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## ORIGINAL ARTICLE

# Community informatics for sustainable management of pandemics in developing countries: A case study of COVID-19 in Nigeria

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**Summary** Although a significant number of the human population in developing countries live in urban communities, majority of the population lives in rural areas. Developing countries, especially in their rural areas, suffer from a lack of healthcare facilities, poverty and high rate of illiteracy. Motivated by the huge socio-economic gap between the developed and the developing worlds, there have been several studies into the COVID-19 pandemic management in developing countries. However, none of these research works emphasised the health cultural beliefs of any developing economy as a basis for their recommendations. Specifically, this paper discusses the pandemic situation in Nigeria with emphasis on the prevalent health cultural beliefs of the citizens of the country, especially those living in rural communities. This is important because each local community defines a socio-ecological cluster of people who are more tightly knitted together in terms of language, relationship, culture, religion, social amenities, business, leadership and so on. As such, there is a need to prepare the socio-ecological units to be more resistant to the spread of the virus; a weaker social-ecological unit will entail

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a higher risk of community transmissions. With respect to the peculiarity of each local community, this paper recommends strategies for controlling and managing the pandemic in Nigeria using community informatics or grass-root computing. We argue that community informatics can empower and support policy makers and governments of developing countries such as Nigeria in combating and effectively managing a pandemic.

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## Introduction

The World Health Organisation (WHO) has established protocols for managing the lethal Coronavirus disease 2019 (COVID-19) pandemic [1]. However, local differences in income, culture, environment and socio-economic factors will need to be put into consideration while adopting the WHO guidelines. The health capacities of different countries, regions, states and local governments will also need to be acknowledged. Similarly, the cultural beliefs of a people in relation to health and well-being is a further vital element in deciding how best to sustainably manage a pandemic such as the COVID-19. These considerations necessitate the need to develop a region-dependent template for implementing the WHO's recommendations. Moreover, researchers have identified concerns with respect to the vulnerability of developing countries to the COVID-19 pandemic. These countries experience inadequate health facilities [2], poverty, high rates of unemployment and poor standards of education. These factors contribute to the difficulties confronting the management of the pandemic.

As a result of the aforementioned challenges, a number of COVID-19 research projects have been tailored towards recommending the best strategies for reducing the level of the virus in developing economies [3–5]. Although these projects have been inspired by the huge socio-economic and developmental gaps between developing and developed countries, none of them derive their recommendations from the basis of the health cultural beliefs of a developed economy. This paper aims at three key objectives. Firstly, it discusses the COVID-19 situation in Nigeria, and then elucidates the prevalent health cultural beliefs in the country. On the basis of these beliefs the paper then recommends a community-informatics strategy for the sustainable management of the pandemic in this country.

The ubiquity of Internet-ready smart devices has played an important role in undermining the impact of digital divides in developing countries. For example, according to the African Infotech Consulting (AIC) report, "in 2016 alone, smartphones gained penetration in Nigeria at about 30 percent while feature phones had a 70 percent entry", and the number of smartphone users in the country was projected to increase to about 34 million in 2018 [6]. This development offers an opportunity for grass-roots computing or community informatics. Community informatics is a useful tool for the management of an infectious disease or virus such as COVID-19. Due to the social distancing policies

in place during the pandemic, it has become even more difficult for governments to effectively reach out to the people for purposes of awareness, testing, treatment, enforcement of guidelines, provision of palliatives and so on. In order to support shared decision-making among stakeholders and to drive the participatory management of COVID-19 in Nigeria this paper recommends the Online GeoHealth Community Structure (OGHCS) as a framework that integrates the requisite stakeholders and resources for the effective management and control of COVID-19. A key function of OGHCS is to provide the required tools to reduce these burdens while providing a virtual community structure that is similar to the physical community structure in terms of trusts and community weaving.

In the remainder of this paper, Section 2 reviews the infection clusters as well as the preparedness of Nigeria towards the pandemic; Section 3 discusses the health cultural beliefs in Nigeria while Section 4 discusses the importance of community informatics in rural communities, Section 5 recommends a community informatics strategy and some policies for managing the virus. Section 6 concludes the paper.

## COVID-19 hotspots and localised intervention targeting

As Nigeria lifts the local lockdowns and progress towards the lifting of international travel, there is a need to focus on the regions and states that still have higher incidences of COVID-19. Higher levels of caution and Non-Pharmaceutical Interventions (NPI) need to be applied to these regions than in any other part of the country. In this section, we look at the basic reproduction number, technical definition of hotspots, the actual areas in Nigeria that could be considered as hotspots, and then the recommended interventions for these red-flag areas.

