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AN ANALYSIS OF COVID-19 INFECTIONS, RECOVERIES AND DEATHS IN RIVERS STATE, NIGERIA

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Introduction. *The objective of the current study is to determine statistical difference in means of COVID-19 infected population, discharged cases and deaths resulting from COVID-19 pandemic and to estimate number of people that can survive it in Rivers State, Nigeria.* ***Material and methods.*** *In this study, extraction of infected population, discharged cases and deaths from COVID-19 was carried out from data obtained from Nigeria Centre for Disease Control which covered a period of 572 days. The test for significance of means among the variables was done using one-way Analysis of Variance followed by Tukey HSD test. The two variables whose means do not significantly differ were tested for strength of relationship and dependence using correlation analysis and cubic polynomial function respectively.* ***Results.*** *Results showed that there is statistically significant difference between infected population, discharged cases and deaths from COVID-19 as obtained from one-way ANOVA (F(2, 1710)=121.958, p=0.000). Use of Tukey HSD test indicated that means of infected population and discharged cases do not differ from each other (p>0.01); however, mean deaths from COVID-19 significantly differ from others at 99% confidence intervals (p<0.01). There was weak positive relationship between deaths due to COVID-19 and other two groups (r=0.360, n=571, p=0.000). However, moderate positive correlation existed between COVID-19 infected population and discharged population (r=0.566, n=571, p=0.000) at 99% confidence interval.* ***Conclusions.*** *Mean of deaths from the study population was significantly different from means from both infected population and discharged cases. This implies that only few people died from COVID-19 in Rivers State Nigeria when compared to those who got infected and recovered from COVID-19 pandemic.*

Cuvinte-cheie: *boală, coronavirus, deces, COVID-19, râuri, Nigeria.*

ANALIZA INFECȚIILOR, RECUPERĂRILOR ŞI A DECESELOR CAUZARE DE COVID-19 ÎN LUNCA R URILOR DIN NIGERIA

Introducere. *Obiectivul studiului este de a determina diferența statistică între mediile populației infectate cu COVID-19, cazurile externate și decesele rezultate în urma pandemiei și de a estima numărul de persoane care pot supraviețui acesteia în lunca râurilor, din Nigeria.* ***Material și metode.*** *În acest studiu extragerea populației infectate, a cazurilor externate și a deceselor din cauza COVID-19 a fost efectuată în baza datelor obținute de la Centrul Nigeria pentru Controlul Bolilor, care a acoperit o perioadă de 572 de zile. Testul pentru semnificația mediilor dintre variabile a fost realizat folosind analiza varianței unidirecționale urmată de testul Tukey HSD. Cele două variabile ale căror medii nu diferă semnificativ au fost testate pentru puterea relației și dependența folosind analiza corelației și, respectiv, funcția polinomială cubică.* ***Rezultate.*** *Rezultatele au arătat că există o diferență semnificativă statistic dintre populația infectată, cazurile externate și decesele cauzate de COVID-19, obținute prin testul ANOVA unidirecțional (F(2, 1710)=121,958, p=0,000). Utilizarea testului Tukey HSD a indicat că mediile populației infectate și cazurile externate nu diferă unele de altele (p>0,01). Cu toate acestea, decesele medii cauzate de COVID-19 diferă semnificativ de altele la intervale de încredere de 99% (p<0,01). A existat o relație pozitivă redusă între decesele cauzate de COVID-19 și alte două grupuri (r=0,360, n=571, p=0,000). Prin urmare, a existat o corelație pozitivă moderată între populația infectată cu COVID-19 și populația externată (r=0,566, n=571, p=0,000) la un interval de încredere de 99%.* ***Concluzii.*** *Media deceselor din populația de studiu a fost semnificativ diferită de media atât de la populația infectată, cât și de la cazurile externate. Aceasta implică faptul că doar puțini oameni au murit din cauza COVID-19 în lunca râurilor din Nigeria, în comparație cu cei care s-au infectat și s-au recuperat după pandemia de COVID-19.*

