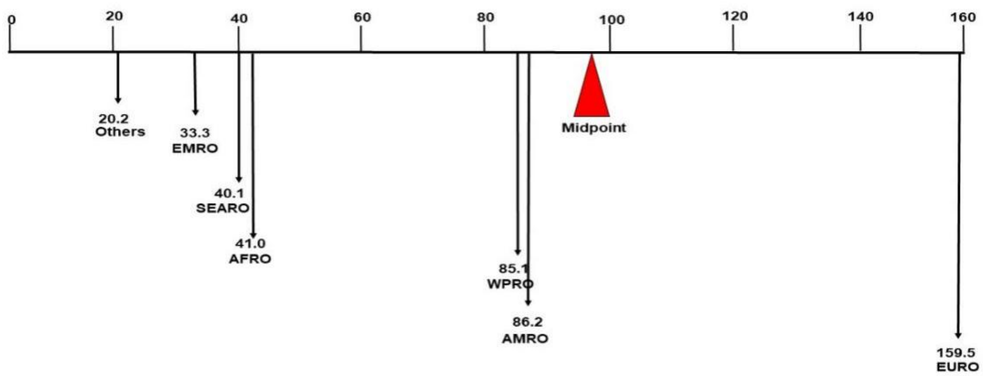

Fig. 5. Moment about theoretical midpoint of COVID-19 mortality rate

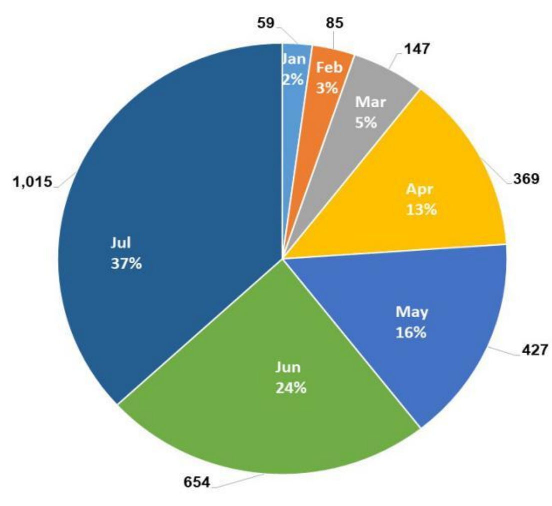

Fig. 6. Average daily cases of COVID-19 monthly

Fig. 7 depicts that in January 2020, the average daily COVID-19 death is 1, in February is 3, in March is 8, in April is 29, in May is 21, in June is 21, while in July is 24. The COVID-19 deaths in this study are the average number of deaths a country can record per day. This shows that COVID-19 death was highest in April, but July is showing that the death rate is likely to rise again in the coming months. Fig. 8 depicts that in January 2020, 2.16% of the COVID-19 infected individuals died of the virus, in February 3.59% died, in March 5.59% died, in April 7.86% died, in May 5% died, in June 3.22% died, while in July 2.41% died. This shows that COVID-19 mortality rate got to its peak in April, and since then it started reducing steadily from 7.86% in April to 2.41% in July. This reduction in COVID-19 induced deaths is expected in August.

