

# **Data Analytics of Over Three and a Half Years of COVID-19 Virus Impacts Based on Total and Rate per Month 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 3.5 years, the coronavirus that causes severe acute respiratory syndrome (SARA-2 (COVID-19)) has impacted the entire world with the total human death of over 6.9 million and in the U.S. it is over 1.17 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. 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 in the U.S. was \$22 trillion. In 2022 the U.S. GDP had reduced by -2.5% to \$21.5 trillion. Also the world GDP had reduced by -9.0% to \$85.8 trillion. Also many states in the U.S.A. also have seen a reduction in GDP with Texas and New York GDPs reduced by -2.3% and -1.3% in the year 2022 by the impact of total and rate of COVID-19 cases. In the year 2023 the total confirmed cases and rate of confirmed cases have dropped a lot and the GDP of the World, U.S., Texas and New York have increased 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 where 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 (Ang, 2020; 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.

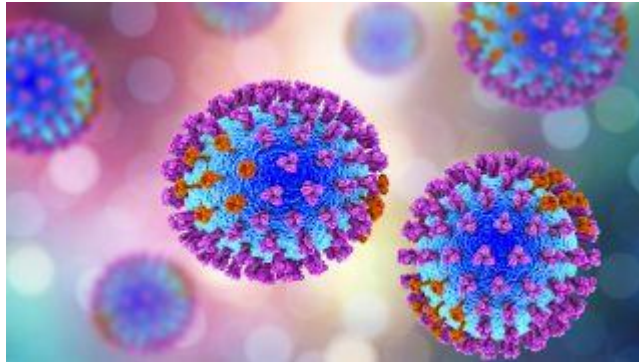
## **SARS-CoV-2 (COVID-19) (Bats)**

**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 3.5 years. The specific objectives are as follows:

- (a) Compare the total and rate of 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 total and rate of 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 thirty six 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 March of 2020, European countries such as Italy, Spain and United Kingdom, above the equator and also very high Gross Domestic Product (GDP), had the largest impact based on the deaths and total number of confirmed cases. There was very little impact on the North and South American continent. Since April 2020, United States (North) and Brazil (South) in the American Continent became the badly affected countries in the world based on the deaths and confirmed cases. Since June, Mexico and India have become two of the leading top 5 countries based on the number of people affected by the COVID-19 virus.

It is important to quantify and interpret the trends observed around the world and the U.S.A. in three years and it is analyzed in five periods. Period-1 was done from February 2020 to July 2020 (6 months), Period-2 was done from August 2020 to January 2021, Period-3 was done from February 2021 to July 2021, Period-4 was done from August 2021 to July 2022 and Period-5 was done from August 2022 to July 2023. Both the total confirmed cases and deaths continuously increased around the world till July 2023, entire 3.5 years but the rates have dropped in the past 7 months (year 2023). In this study, the **focus was also on** monthly changes (rate) in the confirmed cases and total deaths.

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

#### Period-1 (February 2020 to July 2020)

It will be of interest to compare the impact of COVID-19 virus on the world and the U.S.A. with the highest GDP of \$21.5 trillion (Year 2019). The difference in the total and rate of confirmed cases and deaths 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, the confirmed cases per month and death rates per month are summarized.

**Confirmed Cases:** The confirmed cases continuously increased every month and the rate of increase was the highest in July which was **6.8 M/m**.

**Death Cases:** The death rate peaked in April and was **159K/m**. The death rates have reduced in May, June and July to about **146K/m**, **122k/m** and **371K/m**. The death rate was maximum in July, more the 2.3 times the previous maximum of 159K/m. The total death was **673,233** as of July 31, 2020.

## United States of America (USA)

U.S.A. had its highest rate of confirmed cases and deaths in April (Tax Month in the U.S.A) (Table 1(a)).

**Confirmed Cases:** 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.

**Death Cases:** The death rate in April was **58.9K/m**. 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 highest percentage of death was 28% based on the world death in May. The total death is over **152,670**, about 23% 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 5 times higher and hence doesn't match with the total population, which is ranked 3<sup>rd</sup> in the world.

## Period -2 (August 2020 to January 2021)

### World

The data are summarized in Table 1(b).

**Confirmed Cases:** The confirmed cases continued to increase every month and the highest increase was in January 2021 which was **19.4 M/m**.

**Death Cases:** The death rate peaked in January 2021 to **402.8K/m**, 2.5 times the July death cases. The death rates continued to increase except September. In December the death rate was to **277K/m**. The total death was 102,107,858 on January 31, 2021.

## United States of America (USA)

U.S.A. had its highest rate of confirmed cases and deaths in January 2021, more than 6 times and 1.6 times the cases in April (Tax Month in the U.S.A) (Table 1(b)).

**Confirmed Cases:** The confirmed cases in January 2021 was **6.2M/m**. In the month of August, the confirmed cases decreased to **1.5M/m**. In the month of October and December the confirmed cases increased to **2.1M/m** and **4.6M/m** respectively. Total confirmed cases at the end of January 2021 was close to 26 million (Table 1).

**Death Cases:** The death rate was highest in January 2021 and was **94.5K/m** and in April it was **58.9K/m**. In August the death rate was **30.8K/m**. The total death at the end on January 2021 was over **436,799**, about 19.8% 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 4 times higher and hence doesn't match with the total population, which is ranked 3<sup>rd</sup> in the world.

January 2021 has been the worst month for the world and the U.S.A. for the total confirmed cases and total deaths. Total deaths around the world have been over 2.2 million and the U.S.A. had 19.8% of the total deaths.

### **Period -3 (February 2021 to July 2021) (Table 1(b))**

#### **World**

The data are summarized in Table 1(b).

**Confirmed Cases:** 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 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(b)).

**Confirmed Cases:** 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**. Total confirmed cases at the end of May 2021 was over 34 million, about 10% of the U.S. population (Table 1).

**Death Cases:** 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 at the end on June 2021 was **629,064**, about 14.9% of the world deaths and is the highest in the world and **matched with the GDP ranking**. The U.S. population is only 4.2% 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 3<sup>rd</sup> in the world.

## Period -4 (August 2021 to July 2022) (Table 1(c))

### World

The data are summarized in Table 1(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **198,323,140** in the beginning of August 2021 to **580,366,202** end of July 2022. The change in the last one year was **382, 043,062**, which is 1.9 times what was in the first 19 months up to July 2021. The rate of confirmed cases increased from 13.6M/m to 19.4M/m in December 2021. In January 2022 it reduced to 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 total death cases continuously increased from **4,229,777** in the beginning of August 2021 to **6,417,643** end of July 2022. The change in the last one year was **2,187,866** which was 52% of what was in the first 19 months up to July 2021. The rate of death cases 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(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **35,688,506** in the beginning of August 2021 to **93,054,184** end of July 2022. The change in the last one year was **57, 365,678** which is 1.6 times what was in the first 19 months up to July 2021. The rate of confirmed cases increased from 0.8M/m to **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 total death cases continuously increased from **629,064** in the beginning of August 2021 to **1,055,020** end of July 2022. The change in the last one year was **425,956** which was 68% of what was in the first 19 months up to July 2021. The rate of death cases increased from **9.7K/m** in July 2021 to **66.4K/m** in January 2022. It continuously decreased to 12.2K/m in July 2022. The U.S.A. death rates are compared world death rates in Figure 1(b).