INTRODUCTION

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is a virus strain responsible for Corona virus disease 2019(COVID-19). Its first case was discovered in year 2019 in Wuhan, Hubei province of China and has spread to different parts of the world. Since Nigeria's first index case arrived Lagos State on the 27th February 2020, other states of Federal Republic of Nigeria have recorded daily epidemiological case of COVID-19. Rivers State being one of the thirty-six states in Nigeria had its first laboratory confirmed case announced by Nigeria Centre for Disease Control on the 25th March 2020. As part of the proactive measures taken to curtail the spread of the virus, Rivers State government announced closure of all schools within the state and restricted activities related to religious groups, cinemas, night clubs, public parks, weddings and burials (1, 2). Further measures to curb the spread of the virus included indefinite closure of the sea, air and land borders on the 26th March 2020 (3) and on the 28th March 2020, the state government announced indefinite closure of all markets (4).

Some studies have been conducted on COVID-19 for some states in Nigeria (5). Alasia and Maduka (6) investigated prevalence and pattern of COVID-19 infection in Rivers State with emphasis on healthcare workers and concluded that prevalence of COVID-19 among healthcare workers was high. Robinson (7) also assessed COVID-19 safety precautions in radio-diagnostic centres in capital city of Rivers State and concluded that personal protective equipment (PPE) were generally unavailable in many radio-diagnostic centres thereby posing significant increase in risks of COVID-19 infections. In findings of Uzosike et al. (8), they also highlighted experiences of health workers in Rivers State and factors that could improve their performance in handling COVID-19 patients. A positive perspective of the effect of COVID-19 lockdown on farmers in Rivers State, Nigeria was also examined by Anagah (9) where he discussed how the sales of agricultural produce led to very high profits due to surge in demands relative to COVID-19 lockdown.

Investigation of clinical and epidemiological characteristics of some hospitalized SARS-CoV-2 positive patients in Rivers State (10) indicates that patients of COVID-19 disease have leading symptoms of fever, fatigue, dry cough, dyspnea, diarrhoea and vomiting with hypertension, diabetes and increasing age associated severe disease and death in the study population and therefore concluded that such epidemiological and clinical observations of COVID-19 patients in Nigeria is similar to the patterns in Africa and across the globe.

On daily and weekly bases, results of laboratory confirmed COVID-19 cases were published by Nigeria Centre for Disease Control (NCDC) for Rivers State and such painstaking efforts require laboratory tests with use of chemicals and other resources. *The aim of this study* is to statistically determine level of association between infected population, discharged cases and deaths from COVID-19 in Rivers State, Nigeria. Specific objective of this study is to estimate the number of people that can survive the disease whenever infected population is known. This can help gain insight into pattern of spread, recovery and deaths from COVID-19 in the study area.

MATERIAL AND METHODS

Study Area

The study areas Rivers State with estimated population of 7,303,924 as at the year 2016 and is located in south-south geopolitical zone of Nigeria (11). It consists of twenty-three local government areas and has its borders with Atlantic Ocean, Akwa Ibom, Imo, Abia, Bayelsa, Delta and Anambra states. Rivers State has average temperatures ranging between 25°C and 28°C, relative humidity usually above 60% throughout the year and rainfall is seasonal occurring between the months of March and November with peak of wet season usually in July. The inland part of the state around the coastal areas consists of tropical rainforest with typical mangrove swamp environments and the capital city of Rivers State is Port Harcourt (12) which is regarded as the commercial hub of Nigerian oil industry.

Rivers State was created by Nigerian government in the year 1967 and it comprises of minority ethnic groups, some of whom are Ikwerre, Ogoni, Ijaw and Okrika people (12). Presence of petroleum industry has increased revenue for Nigerian government and has attracted other ethnic groups and nationalities.

Epidemic Data

The data for this study was obtained from Nigeria Centre for Disease Control (NCDC). It consists

of daily records of COVID-19 disease data from the first day of disease detection in Rivers State which is 25th March 2020 to 17th October 2021. The period covered by the data for this study includes both the period of non pharmaceutical approach and the period of vaccination of some class of susceptible population in Rivers State. However, due to insufficient number of vaccines at the time of this study, quite a large number of susceptible individuals have not been vaccinated. This still has significant drawbacks on the efforts required to curtail the spread of the virus.

