

Assessing Differential Impacts of COVID-19 on African Countries: A Comparative Study

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Abstract: Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus. Most people who fall sick with COVID-19 experience mild to moderate symptoms and recover without special treatment. A number of deaths have been recorded across world. The aim of this study is to investigate and compare the extent the virus affects Africa relative to other parts of the world and it significant.

Fifty five countries were selected randomly based on their continents and cases of infection. Data from each country were obtained from United Nations Geoscheme and WHO and were analyzed and compared to that of the United State of America (USA). USA was used as a Comparism Factor (CF) because it has one of the best healthcare system and high COVID-19 cases. Subsequent examination of associations between the proportion of COVID-19 cases, recovery and deaths of each country to the United State of America was carried out. All data used in these analyses are from publicly available data sets. Data analyzed revealed that with exception of South Africa, Africa appears to be least affected by the virus. African countries have the least infected, more recovery and lesser number of deaths index.

Result from the study suggests that the virus affect Africa the least when compared to USA and other continents in terms of cases and mortality. This may be due to among other factors a more robust immune response. The result also helps to provide insight as to how significant developing and providing vaccine may be to this part of the world.

Keywords: Africa, USA, COVID-19, Nigeria, continent

I. INTRODUCTION

Coronaviruses are members of the subfamily Orthocoronavirinae, in the family Coronaviridae, order Nidovirales, and realm Riboviria^{1,2}. They are enveloped viruses with a positive-sense single-stranded RNA genome and a nucleocapsid of helical symmetry². The genome size of coronaviruses ranges from approximately 26 to 32 kilobases, one of the largest among RNA viruses^{2,3}. Coronavirus, any virus belonging to the family Coronaviridae. Coronaviruses have enveloped virions (virus particles) that measure approximately 120 nm (1 nm = 10⁻⁹ metre) in diameter. Club-shaped glycoprotein spikes in the envelope give the viruses a crownlike, or coronal, appearance. The nucleocapsid, made up of a protein shell known as a capsid and containing the viral nucleic acids, is helical or tubular^{4,5,6}. The coronavirus

genome consists of a single strand of positive-sense RNA (ribonucleic acid). Coronaviridae is generally considered to contain two genera, *Coronavirus* and *Torovirus*, which differ in nucleocapsid morphology, the former being helical and the latter being tubular⁷. Coronaviruses are important agents of gastrointestinal disease in humans, poultry, and bovines. In humans, a species known as SARS coronavirus (or Severe acute respiratory syndrome coronavirus) causes a highly contagious respiratory disease that is characterized by symptoms of fever, cough, and muscle ache, often with progressive difficulty in breathing. The virus emerged in humans in 2002; it likely jumped to humans from an animal reservoir, believed to be horseshoe bats⁸. The ability of SARS coronavirus to jump to humans undoubtedly required genetic changes in the virus. These changes are suspected to have occurred in the palm civet, since the SARS virus present in horseshoe bats is unable to infect humans directly⁹.

Coronaviruses are a group of RNA viruses that cause diseases in mammals and birds. In humans and birds, they cause respiratory tract infections that can range from mild to lethal (Wertheim et al., 2013). Mild illnesses in humans include some cases of the common cold (which is also caused by other viruses, predominantly rhinoviruses), while more lethal varieties can cause SARS, MERS, and COVID-19¹⁰. In cows and pigs they cause diarrhea, while in mice they cause hepatitis and encephalomyelitis. There are as yet no vaccines or antiviral drugs to prevent or treat human coronavirus infections. Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus^{10,11}.

The COVID-19 pandemic, also known as the coronavirus pandemic, is an ongoing pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)^{12,13}. The disease was first identified in December 2019 in Wuhan, China (ICTV, 2019). The World Health Organization declared the outbreak a Public Health Emergency of International Concern on 30 January 2020 and a pandemic on 11 March. As of 17 September 2020, more than 29.9 million cases have been reported in 188 countries and territories, resulting in more than 942,000 deaths; more than 20.3 million people have

recovered^{2,14}. The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. Many larger droplets rapidly fall to the ground, however some can be suspended in air as aerosols, especially in indoor spaces¹⁵. It may also be transmitted via contaminated surfaces, although this has not been conclusively demonstrated^{16,17}. It can spread for up to two days prior to symptom onset, and from people who are asymptomatic¹⁸. People remain infectious in moderate cases for 7-12 days, and up to two weeks in severe cases¹⁹.