### Basic reproduction number, $R_0$

The  $R_0$  of an infectious disease is the number of secondary infections that occur as a result of one infectious person introduced into a completely susceptible population [7]. This number is a major metric that determines the rate of spread of an infectious disease. This parameter is a function of transmissibility, average contact rate and the duration of infection. A region or suburb with high  $R_0$  mathematically

defines an infectious disease hotspot. The mathematical definition of  $R_0$  is given by Eq. (1):

$$R_0 = \frac{\text{infection}}{\text{contact}} * \frac{\text{contact}}{\text{time}} * \frac{\text{time}}{\text{infection}} = \tau * c * d \quad (1)$$

where  $\tau$  is the probability of getting infected per contact between an infectious and a susceptible individual,  $c$  is the contact rate between infectious and susceptible individuals, while  $d$  is the duration of infectiousness of infected individuals. Hotspots usually have a high contact rate. This is the typical feature of highly crowded places such as Lagos and some parts of Abuja. Hence, areas with high population density usually characterise a hotspot for an infectious disease. The goal of every intervention is to reduce  $R_0$  to a value less than one, ( $R_0 < 1$ ). Once this happens, the epidemic is bound to cease.

### Identified host-spots across Nigeria

Epidemics are often characterised by clusters. This means that the rate of infection will not be equally distributed across the country. According to the report of the Nigerian Presidential Task Force on COVID-19<sup>1</sup>, in May 2020, about 51% of people who tested positive with COVID-19 came from nine densely populated local government areas (LGA). Nigeria has 774 LGAs at the moment. Although they do not mention these LGAs in this report, further reports from Nigeria's Centre for Disease Control (NCDC) and that of Lagos State's ministry of health can help one narrow down to some of these LGAs.

As of the 13th of September 2020, Lagos State had the highest number for COVID-19 incidences in Nigeria, with FCT Abuja coming a distant second. While Lagos State had 18,000+, FCT had 5000+<sup>2</sup>. Following FCT is Oyo State with 3000+ cases. Other states with 2000+ cases include Plateau, Edo, Kaduna and Rivers. However, it should be noted that the efficiency of handling cases in Lagos is far higher than that of any other state as well. Despite the high incidence in Lagos State, it has a smaller number of active cases (2000+) at the moment than FCT, which still has more than 3000 active cases out of the total number of 5000+. But our concern in this section is to drill down to LGAs with high prevalence. The aim is to expose the areas where interventions should be targeted and where travellers may want to reconsider visiting as Nigeria reopens its borders. Eleven out of the 20 LGAs that account for the 60% of the cases in Nigeria are in Lagos State. This brought about the consideration by the Federal Government to implement what it called "Precision Lockdown"<sup>3</sup>. The top LGAs targeted for this precision lockdown included Lagos Mainland Local

Government Area, Abuja Municipal Area Council, Mushin Local Government Area, Eti-Osa Local Government Area in Lagos and Tarauni Local Government Area in Kano State. The idea of precision lockdown has been used in several countries such as the UK and Australia to avoid bringing economic activities to a total halt because of incidences in a few areas or suburbs<sup>4</sup>. With the technical and geographical information provided so far about hotspots in Nigeria, we then recommend general measures and precautions that can be followed by individuals and governments.

### Thematic review of health cultural beliefs in Nigeria

Since the outbreak of COVID-19, much research time has been invested in technologies for combating the virus [8]. However, little attention has been paid to the unique elements of different communities or societies where these technologies could be applied. We are of the opinion that to realise an effective technology for combating a socio-ecological threat like the COVID-19, a community-centric design approach should be followed. This idea is premised on the fact that each community has its own socio-cultural uniqueness and this impacts on how healthcare works in such communities. Among major concerns in the management of a global pandemic such as COVID-19 in developing countries are the scarcity of the health workers and the poor state of health infrastructure in these countries, particularly in rural areas [9]. For example, even though 60% of Nigerian citizens reside in rural areas, these areas suffer gross shortages of health professionals and vital health facilities [10]. These factors, therefore, raise apprehensions towards potential impacts of possible rural community transmissions. Since these shortcomings within the Nigerian healthcare sector have been an age-long problem, some residents of the country patronise private hospitals for healthcare while those who cannot afford a private health facility have resorted to other means of medication. Among other factors, these could result in loss of trust in government guidelines towards the management of a pandemic such as coronavirus.

To provide an objective measure for comparing the health cultural beliefs of different societies, this section discusses health cultural beliefs in Nigeria based on five themes—word-of-mouth as a dominant channel of information acquisition, the prevalence of patent medicine vendors, religious and spiritual beliefs, the culture of patriarchy, and reliance on traditional medicine. Amongst other factors, these contributors influence how the majority of Nigerians respond to government guidelines, as well as COVID-19 related conspiracy theories.

