

Evaluation of Four Years of COVID-19 Virus Impacts Based on Annual Total Confirmed Cases and Deaths Compared to the GDP Around the World, United States, New York and Texas

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Abstract

Over the past 4 years, starting on leap year 2020 (1st Year) the coronavirus that causes severe acute respiratory syndrome (SARA-2 (COVID-19)) has impacted the entire world with the total human death of over 6.97 million and in the U.S. it is was over 1.19 million. The COVID-19 virus is an organic structure with nucleic acid and protein coating and was transferred from bats to humans. Also several vaccines have been developed to control the COVID-19 virus disaster and the death rates have reduced in the past few months. It is also important to quantify the deaths and the number of affected humans due to COVID-19 virus, and the modeling of the trends based on the location might help to better understand the critical parameters influencing the COVID-19 virus impacts. The world and the U.S.A. annual death and annual confirmed cases peaked in year 2021 and 2022 respectively. Because of the COVID-19 impact the world Gross Domestic Products (GDP) was reduced from \$88 trillion to \$84.5 trillion, about 4% drop in year 2020. It also affected the GDP growth in the United States and also impacted all the states in the U.S. by varying amounts. Also the GDP ranking of the U.S. states correlated well with the COVID-19 impact. In the year 2021 the GDP growth (percentage increase) in the world and U.S.A. was the highest. Also the GDP has increased in years 2022 and 2023 at different rates in the world and the U.S.A. Also Texas and New York have had similar trends in the GDP growth. Vipulanandan p-q Model predicted the total death trends with time for the world, U.S.A., Texas and New York very well.

Introduction

Different types of viruses have impacted the human activities around the world over the past hundred years. It is important to understand the impact of virus attacks and cyber-attacks, both are human based disasters. Within the past two and a half years, COVID-19 has resulted in human deaths and also transforming all operations and activities including education of children online. Cyber-attacks have increased by over six times during this COVID-19 pandemic. Virus attack and cyber-attacks can get initiated any ware around the world occupied by humans, about 5% of the

earth surface. Hence monitoring is a major challenge before it starts spreading and impacting many humans in the region, unlike satellite monitoring of hurricane origin and pathway. Also virus spreading among humans can have many pathways and there is an urgent need for understanding the basic and fundamental science behind the virus spreading based on the type of virus, origin and the environment. Over the past hundred years, over dozen viruses have impacted the humans around the world including major economic losses (Vipulanandan 2020; Ettlinger and Hensley 2021).

Virus

Viruses are found wherever there is life and have probably existed since living cells first evolved on earth. Scientific studies have evolved over the past 150 years focused on the composition (nucleic acid (DNA, RNA) with protein coat), structure, size compared to bacteria. By the end of the 19th century, viruses were defined in terms of infectivity (ability to produce infection), ability to pass filters, and requirement for living hosts. Also pig corneal tissue and hen kidney were used in vaccine production. Another breakthrough came in 1931, when the pathologist Ernest William Goodpasture and Alice Miles Woodruff grew **influenza** and several other viruses in **fertilized chicken eggs**. In 1949, John Franklin Enders, Thomas Weller, and Frederick Robbins grew **polio virus** in cultured human embryo cells, the first virus to be grown without using solid animal tissue or eggs. This work enabled Jonas Salk to make an effective **polio vaccine**. The second half of the 20th century was the golden age of virus discovery and most of the over 2,000 recognized species of animal, plant, and bacterial viruses were discovered during these years.

Opinions differ on whether viruses are a form of life, or **organic structures** that interact with living organisms. A complete virus particle, known as a virion, consists of nucleic acid surrounded by a protective coat of protein called a capsid. Although they have genes, they do not have a cellular structure, which is often seen as the basic unit of life. Viruses do not have their own metabolism, and require a host cell to make new products. Viruses display a wide diversity of shapes and sizes, called 'morphologies'. In general, viruses are **much smaller than bacteria**. Most viruses that have been studied have a diameter between 20 and 300 nanometres.

Virus is transferred as a result of human interaction with living cells including animals, birds, plants and bacteria where the virus is very active and represented as follows:.

Living Cells (Animal/bird/plants/bacteria) + human \longrightarrow Virus Transferred

Various types of viruses have impacted the world over the past century.

SARS-CoV-2 (COVID-19) (Bats)

SARS-CoV-2 belongs to the same large family of viruses as SARS-CoV, known as coronaviruses, and was first identified in **December 2019 in the Chinese city of Wuhan (Figure 1)**. The virus likely **originated in bats**, like SARS-CoV, and passed through an intermediate animal before infecting people.

Since its appearance, the virus has infected tens of thousands of people in China and millions of others around the world. The ongoing outbreak prompted an extensive quarantine of

Wuhan and nearby cities, restrictions on travel to and from affected countries and a worldwide effort to develop diagnostics, treatments and vaccines.

The **disease caused by SARS-CoV-2, called COVID-19**, has an estimated mortality rate of about 2.3%. **People who are older or have underlying health conditions** seem to be most at risk of having severe disease or complications. **Common symptoms include fever, dry cough and shortness of breath, and the disease can progress to pneumonia in severe cases.**

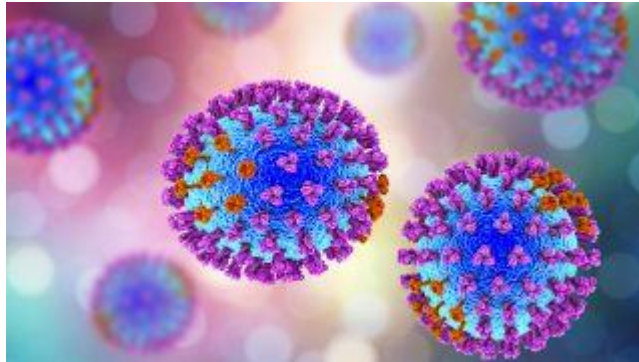


Figure 1 Image of COVID-19 Virus

The COVID-19 virus has really impacted the entire world in a very short time period. It has impacted all activities including education, business, construction and manufacturing. The oil price dropped to its minimum value of -\$40 dollars a barrel on April 20, 2020 in the history of oil market. Hence there is an urgent need to understand the problem to make safe decisions to minimize losses.

Transfer Media

It started in China and then spread around the world in stages going across Indian Ocean and Atlantic ocean from continent to continent. Initially it impacted many countries above the equator but now many countries below the equator are impacted. It is important to understand the modes of transfer of COVID-19 around the world in a very short time period. This will definitely help minimize the human deaths and infected cases. It is also important look at the ground conditions, environments, human activities and also international travel. In the U.S. coastal states have been impacted the most.

Virus therapy

There are two types of therapies characterized as gene therapy and cell therapy. Over the decades gene therapy has been developed for controlling various types of virus attacks. In addition to developing the gene therapy, it is also important to develop the viral vector to deliver the medication to the right location in the body. Also artificial virus are used as part of the viral vector.

