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The Origin, Transmission and Pathogenesis of COVID-19: Suggesting a Better Containment Approach of the Pandemic in Nigeria

Ismail RABIU [1]*, Hassana Ibrahim ADAMU[2], Habeebullah Jayeola OLADIPO[3] and Usman Bello RABIU[4]

[1]*Department of Microbiology, Faculty of Life Sciences, College of Natural and Pharmaceutical Sciences, Bayero University, P.M.B: 3011, Kano, Nigeria.*
[2]*Department of Microbiology, Faculty of Natural Sciences, Kogi State University, P.M.B: 108, Anyigba, Kogi State, Nigeria*
[3]*Department of Microbiology, Faculty of Life Sciences, University of Ilorin, P.M.B: 1515, Ilorin, Nigeria.*
[4]*Department of Biotechnology, Mewar University India.*

Corresponding author: rtismail24@gmail.com +2347037515320

Abstract**:** *Sequel to the outbreak of Severe Acute Respiratory Syndrome Corona Viruses (SARS-CoV) in 2002, and Middle East Respiratory Syndrome Corona Viruses (MERS-CoV) in 2012, the present outbreak, caused by SARS-CoV-2 is the third occurrence of a highly virulent virus among humans. Despite the lives it has claimed, and the interventions by health authorities worldwide, it continues to pose a severe threat. Nigeria being amongst the countries massively hit, many economic activities are yet to commence fully. Coronavirus disease 2019 (COVID-19) is an infection caused by the novel SARS-CoV-2, which is mainly transmitted via droplets. To-date, the molecular pathogenesis of COVID-19 is poorly understood. However, MERS-CoV and SARS-CoV mechanisms can shed light, as studies have sown similarities in the structure of SARS-CoV-2 and SARS-CoV glycoprotein spikes with few structural differences in the Receptor-Binding Domain (RBD). SARS-CoV-2 causes respiratory and systemic disorders. The absence of an effective treatment combined with an exponential growth in infections, led many countries to implement interventions to reduce the high transmission rate. This review is made as to highlights some important information regarding the origin, transmission and pathogenesis of covid-19, thereby suggesting additional and a better containment approach of the pandemic in Nigeria.*

Keywords: β-coronavirus, Angiotensin Converting Enzyme, Coronavirus, Receptor Binding Domain, SARS-CoV-2.

I. Introduction

The coronavirus Disease 2019 (COVID-19) outbreak, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was declared a pandemic by the World Health organisation (WHO) in January 2020 (1). To date, this declaration is about eighteen months old (January, 2020 to May, 2021). The point of concern is that, despite the hundreds of thousands of lives it has claimed, and the subsequent interventions by relevant health authorities worldwide, it continues to pose a severe threat, to the global health and economy, as countries are battling to adjust to the present damages caused.

Nigeria isn't left out, among the countries massively hit, as a number of economic activities are yet to resume fully, with schools, opening on half capacity, and hotels, public/religious event centres remain shut.

Following the outbreak of Severe Acute Respiratory Syndrome Corona Viruses (SARS-CoV) in 2002, and Middle East Respiratory Syndrome Corona Viruses (MERS-CoV) in 2012, the present outbreak, caused by SARS-CoV-2 is regarded as the third introduction of a highly pathogenic virus strain into the human population (2; 3).

Coronaviruses are enveloped viruses with a linear, no segmented, positive-sense, single-stranded RNA genome of about 27–32 kb. They are round and sometimes pleomorphic virions of approximately 80-120 nm in diameter. They are enclosed in a genome that is the largest of all RNA viruses (4). Coronaviruses are classified into four distinct phylogenetic groups, consisting of the alphacoronaviruses (α-CoV), betacoronaviruses (β-CoV), gammacoronaviruses (γ-CoV) and deltacoronaviruses (δ -CoV). The α-CoV, β-CoV and γ-CoV infect mammals,

whereas the δ -CoV infect avian species. All known human coronaviruses (HCoV) belong to the α-CoV and β-CoV (5; 6).

SARS-COV-2 is an enveloped, single-stranded, non-segmented positive-sense RNA virus, belonging to the β-coronavirus (subgenus sarbecovirus, Orthocoronavirinae subfamily). There are currently 7 CoVs, that can cause human respiratory diseases, however, OC43, HKU1, NL63 and 229E remains the commonest cause of infections (7; 8). Coronavirus disease is associated with a range of symptoms, and in most cases includes; common cold, cough, high fever, and the inability to taste or smell (9).

This paper discusses the origin, transmission and pathogenesis of covid-19. However, it also highlights a better containment approach of the dreadful pandemic in Nigeria.

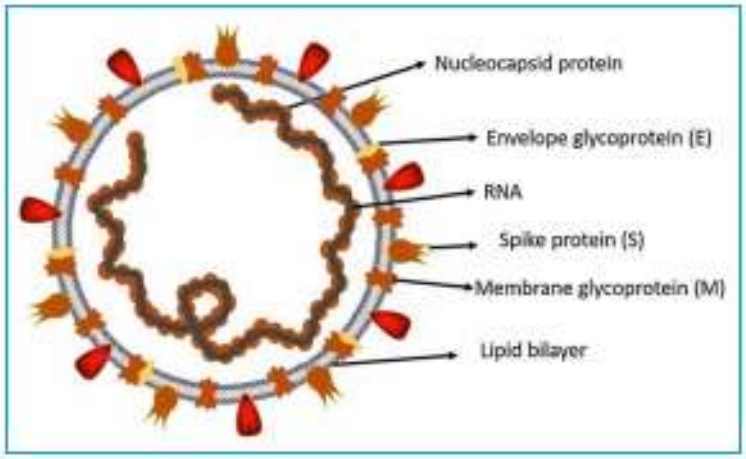

Figure. 1: Molecular structure of SARS-CoV-2 showing a lipid bilayer membrane that contains Envelope (E) and Membrane (M) proteins that make up the envelope. Spike (S) glycoproteins project from the surface of the virion. Nucleocapsid protein (N) is composed of the protein that is associated with the viral genetic material.

II. IMPORTANT LIMELIGHT ASSOCIATED WITH SARS-COV-2 PANDEMIC

A cluster of pneumonia cases of unknown aetiology was reported on 31 December 2019, in Wuhan, Hubei Province, China. Following this outbreak, on 9 January 2020, a novel coronavirus was identified as the cause of this outbreak, as reported by the Chinese health authority (10; 11). Following SARS-CoV and MERS-CoV, the present outbreak is regarded as the third introduction of a highly pathogenic virus strain into the human population, of which all belong to the same corona virus group (12).