### Word-of-mouth as a dominant channel of information acquisition among Nigerians in rural communities

Nigeria's rural areas are characterised by poor infrastructural developments, high rates of illiteracy and

<sup>1</sup> Adebayo Folorunsho-Francis. COVID-19: nine densely populated LGAs responsible for 51% of cases —FG. Punch Newspaper, May 15 2020. <https://healthwise.punchng.com/covid-19-nine-densely-populated-lgas-responsible-for-51-of-cases-fg/>.

<sup>2</sup> Nigerian Centre for Disease Control. An update of COVID-19 outbreak in Nigeria. <https://ncdc.gov.ng/diseases/sitreps/>.

<sup>3</sup> COVID-19: FG considers lockdown of 18 local government areas. Punch Newspaper Healthwise, 29th June, 2020. <https://healthwise.punchng.com/covid-19-fg-considers-lockdown-of-18-local-government-areas/>.

<sup>4</sup> Media Release. Coronavirus update for Victoria - 2 July 2020. <https://www.dhhs.vic.gov.au/coronavirus-update-victoria-2-july-2020>.

unemployment [11,12]. The information gap between urban and rural communities in Nigeria has been widened due to the inability of rural populations to afford urban-centred channels of information such as social media which are commonly used by the government and other agencies in disseminating vital information across the country [13]. Due to this information deprivation within rural populations, word-of-mouth communication from influential, educated or respected individuals suffices as an important channel of information acquisition among rural communities [13]. This factor makes misinformation more likely in rural areas than in urban areas. Enital et al. conducted a survey to assess the knowledge, perception and readiness of Nigerians to participate in the COVID-19 vaccine trial Enitan 2020 assessment.

The results of this study show that 80.0% of the respondents indicated that they are unwilling to take the COVID-19 vaccine, while 20.0% indicated that they were willing. This is in contrast to the latest data of a survey conducted by Morning Consult showing that a higher proportion of Americans (80%) are willing to get the vaccine [14]. This difference in the American-Nigerian responses is most likely due to the gap in public health awareness between the two countries.

### The prevalence of patent medicine vendors in Nigeria

Many Nigerians rely essentially on owner-operated retail drug outlets, also known as proprietary and patent medicine vendors (PPMVs), for their health needs. Statistics show that in 2005 an estimated 200,000 PPMVs were operational in Nigeria [15]; this is much higher than the 2,639 registered retailed pharmacies in the country in the same year and outnumbers all other categories of health workers in the country [16]. Apart from the fact that there are few registered pharmacies in Nigeria, they are often geographically concentrated in urban areas, whereas patent medicine stores are mainly in rural areas [17]. The popularity of PPMVs in Nigeria, especially in rural areas, is largely because its licensure does not require formal training. With primary education, an individual can be licensed to practise as a PPMV in Nigeria after the person has completed an apprenticeship with an experienced PPMV. Since the PPMVs provide cheap medications and are also more connected to their communities, they often have the trust and acceptance of their community members who depend on them for medical advice and treatments. This is not the same situation in developed countries and some middle-income countries such as South Africa and Egypt. In 2004, while Egypt had 24 medical doctors per 1000 population, South Africa had 8 per 1000 and Nigeria had 3 medical doctors per 1000 population. This makes it more attractive for the PPMVs to operate and makes them an important alternative for the people to leverage on for their health needs [18].

### Religious and spiritual beliefs

Nigeria has experienced a continuous proliferation of places of worship due to the deep religiosity of the majority of Nigerians and their significant belief in spiritual powers as a means of receiving help in every sphere of their lives [19,20]. For example, the number of Muslims in Nigeria is far greater than the number of Muslims in any Arab nation [21]. The

number of Christians in Nigeria is second only to Brazil which has the largest number of Christians in the world [21]. As a result of this prevalence of religious organisations in Nigeria, they form a huge part of people's beliefs and behaviours. These religious bodies organise programmes which they claim are targeted at meeting people's needs such as healing, financial breakthroughs, deliverance and so on. Some religious leaders in Nigeria make their followers believe that their misfortunes are due to spiritual causes, therefore many sick people, especially those who cannot afford expensive hospital bills, depend on supernatural interventions for their healing [22]. Moreover, certain religious beliefs disallow members from participating in certain medical exercises. For example, according to Antai's analysis of the 2003 Nigerian Demographic and Health Survey (NDHS), religion has played a role in the risks of non-immunization of children in Nigeria. From the result of this analysis, the author posits that the risks of children of 12 years of age and older not being immunized are largely due to the specific doctrines, beliefs and values associated with religion [23]. Another popular example is the non-acceptance of blood transfusion by the doctrines of Jehovah's Witnesses [24]. In the case of COVID-19, a number of religious leaders in Nigeria have been at the forefront of conspiracy theories. For example, Pastor Chris Oyakhilome, founder of Believers Love World Church, helped to fuel the 5G debate in Nigeria [25]. He has been reported to claim that the COVID-19 lockdown in Nigeria was designed to sequester the population for the government's intention to deploy 5G across the country for obnoxious reasons [25].