Data Analysis

This research investigated test for significance of means among variables using one-way Analysis of Variance (ANOVA) and Tukey HSD test. Correlation analysis and cubic polynomial function were used to test for strength of relationship and dependence respectively among variables. Data analysis and results were obtained with the aid of IBM Statistical Package for Social Sciences (version 23). Research hypothesis for this study consists of null hypothesis which states that there are no statistically significant differences between means of infected population, discharged cases and deaths due to COVID-19. The alternate hypothesis of the study states that there are statistically significant differences between means of infected population, discharged cases and deaths due to COVID-19.

Model Specification

Let X_{ij}be dependent variable which represents each infected COVID-19 patient in each treatment group$j$representing infected population (lab confirmed), discharged cases or deaths due to COVID-19 and μ represent the population mean for treatment effect β_j in the group j, then mathematical model representing one-way ANOVA for a completely randomised design is given by $X_{ij} = \mu + \beta_j + \xi_{i\,(j)}$where $\xi_{i\,(j)}$ is a random error or effect associated with other extraneous variables on COVID-19 infected patients in treatment group j representing infected population (lab confirmed), discharged cases or deaths due to COVID-19. It is assumed that $\xi_{i\,(j)}$is independent and normally distributed with mean zero and equal variance σ^2 written in short notation as $\xi_{i\,(j)} \sim N\,(0, \sigma^2)$.

Pearson Product Moment Correlation (PPMC) of the degree of relationship between variable V representing infected population (lab confirmed) and variable D representing death due to COVID-19 in Rivers State, Nigeria is defined by

$$r = \frac{N\sum VD \; - \; (\sum V)\,(\sum D)}{\sqrt{[N\sum V^2 \; - \; (\sum V)^2]} \;\; . \;\; \sqrt{[N\sum D^2 \; - \; (\sum D)^2]}}$$

where r is the correlation coefficient such that $-1 \leq r \leq 1$.

Define function $f(v)$ simply denoted by F as a dependent variable on independent variable v, then cubic polynomial function is of the form

$$F = p + qv \; + rv^2 + \; s\,v^3$$

which can be referred to as polynomial function of degree 3 where **p**, **q**, **r** and **s** are constants of the functional representation **F** for independent variable **v**.

RESULTS

Graphical analyses of results showing data for daily infected population (lab confirmed), daily discharged cases and daily deaths due to COVID-19 in Rivers State are displayed in Figures 1, 2 and 3.

The contents of table 5 indicate that relationship showing dependence of discharged cases on infected population could be established using polynomial function of degree 3. Simple explanation of this is that data set representing COVID-19 infected population and discharged cases from Rivers State, Nigeria could be fitted to give fairly good approximation of discharged patients whenever daily infected cases are known. From results shown in Table 5, relationship between the COVID-19 infected population and discharged case can be represented by the cubic polynomial given by $F = 4.673 + 1.148\,V - \; 0.007V^2 + \; 1.7265 \; \times 10^{-5}V^3$ where F represents group of people which were discharged free from COVID-19 and V represents variable for COVID-19 infected population in Rivers State, Nigeria.

DISCUSSIONS

It can be observed that patterns shown in Figure 1 follow similar trend as observed in Figure 2 but with some little differences when juxtaposed, but Figure 3 showed very low number of people when compared with Figures 1 and 2. This implies that deaths due to COVID-19 did not have similar pattern with both infected cases and discharged population. It can be observed (fig. 4) that average of 22 people were confirmed infected with COVID-19 daily in Rivers State, Nigeria. While av-

erage of 21 patients was discharged, deaths due to COVID-19 have an average of 1 death per day.