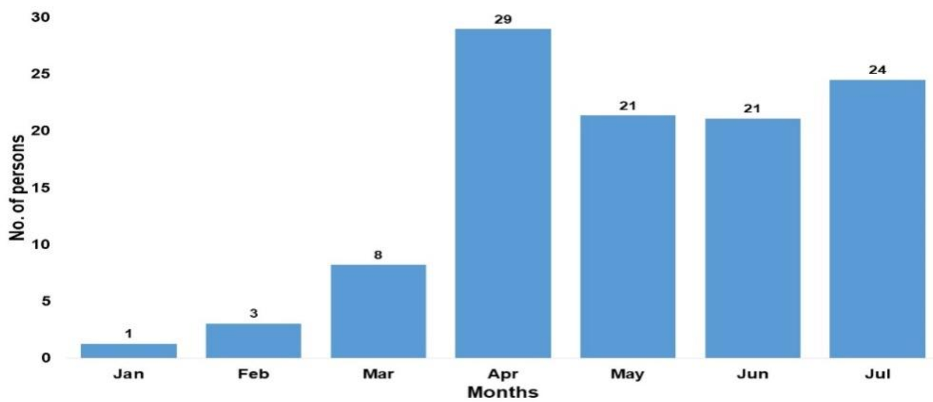

Fig. 7. Average daily deaths of COVID-19 monthly

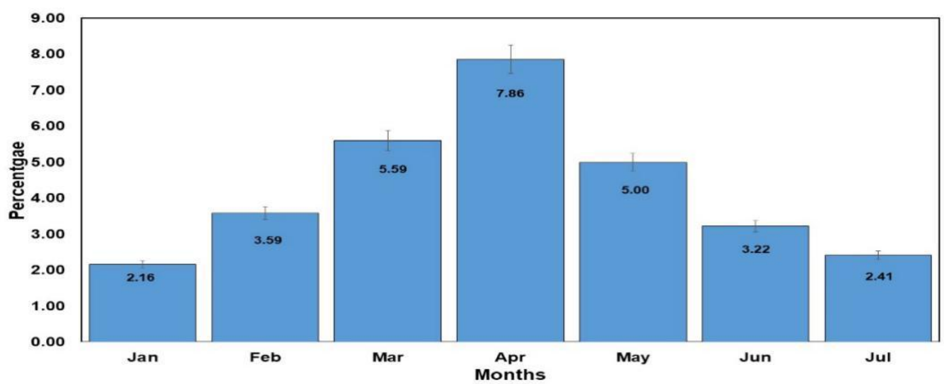

Fig. 8. Percentage of daily deaths per new cases of COVID-19 monthly

Fig. 9 depicts that WHO AMRO region has the highest COVID-19 infected individuals and the highest deaths per day, while WHO EMRO region has the least. Fig. 10 shows that average COVID-19 new case is trending up from January to July.

Fig. 11 also shows upward trend. Fig. 12 shows that WHO AMRO region has the highest COVID-19 new cases for the period under review. Fig. 13 depicts that WHO EURO, WPRO, and other curves are flattening. Fig. 14 depicts that death is higher in countries with new cases than where there are no new cases. Fig. 15 shows that distributions like exponential, gamma, Weibull and convoluted distributions from these families of survival distributions can be used to model COVID-19 new cases, because it they are positively skewed. Fig. 16 depicts that WHO EURO region has the highest mortality rate of COVID-19 per 1000 cases. WHO AMRO region has the highest average new cases, which can be attributed to US, Canada and Brazil as well as the highest deaths.

