# TITLE: THE UNCALLED-FOR INCREASE IN COVID 19 CASES IN ZIMBABWE REGARDLESS OF COVID 19 VACCINES, THE PUBLIC'S RESPONSIBILITY.

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## Abstract

Motivation: Using data science and inferential statistical analysis, we are able to study and analyze raw information produced and collected in our healthcare systems and in turn see our progress, understand outcomes, derive solutions and predict the future. The goal is to acknowledge, maintain and improve health for all. Given the birth and rise of Covid 19 pandemic, many lives were lost and others left strained physically, emotionally, financially and psychologically. Great thanks go to the brave professionals who fought tirelessly. Covid 19 vaccines were introduced and there is no doubt that some lives have been saved from death. Zimbabwe, among other nations, joined the cause and launched its national Covid 19 vaccination program in February 2021.

Method: Inferential statistical analysis.

Results: After the introduction of Covid 19 vaccines in Zimbabwe, following a spike in the rise of Covid 19 daily new cases over time, an overall significant incline in the number of Covid 19 daily new cases was seen whereas a significant decline in Covid 19 related deaths was seen. The average daily new Covid 19 cases in December 2021 was approximately 3.94 times more than the average daily new Covid 19 cases in January 2021, thus showing an increase over time from before Covid 19 vaccines to after Covid 19 vaccines were introduced in Zimbabwe. On the other hand, the average of daily new Covid 19 related deaths in January 2021 was 2.86 times more than the average of daily new Covid 19 related deaths in January 2021. This proves that the Covid 19 vaccines helped reduce the average number of Covid 19 related deaths over time and may have saved the lives of Zimbabwean residents. Unfortunately, the increased rate of infection of Covid 19 following the introduction of vaccines increased rapidly, proving negligence by Zimbabwean residents by a significant extent.

Keywords: Healthcare Data Science, T-test, R, Covid 19

## 1.0 INTRODUCTION

### 1.1 Background

It has been just over 2 years since the Covid 19 pandemic began. The first Covid 19 case is estimated to have risen in October to November 2019. The cases rose unexpectedly and Covid 19 was declared to be a Public Health Emergency of International Concern on 30 January 2020 (World Health Organization, 2020) and a pandemic on 11 March 2020 (World Health Organization, 2020). Many lives have been lost ever since and others left strained physically, emotionally, financially and psychologically. Great thanks go to the brave professionals who fought tirelessly to birth solutions. The introduction of Covid 19 vaccines were a win for the world at large. Prior to Covid 19, vaccines for infectious diseases took at least 5 years to be invented, tested and approved before administering to the public. Urgency and precision were of great importance with the Covid 19 pandemic and thankfully, in only a couple of months, the first administered Covid 19 vaccine was dated as far back as December 2020 (BCC News, 2020). The intention behind being to provide acquired immunity against Covid 19. The Covid 19 vaccines have played a huge role in reducing the severity and death caused by this deadly virus (Dan Vergano, 2021).

### 1.2 Literature Review

Even though the battle with Covid 19 is not yet over, so much action has been done to preserve as much health and life as possible regardless of the fact that it has been over 2 years ever since the declaration of Covid as a world pandemic. The average deaths have relatively declined in most countries that have been taking vaccines by the horns and according to WHO (World Health Organization) and ECDC (European Centre for Disease Prevention and Control), nearly half a million lives were saved by Covid 19 as at 25 November 2021 (European Centre for Disease Prevention and Control, 2021). Even though vaccination did not and does not guarantee complete immunity, it has given the world an upper hand in the fight against the Covid-19 pandemic.

With the administration of Covid 19 vaccines, following healthcare protocols was advised by the CDC (Centers for Disease Control and Prevention) that all health care personnel involved in the administering of Covid 19 vaccines as well as patient care of the infected, be given comprehensive, competency-based training on vaccine administration policies and procedures before administering vaccines. (Centers for Disease Control and Prevention, nd)

Many lives have been expected to be saved following the introduction of Covid 19 vaccines. Zimbabwe, among other nations, joined the cause and launched its national Covid 19 vaccination program using the Sinopharm BIBP vaccine in February 2021 (News24, 2021). As 2021 went by, the number of vaccinated citizens of Zimbabwe increased. By November 2021, about 3.7 million Zimbabweans had received the first dose of Covid 19 vaccines and 2,795,050 had been fully vaccinated (Edouard Mathieu et al, 2021).