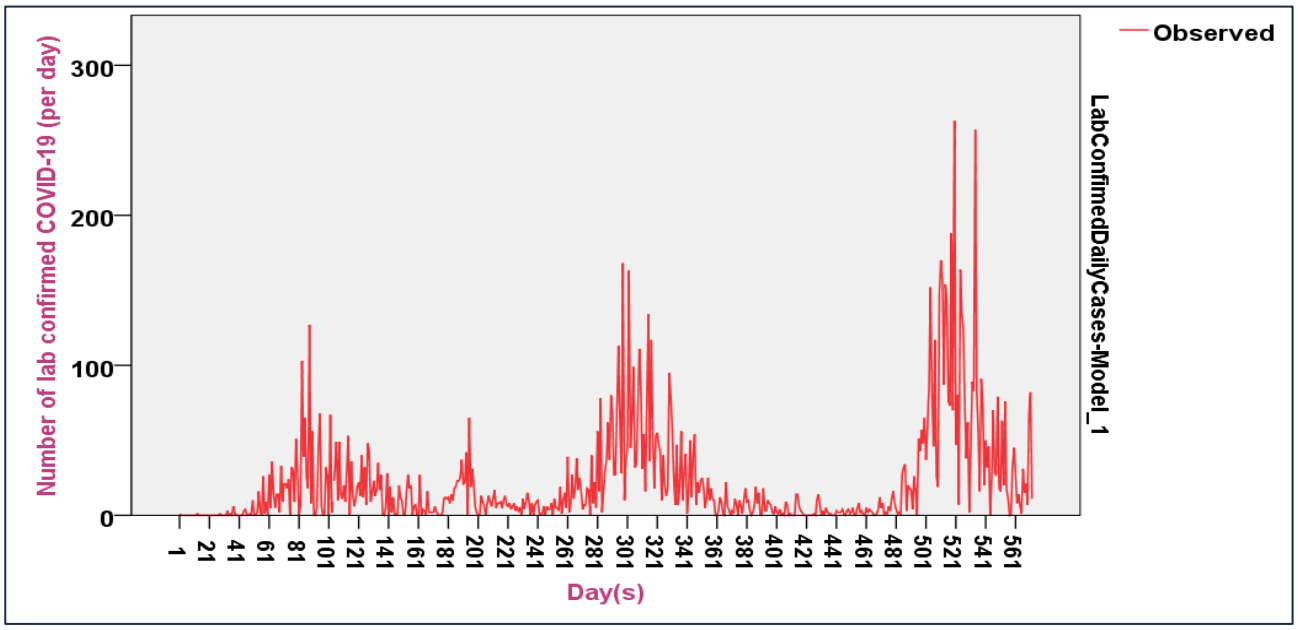

Figure 1. Daily laboratory confirmed COVID-19 cases in Rivers State (25th March 2020 - 17th Oct 2021).

