ABUAD INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES
ISSN: 2955-1021
AIJNAS Volume 3, Issue 2, 2023 pp 94-106
https://doi.org/10.53982/aijnas.2023.0302.13-j

https://journals.abuad.edu.ng/index.php/aijnas

AIJNAS

Epidemiology of Coronavirus, Impact and Sustainability Across Continents: A Report

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Abstract

The Covid-19 (coronavirus disease 2019) was caused by SARS-CoV-2, a highly pathogenic, novel zoonotic β-coronavirus. The infection was reported less than a decade after the outbreak of Middle East Respiratory Syndrome (MERS) in 2012, which was reported precisely a decade after SARS-CoV-1 infection, discovered in 2002; the three viruses being zoonotic β-CoVs, leading to severe and potentially fatal respiratory tract infections. COVID-19 started locally in Wuhan but has spread globally to 231 countries within the six habitable continents of the world as of September 22, 2023, affecting health, socio-lifestyle, and economy, leading to changes to accommodate sustainability. A total of 695, 684,448 cases have been recorded with 6,919,216 deaths and 667,700,972 recoveries as of September 2023. This is a global review across the continents of the world, highlighting the epidemiology and impact of the virus as well as human sustainability despite the pandemic.

Keywords*: COVID-19, SARS-CoV-2, Epidemiology, Global distribution, Impact, Sustainability*

INTRODUCTION

The novel coronavirus known as SARS-CoV-2 is the etiological agent of the disease termed coronavirus disease 2019 (COVID-19) (Lin *et al*., 2020). The disease has spread across all six (6) habitable continents of the world (Asia, Africa, Europe, North America, South America, and Oceania) and was declared a pandemic on March 11 2020 by the World Health Organization (WHO), who also gave it the name COVID-19 since the first cases were recorded late December 2019 (Young *et al*., 2020). Declaration of the disease by WHO as a pandemic was brought about by the 13-fold rise in the case number outside of China and a 3-fold increase in the number of affected countries (Cucinotta and Vanelli, 2020), because, initially, the SARS-CoV-2 outbreak was restricted to Asia and more specifically Wuhan city in China where it was then an outbreak of an ongoing viral pneumonia in 2019. The virus has spread across 231 countries and territories within the six continents. The virus is spreading globally, but the epidemiology and impact differ among continents, with Europe having the highest number of cases and deaths and Africa having the least as of September 22, 2023. Sharing information is crucial to determining the epidemiology, transmission, diagnosis, management, impact, and gaps in research across continents.

SARS-CoV-2: The Virus

Severe Acute Respiratory Syndrome coronavirus-2 (SARS-CoV-2) belongs to a group of viruses called coronavirus (Li *et al*., 2020). Coronaviruses (CoVs) are enveloped positive sense RNA viruses ranging from 60 to 140 nm in diameter with spike-like projections on their surface, giving them a crown-like appearance under the electron microscope; hence the name coronavirus (Richman *et al.,* 2016). The coronaviruses are the largest group within the Nidovirales, an order that comprises the families Coronaviridae, Arteriviridae and Roniviridae; the coronaviridae family is divided into two families- Torovirinae and Coronavirinae (Knipe and Howley, 2013), the latter to which SARS-CoV-2 belongs (McIntosh, 1974).

The subfamily Coronavirinae is divided into four genera - *Alphacoronavirus, Betacoronavirus, Gammacoronavirus and Deltacoronavirus* (α−/β−/γ−/δ-CoV). *Alphacoronaviruses* and *betacoronaviruses* only infect mammals. *Gammacoronaviruses and* *deltacoronaviruses* infect birds and sometimes mammals, including rodents and bats. *Gammacoronaviruses and Betacoronaviruses* are known to cause respiratory diseases in humans and gastroenteritis in animals (McIntosh, 1974).

There are seven Coronaviruses that are known to cause human disease, which is divided into low pathogenic and highly pathogenic variants: Four coronaviruses (HCoV 229E, NL63, OC43, and HKU1) are non-severe acute respiratory syndrome (SARS)-like Coronaviruses, causing mild symptoms including the common cold. The other three; novel zoonotic viruses are SARS-CoV-1 (discovered in 2002), the Middle East Respiratory Syndrome coronavirus (MERS-CoV, discovered in 2012) and SARS-CoV-2 (initially named 2019-nCoV) (Yin and Wunderink, 2018; Tu *et al.,* 2020) are highly pathogenic.

