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Novel Covid–19: Outbreaks Status in Two Main Regions of Nigeria and the Public Health Implication of Bats Population Dynamics in Urban Settlements

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Abbreviations: WHO: World Health Organization; PHEIC: Public Health Emergency of International Concern; SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; MERS: Middle East Respiratory Syndrome; UNEP: United Nations Environment Programme

ABSTRACT

The novel coronaviruses 2019 (COVID-19) cannot be talked about in isolation of bats who serve as reservoir host and are present in urban settlements. The outbreak of COVID-19 in Nigeria has called for concern and a concise review of many facets of development in Nigeria. Compliance to regulations for siting and building settlements all over the country have not always been top priority in the past hence standard protocols may have often been compromised. This review focused on how the spread of COVID-19 pandemic was aided by urban settlement in Northern and Southern regions of Nigeria. All the 37 states in Nigeria confirmed cases in which it was higher in the southern region (67%) than the northern region (33%). Thus, this may imply that the COVID-19 strain in Nigeria may possibly be of two types since one region was more infected than the other. Also, it could be due to the variation in the settlement patterns between the two regions. Residents in crowded and congested settlements tend to have extreme difficulty to maintain social/physical distancing as recommended by WHO and NCDC. There is very crucial need for partnership between policy makers, academics, and representatives of those who live in slums so that such knowledge can grow in tandem with efforts to improve health and wellbeing.in order to control and or reduce similar outbreaks in the nearest future. Bats adaptability to urban landscapes occurs more during dry season than wet season. Despite bats services in the ecosystem their population is being threatened by anthropogenic activities. Hence, more fruiting trees should be planted in urban settlements so as to provide roosting sites for bats in order to prevent them from roosting in ceilings of houses since they are known as zoonotic reservoir host of diseases of public health importance.

Keywords: COVID-19; Urban; Settlements; Northern and Southern Nigeria; Social Distancing; Policy Makers; Academics; Bats; Zoonotic Reservoir Host; Anthropogenic Activities

Introduction

The novel coronaviruses 2019 (nCoV-2019 or COVID-19) cannot be talked about in isolation of bats who serve as reservoir host [1] and are present in urban settlements [2,3]. The COVID–19 which is caused by the novel Severe Acute Respiratory Syndrome Coronavirus 2 (SARs-CoV-2) had been declared a Public Health Emergency of International Concern (PHEIC) by the World Health Organization (WHO) on 30th January 2020 and was subsequently declared a global pandemic by the WHO on 11th March 2020 [4,5]. The risk of emergence of a novel bat-Coronaviruses disease was predicted much earlier by various studies [6-8] prior to its occurrence in Wuhan, Hubei Province, China, in December 2019 and January 2020 [9,10]. Though a report by Cyranoski [11] identified the pangolin as the potential source of nCoV-2019 on the basis of their genetic sequences being 99% similar in relation to coronaviruses taken from animals and infected humans during the outbreak and other findings. Also, Xiao et al. [12] isolated coronavirus from pangolins that is closely related to the novel Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) which suggests them such as potential intermediate host of SARS-CoV-2.

The rise in global human population growth has pushed man to seek for protein from bushmeat [13-15] in which some are intermediate host of zoonotic diseases such as Middle East Respiratory Syndrome (MERS-Cov) and SARS-CoV-2 which is the current enormous price the general public is paying back today for such association with wild animals [16,17]. As a matter of urgency an open letter was written to World Health Organization (WHO) and United Nations Environment Programme (UNEP) in April 2020 on the need to secure a better future to not only humans but also for nature, which supports the health and well-being of all humanity. This can be achieved via holistic and equitable solutions which will reduce zoonotic pandemic risks. The Chinese government threw its weight by vowing to keep wildlife off the menu, though this may be a tough promise to keep [18]. Cohen [19] pointed out that a WHO-led mission was set up to investigate the pandemic's origin based on the global public health challenge at hand. The yearly increase of about 70 million people in the world's urban population as projected by United Nations [20] clearly points to the fact that there will be an eminent demand for housing, employment, and services. If the governments in developing countries fail to meet the needs of the masses then they will be forces to rely on or create their own informal infrastructure. Also, informal housing, informal employment, and self-employment are some of the survival activities adapted by these urban dwellers that are somewhat within their own power to implement [21].

The historic United Nations Millennium Declaration in the year 2000 formally recognized the existence and need to improve the lives of at least 100 million slum dwellers by the year 2020" [22] are likely to become central to this century's most expensive health crisis. The prediction by Riley et al. [21] seems to come true with the outbreak of the unprecedented COVID-19 that is ravaging more lives in the urban settings in especially those dwelling in urban informal settlements. Nigeria like many other countries in the world is being ravaged by COVID-19. After the index case of an Italian citizen who flew into Lagos an urbanized city from Milan on 25th February, the next dozen cases were all linked to travel history from endemic countries [23] after which the spread of infection was by human to human transmission with the local community. Person-to-person transmission has been established between people who are in close contact with one another (within about 2 metres/6 feet), primarily via respiratory droplets. Droplet transmission occurs when respiratory droplets generated via coughing, sneezing or talking contact susceptible mucosal surfaces, such as the eyes, nose or mouth while it may also occur indirectly via contact with contaminated fomites with hands and then mucosal surfaces [24]. Respiratory droplets are large and are not able to remain suspended in the air thus they are usually dispersed over short distances.