### 1.3 Problem Statement

The best outcome would have been a decrease in number of the number of daily new Covid 19 cases and the number of Covid 19 related deaths. Yet, spikes of new cases and new deaths were evident. The question rises, even though the Covid 19 vaccinations have proven in other countries to save lives, has the same taken place in Zimbabwe? And if not, who is responsible? Can it be the public's fault if the number of Covid 19 cases and deaths continued to rise in spite of the introduction of vaccines as well as the many health measures advised by WHO and other health experts?

This study is designed to examine the trends of Covid 19 daily new cases and daily new Covid 19 related deaths before and after the introduction of Covid 19 vaccines in the country of Zimbabwe and to determine the following objectives, where the population is the people residing in Zimbabwe. Since Covid 19 came with multiple variants, two Covid 19 variants were examined in this study. The first variant peaked in Zimbabwe as well as in South Africa in January 2021 (The Mail & Guardian, 2021) and was known as the Beta variant (Cheryl Kahla, 2021). The second variant was known as the Omicron variant and it arrived and peaked in Zimbabwe in December 2021 (Columbus Mavhunga, 2021).

### 1.4 Objectives

i. To compare the trends of the number of Covid 19 daily new cases and related deaths before and after the introduction of vaccines to the Zimbabwean people for the months of January 2021 (peak of Beta Covid 19 variant in Zimbabwe) and December 2021 (peak of Omicron Covid 19 variant in Zimbabwe).
ii. To determine to what extent the vaccinations have impacted the number of Covid 19 daily new Covid 19 cases and daily new Covid 19 related deaths in Zimbabwe for the months of January 2021 (peak of Beta variant) and December 2021 (peak of Omicron variant).
iii. To estimate the reason behind the trends of the number of Covid 19 cases and deaths after the introduction of Covid 19 vaccines.
iv. To draw a data driven conclusion of the above objectives.

## 2.0 DATA DESCRIPTION

### 2.1 Data Source

Data was acquired from the World Health Organization (WHO) website. The statistical figures of Covid 19 on the WHO website are accessible to all and are updated constantly. Where WHO gave the following description:

*New case and death counts: Counts of new cases and deaths are calculated by subtracting previous cumulative total counts from the current count. These counts are updated incrementally throughout the day as more information becomes available. Daily new case and death counts are complete by 23:59 CET/CEST each day. Due to differences in reporting methods, cut-off times, retrospective data consolidation and reporting delays, the number of new cases may not always reflect daily totals published by individual countries, territories or areas. Due to the recent trend of countries conducting data reconciliation exercises which remove large numbers of cases or deaths from their total counts, such data may reflect as negative numbers in the new cases / new deaths counts as appropriate. This will aid users in identifying when such adjustments occur. When additional details become available that allow the subtractions to be suitably apportioned to previous days, data will be updated accordingly* (World Health Organization, nd).

For this study to be done smoothly, the dataset was assessed and it was decided that the following variables will be used:

I. Date
II. Number of daily new Covid 19 cases per day
III. Number of daily new Covid 19 related deaths per day

### 2.3 Data Preparation and Segregation

After extracting the up-to-date Covid 19 dataset as at 3 March 2022, the following steps were taken:

1. Independently outsourced worksheets of January 2021 and December 2021, extracted from the main dataset with statistical figures from March 2020 to March 2022.

2. Ensured that columns were of the following variables: Date_recorded, New_Cases, Cumulative_cases, New_deaths and Cumulative_deaths were in the right format i.e., date and number format (to zero decimal places).

### 2.4 Data Cleaning

A check for duplicated dates after constructing separate worksheets was done to make sure the data was strictly recorded once a day.

### 2.5 Data Transfer To Work Station

The data for January 2021 and December 2021 were imported into R using the *readxl* function.

### 2.6 Data Overview Using Data Visualization/Exploratory Data Analysis

To have a basic understanding of the occurrence of the number of daily new cases and deaths, *ggplot2* package in R gave the following box plots.