The *attack rate* or *transmissibility* (how rapidly the disease spreads) of a virus is indicated by its reproductive number (R_0 , pronounced *R-nought* or *r-zero*), which represents the average number of people to which a single infected person will transmit the virus. WHO's estimated (on Jan. 23) R_0 to be between 1.4 and 2.5^{2,20}.

There has been concern about the consequence of the viral outbreak in Africa. The United Nations Economic Commission for Africa (UNECA) had in April predicted that anywhere between 300,000 and 3.3 million African people could lose their lives as a direct result of COVID-19²¹. The World Health Organisation (WHO) warned African countries to "prepare for the worst", while Melinda Gates, co-chair of the Bill & Melinda Gates Foundation, believed that it was going to be horrible in the developing world. She suggested that part of the reason case numbers don't look very bad is because they don't have access to very many tests²². The aim of this study is to investigate and compare the extent the virus affects Africa relative to other parts of the world and it significant.

II. METHOD

The Corona virus COVID-19 is affecting 213 countries and territories around the world. Fifty five countries from different continent and regions of the world was randomly selected from each continent and based on COVID-19 cases in each country. The list of countries and territories and their continental regional classification is based on the United Nations Geoscheme and WHO. Sources and data used was provided under Latest Updates from WHO/Worldometer's COVID-19 data on September 17, 2020. Data obtained for each country was analyzed and compared to that of the United State of America (USA). USA was used as a Comparism Factor (CF) because it has one of the best healthcare systems in the world and high COVID-19 cases. Subsequent examination of associations between the proportion of COVID-19 cases, recovery and deaths of each country to the United State of America was carried out. All data used in these analyses are from publicly available data sets.

Statistical analyses

Parameters such as total incidences/cases, total deaths and total recovered of countries was compared against figures and values obtained for USA. Bivariate analysis was done with Chi-square test to compare proportions for variables. In reporting these results, country-level characteristics are scaled to represent a comparison of two countries similar in all other respects. Thus, rate ratios greater than one mean that higher levels of a given characteristic are associated with higher rates of COVID-19 cases or deaths, while rate ratios less than one mean that lower levels of a given characteristic are associated with lower rates of COVID-19 cases or deaths.

III. RESULT

Infectious, recovery and mortality rate of COVID-19 based on country

Data analyzed revealed that with exception of South Africa, Africa appears to be least affected by the virus

Table 1: Infectious, recovery and mortality rate of COVID-19 based on country

Country,	Total	Total	Total	Population (D)
Other	Cases (A)	Deaths (B)	Recovered (C)	
World	30,125,256	946,712	21,874,957	
USA	6,839,099	201,638	4,132,329	331,415,157
India	5,141,905	83,433	4,039,986	1,382,863,649
Brazil	4,421,686	134,174	3,720,312	212,879,694
Russia	1,085,281	19,061	895,868	145,947,910
Peru	744,400	31,051	587,717	33,067,784
Colombia	736,377	23,478	610,078	50,996,981
Mexico	680,931	71,978	485,024	129,217,812
South Africa	653,444	15,705	584,195	59,465,326
Argentina	589,012	12,229	456,347	45,283,297
Iran	413,149	23,808	353,848	84,218,051
France	404,888	31,045	90,335	65,304,439
Saudi Arabia	328,144	4,399	307,207	34,926,695
Iraq	307,385	8,332	241,100	40,407,380
Turkey	296,391	7,249	262,602	84,529,937
Italy	293,025	35,658	215,954	60,442,647
Germany	267,512	9,451	239,100	83,841,193
Indonesia	232,628	9,222	166,686	274,132,173
Israel	172,322	1,163	125,671	9,197,590
Ukraine	166,244	3,400	73,913	43,676,580
Canada	140,040	9,196	122,452	37,812,051
Bolivia	128,872	7,478	87,031	11,706,299
Qatar	122,693	208	119,613	2,807,805
Ecuador	121,525	10,996	97,063	17,698,853