Though the rate of infection in Africa has been relatively lower when compared to advanced nations, one hypothesis suggest that the lower mortality rate in African settlements maybe due to regular exposure to other coronaviruses, malaria or many other infections in the past which could have primed the immune system against the novel coronavirus for some early defense response [25,26]. Alternatively, another hypothesis attributes resistance to genetic factors which have not yet been identified [25]. It is important to note that the situation in African countries stating their COVID-19 status could be worse than what is reported because of inadequate preparation for disease outbreak due to poor surveillance and lack of adequate testing facilities such as laboratories [27]. Settlements worldwide are located on the earth's surface with people living in them. Settlements are known to change spatially with time, but the pattern of such change varies according to certain factors such as transportation and socio-economic activities; political fragmentation; population density; infrastructural distribution and social amenities; economic development; industrialization and urbanization; social networks; topographical conditions; religious and cultural factors [28]. Inhabitants of Urban settlements around the world have been affected by the pandemic because one-half of the world's population resides there and because lifestyle demands inhabitants will travel to domestic or international locations for various reasons [29] which has led to the spread of the disease across different locations around the world [30]. Lilford et al. [31] sounded an alarm that the time is ripe to revisit the Urban Agenda with a strong emphasis on slum health and slum upgrading and on strengthening the capacities of urban governments to work with people who live in slums to act on these. They posited that this will go a long way in securing commitments in ensuring that policies are backed up with adequate finance.

The supposed neighbourhood effect in slums is like a coin with two sides. It has both a problem and an opportunity. It is a problem because it is likely to amplify health hazards and it is an opportuni-

ty because one intervention can simultaneously improve so many lives in one densely packed community [31]. Hence, this review compared the relative level of COVID-19 outbreak in urban centers in relation to settlement patterns that could explain the variations in COVID-19 burden in Northern and Southern Nigeria and well as the public health implication of bats population dynamics in urban settlement.

Types of Settlements in Nigeria

The urban settlement is known as a non-agricultural area which has various building types and populations who earn high, medium and low incomes. Upper income earners residential areas is characterized by a low population density while the medium and low income earners residential areas have a moderate and very high population density respectively who are individuals of urban labour force office and factory workers. The location of the medium and low income individuals is in outskirts of towns whose buildings are contiguous and filled beyond capacity with the official occupier and his family, also job seeking relatives and friends visiting from the rural areas. On the other hand, high income earners have spacious houses which are not congested. The township is comprised of the following settlement types: nucleated, compact, isolated, linear, and dispersed settlements [32]. In the year 2020, the estimated population of Nigeria was over 206.14 million, ranking 7th in the world, which suggests that the entire population of Nigeria accounts for about 2.35% of the entire earth's population [33,34]. This means that about 1 out of every 43 people in the world is a Nigerian. Nigeria's pattern of settlement in both northern and southern regions is generally characterized by buildings built close to one another of varying degrees, some of which are without the appropriate approved town planning features which ultimately defy social/physical distancing in the event of any outbreak of any pandemic.

The settlement patterns common to both regions are usually characterized as congested/compact, mostly high population density or overpopulated settlements called shanty/squatter, ghetto, face me I face you, bacha where facilities such as kitchens, bathrooms and toilets are grossly inadequate, and the few available are shared [35]. Furthermore, many living conditions in such settlements violate social distancing due to congestion, grubby environment usually lacking hygiene and water supply. Such shared facilities easily result in contaminating surfaces with the novel virus thus infecting new victims.

COVID-19 Status in Nigeria

The status in Nigeria reveals that all 37 states in the 6 geopolitical zones (North-West, North-Central, North-East, South-West, South-South and South-East) reported at least a confirmed case with 6 states (Lagos, FCT, Oyo, Edo, Rivers and recently Plateau) accounting for more than 60% of cumulative cases [36,37]. Ihekweazu [36] also reported that Lagos state alone accounts for over 35% of all confirmed cases in Nigeria. According to the NCDC as of 29th August 2020, Nigeria has recorded 53,727 COVID-19 cases, 41,314 recoveries, 1,011 (1.9%) confirmed fatalities while demographics reveals infection rate in males is 34,199 (64%) and 19,528 (36%) in females [37]. Interestingly, the most affected age group is 31 - 40 years (25%) but the distribution and burden of mortality from COVID-19 has varied from the Northern and Southern regions of Nigeria via surveillance in the various states. The most affected settlements of the COVID–19 pandemic in both regions include Lagos, FCT, Oyo, Edo, Plateau, Rivers, Kaduna, Delta, Kano, Ogun, Ondo and Enugu. Total number of active cases currently in Nigeria is reported to be 11,402 [37]. Highest numbers of active cases in the North occur in the FCT and Plateau while in the South, they occur in Lagos and Oyo respectively.