## Period -5 (August 2022 to July 2023) (Table 1(c))

### World

The data are summarized in Table 1(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **580,366,202** end of July 2022 to **691,437,926** Middle of July 2023. The change in the last 5 months was **13,850,902**. The confirmed cases was 24.5 M/m in July 2022 and has reduced to 6.21 M/m in February 2023 and 2.9 M/m in July 2023. In June and July 2022 the confirmed cases were **24.5 M/m** the highest rate recorded over the past 3.0 years. The confirmed case rates are compared in Figure 1(a).

**Death Cases:** The total death cases continuously increased from to **6,417,643** end of July 2022 to **6,782,362** in the middle of February 2023. Total deaths in the middle of July 2023 was **6.899,186**. The rate of death cases decreased from **336.6K/m** in July 2021 (highest death rate recorded) to **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(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **93,054,184** end of July 2022 to **107,365,548** in the middle of February 2023. The confirmed cases was **3.5 M/m** in July 2022 and has reduced to **1.2 M/m** in February 2023. It reduced to **0.5 M/m** in July 2023. In January 2022 the U.S. had the highest confirm cases of **18.7 M/m**. The U.S.A. confirmed case rates are compared to the World in Figure 1(a).

**Death Cases:** The total death cases continuously increased from **1,055,020** end of July 2022 to **1,168,538** in the middle of July 2023. In the middle of July 2023 the total death rate was 16.9% of the world death cases. The rate of death cases increased from **12.2K/m** in July 2022 to **5.6K/m** in the Middle of July 2023. The U.S.A. death rates are compared world death rates in Figure 1(b).

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

Date	World		United States		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
1/31/2020	8,234		0	0	World confirmed and deaths cases increased by <b>78K/m</b> and 8K/m. U.S. confirmed and deaths were <b>68/m</b> and <b>Zero</b> .
2/29/2020	86,009	8,000	68	0	
3/31/2020	871,976	74,565	189,967	5,151 <b>(6.9%)*</b>	World confirmed cases and deaths increased by <b>786K/m</b> and <b>68.5K/m</b> . U.S. confirmed and deaths were over <b>190 K/m</b> and <b>5K/m</b> .



Date	World		United States		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
4/30/2020	3,268,000	233,704	1,095,023	63,856 (27.3%)*	World confirmed cases and deaths increased by 2.4M/m and 159K/m. U.S. confirmed and death were 905K/m and 58.7K/m (Highest death rate for the U.S.A.)
5/31/2020	6,162,000	380,000	1,852,029	106,432 (28.0%)*	World confirmed cases and death increased by 2.9M/m and 146K/m. U.S. confirmed and death rate were 757K/m and 42.6K/m.
6/30/2020	10,450,000	502,048	2,728,856	130,122 (26.8%)*	World confirmed cases and death increased by 4.3M/m and 122K/m. U.S. confirmed and death rate were 877K/m and 23.7K/m.
7/31/2020	17,297,276	673,233	4,495,014	152,670 (23%)*	World confirmed cases and death increased by 6.8M/m and 171K/m. U.S. confirmed and death rate were 1.8M/m and 22.5K/m.
8/31/2020	25,330,679	848,030	6,021,465	183,399 (21.6%)*	World confirmed cases and death increased by 8.0M/m and 175K/m. U.S. confirmed and death rate were 1.5M/m and 30.8K/m.

- \*Percentage death in the U.S.A. based on the World Deaths

**Table 1(b). Comparing the COVID-19 Impact on the World and U.S.A. (Period 2 &3)**

Date	World		United States		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
9/28/2020	33,125,652	998,074	7,115,337	204,758 (20.5%)*	World confirmed cases and death increased by 7.8M/m and 150K/m. U.S. confirmed and death rate were 1.5M/m and 30.8K/m.
10/18/2020	39,842,711	1,111,874	8,140,728	219,599 (19.8%)*	World confirmed cases and death increased by 13.4M/m and 227.6K/m. U.S. confirmed and death rate were 2.1M/m and 29.7K/m.

12/31/2020	82,686,157	1,805,002	19,740,468	342,312 (19.0%)*	World confirmed cases and death increased by 17.1M/m and 277.3K/m. U.S. confirmed and death rate were 4.6M/m and 49.1K/m.
1/31/2021	102,107,858	2,207,834	25,932,793	436,799 (19.8%)*	World confirmed cases and death increased by 19.4M/m and 402.8K/m. U.S. confirmed and death rate were 6.2M/m and 94.5K/m.
3/31/2021	129,006,800	2,817,932	30,460,837	552,073 (19.6%)*	World confirmed cases and death increased by 14.6M/m and 281K/m. U.S. confirmed and death rate were 1.8M/m and 37.3K/m.
5/31/2021	171,029,617	3,556,671	34,043,068	609,544 (17.1%)*	World confirmed cases and death increased by 19.9M/m and 360K/m. U.S. confirmed and death rate were 1.6M/m and 28.2K/m.
7/31/2021	198,323,14	4,229,777	35,688,506	629,064 (14.9%)*	World confirmed cases and death increased by 13.6M/m and 336.6K/m. U.S. confirmed and death rate were 0.8M/m and 9.7K/m.
12/28/2021	281,838,851	5,422,991	53,737,689	839,429 (15.5%)*	World confirmed cases and death increased by 19.4M/m and 212.3K/m. U.S. confirmed and death rate were 4.0M/m and 39.0K/m.