### Culture of patriarchy

The patriarchal nature of Nigerian society has contributed to the way women and young adults make their medical decisions. [26]. Akeju et al. presented a study on health-care seeking practices among pregnant Nigerian women as well as the socio-cultural factors that influence these actions [26]. The authors report that some of the participants reveal that women who made independent healthcare decisions were considered to be arrogant, disrespectful and in the word of one female participant, "too forward". In research by Onah and Horton to study the male-female differences in household custody of financial resources and decision-making in south-eastern Nigeria, the authors report that qualitatively, women seek permission from the male household head before any expenditure on healthcare [27]. The following observations underscore the extent to which men, especially household heads, can influence government plans in curbing coronavirus. For example, a male household head who does not trust the COVID-19 vaccination programme is culturally empowered to prevent members of that household from accessing the inoculation even if they are willing to be vaccinated against the virus.

### Reliance on traditional medicine

The WHO defines traditional medicine as "the sum total of the knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement



or treatment of physical and mental illness”<sup>5</sup>. The use of traditional medicine is a prevalent practice in developing countries because people feel safer with cures indigenous to them, which may also be cost effective [28]. According to the WHO’s estimate, up to 80% of the African population depends on traditional medicine [29]. The popularity of traditional medicine in Nigeria has been attributed to its natural origin. Oreagba et al. studied the extent of the use and general knowledge of the benefits and safety of herbal medicines among urban residents in Lagos, Nigeria [30]. This study reveals that over half (58%) of the herbal medicine users considered herbal medicines safe to use; 22.9% believed otherwise; and 19.1% were uncertain. Research has demonstrated that in Nigeria herbal medicines have been used in the traditional management of severe ailments such as HIV [31], diabetes mellitus [32] and cancer [33]. Orisakwe et al. investigated the range of COVID-19 home remedies in Africa including herbal medicines used in Nigeria [34]. Although some of these traditional treatments are not validated by the authorities, people have shown confidence in and significant reliance on them. However, there is the risk of giving false hope to the patient in cases where the traditional remedy is ineffective. For example, Shittu et al. identified reliance on traditional medicine as one of the factors responsible for the spread of the Ebola virus [35].

## Community informatics in developing and developed economies

The cohesive and homogenous nature of communities in developing countries differentiates it from the diverse and heterogeneous nature of communities in developed countries. While developed nations are being innovative in how to harness the diversity which they enjoy, developing countries have communities with well-defined cultural attachment and value system. Deviation from this well-established cultural cohesion is difficult in developing countries. This difference in cultural attachment also affects how individuals in each of these settings trust whom they give and receive information from.

In Nigeria, the southern part of the country is more exposed to developed community system than the northern part, which has a stronger attachment to their local community. This difference is reflected by how they receive and give information during vaccination programs including Polio and HIV. A case to buttress this difference is the boycott of the polio vaccination by the three northern Nigeria states of Kaduna, Kano and Zamfara in 2003 [36]. The cultural leaders, who double as religious leaders in the north, played a greater role in this boycott than the political leaders. This is unlike the developed countries of UK, Canada, Australia and New Zealand where direct interactions between the government and individuals are well established as opposed to the local communities. Hence, there is a block effect in

information assimilation in developing countries than in the developed countries.

Informatics is the development, adoption and use of Information and Communication Technologies (ICT) in addressing societal needs. It is pertinent to realise that major constraints such as Internet coverage, power outage and low level of education are challenges that affect the deployment of ICT in local developing communities. Besides, the development of these information gathering and dissemination systems must take into cognizance the cultural beliefs of the local users. The questions that are asked and the mode of collecting this information must consider the local beliefs of the people otherwise the local community will not be comfortable with the system. In this paper, we posit that effective monitoring and intervention through ICT in rural settings should have a different approach. The conventional health information systems (HIS) deployed in district hospitals are not suitable as most of the rural communities prefer to visit patent medicine shops [37] that are closer to them. Hence, more informal reporting hierarchy should exist unlike in the developed communities. This peculiarity shows that the deployment of ICT systems in rural communities should not assume a direct connection between individual patients and the HIS but should recognize a feeder line from the patent medicine practitioners who are closer to the rural dwellers. In Nigeria, unlike in most developed countries, patent medicine shops are private but government licensed medicine shops. These healthcare providers bring healthcare closer to the local people as an alternative for standard hospitals and pharmacies. The information provided to and by these medicine shops will be very relevant in monitoring and control of COVID-19 in Nigeria.