COVID-19 Outbreak Status in Northern and Southern Regions of Nigeria

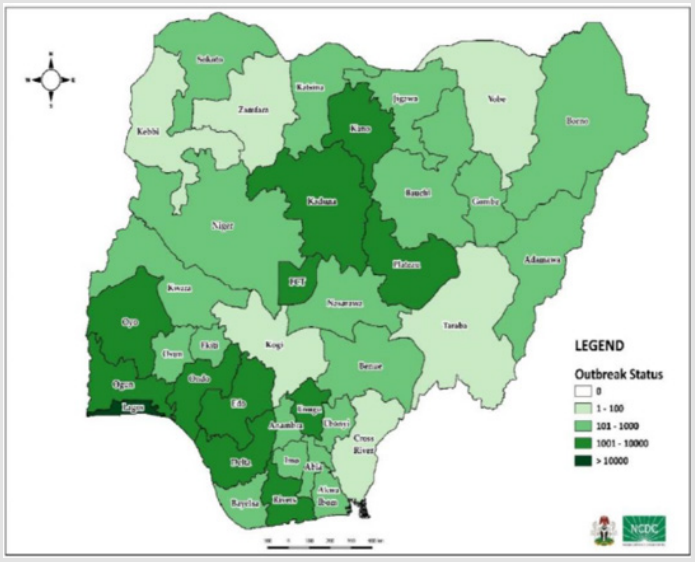

Figure 1: Map of Nigeria showing Outbreak status of COVID-19 Status in relation to the 36 states and FCT (Source: 37).

The outbreak status between the northern and southern region of Nigeria shows a high variation as shown in (Figure 1) [37]. The southern region was more affected in terms of states with higher number of cases from 1,001-10,000 (7 states, 64%) and those >10,000 (1 state [Lagos], 100%) while the lower number of cases was predominant in the northern region from 1-100 (5 states, 83%) and 101-1000 cases (11 states, 58%). (Table 1) showed that the total number of confirmed cases in Nigeria was higher in the southern region 36,263 (67%) than the northern region 17,464 (33%) [37]. This may imply that the COVID-19 strain in Nigeria may possibly be of two types since one region was more infected than the other. Also, it could be due to the variation in the settlement patterns between the two regions. Furthermore, it may be due to variation in climatic conditions across the two regions.

Table 1: Total number of confirmed COVID-19 cases in Nigeria as at 29th August, 2020. (Source: 37 [Accessed 29th August, 2020])

Region	State	Total No. of Confirmed Cases
Northern	FCT-Abuja	5149
	Plateau	2443
	Kaduna	2114
	Kano	1725
	Kwara	958
	Katsina	789
	Borno	740
	Gombe	723
	Bauchi	666
	Benue	451
	Nasarawa	434
	Jigawa	322
	Niger	241
	Adamawa	221
	Sokoto	158
	Kebbi	93
	Taraba	87
	Zamfara	78
	Yobe	67
	Kogi	5
	Sub-total for northern region (%)	17464 (33%)
Southern	Lagos	18104
	Oyo	3107
	Edo	2577
	Rivers	2134
	Delta	1744
	Ogun	1646
	Ondo	1534
	Enugu	1155
	Ebonyi	973
	Osun	779
	Abia	763
	Imo	527
	Bayelsa	391
	Akwa Ibom	278
	Ekiti	262
	Anambra	207
	Cross River	82
	Sub-total for southern region (%)	36263 (67%)
	Grand Total	53727

Level of Adherence to COVID-19 Precautionary Measures in Northern and Southern Settlements of Nigeria

Residents in crowded and congested settlements as shown in tend to have extreme difficulty to maintain social/physical distancing as recommended by WHO and NCDC. Shared corridors, rooms, cooking areas, wells and the presence of large number of family dependents as well as dependents all contribute to the violation. Though some residents in some of the settlements were aware, some others were forgetful, not willing or express disbelief while some were completely ignorant especially in some northern settlements [35]. Though predictive models indicate that in Lagos 55% of the inhabitants comply with social distancing, use of nose masks, contact tracing and testing [38], it is possible that such measures were not done properly hence Lagos alone accounting for 18,000 confirmed cases in Nigeria [36,37]. According to the studies as shown in (Table 2), both Northern and southern regions have shown high rates of lack of compliance in maintaining social distance with Kano and Jigawa States having the highest values in the North while Edo had the highest from the South. (Table 2) shows that the sharing of facilities in the north was predominant in Kano and Jigawa while Lagos on the other hand recorded a settlement (Makoko) where there were no shared facilities because of the absence of such facilities completely. Practices to reduce the spread of the infection such as social/physical distancing, the constant use of nose mask, regular washing of hands with soap and running water, use of alcohol based sanitizers are very alien to the inhabitants of the various settlements. Any attempt to intervene in such settlements must consider the peculiarities of the two main regions [39] Plates 1 and 2.

