Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Estimating the impacts of lockdown on Covid-19 cases in Nigeria

Kazeem Bello Ajide,⁎,1, Ridwan Lane Ibrahim, Olorunfemi Yasilu Alimi

University of Lagos, Lagos State, Nigeria
Lead City University, Ibadan, Oyo State, Nigeria

1. Introduction

The present millennium has witnessed a series of health challenges ranging from the Middle East Respiratory Syndrome (MERS), first discovered in Saudi Arabia in 2012, the Western African Ebola virus in Guinea between 2013 and 2016, to the Brazilian Zika virus in 2015. Unexpectedly, the beginning of the year 2020 saw the emergence of yet another deadly virus (COVID-19), which is a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (WHO, 2020). The first index case of COVID-19 surfaced as unknown acute pneumonia in Wuhan hospital, a city in Eastern China. Consequently, WHO declared the virus a global pandemic on March 11, 2020, WHO (Cai et al., 2020; Wang et al., 2020) having been previously recognized as a “Public Health Emergency of International Concern (PHEIC)” on January 30, 2020.

The sudden emergence of the novel coronavirus has affected the entire world in an unprecedented manner. Thus, the issue has and continues to gather momentum by day owing largely to the growing rate of human-to-human transmission, causing severe respiratory disorder, and more damaging, is its unrestrained lethality. In fact, within the space of 6 months, over 7 million people have contacted the virus, causing the death of nearly 434,376 people, while about 4,272,909 recovered from the virus (Worldometer, 2020). The lack of available clinical vaccines to combating the virus prompted the global resolve for the adoption of lockdown measures, which was first implemented by the central government of China in Wuhan on January 23, 2020. This lockdown move was commended globally and particularly by the World Health Organization (WHO), tagging it as “unprecedented in public health history” (Crossley, 2020). Subsequently, there were widespread declarations of lockdown in over 100 countries between April and June 2020. This lockdown move became an inevitable option owing to both the anticipated and unanticipated macro-economic shocks that could be triggered by the evolving virus.

Conceptually speaking, lockdown has been referred to as an emergency response imposed by the government, mandating people to stay indoors in the event of an outbreak. In the case of COVID-19, the ultimate goal of a lockdown measure is to flatten the curve of the novel virus. The exercise entails the closure of all activities-based centres such as schools, hotels, clubs, and religious houses that could make a sizable number of people come together. This apart, directives such as social distancing, banning of congregation of more 20 people, and compulsory usage of the face masks, particularly, in public places were all forcefully enforced (NCDC, 2020; CDC, 2020; WHO, 2020).

However, on the heels of the persistent increase and spread of the COVID-19 virus in the Nigerian case, the federal government eventually announced a nationwide lockdown on March 30, 2020, taking immediate effect in three states of the federation: Lagos, Ogun, and Abuja. This lockdown exercise could not, however, be sustained in the face of growing agitation of the people occasioned by the exorbitant socio-economic consequences of the exercise, thus prompting the easing of the lockdown in

⁎ Corresponding author.
E-mail addresses: kazeemajide@gmail.com, kajide@unilag.edu.ng, (K.B. Ajide), lanrid23@gmail.com, (R.L. Ibrahim), haleemphemy480@gmail.com, alimi.olorunfemi@lcu.edu.ng, (O.Y. Alimi).
1 Specifically, these periods ranging from January to June 2020
these states on May 4, 2020. This singular decision has consequently led to the rising cases of the virus across the states. According to official data, the reported daily case of the first day of easing-May 4, 2020, saw the pandemic rising to 245, the highest since the first index case was reported for the country (NCDC situation report, 2020). While the health pundits and other stakeholders alike supposedly linked the escalation of the newly reported cases of COVID-19 to easing up of the lockdown, on the one hand, there has been no systematic research attempt directed at validating or refuting this unverified claim for the country on the other hand. This study fills this void.

Against the foregoing backdrop, this study seeks to examine the impact of lockdown on COVID-19 cases in Nigeria. The present study, to the best of knowledge is the first empirical attempt at examining the effects of lockdown on COVID-19 for the country, specifically from an econometric perspective. There is no denying the fact that there have been a series of policy papers, opinions, and predictions about the pandemic for the country. However, most of these submissions can be best described as purely qualitative empirical exercise, building merely on hunches, perceptions or at best, intuitive logics. Thus, this study is quantitative based in nature, thus presenting the contribution to the stock of extant literature on COVID-19 for the country, specifically from an econometric perspective. The literature on COVID-19 can, at best, be described as emerging or in its embryonic stage. Thus far, the available studies on COVID-19 have only examined the prevalence and control measures (Ceylan, 2020; Zhao et al., 2020), governance, technology, and citizen behavior (Shaw et al., 2020), socio-economic impacts (Tang et al., 2020). Other strands had equally focused on respiratory syndrome (Al-Raddadi et al., 2020), temperature (Briz-Redón and Serrano-Aroca, 2020), mortality rates (Ferdinand and Nasser, 2020; Wang et al., 2020), and climate factor (Tosepu et al., 2020), among others.