On 12 January 2020, the Coronavirus was initially named as the 2019-novel coronavirus (2019-nCoV) by World Health Organization (WHO). On 11 February 2020, the Coronavirus Study Group (CSG) of the International Committee on Taxonomy of Viruses (ICTV) proposed a new name, as; SARS-CoV-2. On the same date, the WHO officially named the disease as coronavirus disease 2019 (COVID- 19) (10) (1; 13). However, on 30th January 2020, The WHO declared the outbreak, a pandemic and a Public Health Emergency of International Concern (PHEIC) (1; 14).

The total global reported confirmed cases as at Friday, 21st May, 2021 is 165,158,285 with over 3,425,017 deaths reported to WHO, exceeding the combined number of cases and deaths of all the previously occurred pandemics (15). At this same date, the total deaths recorded in Nigeria, has exceed 2,067 out of a total confirmed cases of 165,944. So far, the WHO has administered over 1,448,242,899 vaccine doses. However, the rising number of positive cases and deaths, continued to pose a serious threat to international health (16; 17; 6).

III. ORIGIN OF SARS-COV-2

The first cases of coronaviruses in human, were first identified in 1965 by Tyrrell and Bynoe, who observed that they could passage a virus named B814. The viruses were identified in human embryonic tracheal organ cultures obtained from the respiratory tract of an adult patient presented with mild colds, and are classified as; alphacoronaviruses (α-CoV), betacoronaviruses (β-CoV), gammacoronaviruses (γ-CoV) and deltacoronaviruses (δ -CoV) phylogenetic groups (7; 18; 5).

SARS-COV-2 the causative agent of the present pandemic, which was first identified in the city of Wuhan, Hubei Province China in December 2019, belongs to the β-coronavirus (subgenus sarbecovirus, Orthocoronavirinae subfamily). At present, there are Seven coronaviruses that can cause human respiratory diseases but the common ones which often infect people are; 229E, NL63, OC43, and HKU1 (7; 8).

Bats as primary reservoirs, have been known to harbour more coronaviruses than any other species and play an important role as the gene source in the evolution of these viruses (19)). For many decades' numerous studies in

Africa, America, Asia and Europe have discovered the existence of novel coronaviruses in a wide variety of bat species (20). However, 7 out of the 15 currently assigned species within the genera (α-CoV), and (β-CoV), which mainly infect mammals, have only been found in bats (21).

Hu *et al.* (19), reiterates the fact that of all the coronaviruses harboured by bats, the ones of particular interest have been found to be associated with two high profile human disease outbreaks in 2002-2003 and 2012, caused by Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) respectively.

The present pandemic of SARS-CoV-2 first broke out in Wuhan, China, since 12 December 2019, and studies have possibly related it to a seafood market in China (10; 11). However, SARS-CoV-2 might be transmitted from bats via unknown intermediate hosts to infect humans. Further genome sequencing of the virus showed the presence of a previously (β-CoV) and upon isolation and sequencing of the β-CoV, it shows 88% identity to the sequence of two bat-derived severe acute respiratory syndromes (SARS)-like coronaviruses, batSL-CoVZC45 and bat-SL-CoVZXC21, and about 50% identity to the sequence of middle east respiratory syndrome coronavirus (MERS-CoV) (22).

Although several studies have suggested that bat may be the potential reservoir of SARS-CoV-2, to date, substantial evidence do not exist, that the origin of SARS-CoV-2 was from the seafood market. nevertheless, this claim may be linked with the fact that bat has been suspected as natural host of coronaviruses which was supported by virus genome sequencing results and other evolutionary analysis (13; 19).

Further studies using protein sequence alignments and phylogenetic analysis on coronaviruses identified in pangolins showed a 90% sequence identity to SARS-CoV-2 suggesting pangolins as the most likely intermediate hosts for SARS-COV-2 (23). The outcome of phylogeny analyses does not certainly support the view that pangolin is the exact intermediate host of SARS-CoV-2, as other animals may also serve as intermediate hosts. Other studies reported the presence of the same ACE2 receptor residues in other animal species such as turtles and snakes, creating the possibilities for alternative intermediate hosts (8).

Beside SARS-CoV and MERS-CoV which emerged recently, studies have revealed that the other four human-pathogenic coronaviruses, namely, HCoV-229E, HCoV-OC43, HCoVNL63 and HCoV-HKU1, have been continuously circulating in human for centuries (24). Coronaviruses contain the largest RNA genomes, with a high nucleotide substitution rates across the genome, and have been reported since 2016 as one of the rapidly evolving viruses (25). The genome is subjected to homologous recombination during viral replication, which is caused by RNA template switching mediated by the copy-choice mechanism (26). Recombination events in the spikes, Nucleocapsid, and the RNA dependent RNA polymerase (RdRp) within the 1a gene of certain corona viruses such as HCoV-OC43 and HCoV-HKU1 have led to the emergence of unique recombinant genotypes (27). These genetic recombination of coronaviruses have been reported by Al-Khannaq (25), as the possible cause of the emergence of lethal pathogens such as Middle East respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV), which caused up to 50 % mortality in infected individuals. These along with many others have for long alerted researchers on the emergence of the present COVID-19 pandemic. However, there is the need for further studies with a view to identify the exact animal reservoir and host ranges for SARS-CoV-2.

IV. TRANSMISSION OF SARS-COV-2

The Severe acute respiratory syndrome Coronavirus-2 (SARS-CoV-2) is a highly transmittable and pathogenic virus and is mainly transmitted through body contact, respiratory droplets (e.g. sneezing, common cold or coughing from the nose and mouth), potential route of faecal-oral and contact with other body fluids of an infected patients with or without clinical symptoms or incubation carriers (7). It is clear now that SARS-CoV-2 could use angiotensin-converting enzyme 2 (ACE2), the same receptor as SARS-CoV, to infect humans as demonstrated in figure 4.

Human-to-human transmission of SARS-CoV-2 occurs mainly between family members, including relatives, and friends who had an intimate contact with infected patients or incubation carriers. In some cases, transmission do occur from infected patients or incubation carriers to health care workers. These necessitated the need for all health care workers to observe all safety and precautionary measures at all time. However, some proportion of SARS-CoV-2 infected Patients also developed gastrointestinal associated symptoms like diarrhoea. There are general susceptibilities in all age groups, with the elderly and people with an underlying health conditions, more likely to develop a severe or complicated cases. Children may have mild clinical symptoms after infection (28).

