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An Assessment of Locational Distribution and Movement of COVID-19 in Nigeria

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Abstract: *The coronavirus known as covid 19 pandemic created a profound impact on people in Nigeria and around the world. The pandemic caused widespread disruption to physical, social and economic activity. The impacts were mostly felt in activites like education, and social life. The spatial distribution of Covid-19 in Nigeria has been a major concern for public health officials. The virus spread unevenly across the country, with some states experiencing much higher caseloads than others. This has made it difficult to control the pandemic. Spatial statistical approaches were used to understand the spatial distribution of Covid-19 in Nigeria. These approaches can identify spatial clusters of cases and help to target interventions and resources. Spatial autocorrelation was used to identify areas where cases are clustered together. This information can be used to target public health interventions, such as contact tracing and testing, in these areas. Spatial clustering was used to see if the disease is clustering at any location. This information can be used to prevent the spread of the virus by taking steps to reduce transmission, such as social distancing and mask-wearing. A dynamic dashboard can visualize data on cases, deaths, and vaccination rates. This information can be used to track the progress of the pandemic and identify areas that need additional resources. By using spatial statistical approaches and building a dynamic dashboard, public health officials can better understand the spatial distribution of Covid-19 in Nigeria and take steps to mitigate the impact of the pandemic.*

Keywords: *Spatial Statistics, Covid-19, Spatial Distribution, Autocorrelation, Clustering.*

INTRODUCTION

The worldwide outbreak of the Coronavirus pandemic had significant consequences on human lives and caused widespread disruptions to economic activities globally (World Bank, 2020). The extensive influence of this unparalleled crisis on both human well-being and the international economy underscores the rapid spread and scale of the contagion, highlighting the interconnectedness of the world. Initially, there was widespread apprehension about the impact of the health crisis on Africa as the Covid-19 outbreak began. However, the anticipated dire consequences related to the health crisis have not materialized, sparking global interest in understanding the factors responsible for the comparatively mild course of the Covid-19 outbreak in contrast to the initial projections.

The pandemic continued its devastating impact on various countries worldwide, leading to the loss of thousands of lives, a surge in illness, and the upheaval of daily routines

(Badu et al, 2020). The global scientific community faced an urgent need for relevant evidence to comprehend the challenges and gaps in knowledge, as well as to identify opportunities for controlling the virus's spread. In the context of the novel COVID-19, most studies have focused on understanding the temporal dynamics of the disease. However, a few studies have also assessed the spatiotemporal dynamics of the disease. This is significant because infectious diseases, including respiratory infections, have substantial geographical variations in intensity and range of transmission. This is due to the uneven distribution of vulnerable populations and risk factors that facilitate (or hamper) the spatial diffusion of the pathogen. This is of high relevance considering the unequal distribution of the capacity of the healthcare system, which might strongly determine disease outcomes.

However, Lawal and Nwegbu (2020) conducted a study focusing on the movement and risk perception during the lockdown period in Nigeria. Their investigation utilized spatial analysis of mobile phone data to comprehend how individuals perceived hazards and their level of compliance with the restrictions across various states. Also Ayodele et al., (2021) conducted another research into the dynamics of COVID-19 by employing compartmental models involving susceptible, infected, recovered, and deceased individuals. Their investigation included the identification of states exhibiting analogous patterns of outbreak dynamics.

The current state of research on COVID-19 in Nigeria lacks sufficient focus on the spatial and temporal distribution of the disease. Existing studies have primarily centred around national-level data during the initial six months of the outbreak. Therefore, this research aims to bridge the gap by analysing extended timeframe data to gain deeper insights into the disease outbreak. By doing so, it seeks to identify states with higher infection risks and facilitate targeted interventions to curb transmission effectively.

Few studies have used spatial analysis and spatial statistics to examine the spatial and temporal distribution of COVID-19 in Nigeria. Most COVID-19 studies in Nigeria have used data from the first few months of the pandemic. There has been no research that examined the spatial and temporal trends of COVID-19 in Nigeria over a longer period.

In the review of the first half of 2020 on GIS and spatial analysis carried out by Franch-Pardo et al., (2020), the authors alluded to the fact that Tobler's (1970) law was much less evidence in the geographic analyses of COVID-19 since numerous works conducted studies on global and national scales. This was so because spatial analysis requires adequate spatial and spatiotemporal data sets, which was rare in the early months of 2020. This is the same for Nigeria; the available literature on COVID-19 in Nigeria was carried out within the first 6 months of the disease outbreak. No study has taken a critical look at the datasets from the start of Covid-19 till now. This is a gap that this research intends to fill.

The aim of this study is to examine the spatial distribution of the COVID-19 pandemic in Nigeria. The Objectives are: -

1. To create visual representations/Graphs/maps that showcase Nigeria's spatial and temporal distribution of pandemic data.
2. Determine the spatial relationship between covid-19 cases/deaths and location in Nigeria.
3. To develop a thorough representation of the COVID-19 cases and fatalities in Nigeria and examine the pattern of their geographical distribution.
4. Develop the COVID-19 Dashboard for Nigeria

The study shows the importance of spatial distribution and analysis in understanding the patterns and trends of the pandemic. The analysis of spatial autocorrelation, of high and low clustering highlights the areas that are most affected by the pandemic and can be used to prioritize resource allocation and intervention efforts. Furthermore, the use of GIS and Spatial Analysis proved to be effective in identifying areas with a high incidence of COVID-19 cases and in detecting spatial patterns in the distribution of cases. The analysis revealed the existence of low clustering of COVID-19 cases/deaths in different parts of Nigeria, though not statistically significant. This information can be useful in targeting interventions and resources to the areas that need them the most. Visualizations of Covid-19 data will help to create a shared understanding of the changing nature of the pandemic and to enable a more unified response. Spatiotemporal analysis can inform forecasting of the potential future burden of the disease, help identify drivers of local transmission and populations at higher risk and guide the designing of targeted interventions in resource-limited settings (Wilson and Halperin, 2008; Meyer-Rath et al., 2018). Recognizing the temporal and spatial dynamics of the infection can provide insights into the epidemiological characteristics of the disease and the identification of disease hotspots.

Since the start of the pandemic in Nigeria, government agencies and other private and non-profit agencies in Nigeria often work at cross purposes. This research will create maps and tools that can bring together disparate government agencies and other private and non-profit partners to work together using common data and in turn, serve as a platform for information sharing. These visualizations will help to create a shared understanding of the changing nature of the pandemic and to enable a more unified response.