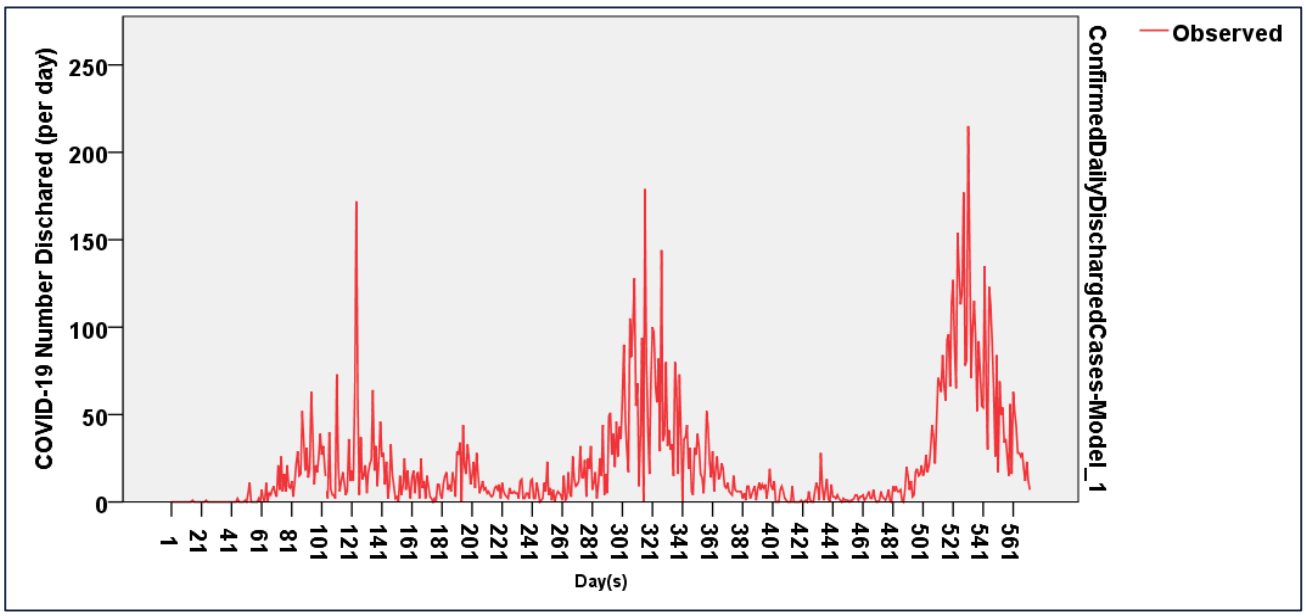

Figure 2. Daily discharged cases (formerly infected with COVID-19) in Rivers State (25th March 2020 - 17th Oct 2021).

In order to determine whether there are statistically significant differences between means of infected population (lab confirmed), discharged cases and deaths due to COVID-19, results for One-Way Analysis of Variance are shown in Table 1. Furthermore, from results displayed in Table 1, it can be seen that there is a statistically significant difference between COVID-19 infected population, discharged cases and deaths from COVID-19 ($F(2,1710)=121.958$, $p=0.000$). However, results in Table 1 do not indicate specific groups which were significantly different from others. Since it has been affirmed from the results presented in Table 1 that at least two groups were different, it is pertinent to show which of the groups differ from others with aid of post hoc test. Thus, using Tukey post hoc test, results are shown in Table 2 which are multiple comparisons.

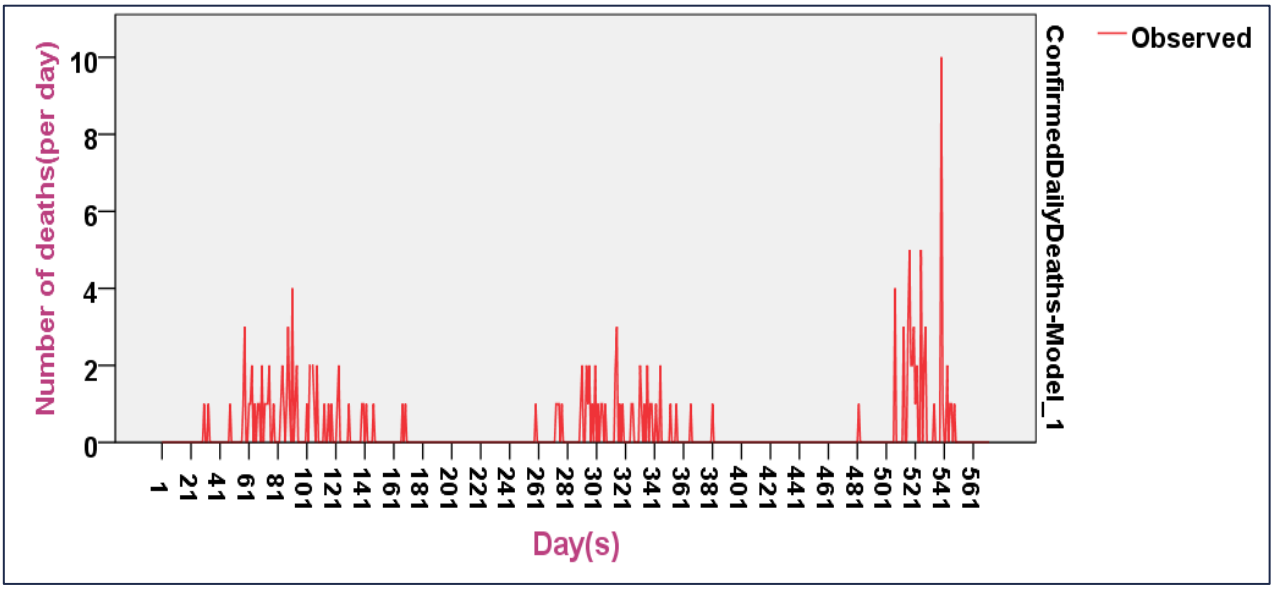

Figure 3. Deaths per day due to COVID-19 in Rivers State (25th March 2020 - 17th Oct 2021).