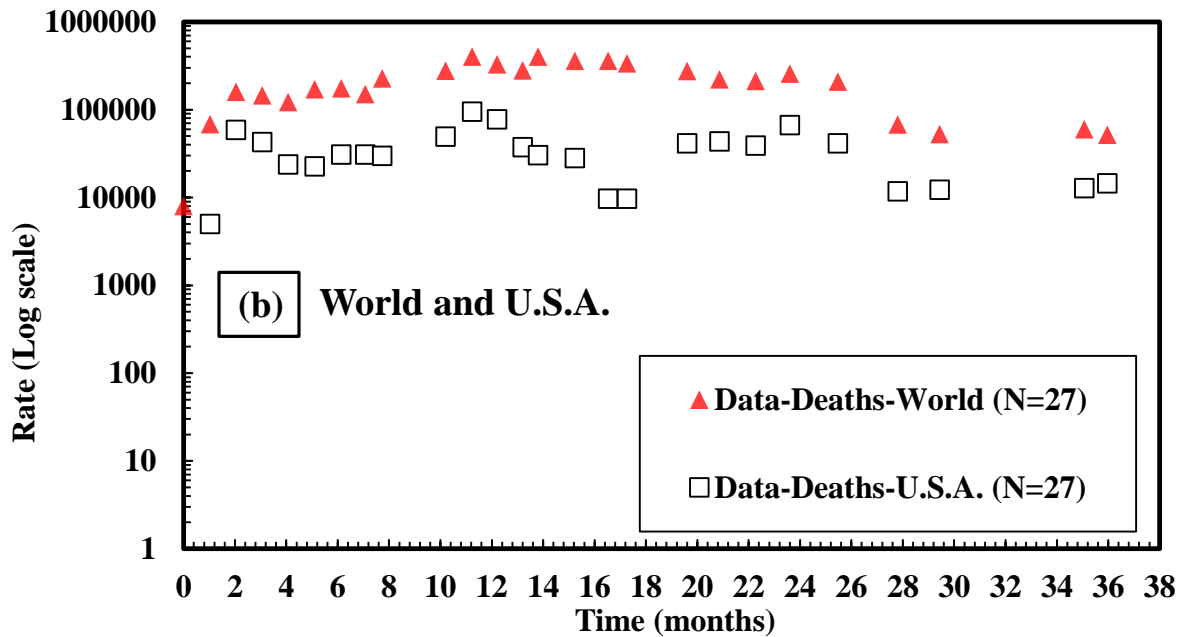
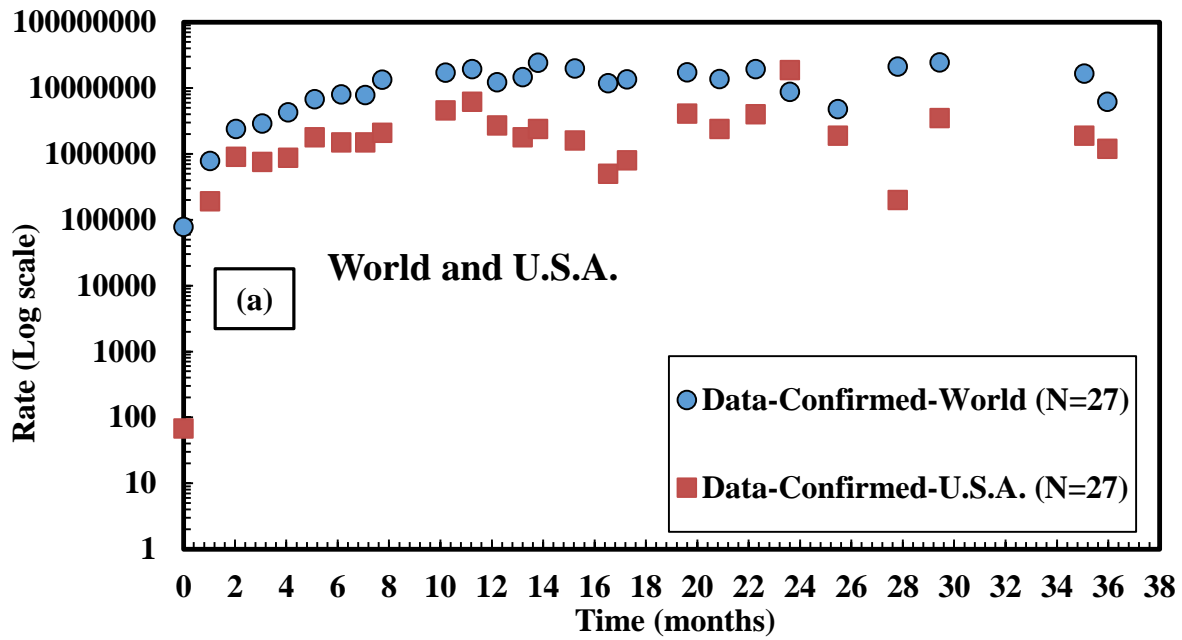
- \*Percentage death in the U.S.A. based on the World Deaths

Table 1(c). Comparing the COVID-19 Impact on the World and U.S.A. (Period 4 &5)

Date	World		United States		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
2/06/2022	395,659,140	5,757,189	78,001,369	925,794 (16.1%)*	World confirmed cases and death increased by 8.8M/m and 257.1K/m. U.S. confirmed and death rate were 18.7M/m and 66.4K/m.
4/3/2022	491,562,847	6,175,764	81,831,520	1,008,181 (16.3%)*	World confirmed cases and death increased by 4.8M/m and 209.3K/m. U.S. confirmed and death

					rate were <b>1.9M/m</b> and <b>41.2K/m</b> .
<b>6/12/2022</b>	<b>540,313,523</b>	<b>6,331,213</b>	<b>87,305,419</b>	<b>1,035,088</b> <b>(16.3%)*</b>	<b>World</b> confirmed cases and death increased by <b>21.2M/m</b> and <b>67.6K/m</b> . <b>U.S.</b> confirmed and death rate were <b>0.2M/m</b> and <b>11.7K/m</b> .
<b>7/31/2022</b>	<b>580,366,202</b>	<b>6,417,643</b>	<b>93,054,184</b>	<b>1,055,020</b> <b>(16.4%)*</b>	<b>World</b> confirmed cases and death increased by <b>24.5M/m</b> and <b>52.9K/m</b> . <b>U.S.</b> confirmed and death rate were <b>3.5M/m</b> and <b>12.2K/m</b> .
<b>1/16/2023</b>	<b>671,375,010</b>	<b>6,730,560</b>	<b>103,577,391</b>	<b>1,125,541</b> <b>(16.7%)*</b>	<b>World</b> confirmed cases and death increased by <b>16.5M/m</b> and <b>59.6K/m</b> . <b>U.S.</b> confirmed and death rate were <b>1.9M/m</b> and <b>12.8K/m</b> .
<b>2/12/2023</b>	<b>677,587,006</b>	<b>6,782,362</b>	<b>104,764,296</b>	<b>1,140,015</b> <b>(16.8%)*</b>	<b>World</b> confirmed cases and death increased by <b>6.2M/m</b> and <b>51.8K/m</b> . <b>U.S.</b> confirmed and death rate were <b>1.2M/m</b> and <b>14.5K/m</b> .
<b>7/13/2023</b>	<b>691,437,926</b>	<b>6,899,186</b>	<b>107,365,548</b>	<b>1,168,558</b> <b>(16.9%)*</b>	<b>World</b> confirmed cases and death increased by <b>2.9M/m</b> and <b>23.4K/m</b> . <b>U.S.</b> confirmed and death rate were <b>0.5M/m</b> and <b>5.6K/m</b> .
<b>Remarks</b>	Over 691 Millions of humans have been affected during the past 3.5 years (41 months).	Very high total death and rate of deaths. Total death was over 6.9 million and the highest rate of death was 402.8K/m	U.S. has the highest confirmed cases.	U.S. has the highest total deaths of over 1.17 million and 16.9% of the world deaths.	<b>COVID-19 has impacted the world. U.S.A. had the highest confirmed cases and total deaths (No. 1) and matched with the world GDP rating of being No. 1.</b>

- **\*Percentage death in the U.S.A. based on the World Deaths**



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

### 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.

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

Model parameters (p, q, Y<sub>0</sub>, Y<sub>f</sub> and t<sub>0</sub>) 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 <sub>f</sub> )	Time for Max. Death (t <sub>f</sub> ) (days)	p	q	R <sup>2</sup>	RMSE (Number of people)	Remarks
<b>World</b>	6,899,186	1251	0.068	0.190	1.0	122,026	Rate of deaths increased up to about 600 days and then decreased with time
<b>U.S.A</b>	1,168,538	1251	0.070	0.180	0.99	25,277	Rate of deaths increased with time for a long time.
<b>Remarks</b>	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.