Moreover, SARS-CoV-2 has been frequently detected in urine and other non-respiratory specimens (29). To date, no virus has been detected in peritoneal exudate, cerebrospinal fluid, semen, joint fluid, pericardial effusion, posterior fornix and female reproductive tract secretions etc. However, it is recommended that these samples be considered infectious (30). To reduce the transmission among people, there is the need to develop methods for the identification of various routes of transmission (31).

A single cough can circulate, about 3.000 droplets, which can land on nearby people, and other objects or surfaces around them, leaving smaller particles flying on air. Some people can contaminate their hands, and

proceed to get infected, as they touch these objects or surfaces, and further touches their eyes, nose or mouths (7; 28).

It is reported that the virus can be shed in faecal matter, faecal oral contamination, and improper hand hygiene following the use of toilets which can contaminate anything touched. This necessitates the need for stay at home, or stay more than 1 meter (3 feet) away from sick patients, and any one as some people can harbour the virus and yet stay asymptomatic. Urbanization and the increasingly frequent mixing of different animals in densely populated areas may have facilitated the emergence and re-emergence of coronaviruses. On the other hand, coronaviruses are known to have high mutation and recombination rates, which may allow them to cross species barriers and adapt to new hosts (24).

Current estimates suggest a median incubation period from 5–6 days for SARS-CoV-2, with a range from 1–14 days (25). The recent determination of the protein spikes, has revealed a number of mutations in the receptor-binding domain of the glycoproteins spike in some domains, but these have so far been rare and are not present in any of the major SARS-CoV-2 clades (ECDC, 2020a). These mutations are of global health concern as they may affect infectivity and host-specificity of SARS-CoV-2 (32).

V. REPLICATION AND PATHOGENESIS OF SARS-COV-2

To-date, the molecular pathogenesis of COVID-19 is poorly understood. However, MERS-CoV and SARS-CoV mechanisms can shed light, as studies have sown similarities in the structure of both SARS-CoV-2 and SARS-CoV spike glycoprotein with few structural differences in the Receptor-Binding Domain (RBD). The SARS-CoV-2 RBD is an angle closer to the central cavity of the trimer in the down conformation, while that of SARS-CoV can packs tightly against the domain of the N-terminal of the neighbouring protomer in the down conformation (33).

Virus-host interactions affect viral entry and replication as demonstrated in figure 2. However, the basic reproduction number (R0) of this virus was estimated to be around 2.2, or even more (range from 1.4 to 6.5) (8; 34).

The cell receptor, Angiotensin Converting Enzyme 2 (ACE2) for SARS-CoV is found in the lower respiratory tract of humans and is responsible for the regulation of both the cross-species and human-to-human transmission. Studies have confirmed that the SARS-CoV-2 uses the same cellular entry receptor, ACE2, as SARS-CoV. Two-thirds of viral RNA, are mainly located in the first open reading frame (ORF 1a/b), and encodes 16 non-structural proteins (NSPs). The rest part of the virus genome encodes four essential structural proteins called nucleocapsid (N), glycoprotein spikes (S), envelope (E), membrane proteins (M), and several accessory proteins. The N protein holds the viral genome, while S, E and M construct the viral envelope. The S glycoprotein binds to host cell receptors, angiotensin-converting enzyme 2 (ACE2), which is a critical step for virus entry. The S glycoprotein on the surface, mediates the virus entry into the host cell and determines to a certain degree the host range during virus infection (13; 30; 35). However, the exact and all possible molecules that facilitated membrane invagination for SARS-CoV-2 endocytosis are still unclear.

The S glycoprotein includes two subunits, S1 and S2. S1 determines the virus-host range and cellular tropism with the key function domain (RBD), while S2 mediates virus-cell membrane fusion by two tandem domains, heptad repeats 1 (HR1) and HR2 (13). After membrane fusion, the viral genome RNA is released into the cytoplasm, and the uncoated RNA translates two polyproteins, pp1a and pp1ab, which encode non-structural proteins, and form replication-transcription complex (RTC) in double-membrane vesicle (36). Continuously RTC replicate and synthesize a nested set of subgenomic RNAs, which encode accessory proteins and structural proteins. Mediating endoplasmic reticulum (ER) and Golgi (37; 38).

Newly formed genomic RNA, nucleocapsid proteins and envelope glycoproteins assemble and form viral particle buds. Lastly the virion-containing vesicles fuse with the plasma membrane to release the virus. Human transition has been largely fostered by emergence of mutations in the S protein, which has amplified the affinity of this protein moiety (within a furin-cleavage site) for (ACE2), its natural receptor at the surface of cells and tissues, especially alveolar type 2 cells in the lungs (AT2), lymphocytes and cells of the heart, kidney and gastrointestinal
system (39; 40).

After infecting human cells, the Disorders caused by SARS-CoV-2 includes both respiratory (Sneezing, Pneumonia and Acute Respiratory Distress Syndrome, etc).and systemic disorders (Cough, Fever, Fatigue, Headache etc.) as illustrated in table 1 (12; 13).