STUDY AREA AND METHODOLOGY

The study area is in Nigeria (See Fig.1) The data for this research was obtained from the Nigerian Centre for Disease Control ((https://covid19.ncdc.gov.ng/). The data was sorted and integrated with other data sets like population data etc. Using Excel, the downloaded data was catalogued. These were then input into the ArcGIS software for visualization and spatial analysis. For example, High and low clustering tests were carried out to see whether Covid19 cases and deaths are clustered, spatial autocorrelation or Global Moran 1 was used to examine the relationship between

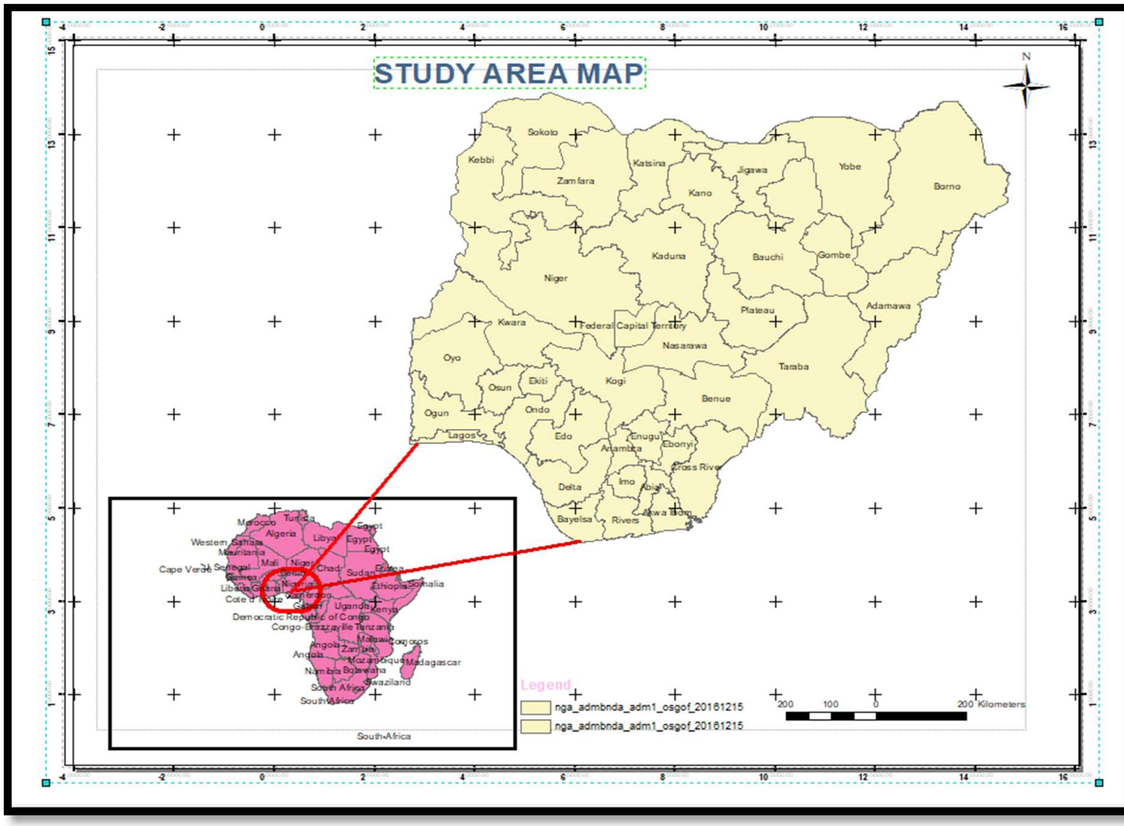

Figure 1: Study Area Map

Table 1: Covid_19 X Y to point table.

nga_admbnda_adm1_osgof_201612

FID *	Shape *	admin1Name	Shape_Leng	CASES	ADMISSION	DISCHARGE	DEATHS	POP_2019	LAT	LONG	STATES	ORIG_FID	POINT_X	POINT_Y	START_X	START_Y
1	Point	Abia	4.695135	2253	14	2205	34	3841943	5.44045	7519150	ABIA STATE	0	7.52319	5.453302	3.40644	6.46542
2	Point	Adamawa	11.525443	1203	68	1103	32	4536948	9.29472	12.387	ADAMAWA STATE	1	12.400241	9.323227	3.40644	6.46542
3	Point	Akwa Ibom	5.26383	4989	38	4907	44	4780581	5036380	7.9122	AKWA IBOM	2	7.846395	4.907245	3.40644	6.46542
4	Point	Anambra	3.59596	2825	46	2760	19	5599910	6.2072	6.93601	ANAMBRA STATE	3	6.932186	6.222776	3.40644	6.46542
5	Point	Bauchi	13.952005	1990	18	1948	24	7540663	10.7482	9.97651	BAUCHI STATE	4	9.876172	10.301636	3.40644	6.46542
6	Point	Bayelsa	5.046708	1363	10	1325	28	2394725	4.76982	6.06958	BAYELSA STATE	5	6.080418	4.766315	3.40644	6.46542
7	Point	Benue	9.40808	2129	340	1764	25	5787706	7.32684	8.73557	BENUE STATE	6	8.751908	7.341086	3.40644	6.46542
8	Point	Borno	13.714364	1629	5	1580	44	5751590	11.8743	13.1463	BORNO STATE	7	13.153347	11.88898	3.40644	6.46542
9	Point	Cross River	8.779796	882	5	852	25	4175020	5.8344	8.57609	CROSS RIVERS	8	8.599106	5.874565	3.40644	6.46542
10	Point	Delta	7.372526	5664	382	5170	112	5307543	5.68798	5.93012	DELTA STATE	9	5.876631	5.499709	3.40644	6.46542
11	Point	Ebonyi	4.489355	2064	28	2004	32	3007155	6.24323	8.00804	EBONYI	10	8.016266	6.262027	3.40644	6.46542
12	Point	Edo	7.889425	7821	102	7398	321	4461137	6.33144	5.60327	EDO STATE	11	5.930215	6.633537	3.40644	6.46542
13	Point	Ekiti	3.395633	2457	12	2417	28	3350401	7.71004	5.3081	EKITI STATE	12	5.309516	7.72008	3.40644	6.46542
14	Point	Enugu	4.319893	2952	13	2910	29	3350401	7.71004	5.5081	ENUGU STATE	13	7.440611	6.536245	3.40644	6.46542
15	Point	Federal Capital Territory	3.498412	29257	164	28845	249	2702443	9.07448	7.39786	FCT	14	7.254198	8.825591	3.40644	6.46542
16	Point	Gombe	5.955286	3310	6	3238	66	3623462	10.3274	11.1776	GOMBE STATE	15	11.191995	10.383588	3.40644	6.46542
17	Point	Imo	2.878088	2655	7	2590	58	5467722	5.56113	7.05692	IMO STATE	16	7.062308	5.57302	3.40644	6.46542
18	Point	Jigawa	11.771497	669	2	649	18	6779080	12.2039	9.56159	JIGAWA STATE	17	9.563558	12.23842	3.40644	6.46542
19	Point	Kaduna	12.613678	11541	37	11415	89	8324285	10.3448	7.69431	KADUNA STATE	18	7.705979	10.392367	3.40644	6.46542
20	Point	Kano	8.244195	5263	112	5024	127	14253549	11.9997	8.59172	KANO STATE	19	8.529557	11.745202	3.40644	6.46542
21	Point	Katsina	9.105637	2418	0	2381	37	9600382	12.98	7.26179	KATSINA STATE	20	7.628834	12.378301	3.40644	6.46542
22	Point	Kebbi	14.968981	480	10	454	16	5001610	11.459	4.22955	KEBBI STATE	21	4.161723	12.138429	3.40644	6.46542
23	Point	Kogi	10.476383	5	0	3	2	4153734	7.7274	6690580	KOGI STATE	22	6.57867	7.803185	3.40644	6.46542
24	Point	Kwara	12.046963	4691	452	4175	64	3259613	8.95008	4.39119	KWARA STATE	23	3.599367	9.455692	3.40644	6.46542
25	Point	Lagos	4.28777	103463	320	102372	771	12772884	6.5232	3.37968	LAGOS STATE	24	3.586975	6.522424	3.40644	6.46542
26	Point	Nasarawa	9.537188	2777	393	2345	39	2632239	8.47821	8.1978	NASARAWA STAT	25	8.197963	8.510447	3.40644	6.46542
27	Point	Niger	18.921559	1183	165	998	20	6220617	8.47821	8.1978	NIGER	26	5.590435	9.933226	3.40644	6.46542
28	Point	Ogun	9.649774	5810	11	5717	82	5945275	6.98197	3.47374	OGUN STATE	27	3.473262	6.995135	3.40644	6.46542
29	Point	Ondo	7.751109	5173	315	4749	109	4969707	7.25607	5.20532	ONDO STATE	28	5.192575	7.104774	3.40644	6.46542
30	Point	Osun	4.66014	3311	29	3190	92	4237396	7.7809	4.54086	OSUN STATE	29	4.517762	7.562919	3.40644	6.46542
31	Point	Oyo	8.624586	10329	2	10125	202	7512885	8.11804	3.61465	OYO STATE	30	3.612912	8.158827	3.40644	6.46542
32	Point	Plateau	8.575527	10317	10	10232	75	4400974	9.5652	9.08255	PLATEAU STATE	31	9.596843	8.96153	3.40644	6.46542
33	Point	Rivers	5.814545	17831	173	17503	155	7034973	4.80467	6.89986	RIVERS STATE	32	6.918181	4.845392	3.40644	6.46542
34	Point	Sokoto	10.503159	822	0	794	28	5863187	13.0146	5.30333	SOKOTO STATE	33	5.31881	13.037993	3.40644	6.46542
35	Point	Taraba	13.696255	1474	63	1377	34	3831885	7.97501	10.774	TARABA STATE	34	10.509575	7.943946	3.40644	6.46542
36	Point	Yobe	11.096937	638	4	625	9	3398177	12.2624	11.4315	YOBE STATE	35	11.437066	12.29868	3.40644	6.46542
37	Point	Zamfara	9.466144	375	0	366	9	5317793	12.0944	6.2198	ZAMFARA STATE	36	6.246535	12.101505	3.40644	6.46542