The Pfizer vaccine that is being used in the U.S. and around the world is a gene therapy. Few other vaccines have been developed around the world for COVID-19 virus treatment.

Objectives

The objective is to investigate the trends and impact of COVID-19 virus around the world and United States and also selecting two states in the U.S.A. in the past 4 years. The specific objectives are as follows:

- (a) Compare the annual total confirmed cases and deaths around the world and in the U.S.A. and develop models to predict the confirmed cases and the deaths. Also verify the impact on the Gross Domestic Products (GDP).
- (b) Compare the annual total confirmed cases and deaths in Texas and the New York (initially badly affected state in the U.S.A.) and develop models to predict the confirmed cases and the deaths. Also verify the impact on the Gross Development of Products (GDP).

In this study, data collected on COVID-19 impact over the past 48 months was used. The data was collected from various data bases and it included the world, U.S.A. and two states in the U.S.A.

COVID-19 Virus

Data Analyses

In the year 2020, European countries such as Italy, Spain and United Kingdom and the U.S.A., above the equator with very high Gross Domestic Product (GDP), had the largest impact on the annual growth of GDP based on the deaths and total number of confirmed cases. It is important to quantify and interpret the trends observed around the world and the U.S.A. in 4 years and it is analyzed annually.

(a). World versus U.S.A. (Table 1)

Year-1 (2020)

It will be of interest to compare the impact of COVID-19 virus around the world and the U.S.A. with the highest GDP of \$21.06 trillion (Year 2019). The difference in the annual total confirmed cases and annual death numbers between the world and the U.S.A was investigated.

World

There are over 210 countries around the world with a total population of 8 billion. The COVID-19 has impacted the countries in many different ways based on the location, environment, economic activities (GDP) and population density. In Table 1, annual confirmed cases and deaths are summarized.

Confirmed Cases: The year-1 confirmed cases was over 82.6 million, over 1% of the world population (Table 1). Based on past studies the rate of increase in confirmed cases was the highest in July which was **6.8 M/m** and also shown in Figure 1 (Vipulanandan 2023)

Death Cases: The year -1 deaths were over 1.8 million as summarized in Table 1. Based on past studies the death rate peaked in April and was **159K/m**. The death rates have reduced in May and

June to about **146K/m** and **122k/m** respectively. The death rate was maximum in July and was **371K/m**, more the 2.3 times the previous maximum of 159K/m and also shown in Figure 1 (Vipulanandan 2023).

United States of America (USA)

Confirmed Cases: The total confirmed cases were over 19.7 million, 23.8% of the world confirmed cases also highest in the world and **matched with the GDP ranking**. Based on the past studies the confirmed cases in April were **905K/m**. In the month of May, the confirmed cases decreased to **757K/m**. In the month June the confirmed cases have increased to **877K/m**. The confirmed case in July increased to **1.8M/m**. The highest confirm cases per day were on July 1, and it was 51,091 and also shown in Figure 1(a) (Vipulanandan 2023).

Death Cases: Total death cases were over 342 thousand (Table 1), 19% of the world death also highest in the world and **matched with the GDP ranking**. Based on the past studies the death rate in April was **58.9K/m**. Also the highest death rate for a day was **2683/day** on April 21 and on April 15 it was **2631/day**. In the month of May, the death rate was **42.6K/m** and in June it has reduced to **23.7K/m**. In July the death rate was **22.5K/m**. The U.S. population is only 4.5% of the world population, so the death rate is over 4 times higher and hence doesn't match with the total population, which is ranked 3rd in the world (Vipulanandan 2023)..

Year -2 (2021)

World

The data are summarized in Table 1.

Confirmed Cases: The year-2 confirmed cases was over 199.1 million, about 2.5% of the world population (Table 1). Based on the past studies the confirmed cases reduced for two months and then increased in April 2021 which was **24.2 M/m**. In the following months it has decreased.

Death Cases: The year -2 deaths were **over 3.6 million** as summarized in Table 1, doubled year-1 (2020) also the **highest per year in world history**. Based on the past studies the death rate reduced for two months from the peak in January 2021 of **402.8K/m**. The death rate increased in April to 400K/m and reduced in the following months till end of July 2021.

United States of America (USA)

The rate of confirmed cases and deaths continuously decreased (Table 1).

Confirmed Cases: The year-2 confirmed cases was about 34 million, over 70% more than year-1 (Table 1) about 10% of the U.S. population. Based on the past studies the confirmed cases in February 2021 was **2.7M/m**. In the month of June, the confirmed cases decreased to **0.5M/m** but increased in July to **1.4M/m**. The confirmed case rates are compared in Figure 1(a).

Death Cases: The year -2 deaths were over 497 thousand as summarized in Table 1, 45% more than year -1. Based on the past studies the death rate has continuously decreased from **94.5K/m** in January 2021. In April it was **30.3K/m**. In August the death rate was **30.8K/m**. The total death in year -2 (2021) was about 13.7% of the world deaths and is the highest in the world and **matched with the GDP ranking**. The U.S. population is only 4.5% of the world population, so the death

rate is over 3 times higher and hence doesn't match with the total population, which is ranked 3rd in the world.

Year - 3 (2022)

World

The data are summarized in Table 1.

Confirmed Cases: The year-3 confirmed cases was over **389 million**, nearly doubling year-2 (Table 1) and the **highest in world history**. Based on the past studies the total confirmed cases continuously increased to **580,366,202** end of July 2022. In January 2022 the confirm cases were 8.8 M/m. And in February and March 2022 it reduced to 4.8 M/m and in April and May it increased to 21.2 M/m. In June and July 2022 it increased to **24.5 M/m** the highest rate recorded over the past 2.5 years. The confirmed case rates are compared in Figure 1(a).

Death Cases: The year -3 deaths were over 1.3 million as summarized in Table 1, about 36% of year-2. Based on past studies the death rate decreased from **336.6K/m** in July 2021 (highest death rate recorded) to **52.9K/m** in July 2022. The death rates are compared in Figure 1(b).

United States of America (USA)

The data are summarized in Table 1.

Confirmed Cases: The year-3 confirmed cases was **over 49.8 million**, the **highest in the U.S. history** (Table 1). Based on past studies the rate of confirmed cases was **18.7M/m in January 2022, the highest rate of confirmed cases in the U.S.A.** In February and March it reduced to 1.9 M/m and in April and May it reduced to 0.2 M/m. In June and July 2022 it increased to **3.5 M/m**. The U.S.A. confirmed case rates are compared to the World in Figure 1(a).

Death Cases: The year -3 deaths were over 286 thousand as summarized in Table 1, 58% of year-2. Based on past studies the total death rate was **66.4K/m** in January 2022. It continuously decreased to 12.2K/m in July 2022. The U.S.A. death rates are compared to the world death rates in Figure 1(b).

Year - 4 (2023)

World

The data are summarized in Table 1.