It is important to stress that community informatics (CI) in both developing and developed countries have similar uses. The application is most relevant to the rural communities whether in developed or developing countries. However, the engagement with the local community and the support from the central government is stronger in developed countries. This assertion can be seen in the implementation of community informatics in the United Kingdom [38]. In this work, they applied CI to drive and facilitate social change within the local communities in the UK.

## Recommendations

This section presents both technological and policy recommendations for the management and control of the virus. It recommends OGHCS for a participatory and sustainable control of the pandemic as well as suggests strategies for preventing possible spread of the virus in the identified hotspots.

### Online GeoHealth community structure for management of community transmission

Considering the dominant health cultural beliefs in Nigeria, we recommend a grass-root computing technique for the management of COVID-19 in Nigeria. For an effective application of community informatics strategy, there is a need for trust building and community weaving among members of a community. As such, the paper recommends the OGHCS

<sup>5</sup> <https://www.who.int/health-topics/traditional-complementary-and-integrative-medicine> [accessed January 10, 2021].

as a framework that integrates the requisite stakeholders and resources for the effective management and control of COVID-19.

OGHCS is inspired by the online GeoHubNet community structure proposed by Ozuomba et al. as shown in figure [39]. GeoHubNet is designed to manage and organise a community for informatics applications; it has been considered as a tool for realising an online community for participatory development [39]; and also as a tool for ICT-based community policing [40]. GeoHubNet helps in organising online communities according to some geopolitical divisions such as nation, state, region or city geo-communities. Fig. 1 represents a state-wide GeoHubNet. Inside this structure are regional geo-communities representing citywide, senatorial or local government geo-communities within that state. Within each regional local community in the state are local groups, institutions and individuals who are members of the online geo-community. Each regional geo-community has a set of facilitators that moderate the interconnection and interaction of the members in that regional community. The facilitator also conducts regional community network weaving. All the regional community facilitators in a state make up the HubNet.

It is easy to imagine that a nation-wide GeoHubNet is made-up of state-wide geo-communities, which themselves are a GeoHubNet of regional geo-communities. Realising a community informatics social network that follows this methodology can be likened to a transformation from a physical to a virtual community. In the case of OGHCS, the HubNet is the local community organization that champions the pandemic management programme.

### People and institutions for the OGHCS in Nigeria

Nigeria's current epidemic preparedness index has been rated as 38.9%, which is higher than the African and global averages [41]. NCDC, the leading public health agency in Nigeria, has done well in terms of point-of-entry screening for travellers coming into the country. Furthermore, the agency has been in charge of testing, contact tracing, training of response teams in all the 36 states of the nation and increasing awareness in the population [42] through SMS, press conferences and publications both on its websites and on social media.

In order to coordinate and oversee the country's multi-sectorial inter-governmental efforts to contain the spread and mitigate the impact of the virus, a presidential task force (PTF) on COVID-19 was established on March 9, 2020 [43]. Despite these commendable efforts by the NCDC and the federal government of Nigeria there have been serious concerns around the capacity of the country to effectively manage local and community transmissions [44]. These concerns are a major motivations for OGHCS. OGHCS seeks to integrate all the resources required for management of a pandemic on a single platform. The major stakeholders involved in OGHCS will include NCDC, PTF, national and state response teams, community members, PPMVs, age groups, religious institutions, volunteers, law enforcement agencies, community leaders, security officers and health workers.

With OGHCS, the online geo-communities are organised the same way they are offline, with each geo-community having a HubNet of facilitators and co-facilitators which involve personnel from different walks of life. For example, a HubNet for a geo-community can include selected PPMVs, community leaders, security officers, religious leaders, health workers and so on. Each geo-community GeoHubNet has a representative in a wider community; for example a state-wide GeoHubNet of facilitators from lower GeoHubNets; from the state-wide HubNet representatives are selected into the nation-wide GeoHubNet. This creates a hierarchical framework for managing the pandemic through training, sensitisation, provision of support and understanding of the through state of the pandemic in the country. An important advantage of this framework is that trust from community members is higher since the government reaches out to them with people with shared culture.

### Technologies for OGHCS

For a community informatics application, OGHCS requires a number of technologies. These technologies are to enhance data collection, information dissemination, data analytics, community weaving, disease mapping, training and so on. Technologies that are suitable for this purpose are presented as follows:

**Social networks:** this is the virtual implementation of a community network similar to the way it is structured offline. This is for the purposes of community weaving, coordination and information sharing amongst the members of a community and between different community HubNets, either vertically or horizontally. Moreover, social networks allow for user generated content (UGC) which is a rich source of unbiased data for analytics.