Panama	103,466	2,198	76,787	4,328,896
Egypt	101,500	5,696	86,549	102,733,067
Kuwait	97,824	575	87,911	4,283,737
Belgium	95,948	9,935	18,810	11,600,376
Morocco	92,016	1,686	72,968	37,002,355
Portugal	66,396	1,888	44,794	10,190,277
Ethiopia	66,224	1,045	26,665	115,543,700
Costa Rica	59,516	649	21,752	5,103,936
Singapore	57,532	27	57,039	5,860,079
Nigeria	56,604	1,091	47,872	207,180,371
Armenia	46,671	925	42,231	2,964,430
Ghana	45,714	294	44,896	31,206,289
Afghanistan	38,872	1,436	32,505	39,107,897
Kenya	36,576	642	23,611	54,014,150
Palestine	33,843	244	23,060	5,125,660
Cameroon	20,303	415	18,837	26,680,436
Ivory Coast	19,132	120	18,289	26,511,343
Senegal	14,618	300	10,923	16,833,475
Zambia	13,887	326	12,869	18,488,027

Sudan	13,535	836	6,759	44,058,529
DRC	10,442	267	9,840	90,108,576
Guinea	10,154	63	9,612	13,204,954
Tunisia	8,100	129	2,309	11,844,645
Zimbabwe	7,598	224	5,823	14,908,051
Mozambique	5,994	39	3,267	31,432,436
Malawi	5,704	178	3,764	19,230,396
Uganda	5,380	60	2,489	46,030,454
Equatorial Guinea	5,000	83	4,496	1,412,192
Burkina Faso	1,748	56	1,162	21,019,299
Togo	1,608	40	1,230	8,318,376
Benin	2,280	40	1,942	12,187,668
Guinea-Bissau	2,275	39	1,127	1,977,502

Infectious, recovery and mortality rate of COVID-19 based on country and relative to the USA

When compared against USA, African countries were among the least infected, more recovery and lesser number of deaths.

Table 2: Infectious, recovery and mortality rate of COVID-19 based on country and relative to the USA

Country,	Percentage of A to D	Percentage of B to D	Percentage of C to D	E/2.064	F/0.061	G/1.25
Other	(E)	(G)	(H)	(F ₁)	(F ₂)	(F ₃)
World						
USA	2.0636048	0.061	1.25	1.00	1.00	1.00
India	0.3718302	0.006	0.29	0.18	0.10	0.23
Brazil	2.0770821	0.063	1.75	1.01	1.03	1.40
Russia	0.7436085	0.013	0.61	0.36	0.21	0.49
Peru	2.2511336	0.094	1.78	1.09	1.54	1.42
Colombia	1.4439619	0.046	1.20	0.70	0.75	0.96
Mexico	0.5269637	0.056	0.38	0.26	0.91	0.30
South Africa	1.0988656	0.026	0.98	0.53	0.43	0.79
Argentina	1.3007268	0.027	1.01	0.63	0.44	0.81
Iran	0.4905706	0.028	0.42	0.24	0.46	0.34
France	0.6200007	0.048	0.14	0.30	0.78	0.11
Saudi Arabia	0.9395220	0.013	0.88	0.46	0.21	0.70
Iraq	0.7607150	0.021	0.60	0.37	0.34	0.48
Turkey	0.3506344	0.009	0.31	0.17	0.14	0.25
Italy	0.4847984	0.059	0.36	0.23	0.97	0.29
Germany	0.3190699	0.011	0.29	0.15	0.18	0.23
Indonesia	0.0848598	0.003	0.06	0.04	0.06	0.05
Israel	1.8735560	0.013	1.37	0.91	0.21	1.09
Ukraine	0.3806250	0.008	0.17	0.18	0.13	0.14
Canada	0.3703581	0.024	0.32	0.18	0.40	0.26