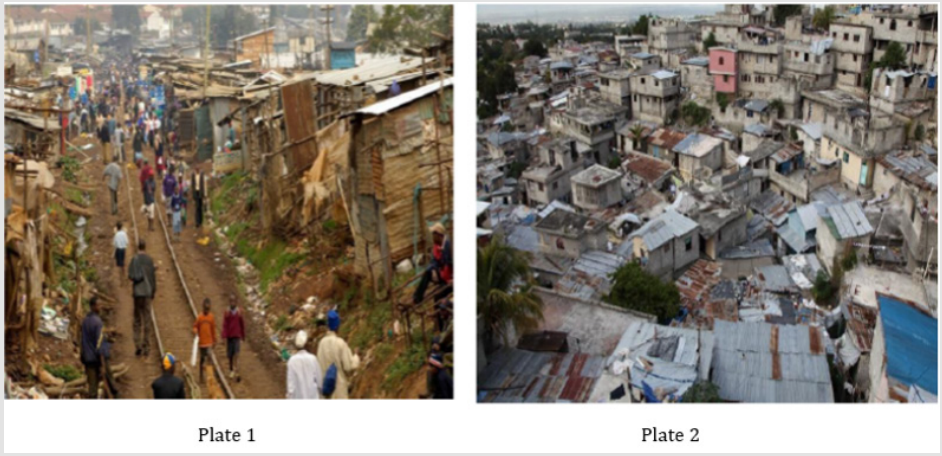

Plate 1 Plate 2

Plate 1: Photo of Bariga, Lagos (Source: 35)

Plate 2: Photo of Ancient Kano city (Source: 35).

Table 2: Urban Settlement not maintaining Social distance and with shared facilities (Source: 35).

Region	State	Urban Settlement	Frequency (%) not Maintaining Social Distance	Frequency (%) with Shared Facilities
Northern	Abuja	Kugbo	5 (50)	5 (50)
	Abuja	Nyanya	5 (50)	5 (50)
	Kano	Gwarzo	3 (30)	8 (80)
	Kano	Ancient Kano City	7 (70)	2 (20)
	Kaduna	Gwari	4 (40)	4 (40)
	Kaduna	Kakuri	6 (60)	6 (60)
	Katsina	Batagarawa	6 (60)	6 (60)
	Katsina	Katsina Central	4 (40)	4 (40)
	Yobe	Damaturu	5 (50)	5 (50)
	Yobe	Potiskum	5 (50)	5 (50)
	Jigawa	Dutse	2 (20)	8 (80)
	Jigawa	Gagarawa	8 (80)	2 (20)
	Plateau	Gadu Biu	6 (60)	5 (50)
	Plateau	Angwan Rukuba	4 (40)	5 (50)
Southern	Lagos	Bariga	6 (60)	10(100)
	Lagos	Makoko	4 (40)	0 (0)
	Ogun	Ajeromi	4 (40)	6 (60)
	Ogun	Abeokuta	6 (60)	4 (40)
	Edo	Benin Inner City	3 (30)	3 (30)
	Edo	Sabongida-Ora	7 (70)	7 (70)
	Oyo	Bere	5 (50)	7 (70)
	Oyo	Oyo Town	5 (50)	3 (30)

Population Dynamics of Bats in Urban Settlements in Nigeria

The order Chiroptera is the second most diverse and abundant order of mammals with great physiological and ecological diversity. They play important ecological roles as prey and predator, arthropod suppression, seed dispersal, pollination, material and nutrient distribution, and recycle. They have great advantage and disadvantage in economic terms [40]. Bats represent an order of great evolutionary success, with elevated geographical diffusion and species diversity [2]. They form one of the largest nonhuman aggregations and the most abundant groups of mammals when measured in numbers of individuals. They are diversified into more than 1,232 extant species [41]. They are small, with adult masses

ranging from 2g to 1kg; although most living bats weigh less than 50g as adults [42]. They have evolved into an incredibly rich diversity of roosting and feeding habits. Many species of bats roost during the day time in foliage, caves, rock, crevices, hollow soft trees, beneath exfoliating bark, and different manmade structures [43]. During night, they become active and forage on diverse food items like insects, nectar, fruits, seeds, frogs, fish, small mammals, and even blood [41].

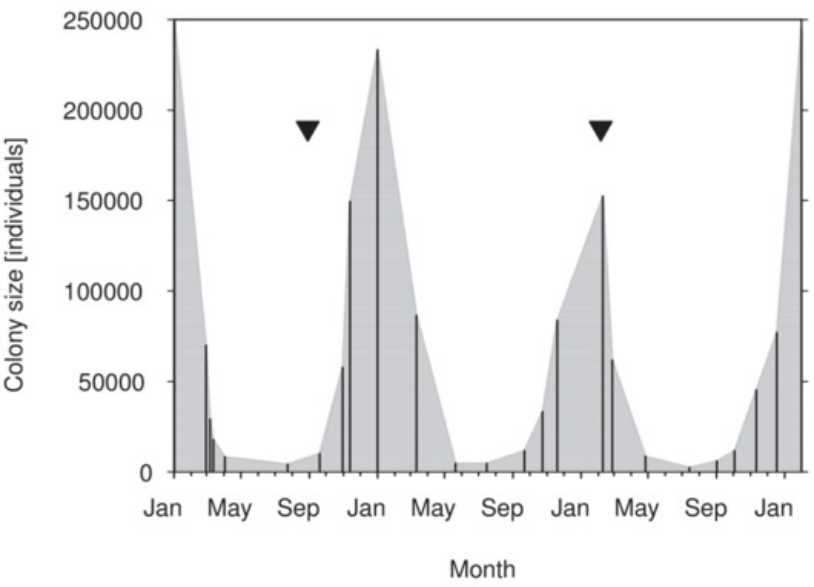

Figure 2: Seasonal colony fluctuations of *E. helvum* in Accra from January 2009 through January 2012. Triangles indicate tracking periods of the present study during population low (wet season 2009) and population high (dry season 2011); vertical lines represent colony counts (Source: 44).