## 3.0 DATA VIZUALIZATION AND ANALYSIS RESULTS

### 3.1 Covid 19 Daily New Cases

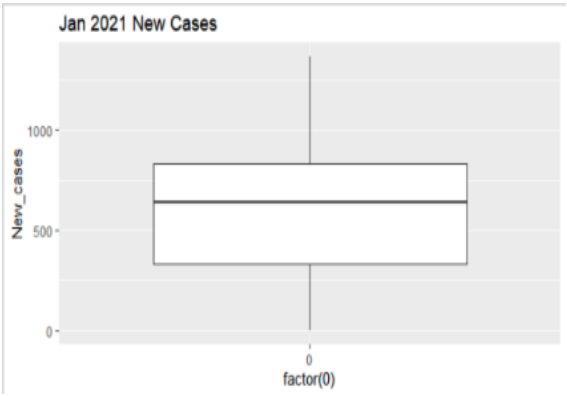


**Figure 1: Daily New Cases For January 2021**

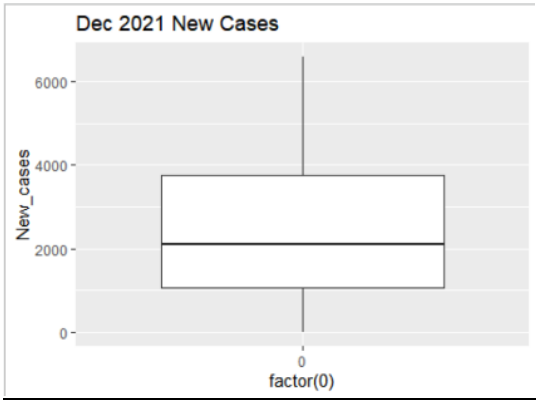


**Figure 2: Daily New Cases For December 2021**

```
> summary(dfJan2021$New_cases)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
    0.0   334.0   639.0   633.7   829.5  1365.0
```

**Figure 3: Statistical Summary For January 2021 New Cases**

```
> summary(dfDec2021$New_cases)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
      0    1072    2099    2500    3755    6586
```

**Figure 4: Statistical Summary For December 2021 New Cases**

Given Figure 1, Figure 2, Figure 3 and Figure 4, it was observed that averagely, more daily new Covid 19 cases were obtained in December 2021 in comparison to January 2021. Evidently:

1. December 2021 had a maximum of 6586 new cases whereas January 2021 had a maximum of 1365 cases.
2. The average daily new Covid 19 cases in December 2021 of 2500 was 3.95 (rounded off to 3 significant figures) times more than the average daily new Covid 19 cases in January 2021 of 633.7.
3. There were no significant outliers in January 2021 and December 2021.

### 3.2 Covid 19 Daily New Deaths

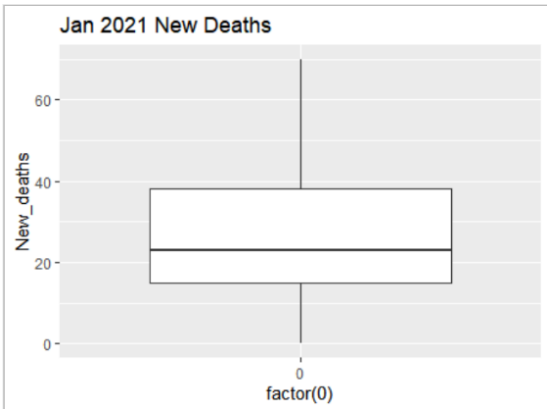


**Figure 5: Daily New Deaths For January 2021**

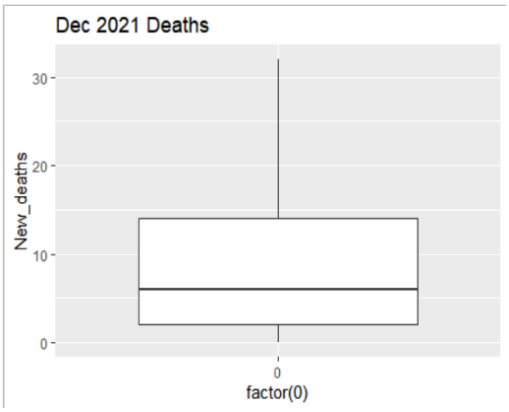


**Figure 6: Daily New Deaths For December 2021**

```
> summary(dfJan2021$New_deaths)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.00   15.00   23.00   26.87   38.00   70.00
```