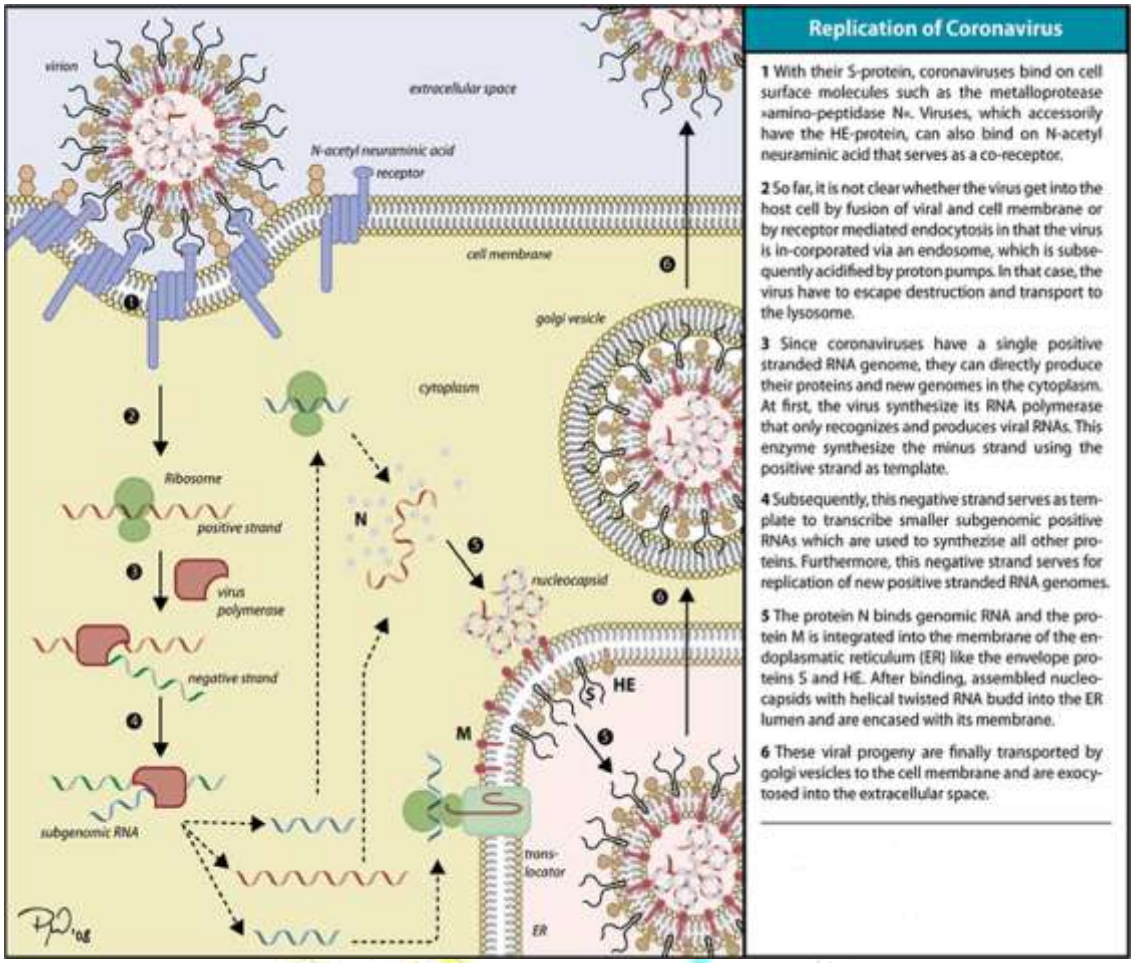

Figure 2: Replication process of Coronaviruses. Adapted from Ahmad *et al.* (7).

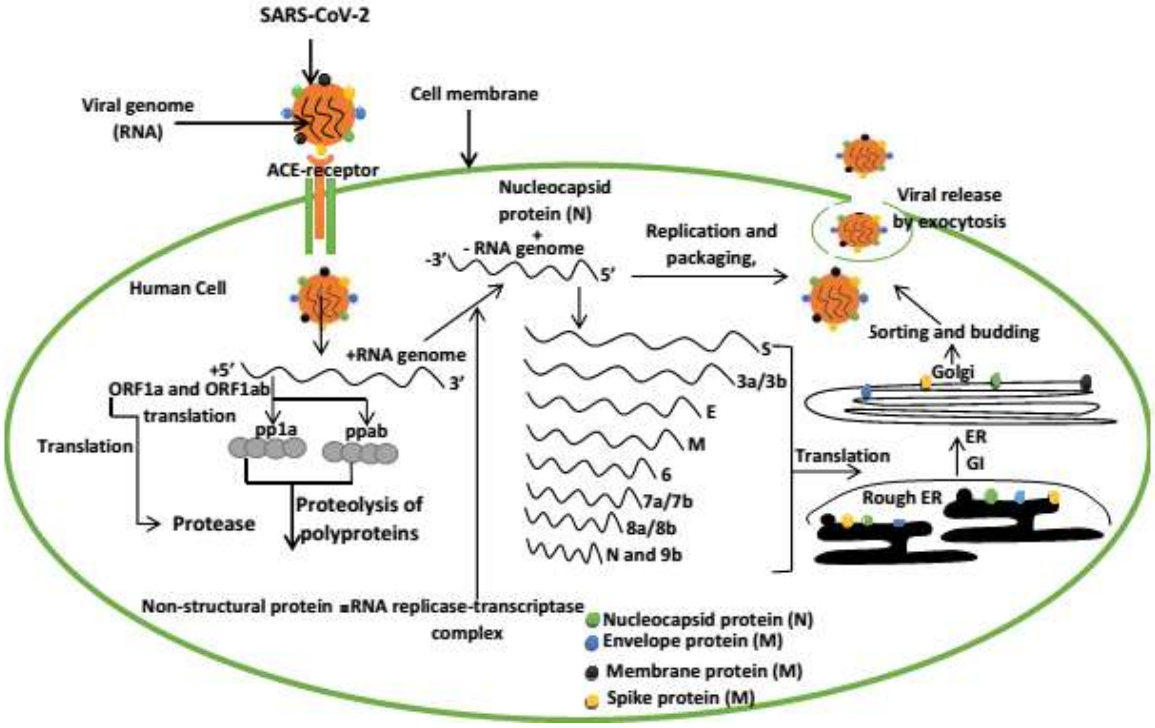

Figure 3: An overview of SARS-CoV-2 pathogenesis. The virus binds to the ACE2 receptor to enter the human cell and its RNA got translated to structural proteins (spike, nucleocapsid, membrane, and envelope), these proteins are essential in the invasion and infection of the human cell (12).

