A Poisson Regression Analysis of COVID-19 Pandemic: Implication on Food Security in North Eastern Nigeria

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Abstract

The North East region of Nigeria is the worst hit by the activities of Boko Haram terrorist group displacing homes, livelihoods, destruction to lives and properties with Internally Displaced Persons (IDPs) with about 3.6 million people projected to be in severe acute food insecurity. The COVID-19 Pandemic has further aggravated the precarious food security in the region. The study was therefore conducted to examine COVID-19 pandemic in the region and its likely effects on food security. The data for the study was extracted from the daily COVID-19 cases update released by the Nigeria Centre for Disease Control (NCDC) online database from February 28th, 2020 to 7th December 2020. The extracted data were analyzed using descriptive statistics and Poisson Regression. Results of the analysis revealed that admitted and discharged cases had negative and inverse relationship with COVID-19 related deaths in the North East region of the country. Furthermore, increased cases have a positive and significant effect on the number of deaths. The effect of the pandemic has also worsen food security with decrease in minimum food items needed for survival of a household in a month as a result of the increase in the Survival Minimum Expenditure Basket (SMEB) from N19,072($47.68) to N19,345 ($48.36) in selected markets in the region.

Keywords: *Poisson regression, Food security, COVID-19, Centre for disease control, North east, Nigeria*

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Background to the Study

The current novel Coronavirus (COVID-19) outbreak originated from a seafood and wild food wet market in Wuhan and has quickly spread across China and to almost all countries in the world. The outbreak of corona virus disease (COVID-19) has been declared a public health emergency of international concern (PHEIC). The virus has now spread to many countries and territories. COVID-19 is transmitted through direct contact with respiratory droplets of an infected person generated through coughing and sneezing. Experts also suggest that individuals can also be infected by touching surfaces contaminated by the virus and touching their faces including eyes, nose, mouth, etc. Experts also postulate that COVID-19 infection and spread can be contained through hand washing protocol, personal hygiene, use of alcohol-based hand sanitizers, avoiding touching the eyes, nose, mouth, avoiding crowds, avoiding unnecessary outings and travels, use of face masks among other WHO recommended protocols, including coughing protocol and physical distancing (Forsido etal.,2020). Reperant and Osterhaus (2017) stated that all the past pandemics like Ebola, Severe Acute Respiratory Syndrome (SARS), and Middle East Respiratory Syndrome (MERS) had negative impacts on food and nutrition security particularly for vulnerable populations including internally displaced people, children, women, the elderly, persons with disabilities and the people living in poverty. Ozili (2020) reported that pandemic and epidemic outbreaks related to animals affecting food security were traced to the first poultry disease- Avian influenza of 1878; the Newcastle disease of 1926 and highly pathogenic avian influenza subtype H5N1 of 1997.

COVID-19 was confirmed in Nigeria on 27th February 2020 through an infected Italian citizen who came in contact with a Nigerian citizen who was subsequently infected with the corona virus. The corona virus then spread to other citizens in Lagos and to other parts of the country. The measures adopted in containing the virus namely physical distancing and lockdown though a necessity, but could adversely affect food and nutrition security through disruption of food supply chains. According to African Development Bank, ADB (2020), disruptions to domestic and international food supply chains have undermined food availability and accessibility as well as disrupted food production and distribution. Nirmal *et al.* (2020) reported that livelihoods of millions of people in the world, food and nutritional security, people already living in poverty globally are expected to be increased to 548 million while food insecure is estimated at 183 million because of the COVID-19 pandemic

Food security as defined by the United Nations' Committee on World Food Security , means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. Currently, the COVID-19 pandemic is already having its toll on a wide range of economic activities like supply chains and logistics, both for producers and consumers as a result of closure of borders, national lockdowns and the restriction of movement and reduction in air traffic. This will further aggravate the already precarious food security particularly in the North - Eastern part of Nigeria that is ravaged by insurgency and farmer-herders conflict. Food and Agriculture Organization, FAO (2020) estimated that around 3.6 million people in the Borno, Adamawa Yobe, BAY states of the region are projected to be in severe acute food insecurity from June to August 2020 – traditionally the lean season in the North-East. This

paper analyzes COVID-19 pandemic and its implication on Food security in North eastern Nigeria.

Methodology
The Data
Data from the daily COVID-19 cases update released by the Nigeria Centre for Disease Control (NCDC) online database covering the periods of February 28th, 2020 to 7th December 2020 were collected. The data were made up of 3,117 laboratory confirmed cases, 2861 discharged cases, 148 admitted cases and 108 deaths in all the states in the North East region of Nigeria (www.COVID19.ncdc.gov.ng). Prices of basic Food staples in the country before and after the declaration of the pandemic were collected online from National Bureau of Statistics.