**Figure 7: Statistical Summary For January 2021 New Deaths**

```
> summary(dfDec2021$New_deaths)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  0.000   2.000   6.000   9.387  14.000  32.000
```

**Figure 8: Statistical Summary For January 2021 New Deaths**

On the contrary, given Figure 5, Figure 6, Figure 7 and Figure 8, it was observed that less daily new Covid 19 related deaths were obtained in December 2021 in comparison to January 2021. Evidently:

1. December 2021 had a maximum of 32 daily new Covid 19 related deaths whereas January 2021 had a maximum of 70 daily new Covid 19 related deaths.
2. The average of daily new Covid 19 related deaths in January 2021 of 26.87 was 2.86 (rounded off to 3 significant figures) times more than the average of daily new Covid 19 related deaths in January 2021 of 9.387.
3. There were no significant outliers in January 2021 and December 2021.

### 3.3 Irregularities

Zero values under the daily new number of cases column show irregularities. An assumption is made that the data entries with 0 as daily new Covid 19 cases are missing data since it vastly mismatches with the average number of daily new cases of each the months. Refer to table 1.

**Table 1: Data With Versus Without Missing Entries**

| Month | Number Of Missing Entries | Dates Of Missing Entries | Average Daily New Cases (Including Zero) | Average Daily New Cases (Excluding Zero) | Second Minimum Daily New Cases After Removing Zero | Maximum Daily New Cases |
|---|---|---|---|---|---|---|
| Jan 2021 | 1 | 2021/01/02 | 633.74 | 654.87 | 242 | 1365 |
| Dec 2021 | 1 | 2021/12/07 | 2500 | 2583 | 426 | 6586 |

Assuming that the missing of data is Missing Completely at Random (MCAR), where there is no relationship linking the various missing data points together, meaning that the number of daily new Covid 19 cases on a given day that is missing is not dependent on the data we have or the data that is missing. And so, by Complete Case Analysis or Listwise Analysis, we deleted the missing day entries to have the following data overview where new datasets without entries from the days *2021/01/02* and *2021/12/07* gave rise to new datasets: $Jan_0$ 2021 and $Dec_0$ 2021.

### 3.4 Updated Covid 19 Daily New Cases

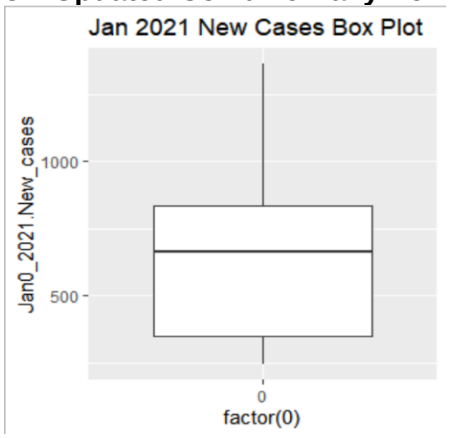


**Figure 9: Updated Daily New Cases For January 2021**

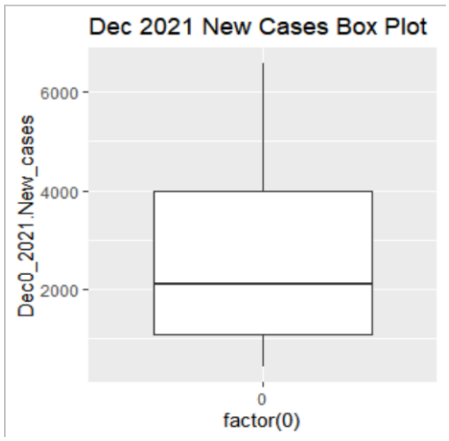


**Figure 10: Updated Daily New Cases For December 2021**

```
> summary(Jan0_2021$New_cases)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  242.0   346.0   664.0   654.9   834.2  1365.0
```