Epidemiology

Origin of SARS-CoV-2

The coronavirus pandemic broke out in Wuhan, China, in December 2019, and it was associated with a seafood market (Guo *et al*., 2020). Bats are the natural reservoirs of different CoVs, and studies have also suggested bats to be the potential reservoirs of SARS-CoV2 (Benvenuto *et al*., 2020; Giovanetti *et al*., 2020). Zhou *et al*. (2020) showed a 96.2% overall similarity in the genome (after complete sequencing of the COVID-19 etiological agent) to the Bat CoV RaTG13. Viral protein comparison between the two CoVs was also reported to be greater than 95% in similarity and identity, whereas this similarity is about 38% between Sars-CoV-2 and Sars-CoV (Mohammed, 2021). These two reports suggest that Bat CoV and human SARS-CoV2 might have the same ancestor, although bats are not sold in the seafood market where the virus originated (Wu *et al*., 2020). However, a recent metagenomics study has detected the most similar coronaviruses to SARS-CoV-2 in the Malayan pangolin (*Manis javanica*), one of the species presumably smuggled to the Huanan wet market in Wuhan (Tu *et al.,* 2020).

Transmission and Spread

SARS-CoV2 is transmitted majorly between people through routes such as respiratory droplet particles (which are > 5-10μm) and contact (WHO, 2014) and the former occurs when a person is in close contact about 1m with an infected person with or without respiratory symptom including coughing, or sneezing. Other routes that expose the uninfected respiratory outlets (mouth and nose) and eyes to infectious respiratory particles include speaking, singing, or breathing (WHO, 2020). It can also occur indirectly (Ong *et al*., 2020) through fomites, either in the immediate surroundings of the infected person (Ong *et al*., 2020; WHO, 2020) or through objects used on infected persons such as stethoscope and thermometer (Ong *et al*., 2020).

The airborne transmission was not reported in studies conducted in China (Chan *et al*., 2020; Huang *et al*., 2020; Li *et al*., 2020; Liu *et al*., 2020; WHO, 2020). However, in certain conditions and settings such as those that generate aerosols including endotracheal intubation, bronchoscopy, open suctioning administration of nebulized treatment, manual ventilation before intubation, turning the patients to the prone position, disconnecting the patients from the ventilator, non-invasive position, pressure ventilation, tracheostomy and cardiopulmonary resuscitation, airborne transmission is possible (WHO, 2020). The initial supposition of airborne transmission of SARS-CoV-2 was confirmed by numerous studies, reviewed by (Parvez et al., 2020). At the same time, some studies also suggest faecal-oral transmission (Parvez et al., 2020b; Yeo et al., 2020), rare sexual transmission (Masoudi et al., 2022), and vertical transmission from mother to child during birth that does not involve the amniotic fluid (Sánchez-García et al., 2022)

Pathogenesis and Complications

SARS CoV-2 uses the ACE-2 receptor found in some cells (such as the alveolar type 2 cells of the lungs and other extrapulmonary tissue such as the heart, intestine and kidney) (Zhang *et al*., 2020) to bind and gain entrance into such target cell. However, the binding success depends on the help of a host cell Furin protease known as the Transmembrane serine protease 2 (TMPRSS2). The TMPPRSS2 is responsible for priming the Spike protein (S protein) of the virus through cleavage at the spike (S) S1/S2 site (Hoffman *et al*., 2020). The S1 functions in the attachment of the virus to the ACE-2 receptor in the lungs, while the S2 protein serves as the stalk of the spike molecule and allows for the fusion of the virus membrane and the host cell membrane (Hoffman *et al*., 2020) and thus facilitates the virus entrance into the host cell.

The binding of the virus S protein to the ACE-2 receptor downregulates its expression in the lungs and this contributes to severe lung injury (Kuba et al., 2005) by interfering with the normal function of ACE-2. ACE-2 regulates the renin-angiotensin system (RAS) by aiding vasodilation through its cleavage of angiotensin II (ANG-II) a vasoconstrictor into angiotensin 1-7 (ANG 1-7) a vasodilator (Reudelhuber, 2005). Following the downregulation of the ACE-2 receptor, constriction (narrowing) of blood vessels in the lungs occurs (vasodilation is hindered) and this results in pressure build up in the blood vessels surrounding the alveolar type 2 cells of the lungs (where gas exchange takes place). Consequently, there is a reduction in blood flow through the lungs, and between the lungs and the heart (pulmonary hypertension). (Jin *et al.,* 2020; Shirbhate, *et al.,* 2021), therein lies the possibility that COVID-19 patients might suffer from pulmonary hypertension.