Table 1: Disorders caused by COVID-19 after infecting Human cells

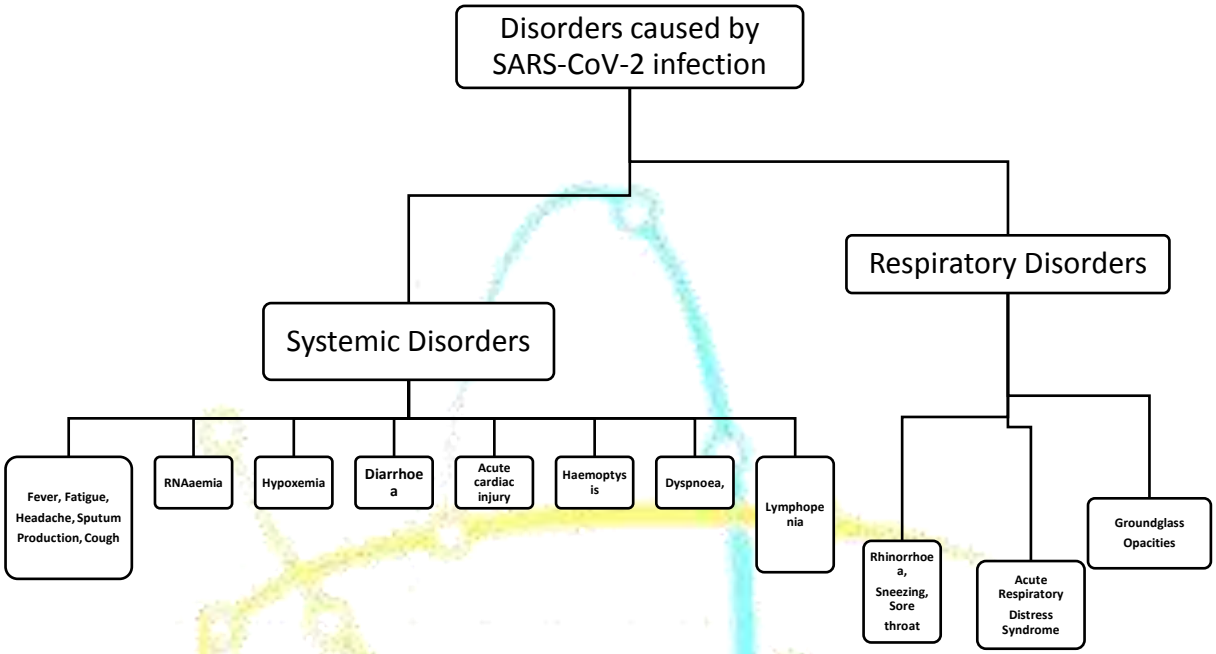

Table 2 Characteristics of patients who have been infected with COVID-19, MERS and SARS. Adapted from Vishal (28).

Characteristics	SARS-CoV-2	MERS	SARS
Date	December, 2019	June, 2012	November, 2002
Location	Wuhan, China	Jeddah, Saudi Arabia	Guangdong, China
Fever	98%	98%	99-100%
Dry cough	76%	47%	29-75%
Dyspnoea	55%	72%	40-24%
Diarrhoea	1	26%	20-25%
Sore throat	0	21%	13-25%

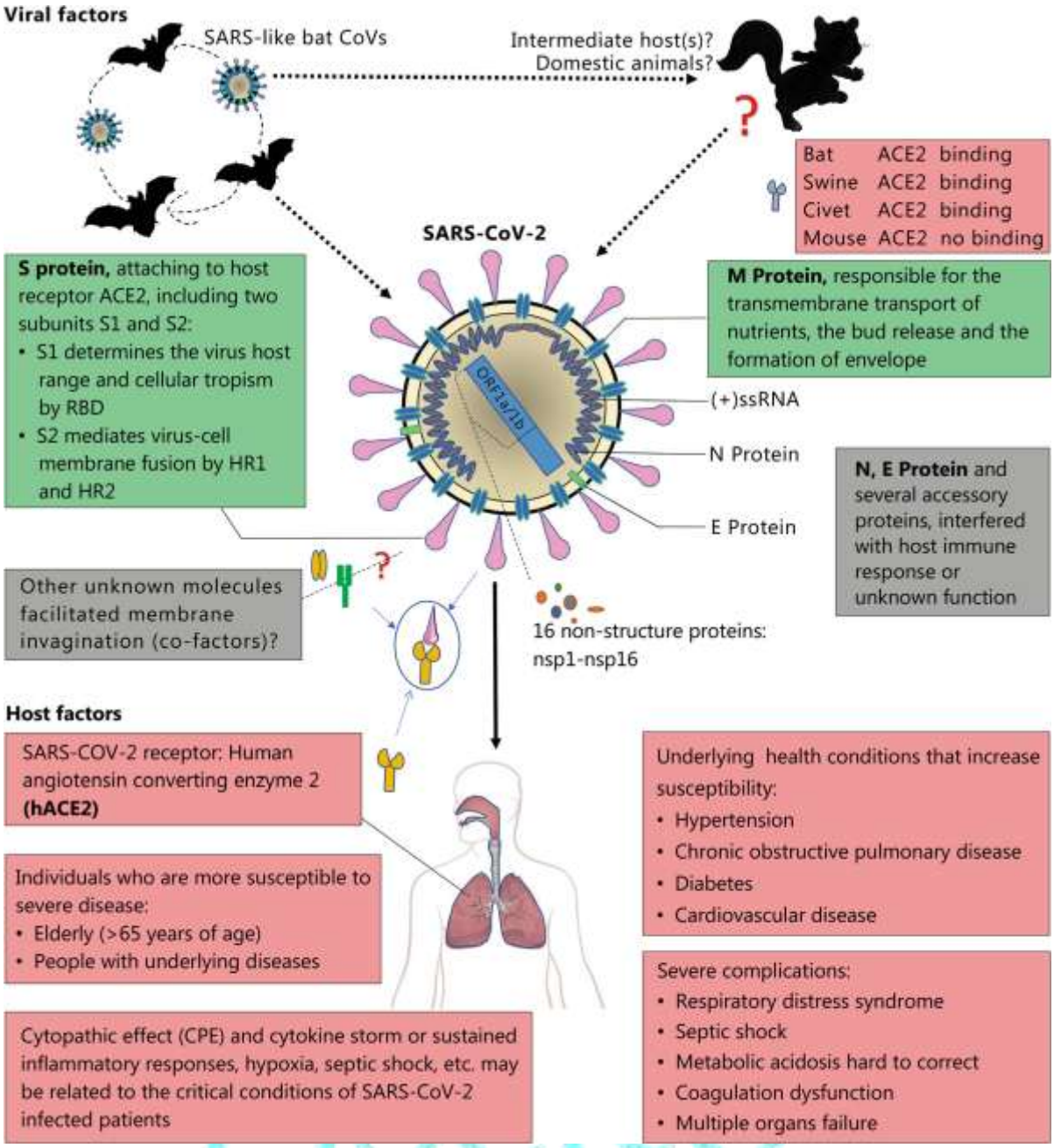

Figure 4: Viral and host factors that influence the spread of SARS-Cov-2. The picture depicts the reservoirs (Bats) of varieties of coronaviruses including SARS-CoV-2 and cross the species barrier into humans. Virus-host interactions affect viral entry and replication.

The Upper panel depicts viral factor. SARS-CoV-2 is an enveloped positive single-stranded RNA (ssRNA) coronavirus. The viral RNA encodes 16 non-structure proteins (NSPs), and four essential structural proteins along with numerous accessory proteins. The Surface glycoprotein binds to host cell receptors, angiotensin-converting enzyme 2 (ACE2), which is a critical for virus entry.

The Lower panel depicts host factors. This effect susceptibility to infections (among the elderly, immunocompromised and those with certain medical conditions) and disease progression. Adapted from Guo *et al.* (13).