Fahr et al. [44] opined that straw-coloured fruit bats (*Eidolon helvum*) migrate over vast distances across the African continent due to seasonal bursts of resource availability. Thus, causing enormous fluctuations in population size as shown in (Figure 2), which in turn may influence the bats' impact on local ecosystems. According to the study by Fahr et al. [44] in Accra city which is an urban center in Ghana had bat population in wet season that was low with about 4000 individuals during the months of May to September and the distance covered to forage locally was 3.5-36.7km and their main food source is introduced trees. But during dry season foraging distance almost tripled (24.1–87.9km) and population size between January and February was thirty eight times (150,000 individuals) more than the wet season period (Figure 3). With respect to urban footprint and tree cover, dry season foraging was random and they exclusively fed on nectar and pollen of native trees. Similarly, Thomas [45] reported that the straw-coloured fruit bats reside in colonies along the West African coast during the dry season, and then migrate into northern savannas with the onset of the wet season, following simultaneous resource flushes. In past years, several viruses infecting humans have been linked to bats: Rhabdoviridae, Orthomyxoviridae, Coronaviridae, Flaviviridae, Filoviridae and others [46]. With some exceptions, the direct transmission of viruses from bats to humans is uncommon. Instead, bats more frequently act like reservoirs of ancestral viruses which through a species jump, arrive in secondary hosts where they acquire a tropism for the human host [47]. Due to the elevated geographical diffusion and the elevated species diversity of bats, this order harbors viruses of high variability which have a greater possibility of acquiring the capacity of infecting other animals, including humans. In recent years, several anthropogenic and natural changes in the environment, due to deforestation, alteration of natural habitats, changes in animal diversity and climatic events, have shifted the ecology of bats and have exposed humans to new pathogens [48]. The last twenty years have seen an increase in the number of outbreaks caused by pathogens with bats as the reservoir of infection [46]. Bat populations appear to be declining presumably in response to human induced environmental stresses like habitat destruction and fragmentation, disturbance to caves, depletion of food resources, overhunting for bush meat and persecution, increased use of pesticides, infectious disease, and wind energy turbine. As bats are among the most overlooked in spite of their economic and ecological importance, their conservation is mandatory [41,49]. It is however sad but true that bats rank amongst the least known of any mammalian group; little information available on their diversity, distribution and ecological requirements [50-53].

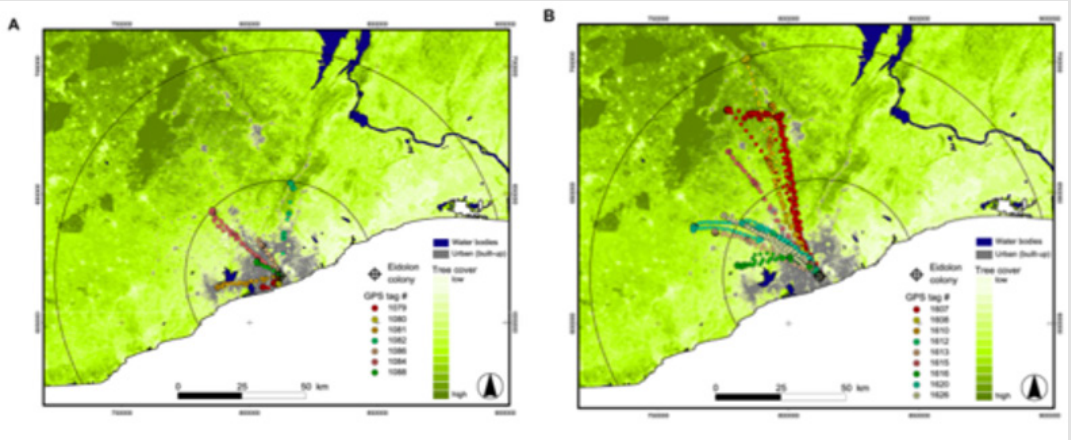

Figure 3: GPS tracks of *E. helvum* from wet (a) and dry season (b). Round dots represent commuting and roosting locations, and octagons foraging locations of *E. helvum*. Black circles indicate the maximum foraging distance of wet season (37 km) and dry season (88 km). Southern part of map corresponds to Atlantic Ocean (Source: 44).

More importantly, information is sparse on bats in Nigeria. As observed by Adeyanju et al. [54], bat species diversity and abundance decreased with increase in density of trees and that diversity decreased with increase in the amounts of litter cover. Similarly, Tibbels et al. [55] and Owen et al. [56] showed that higher abundance of forest dwelling bats have been connected with greater availability of roosting sites. More bat species occur in plantations due to availability of fruiting trees compared to the forest [57]. The increase in number of trees and litter cover causes a decrease in bats diversity [57]. Among the taxa capable of adapting to urban landscapes, bats are particularly ubiquitous. They play important roles in the maintenance of biodiversity by providing many substantial services to the ecosystems (e.g. seed dispersal and pollination) and to human economic activities (e.g. biological pest control) [41,58,59]. There is a growing body of knowledge on bat's sensitivity to urban environments, showing that they present a species-specific response to this process [60-62]. A reduction in bat richness and in the abundance of certain species in urban areas indicates that this process has negative effects on most bat species. These effects are being increased exponentially as a result of an increasing anthropogenic pressure, which causes habitat loss, fragmentation and biodiversity decline [49,63,64].