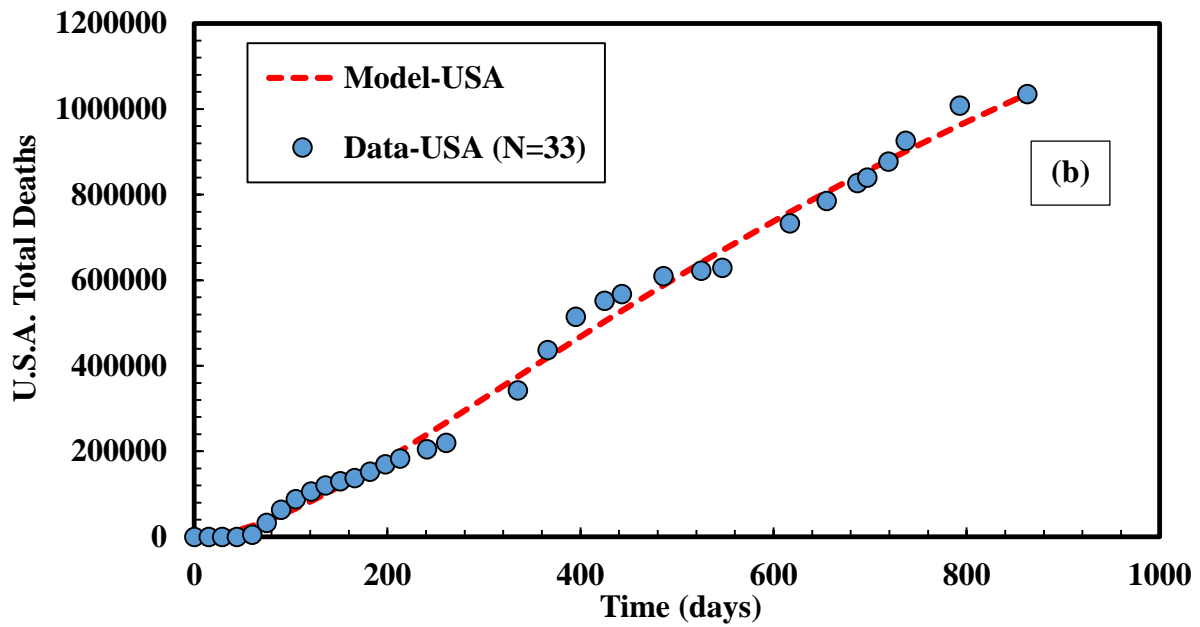
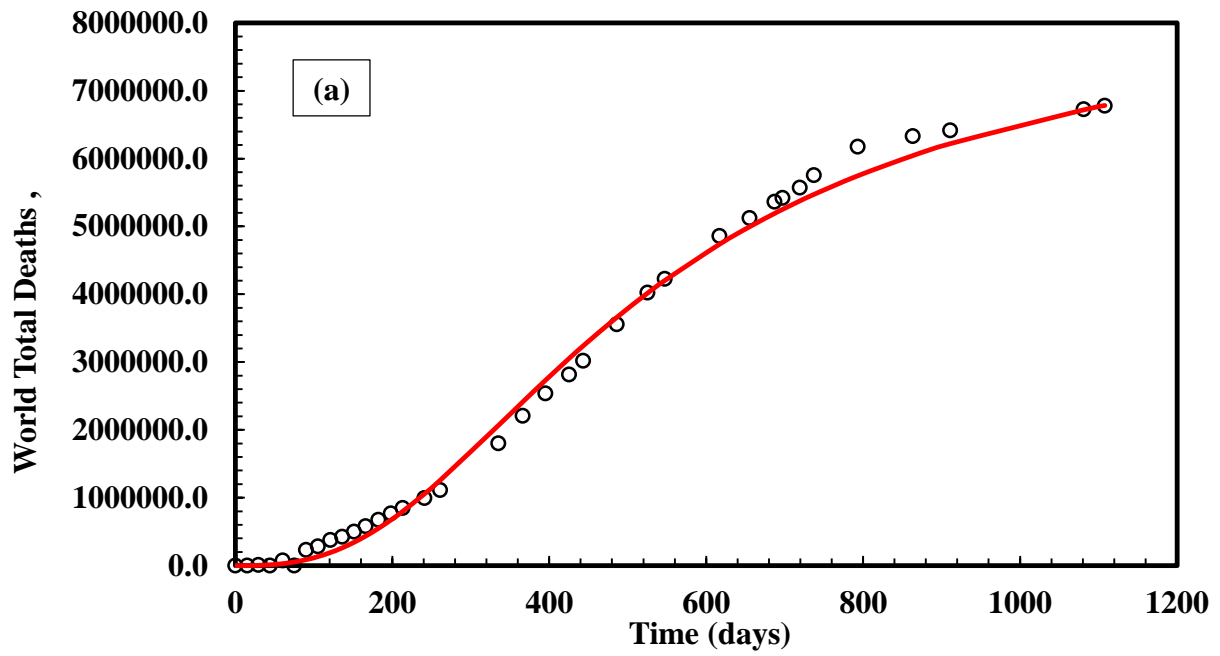


Figure 2. Vipulanandan Model Prediction of Total Deaths with Time (a) World and (b) United States of America

## **(b). New York Versus Texas (Table 3)**

### **Period-1 (February 2020 to July 2020) (Table 3(a))**

#### **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 5, Table 6 and Table 7.

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

New York State has had the highest confirmed cases and deaths in the U.S.A. during first year (Table 3(a)).

**Confirmed Cases:** 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 and the death rates have reduced to 79K/m, and 6.7K/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** with death rate of 888/day. The total confirmed cases on July 31 was over 443,000 (July 31), 10% of the U.S. confirmed cases.

**Death Cases:** 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. The last few weeks death rate has dropped to below 40/day. The total deaths is over 32,765 (July 31), 23% of the U.S. deaths.

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 has very high confirmed cases comparable to New York but the total deaths were much lower during the initial time period (Table 3(a)).

**Confirmed Cases:** Texas had its highest rate of confirmed cases of **276K/m in July** (Table 2). 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 with death rate of 45/day. The total confirmed cases was over 443,000 (July 31), comparable to New York and 10% of the U.S.

**Death Cases:** 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. The total deaths is 6998 (July 31), about 21.4% of the New York deaths.

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.

### **Period -2 (August 2020 to January 2021) (Table 3(b)).**

#### **New York**

**Confirmed Cases:** In August the confirmed cases were **16.6K/m** and it has increased to **433.8K/m** in January 2021, the highest confirmed cases in one year. The total confirmed cases were over 1.4 million (January 31), about 5.5% of the U.S. cases.

**Death Cases:** Death rate in New York has decreased In August it was 196/m. It increased to 1.8K/m in December and in January it was 5.5K/m lower than the deaths in April (Tax Month in the U.S.). Total death was 9.9% of the U.S deaths.

#### **Texas**

**Confirmed Cases:** Texas had its highest rate of confirmed cases of **596K/m in January 2021** (Table 4). The confirmed cases in August was **160K/m** and it has continuously increased to 596K/m. The total confirmed cases were over 2.3 million (January 31), much higher than New York and was about 10% of the U.S. cases.