However, in the infection by SARS CoV-2, pulmonary hypertension is not the only case, as lung injury also occurs as earlier stated, which results in part from continued vasoconstriction in the blood vessels of the lungs and from ARDS (acute respiratory distress syndrome). This has been reported to be part of the symptoms of COVID-19 especially in old people and those with underlying conditions such as hypertension, chronic obstructive pulmonary disease, diabetes, and cardiovascular disease (Huang *et al*., 2020). Another characteristic is lung inflammation (pulmonary edema) (Roch *et al*., 2011), which is due to the raised level of angiotensin II (ANG II) causing leakage/seepage of fluid from the blood vessels (capillaries)(vascular permeability) (Fyhrquist and Saijonmaa, 2008) that are found around the air space (alveolar) of the lungs into this alveolar, causing lung inflammation (Fyhrquist and Saijonmaa, 2008) and this is one/major cause of mortality in SARS-COV2 infection. The leakage or seepage of fluids from the blood vessels is as a result of constriction and consequently pressure buildup in the blood vessels. This whole process contributes to lung injury in the disease caused by SARS-COV2 referred to as COVID-19.

Diagnosis

The recommended method for the identification and laboratory confirmation of any COVID-19 case is molecular examination of respiratory samples collected from patients using the reverse transcriptase polymerase chain reaction RT-PCR (WHO, 2020). Point of care immunodiagnostics which proves to be more rapid than the conventional RTP-PCR is only allowed for use in research settings for disease surveillance as well as epidemiological studies, but not in making clinical decision (WHO, 2020). The use of RT-PCR kit however requires costly equipment, trained persons to handle it, and even more time before the result is obtained (Kashir and Yaqinuuddin, 2020). Although RT-PCR remains the recommended standard for diagnosis of COVID-19 cases by WHO, the inability to rapidly diagnose infected patients with this method due to the high false negative results (Chan *et al*., 2020) and because it is not applicable in the initial phase of the disease (Zu *et al*., 2020) was a limitation.

Development of rapid, convenient, accurate, and efficient testing kits was of great importance as it enhances testing capacity worldwide, consequently helping to unravel asymptomatic cases thus reducing the spread of COVID-19 by this means (Bendavid *et al*., 2020). It also cancels out unwarranted isolation of COVID-19-negative persons and continued transmission of the virus by positive individuals since efficient testing help to separate COVID-19 patients from those with some other illness but similar symptom. As well, COVID-19 patients who might possibly develop more serious complications are quickly identified by doctors via early diagnosis of their state i.e. whether they are positive or not (Carter *et al*., 2020).

Some other assays apart from the RT-PCR have been developed to aid rapid diagnosis of COVID-19 cases:

Molecular Assay

Isothermal Nucleic acid Amplification

Isothermal Nucleic acid Amplification amplifies nucleic acid present in the sample at a constant temperature (Notomi *et al*., 2000), thus eliminating the requirement for a thermal cycler as seen in RT-PCR reaction. As a result of this, different methods that operate on this principle have been developed including Reverse Transcription Loop-mediated isothermal amplification (RT-LAMP), Transcription-Mediated Amplification (TMA), CRISPR-Based Assays, and Rolling Circle Amplification (Carter *et al*., 2020).

Reverse Transcription Loop-mediated isothermal amplification (RT-LAMP)

RT-LAMP uses 4 different primer sets that recognize a minimum of 6 different sequences on the SARS-CoV-2 RNA accounting for its specificity (Kitagawa *et al*., 2020) and when the performance of the RT-LAMP kit was compared with the conventional RT-PCR kit, a 97.4% (74/76) agreement was obtained with 32 patients out of the 76 patients tested showed positive (44 negative) with RT-LAMP while the RT-qPCR test showed that 30 were positive and 46 were negative for the virus. Although diagnosis with the RT-LAMP kit looks promising, Kitagawa *et al*. (2020) reported that limitation still exists due to the small sample size used and the lack of validation of whether there exists cross-reactivity with other respiratory agents.