Confirmed Cases: The year- 4 confirmed cases was over 31 million, over 8% of the worst year-3 (Table 1). Based on past studies the confirmed cases was 6.21 M/m in February 2023 and 2.9 M/m in July 2023. The confirmed case rates are compared in Figure 1 (a).

Death Cases: The year - 4 deaths were over 243 thousand as summarized in Table 1. Based on past studies the rate of death was **51.8K/m** in February 2023. The death rates are compared in Figure 1(b).

United States of America (USA)

The data are summarized in Table 1.

Confirmed Cases: The year-4 confirmed cases was over 7.1 million, 14% of year-3 the worst in the U.S. history (Table 1). Based on past studies the confirm case was **1.2 M/m** in February 2023. It reduced to **0.5 M/m** in July 2023. The U.S.A. confirmed case rates are compared to the World in Figure 1(a).

Death Cases: The year-4 deaths was over 68 thousand as summarized in Table 1, the lowest in the past 4 years. The U.S.A. death rates are compared world death rates in Figure 1(b).

Table 1. Comparing the COVID-19 Impact on the World and U.S.A. (Annual)

Date	World		United States		Remarks
	Total and Yearly Confirmed Cases	Total and Yearly Deaths	Total and Yearly Confirmed Cases	Total and Yearly Deaths	
12/31/2020 (Year 1) 2020	82,686,157 82,686,157	1,805,002 1,805,002	19,740,468 19,740,468	342,312 (19.0%)* 342,312 (19.0%)*	World annual confirmed cases and death were 82.7M/year and 1.8M/year . U.S. confirmed cases and death were 19.7M/year and 0.34M/year .
12/28/2021 (Year 2) 2021	281,838,851 199,152,694	5,422,991 3,617,989	53,737,689 33,997,221	839,429 (15.5%)* 497,117	World annual confirmed cases and death were 198.2M/year and 3.6M/year . U.S. annual confirmed and death were 34M/year and 0.5M/year .
1/16/2023 (Year 3) 2022	671,375,010 389,536,159	6,730,560 1,307,569	103,577,391 49,839,702	1,125,541 (16.7%)* 286,112	World annual confirmed cases and death were 389.5M/year and 1.3M/year . U.S. annual confirmed and death rate were 49.8M/year and 286.1 K/year .
1/26/2024 (Year 4) 2023	702,382,516 31,007,586	6,973,669 243,109	110,757,619 7,180,228	1,193,694 (17.1%)* 68,153	World annual confirmed cases and death were 31.0M/year and 0.24M/year . U.S. annual confirmed and death were 7.2M/year and 68.1K/year .
Remarks	Over 702 Millions of confirmed cases during the past 4 years. Highest	Total death was over 6.9 million and the highest	U.S. had the highest annual confirmed cases in year 2022.	U.S. had the highest annual deaths of over 497,000	COVID-19 has impacted the world. U.S.A. had the highest annual confirmed cases and annual total deaths (No. 1) for the past four years and matched

	was in year 2022	was in year 2021		in year 2021	with the world GDP rating of being No. 1.
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- *Percentage total death in the U.S.A. based on the total World Deaths

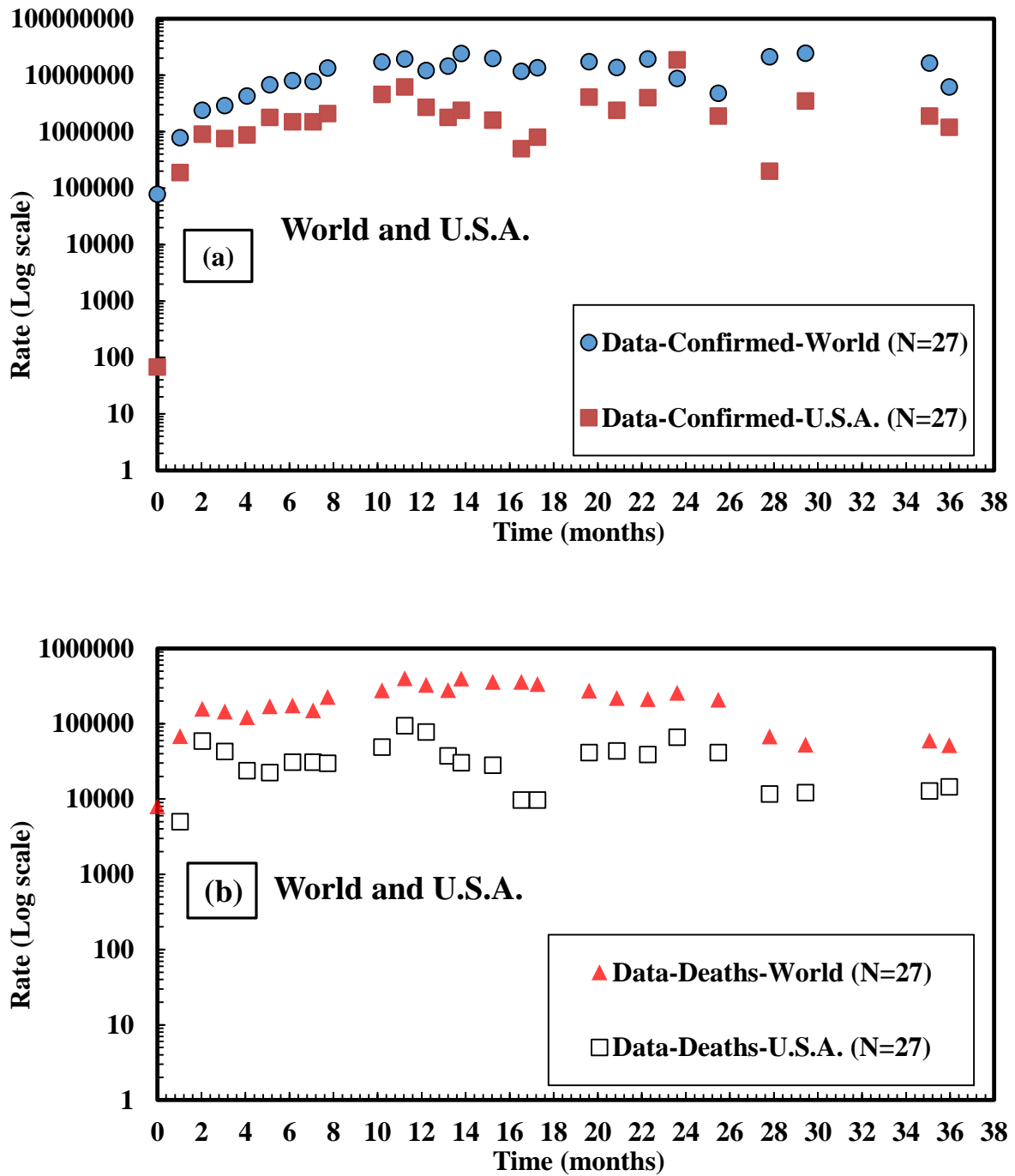


Figure 1. Comparing the World and the U.S.A. (a) Rate of Confirmed Cases and (b) Rate of Deaths (Vipulanandan 2023)

Vipulanandan p-q Model

It is important to predict the observed trends for the total deaths (Y) with time (t) using analytical models. Preliminary investigation was done using Vipulanandan p-q model (Vipulanandan et al. 2018). The model parameters can be used to evaluate the important parameters that are impacting the COVID-19 the total deaths.

$$\frac{Y-Y_0}{Y_f-Y_0} = \left[\frac{\frac{t-t_0}{t_f-t_0}}{q+(1-p-q)\frac{t-t_0}{t_f-t_0} + p \left(\frac{t-t_0}{t_f-t_0}\right)^{\frac{p-q}{p}}} \right] \tag{1}$$

Model parameters (p, q, Y₀, Y_f and t₀) will be related to the critical variables such as population, population density, GDP (economic activity), temperature, relative humidity, food, transport facilities, animals and others.