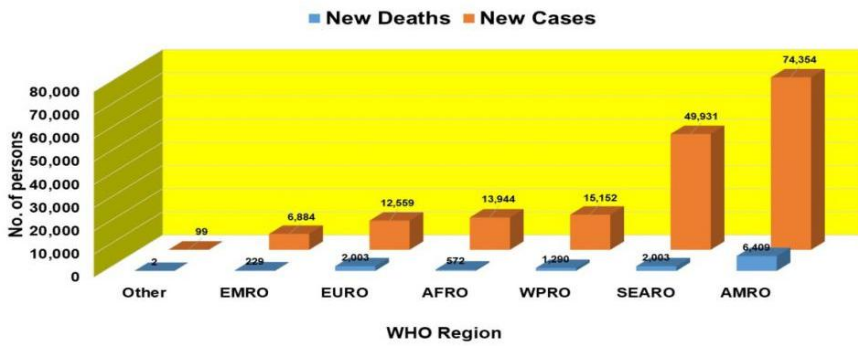

Fig. 9. Average daily deaths and average new cases of COVID-19 by WHO region

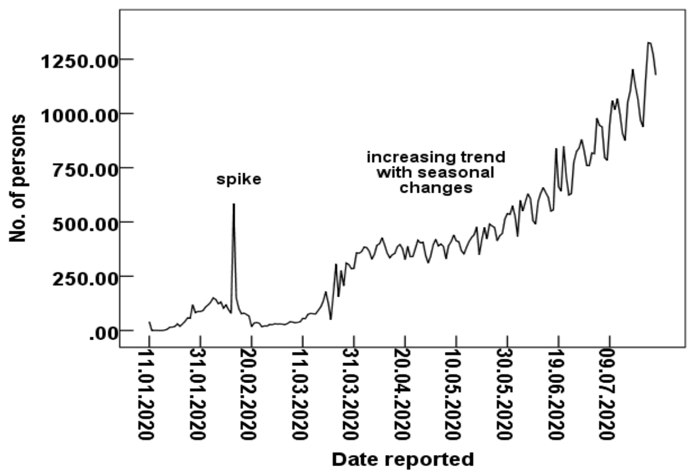

Fig. 10. Average new cases of COVID-19 for period under review

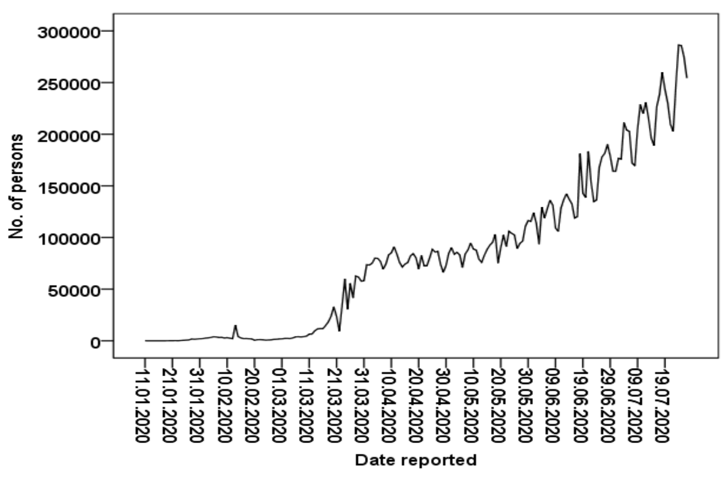

Fig. 11. Daily new cases of COVID-19 reported for period under review

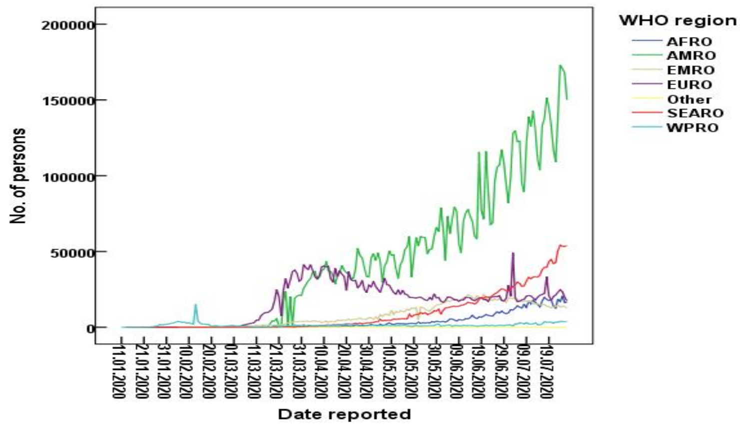

Fig. 12. Daily new cases of COVID-19 reported by WHO region

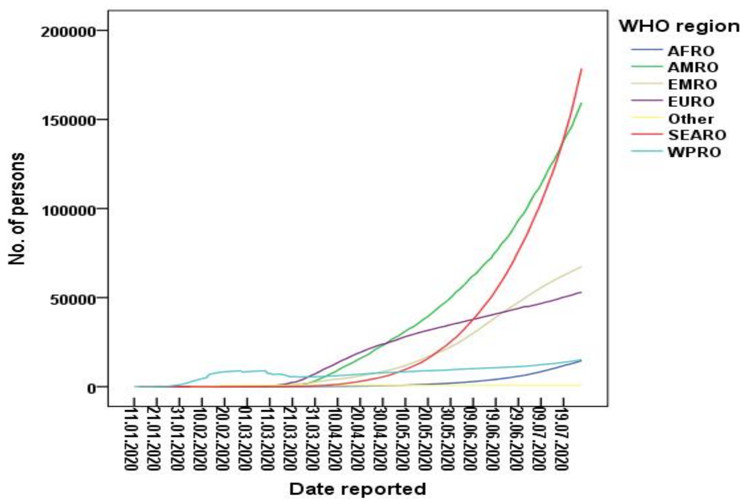

Fig. 13. Cumulative cases of COVID-19 reported by WHO region

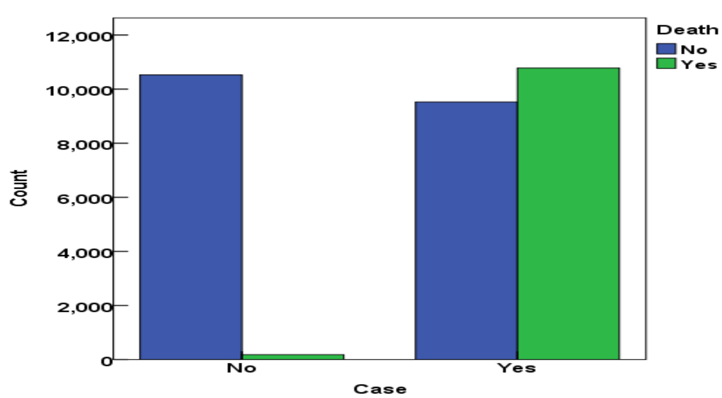

Fig. 14. New cases and deaths of COVID-19 reported by WHO region

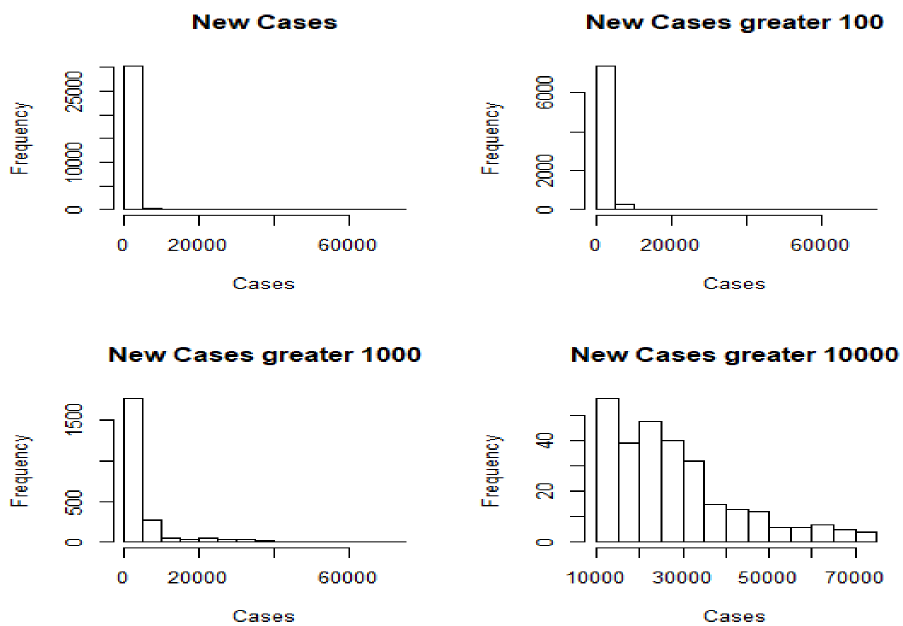

Fig. 15. New and cumulative cases and deaths of COVID-19

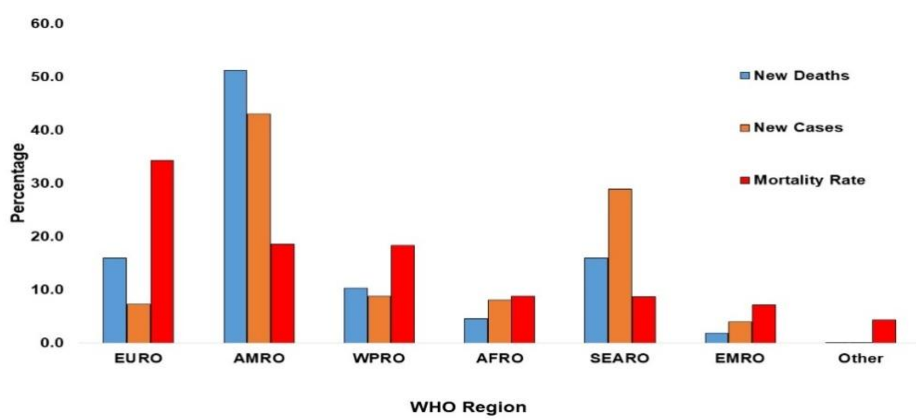

Fig. 16. New cases, deaths and mortality rate of COVID-19

3.3 Expository data analysis

Base on the moment about the midpoint and EDA we give an expository story of the COVID-19 data. Table 2 displays cumulative confirmed COVID-19 cases and cumulative deaths from January to July 2020 with the percentage in cumulative cases and deaths. The percentage change is calculated as

$$\%\ change = \frac{current\ month - previous\ month}{previous\ month} \times 100$$

Table 2. Cumulative cases and deaths with percentage change with time

	Cum. cases	Cum. deaths	% Change in Cum. cases	% Change in Cum. deaths
January	9,932	213	-	-
February	84,350	2,942	749	1,281
March	767,609	40,655	810	1,282
April	3,104,300	224,723	304	453
May	5,939,447	367,842	91	64
June	10,166,102	503,916	71	37
July	13,002,286	662,095	28	31

