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On Experimental Design Modelling of Reported Cases of Corona Virus Disease in Nigeria: An Empirical Study

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Abstract:

The novel Corona Virus Pandemic has been a major threat to low and middle income countries and has affected every sector of the economy. A lot of efforts have been made by the Government, researchers, religious Organizations and NGOs towards curbing the spread of this pandemic. To contribute to solving this problem, the study examines the reported cases of corona virus diseases in all the six geo political zones in Nigeria. The datasets for this study are secondary sourced from the web page of Nigeria Centre for Disease Control (NCDC) on the monthly number of reported cases of this disease in all the six zones. The randomized complete block design (RCBD) is used to collect the datasets. The datasets is examined by checking the validity of all the basic assumptions of modelling analysis of variance using normality and variance homogeneous tests. The results show that the datasets have homogeneous error-variances and that the reported cased of Covid-19 pandemic across the six zones are significantly different. We also conduct a post HOC analysis using Turkey Honestly Significant Difference (Turkey-HSD) test. The results show that South-West is distantly significantly different from other zones when compared.

Keywords **—**Nigeria Centre for Disease Control (NCDC), World Health Organization (WHO), Infection Prevention Control (IPC), Thrombectomy**,** Corona Virus, Nigeria, South-West

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1. INTRODUCTION

The novel Corona virus disease, popularly known as Covid-19, is an infectious disease caused by a newly discovered severe acute respiratory syndrome coronavirus 2: SARS-CoV-2, [20]. This virus was widely reported to have first been discovered in Wuhan, Hebei province in China in December, 2019 and was declared a global pandemic by the World Health Organization (WHO) on 11th March 2020.Shortly after the first outbreak, the Covid-19 continued to spread to all provinces in China and rapidly to other countries within and outside Asia. Today, it has spread to over 200 countries in the world [10],[7], [20], [22]. The common symptoms of the viral infection are fever, cold, cough, bone pain, treating problems and ultimately leading to pneumonia.The ongoing pandemic has severely damaged the world's most developed countries and has become a major threat to low-and middle-income countries. It has affected day to day life, businesses, disrupted the world trade and movements and even slowing down the global economy.Global reports on this deadly virus show that over 189 million cases of infected individuals have been confirmed in over 220 countries with over 4 million deaths[21]. The poorest continent, Africa with the most vulnerable populations for infection disease, over 5 million individuals have been infected with the virus. In Africa continent, South Africa is the most drastically affected country with more than 1.87 infections as of June 24, 2021.As Covid-19 pandemics spreads, technological applications and initiatives are multiplying in an attempt to control the situation, treat patients in an effective way and facilitate the efforts of overworked healthcare workers, while developing new effective vaccines. The World Health Organization (WHO) has been unrestlessly closed with global experts, educational institutions, government and partners to rapidly expand scientific knowledge on this pandemic, to track the spread and virulence of the virus and to provide advice to countries and individuals on measures to protect health and prevent the spread of the outbreak[8], [15], [19].

1.1 SITUATION REPORT IN NIGERIA

The first case of the novel Corona virus in Nigeria was detected on 27th of February 2020. It was the first case reported in Sub-Saharan Africa. Since then, Nigeria's response has been led by science and driven by the power of coordination, collaboration and solidarity across federal and state governments, partners, private sectors and citizens.Prior to the confirmation of the first case in Nigeria, NCDC with support from its partners, began preparedness activities. The NCDC began working with states and hospitals to map out and establish isolation and treatments centres for managing Covid-19 cases. In addition to this, NCDC began training health workers across all states on case management, Infection prevention control (IPC), surveillance, risk communication and other areas of epidemic preparedness and response. The agency also began to preposition medical supplies such as personal protective equipment to all states. Importantly, NCDCdeveloped preparedness guidelines and plans that Incorporated in all inclusive 'One Health' approach.In the last one year, NCDC has been working under the Presidential Task Force on Covid-19 (PTF Covid-19) chaired by the secretary for the government of federation, Mr. Boss Mustapha. This has enabled a multi-sectional response to the pandemic, which has affected multiple facets of Nigeria's Economy [13].The NCDC has lead Nigeria's public health response to the pandemic. This includes establishing and scaling up capacity for Covid-19 testing, surveillance activities, developing public health guidelines, as well as providing technical support to states. The pandemic also provided the opportunity to rapidly scale up Nigeria.As at July 16, 2021, over 160 thousands cases of infected individuals have been confirmed with over 2 thousands deaths recorded in Nigeria [14].The present study primarily aims at modelling reported cases of coronavirus in Nigeria using experimental design approach with the intention of determining whether all the geopolitical zones are equitably affected, and if not, which of them is mostly affected. The study also will reveal which of the zones requires more attention by government with a view to well-managing the virus.