**Death Cases:** Texas had its highest rate of deaths in January 2021 of **9.0K/m**, double the rate in July. The total death was 36,887, 8.4% of the U.S. deaths and 85% of the New York deaths.

### **Period -3 (February 2021 to July 2021) (Table 3(b))**

#### **New York**

**Confirmed Cases:** In August the confirmed cases were **16.6K/m** and it has increased to **433.8K/m** in January 2021, the highest confirmed cases in one year. The total confirmed cases were over 1.4 million (January 31), about 5.5% of the U.S. cases.

**Death Cases:** Death rate in New York has decreased In August it was 196/m. It increased to 1.8K/m in December and in January it was 5.5K/m lower than the deaths in April (Tax Month in the U.S.). Total death was 9.9% of the U.S deaths.

#### **Texas**

**Confirmed Cases:** Texas had its highest rate of confirmed cases of **596K/m in January 2021** (Table 2). The confirmed cases in August was **160K/m** and it has continuously increased to 596K/m. The total confirmed cases were over 2.3 million (January 31, 2021), much higher than New York and was about 10% of the U.S. cases.



**Death Cases:** Texas had its highest rate of deaths in January 2021 of **9.0K/m**, double the rate in July. The total death was 53,446, 8.5% of the U.S. deaths and 99% of the New York deaths.

#### **Period -4 (August 2021 to July 2022) (Table 3(c))**

##### **New York**

The data are summarized in Table 3(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **2,210,612** in the beginning of August 2021 to **5,982,228** end of July 2022. The change in the last one year was **3,771,616**, which is 1.7 times what was in the first 19 months up to July 2021. The rate of confirmed cases increased from **28.5K/m** to **440K/m** in December 2021. In January 2022 it 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 total death cases continuously increased from **54,232** in the beginning of August 2021 to **70,724** end of July 2022. The change in the last one year was **16,492** which was 30% of what was in the first 19 months up to July 2021. The rate of death cases increased from **326/m** in July 2021 to **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(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **3,233,363** in the beginning of August 2021 to **7,502,596** end of July 2022. The change in the last one year was **4,269,233** which is 1.3 times what was in the first 19 months up to July 2021. The rate of confirmed cases increased from **140K/m** 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 total death cases continuously increased from **53,446** in the beginning of August 2021 to **89,721** end of July 2022. The change in the last one year was **35,275** which was 68% of what was in the first 19 months up to July 2021. The rate of death cases increased from **0.8K/m** in July 2021 to **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).

#### **Period -5 (August 2022 to July 2023) (Table 3(c))**

##### **New York**

The data are summarized in Table 3(c)

**Confirmed Cases:** The total confirmed cases continuously increased from **5,982,228** end of July 2022 to **6,916,219** in the middle of February 2023. The confirmed cases in July 2022 was **18.1 K/m** has increased to **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 total death cases continuously increased from **70,724** end of July 2022 to **76,800** in middle of February 2023. The total death was **6.7%** of the U.S. death. The rate of death was **0.4 K/m** in July 2022 and has increased to **0.9 K/m** in February 2023. The death rates are compared in Figure 3(b).

**Texas**

The data are summarized in Table 3(c).

**Confirmed Cases:** The total confirmed cases continuously increased from **7,502,596** end of July 2022 to **8,362,133** in the middle of February 2023. The rate of confirmed cases in July 2022 was **46 K/m** and has increased to **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 total death cases continuously increased from **89,721** end of July 2022 to **93,364** in the middle of February 2023. The total death was **8.2%** of the U.S. death. The death rate was **0.8 K/m** in July 2022 and it decreased to **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(a). Comparing the COVID-19 Impact on New York and Texas. (Period 1)**

Date	Texas		New York		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
2/29/2020	0	0	20	0	Texas confirmed cases and deaths were 3.7K/m and 56/m. New York confirmed and deaths were 77K/m and 2.7K/m
3/31/2020	3,666	56	76,946	2677	
4/30/2020	28,455	802	310,839	23,780	Texas confirmed cases and deaths increased by 24.8K/m and 746/m. New York confirmed cases and death were 234K/m and 21.1K/m (Highest for New York)

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

5/31/2020	64,899	1,686	389,903	30,509	Texas confirmed cases and death increased by 36.4K/m and 884/m. New York confirmed and death rate were 79K/m and 6.7K/m.
6/30/2020	167,269	2,496	417,836	32,129	Texas confirmed cases and death increased by 102K/m and 810/m. New York confirmed and death rate were 27.9K/m and 1.6K/m.
7/30/2020	443,026	6,998 (4.6%)*	443,745	32,765 (21.5%)*	Texas confirmed cases and death increased by 276K/m and 4.5K/m. New York confirmed and death rate were 26K/m and 636/m.
8/23/2020	603,025	11,801	460,312	32,961	Texas confirmed cases and death increased by 160K/m and 4.8K/m. New York confirmed and death rate were 16.6K/m and 196/m.
9/28/2020	770,230	15,861	489,864	33,215	Texas confirmed cases and death increased by 167K/m and 4.06K/m. New York confirmed and death rate were 29.6K/m and 254/m.

Table 3(b). Comparing the COVID-19 Impact on New York and Texas (Periods 2 and 3)

Date	Texas		New York		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
10/18/2020	867,751	17,554	519,783	33,477	Texas confirmed cases and death increased by 195K/m and 3.4K/m. New York confirmed and death rate were 59.8K/m and 524/m.
12/31/2020	1,759,131	27,898	998,524	37,868	Texas confirmed cases and death increased by 357K/m and 4.1K/m. New York confirmed and death rate were 191.5K/m and 1.8K/m.

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

1/31/2021	2,355,309	36,887 (8.4%)*	1,432,343	43,388 (9.9%)*	Texas confirmed cases and death increased by 596K/m and 9.0K/m. New York confirmed and death rate were 433.8K/m and 5.5K/m. (Highest death rate in Texas)
3/31/2021	2,795,916	48,504 (8.8%)*	1,915,254	50,587 (9.2%)*	Texas confirmed cases and death increased by 133K/m and 4.3K/m. New York confirmed and death rate were 228K/m and 2.6K/m.
5/31/2021	2,954,340	51,727 (8.5%)*	2,153,469	53,581 (8.8%)*	Texas confirmed cases and death increased by 53.5K/m and 1.2K/m. New York confirmed and death rate were 57.8K/m and 1.1K/m.
7/31/2021	3,233,363	53,446 (8.5%)*	2,210,612	54,232 (8.6%)*	Texas confirmed cases and death increased by 140K/m and 0.8K/m. New York confirmed and death rate were 28.5K/m and 326/m.
12/28/2021	4,530,738	75,876 (9.0%)*	3,333,938	59,598 (7.1%)*	Texas confirmed cases and death increased by 175K/m and 1.9K/m. New York confirmed and death rate were 440K/m and 2.1K/m.

**Table 3(c). Comparing the COVID-19 Impact on New York and Texas (Periods 4 and 5)**

Date	Texas		New York		Remarks
	Confirmed Cases	Total Deaths	Confirmed Cases	Total Deaths	
2/06/2022	6,428,427	81,028 (8.8%)*	4,989,404	66,039 (7.1%)*	Texas confirmed cases and death increased by 1.5M/m and 4.0K/m. New York confirmed and death rate were 1.3M/m and 5.0K/m. (Highest confirmed cases for Texas)
4/3/2022	6,754,830	87,894 (8.7%)*	5,157,785	68,500 (6.8%)*	Texas confirmed cases and death increased by 163K/m and 3.4K/m. New York confirmed and death rate were 84.2K/m and 1.2K/m.