The incident of COVID-19 started in December 2019 but WHO did not start reporting cases until 11th January 2020 with 41 cases reported only in China. As at 31st January 2020, the cumulative COVId-19 confirmed cases had risen to 9,932 cases with only 213 deaths recorded. At the end of February, 29th February 2020, cumulative cases had risen to 84,350 with 2,942 deaths. The percentage change in cases from January to February was 749% and percentage change in deaths was 1,281%. At the end of March, 31st March 2020, cumulative confirmed cases had risen to 767,609 globally recording 40,655 deaths. The percentage change in confirmed cases from February to March was 810% and 1,282% change in deaths. At the end of April, cumulative confirmed cases rose to 3,104,300 with 224,723 deaths reported. At this point the increase was evident but the percentage change in confirmed cases reduced to 304%, and 453% for deaths. Any predictive model may fail at this point because the increase will not be as predicted. This could be attributed to compliance to WHO regulations by many countries of the world. By May 2020, many countries have put up different control measures to reduce the spread of the virus, unfortunately new countries/territories begin to record their index cases. By 31st May 2020, confirmed cases had risen to 5,939,447 with 367,842 deaths cumulated globally. The percentage change in confirmed cases globally from April to May dropped to 91% while for deaths dropped to 64%, figures below 100%. To a lame man, the virus is still increasing but to trend analysts, the result is encouraging. By the end of June 2020, the confirmed cases had reached 10,166,102 (tens of million) and the cumulative deaths had climbed to 503,916 (half a million) as at 30th June 2020. At this time many individuals have recovered from the pandemic and people have started improving their immune system, hygiene have been improved significantly and information have been made available to educate the susceptible population. The percentage change in COVID-19 confirmed cases from May to June dropped further to 71% and change in deaths globally reduced to 37%. Finally, as at 31st July, 2020, COVID-19 confirmed cases rose to 13,002,286 as the curve become flattened in some countries/territories, while cumulative deaths rose to 662,095. The percentage change in COVID-19 confirmed cases globally form June to July have now reduced to as low as 28% and that of deaths have reduced to 31%. It is left for observers and policy makers to determine what the likely figures would be at the end of August. Following the trend in percentage change, the cumulative COVID-19 confirmed cases might not go beyond 15 million at the end of August 2020. There is no known cure yet, but people have learnt overtime how to manage the pandemic. This expository remark is depicted clearly in Fig. 17. Further stories would be provided from other plots.

It is also important to know how the virus spread from China under WHO Western Pacific region to other regions. WHO partition the world into 6 regions and other territories not in any of these partitions are under others, making 7 WHO regions. Fig. 18 depicts that China has 199 days of reporting COVID-19 from 11th January to 27th July 2020. Japan and Republic of Korea are other countries in this region to have reported COVID-19 cases for more than 190 days. The lowest in this region is Northern Mariana Islands with 121 days of reporting COVID-19. The number of days is the day an index case is reported in a country/territory up till 27th July 2020. The WHO WPRO region comprises 19 countries/territories with other territories not defined as a unit as shown in Fig. 18. The second region that experienced COVID-19 was the WHO South-East Asia region (SEARO). Fig. 19 depicts that COVID-19 pandemic reached SEARO region just after two days that WHO officially reported China COVID-19 cases. The first country in this region to report this COVID-19 case was Thailand with 197 days COVID-19 experience. The last country in this region to report

COVID-19 case is Myanmar with 126 days COVID-19 experience. There are total of10 countries/territories in this region.

Fig. 20 depicts that COVID-19 pandemic reached the WHO Americas region (AMRO) through an imported case that arrived United States (US) after nine days that WHO officially reported China COVID-19 cases. Just 6 days after US reported her index case, Canada also reported her index case. So, US and Canada her the first two countries in the WHO AMRO region to report COVID-19 cases, making them to have 190 days and 184 days COVID-19 experience respectively. The last country in this region to report COVID-19 case is Saint Pierre and Miquelon, which have 111 days COVID-19 experience. There are 54 countries/territories that have reported COVID-19 cases in WHO AMRO region. Fig. 21 depicts that COVID-19 pandemic reached the WHO Europe region (EURO) through France, who reported her index case on the 24th January 2020 and reached 186 days of reporting COVID-19 on the 27th July 2020. Germany is the second country in EURO region to report COVID-19 with 182 days of reporting the pandemic. Other countries in this region are Finland and Italy who reported their index cases on the same day (29th January, 2020), making them to have 181 days COVID-19 experience. There are 61 countries/territories in EURO region, making them the region that has countries more than any other region to have reported COVID-19 pandemic. The last country in this region to report COVID-19 case is Tajikistan with 130 days COVID-19 experience.