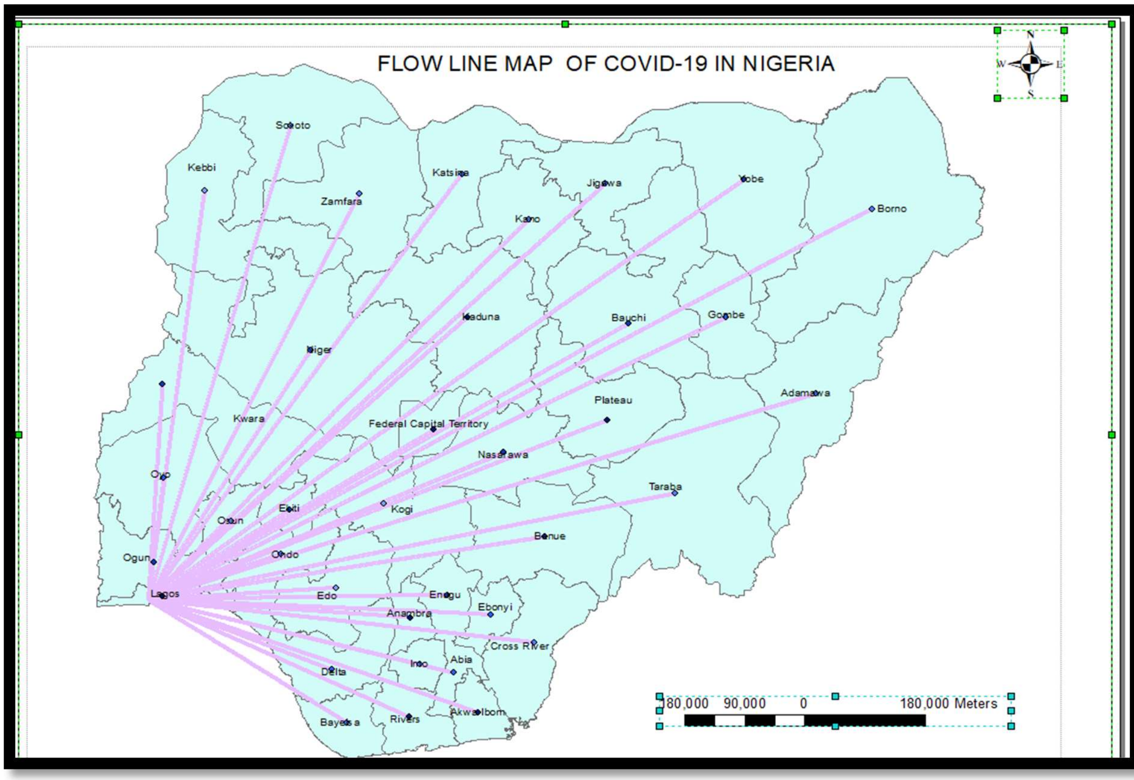

Figure 2: Flow line Map of COVID-19 in Nigeria

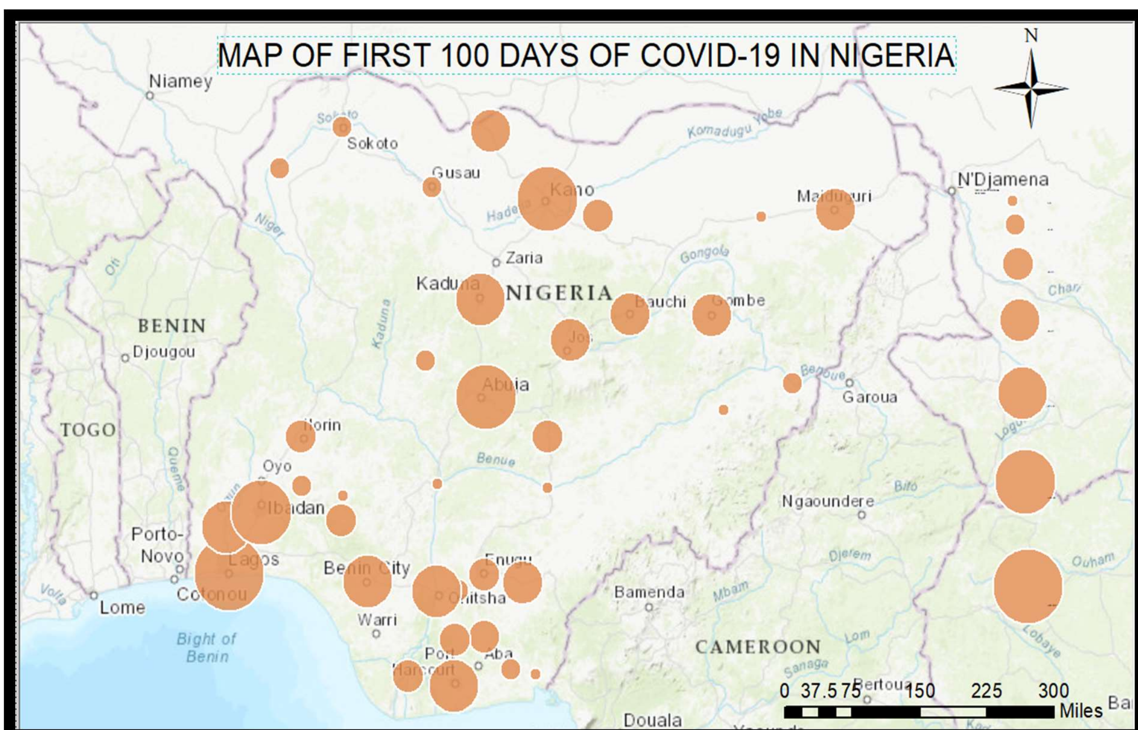

Figure 3: Cartograms of Covid_19 cases for the first 100 days

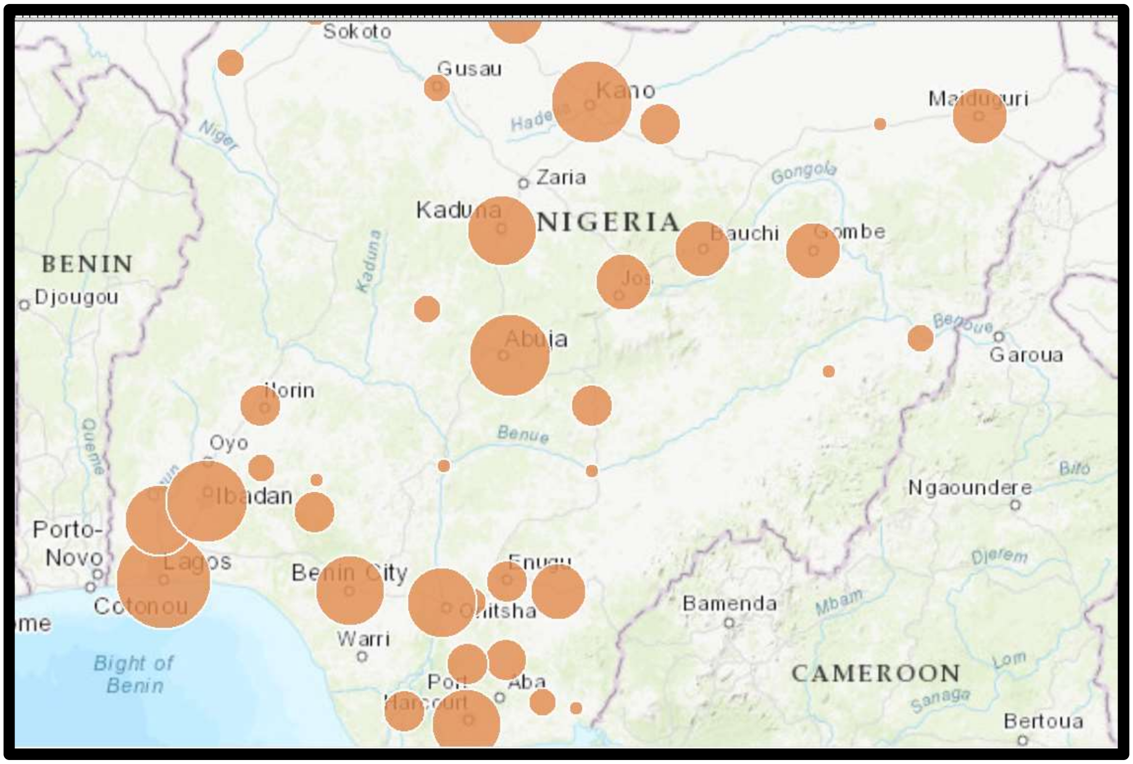

Figure 4: Cartograms of Covid_19 cases for Nigeria

Table 2: Data for the first 100 days of COVID-19 in Nigeria

STATE	CAPITAL	NO. OF CASES	NO. ADM IN HOSP.	NO. DISCHARGED	NO. OF DEATHS	LONG	LAT
ABIA	UMUAHIA	83	76	7	0	7.4946	5.5249
ADAMAWA	YOLA	42	11	27	4	12.4582	9.2795
AKWA IBOM	UYO	45	29	14	2	7.9266	5.0333
ANAMBRA	AWKA	29	25	3	1	7.0919	6.2127
BAUCHI	BAUCHI	291	58	224	9	9.8439	10.3103
BAYELSA	YENEGOA	32	1	28	3	6.2676	4.9268
BENUE	MAKURDI	13	12	1	0	8.5214	7.7337
BORNO	MAIDUGRI	356	142	188	26	13.1571	11.8469
CROSS RIVERS	CALABAR	0	0	0	0	8.3269	4.9589
DELTA	ASABA	148	105	35	8	6.7274	6.1984
EBONYI	ABAKALIKI	103	78	25	0	8.1137	6.3248
EDO	BENIN CITY	401	268	109	24	5.6257	6.3381
EKITI	ADO EKITI	29	9	18	2	5.2209	7.6233
ENUGU	ENUGU	30	15	14	1	7.4988	6.4413
FCT	ABUJA	952	664	265	23	7.5333	9.0833