Bolivia	1.1008774	0.064	0.74	0.53	1.05	0.59
Qatar	4.3697123	0.007	4.26	2.12	0.12	3.41
Ecuador	0.6866264	0.062	0.55	0.33	1.02	0.44
Panama	2.3901244	0.051	1.77	1.16	0.83	1.42
Egypt	0.0987997	0.006	0.08	0.05	0.09	0.07
Kuwait	2.2836136	0.013	2.05	1.11	0.22	1.64
Belgium	0.8271111	0.086	0.16	0.40	1.40	0.13
Morocco	0.2486761	0.005	0.20	0.12	0.07	0.16
Portugal	0.6515623	0.019	0.44	0.32	0.30	0.35
Ethiopia	0.0573151	0.001	0.02	0.03	0.01	0.02
Costa Rica	1.1660805	0.013	0.43	0.56	0.21	0.34
Singapore	0.9817615	0.000	0.97	0.48	0.01	0.78
Nigeria	0.0273211	0.001	0.02	0.01	0.01	0.02
Armenia	1.5743667	0.031	1.42	0.76	0.51	1.14
Ghana	0.1464897	0.001	0.14	0.07	0.02	0.12
Afghanistan	0.0993968	0.004	0.08	0.05	0.06	0.07
Kenya	0.0677156	0.001	0.04	0.03	0.02	0.03
Palestine	0.6602662	0.005	0.45	0.32	0.08	0.36
Cameroon	0.0760970	0.002	0.07	0.04	0.03	0.06
Ivory Coast	0.0721653	0.000	0.07	0.03	0.01	0.06
Senegal	0.0868389	0.002	0.06	0.04	0.03	0.05
Zambia	0.0751135	0.002	0.07	0.04	0.03	0.06
Sudan	0.0307205	0.002	0.02	0.01	0.03	0.01
DRC	0.0115882	0.000	0.01	0.01	0.00	0.01
Guinea	0.0768954	0.000	0.07	0.04	0.01	0.06
Tunisia	0.0683853	0.001	0.02	0.03	0.02	0.02
Zimbabwe	0.0509657	0.002	0.04	0.02	0.02	0.03
Mozambique	0.0190695	0.000	0.01	0.01	0.00	0.01
Malawi	0.0296614	0.001	0.02	0.01	0.02	0.02
Uganda	0.0116879	0.000	0.01	0.01	0.00	0.00
Equatorial Guinea	0.3540595	0.006	0.32	0.17	0.10	0.25
Burkina Faso	0.0083162	0.000	0.01	0.00	0.00	0.00
Togo	0.0193307	0.000	0.01	0.01	0.01	0.01
Benin	0.0187074	0.000	0.02	0.01	0.01	0.01
Guinea-Bissau	0.1150441	0.002	0.06	0.06	0.03	0.05

Figures obtained for USA were used as the comparison factor (CF), which is a ratio of figure obtained to the respective country population divided by the value obtained for USA.

Values of F_1 , F_2 and F_3 represent case/incidence, mortality and recover index.

Factor of more than 1 = very high infection, mortality and recovery index

Factor of approximately 1 = high infection, mortality and recovery index

Factor of ≤ 1 but ≥ 0.5 = moderately high infection, mortality and recovery index