**Figure 11: Updated Statistical Summary For January 2021 New Cases**

```
> summary(Dec0_2021$New_cases)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
    426    1086    2102    2583    4001    6586
```

**Figure 12: Updated Statistical Summary For December 2021 New Cases**

Given Figure 9, Figure 10, Figure 11 and Figure 12, it was still evident that more daily new Covid 19 cases were obtained in December 2021 in comparison to January 2021. Evidently:

1. December 2021 had a maximum of 6586 new cases whereas January 2021 had a maximum of 1365 cases.
2. The average daily new Covid 19 cases in December 2021 of 2583 was 3.94 (rounded off to 3 significant figures) times more than the average daily new Covid 19 cases in January 2021 of 654.9

3. There were no significant outliers in January 2021 and December 2021.

### 3.5 Updated Covid 19 Daily New Deaths

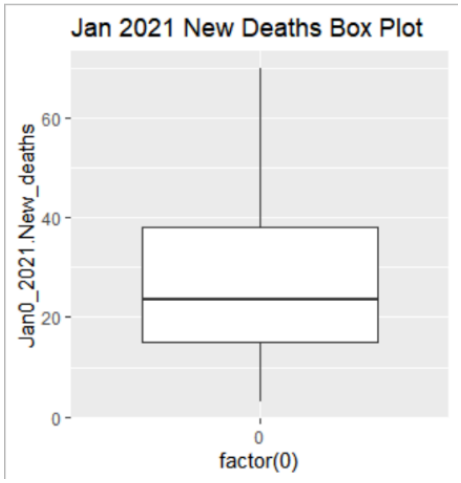


**Figure 13: Updated Daily New Deaths For January 2021**

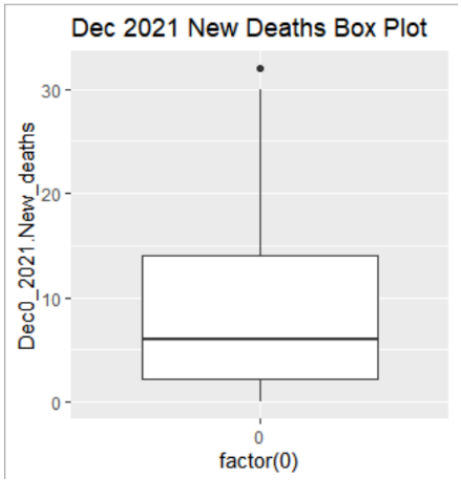


**Figure 14: Updated Daily New Deaths For December 2021**

```
> summary(Dec0_2021$New_deaths)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.00    2.25    6.00    9.70   14.00   32.00
```

**Figure 15: Updated Statistical Summary For January 2021 New Deaths**

```
> summary(Jan0_2021$New_deaths)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   3.00   15.00   23.50   27.77   38.00   70.00
```

**Figure 16: Updated Statistical Summary For December 2021 New Deaths**

On the other hand, given Figure 13, Figure 14, Figure 15 and Figure 16, it was observed that less daily new Covid 19 related deaths were obtained in December 2021 in comparison to January 2021. Evidently:

1. December 2021 had a maximum of 32 daily new Covid 19 related deaths whereas January 2021 had a maximum of 70 daily new Covid 19 related deaths.
2. The average of daily new Covid 19 related deaths in January 2021 of 27.77 was 2.86 (rounded off to 3 significant figures) times more than the average of daily new Covid 19 related deaths in January 2021 of 9.70
3. There were significant outliers in December 2021.

## 4.0 INFERENTIAL STATISTICAL ANALYSIS RESULTS

### 4.1 Overview

Given our data, the exposed data was the Covid 19 data of December 2021 that contained residents of Zimbabwe that were vaccinated against Covid 19. On the other hand, the unexposed or control group was January 2021 data that did not contain any vaccinated residents of Zimbabwe. Our outcome of interest was the number of daily new Covid cases as well as the daily new Covid 19 related deaths per days of the months, either January 2021 or December 2021. Our independent variable was the days of the months of either January 2021 or December 2021. The purpose of the inferential statistical analysis was to identify whether there is a difference between the outcome of interest of the exposed group and the unexposed data group. We used the 2-sample t-test (Welch Two Sample t-test) to further prove the difference between the control group verses the exposed group and how Covid 19 vaccines impacted the number of daily new Covid 19 cases and the daily new Covid 19 related deaths.