VI. PREVENTION & PRECAUTION OF COVID-19

Globally, the following measures have been identified as the most effective approaches to curtailing the spread of coronaviruses (7; 41).

6.1 Steps to protect yourself

1. After blowing one's nose, sneezing or coughing, extra caution must be applied to avoid the contamination of eyes, nose, and mouth. One must avoid touching these organs with unwashed hands.
2. To get rid of all contaminations, which might result from touching surfaces or handshakes, there is the need to wash one's hands regularly, and thoroughly with soap and water or with an alcohol based hand sanitizers for at least 20 seconds as recommended by WHO.
3. After removing face mask, hands must be washed immediately. All reusable face masks should be washed after each use before reusing.
4. Maintain social distancing of at least 3 feet, i.e. 1 metre to avoid inhaling droplets, which might contain the virus.
5. For the Police and other Law Enforcement Agencies in Nigeria, there is the need to stick to the enforcement of COVID-19 regulation and other operational guidelines set aside by the National Centre for Disease Control (NCDC) in collaboration with other sister agencies. These entails wearing face mask always and gloves when necessary, limited contact along with appropriate hand hygiene should be observed, when dealing with uncooperative individuals.

6.2 Steps to protect others

1. Avoid large gatherings, and whenever one is to cough or sneezes, the mouth and nose should be covered completely with tissue, or handkerchief. The handkerchief should be washed regularly with clean water, and ironed or sun dried.
2. If any symptoms such as; cough, fever and difficulty in breathing is observed, necessary medical attention should be sought for, via the approved channel, such as calling the NCDC or one's State Toll free lines. However, on no account should anyone with any suspected COVID-19 cases visit any hospital. This is to avoid further spread of the virus
3. If possible, stay isolated in a separate room from family and pets and wear a facemask when you are around other people (e.g., sharing a room or vehicle). If you are unable to wear a facemask (due to its causes trouble breathing or other reason) then you should cover your coughs and sneezes, and but when the people who are caring for you enter your room they should wear a facemask (Facemasks may be in short supply and they should be saved for caregivers).
4. Frequently used surfaces should be decontaminated regularly and with appropriate disinfectants.

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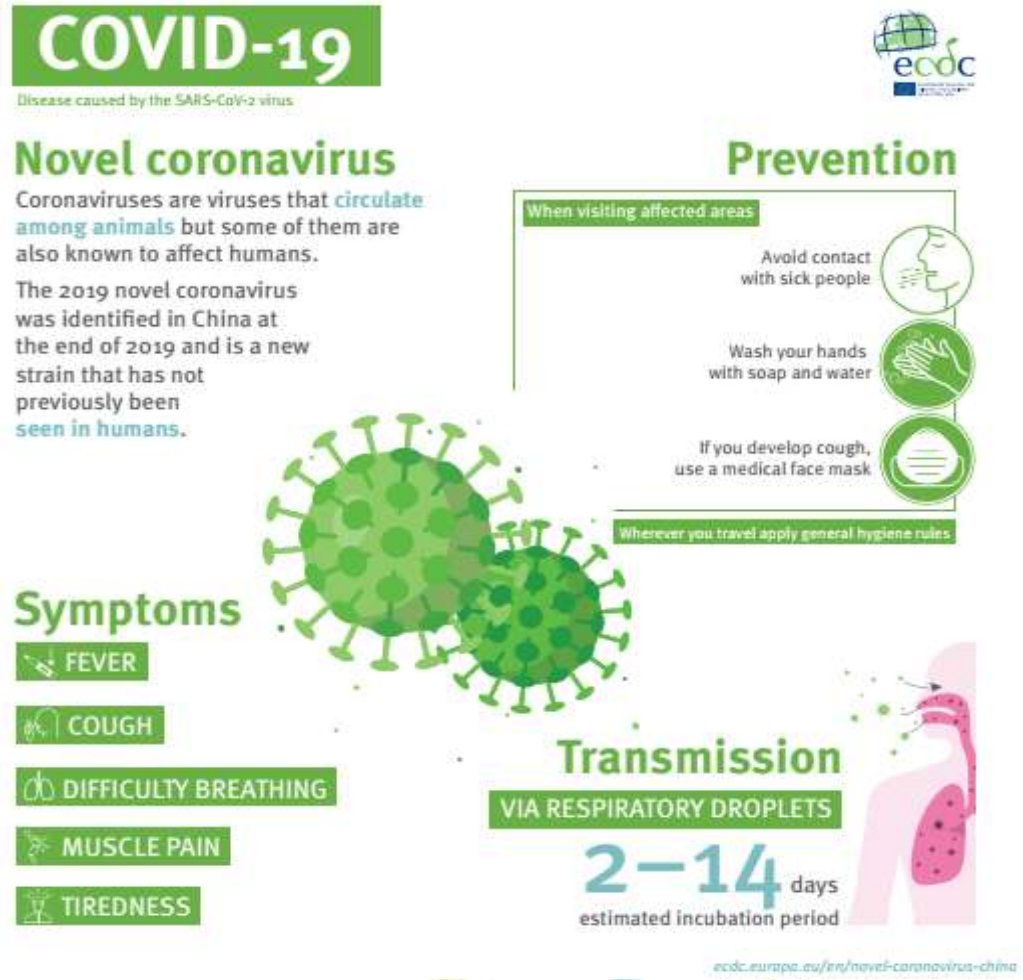

Fig. 5: Brief summary of Novel coronavirus, disease prevention, symptoms and transmission (10).

VIII. A Better Containment Approach of COVID-19 in Nigeria

The Nigerian Government have risen up in the fight against SARS-CoV-2 pandemic, as it has put in place many plans and action. This includes the presidential task force on COVID-19 which is the general overseer of all COVID-19 strategies of action. This is followed by State Governors been the head of their state task force.

The absence of an effective treatment combined with an exponential growth in infections, led many countries to implement non-pharmaceutical interventions such as 'stay-at-home' policies (recommended or enforced) alongside other community and physical distancing measures such as the cancellation of mass gatherings, closure of educational institutions and public spaces. This approach has collectively reduced the high transmission rate. Although the transmission rate has been reduced, these measures are highly disruptive to society, both economically and socially. Nigeria's approach in the management of COVID-19 infections is at present ineffective. This is why there is significant interest in defining a sound approach for adjusting the measures, thereby suggesting a better containment approach in Nigeria and phasing out the continued close down of several institutions.