Factor of ≤ 0.5 but ≥ 0.1 = low infection, mortality and recovery index

Factor of < 0.5 = very low infection, mortality and recovery index

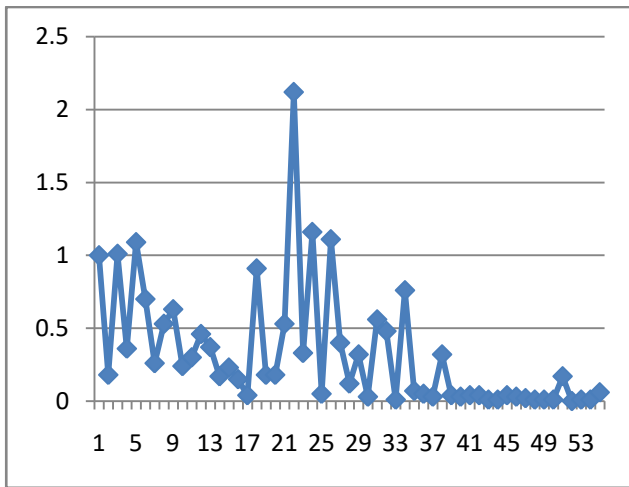


Figure 1: graph comparing infection per country relative to USA

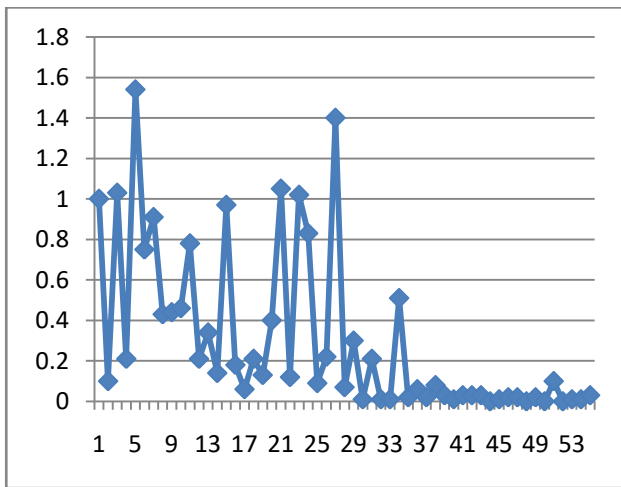


Figure 2: graph comparing death per country relative to USA

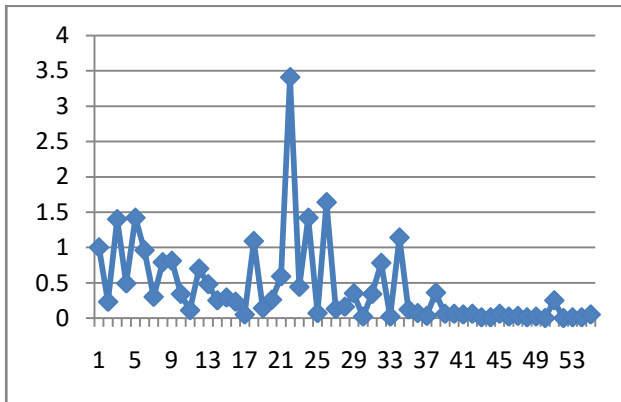


Figure 3: graph comparing recovery per country relative to USA

IV. DISCUSSION

Africa is the world's second-largest and second-most populous continent, after Asia^{23,24,25,26}. It is confronted by a heavy burden of communicable and non-communicable diseases^{23,25}. Cost-effective interventions that can prevent the disease burden exist but coverage is too low due to health

systems weaknesses^{27,28}. The World Health Organization (WHO) has rushed to beef up the ability of African countries to test for the virus and train health professionals in caring for people affected by it². From the table above South Africa is the only African country with moderately high infection, mortality and recovery index. Morocco, Ghana and Equatorial Guinea have low infection, mortality and recovery index, while most African countries have very low infection, mortality and recovery index. Most countries in Africa have a communal lifestyle compared to the isolational lifestyle of the western countries. Hence, it is possible that a large proportion of Africans may have been exposed to COVID-19 but few have presented visible symptoms or tested positive to the virus. Interestingly, Africa-Americans are the most hit among other Americans by this pandemic²⁹.

It is expected that due to the virus mode of transmission, the index value is supposed to be very high for African countries. There have been several suggestions to explain why Africa appears to be less affected by the pandemic. These include notable difference in the population age pyramids of USA, European and African countries, slow or low testing rate, low records of hospital reporting the disease, relatively high temperature and high humidity and high consumption of antioxidant food/fruit substances²⁵. Because of the density of the virus in tropical Africa, it cannot travel far. Hence, the recommendation of two metres of social distancing rule does not apply because the virus cannot go far. Africans food contents also raised the diet factor. African food have a lot of zinc, vitamin C and other antioxidants. They take all these on a daily basis without even thinking about it²⁵. They also take a lot of phytomedicines which contains a lot of antioxidant³⁰.

Evolutionary or adaptive immune response to the virus may also have immensely contributed to low infectious and mortality case in Africa. The African-American population is more affected by COVID-19 when compared to other Americans in the USA^{30,31,32,33}. Therefore, it is unlikely to be genetic, but more likely related to the environment. A study showed that children in low- and middle-income countries experience a high incidence of infectious disease in their first years of life^{34,35,36,37}. Babraham Institute (2020) studied immune responses of African children compared to Dutch children. They found that the immune systems of African children develop faster than those of Dutch children³⁸. Exposure to germs in childhood may have helped to strengthen the immune system and protect children from developing allergies, asthma and other infectious diseases, on subsequent exposure to the same/similar allergen/pathogen or cross allergen/pathogen. This supports the 'hygiene hypothesis'^{39,40,41,42}, which contends that such diseases are more common in the developed world where the prevalence of antibiotics and antibacterials reduce children's exposure to microbes^{43,44,45}. Thus, early exposure to some diseases in Africa may have resulted in a more robust innate and/or adaptive immune response. As a result countries in Africa are

both vulnerable and potentially more resilient to the coronavirus.

V. CONCLUSION

The study was focused on effect of COVID-19 on countries in Africa. African countries maybe more exposed to the virus, but they do not appear to be significantly affected by it. Many factors may have contributed to low case and mortality, such as the population age pyramids, relatively high temperature and high humidity, high consumption of antioxidant food/fruit substances, evolutionary and/or adaptive immune response. Also, Africa is home to several viral diseases such as dengue fever, small pox, chicken pox, measles, Ebola and polio disease some of which the body system has developed and evolved a way to cope with. This may have resulted in direct or indirect cross immune response/defense that is beneficial on exposure to same, similar or different viral infection including corona virus disease.