1.2 LITERATURE REVIEW

Pandemic has been in existence and have occurred at different stages in human history [6]. More so there have been many outbreaks and human catastrophes and there has been a traceable rise in the frequency of pandemics from the year 2000 and beyond. As a result of this, it increased emergence of pandemics through various research including [11]and recently[13] and [5] argued that a large scale global pandemic was inevitable.[6] indicates it from the imperial college London Covid-19 response team investigate that Covid-19 is the widest episode since the 1918 Spanish influenza pandemic. [2]has come up with a comparison and concludes that the pharmaceutical techniques implemented during 1918 Spanish influenza pandemic were not successful in reducing overall deaths.In previous studied it has showed the levels of genetic similarity between the 2019-ncov and BaTG13 suggest that the latter does not provide the exact variant that caused the outbreak in human but the hypothesis in that research showed that 2019-ncov has originated from bats is very likely[9]. A research was carried out in the impact of Corona virus disease 2019 pandemic concerning stroke thrombectomy service in United Kingdom [9]. From the studied it appeared that Covid-19 pandemic has had a negative impact on the stroke admission numbers but not stroke thrombectomy rate, successful recanalization rate or early neurological outcome, [9]. In March, 2020 World Health Organization, due to high rate of infection and inherent complications, research has focused on preventing its spread and trying to establish pharmacological treatments. There are studies with various drugs tested until now ventilating support has been the fundamental basis of treatment in severe cases that develop adult respiratory distress syndrome,[3]. Other studied such as Artificial intelligence tools based on machine learning and mathematical models are being used to estimate the nature of the spread across each country, and to detect the potential amplifiers hampering the effects of the epidemic [12]. It has showed The COVID-19 virus infects people of all ages. However, evidence to date suggests that two groups of people are at a higher risk of getting severe COVID-19 disease. These are older people; and those with underlying medical conditions. WHO emphasizes that all must protect themselves from COVID-19 in order to protect others WHO [21]. In the second scenario, the researcher shows this is likely to require a combination of social distancing of the entire population, home isolation of cases and household quarantine of their family members including schools.The studies explained that by closely monitoring disease trends, it may be possible for these measures to be relaxed temporary as things progress, but they will need to be rapidly re-introduced when case numbers rise [1], [6]

2.0 MATERIALS AND METHODS

2.1 The Datasets

The datasets are secondary sourced from the webpage of Nigeria Centre for Disease Control (NCDC) on the monthly number of reported cases of coronavirus disease in all the six geopolitical zones in Nigeria. These are carefully extracted and are tactically used for this study.

2.2 The Model

The randomized complete block design (RCBD) is used to collect the datasets. The two-way analysis of variance (ANOVA) model is

$$y_{ij} = \mu + \alpha_j + \beta_i + \lambda_{ij} \qquad (1)$$

For which $i = 1, 2, ..., b$ and $j = 1, 2, ..., a$

And y_{ij} $is\,(ij)^{th}$ is the observation from treatment ‘a’ and block I, μ *is overall mean*

α_j *is effect of treatment* 'a', β_i *is effect of block i*

λ_{ij} *is error component assumed to be* $NIID(0, \sigma^2)$

2.3 Assumptions of ANOVA Model

2.3.1Normality

Before obtaining analysis of variance model, normality of the datasets should be checked, and this is confirmed by Shapiro-Wilk test of normality, which is embedded in R software (R Core Team, 2020).

2.3.2 Homogeneity of Variance

You will recall that experimental design modelling is sensitive to possessing equal variances, which can have a very passive effect on the judgment of the conclusion. Under normal atmosphere, datasets should not contain different error variance, meaning that equal treatment should be given to every element of our datasets. Bartlett's test statistic is used to check the homogeneity of the error variance, and R has provided us the results with ease.

2.4 ESTIMATION OF MODEL PARAMETERS

Recall that:

$$y_{ij} = \mu + \alpha_j + \beta_i + \lambda_{ij}$$

From the model and by OLS approach, the estimates of the parameters are computed via the following formula

$$\hat{\mu} = \frac{y_{..}}{bt} = \bar{y}_{..} \qquad (2)$$

$$\hat{\alpha}_j = \frac{1}{b}\sum_{j=1}^{a} y_{.j} - \frac{y_{..}}{bt} \qquad (3)$$

$$\hat{\beta}_i = \frac{1}{t}\sum_{i=1}^{b} y_{i.} - \frac{y_{..}}{bt} \qquad (4)$$

2.5 ANALYSIS OF VARIANCE

The table below shows the Analysis of Variance theoretical table in a two-way ANOVA setting.