GOMBE	GOMBE	217	72	135	10	11.1672	10.2896
IMO	OWERRI	68	49	19	0	7.0332	5.4836
JIGAWA	DUTSE	283	125	153	5	9.3389	11.7562
KADUNA	KADUNA	343	127	206	10	7.4387	10.5264
KANO	KANO	999	501	450	48	8.5132	12.0023
KATSINA	KATSINA	395	176	199	20	7.6017	12.9908
KEBBI	BIRNIN KEBBI	35	2	29	4	4.1975	12.4538
KOGI	LOKOJA	3	3	0	0	6.7404	7.7968
KWARA	ILORIN	135	89	45	1	4.5421	8.4966
LAGOS	IKEJA	5,767	4,756	944	67	3.3946	6.4541
NASARAWA	LAFIA	112	76	31	5	8.5133	8.4938
NIGER	MINNA	44	17	28	1	6.5477	9.6152
OGUN	ABEOKUTA	355	156	186	13	3.3451	7.1557
ONDO	AKURE	42	14	21	7	5.1931	7.2526
OSUN	OSOGBO	49	7	38	4	4.5569	7.771
OYO	IBADAN	365	246	112	7	3.9059	7.3775
PLATEAU	JOS	115	29	84	2	8.8921	9.9285
RIVERS	PORT HARCOURT	332	175	136	21	7.0134	4.7774
SOKOTO	SOKOTO	129	14	101	14	5.2143	13.048
TARABA	JALINGO	18	8	10	0	11.3595	8.8936
YOBE	DAMATURU	52	20	25	7	11.96408	11.7469
ZAMFARA	GUSAU	76	0	71	5	6.6599	12.1704