Methods of Data Analysis
Descriptive statistics and inferential statistics were employed in the analysis of the data collected. Mean, standard deviation, tables and percentages were the descriptive statistics used to examine the nature of the data. Inferential statistics such as T- test statistic was used to examine the impact of COVID-19 Cases on food prices while Poisson Regression was used in the analysis of COVID-19 data.

Poisson regression, a nonlinear regression analysis of the Poisson distribution can be used to predict a dependent variable consisting of discrete or count data given one or more independent variables. The predicted variable or the dependent variable) is often referred to as the response, outcome, target, or criterion variable. The variables used to predict the value of the dependent variable are called the independent variables (or sometimes the predictor, explanatory, or regressor variables). Over dispersion occurs when there is the presence of statistical variability in a data or violation of the assumption of a Poisson distribution. The violation can be addressed by subjecting the data set to Negative Binomial Regression (NBR) and the Generalized Poisson Regression (GPR) models (Famoye, 1993). The rate at which COVID-19 death occurs in North East Nigeria is a random variable denoted by Y said to follow a Poisson distribution with parameter $\lambda > 0$, the probability function is given by

$$P(Y = y) = \frac{e^{-\lambda}}{y!} \qquad (1)$$

Where n=1, 2,3 is the number of occurrences of an event and λ is defined as $\lambda = E(Y)$. One of the useful properties of the Poisson distribution is that the variance depends on the mean and also the variance is equal to the mean.

The first function describes how mean, $E(Y_i) = \lambda i$ which depends on a linear predictor $\varphi(\lambda_i) = j_i$ while the second functions describe how the variance, $Var(Yi)$ (depends on the mean.

$Var(Y_i) = \varphi var(\lambda_i)$ where the dispersion parameter φ is a constant, supposing Y_i is a Poisson distribution, then $Y_i \sim Poisson(\lambda_i)$, $E(Y_i) = \lambda_i$ and $Var(Y_i) = \lambda_i$, the variance function is given $Var(\lambda_i) = \lambda$ and the function must map from $(0, \infty)$. A natural log function is given as $\ell(\lambda_i) = \log_e(\lambda_i)$.

The Poisson Regression model fitted to the number of deaths from COVID -19 cases in Nigeria is stated as:

$$\text{Log}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \qquad (2)$$

where X_1 = Laboratory confirmed cases, X_2 = admitted cases and X_3 = discharged cases while β represents expected change in the logarithm of the mean per unit change in the predictor variables (X_i) which were estimated using the maximum likelihood estimate methods.

The Maximum Log-Likelihood function of the distribution is expressed as

$$\text{Log}(\beta, \alpha) = \sum_i \left(\sum_{r=1}^{y_i} log(1 + ar) \right) - y_i log(\alpha) - log(y_i!) + y_i \, log(\alpha \mu_i) - (y_i + \alpha^{-1}) log(1 + \alpha \mu_1) \qquad (3)$$

The parameter (β, α) can be estimated by a partial differential of the Maximum Likelihood function with respect to β and α. The negative Binomial Regression does not assume the equality of the mean and variance but it corrects for over dispersion that arises when the variance is greater than the conditional mean (Samuel *et al.,* 2020).

T – test statistics was used to evaluate the impact of COVID-19 on food prices and is given as:

$$T = \frac{ya - yb}{\sqrt{\frac{na}{sa} + \frac{nb}{sb}}} \qquad (4)$$

Where: y_a = mean food price before COVID-19, y_b = mean food prices during COVID- 19, S_a = standard error of food price before COVID-19, S_b = Standard error of food price during COVID 19, n_a = number of basic food items before COVID-19 and n_b = number of basic food items.

Results and Discussion
COVID-19 Cases in North East Nigeria
The reported cases in Nigeria as at 7/12/2020 had a laboratory confirmed cases of 69,645 which affected all the states in Nigeria including Federal Capital Territory, FCT. Out of the laboratory confirmed cases of 69,645, 4.48% (3,117) were from the North East region. The discharged (64,947 cases) only 2,861 representing 4.41% were from the North East Region. Admitted cases were 3,517 for the country while the North east Region was a paltry of 148 cases (4.21%). For total deaths, it was 1,181 and 108(9.14%) cases for the country and North east region respectively.

Data in Table 1 are extracts from the NCDC for States in the North east as affected by the pandemic. From the Table 1, Gombe State had the highest number of laboratory confirmed cases followed by Bauchi State while Yobe State is the least.