The rate of death increased with time and then decreased. The model is predicting this trend very well. The total death model predictions are compared to the data in Figure 3 for the world and the U.S.A. The model parameters p and q for the world and U.S. are summarized in Table 2. Also the model parameter ratio q/p was 3.0 and 0.52 for the world and the U.S.A. respectively.

Table 2. Vipulanandan p-q Model parameters for the death predictions for the World and U.S.A.

State	Maximum Death (Y _f)	Time for Max. Death (t _f) (days)	p	q	R ²	RMSE (Number of people)	Remarks
World	6,973,669	1440	0.068	0.190	1.0	122,026	Rate of deaths increased up to about 600 days and then decreased with time
U.S.A	1,193,694	1440	0.070	0.180	0.99	25,277	Rate of deaths increased with time for a long time.
Remarks	U.S.A. had the highest number of deaths in the world.	January 2021 had the highest rate of deaths in the world. Slope was highest.	Decreased with the increased number of deaths and also shape of the trend.	Increased with the increased number of deaths and also shape of the trend	Coefficient of determination was good for the highly varying data .	Represents the accuracy of the predictions	The Model predicted the total deaths with time very well.

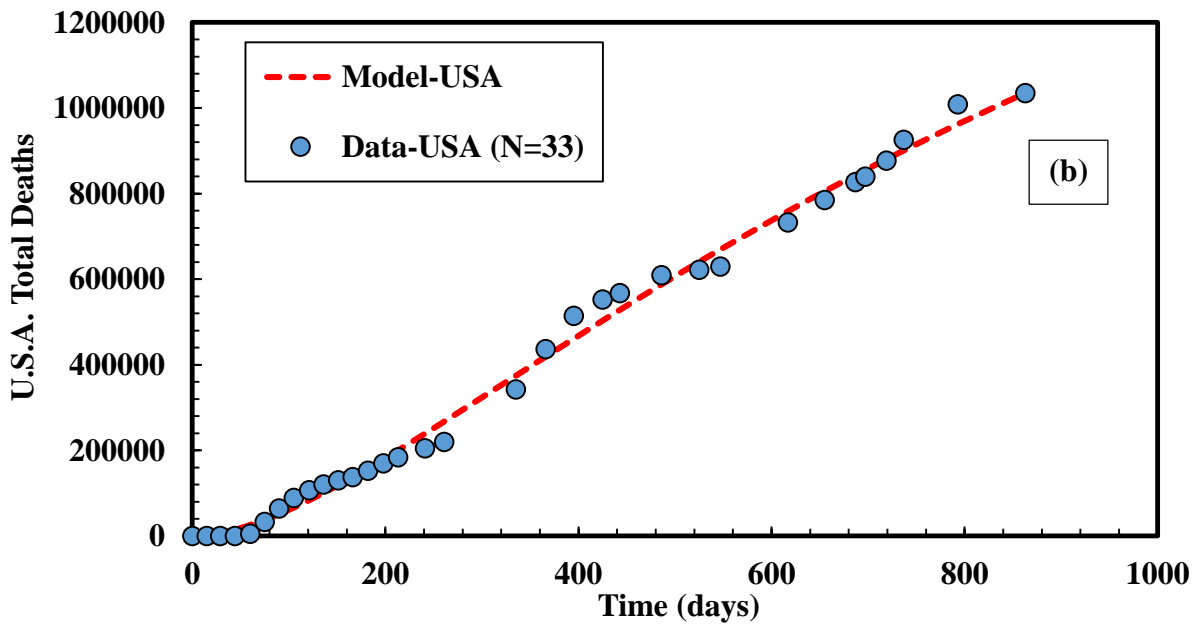
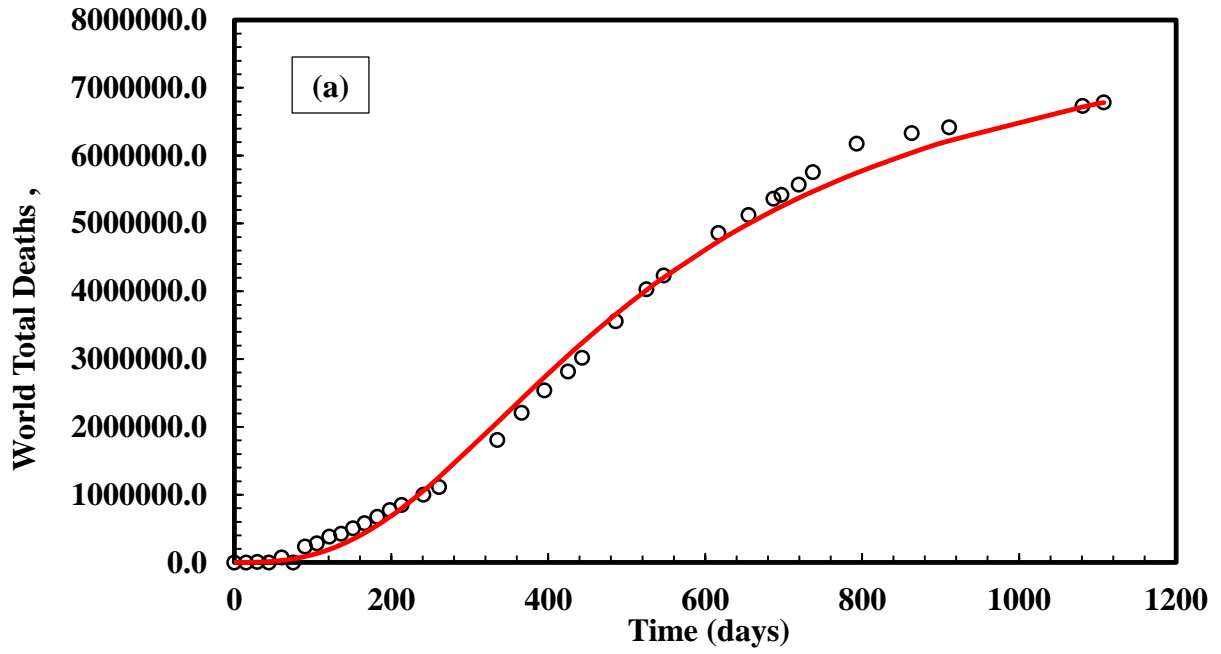


Figure 2. Vipulanandan Model Prediction of Total Deaths with Time (a) World and (b) United States of America

(b). New York Versus Texas (Table 3)**Year-1 (2020)****New York Versus Texas**

In the U.S.A. the coastal states were more impacted by the COVID-19. For comparison, State of New York (GDP no.3 in the U.S.) was selected to represent the east coast with the Atlantic Ocean and Texas (GDP no.2 in the U.S.) along the Gulf of Mexico (GOM). Both these states are also impacted by hurricanes and flooding. Data are summarized in Table 3.