The abundance of bat populations could depend on the availability of suitable roosting sites [65]. In Nigeria, bats natural roosting sites appear to be declining in numbers, presumably due to urbanization resulting in change in their natural habitat [66]. The hitherto biggest colony and abode of bats which used to be the tick Forests of Nigeria are now giving way to the modern structures particularly roof tops of buildings and domestic trees, thereby bringing this wildlife's closer to man and resultantly in a possible zoonotic implication [49,65]. There is an increasing bats dependence on man-made structures that meet their thermoregulation and security needs in urban areas. Considering their nature in terms of level of human disturbances and availability of accessible large roof voids with unobstructed flying spaces, public structures such as schools, churches and administrative buildings offer a range of possible roosting opportunities for bats. Presence of active bats within urbanized environment can have several economic and aesthetic benefits [67]. However, given the wrong set of circumstances, bat species can become a nuisance. Besides being providers of many ecosystem services such as control of insect populations, pollination, and seed dispersal [49,68]. Bats are often unwanted visitors in the urban landscape. Aside their destructive roosting activities, they are mostly regarded as causative agent of perilous diseases. Also, locals believe them to be of spiritual significance[65].

Conclusion

To successfully eliminate or reduce the infection rate of COVID-19 by agencies of government or non-governmental organizations, priority should also be given to the nature of settlement which will determine the most effective strategy in relation to other demographic structure and associated risk factors. For settlements that are established contrary to the approved standards, the right steps must be taken to correct such anomalies no matter the challenges. This will ensure that in the future, the effect of outbreaks can be minimized to the barest minimum. There is a very crucial need for a new approach to health assessment and characterization of social-cluster determinants of health and as well as academic development of urban slum health in relation to partnership between policy makers, academics, and representatives of those who live in slums so that such knowledge can grow in tandem with efforts to improve health and wellbeing. Also, the continuous neglect of ever-expanding urban slum populations in Nigeria could inevitably lead to greater expenditure and diversion of health care resources to the management of end-stage complications of diseases that are preventable. Bats are known as

highly potential zoonotic reservoir host but their services in the ecosystem cannot be ignored, thus, they should be well protected in urban settlements.