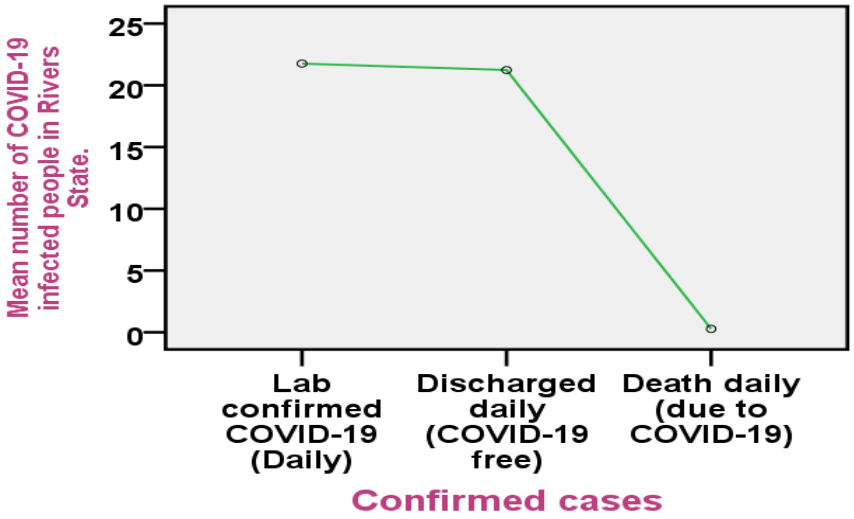

Figure 4. Mean number of COVID-19 infected, discharged and deceased cases in Rivers State (25th March 2020 - 17th Oct 2021).

Table 1. One-way ANOVA for COVID-19 infected, discharged and deceased cases in Rivers State (25th March 2020 - 17th Oct 2021).

Model	Sum of squares	df	Mean square	F	p-value
Between Groups	171554.891	2	85777.445	121.958	0.000
Within Groups	1202705.110	1710	703.336		
Total	1374260.001	1712			

It can be observed that there is no statistically significant difference between the group representing COVID-19 infected population (lab confirmed) and the group representing discharged cases (p=0.941) but there is statistically significant difference between COVID-19 infected population (lab confirmed) and group representing deaths due to COVID-19 (p=0.000).

Also, there was statistically significant difference between the groups representing discharged cases and daily deaths due to COVID-19 in Rivers

Table 2. Tukey post hoc test of multiple comparison.

(i) COVID-19 infected population (lab confirmed)	(j) COVID-19 infected population (lab confirmed)	Mean Difference(i-j)	Std. Error	p-value	99% confidence Interval	
					LBound	UBound
COVID-19 infected population (lab confirmed)	Discharged case (COVID-19 free)	0.522	1.570	0.941	-3.16	4.20
	Deathdaily (due to COVID-19)	21.485	1.570	0.000	17.80	25.17
Discharged case (COVID-19 free)	COVID-19 infected population (lab confirmed)	-0.522	1.570	0.941	-4.20	3.16
	Deathdaily (due to COVID-19)	20.963	1.570	0.000	17.28	24.65
Deathdaily (due to COVID-19)	Discharged case (COVID-19 free)	-21.485	1.570	0. 000	-25.17	-17.80
	COVID-19 infected population (lab confirmed)	-20.963	1.570	0.000	-24.65	-17.28

Table 3. Strength of relationship between infected population and deaths due to COVID-19.

		Infected population (lab confirmed)	Deaths due to COVID-19	p-value
Infected population (lab confirmed)	Pearson Correlation	1	0.360+	0.000++
Deaths due to COVID-19		0.360+	1	0.000++

\+ Value correlation coefficient r
++ Significant at α = 0.01 level

Table 4. Strength of association between infected population and discharged cases.