1. **Pharmaceutical prophylaxis and treatment**: At present, no medicine has demonstrated efficacy in the prevention or treatment of COVID-19 (10). Potential local treatments should be carefully assessed in randomised controlled trials (RCTs), by authorities' concern, such as National Agency for Food Drug administration and Control (NAFDAC). When the need arise, enrolment of patients in clinical trials should be encouraged. In Nigeria, there should be a published and easily accessible recommendation on compassionate use of all the investigational antiviral agents. This has proven effective, as practiced in many European countries (1; 10).

2. **Banning of the wide use of non-medicated/ locally made face mask** from **ordinary fabrics, substandard hand sanitisers and other medical consumables;** this should be discouraged, and there is the all

need for Government and stakeholders to join hands in boosting the local production of certified protective masks and other standard medical equipment's for the control of the present and subsequent pandemic which might arise.

3. **Prompt identification and management of contacts of COVID-19 cases and secondary cases**: The purpose of identifying and managing the contacts of probable or confirmed COVID-19 cases is to rapidly identify secondary cases that may arise from transmission from the primary known cases and to intervene to interrupt further onward transmission (42). Contact tracing is an essential measure to fight the ongoing epidemic of COVID-19. In conjunction with active case finding and testing, and in synergy with other measures such as physical distancing, it is recommended in all transmission scenarios (43).

4. **Solving the problems of Ineffective contact tracing:** A contact of a COVID-19 case is any person who had contact with a COVID-19 case within a timeframe ranging from 48 hours before the onset of symptoms of the case to 14 days after the onset of symptoms (43). In asymptomatic case, a contact person is defined as someone who had contact with the case within a timeframe ranging from 48 hours before the sample which led to the confirmation was taken, to 14 days after the sample was taken (42; 43). Ineffective contact tracing in Nigeria is contributed by the poor house numbering system, and in some places the absence of such numbers at all. However, government must work to capture major cities on google map, for easy and rapid tracing of victims and suspected victims of SARS-CoV-2 infections. There is the need for prompt identification of contacts of a probable or confirmed case of COVID-19 (14; 44). This should be followed by; interviewing the case to collect information on clinical history and possible contacts, tracing the contacts and classifying them into high-risk exposure 'close contact' or low-risk exposure, Information should be collected on whether the contact works with vulnerable populations (elderly or to immunocompromised), and providing information about suitable infection control measures, symptom monitoring and other precautionary measures such as the need for quarantine (14; 42).

5. **Public/community testing for all**: There is the urgent need to test/diagnose communities to ascertain each individuals true COVID-19 status, this will reduce the high coinfection rate among individuals.

6. **Regular public/community sensitisation campaign on the Proper hand washing techniques:** people must be enlightened on the proper hand hygiene, hand washing protocols and respiratory etiquette measures, put in place by NCDC, CDC and WHO. Hands must be washed in a running water, and if the water source is to be opened e.g. a tap, contaminated hands shouldn't be used to open or close the tap after the hand washing, the hand knees is to used. There should be minimum contacts of hands with face, mouth, nose and other body surfaces, to avoid further transmission of infections (45).

7. **Establishment of well-equipped and easy to assessed testing centres:** The shortage of testing centres can be solved via the establishment of at least one testing centre in every senatorial districts. This will amount to three per states, and a total of (111) in the entire 37 states, with the federal capital territory inclusive. Laboratories involved in the COVID-19 national response are encouraged to participate in the ECDC and WHO external quality assessments to evaluate the reliability of their testing assays and resulting data quality (14).

8. **Strict adherence to biosafety regulations**: as per WHO biosafety guideline, non-propagative diagnostic laboratory work (sequencing and nucleic acid amplification) should be conducted at a facility using procedures equivalent to biosafety level 2 (BSL-2). Propagative work (virus culture, isolation or neutralisation assays) should be conducted at a containment laboratory with inward directional airflow (BSL-3) (3). Patient specimens from suspected or confirmed cases is to be transported as UN3373, 'biological substance category B'. Viral cultures or isolates should be transported as category A, UN2814, 'infectious substance, affecting humans" (3; 46).

9. **Collaboration with relevant stakeholders, community and religious leaders in the fight to defeat COVID-19 in Nigeria**: it is surprising, that of to present day, there are people who still considers Covid-19 infections as imaginary, and doesn't exist. This is coupled with the high rate of illiteracy in especially the rural communities. Collaboration with religious and community leaders will be of help towards creating the believe, that COVID-19 in Nigeria is real, and continue to claimed lives.

10. **Focussing on other community means of COVID-19 protection, especially the preventive measures**: providing the populace, especially those in high risk areas, with information on self-quarantine, is of paramount importance, along with advice on what to do if they develop symptoms; alongside timely laboratory testing (all those with symptoms and, if resources allow, asymptomatic high-risk exposure contacts). (14; 45). It is easier, cheaper and safer to prevent a disease than to treat it. Government should provide and encourage the intake of immune boosting foods/ fruits, regular indoor exercises, enough sleep, and above all, curtail the unnecessary fears which kills faster than the disease itself (45; 42).

11. Tre**atment of Corona infections, along with that of other endemic Infection**s: The treatment of Corona, should as well go hand in hand with other disease which are endemic in Nigeria, and places patients at more risk of contracting CPOVID-19 infections.

12. **The shortage of testing kits can as well be avoided via the provision of research centres with all the required equipment and the technical knowhow in other to compete with other global centres in the fight to defeat this pandemic**. this is evident by the recent Corona virus DNA extraction, carried out in the National Biotechnology Development Agency (NABDA) in collaboration with Imperial College London, and other African Governments.

13. **Sequencing to Monitor COVID-19 Evolution:** to monitor the virus evolution and changes in their genome, the European Centre for Disease Control (ECDC) have recommended that representative viruses from different geographic locations, time of occurrence during the epidemic, age, medication, underlying conditions, gender and severity should be selected for RNA sequencing (10; 14). However, the (ECDC) have pledges support, that Countries that do not have sequencing capacity, through their national laboratories can send specimens to referral laboratories or request sequencing support from ECDC (via sending an email to typing@ecdc.europa.eu with their request). And the viral sequences will be deposited in GISAID (10). however, it is of paramount importance for Nigeria and other developing countries, to utilise such opportunity, for a better understanding of SARS-CoV-2 virus and effective containment.

14. **Cell-mediated immune response:** Wang *et al.* (40), reported a decrease in total numbers of T lymphocytes, CD8+ T cells and CD4+ T cells, observed in both mild cases and severe cases of COVID-19 infections, and the decrease was more observed in the severe cases. However, total lymphocytes, CD4+ T cells, CD8+ T cells, B cells, and natural killer cells showed a significant association with inflammatory status in SARS-CoV-2, especially CD8+ T cells and CD4+/CD8+ ratio. In multivariate analysis, post-treatment decrease in CD8+ T cells and B cells and increase in CD4+/CD8+ ratio are predictors of poor treatment outcome (47). There is the need for such investigation among Nigerians, as it will give an idea on the effectiveness of the various treatment options used.