References

1. Banerjee A, Kulcsar K, Misra V, Frieman M, Mossman K (2019) Bats and Coronaviruses. Viruses 11(1): 41.
2. Nunes H, Rocha FL, Cordeiro Estrela P (2017) Bats in urban areas of Brazil: roosts, food resources and parasites in disturbed environments. Urban Ecosyst 20: 953-969.
3. Jung K, Threlfall CG (2018) Trait-dependent tolerance of bats to urbanization: a global meta-analysis. Proc R Soc B 285(1885): 20181222.
4. Abdullahi WH, Sume GE, Isiaka HA, Zakari F, Nuhu N, et al. (2020) Dimensions of the COVID-19 Pandemic in the Federal Capital Territory, Abuja, Nigeria. African Journal of Biology and Medical Research 3(2): 197-203.
5. Obeta MU, Ejinaka RO, Ofor IB, Ikeagwulonu RC, Agbo EC, et al. (2020) Nigerian COVID-19 (Coronavirus) Patients Update, the Realities with Medical Laboratory Diagnostic Sites in American Journal of Epidemiology and Infectious Disease 8(1): 13-15.
6. Han H, Wen H, Zhou C, Chen F, Luo L, et al. (2015) Bats as reservoirs of severe emerging infectious diseases. Virus Research 205(2): 1-6.
7. Afelt A, Frutos R, Devaux C (2018) Bats, Coronaviruses, and Deforestation: Toward the Emergence of Novel Infectious Diseases? Frontiers in Microbiology 9: 702.
8. Li H, Mendelsohn E, Zong C, Zhang W, Hagan E, et al. (2019) Human-animal interactions and bat coronavirus spillover potential among rural residents in Southern China. Biosafety and Health 1(2): 84-90.
9. Li Q, Guan X, Wu P, Wang X, Zhou L, et al. (2020) Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. New England Journal of Medicine 382(13): 1199-1207.
10. Zhu N, Zhang D, Wang W, Li X, Yang B, et al. (2020) Novel Coronavirus from Patients with Pneumonia in China, 2019. China Novel Coronavirus Investigating and Research Team. New England Journal of Medicine 382: 727-733.
11. Cyranoski D (2020) Did Pangolins spread the China coronavirus to people? Nature News Article.
12. Xiao K, Zhai J, Feng Y, Zhou N, Zhang X, et al. (2020) Isolation of SARS-CoV-2-related coronavirus from Malayan pangolins. Nature 583(7815): 286-303.
13. Kümpel NF, Cunningham AA, Fa JE, Jones JPG, Rowcliffe JM, et al. (2015) Ebola and bushmeat: myth and reality. A Newsletter on Non-Wood Forest Products p. 6.
14. Duda R, Gallois S, Reyes García V (2018) Ethnozoology of bushmeat: Importance of wildlife in diet, food avoidances and perception of health among the Baka (Cameroon). Revue d'ethnoécologie 14: 1-41.
15. Akem ES, Pemunta NV (2020) The bat meat chain and perceptions of the risk of contracting Ebola in the Mount Cameroon region. BMC Public Health 20(593): 1-10.
16. Contini C, Nuzzo MD, Barp N, Bonazza A, Giorgio RD, et al. (2020) The novel zoonotic COVID-19 pandemic: An expected global health concern. Journal of Infection in Developing Countries 14(3): 254-264.
17. Dobson AP, Pimm SL, Hannah L, Kaufman L, Ahumada JA, et al. (2020) Ecology and Economics: COVID-19. Science 369(6502): 379-381.
18. Myers SL (2020) China Vowed to Keep Wildlife Off the Menu, a Tough Promise to Keep. The New York Times.
19. Cohen J (2020) A WHO-led mission may investigate the pandemic's origin. Here are the key questions to ask. Science.
20. United Nations (2003) United Nations Human Settlements Programme: The challenge of slums: global report on human settlements 2003. London and Sterling, Earthscan Publications Ltd: 1-310.
21. Riley LW, Ko AI, Unger A, Reis MG (2007) Slum health: Diseases of neglected populations. BMC International Health and Human Rights 7: 2.
22. United Nations (2000) United Nations Millennium Declaration. General Assembly A/RES/55/2: 1-9.
23. Hassan Z, Hashim MJ, Khan G (2020) Population risk factors for COVID-19 deaths in Nigeria at subnational level. Preprints.
24. Nigeria Centre for Disease Control (2020) National Interim guidelines for clinical Management of COVID-19. Version 1: 1-38.
25. Nordling L (2020) Africa's pandemic puzzle: why so few cases and deaths? Science 369(6505): 756-757.
26. Bazell R (2020) Looking for the Light in Haiti. Science 369(6505): 755-756.
27. Adegboye OA, Adekunle AI, Gayawan E (2020) Early Transmission dynamics of novel Coronavirus (COVID-19) in Nigeria. Int. J. of Environ. Res. Public Health 17(19): 3054.
28. Oloyiwole AM, Ajala OA, Sargodipe JA (2014) Physical Growth Pattern of Settlements in a Traditional Region, Southwest Nigeria. International Journal of Geosciences 4(1): 1345-1360.
29. Aijaz R (2020). Urban Affairs in the Pandemic Era. Observer Research Foundation.
30. Abdullahi WH, Sume GE, Isiaka HA, Zakari F, Nuhu N et al. (2020). Epidemiology of the COVID-19 in the Federal Capital Territory, Abuja, Nigeria. African Journal of Biology and Medical Research 3(2): 188-196.
31. Lilford RJ, Oyebode O, Satterthwaite D, Melendez Torres GJ, Chen Y, et al. (2017) The health of people who live in slums 2: Improving the health and welfare of people who live in slums. Lancet 389 (10068): 559-570.
32. Floyd B (1969) Settlement Patterns. In Floyd B (eds.) Eastern Nigeria, London Palgrave Macmillan: 55-64.
33. Asogwa OC, Eze NM, Eze CM, Okonkwo CI, Onwuamaeze CU (2020) On the Modeling of the Effects of COVID-19 Outbreak on the Welfare of Nigerian Citizens, Using Network Model." American Journal of Applied Mathematics and Statistics 8(2): 58-63.
34. Nigeria Population (2020) Demographics, Maps and Graphs.
35. Obongha UE, Ukam LE (2020) The Impact of Settlement pattern of some Nigerian cities on the spread of COVID-19 Pandemic. European Journal of Environment and Earth Sciences 1(4): 1-6.
36. Ihekweazu C (2020) COVID-19 Response in Nigeria: The Science and the Policy. A paper presented to the Nigerian Academy of Science by the Director General, Nigeria Centre for Disease.
37. Nigeria Centre for Disease Control (2020) COVID - 19 situation report 183.
38. Okuonghae D, Omame A (2020) Analysis of a Mathematical model for COVID-19 population dynamics in Nigeria. Chaos, Solitons and Fractals 139: 110032.
39. Okoye JO (2020) Attitudinal, regional and sex related vulnerabilities to COVID-19: Considerations for Early flattening of curve in Nigeria. Med. J Islam Repub Iran 34(1): 61.
40. Mohammed K, Mundanthra B (2013) Ecological and Economic Importance of Bats (Order Chiroptera). Hindawi 2013: 187415.
41. Kunz TH, Torrez EB, Bauer D, Lobova T, Fleming TH (2011) Ecosystem services provided by bats. Ann N Y Acad Sci 1223(1): 1-38.

42. Fenton MB (2003) Science and the conservation of bats: where to next? Wildlife Society Bulletin 31(1): 6-15.

43. Jones G, Jacobs D, Kunz TH, Wilig MR, Racey PA (2009) Carpe Noctem: the importance of bats as bio indicators. Endangered Species Research 8(1): 93-115.