6/12/2022	7,009,037	88,924 (8.6%)*	5,667,051	69,748 (6.7%)*	Texas confirmed cases and death increased by 111K/m and 0.4K/m. New York confirmed and death rate were 221K/m and 0.5K/m.
7/31/2022	7,502,596	89,721 (8.5%)*	5,982,228	70,724 (6.7%)*	Texas confirmed cases and death increased by 46K/m and 0.8K/m. New York confirmed and death rate were 18.1K/m and 0.4K/m.
1/16/2023	8,268,095	92,600 (8.2%)*	6,827,542	75,909 (6.7%)*	Texas confirmed cases and death increased by 139K/m and 0.5K/m. New York confirmed and death rate were 154K/m and 0.9K/m.
2/12/2023	8,362,133	93,364 (8.2%)*	6,916,219	76,800 (6.7%)*	Texas confirmed cases and death increased by 46K/m and 0.8K/m. New York confirmed and death rate were 18.1K/m and 0.4K/m.
7/13/2023	8,630,987	94,628 (8.1%)*	7,040,515	77,756 (6.7%)*	Texas confirmed cases and death increased by 53.8K/m and 0.3K/m. New York confirmed and death rate were 24.9K/m and 0.2K/m.
<b>Remarks</b>	Confirmed cases have exceeded 8.6 million, 25% of the Texas population. Confirm cases rate of 1.5 M/m was highest in January 2022.	Deaths were highest in January 2021	Fourth highest confirmed cases in the U.S.	Fourth highest deaths in the U.S.	<b>COVID-19 has impacted the coastal states, Texas and New York having the high GDP rating and populations in the U.S.A.</b>

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

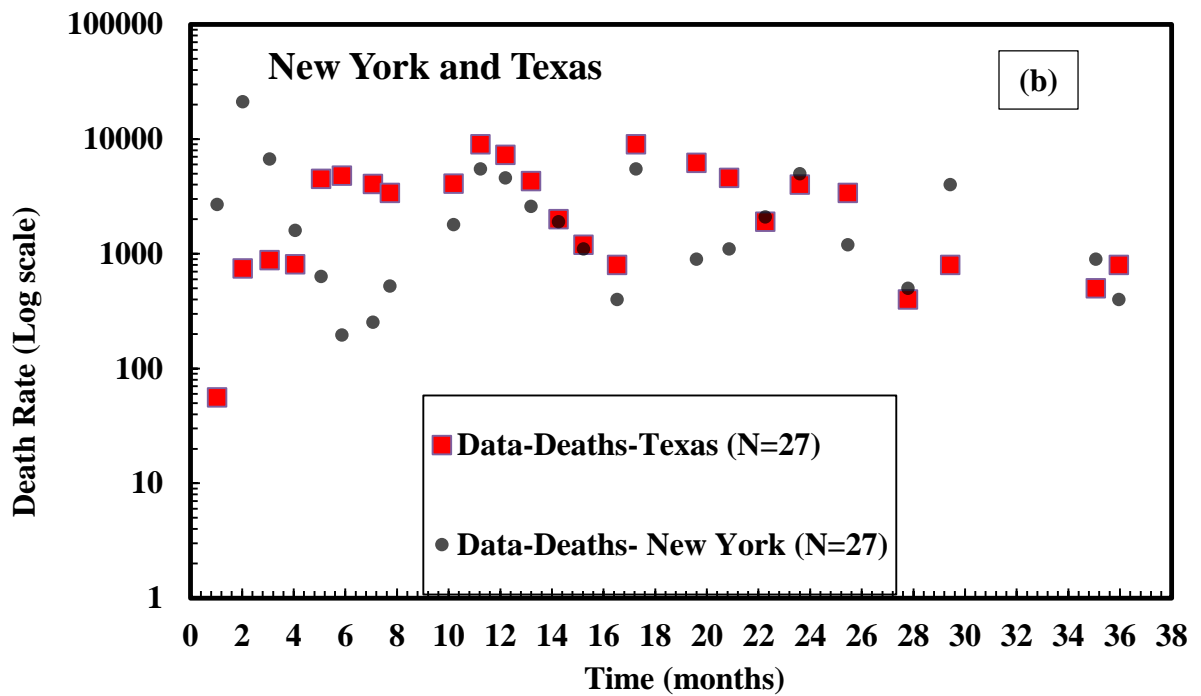
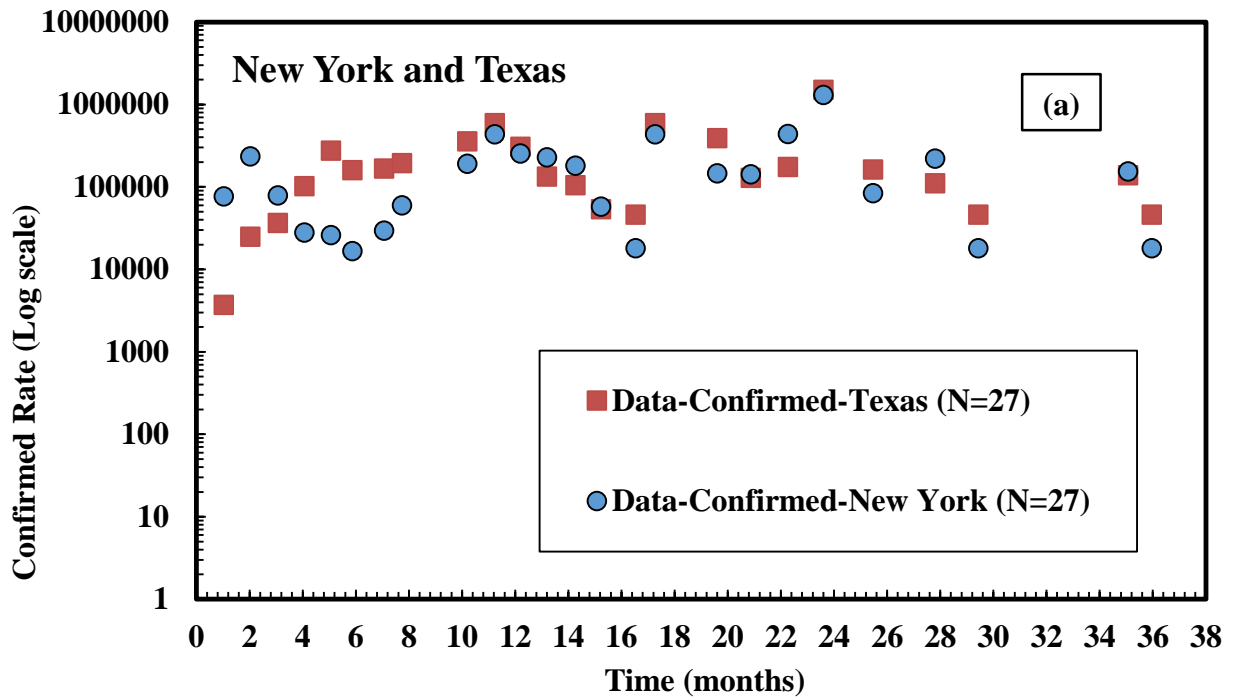