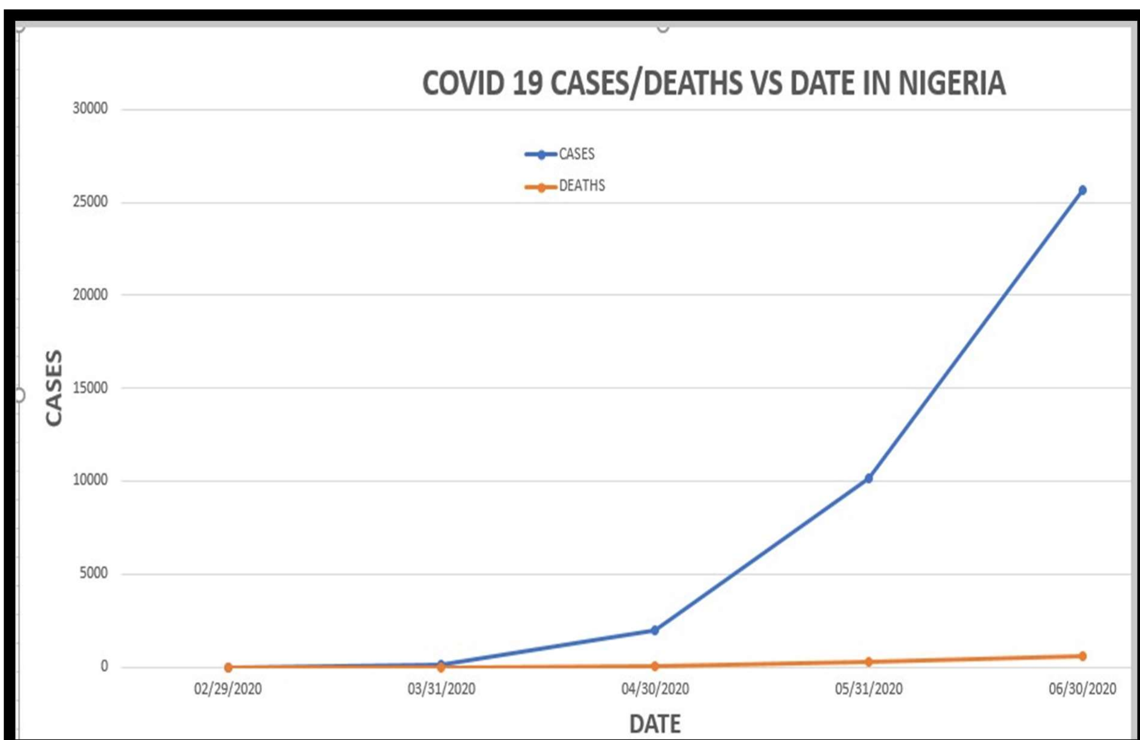

Figure 5: Time Series graph for the first 100 days of COVID-19

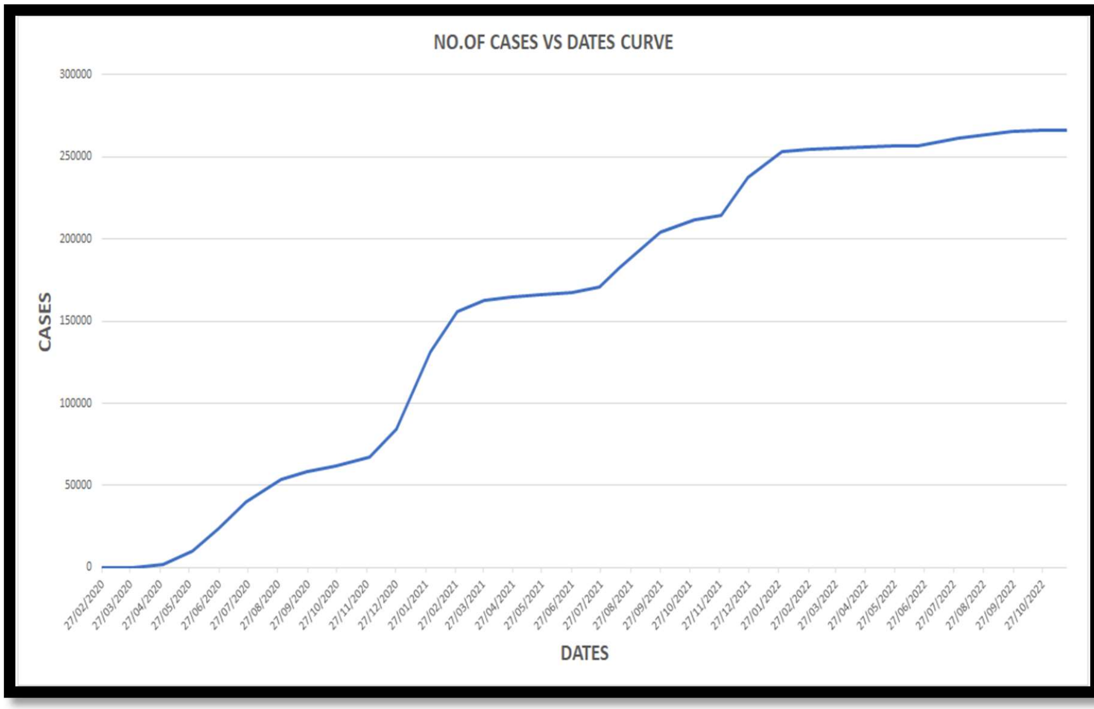

Figure 6: Time series of Cases vs Dates

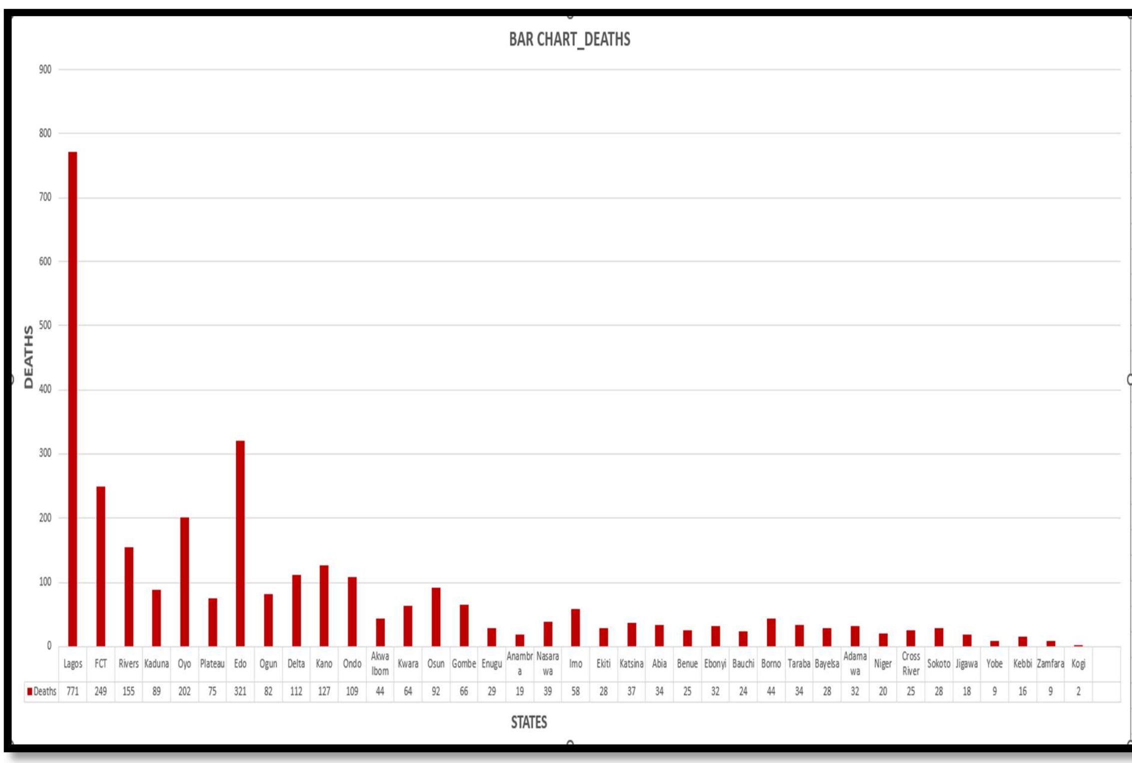