Table 1: COVID-19 Cases showing affected States in North East Nigeria

States Affected	No. of Laboratory confirmed cases	Percentage of Laboratory confirmed cases	Cases on admission	Percentage of cases on admission	Number Discharged	Percentage of discharged cases	Number of Deaths	Percentage of total deaths
Gombe	1,027	32.94	71	47.97	931	32.54	25	23.14
Bauchi	790	25.34	34	22.97	742	25.93	14	12.96
Borno	758	24.32	17	11.48	705	24.64	36	33.33
Adamawa	261	8.37	4	2.70	238	8.32	19	17.59
Taraba	181	5.80	14	9.46	161	5.63	6	5.55
Yobe	100	3.21	8	5.41	84	2.93	8	7.41
Total	**3,117**	100	**148(4.75)**	100	**2,861(91.78)**	100	**108(3.45)**	100

Source: Authors computation. Figures in Parenthesis are percentages.

Analysis in table 2 shows that the mean and standard deviation of total death as a result of COVD-19 was 18 ± 11.261. Similarly, the mean and standard deviation of confirmed cases of COVID-19 was 520±386.003. The mean and standard deviation of the critical cases of COVID-19 as presented in the result showed that the mean and standard deviation of admitted cases of COVID-19 was 25±24.94 whereas the discharged cases were 477±357.70. One can infer from this analysis that admitted cases and discharged cases are the indicators that can flatten the curve of COVID-19 cases thereby reducing the number of related deaths in the North East region of the country.

The choice of Poisson Regression for the data was as a result of the finding in Table 3 which confirmed that there was no over dispersion problem necessitating fitting of other models like the Negative Binomial Regression and Generalized Poisson Regression. Result of the Poisson regression analysis (Table 4) revealed that two of the variables of the COVID-19 cases in North East Nigeria were negative except the confirmed cases. Confirmed was statistically significant at 5% probability level. A unit increase in COVID-19 case may lead to 7.17% increase in the number of COVID-19 related deaths in North East Nigeria. Increase in the number of confirmed cases has the tendency of increasing the number of deaths especially when there are no enough medical facilities and personnel to manage the upsurge. This result is in contrast to the finding of Samuel et *al.* (2020) who reported that confirmed cases had negative effect on the number of COVID- 19 related deaths. However, admitted cases have a negative coefficient of -0.05 82243 is statistically significant at 5% and inversely related with COVID-19 deaths. This shows that a 1% increase in the number of admitted cases of COVID-19 would lead to a decrease in the number of deaths by 5. 82 % *ceteris paribus*. The coefficient for discharged cases was also negative and significant at 5% probability level and this implies that discharged cases reduce the number of deaths associated with COVID-19 by 7.31% when a 1% increase in the number of discharged cases occurs. The more the number of admitted and discharged cases the more the likelihood of flattening the COVID-19 curve.

Table 2: Summary of Descriptive Statistics of COVID-19 cases in North East Nigeria

Variable	Mean	Std. Dev.	Min	Max
Total deaths	18	11.261	6	36
Lab Confirmed cases	520	386.003	100	1,027
Admitted cases	25	24.94	4	71
Discharged cases	477	357.70	84	931

Source: Researcher's Computation, 2020 using STATA Version 11

Table 3: Value of Deviance and Pearson Poisson Regression Model

Criterion	Value	Df	Value/df
Deviance	0.421	2	0.211
Pearson Chi-square	0.418	2	0.209

Source: Authors' computation, 2020 using STATA Version 11

Table 4: Result of Poisson Regression (PR) of COVID-19 Cases in North East Nigeria

Parameters	Coefficient	Std. error	Z	P>|z|	LRChi square	Log likelihood	AIC	BIC
Constant	1.425842	.3788161	3.76*	0.000	36.01*	-13.646219	35.292	34.459
Laboratory Confirmed cases	.0717863	.0289315	2.48**	0.013				
Admitted cases	-.0582243	.0200466	-2.90**	0.017				
Discharged cases	-.0730949	.0305252	-2.39**	0.004				

Source: Authors' computation, 2020 using STATA Version 11 *, ** indicate significance at 1%&5%

Table 5: Food Prices

Food Items	Pre COVID-19 Price (₦)	COVID -19 Price (₦)	Price Change (₦)	Percentage Change
Beans brown, sold loose	355.	305	-50	-13.97
Beans: white black eye. sold loose	317	275	-42	-13.43
Maize grain white sold loose	147	190	+43	+28.73
Maize grain yellow sold loose	151	192	+41	+27.75
Palm oil: 1 bottle	460	500	+40	+8.60
Rice agric sold loose	317	413	+96	+30.25
Rice local sold loose	278	375	+97	+34.81
Rice Medium Grained	313	415	+102	+32.82
Rice, imported high quality sold loose	360	502	+142	+39.52
Vegetable oil:1 bottle	500	584	+84	+16.69
Grand total	3,198	3,751	553	+17.27

Source: Authors' computation 2020

The effects of COVID- 19 on Food prices and Implications on Food Security in the North East Region