On the Nigerian front, studies have concentrated on the resurgence of Lassa fever amidst COVID-19 outbreak (Reuben et al., 2020), Almajiris displacement (Akintunde et al., 2020), comparative analysis of models and estimators (Ayinde et al., 2020), hunger prevalence (Kalu, 2020), online forecasting (Abdulmajeed et al., 2020), impact on transportation (Mogaji, 2020), and economic crisis (Ozili, 2020).

3. A concise literature review

The literature on COVID-19 can, at best, be described as emerging or in its embryonic stage. Thus far, the available studies on COVID-19 have only examined the prevalence and control measures (Ceylan, 2020; Zhao et al., 2020), governance, technology, and citizen behavior (Shaw et al., 2020), socio-economic impacts (Tang et al., 2020). Other strands had equally focused on respiratory syndrome (Al-Raddadi et al., 2020), temperature (Briz-Redón and Serrano-Aroca, 2020), mortality rates (Ferdinand and Nasser, 2020; Wang et al., 2020), and climate factor (Tosepu et al., 2020), among others.

On the Nigerian front, studies have concentrated on the resurgence of Lassa fever amidst COVID-19 outbreak (Reuben et al., 2020), Almajiris displacement (Akintunde et al., 2020), comparative analysis of models and estimators (Ayinde et al., 2020), hunger prevalence (Kalu, 2020), online forecasting (Abdulmajeed et al., 2020), impact on transportation (Mogaji, 2020), and economic crisis (Ozili, 2020).

2. Stylized facts about lockdown measures vis-a-vis COVID-19 cases in Nigeria

This segment presents the stylized facts about coronavirus cases in Nigeria during the lockdown periods. For ease of comprehension, the lockdown period is partitioned into three phases: pre-lockdown, lockdown, and lockdown easing. This division will provide a deep understanding regarding COVID-19 cases during these identified phases (see Fig. 1).

In the pre-lockdown phase, no palpable pattern can be discerned from the trend regarding the number of confirmed cases. The lockdown phase witnesses some dramatic changes in COVID-19 cases as compared to the pre-lock down period. However, in the latter part of the lockdown, there were several sporadic spikes with the highest reported cases being 238 in a single day. The easing period equally experiences some increases, as can be observed from the diagram. On the first day of the easing, 245 cases were recorded, while the subsequent days witness upward trends in the number of confirmed cases. Fig. 2 presents the summarized version for the three periods in which the total aggregate of the easing surpasses 13,000 altogether. The same Fig. 2 displays the state ranking with respect to the reported cases of COVID-19 in which the Lagos State surpasses other states, thus topping the list, and directly followed by FCT, Kano in that order.

![Fig. 1. Number of COVID-19 confirmed cases in Nigeria. Source: NCDC (2020).](image-url)
Relatively, studies on social distancing and the spread of COVID-19 cases include De Vos (2020), Freedman et al. (2020), Schueller et al., (2020), Musinguzi and Asamoah, (2020), Vinceti et al. (2020), and Zhang et al. (2020). These studies only focused on countries from the developed and emerging nations, implying that little or nothing is on record concerning African countries. This is in fact, surprising given the prevalent rate of patients who have tested negatives after treatment and are certified free of the virus by medical personnel. Death = the number of people who lost their lives courtesy of the virus.

**4. Methodology and data**

This study employs a negative binomial regression to unravel the impact of lockdown on COVID-19 cases in Nigeria for at least two reasons; first, the dependent variable used is a count data that only covers discrete and nonnegative values. Thus, as a skewed discrete distribution, using ordinary least squares (OLS) estimates can only yield inefficient, inconsistent, and biased (Long, 1997). Second, if this dependent variable fits equi-dispersion, then the Poisson regression model becomes inevitable. If otherwise, using negative binomial model remains a credible option. This estimator is often used when the variance is larger than its mean (over-dispersion). The robust standard errors are further clustered in order to produce standard errors that are robust to both heteroskedasticity and a general-type of serial correlation within the cross-sectional unit. More importantly, this estimator has found extensive application in studies such as accidents, conflicts, terrorism among others (Akintunde et al., 2020; Al-Raddadi et al., 2019; Crossley, 2020; Mogaji, 2020; Ozili, 2020; Shaw et al., 2020), while those embracing econometric approaches are scanty to date (Ayinde et al., 2020; Ceylan, 2020).