Figure 7: Bar charts of Covid-19 Deaths in Nigeria

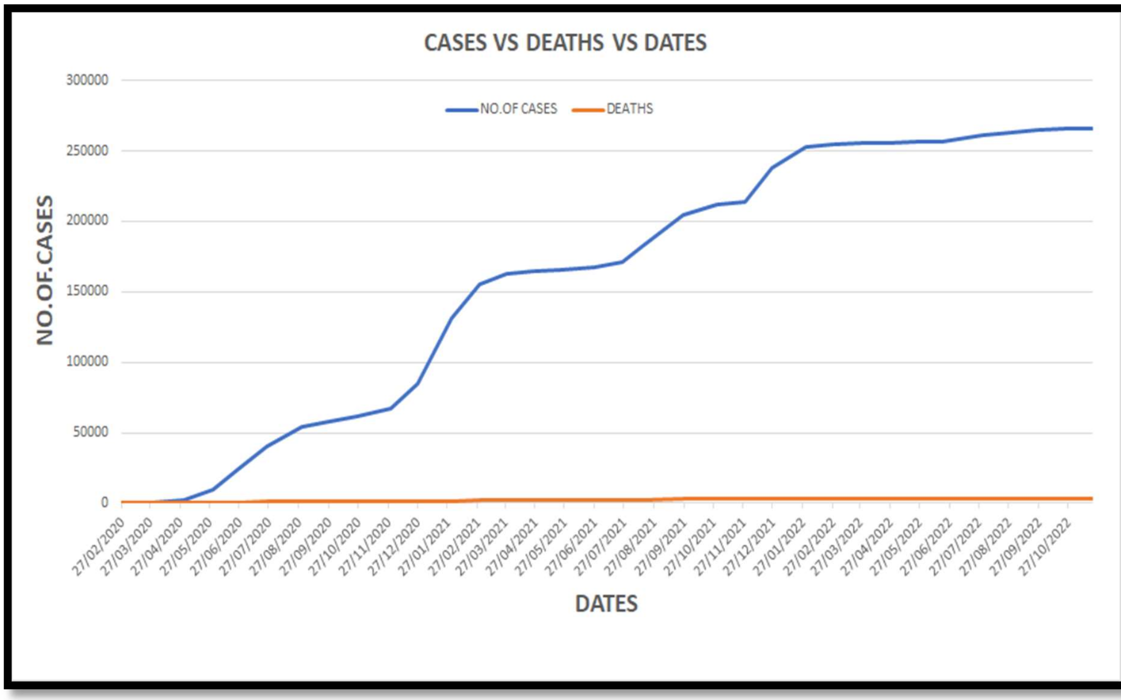

Figure 8: Time series graph of Cases/Deaths vs Dates

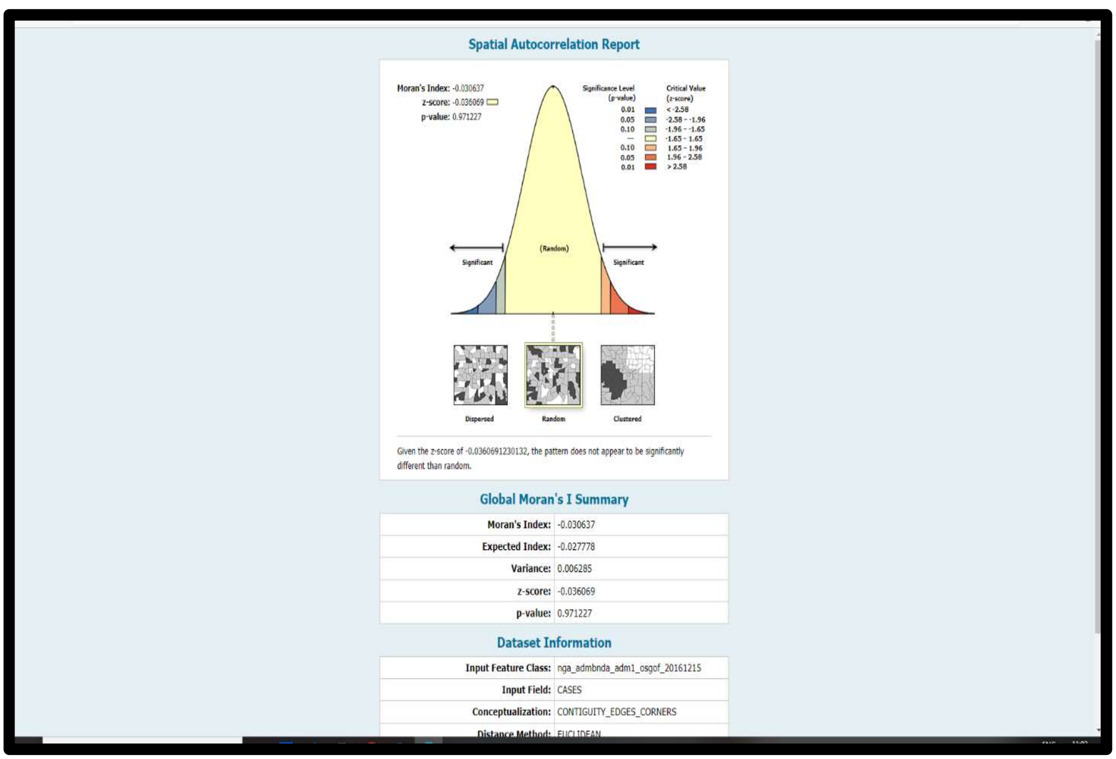

Figure 9: Spatial Autocorrelation test result for cases.