**Database and content repository:** this is a tool for data collection and storage.

**Multi-media:** multi-media functionalities are required for trainings and awareness programmes. For example, PPMVs can be trained on how to manage the early symptoms of the virus.

**Google maps mash-up application:** this is required for the collection of location-based information for virus transmission mapping. Such a map would serve as a guide for contact tracing.

**Data analytics tool:** tools that support real-time analyses and summarisation of data relating to the virus are required for future research and insights.

### Policy recommendations for managing hotspots

The general goal for interventions by governments is to shrink the epidemic curve while for individuals, the goal is to avoid contracting the virus. In the absence of vaccines and confirmed drugs, the required effects of interventions are shown in Fig. 2. For each of the hotspot LGAs, the peak of the epidemic should be reduced and spread out over time. The target is to achieve the blue curve instead of the red curve.

Firstly, the government should implement high levels of restrictions within these hotspots. The closure of large social gatherings should be implemented including high

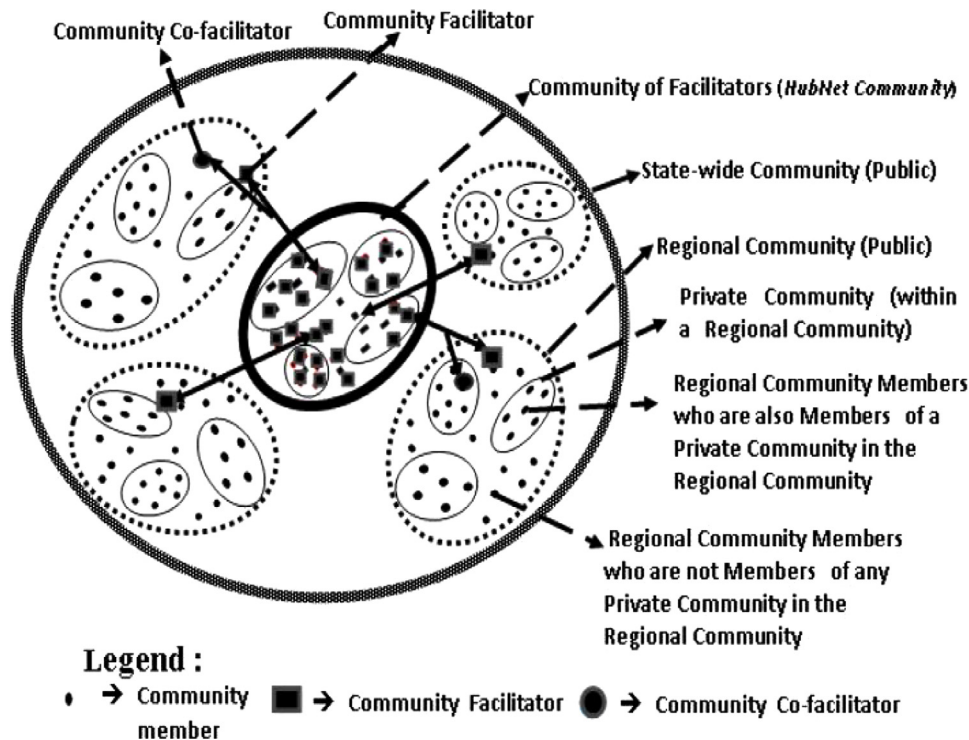


Figure 1. The GeoHubNet Community Structure [40].

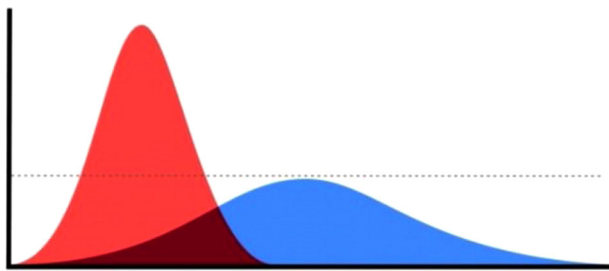


Figure 2. Public health measures to shrink the epidemic curve. Non-pharmaceutical measures include targeted lockdowns, intensive case finding, strict isolation and quarantine measures. These help to slow down incident cases while we hope to produce vaccines. The red curve applies to situation without such interventions while the blue curve helps to reduce incidence per day and ensure the health system is not overwhelmed [Image Source: Shutterstock].

enforcement of personal protective equipment (PPE) such as facemasks. These restrictions will reduce the force of infection and bring down the expected peak. Individuals should reconsider non-essential travel into these LGAs. Alternative destinations for goods and services should be used. Again, testing resources should be focused in these LGAs. Contact tracing and testing should be implemented with full force within these territories. It is very important to increase public awareness, messaging and re-orientation about public health measures in these areas. These activities are important because all interventions are only as good as people's compliance with them. Various models have attributed different levels of compliance to different interventions in order to measure how effective those interventions are. In addition to public awareness, the government should also provide palliatives that are commensurate with the

economic losses that will be suffered by these areas due to lockdown in economic activities. Businesses should be exempted from taxes and some salary relief given to companies that would be completely shut down. Without the palliatives, it will be difficult to achieve a high level of compliance for a prolonged time, which is required to reduce the daily incidence to a single digit or make  $R_0 < 1$ .