44. Fahr J, Abedi Lartey M, Esch T, Machwitz M, SuuIre R, et al. (2015). Pronounced Seasonal Changes in the Movement Ecology of a Highly Gregarious Central-Place Forager, the African Straw Coloured Fruit Bat (Eidolon helvum). PLoS ONE 10(10): e0138985.

45. Thomas DW (1983) The annual migrations of three species of West African fruit bats (Chiroptera:Pteropodidae). Can J Zool 61(10): 2266-2272.

46. Calisher CH, Childs JE, Field HE, Holmes KV, Schountz T (2006) Bats: important reservoir hosts of emerging viruses. Clinical Microbiology Rev 19(3): 531-545.

47. Hutson AM, Mickleburgh SP, Racey PA (2001) Micro chiropteran Bats: Global Status Survey and Conservation Action Plan. IUCN/SSC chiroptera specialist group, IUCN, Gland, Switzerland.

48. Wang LF, Zhi Z, Zhang S, Field H, Daszak P, et al. (2006) Review of bats and SARS. Emerging Infectious Diseases 12(12): 1834-1840.

49. Jeffries B, Galaverni M, Bologna G, Danovaro R, Bagordo G (2020) The loss of nature and the rise of pandemics protecting human and planetary health. WWF International p. 1-24.

50. Lee YF, Kuo YM, Chu WC, Lin YH (2007) The chiropteran diversity in different settings of the uplifted coral reef of tropical forest of Taiwan. Journal of Mammalogy 88(5): 1239-1247.

51. Monadjem A, Taylor PJ, Cotterill FPD, Schoeman MC (2010) Bats of Southern and Central Africa: a biogeographic and taxonomic synthesis. Journal of Mammalogy 94(2): 518-519.

52. Happold M, Happold DCD (2013) Mammals of Africa Volume IV: Hedgehogs, Shrews, and Bats. In Happold M, Happold DCD (Eds.) Bloomsbury Publishing, London, UK, pp. 800.

53. Voigt CC, Kingston T (2016) Bats in the Anthropocene: Conservation of Bats in a Changing World. In CC Voigt and T Kingston (eds.) Springer, Germany.

54. Adeyanju TE, Adeyanju AT, Ottosson U Manu S (2017) Bat diversity and abundance in Omo forest reserve. Journal of Research in Forestry, Wildlife and Environment 9(4): 9-18.

55. Tibbels AE, Kurta A (2003) Bat activity is low in thinned and unthinned stands of red pine. Canadian Journal of Forestry Research 33(12): 2436-2442.

56. Owen SF, Menzel MA, Edwards JW, Ford WM, Memzel JM, et al. (2004) Bat activity in harvested and intact forest stands in the Allegheny Mountains. Northern Journal of Applied Forestry 21(3): 154-159.

57. Adeyanju TE, Adeyanju AT (2018) Species richness and diets of bats from two sites in south-west, Nigeria. Ethiopian Journal of Environmental Studies & Management 11(2): 215-230.

58. Kunz TH, Fenton MB (2003) Bat ecology. In Kunz TH, Fenton MB (Eds.) The University of Chicago Press, Chicago, USA, p. 3-89.

59. Kasso M, Balakrishnan M (2013) Ecological and Economic Importance of Bats (Order Chiroptera). Hindawi Publishing Corporation ISRN Biodiversity 2013(1): 1-9.

60. Jung K, Kalko EKV (2010) Where forest meets urbanization: foraging plasticity of aerial insectivorous bat in an anthropogenically altered environment. J Mammal 91(1): 144-153.

61. Pacheco SM, Sodré M, Gama AR, Bredt A, Cavallini-Sanches EM et al. (2010) Morcegos urbanos: Status do conhecimento e plano de ação para a conservação no Brasil. Chiroptera Neotropical 16(1): 630-647.

62. Russo D, Ancillotto L (2015). Sensitivity of bats to urbanization: a review. Mamm Biol 80(3): 205-212.

63. Czech B, Krausman PR, Devers PK (2000) Economic associations among causes of species endangerment in the United States. Bioscience 50(7): 593-601.

64. Newbold T, Hudson LN, Phillips HRP, Hill SLL, Contu S, et al. (2014) A global model of the response of tropical and sub-tropical forest biodiversity to anthropogenic pressures. P Roy Soc Lond B Bio 281(1792): 20141371.

65. Usman M (2010) The Distribution and Species Composition of Bats (Order: Chiroptera) Roosting Sites in Zaria, Nigeria. Unpublished B.Sc. project. Department of Biological Sciences, Ahmadu Bello University Zaria, Nigeria.

66. Ismail A, Ibrahim M, Gadzama K, Bako SP (2016) Bat roosts and associated nuisance in public primary and secondary schools in Zaria, Nigeria: A problem worth addressing. International Journal of Education and Research 4(1): 47-56.

67. Bat Conservation Trust (2014) Bats and Buildings. Bats and the built environment series. Bat Conservation Trust, London

68. Kelly G (2012) Conserving Bats and Buildings: A Natural Synergy.

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