Table 1: RCBD ANOVA Table

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F_{cal}
Subjects (A)	$a-1$	SSA	$\frac{SSA}{a-1}$	$\frac{MSA}{MSE}$
Exam Year (B)	$b-1$	SSB	$\frac{SSB}{b-1}$	$\frac{MSB}{MSE}$
Error	$(a-1)(b-1)$	SSE	$\frac{SSE}{(a-1)(b-1)}$	
Total	$ab-1$	SST_0		

Source: Authors (2021)

Explicitly, we define the following concepts empirically

$$SST_O = \sum_{i=1}^{b}\sum_{j=1}^{a} y_{ij}^2 - \frac{y_{..}^2}{ab} \qquad (5)$$

$$SSA = \frac{1}{b}\sum_{j=1}^{a} y_{.j}^2 - \frac{y_{..}^2}{ab} \qquad (6)$$

$$SSB = \frac{1}{a}\sum_{i=1}^{b} y_{i.}^2 - \frac{y_{..}^2}{ab} \qquad (7)$$

$$SSE = \left[\sum_{i=1}^{b}\sum_{j=1}^{a} y_{ij}^2 - \frac{y_{..}^2}{ab}\right] - \left[\frac{1}{b}\sum_{j=1}^{a} y_{.j}^2 - \frac{y_{..}^2}{ab}\right] - \left[\frac{1}{a}\sum_{i=1}^{b} y_{i.}^2 - \frac{y_{..}^2}{ab}\right] \ldots\ldots\ldots (8)$$

$$MSA = \frac{\left[\frac{1}{b}\sum_{j=1}^{a} y_{.j}^2 - \frac{y_{..}^2}{ab}\right]}{a-1} \qquad (9)$$

$$MSB = \frac{\left[\frac{1}{a}\sum_{i=1}^{b} y_{i.}^2 - \frac{y_{..}^2}{ab}\right]}{b-1} \qquad (10)$$

$$MSE = \frac{\left\{\left[\sum_{i=1}^{b}\sum_{j=1}^{a} y_{ij}^2 - \frac{y_{..}^2}{ab}\right] - \left[\frac{1}{b}\sum_{j=1}^{a} y_{.j}^2 - \frac{y_{..}^2}{ab}\right] - \left[\frac{1}{a}\sum_{i=1}^{b} y_{i.}^2 - \frac{y_{..}^2}{ab}\right]\right\}}{(a-1)(b-1)} \qquad (11)$$

$$F_{cal\,for\,A} = \left\{ \left(\frac{\left[\frac{1}{b}\sum_{j=1}^{a} y_{.j}^2 - \frac{y_{..}^2}{ab}\right]}{(a-1)} \right) \Bigg/ \frac{\left\{\left[\sum_{i=1}^{b}\sum_{j=1}^{a} y_{ij}^2 - \frac{y_{..}^2}{ab}\right] - \left[\frac{1}{b}\sum_{j=1}^{a} y_{.j}^2 - \frac{y_{..}^2}{ab}\right] - \left[\frac{1}{a}\sum_{i=1}^{b} y_{i.}^2 - \frac{y_{..}^2}{ab}\right]\right\}}{(a-1)(b-1)} \right\}$$

(12)

$$F_{cal\,for\,B}=\left\{\dfrac{\left(\dfrac{\left[\frac{1}{a}\sum_{i=1}^{b}y_{i.}^{2}-\frac{y_{..}^{2}}{ab}\right]}{(b-1)}\right)}{\left\{\dfrac{\left[\sum_{i=1}^{b}\sum_{j=1}^{a}y_{ij}^{2}-\frac{y_{..}^{2}}{ab}\right]-\left[\frac{1}{b}\sum_{j=1}^{a}y_{.j}^{2}-\frac{y_{..}^{2}}{ab}\right]-\left[\frac{1}{a}\sum_{i=1}^{b}y_{i.}^{2}-\frac{y_{..}^{2}}{ab}\right]}{(a-1)(b-1)}\right\}}\right\} \quad (13)$$

2.6 RESULTS AND INTERPRETATIONS

2.6.1 Confirmation of Assumptions

We examine the datasets by checking the validity of all the basic assumptions of modelling analysis of variance. This examination of each assumption is detailed as follows:

2.6.1.1 Checking Normality of Assumptions

We employ both Shapiro-Wilk normality test and Normal Quantile-Quantile plot to check whether the datasets come from normal distribution. The outputs of the two techniques are displayed below:

Table 2: Shapiro-Wilk Normality Test Statistics

Data: Residuals
Test Statistic (W) =0.93895 p-value = 0.001678

Source: Authors' Computation (2021)

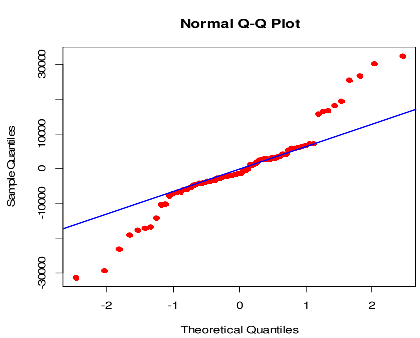

Fig. 1

From our results and the visual expression, it can be established that our datasets emanate from the normally distributed situation. Therefore, the assumption of normality is not violated.

2.6.1.2 Checking for Homogeneity of Variance Assumptions

We employ Bartlett's variance-homogeneous test to check whether the datasets possess equal error-variance throughout the experiment. The results are presented in Table 3.

Table 3: Bartlett's Test Statistic

Data: Residuals
Test Statistic (B) = 81.36 p-value = 0.00000

Source: Authors' Computation (2021)

From the results obtained, it is evident to empirically establish that our datasets have homogenous error-variances and as such, the datasets are fit for modelling.

2.6.1.3 Analysis of Variance Results

We employ ordinary least square method embedded in R software to compute the parameters of the analysis of variance and the results are presented in Table 4

Table 4

Source	***df***	**Sum of squares**	**Mean square**	**F-statistic**	**P-value**
Zones	5	$1.547\ X\ 10^{10}$	$3.094\ X\ 10^{9}$	18.947	0.0000
Months	6	$1.481\ X\ 10^{8}$	$2.468\ X\ 10^{7}$	0.151	0.988
Residuals	60	$9.799\ X\ 10^{9}$	$1.633\ X\ 10^{8}$	-	-

Source: Authors' Computation (2021)

From the results obtained in Table 3, it is evident that reported cases of COVID-19 pandemic across the six geopolitical zones are significantly difference, therefore calling for the post-hoc analysis with a view to determining which of the pairs of zones are truly different.

2.6.1.4 Post-Hoc Analysis

Since it has been established from the results of analysis of variance that reported cases of coronavirus disease are significantly different, there is need for the conduct of post-hoc analysis. We therefore employ the use of Tuckey Honestly Significant Difference (Tuckey HSD) test to check which pairs are and are not. The results are, however, presented in Table 5.

Table 5: Turkey HSD Test Statistics

Comparing zones	Mean differences	Lower	Upper	P-value
NE – NC	–14072.167	–29430.595	1286.262	0.0907
NW – NC	–8063.750	–23422.179	7294.679	0.6366
SE – NC	–12648.00	–28006.429	2710.429	0.1644
SS – NC	–7159.000	–22517.429	8199.429	0.7432
SW – NC	**29030.917**	**13672.488**	**44389.345**	**0.0000****
NW – NE	6008.417	–9350.012	21366.845	0.8574
SE – NE	1424.167	–13934.262	16782.595	0.9997
SS – NE	6913.167	–8445.262	22271.595	0.7700
SW – NE	**43103.083**	**27744.655**	**58461.512**	**0.0000****
SE – NW	–4584.250	–19942.679	10774.179	0.9501
SS – NW	904.750	–14453.679	16263.179	0.9999
SW – NW	**37094.667**	**21736.238**	**52453.095**	**0.0000****
SS – SE	5489.000	–9869.429	20847.429	0.8980
SW – SE	**41678.917**	**26320.488**	**57037.345**	**0.0000****
SW – SS	**36189.917**	**20831.488**	**51548.345**	**0.0000****

Source: Authors' Computation (2021)

From the results, the double-asterisked results show significant difference, since their probability values are far less than 0.05, whereas others are not.

2.7 CONCLUSIONS AND RECOMMENDATIONS

We employ two-way analysis of variance to model number of confirmed cases of COVID-19 within the six geopolitical zones in Nigeria spanning a period of 12 months. The results show that south west zone is distantly significantly difference from other zones when compared. At first, we are able to establish that reported cases across the zones are not the same and, therefore we investigate further to know which zone is different from others. From our investigation, reported cases of coronavirus in south west zone are significantly different from the number of confirmed cases reported in other zones. Therefore, more attention must be given to the South-West zone of the country in an attempt to end the spread of the novel virus.

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