## Conclusions

Considering the prevalent health cultural beliefs of a people is important for the sustainable management of a socio-ecological threat such as the COVID-19 pandemic. This paper discusses the health cultural beliefs in Nigeria and suggests a community informatics strategy for managing the virus while following the WHO's advice on social distancing. In addition to its potential for community weaving and trust building, community informatics application can be deployed to collect and report information about population density, possible hotspots, super-spreader events and ultimately for contact tracing. Just like community policing for tighter security, community intelligence on the behaviour of citizens at the local level can help to alert the government about the required local intervention before an outbreak occurs. Although we have presented the hotspots as reported by official sources, a community informatics platform will enable the gathering of citizen-based information that can predict how these hotspots might change in the future. It is therefore advised that the government of Nigeria should leverage the rural structures including the patent medicine shops to gather timely information in order



to expedite a response. These structures will remain valuable even when a vaccine becomes available as they will form part of the vaccine distribution chain.

## Disclosure of interest

The authors declare that they have no competing interest.

## References

- [1] WHO. WHO interim protocol: rapid operations to contain the initial emergence of pandemic influenza. Geneva: World Health Organization; 2007.
- [2] Etteh CC, Adoga MP, Ogbaga CC. Covid-19 response in Nigeria: health system preparedness and lessons for future epidemics in Africa. *Ethics Med Public Health* 2020;15:100580.
- [3] Lee D, Heo K, Seo Y. Covid-19 in South Korea: lessons for developing countries. *World Dev* 2020;135:105057.
- [4] Reardon T, Bellemare MF, Zilberman D, et al. How covid-19 may disrupt food supply chains in developing countries. In: IFPRI book chapters; 2020, pp. 78–80.
- [5] Singh AK, Misra A. Impact of covid-19 and comorbidities on health and economics: focus on developing countries and India. *Diabetes Metab Syndr* 2020;14:1625–30.
- [6] Efiog JE, Aranuwa FO. Mobile devices' features and usability: the Nigerian utilization experience. *Int J Computer Trends Technol* 2017;48:200–7.
- [7] Jones JH. C notes on r0. In: *Anthropological Sciences*; 2007.
- [8] Borra S. Covid-19 apps: Privacy and security concerns. In: *Intelligent Systems and Methods to Combat Covid-19*. Springer; 2020, pages 11–17.
- [9] Amzat J. Health inequality in Nigeria. In: *Assessment of democratic trends in Nigeria*. Gyan Publishing House; 2011, pp. 313–22.
- [10] Amzat J, Razum O. Towards a sociology of health discourse in Africa. Springer; 2017.
- [11] Harande YI. Information services for rural community development in Nigeria. In: *Library philosophy and practice*; 2009, page 1.
- [12] Onyenachi JC, Akidi JO, Onyekweodiri NE. Public library services for rural transformation. *Int J Library Information Sci* 2015;4:40–6.
- [13] Omogor M. Channels of information acquisition and dissemination among rural dwellers. *Int J Library Information Sci* 2013;5:306–12.
- [14] Kuppalli K, Brett-Major DM, Smith TC. Covid-19 vaccine acceptance: we need to start now. In: *Open Forum Infectious Diseases*; 2021.
- [15] Barnes J, Chandani T, Feeley R. Nigeria private sector health assessment. In: *Bethesda: Private Sector Partnerships-One project*, Abt Associates Inc; 2008.
- [16] Labiran A, Mafe M, Onajole B, Lambo E. Human resources for health country profile – Nigeria. *Africa Health Workforce observatory*; 2008.
- [17] Beyeler N, Liu J, Sieverding M. A systematic review of the role of proprietary and patent medicine vendors in healthcare provision in Nigeria. *PLoS One* 2015;1:e0117165.
- [18] Naicker S, Eastwood JB, JPlange-Rhule J, Tutt RC. Shortage of healthcare workers in developing countries – Africa. *Ethn Dis* 2009;19:60–4.
- [19] Hundu JT, Azembah J, Pastorpreneurship: A critical analysis of proliferation of churches in Nigeria. *SBS Jos J Religious Studies Humanities* 2018;1:43.