New York State (GDP \$1.9 Trillion, 8% of U.S. GDP and #3 in the U.S.)

New York State data are summarized in Table3.

Confirmed Cases: The year-1 confirmed cases was over 998 thousand. Based on past studies New York had its highest rate of confirmed cases in April (Tax Month in the U.S.). The confirmed cases in April were 234K/m (26% of U.S.). In the month of June the confirmed cases reduced to 79K/m. The last few weeks death rate has dropped to below 40/day. The highest confirm cases per day was on **April 15, and it was 11,661**. Also the confirmed cases per month are in Figure 3 (a).

Death Cases: The year -1 deaths were over 37.8 thousand as summarized in Table 3. Based on past studies the New York had its highest rate of deaths in April (Tax Month in the U.S.). The death rate was 21.1K/m (36% of U.S.). The highest death rate for a day was 1025/day on April 17 and on April 15 it was 888/day. In the month of June the death rate has reduced to 6.7K/m and are in Figure 3(b) (Vipulanandan 2023).

The population in New York City is about 8.4 million and the population density is 27,558 people/square miles. This is about 7.6 times higher than Houston, largest city in Texas.

Texas State (GDP \$2.1 Trillion, 11.3% of U.S. GDP and #2 in the U.S.)

Texas had very high confirmed cases compared to New York but the total deaths were lower during the Year- 1 (Table 3).

Confirmed Cases: The year-1 confirmed cases was over 1.7 million, 76% higher than New York (Table 1). Based on past studies the Texas had its highest rate of confirmed cases of **276K/m in July**. The confirmed cases in May was 36.4K/m. In the month June the confirmed cases have increased to 102K/m. The highest confirm cases per day was on July 28, and it was 11,037.

Death Cases: The year -1 deaths were about 27.9 thousand as summarized in Table 1. Based on past studies the Texas had its highest rate of deaths in July of **4.5K/m**. The highest death rate for a day was 154/day on July 15 and on April 15 it was 30/day. In the month June the death rate was 810/m. The last few weeks death rate has increased and the maximum was 499/day on July 13 (Vipulanandan 2023).

The population in Houston, largest city in Texas is 2.3 million and the population density is 3,634 people/square miles. Houston population is 27.4% and population density is 13% of New York City. The Houston death percentage is in between the population and population density.

Year -2 (2021)

New York

The data are summarized in Table 3.

Confirmed Cases: The year-2 confirmed cases was over 2.3 million, over 233% higher than year-1 (Table 1). Based on past studies the confirmed cases was **433.8K/m** in January 2021, the highest confirmed cases in one year.

Death Cases: The year -2 deaths were over 21.7 thousand (**K**) as summarized in Table 3. Based on past studies the death rate in New York has decreased In August it was 196/m. It increased to 1.8K/m in December (Figure 3(b)).

Texas

Confirmed Cases: The year-2 confirmed cases was over 2.7 million, increased by 57.5% over year-1 (Table 1). Based on past studies the Texas had its highest rate of confirmed cases of **596K/m in January 2021**.

Death Cases: The year-2 deaths were over 47.9 thousand (**K**) as summarized in Table 3, increased by 72%. Based on past studies the Texas had its highest rate of deaths in January 2021 of **9.0K/m**, double the rate in July 2020.

Year -3 (2022)

New York

The data are summarized in Table 3.

Confirmed Cases: The year-3 confirmed cases was about 3.5 million, the highest and about 50% higher than year-2. Based on past studies in January 2022 the confirmed cases increased to **1.3M/m**. And in February and March 2022 it reduced to **84.2K/m** and in April and May it increased to **221K/m**. In June and July 2022 it reduced to **18.1K/m**. The confirmed case rates are compared in Figure 3(a).

Death Cases The year-3 deaths were over 16.3 thousand (**K**) as summarized in Table 3. Based on past studies the rate of death was **5.0K/m** in January 2022 and then decreased. The death rates are compared in Figure 3(b).

Texas

The data are summarized in Table 3.

Confirmed Cases: The year-3 confirmed cases was over 3.7 million, the highest cases per year and was 35% higher than year-2 (Table 3). Based on past studies the rate of confirmed cases increased to **1.5M/m in January 2022, the highest rate of confirmed cases in Texas**. In February and March it reduced to **163K/m** and in April and May it reduced to **111K/m**. In June and July

2022 it reduced to **46K/m**. The Texas confirmed case rates are compared to New York in Figure 3(a).

Death Cases: The year -3 deaths were over 16.7 thousand as summarized in Table 3. Based on past studies the death rate was **4.0K/m** in January 2022. It continuously decreased to **0.8K/m** in July 2022. The Texas death rates are compared to the New York death rates in Figure 3(b).

Year - 4 (2023)

New York

The data are summarized in Table 3.

Confirmed Cases: The year-4 confirmed cases was over 620 thousand (**K**), the lowest in the 4 years (Table 3). Based on past studies the confirmed cases were **154 K/m** in January and **89 K/m** in February 2023. The confirmed case rates are compared in Figure 3(a).

Death Cases: The year -4 deaths were over 6.4 thousand (**K**) as summarized in Table 3, the lowest in the past 4 years. Based on past studies the death rate was **0.9 K/m** in February 2023. The death rates are compared in Figure 3(b).

Texas

The data are summarized in Table 3.

Confirmed Cases: The year-4 confirmed cases was over 762.7 thousand (**K**) as summarized in Table 3, the lowest in the past 4 years (Table 3). Based on past studies the total confirmed cases was **139 K/m** in January and **94 K/m** in February 2023. The Texas confirmed case rates are compared to New York in Figure 3(a).

Death Cases: The year -4 deaths were over 3.1 thousand (**K**) as summarized in Table 3, the lowest in the past 4 years. Based on past studies the death rate was **0.5 K/m** in January and was **0.8 K/m** in February. The Texas death rates are compared to the New York death rates in Figure 3(b).

Table 3. Comparing the COVID-19 Impact on New York and Texas. (Annual)

Date	Texas		New York		Remarks
	Total and Yearly Confirmed Cases	Total and Yearly Deaths	Total and Yearly Confirmed Cases	Total and Yearly Deaths	
12/31/2020 (Year 1) 2020	1,759,131	27,898	998,524	37,868	Texas annual confirmed cases and deaths were 1.76M/year and 27.9K/year. New York annual confirmed and deaths were 1.0M/year and 37.9K/year.