		Infected population (lab confirmed)	Dailydischarged cases	p-value
Infected population (lab confirmed)	Pearson correlation	1	0.566+	0.000++
Dailydischarged cases		0.566+	1	0.000++

\+ Value correlation coefficient r
++ Significant at α = 0.01 level

Table 5. Cubic polynomial approximation of daily discharged case from COVID-19 infected population.

Model	B	Std Error	Beta	t	p-value
(constant)	4.673	1.519		3.077	0.002
Daily infected case	1.148	0.119	1.265	0.9643	0.000
Daily infected case (square)	-0.007	0.002	-1.343	-4.485	0.000
Daily infected case (cube)	1.7265×10^{-5}	0.000	0.672	3.316	0.010

State (p=0.000). This implies that deaths due to COVID-19 significantly differ from both COVID-19 infected population and discharged cases in Rivers State, Nigeria (p=0.000). It is worthwhile to determine degree of relationship between the categories of COVID-19 infected population, discharged cases and deaths due to COVID-19.

In order to determine the degree of relationship between the categories of COVID-19 infected population, discharged cases and deaths due to COVID-19, results for correlation analysis between COVID-19 infected population and deaths due to COVID-19 are shown in Table 3. Though relationship exists between COVID-19 infected population and deaths due to C0VID-19, it is a weak positive relationship (r=0.360, n=571, p=0.000) at 99% confidence interval.

From results in Table 4, the degree of relationship indicated a moderately strong relationship between the two groups. This implies that the relationship between COVID-19 infected population and daily discharged cases exhibited moderately positive relationship (r=0.566, n=571, p=0.000) at 99% confidence interval.

From results obtained using One-Way ANOVA and Correlation Analysis, it may not be necessary to further analyse the association between deaths and other groups. However, more investigation could still be explored with respect to relation ship between characteristics of COVID-19 infected population and discharged cases; hence results from cubic polynomial functional relationship are displayed (tab. 5).

The essence of Table 5 is the formulation of mathematical equation which can be used to determine number of people F that may be discharged free from Covid-19 whenever population of COVID-19 infected people V are known in Rivers State Nigeria. For instance, if 800 people are COVID-19 infected, then set V=800 in the derived equation to obtain an approximate $F \approx 5283$ which implies that about 5283 people may be discharged free from COVID-19. This means that knowing lab confirmed cases, the formulated mathematical equation can facilitate estimation of the number of people that can survive the disease.

While the studies conducted by Alasia and Maduka centred on healthcare workers without considering discharged cases, this study concurs with their conclusion and extends to a wider population, suggesting a high spread of COVID-19 among the population. However, the succour provided by this study is the possibility of high recovery rate from COVID-19 in Rivers State. The reasons, however, could be due to the non-adherence of the infected population to measures aimed at curtailing the spread of the virus.

CONCLUSIONS

1. In this study, analysis of infections, recoveries and deaths from COVID-19 in Rivers State, Nigeria was carried out. The results from One-Way Analysis of Variance showed that there was a statistically significant difference between COVID-19 infected population (lab confirmed), discharged cases and deaths due to COVID-19 (F(2,1710)=121.958, p=0.000). Tukey post hoc test indicated that deaths from COVID-19 significantly differ from both infected population (lab confirmed) and discharged cases (p=0.000). However, there was no significant difference between the COVID-19 infected population (lab confirmed) and discharged population (p=0.941).
2. Results from Pearson Product Moment Correlation to determine the degree of relationship between deaths due to COVID-19 and the other two groups showed that there was a weak positive relationship (r=0.360, n=571, p=0.000) at 99% confidence interval. However, moderate positive correlation existed between COVID-19 infected population and discharged cases (r=0.566, n=571, p=0.000) at 99% confidence interval. Also, a cubic polynomial equation was derived in order to predict discharged cases whenever infected cases are known in Rivers State, Nigeria.

CONFLICTS OF INTEREST

Authors declare that they do not have conflicts of interest.

ETHICAL APPROVAL

The Nigeria Centre for Disease Control approved the study protocol and data in accordance with Nigerian legislation and the ethical standards using multi-sectoral emergency oper

ation centre (EOC) as contained in COVID-19 Outbreak in Nigeria Situation Report S/N 001; 29.02.2020.

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