Table 5 shows major food items usually referred to as the Survival Minimum Expenditure Basket (SMEB) which outlines the minimum food items needed for survival of a household in a month. The basket comprises basic energy food requirements of 2,100 kilocalories per person per day and includes food items like rice, maize, red beans, palm oil, vegetable oil, salt and sugar, consumed by the majority of households in the North East. prices before and during the COVID-19 Cases in North Eastern Nigeria as contained in Table 5 revealed 13.96% and 13.43 % reductions in prices of only two out of the ten basic food staples namely beans brown, sold loose and beans: white black eye sold loose. The remaining 8 basic food items experienced variations in the prices. Imported rice had the highest increase in price, followed by local rice and medium rice. The implication for the hike in the price of foreign rice was the ban placed on rice import by the government in order to boost local rice production in the country. The overall regional food price increase was 17.27%. The pandemic had impact on food prices as revealed by the t-test statistic (p≤0.001) (Table 6). The result is in tandem with World Food Programme(2020) report which revealed that between June and July, the cost of 70% of the Survival Minimum Expenditure Basket (SMEB) for a family of five increased slightly from N19,072($47.68) to N19,345 ($48.36) in Maiduguri and Jere. Seasonal decline in household food stocks and increased demands would contribute to sustained increase in food prices in the region; this will further hamper food access for the most vulnerable households who are already facing limited livelihood opportunities as the result of the Boko Haram insurgents in the region.

Table 6: T- test analysis of the impact of COVID-19 on Food prices

Variable	Mean Food price	Standard error	Mean dif	Df	T. value
Pre- COVID-19	319.85	35.79	55.25	9	8.87***
COVID-19 period	375.10	42.30			

Source: Authors' computation, 2020. ** Significant at 1%

In Nigeria, like other African nations, the pandemic has greatly limited agricultural production, processing, and transportation between farmers, industries and markets. Upscale of food production to take care of the 200 million people in Nigeria has become necessary. Shortage of food will be more devastating than the COVID-19 itself because hunger will affect more in terms of population. For instance, farmers who planted in 2019/2020 dry season were affected because by the time they were about to go for harvest, this problem came in and hindered their movement to the farms this will affect production target for the period. Farmers' inability to access seeds and other farm inputs will affect food production and food security generally. Farmers complained that seeds and other inputs are not getting to where they are needed from the production levels. This is as a result of elite capture of inputs especially politicians who hijacked them and give to those loyal to their political parties depriving the real farmers. Electronic wallet input distribution was initially introduced by the previous government and later abandoned by the present regime. Consistent input distribution should be maintained to ensure timely and supply of inputs as agricultural production are time bound operations and delay in the supply of inputs will affect production levels.

The agricultural Promotion policy document of Nigeria considers Food as a human right – focusing the policy instruments for agricultural development on the social responsibility of government with respect to food security, social security and equity in the Nigerian society; and compelling the government to recognize, protect and fulfil the irreducible minimum degree of freedom of the people from hunger and malnutrition. Factors affecting food security in the North East of the country are manifold: the region is the worst hit by activities of Boko Haram terrorist group displacing homes, livelihoods, destruction to lives and properties, ban on the supply of nitrogenous fertilizers by the Federal Government of Nigeria in the region to stop their production of local weapons, the influx of nomadic pastoralist away from the Chad Basin with constant clashes between farmers and herders who seek for pastures away from the epicentre of the conflict and the Internally Displaced Persons (IDPs) in the zone which has depleted the Food Reserve silos. The cumulative effects of ban on nitrogenous fertilizers has greatly affected input supply chain whereas the influx of herders has always resulted to conflicts between farmers and pastoralists affecting both food and livestock production which are the major livelihoods of the people in the region. The three north eastern states (the BAY states i.e. Borno, Adamawa and Yobe) has about 3.6 million people in the region projected to be in severe acute food insecurity from June to August 2020 – traditionally the lean season in the North-East to be up by almost 20 percent compared with the projection for last year's lean season (FAO 2020).

Conclusion and Policy Implication
Admitted and discharged cases are the key factors reducing the number of deaths associated with COVID- 19 cases in the North east region of Nigeria. The imposition of lockdowns and regulatory measures to contain the spread of the virus by the government has equally subjected the people in the region who are already facing limited likelihood opportunities as a result of the attacks by Boko Haram insurgents and other related conflicts emanating from the use of resources in the Chad Basin to food insecurity. Food prices are affected as a result of the pandemic aggravating food security. The question is how would the people in the region cope up with COVID- 19 pandemic? Short- and long-term policies to help them cope up and mitigate the negative effects of the pandemic are necessary. Government should intensify efforts in increasing the number of health personnel, medical facilities, increase in the number of laboratories for testing, detection and treatment would reduce the number of mortalities. Strategies such as the establishment of integrated, climate-smart production systems with food crops, cash crops and agro forestry should be put in place to enhance likelihood of the people in the region.

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