12/28/2021 (Year 2) 2021	4,530,738 2,771,607	75,876 (9.0%)* 47,978	3,333,938 2,335,414	59,598 (7.1%)* 21,730	Texas annual confirmed cases and deaths were 2.77M/year and 48.0K/year . New York annual confirmed and deaths were 2.3M/year and 21.7K/year .
1/16/2023 (Year 3) 2022	8,268,095 3,737,357	92,600 (8.2%)* 16,724	6,827,542 3,493,604	75,909 (6.7%)* 16,311	Texas annual confirmed cases and deaths were 3.74M/year and 16.7K/year . New York annual confirmed and deaths were 3.5M/year and 16.3K/year .
1/26/2024 (Year 4) 2023	9,030,821 762,726	95,747 (8.0%)* 3,147	7,448,149 620,607	82,367 (6.9%)* 6,458	Texas annual confirmed cases and deaths were 0.76M/year and 3.1K/year . New York annual confirmed and deaths were 620K/year and 6.5K/year .
Remarks	Confirmed cases have exceeded 9.0 million, 30% of the Texas population. Confirm cases of 3.7 M/year was highest in year 2022.	Deaths were highest in year 2021	Highest confirmed cases was in year 2022	Highest annual deaths was in year 2020.	COVID-19 has impacted the coastal states, Texas and New York having the high GDP rating and populations in the U.S.A.

- *Percentage death in the State based on the U.S. Deaths

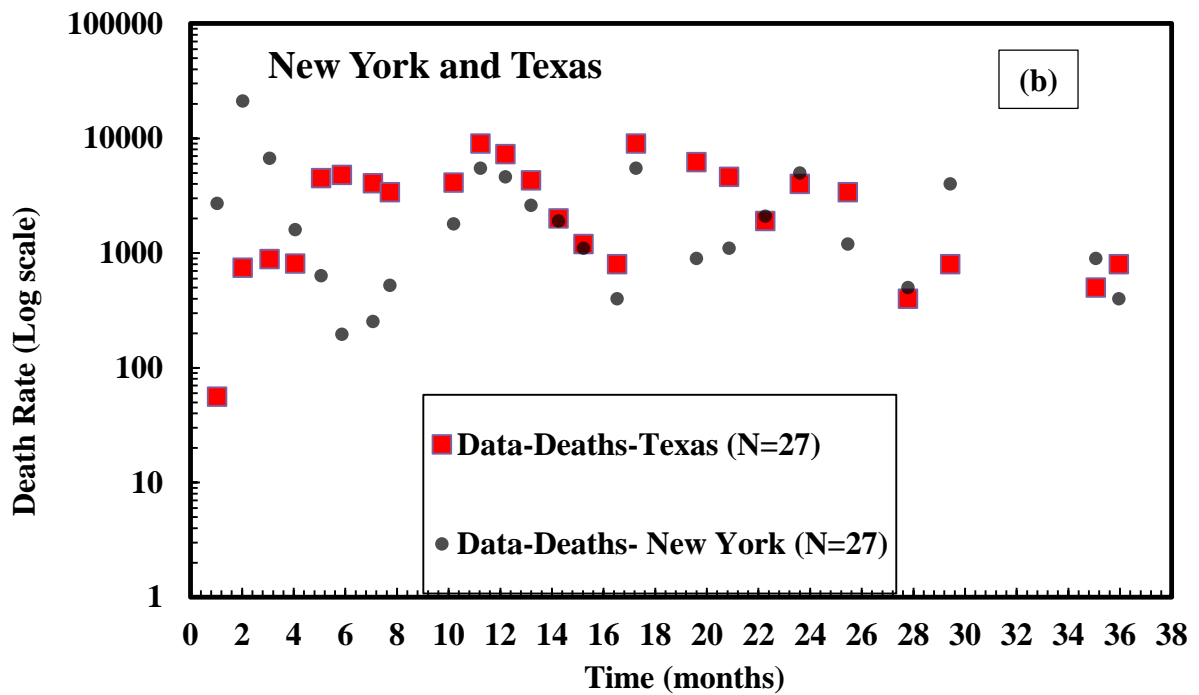
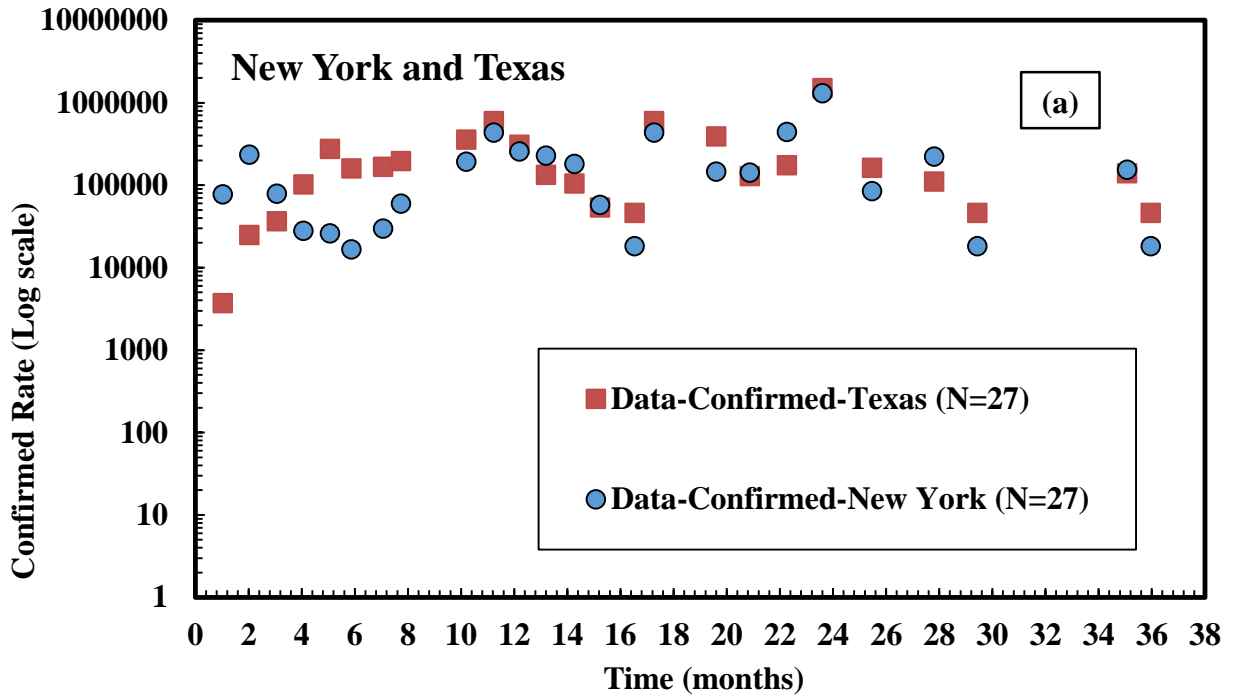


Figure 3. Comparing New York and Texas (a) Rate of Confirmed Cases and (b) Rate of Deaths

Vipulanandan p-q Model Predictions

The model predictions are compared to the data in Figure 4 for New York and Texas. Also the model parameters are summarized in Table 4. Both p and q parameters were lower for New York compared to Texas. The Model parameter ratio q/p was 0.11 and 2,6 for New York and Texas respectively and represents the shape of the trends for the equal time period. The model parameter q decreased with the decrease in deaths.