15. **Self-sampling and self-testing:** self-sampling approaches, while symptomatic people continue to self-isolate, may provide an efficient way to screen patients for COVID-19 on a large-scale basis, while reducing the risk of contaminating workers at healthcare facilities and decreasing the risk of non-infected people becoming infected in waiting rooms. To date, there are no validated self-testing or community-based testing SARS-CoV-2 assays available (10). Some EU countries, including Belgium, Finland, Sweden, Ireland, Germany and the Netherlands, have warned against or even banned self-tests for coronavirus at this stage. There is the need for relevant authorities in Nigeria to take heed.

16. **Hospital-based Severe Acute Respiratory Infections (SARI) surveillance:** ECDC (2020b), reported that countries no longer testing mild suspected cases for COVID-19 should at least test all severe acute respiratory infection (SARI) cases admitted to hospitals, and monitor the proportion of confirmed COVID-19 cases among all SARI. There is the need to Nigeria to implement these. Key indicators which can inform the

lifting (or reimplementation) of physical distancing measures are those obtained from hospital-based surveillance (10). Such indicators could include the number and proportions of severe acute respiratory infected (SARI) patients positive for SARS-CoV-2 in all isolation centres (IC). Enhanced surveillance of hospitalised-confirmed COVID-19 cases in all (IC) can provide additional data on risk factors and allow for rapid identification of changes and implementation of specific control measures. The capacity in (IC) and specifically in intensive care units also needs to be monitored and physical distancing measures should not be lifted if the healthcare system is operating at full capacity (10; 14).

17. **Antibody-mediated immune response:** Based on the currently available data, the IgM and IgG antibodies to SARS-CoV-2 develop between 6–15 days' post disease onset (48; 49). However, correlates of protection for COVID-19 have not yet been established, so the detection of antibodies to SARS-CoV-2 does not indicate directly protective immunity especially if a neutralisation assay has not been used as the detection method. (35; 48; 50). Zhao *et al*. (35; 50), Reported the presence of antibodies, detected in <40% among patients within 1-week from onset, and rapidly increased to 100% (total Antibodies), 94.3% (IgM) and 79.8% (IgG) from day-15 after onset. Despite the significant level of antibody recorded among patients, it is too early to know how long the protective immune response against SARS-CoV2 will last, as this will require longitudinal serological studies that follow patients' immunity over an extended period of time (10). However, the possibility of re-infection and the duration of immunity still remain to be studied. This necessitates the need for enlightenment among Nigerians (6).

18. **Extreme caution on the use of the new point-of-care immunodiagnostic tests:** At present, based on current evidence, WHO recommends the use of these new point-of-care immunodiagnostic tests only in research settings. They should not be used in any other setting, including for clinical decision making, until evidence supporting use for specific indications is available (46).

19. How well the tests work depends on several factors, including the time from onset of illness, the concentration of virus in the specimen, the quality of the specimen collected from a person and how it is processed, and the precise formulation of the reagents in the test kits. Based on experience with antigen-based Random Diagnostic Tests (RDTs) for other respiratory diseases such as influenza, in which affected patients have comparable concentrations of influenza virus in respiratory samples as seen in COVID-19, the sensitivity of these tests might be expected to vary from 34% to 80% (46; 51; 6).

20. Based on this information, half or more of COVID-19 infected patients might be missed by such tests, depending on the group of patients tested. However, this assumption requires further study to understand whether they are accurate. The challenge of false positive, which could occur if the antibodies on the test strip also recognize antigens of viruses other than SARS-CoV-2, such as from human coronaviruses that cause the common cold. With the limited data now available, WHO does not currently recommend the use of antigen-detecting rapid diagnostic tests for patient care, and the use of antibody-detecting rapid diagnostic tests for patient care but encourages more research to establish their usefulness in disease surveillance and epidemiologic research (41; 51; 52).

VIII. Conclusion

SARS-COV-2 is an enveloped, single-stranded, non-segmented positive-sense RNA virus. They are enclosed in a genome that is the largest of all RNA viruses. Coronaviruses are classified as alphacoronaviruses (α-CoV), betacoronaviruses (β-CoV), gammacoronaviruses (γ-CoV) and deltacoronaviruses (δ -CoV). SARS-CoV-2 belongs to the β-coronavirus and was first identified in China, in the city of Wuhan in December 2019. Bats are regarded as the primary reservoirs, and have been known to harbour more coronaviruses than any other species. They play an important role as the gene source in the evolution of these viruses. More so, there is the need for further studies with a view to identify the exact animal reservoir and host ranges for this virus.

SARS-CoV-2 pandemic is regarded as the third introduction of a highly pathogenic virus strain into the human population, following SARS, and MERS. The virus is mainly transmitted through body contact, respiratory droplets, potential route of faecal-oral and contact with other body fluids of an infected patients with or without clinical symptoms or incubation carriers. A single cough can circulate, about 3.000 droplets, which can land on nearby people, and other objects or surfaces around them, leaving smaller particles flying on air, which can proceed to infect others.

To-date, the molecular pathogenesis of COVID-19 is poorly understood. However, MERS-CoV and SARS-CoV mechanisms can shed light, as studies have sown similarities in the structure of both SARS-CoV-2 and SARS-CoV glycoprotein spikes with few structural differences in the Receptor-Binding Domain (RBD). After infecting human cells, the Disorders caused by SARS-CoV-2 includes both respiratory and systemic disorders, that is

characterised by a range of symptoms such as common cold, cough, high fever, and the inability to taste or smell. The various containment approach highlighted in this study, is aimed at minimising the current COVID-19 pandemic related pressure on the health systems in Nigeria, alongside, boosting the overall containment approach by the relevant authorities, saddled with the task of combating the pandemic in Nigeria.

10. Declarations of interest

Each author declares that he or she has no any conflict of interest in connection with this article, and take responsibility of the data and the accuracy of the data analysis.

11. Recommendations

Based on this research paper, immune system plays a vital role in overcoming SARS-CoV-2 infections. Therefore, frequent intake of immune boosting foods such as fruits and vegetables are highly recommended, in other to boost the immune system. It is highly recommended that the populace should adhere strictly to all the protocols laid down by the WHO, and NCDC as earlier stated, so as to cut down the disease transmission.

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