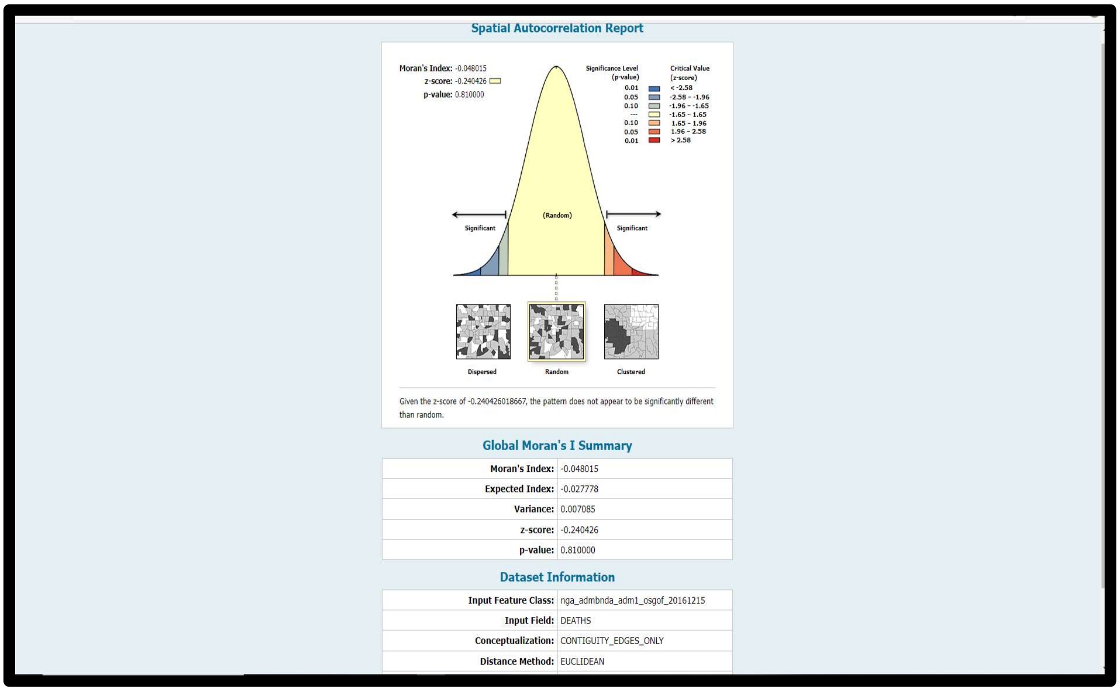

Figure 10: Spatial autocorrelation results for Covid-19 deaths in Nigeria

Table 3: Covid_19 Data for Dashboard

FID	STATES	LAT	LONG	No_Cases_Confirmed	No_Cases_On_Admission	No_Discharged	No_Deaths	VACCINATED_PARTIALLY	VACCINATED_FULLY	VACCINATED_BOOSTER D	POPULATION_2019
1	Lagos	6.523198	3.379681	103,463	320	102,372	771	434,582	1,927,076	433,137	12,772,884
2	FCT	9.074482	7.39786	29,258	164	28,845	249	200,121	788,036	153,547	2,702,443
3	Rivers	4.804666	6.899855	17,831	173	17,503	155	216,851	529345	63,357	7,034,973
4	Kaduna	10.34475	7.694312	11,541	37	11,415	89	276,923	6,403,776	821,146	8,324,285
5	Oyo	8.118045	3.614653	10,329	2	10,125	202	394,859	2,053,931	637,770	7,512,855
6	Plateau	9.565199	9.082551	10,317	10	10,232	75	108,659	2,083,770	515,729	4,400,974
7	Edo	6.331442	5.603271	7,821	102	7,398	321	87,771	625,177	43,452	4,461,137
8	Ogun	6.981967	3.473738	5,810	11	5,717	82	300,546	1,282,849	230,702	5,945,275
9	Delta	5.687981	5.930123	5,664	382	5,170	112	201,890	591,819	43,452	4,461,137
10	Kano	11.99974	8.591718	5,263	112	5,024	127	3,025,893	7,789,831	1,436,464	14,253,549
11	Ondo	7.256071	5.205315	5,173	315	4,749	109	217,259	393,630	63,899	4,969,707
12	Akwa Ibor	5.036377	7.9122	4,989	38	4,907	44	139,859	515,751	50,706	4,780,581
13	Kwara	8.95008	4.391188	4,691	452	4,175	64	143,048	1,541,242	378,475	3,259,613
14	Osun	7.780904	4.540863	3,311	29	3,190	92	313,632	3,467,808	959,686	4,237,396
15	Gombe	10.32738	11.17758	3,310	6	3,238	66	184,191	1,581,732	63,171	3,623,462
16	Enugu	6.520326	7.429926	2,952	13	2,910	29	166,921	1,066,282	153,547	4,396,098
17	Anambra	6.207202	6.936006	2,825	46	2,760	19	240,058	949,284	123,980	5,599,910
18	Nasarawa	8.478208	8.197796	2,777	393	2,345	39	276,721	2,091,252	387,467	2,632,239.00
19	Imo	5.561135	7.056921	2,655	7	2,590	58	130,071	1,427,307	173,279	5,167,722
20	Ekiti	7.71004	5.308099	2,457	12	2,417	28	292,771	1,562,546	412,614	3,350,401
21	Katsina	12.98	7.621791	2,418	0	2,381	37	449,076	1,862,294	173,404	9,300,382
22	Abia	5.440455	7.519148	2,253	14	2,205	34	65,676	789,568	270,594	3,841,943
23	Benue	7.326843	8.735575	2,129	340	1,764	25	422,411	955,483	89,277	5,787,706
24	Ebonyi	6.243228	8.008037	2,064	28	2,004	32	94,405	251,923	3,582	3,007,155
25	Bauchi	10.7482	9.976505	1,990	18	1,948	24	197,484	1,523,921	186,260	7,540,663
26	Borno	11.87425	13.1463	1,629	5	1,580	44	213,880	1,470,946	204,722	5,751,590
27	Taraba	7.975006	10.77399	1,474	63	1,377	34	180,801	396,350	34,434	3,331,177
28	Bayelsa	4.769825	6.06958	1,363	10	1,325	28	38,566	189,305	29,765	2,394,725
29	Adamawa	9.294716	12.38703	1,203	68	1,103	32	101,954	2,493,489	458,941	4,536,948
30	Niger	9.902952	5.598321	1,183	165	998	20	234,970	1,579,767	91,278	6,220,617
31	Cross Rive	5.834405	8.576094	882	5	852	25	162,655	945,353	157,837	4,175,020
32	Sokoto	13.01455	5.303325	822	0	794	28	464,029	2,247,922	804	5,863,187
33	Jigawa	12.20395	9.561587	669	2	649	18	1,016,005	5,029,312	120,645	6,779,080
34	Yobe	12.26241	11.43146	638	4	625	9	241,105	1,258,630	76,491	3,398,177
35	Kebbi	11.45899	4.229554	480	10	454	16	336,945	1,963,905	210,283	5,001,610