- [20] Iheanacho NN, Ughaerumba CA. The rising paradigm of Pentecostapreneurship in Nigeria: impacts on national development. *Open J Philosophy* 2016;6:288–98.
- [21] Mbachirin AT. The responses of the church in Nigeria to socio-economic, political, and religious problems in Nigeria: a case study of the Christian Association of Nigeria (CAN). PhD thesis; 2007.
- [22] Obiefuna BAC, Nwadiakor KL, Umeanolue IL. Costs and benefits of proliferation of Christian denominations in Nigeria. *UJAH: Unizik J Arts Humanities* 2016;17:19–44.
- [23] Diddy A. Faith and child survival: the role of religion in childhood immunization in Nigeria. *J Biosocial Sci* 2009;41:57.
- [24] McInroy A. Blood transfusion and Jehovah's witnesses: the legal and ethical issues. *Br J Nurs* 2005;14:270–4.
- [25] Ndinojuo BCE. 5G, religion, and misconceptions in communication during Covid-19 in Nigeria. *J The Messenger* 2020;12:97–110.
- [26] Akeju DO, Oladapo OT, Vidler M, et al. Determinants of health care seeking behaviour during pregnancy in Ogun state, Nigeria. *Reprod Health* 2016;13:32.
- [27] Onah MN, Horton N. Male-female differences in households' resource allocation and decision to seek healthcare in south-eastern Nigeria: Results from a mixed methods study. *Soc Sci Med* 2018;204:84–91.
- [28] Igoli JO, Ogaji OG, Tor-Ayiin TA, et al. Traditional medicine practice amongst the Igede people of Nigeria. Part ii. *AJTAM* 2005;2:134–52.
- [29] Raphael EC. Traditional medicine in Nigeria: current status and the future. *Res J Pharmacol* 2011;5:90–4.
- [30] Oreagba IA, Oshikoya KA, Amachree M. Herbal medicine use among urban residents in Lagos, Nigeria. *BMC Complement Altern Med* 2011;11:1–8.
- [31] Tamuno I. Traditional medicine for HIV infected patients in antiretroviral therapy in a tertiary hospital in Kano, northwest Nigeria. *Asian Pac J Trop Med* 2011;4:152–5.
- [32] Soladoye MO, Chukwuma EC, Owa FP. An 'avalanche' of plant species for the traditional cure of diabetes mellitus in south-western Nigeria. *J Nat Prod Plant Resour* 2012;2:60–72.
- [33] Abubakar MS, Musa AM, Ahmed A, et al. The perception and practice of traditional medicine in the treatment of cancers and inflammations by the Hausa and Fulani tribes of northern Nigeria. *J Ethnopharmacol* 2007;111:625–9.
- [34] Orisakwe OE, Orish CN, Nwanaforo EO. Coronavirus disease (covid-19) and Africa: acclaimed home remedies. *Scientific Afr* 2020;10:e00620.
- [35] Shittu RO, Sanni MA, Odeigah LO, et al. Awareness, knowledge and misconceptions about Ebola virus disease (evd) in a family practice setting in Nigeria, west Africa. *J Antivir Antiretrovir* 2015;7:10–4.
- [36] Jegede AS. What led to the Nigerian boycott of the polio vaccination campaign? *PLoS Med* 2007;4:e73.
- [37] Oyeyemi AS, Oladepo O, Adeyemi OA, et al. The potential role of patent and proprietary medicine vendors' associations in improving the quality of services in Nigeria's drug shops. *BMC Health Serv Res* 2020;20:567.
- [38] Goodwin I. Community informatics and the local state in the UK: facilitating or assimilating an agenda for change? *Inform Communi Soc* 2007;10:194–218.
- [39] Ozuomba S, Chukwudebe GA, Opara FK, et al. Social networking technology: a frontier of communication for development in developing countries. In: *Green Technology Applications for Enterprise and Academic Innovation*. IGI Global; 2014, pages 102–17.
- [40] Ezenkwu CP, Ozuomba S, Kalu C. Strategies for improving community policing in Nigeria through community informatics social network. In: *2013 IEEE International Conference on*

- Emerging & Sustainable Technologies for Power & ICT in a Developing Society (NIGERCON). IEEE; 2013, pages 163–8.
- [41] Donnelly E. Nigeria's political leaders need to win trust to tackle covid-19. Chatham House; 2020. p. 2020. Accessed September 03, 2020.
- [42] Ajisegiri W, Odusanya O, Joshi R. Covid-19 outbreak situation in Nigeria and the need for effective engagement of community health workers for epidemic response. *Global Biosecur* 2020;1:4.
- [43] Agbakwuru J. Buhari sets up 12 member task force to control coronavirus. Accessed September 03, 2020.
- [44] Ebenso B, Out A. Can Nigeria contain the covid-19 outbreak using lessons from recent epidemics? *Lancet Global Health* 2020;8:e770.