Firstly, we checked whether our data was fit for t-test by generating a histogram for all 4 groups of data. Since each month had over 25 observations with no extreme outliers and was moderately skewed, the t-test was to work even for moderately skewed distributions of the outcome variable (Saskia le Cessie et al, 2020). Refer to histograms below.

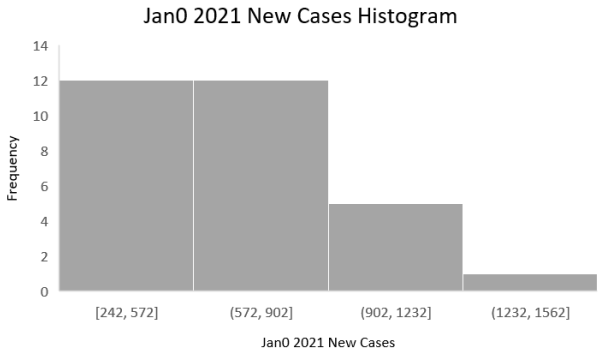


**Figure 14: January 2021 New Cases Histogram**

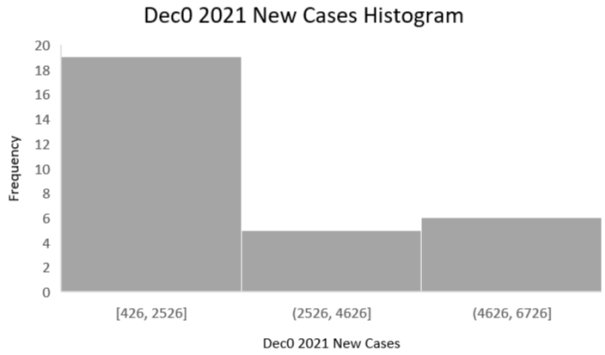


**Figure 15: December 2021 New Cases Histogram**

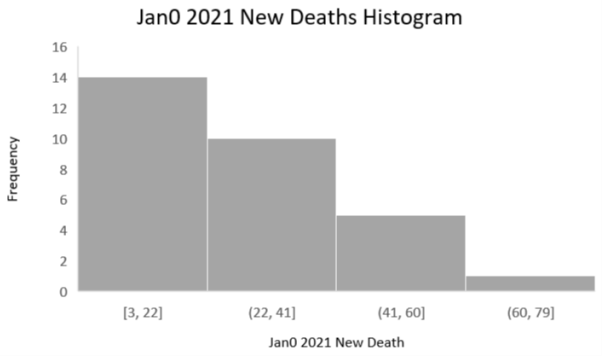


**Figure 16: January 2021 New Deaths Histogram**

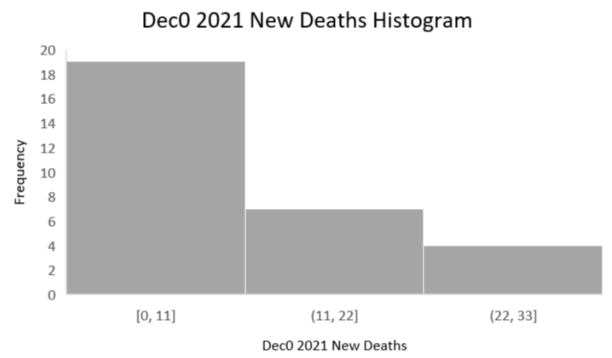


**Figure 17: December 2021 New Deaths Histogram**

Using the Welch Two Sample t-test, it was not assumed that the variances were equal between the groups. In addition, a 95% confidence interval was. The *t.test()* command in R was used. Our test ran on the following hypothesis:

$H_0$: difference in mean is equal to 0.

$H_1$: difference in mean is not equal to 0.