**4.1. Data**

The study employs an all-inclusive daily situation report of COVID-19 from relevant sources such as the WHO website (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/), Worldometer (https://www.worldometers.info/coronavirus/), Google mobility data (https://www.google.com/covid19/mobility/), and Nigeria Centre for Disease Control (NCDC) Situation report (https://covid19.ncdc.gov.ng/). Specifically, the data on COVID-19 cases are sourced from the daily report from NCDC for each of the states over the coverage periods (Situation report 001 (February 29th covering 27th) to 88 (reporting May 26th cases). The data on lockdown is obtained from Google mobility data.

**4.2. Strategic modeling and estimation technique**

Following the extant literature, the baseline model for estimating the impact of lockdown on COVID-19 is stated as follows:

\[
\text{CovCases}_{i} = f(\text{Lockdown}_{i})
\]  

(3)

\[
\text{Eq. (3) is explicitly re-written in an estimable form as:}
\]

\[
\text{CovCases}_{i} = \sigma_{i} + \phi \text{Lockdown}_{i} + \epsilon
\]  

(4)

Where; CovCases_{i} denotes the total confirmed COVID-19 cases in state i at time t, lockdown is a vector of explanatory variables comprising retail and recreation, grocery and pharmacy, parks, transit stations, and workplaces and residential in various states at time t period; \( \sigma \) stands for the parameter estimates, and \( \epsilon \) is the error term with mean zero and constant variance.
4.3. Preliminary results

The descriptive statistics are presented in Table 1. From the Table, it is clear that the number of reported COVID-19 cases averaged 3.2 with the maximum being 439. The negative values for all the lockdown indicators except residential, imply that they are inhibiting predictors. At the level of the states, Lagos has the highest recorded COVID cases (see Table 2), which is consistent with Fig. 2 above. The correlation coefficients of the variables are presented in Table 3.

5. Empirical analysis

5.1. Analysis of empirical results

Table 4 presents the results of the negative binomial regression estimations of the lockdown effects on Covid-19 for Nigeria. The results for all the indicators of lockdown variables are statistically significant and negative except for the residential variable. These results consistent with the theoretical priors, suggesting the mitigating role of lockdown policies on COVID-19.
coronavirus spread. By implication, as people comply with the “stay-at-home” order, and limit their visits to essential places, thus reduce their chances of being infected by COVID-19. Correspondingly, this also tends to reduce human-to-human contact, which is the main transmission channel of COVID-19. Intuitively, a 1% increase in compliance to the stay-at-home order leads to a corresponding reduction by the magnitudes 0.026%, 0.019%, 0.035%, 0.020% and 0.020%. On the contrary, the impact of residential is positive and statistically relevant. This sounds plausible as people desert essential places of visits, they tend to increase their presence at home. In particular, the majority of infected persons usually have one or more of their family members or close relatives infected. This explains why residential remains a key predicting channel to contacting COVID-19 and such reasons can be advanced as why COVID increases during the lockdown.

Table 5 presents the results of the alternative estimator of Poisson regression. The significance and signs of all the lockdown indicators are in agreement with the results in Table 4. This further accentuates the proposition underlining the effectiveness of lockdown measures as a potential determinant of COVID-19 cases in Nigeria.

### 6. Conclusion and policy implications

This study examines the extent to which lockdown measures impact on COVID-19 confirmed cases in Nigeria. Using the negative binomial regression estimator on the daily situation data, the following results are established. First, retail and recreation, grocery and pharmacy, parks, transit stations, and workplaces are negative and statistically significant across the models. Second, the impact of residential is positive and statistically relevant, thus running contrary to other lockdown measures with negative theoretical priors. Lastly, the obtained results are robust to an alternative estimator of Poisson Regression.