Table 4. Vipulanandan p-q Model parameters for the death predictions for Texas and New York

State	Maximum Death (Y_f)	Time for Max. Death (t_f) (days)	p	q	R^2	RMSE (Number of people)	Remarks
New York	82,367	1440	2.0	0.19	0.94	4,444	Rate of deaths initially decreased with time and increased and then decreased again.
Texas	95,747	1440	0.062	0.163	0.99	2,183	Rate of deaths initially increased then decreased with time and increased again and then decreased.
Remarks	New York had the 4 th highest number of deaths in the U.S.	Deaths over 1251 days (Over 41 months)	Decreased with number of deaths.	Increased with number of deaths.	Coefficient of determination was very high and good	Represents the accuracy of the predictions	Predicted the total deaths with time very well.

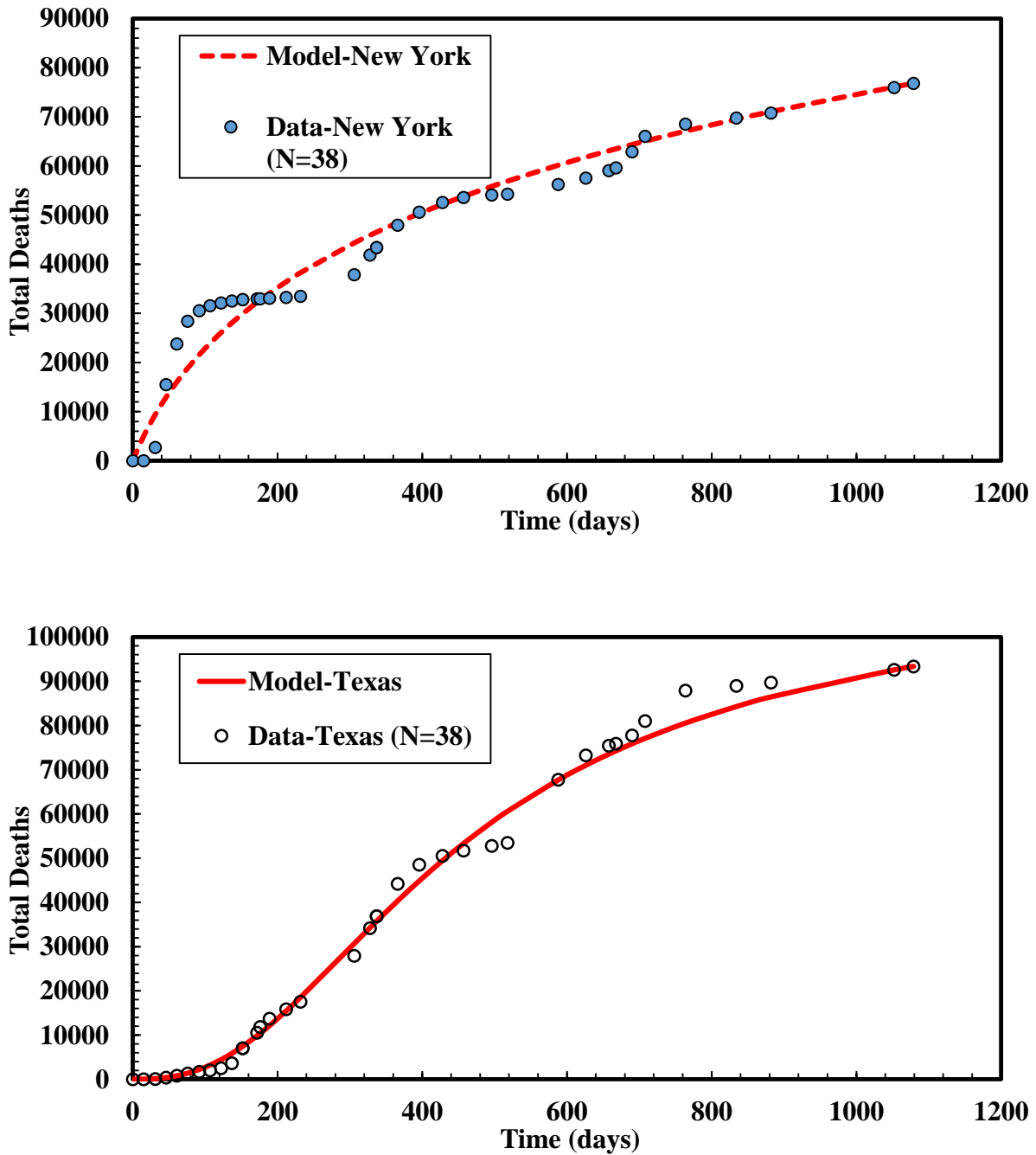


Figure 3. Vipulanandan p-q model predictions are compared to the death data (a) New York and (b) Texas

Gross Domestic Product (GDP)

World (Table 5)

Economic activity, as measured by Gross Domestic Product (GDP), was down in year 2020 from year 2019. The GDP was \$88 trillion in 2019 and it dropped to \$84.5 trillion on 2020,

reduction of 4.0% may be because of the COVID-19 total confirmed cases and also total deaths. In 2021 the world GDP will be \$96.9 trillion, 14.7% increase over year 2020 although world had the largest annual total deaths and also the highest rate of deaths. In year 2022 the GDP was \$100.6 trillion, an increase of 3.8% which was lower than the previous year growth of 14.7%. This agrees with the highest number of COVID-19 cases and also highest rate of confirmed cases in year 2022 as summarized in Table 5.

In year 2023, the GDP was \$103.1 trillion, a growth rate of 2.5% from 2022. The growth rate of increase may have decreased because of the highest number of COVID-19 cases and also highest rate of confirmed cases in the previous year 2022 as summarized in Table 5

Table 5. World GDP Trends

Year	2019	2020	2021	2022	2023
Amount	\$ 88 trillion	\$ 84.5 trillion	\$ 96.9 trillion	\$ 100.6 trillion	\$ 103.1 trillion
Percent Change		-4.0%	14.7%	3.8%	2.5%
COVID					
Total Confirmed Cases	0	82,686,157	199,152,694	389,536,617	31,007, 506
Rate of Confirmed Cases per month	0	78 K/m to 17.1 M/m	13.6M/m to 19.9M/m	8.8 to 24.5M/m	Reduced from 16.5M/m to 2.9M/m
Total Deaths	0	1,805,002	3,617,989	1,307,569	243,109
Rate of Deaths	0	8 K/m to 277.3K/m	402.8K/m to 212.3K/m	257.1K/m to 52.9K/m	59.6K/m to 23.4K/m

Number in Red Color is the Highest Number for that Row

U.S. (Table 6)

Nationally, GDP reduced from \$21.38 trillion to \$21.06 trillion as summarized in Table 6 due to the COVID-19 impact. The percentage growth in year 2019 was 4.13% and it decreased to -1.5% in year 2020 due to the COVID -19 impact with the confirmed cases and total deaths in year 2020.