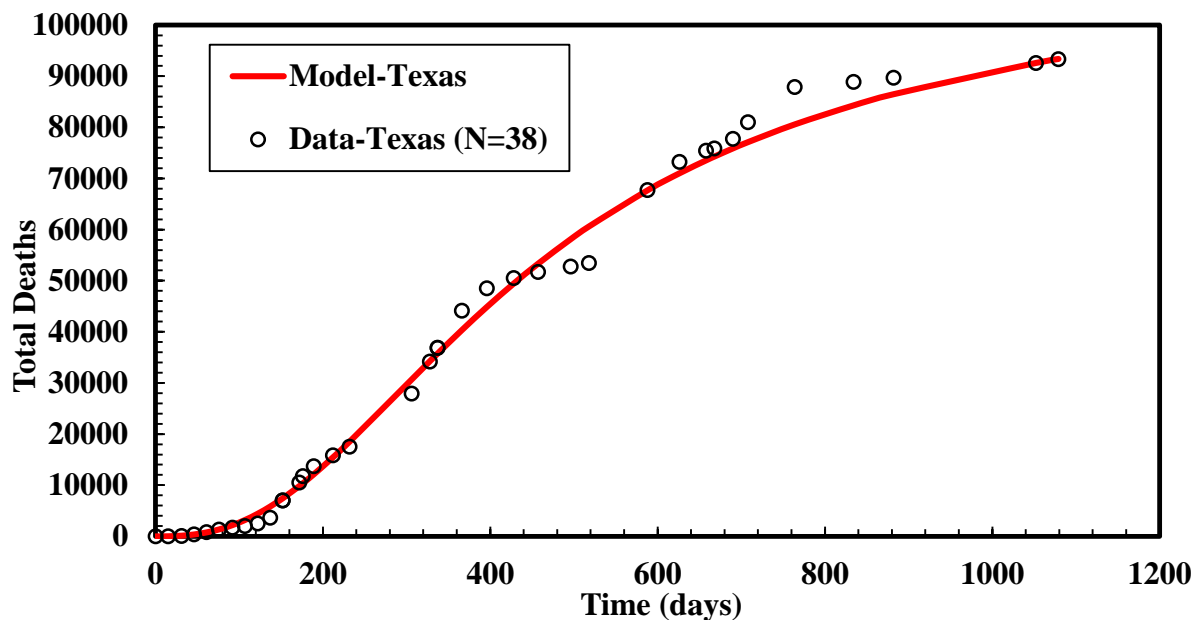
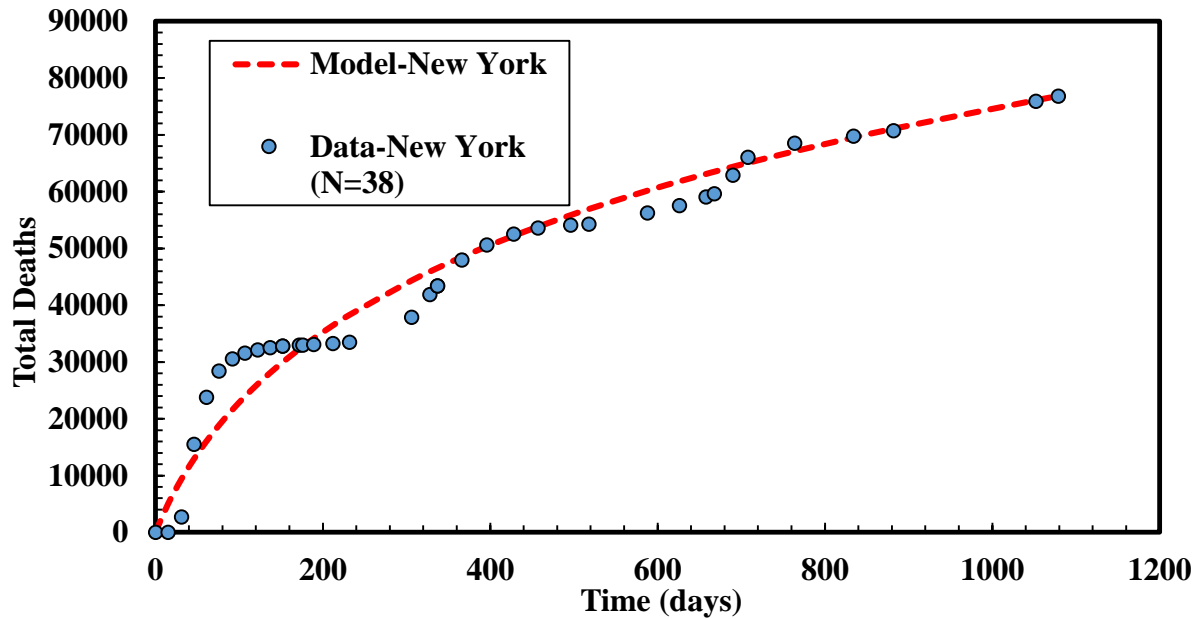
Figure 3. Comparing New York and Texas (a) Rate of Confirmed Cases and (b) Rate of Deaths

## 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	77,756	1251	2.0	0.19	0.94	4,444	Rate of deaths initially decreased with time and increased and then decreased again.
Texas	94,628	1251	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 <sup>th</sup> 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 the end of 2019 to the third quarter of 2020. The GDP was \$88 trillion in 2019 and it dropped to \$84.5 trillion on 2020, reduction of 3.3%. In 2021 the world CDP will be \$93.6 trillion, 6.4%



increase over year 2019. In year 2022 the GDP was \$85.18 trillion, a -9.0% reduction from 2021. This agrees with the highest number of COVID-19 cases and also highest rate of confirmed cases as summarized in Table 5.

In year 2023, the predicted GDP is \$96.4 trillion, greater than 5% from 2021. This agrees with the lowest number of COVID-19 cases and also lowest rate of confirmed cases as summarized in Table 5.

**Table 5. World GDP Trends**

Year	2019	2020	2021	2022 (Predicted GDP)	2023 (Predicted GDP)
Amount	\$ 88 trillion	\$ 84.5 trillion	\$ 93.6 trillion	\$ 85.18 trillion	\$ 96.4.trillion
Percent Change		-3.3%	6.4%	<b>- 9.0%</b>	> 5%
COVID					
Total Confirmed Cases	0	82,686,157	199,152,694	<b>389,536,617</b>	20,0626,916
Rate of Confirmed Cases	0	78 K/m to 17.1 M/m	13.6M/m to 19.9M/m	<b>8.8 to 24.5M/m</b>	Reduced from 16.5 to 2.9M/m
Total Deaths	0	1,805,002	<b>3,617,989</b>	1,307,569	169,626
Rate of Deaths	0	8 K/m to 277.3K/m	<b>402.8K/m to 212.3K/m</b>	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 remained 3.4% lower than it was at the end of 2019 following a small drop in the first quarter of 2020, a cataclysmic drop in the second quarter, and a rebound in the third quarter. Official data on the overall level of economic activity lag employment data, but through the first three quarters of 2020 the Gross Domestic Product (GDP) was down for every state except Utah. The size of 49 states' economies shrunk through the first three quarters of 2020, with declines in GDP ranging from 0.2% to 8.8%.