The study has some relevant policy implications. First, since the importance of lockdown policy has been quantitatively confirmed to be effective in combating the spread of COVID-19 cases, focus should be placed on residential houses, which act as a spur to the virus. This can be effectively achieved through public enlightening programs and general awareness on the need to comply with lockdown measures. More importantly, the government should guarantee and ensure constant supply of electricity to the people, their staying at home is largely predicated on enjoying uninterrupted supply of electricity. This sounds plausible in the Nigerian context where the supply of electricity has been erratic most times. This has often resulted in one of the reasons why people seek pleasure outside of their homes. This mostly takes the form of visits to relaxation centres like parks, recreation centres, restaurants, etc. Second, if the government has to ease the lockdown, at all, it must be gradual with all the necessary precautions duly enforced. Notwithstanding, this must be supported by sanctions to the defaulters. Third, lack of necessary welfare-oriented supports from the government serves as a reason people often advanced for not making them “compliant agent(s)” during the lockdown periods. Going forward, future research can be conducted using the state-level unit of observations for analysis in order to arrive at a more robust policy.
generalization. What is more, since Nigeria shares similar socioeconomic and political characteristics with other African countries, the outcome of this research work could serve as useful research inputs for other countries in the region to extrapolate.

CRediT authorship contribution statement

All the authors participated in the making of the manuscript. Specifically, Kazeem Bello Ajide conceived and designed the manuscript. Ridwan Lare Ibrahim provided empirical studies, data, and proofread the manuscript. Olorunfemi Yasiru Alimi handled the model estimation and proofread the manuscript.

Declaration of competing interest

The authors have no conflict of interest and no fund was received in favor of this study.

Appendix I. Definition of variables

| Signs | Variables | Measurement | Sources |
|-------|-----------|-------------|---------|
| Cases | Cases Number of reported COVID-19 cases | Number of reported COVID-19 cases | Nigeria Centre for Disease Control (NCDC, 2020) |
| Rrpc | % Δ of retail and recreation change from baseline | Retail and recreation percent change from baseline | NCDC (2020) |
| ggpc | % Δ of grocery and pharmacy percent change from baseline | Grocery and pharmacy percent change from baseline | NCDC (2020) |
| Ppc | % Δ of Parks percent change from baseline | Parks percent change from baseline | NCDC (2020) |
| Tspc | % Δ of transit stations percent change from baseline | Transit stations percent change from baseline | NCDC (2020) |
| Wpc | % Δ of workplaces percent change from baseline | Workplaces percent change from baseline | NCDC (2020) |
| Rrpc | % Δ of residential percent change from baseline | Residential percent change from baseline | NCDC (2020) |

References

Abdulmajeed, K., Adeleke, M., Popoola, L., 2020. Online Forecasting of COVID-19 Cases in Nigeria Using Limited Data (Data in Brief, 105683).

Ajide, K.B., Raheem, I.D., 2020. Does democracy really fuel terrorism in Africa? Int. Econ. J. 162, 50–66.

Al-Raddadi, R.M., Shabouni, O.I., Alraddadi, Z.M., Alzalabani, A.H., Al-Asmari, A.M., Ibrahim, A., 2020. Burden of Middle East respiratory syndrome coronavirus infection in Saudi Arabia. J. Infect. Public Health 13 (5), 692–696 (2019 Dec 13).

Al-Raddadi, R.M., Shabouni, O.I., Alraddadi, Z.M., Alzalabani, A.H., Al-Asmari, A.M., Ibrahim, A., Almarashi, A., Madani, T.A., 2019. Burden of Middle East respiratory syndrome coronavirus infection in Saudi Arabia. J. Infect. Public Health 14, 100544. https://doi.org/10.1016/j.jemep.2020.100544. 

Briz-Rodríguez, A., Serrano-Aroca, Á., 2020. A spatio-temporal analysis for exploring the effect of temperature on COVID-19 early evolution in Spain. Sci. Total Environ. 138811.

Cai, J., Sun, W., Huang, J., Gamber, M., Wu, J., He, G., 2020. Indirect Virus Transmission in the Mediterranean Basin. Sci. Total Environ. 138817.

Cao, J., Sun, W., Huang, J., Gamber, M., Wu, J., He, G., 2020. Indirect Virus Transmission in the Mediterranean Basin. Sci. Total Environ. 138817.

Ceylan, Z., 2020. Estimation of COVID-19 prevalence in Italy, Spain, and France. Sci. Total Environ. 138811.

Ceylan, Z., 2020. Estimation of COVID-19 prevalence in Italy, Spain, and France. Sci. Total Environ. 138817.

Crosley, G., 2020. Wuhan Lockdown Unprecedented, Shows Commitment to Contain Virus: WHO Representative in China. Thomson Reuters.

De Vos, J., 2020. The effect of COVID-19 and subsequent social distancing on travel behavior. Transportation Research Interdisciplinary Perspectives, 100121.

Ferdinand, K.C., Nasser, S.A., 2020. African American COVID-19 mortality: A sentinel event. J. Am. Coll. Cardiol. 75 (21), 2746–2748.