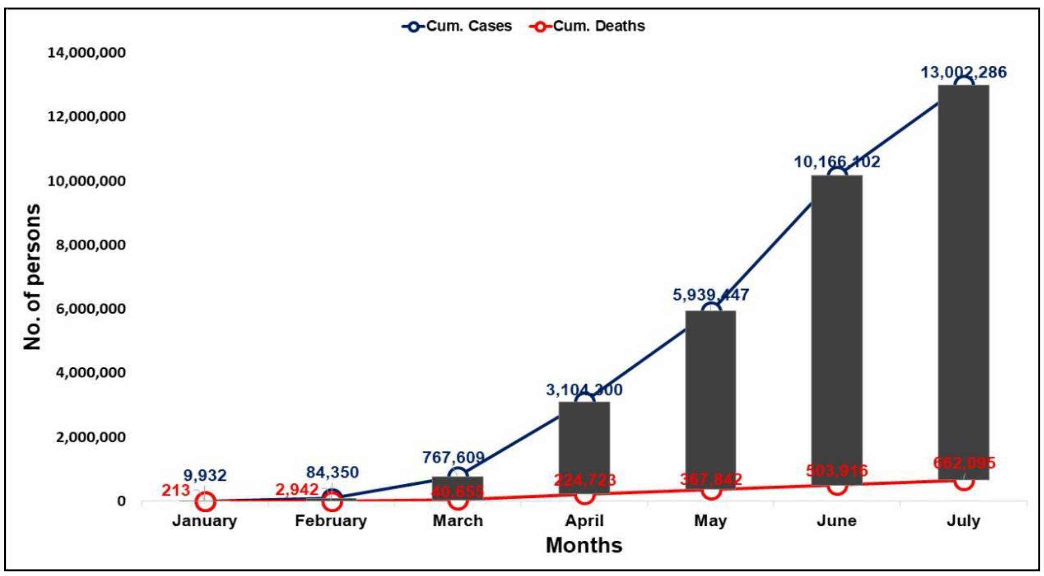

Fig. 17. Cumulative confirmed cases and deaths of COVID-19

Fig. 22 depicts that the United Arab Emirate (UAE) was the first country in the WHO Eastern Mediterranean region (EMRO) to report COVID-19 pandemic with 181 days reporting experience. Egypt is the second country in EMRO region to report COVID-19 on 14th February 2020 with 165 days reporting experience. Egypt, Morocco, Tunisia, Sudan, Somalia and Libya are all classified under WHO EMRO region. Yemen is the country with least days of COVID-19 experience. Yemen reported her index case on the 10th April 2020 with just 109 COVID-19 reporting experience. There are 22 countries in this EMRO region. Fig. 23 depicts that the Algeria was the first country in the WHO Africa region (AFRO) to report COVID-19 pandemic with 154 days reporting experience. Nigeria is the second country in AFRO region to report COVID-19 on 28th February 2020 with 151 days reporting experience. Lesotho is the country with the least days of COVID-19 experience, which reported her index case on the 14th May 2020, just two months ago with 75 days COVID-19 experience. There are 49 countries in WHO AFRO region. The number of countries/territories in each WHO region is depicted in Fig. 24.