Also, the communal system and poor government health regulation in Africa would have allowed for rapid transmission of the virus from person(s) to person(s) within the shortest possible time. This means most Africans may have been exposed to the virus without showing noticeable symptoms and may have recovered, but very few people have shown symptom to it. Therefore, there is need for COVID-19 antibody testing, which will reveal the true picture of who has been exposed than the current antigen testing which only provides active disease information.

The study also shows that Africa need vaccine, but vaccination may not be an emergency when compared to western world because most individuals in Africa countries may have been naturally and unconsciously inoculated.

VI. RECOMMENDATION

More studies and surveys need to be conducted to understand why and how primarily the virus affects Africa and it significances to Africa and maybe the world.

CONFLICT OF INTEREST

The authors declare that there are not any potential conflicts of interest.

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REFERENCE

- [1] www.britannica.com/science/orthomyxovirus
- [2] www.who.int/emergencies/diseases/novel-coronavirus-2020
- [3] Virus Taxonomy: (2019) Release". International Committee on Taxonomy of Viruses (ICTV). .
- [4] Giaimo C (2020). The Spiky Blob Seen Around the World. The New York Times. Page 1-12.

- [5] International Committee on Taxonomy of Viruses (ICTV). October 2018. Archived from the original on 2019-05-14. Retrieved 2020-01-24.
- [6] International Committee on Taxonomy of Viruses (ICTV). Retrieved 2020-01-24.
- [7] Fan Y, Zhao K, Shi ZL, Zhou P (March 2019). Bat Coronaviruses in China. *Viruses*. 11 (3): 210-223.
- [8] Cherry, James; Demmler-Harrison, Gail J.; Kaplan, Sheldon L.; Steinbach, William J.; Hotez, Peter J. (2017). Feigin and Cherry's Textbook of Pediatric Infectious Diseases. Elsevier Health Sciences. p. PT6615. ISBN 978-0-323-39281-5.
- [9] Woo PC, Huang Y, Lau SK, Yuen KY (2010). Coronavirus genomics and bioinformatics analysis. *Viruses*. 2 (8): 1804–20.
- [10] Almeida JD, Berry DM, Cunningham CH, Hamre D, Hofstad MS, Mallucci L, McIntosh K, Tyrrell DA (November 1968). Virology: Coronaviruses. *Nature*. 220 (5168): 265-278.
- [11] Definition of Coronavirus by Merriam-Webster". Merriam-Webster. Archived from the original on 2020-03-23. Retrieved 2020-03-24.
- [12] Joseph O. T, Obianime. A. W., Siminialaye M. I., Joseph O. S., Anyanwu C. and Musa T. L. (2019). Clinical study on the effect of *Moringa oleifera* on serum level of glucose and tryglyceride in subjects taken tenofovir, lamivudine and efavirenz combination regimen. *European Scientific Journal*. Vol.15, (.21). Page 280 - 293.
- [13] Wertheim JO, Chu DK, Peiris JS, Kosakovsky Pond SL, Poon LL (2013). A case for the ancient origin of coronaviruses. *Journal of Virology*. 87 (12): 7039–45.
- [14] Wertheim JO, Chu DK, Peiris JS, Kosakovsky Pond SL, Poon LL (2014). A case for the ancient origin of coronaviruses. *Journal of Virology*. 87 (12): 7039–45.
- [15] Novel Coronavirus (2019-nCoV) situation reports - World Health Organization (WHO)
- [16] 2019 Novel Coronavirus (2019-nCoV) in the U.S. -. U.S. Centers for Disease Control and Prevention (CDC)
- [17] Outbreak Notification - National Health Commission (NHC) of the People's Republic of China
- [18] Novel coronavirus (2019-nCoV)- Australian Government Department of Health
- [19] Jonathan M. Read et al. (2020). Novel coronavirus 2019-nCoV: early estimation of epidemiological parameters and epidemic prediction -
- [20] Maimuna Majumder and Kenneth D. Mandl. (2020). Early Transmissibility Assessment of a Novel Coronavirus in Wuhan, China - Harvard University - Computational Health Informatics Program -
- [21] Imperial College London (2020). Report 3: Transmissibility of 2019-nCoV - 25
- [22] <https://healthwise.punchng.com/covid-19-may-lead-to-high-death-toll-in-africa-melinda-gates/>
- [23] Joseph O. S., Builders M., Joseph O. T., Zubairu S.A., Musa T. and Oyepata p.j. (2019). Sub-acute toxicity study of ethanol leaf extract of *Ocimum canum* on the kidney of wistar rats. *African Journal of Pharmaceutical Research & Development*. Vol. 11 No.1. Page 1-7.
- [24] Joseph O. S., Builders M., Joseph O. T., Zubairu S.A., Musa T. and Oyepata p.j. (2019). Sub-acute toxicity study of ethanol leaf extract of *Ocimum canum* on brain, lungs, stomach and spleen of wistar rats. *African Journal of Pharmaceutical Research & Development*. Vol. 11 No.1. Page 35-42.
- [25] The Guardian. (2020). why Africa is least affected by deaths from covid-19 <https://guardian.ng/news/why-africa-is-least-affected-by-deaths-from-covid-19/>
- [26] Joseph O. S., Joseph O. T., Musa T. L and Oyepata P. J. (2019). Histological evaluation of the nephroprotective activity of the ethanol stem extracts of *Homalium leteui* in Gentamicin – induced albino rats injury, using various staining techniques. *Global Scientific Journal*. Volume 7, Issue 8. Page 1065-1087.
- [27] Joseph O.S., Builders M., Emem E.U and Joseph O.T. (2019). EFFECT OF ETHANOL LEAF EXTRACT OF *Cassia*