In the first three quarters of 2020, the changes ranged from the 0.1% gain for Utah to losses of over 5% for Hawaii (8.8%), Wyoming (7.8%), New York (6.1%), Oklahoma (5.6%), and Louisiana (5.3%). Texas and California losses were 3.6% and 3.7% respectively.

In year 2021 the GDP was \$23.32 trillion, a 10.71% increase from year 2020, although U.S.A. had the highest number of deaths in year 2021.

In year 2022 the GDP increased to 25.46 trillion, a 9.2% increase over 2021. The percentage increase in the GDP reduced from 10.71% to 9.2% may be because of the highest total and rate of confirmed cases in year 2022. Also the highest total death and rate of death in year 2021 may have impacted the rate of growth.

In year 2023 the GDP increased to \$27.36 trillion, 6.3% increase over year 2022. The percentage increase in the GDP may have reduced from 9.2% to 6.3% may be because of the highest total and rate of confirmed cases in year 2022.

Table 6. U.S.A. GDP Trends

Year	2019	2020	2021	2022	2023
Amount	\$ 21.38 trillion	\$ 21.06 trillion	\$ 23.32 trillion	\$ 25.46 trillion	\$ 27.36 trillion
Percent Change	4.13%	-1.5%	10.73%	9.2%	7.5%
COVID					
Total Confirmed Cases	0	19,740,468	33,997,221	49,839,702	7,180,228
Rate of Confirmed Cases per month	0	68/m to 4.6 M/m	0.8M/m to 6.2M/m	0.2 to 18.7M/m	1.9 M/m to 0.5M/m
Total Deaths	0	342,312	497,117	286,112	68,153
Rate of Deaths	0	0 to 49.1K/m	9.7 K/m to 94.5K/m	11.7K/m to 66.4K/m	12.8K/m to 5.6K/m

Number in Red Color is the Highest Number for that Row

Texas (Table 7)

Texas is ranked No. 2 in the U.S. and the year 2019 the GDP was \$1.779 trillion it increased by 1.9%. In year 2020 the GDP was \$1.747 trillion and it dropped by -1.8% as summarized in Table 7 due to the COVID-19 virus impact

In year 2021 the GDP was \$1.815 trillion, a 3.9% increase In 2021 the death was highest. So deaths did not correlate with the increase in GDP and agreeing with the trends observed for the U.S.A. GDP and world GDP.

In year 2022 the GDP increased to \$1.876 trillion, a 3.4% increase from year 2021. The percentage increase in GDP reduced to 3.4% from 3.9% in year 2021 may be because of the highest number of total and rate of confirmed cases.

In year 2023, the GDP was \$2.5 trillion, 33.2% increase. Part of the reason for the increase in GDP may be due to the lowest number of total confirmed cases and deaths in year 2023 as summarized in Table 7.

Table 7. Texas GDP Trends

Year	2019	2020	2021	2022	2023
Amount	\$ 1.779 trillion	\$ 1.747 trillion	\$ 1.815 trillion	\$ 1.876 trillion	\$ 2.5 trillion
Percent Change	1.9%	-1.8%	3.9%	3.4%	33.2%
COVID					

Total Confirmed Cases	0	1,759,131	2,777,607	3,737,357	762,726
Rate of Confirmed Cases	0	3.7 K/m to 357K/m	53.5K/m to 596K/m	46K/m to 1.5M/m	Reduced from 139K/m to 53.8K/m
Total Deaths	0	27,898	47,978	16,724	3,147
Rate of Deaths	0	56/m to 4.8K/m	0.8K/m to 9.0K/m	0.4K/m to 4.0K/m	0.8K/m to 0.3K/m

Number in Red Color is the Highest Number for that Row

New York (Table 8)

New York is ranked No. 3 in the U.S. based on the GDP. In year 2019 the GDP growth was 2.6% and the GDP dropped by -3.4 % in year 2020 because of the COVID-1 impact and also it correlated to the deaths in New York comparing to Texas in year 2020. The New York GDP in 2021 was \$1.724 trillion and it increased by 4.3%.

In year 2022 the GDP was \$1.763 trillion and had a 2.2% increase from year 2021. The percentage increase in year 2022 was lower than year 2021 because of the highest total and rate of confirmed cases in New York.

In year 2023, the GDP was \$2.5 trillion with a percentage growth of 24.8%. This may be due to the lowest total confirmed cases and deaths in year 2023. Also the New York trends agree with the trend observed over the 4 years for the world GDP, U.S.A. GDP and Texas GDP.

Table 8. New York GDP Trends

Year	2019	2020	2021	2022	2023
Amount	\$ 1.709 trillion	\$ 1.650 trillion	\$ 1.724 trillion	\$ 1.763 trillion	\$ 2.2 trillion
Percent Change	2.6%	-3.4%	4.3%	2.2%	24.8%
COVID					
Total Confirmed Cases	0	998,524	2,335,414	3,493,604	620,607
Rate of Confirmed Cases	0	77K/m to 234K/m	28.5K/m to 433.8K/m	18.1K/m to 1.3M/m	Reduced from 154K/m to 24.9K/m
Total Deaths	0	37,868	21,730	16,311	6,458
Rate of Deaths	0	196/m to 21.1K/m	326/m to 5.5K/m	0.4K/m to 5.0K/m	0.9K/m to 0.2K/m

Number in Red Color is the Highest Number for that Row

CONCLUSIONS

Based on the COVID-19 pandemic data analyses over the past 4 years, starting in year 2020 following conclusions are advanced:

1. United States of America was the worst impacted nation and is ranked number one in the world coinciding with the GDP ranking. The vaccine has reduced the rate of death in the U.S. in year 2022.
2. Confirmed cases and rate of confirmed cases of COVID-19 virus in year 2022 around the world, U.S.A., Texas and New York have been the highest and has impacted the percentage GDP growth.
3. New York death rate peaked in April 2020 and was 21.1K/m. The Texas death rate peaked in January 2021 and was 9K/m. Texas and New York had the highest confirmed cases per month in January 2021 which agreed with the U.S. and world trends.
4. COVID-19 had negative impact on the GDP in year 2020 and around the world, U.S.A. Texas and New York.
5. Vipulanandan p-q Model predicted the total death trends with time for the world, U.S.A., Texas and New York very well.

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