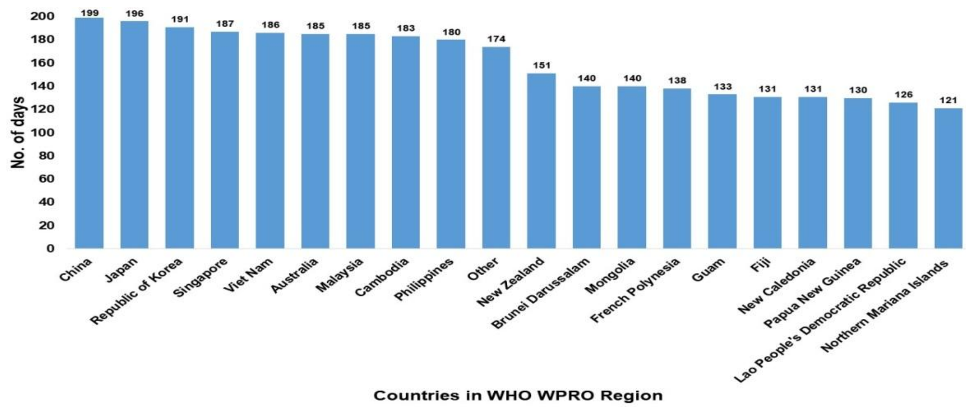

Fig. 18. COVID-19 experience in days of countries under WHO WPRO Region

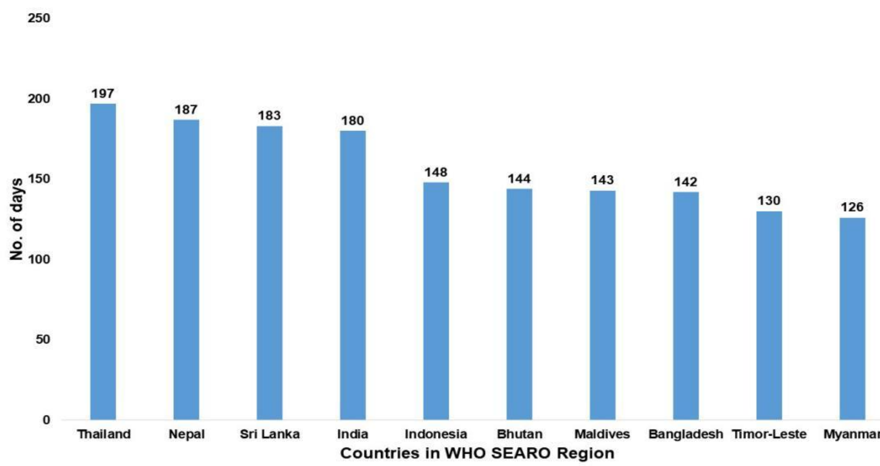

Fig. 19. COVID-19 experience in days of countries under WHO SEARO Region

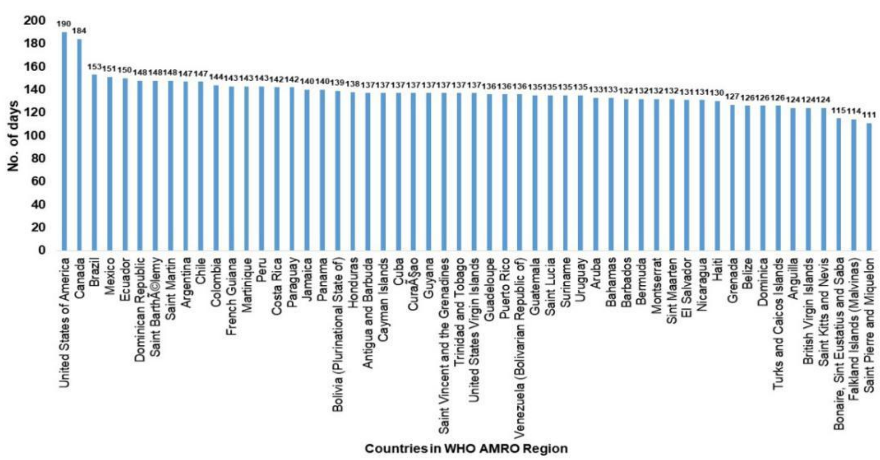

Fig. 20. COVID-19 experience in days of countries under WHO AMRO Region

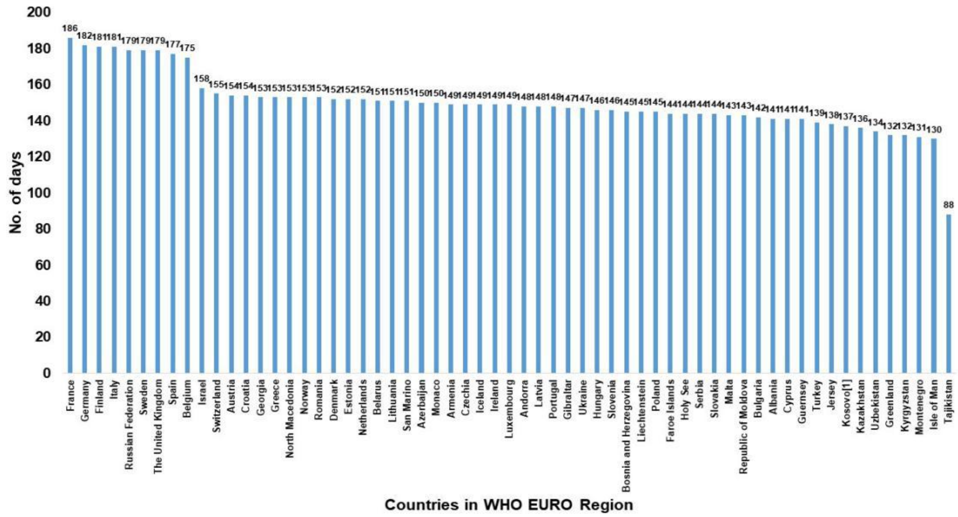

Fig. 21. COVID-19 experience in days of countries under WHO EURO Region

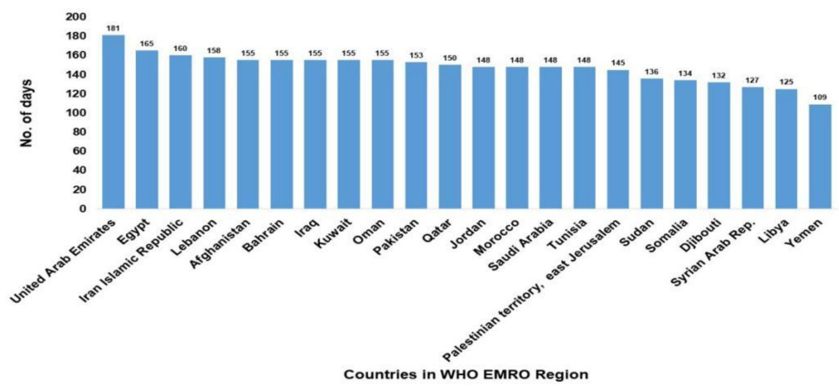

Fig. 22. COVID-19 experience in days of countries under WHO EMRO Region

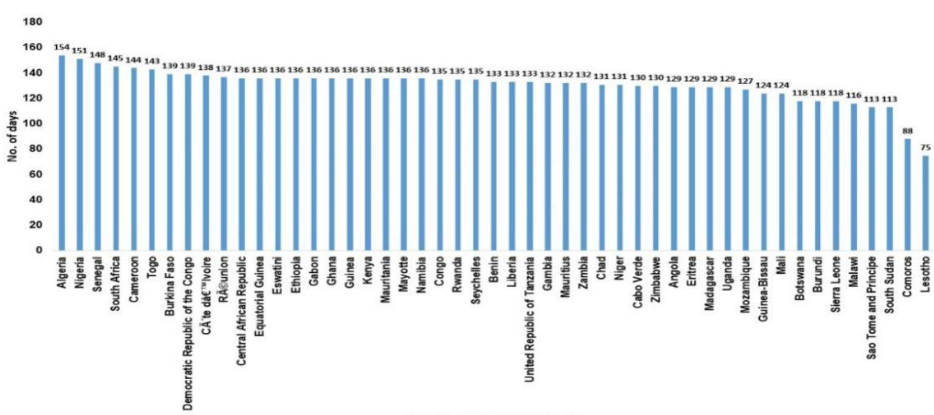

Fig. 23. COVID-19 experience in days of countries under WHO AFRO Region

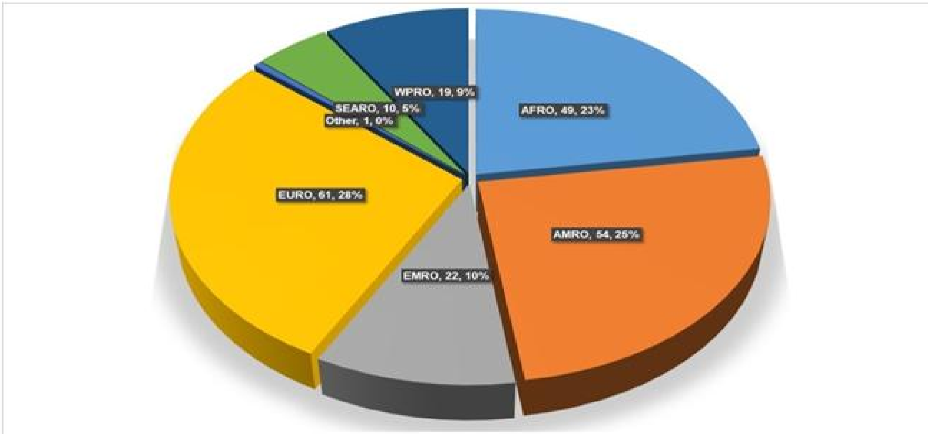

Fig. 24. Number of countries/ territories in WHO regions

4 Conclusion

The trending phenomenon of global emergency is COVID-19. Many dynamic and static models have been developed to forecast COVID-19 cases and mortality rate, but have not concentrated so much on the current report of COVID-19. This study has helped to discuss COVID-19 pandemic in detailed expository report taking account of monthly variations and aggregations based on WHO defined regions. The moment about empirical midpoint and adjusted theoretical midpoint was discussed as a novel method of describing a dataset. The EDA as a visualization tool to narrate the COVID-19 pandemic story. The results of the analysis show that the cumulative cases might be increasing but with slower changes flattening the cumulative curve. The good news from the analysis is that COVID-19 is not as deadly as initially portrayed. Then Africa is among the counties with less cases and mortality rates as compared with Europe and Americas. In months to come it is expected that number of deaths per day on the average will begin to drop from month to month. We also see that the midpoint can be used as a measure of average where mean and median are not appropriate. It is also seen from the cumulative time plots that the Europe region curve is flattening and that of Western Pacific. These regions started combating COVID-19 early with worst cases scenarios. But it is subsiding in these regions. It is expected that other regions will learn from the mistakes of these two regions and that of America region.

Consent

Authors have declared that no consent is required for this study.

Ethical Approval

Authors have declared that ethical approval is not required for this study. The data used is available on WHO situation report website. Anybody interested can have access to it and download it for their study.

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Competing Interests

Authors have declared that no competing interests exist.

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