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. The 2020 GDP for U.S. was \$21.5 trillion.

In year 2021 the GDP was \$22.1 trillion, a 2.32% increase. It will be 23.6% of the world GDP. In 2021 the confirmed cases were low but the death was the highest. So deaths do not correlate with the increase in GDP. In year 2022, the GDP reduced by -2.5% and -0.9% respectively resulting in -2.5% reduction to \$21.6 trillion as summarized in Table 6. This agrees

with the highest number of COVID-19 cases and also highest rate of confirmed cases as summarized in Table 6 and also agrees with the trend observed for the world GDP for 2022.

In year 2023, the predicted GDP is \$23.1 trillion, greater than 3% from 2021. This agrees with the lowest number of COVID-19 cases and also lowest rate of confirmed cases as summarized in Table 6.

**Table 6. U.S.A. GDP Trends**

<b>Year</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023 (Predicted GDP)</b>
<b>Amount</b>	<b>\$ 22.3 trillion</b>	<b>\$ 21.5 trillion</b>	<b>\$ 22.1 trillion</b>	<b>\$ 21.6 trillion</b>	<b>\$ 23.1 trillion</b>
<b>Percent Change</b>		-3.4%	2.3%	<b>- 2.5%</b>	> 3%
<b>COVID</b>					
<b>Total Confirmed Cases</b>	<b>0</b>	<b>19,740,468</b>	<b>33,997,221</b>	<b>49,840,202</b>	<b>3,788,157</b>
<b>Rate of Confirmed Cases</b>	<b>0</b>	<b>68/m to 4.6 M/m</b>	<b>0.8M/m to 6.2M/m</b>	<b>0.2 to 18.7M/m</b>	<b>Reduced from 1.9 to 0.5M/m</b>
<b>Total Deaths</b>	<b>0</b>	<b>342,312</b>	<b>497,117</b>	<b>286,112</b>	<b>43,017</b>
<b>Rate of Deaths</b>	<b>0</b>	<b>0 to 49.1K/m</b>	<b>9.7 K/m to 94.5K/m</b>	<b>11.7K/m to 66.4K/m</b>	<b>12.8K/m to 5.6K/m</b>

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 GDP dropped by 3.6% during the first three quarters of 2020. The Texas GDP in 2020 was \$1.82 trillion and will increase by 3.37% in 2021 to \$1.88 trillion. The GDP growth rate (annual Q4 2020-Q1 2021) was 4.3%.

In year 2021 the GDP was \$1.88 trillion, a 3.37% increase In 2021 the confirmed cases were low but the death was the highest. So deaths do not correlate with the increase in GDP and agreeing with the trends observed for the U.S.A. GDP and world GDP. In 2022 the GDP reduce by -2.31% which is agreeing with the highest number of COVID-19 cases and also highest rate of confirmed cases as summarized in Table 7 and also agrees with the trend observed for the world GDP and U.S.A. GDP for 2022.

In year 2023, the predicted GDP is \$2.4 trillion, greater than 8% from 2021. This agrees with the lowest number of COVID-19 cases and also lowest rate of confirmed cases as summarized in Table 7.

**Table 7. Texas GDP Trends**

Year	2019	2020	2021	2022	2023(Predicted GDP)
Amount	\$ 1.89 trillion	\$ 1.82 trillion	\$ 1.88 trillion	\$ 1.84 trillion	\$ 2.4 trillion
Percent Change		-3.6%	3.37%	- 2.31%	> 8%
<b>COVID</b>					
Total Confirmed Cases	0	1,759,131	2,777,607	3,737,357	362,892
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	4,028
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. and the GDP dropped by 6.1% during the first three quarters of 2020 and it correlated to the deaths in New York comparing to Texas. The New York GDP in 2020 was \$1.78 trillion and will drop by 1.13% in 2021 to \$1.76 trillion. The GDP growth rate (annual Q4 2020-Q1 2021) was 6.6%. In 2022, the GDP reduce by -1.3% which is agreeing with the highest number of COVID-19 cases and also highest rate of confirmed cases as summarized in Table 10 and also agrees with the trend observed for the world GDP, U.S.A. GDP and Texas GDP for 2022.

**Table 8. New York GDP Trends**

Year	2019	2020	2021	2022	2023 (Predicted GDP)
Amount	\$ 1.88 trillion	\$ 1.78 trillion	\$ 1.76 trillion	\$ 1.74 trillion	\$ 2.1 trillion
Percent Change		-6.1%	-1.13%	- 1.3%	> 8%
<b>COVID</b>					
Total Confirmed Cases	0	998,524	2,335,414	3,493,604	212,073
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	1,847
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

In year 2023, the predicted GDP is \$2.1 trillion, greater than 8% from 2021. This agrees with the lowest number of COVID-19 cases and also lowest rate of confirmed cases as summarized in Table 8.

## CONCLUSIONS

Based on the COVID-19 pandemic data analyses over the past 3.5 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. But the confirmed cases have increased around the world, U.S.A., Texas and New York.
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 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 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 2022 around the world, U.S.A. and also over 40 states in the U.S.
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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## REFERENCES

- Ettlenger, M. and Hensley, J. (2021) “COVID-19 Economic Crisis: By State” (<https://carsey.unh.edu>)
- May, M. (2020), “Gene Therapy Developers,” GEN Magazine, pp. 18-19.
- Seymour, A. (2020), “New Hope for COVID-19 Antivirals,” GEN Magazine, pp. 10-13.
- U.S. Bureau of Economic Analysis (BEA) 2021 (<https://www.bea.gov> )
- Vipulanandan, C., and Ali, K., (2018) “Smart Cement Grouts for Repairing Damaged Piezoresistive Cement and the Performances Predicted Using Vipulanandan Models” Journal of Civil Engineering Materials, American Society of Civil Engineers (ASCE), Vol. 30, No. 10, Article number 04018253.

Vipulanandan, C., and Amani, N., (2018) “Characterizing the Pulse Velocity and Electrical resistivity Changes In Concrete with Piezoresistive Smart Cement Binder Using Vipulanandan Models” *Construction and Building Materials*, Vol. 175, pp. 519-530.

Vipulanandan, C., and Mohammed, A., (2018) “Smart Cement Compressive Piezoresistive Stress-Strain and Strength Behavior with Nano Silica Modification, *Journal of Testing and Evaluation*, ASTM, doi 10.1520/JTE 20170105.

Vipulanandan, C. (2020) “Impact of COVID-19 Virus and Cyber Attacks on the Multiple Disaster Management and Rapid Recovery Plans,” *Proceedings THC-2020 Conference on Hurricane, Major Disasters, Coastal Protection and Rapid Recovery in Texas and Coastal Region*,” pp. 3-28 (<http://hurricane.egr.uh.edu>)

Vipulanandan, C. *Smart Cement: Development, Testing, Modeling and Real-Time Monitoring*, Taylor and Francis group, CRC Press, 440 pp.

World Bank National Accounts Data 2021 (<https://data.worldbank.org>)