VACCINATION DATA

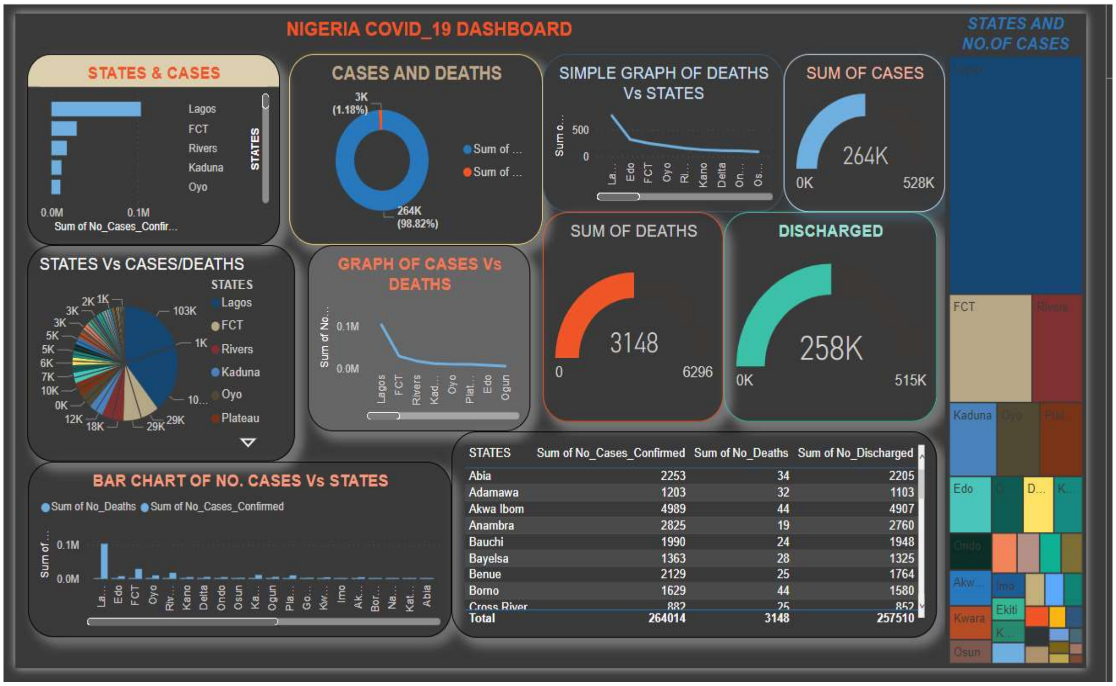

Figure 11: Covid-19 Pandemic Dashboard for Nigeria

DISCUSSION

Fig.2 shows the cartogram of Covid-19 cases in Nigeria.Fig.3 and 4 show the cases and deaths respectively. Fig.5a and b show the Global Moran 1 test for cases and deaths. Fig.6 shows the spatial autocorrelation test for population density. Fig 7 and 8 shows the clustering pattern of cases and death for the Covid-19 pandemic in Nigeria This study utilized spatial analysis and Geographic Information System (GIS) to study the spatial distribution of Covid-19 pandemic data in Nigeria. A spatial statistical approach/test was deployed /carried out to determine the spatial dependency/relationship between covid-19 cases/deaths and population density across the states. The finding reveals a low significant clustering of covid-19 cases and deaths across Nigeria. To put it differently, the spatial distribution of covid-19 cases and deaths are not clustered in any area or region of the country, meaning that they are distributed randomly across Nigeria (Fig.7 and 8)

In the area of spatial autocorrelation, the study reveals that there is evidence of spatial autocorrelation, but it is not significant enough to say that covid-19 cases and deaths across the states in Nigeria were dependent on the location of the states or region9Fig.5a and b)

On the contrary, there is strong statistical evidence of spatial autocorrelation or dependency of covid-19 cases and deaths on the population density across the states. The Moran index of 0-136550 indicates that there is positive autocorrelation in covid-19 cases and deaths because of high or low population density data (Fig.6). This means that areas with most areas with low populations tend to have low covid-19 cases /deaths while areas with high populations tend to have high covid-19 cases/deaths.

CONCLUSION

Firstly, the study shows the importance of spatial analysis in understanding the patterns and trends of the pandemic. The analysis of spatial autocorrelation, and high and low clustering highlights the areas that are most affected by the pandemic and can be used to prioritize resource allocation and intervention efforts. Furthermore, the use of GIS and Spatial Analysis proved to be effective in identifying areas with a high incidence of COVID-19 cases and in detecting spatial patterns in the distribution of cases. The analysis revealed the existence of both high and low clustering of COVID-19 cases/deaths in different parts of Nigeria, though not statistically significant. This information can be useful in targeting interventions and resources to the areas that need them the mos.t The study found evidence of spatial autocorrelation in the distribution of COVID-19 cases in Nigeria, indicating that the presence of a case in one location may influence the likelihood of a case occurring in a nearby location.

Finally, the creation of a dashboard for the pandemic allowed for real-time monitoring and visualization of the spread of the disease, which can assist policymakers in making informed decisions and allocating resources efficiently. Overall, the use of GIS and Spatial Analysis tools in studying the COVID-19 outbreak in Nigeria proved to be valuable in providing insights into the spatial patterns and distribution of the disease, which can inform targeted interventions and resource allocation. Limitations of this Study

-inadequate surveillance and testing: Nigeria is faced with challenges regarding adequate surveillance and testing for COVID-19, which can impact the accuracy of data and understanding of the disease. Overall, there is a need for more comprehensive and interdisciplinary studies that consider both biological and social factors to better understand the disease's spread. Therefore, future studies need to

investigate other correlations, such as ecological, climatological, and socioeconomic variables, to effectively determine the relationship between COVID-19 hotspots, cold spots, and population density.

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