### 4.2 January 2021 Daily New Cases versus December 2021 Daily New Cases

The t-test statistic between December 2021 and January 2021 daily new cases was *5.7008* and the degrees of freedom (df) associated with this t-test statistic was *30.452*. The p-value that corresponded to the t-test statistic of *5.7008* and df = *30.452* was *3.064e-06*.

Our null hypothesis, $H_0$ stated that there was no difference between the average daily new Covid 19 cases of January 2021 and the average daily new Covid 19 cases of December 2021. On the other hand, the alternative hypothesis, $H_1$, stated that the true difference in mean between the daily new Covid 19 cases of January 2021 and December 2021 is not equal to zero.

The 95% confidence interval for the difference in means between daily new January 2021 Covid 19 cases and daily new December 2021 Covid 19 cases was [*1238.073, 2618.994*]

Lastly, the sample estimates mean of January 2021 was *654.8667* and that of December 2021 was *2583.4000*.

Since *3.064e-06 < 0.05*, we reject the null hypothesis, $H_0$ and conclude that there was sufficient evidence to say that the mean daily new Covid 19 cases between January 2021 and December 2021 had a true difference that is not zero. Conclusively, the introduction of Covid 19 vaccines indicate a difference in the average daily new Covid 19 cases, with December 2021 carrying a higher mean of daily new Covid 19 cases after the introduction of Covid 19 vaccines in Zimbabwe.

### 4.3 January 2021 Daily New Covid 19 Related Deaths versus December 2021 Daily New Covid 19 Related Deaths

The t-test statistic between January 2021 and December 2021 daily new Covid 19 related deaths was *5.0704* and the degrees of freedom (df) associated with this t-test statistic was *45.081*. The p-value that corresponded to the t-test statistic of *5.0704* and df = *45.081* was *7.246e-06*.

Our null hypothesis, $H_0$ stated that there was no difference between the average daily new Covid 19 related deaths of January 2021 versus the daily new Covid 19 related deaths of December 2021. On the other hand, the alternative hypothesis, $H_1$, stated that the true difference in mean between the daily new Covid 19 related deaths of January 2021 and December 2021 is not equal to zero.

The 95% confidence interval for the difference in means between January 2021 Covid 19 related deaths and December 2021 Covid 19 related deaths was [*10.89043, 25.24290*]

Lastly, the sample estimates mean of January 2021 was *27.76667* and that of December 2021 was *9.70000*.

Since *7.246e-06 < 0.05*, we rejected the null hypothesis, $H_0$ and conclude that there was sufficient evidence to say that the mean daily new Covid 19 related deaths between January 2021 and December 2021 had a difference that is not zero. Conclusively, the introduction of Covid 19 vaccines indicate a difference in the average daily new Covid 19 related deaths, with December 2021 carrying a lower mean of daily new Covid 19 related deaths after the introduction of Covid 19 vaccines in Zimbabwe.

## 5.0 CONCLUSION

After the introduction of Covid 19 vaccines in Zimbabwe, following a spike in the rise of Covid 19 daily new cases and Covid 19 related deaths over time, an overall significant incline in the number of Covid 19 daily new cases was seen whereas a significant decline in Covid 19 related deaths was seen.

It is evident that even though Covid 19 vaccinations were introduced, Zimbabwe experienced an increase in the average number of daily new Covid 19 cases per month but thankfully, a reduced amount of the average Covid 19 related deaths per month. The average daily new Covid 19 cases in December 2021 was approximately 3.94 times more than the average daily new Covid 19 cases in January 2021, thus showing an increase over time from before Covid 19 vaccines to after Covid 19 vaccines were introduced in Zimbabwe. On the other hand, the average of daily new Covid 19 related deaths in January 2021 was 2.86 times more than the average of daily new Covid 19 related deaths in January 2021. This proves that the Covid 19 vaccines helped reduce the average number of Covid 19 related deaths over time and may have saved the lives of Zimbabwean residents. Unfortunately, the increased rate of infection of Covid 19 following the introduction of vaccines increased rapidly, proving negligence by Zimbabwean residents by a significant extent.

It would be best to continue to spread awareness and inform Zimbabwean residents to stay watchful of Covid 19 in spite of available vaccines and to follow all Covid 19 regulations in order to stop the spread of Covid 19 and save as many lives as possible.

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