- angustifolia* extract ON LIVER OF WISTER RATS. *Global Scientific Journal*. Volume 8, Issue 9. Page 1112-11120.
- [28] Joseph O.S., Builders M., Emem E.U and Joseph O.T. (2019). EFFECT OF ETHANOL LEAF EXTRACT OF *Cassia angustifolia* extract ON Kidney OF WISTER RATS. *Global Scientific Journal*. Volume 8, Issue 9. Page 1023-1031.
- [29] Imperial College London. (2019). Report 3: Transmissibility of 2019-nCoV - 25 January
- [30] *Epidemiology* (2019). Case fatality risk of influenza A (H1N1pdm09): a systematic review
- [31] Chen Want et al (2019). A novel coronavirus outbreak of global health concern -. *The Lancet*.
- [32] CDC (2005). Symptoms of Novel Coronavirus (2019-nCoV) .
- [33] China's National Health Commission news conference on coronavirus (2020) - Al Jazeera.
- [34] Reuters report, January 23, 2020. Wuhan lockdown 'unprecedented', shows commitment to contain virus: WHO representative in China -.
- [35] Statement on the meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV) - WHO, January 23, 2020
- [36] Antonio Villalonga Morales. 2020: Factors that may explain why COVID is less deadly in Africa. Newsletter
- [37] Gregorio A., Millett MPH, Austin T., Jones MA, David Benkeser MPH, Stefan Baral LM et al. (2020). Differential impacts of COVID-19 on black communities Pages 37-44
- [38] BABRAHAM INSTITUTE (2020). Charting immune system development in sub-Saharan African
- [39] Johns Hopkins University COVID-19 Dashboard. 2020. Center for Systems Science and Engineering (CSSE). Johns Hopkins University (2020), Accessed 24th Apr 2020
- [40] New York State Department of Health COVID-19. 2020. fatalities. <https://covid19tracker.health.ny.gov/views/NYS-COVID19-Tracker/NYSDOHCOVID-19Tracker-Fatalitiesno>. Accessed 8th Apr 2020
- [41] Willis H, Williams V. A (2020). Funeral is thought to have sparked a COVID-19 outbreak in Albany, Ga. — and led to many more funerals. *The Washington Post*, Washington, DC. Page 54-67.
- [42] Centers for Disease Control and Prevention Coronavirus Disease 2019 (COVID-19): Cases in U.S. <https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html>(2020), Accessed 15th Apr 2020
- [43] Georgia Department of Public Health COVID-19 Daily Status Report. <https://dph.georgia.gov/covid-19-daily-status-report> (2020), Accessed 9th Apr 2020
- [44] Helen Thompson. (2012). Early exposure to germs has lasting benefits. *Nature*. Page 163-176
- [45] *The Guardian*. (2020). why Africa is least affected by deaths from covid-19 <https://guardian.ng/news/why-africa-is-least-affected-by-deaths-from-covid-19/>.