Other molecular assays that have been developed include Nucleic Acid Hybridization Using Microarray and Amplicon-Based Metagenomic Sequencing (Carter *et al*., 2020).

Serological Assays

Different serological assay with high throughput has also been developed by various diagnostic companies (Carter *et al*., 2020). These serological assays are also being used not just to track the stages of disease progress but also to identify those who were previously exposed/ infected as well as cases of immunity, hence useful for epidemiological study, unlike the RT-PCR which can only be used for diagnosis of COVID-19 cases (Carter *et al*., 2020). The serological assay involves the analysis of appropriate samples such as serum or plasma and in this case even saliva, sputum, and other body fluid to detect either immunoglobulin M (IgM) which is a marker seen at the early stage of the infection, or immunoglobulin G (IgG) which indicates prior or current infection, and this can also infer post-infection immunity (Carter *et al*., 2020).

(a) **Enzyme-linked immunosorbent Assay (ELISA)**
This assay involves the use of viral protein-coated microplate wells to which antibodies generated against the SARS-CoV-2 virus if present in the patient sample bind to specifically, producing a resultant antigen-antibody complex that can be easily detected when a tracer antibody is added, thus generating a colorimetric or fluorescent-based readout (Carter *et al*., 2020).

(b) **Rapid Antigen Test**
This test helps the rapid detection of viral antigens in samples collected from individuals. This is achieved with the aid of monoclonal antibodies that capture the viral proteins if present in a patient sample. This test is however not limited to a specific format. An example is the recent development of fluorescence lateral flow assay (Diao *et al*., 2021) that can detect the nucleocapsid protein of SARS-CoV-2 (Yang and Sun, 2005)

(c) **Luminescent Immunoassay**
A magnetic chemiluminescence enzyme immunoassay which is peptide based was developed by Cai *et al*. for detection of SARS-CoV-2. Also, two fully automated serological test that uses the Diazyme DZ-LITE 3000 fully automated chemiluminescence analyzer was also declared to be available by Diazyme Laboratories, Inc. located in San Diego, California (Carter *et al*., 2020).
Other serological tests developed include Neutralization assay, Biosensor test, Lateral Flow immunoassay (Carter *et al*., 2020).

Global distribution
COVID-19 has spread across six continents of the world from the time it was first discovered in Wuhan till date. After it was declared a pandemic, as of September 22, 2023, a total of 695, 684,448 cases have been reported globally. Presently, the total number of laboratory-confirmed cases is 117 times the original case number reported as of March 26, 2020 (472,529 cases globally), with 6,919,216 deaths, 667,700,972 recoveries, and 21,064,260 (Mamoon and Rasskin, 2023).

The global distribution of COVID-19 by continent as of September 23, 2023, shows that Europe has the highest number of cases, followed by Asia, South America, Oceania, and Africa having the least number of cases (Fig.1). There has been a sharp decline in the number of new cases and deaths, while recovery has greatly increased from 2021 to 2023 representing 96% recovery (total recovery as at the time of data retrieval is 667,700,972) globally as at September 2023 (Mamoon and Rasskin, 2023). The decline in new cases has been attributed to the administration of the COVID-19 vaccine due to herd immunity. The WHO has grouped the affected countries into continents with regions and territories (Europe, Americas, Africa, Eastern Mediterranean, South-East Asia, and Western Pacific) with situations in number. The distribution of cases by continent is shown in Fig 2A-F. The rate of spread of the virus from January to May across these WHO regions is depicted in Fig.3.

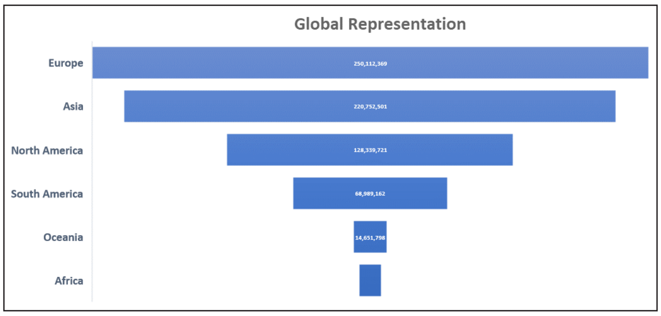
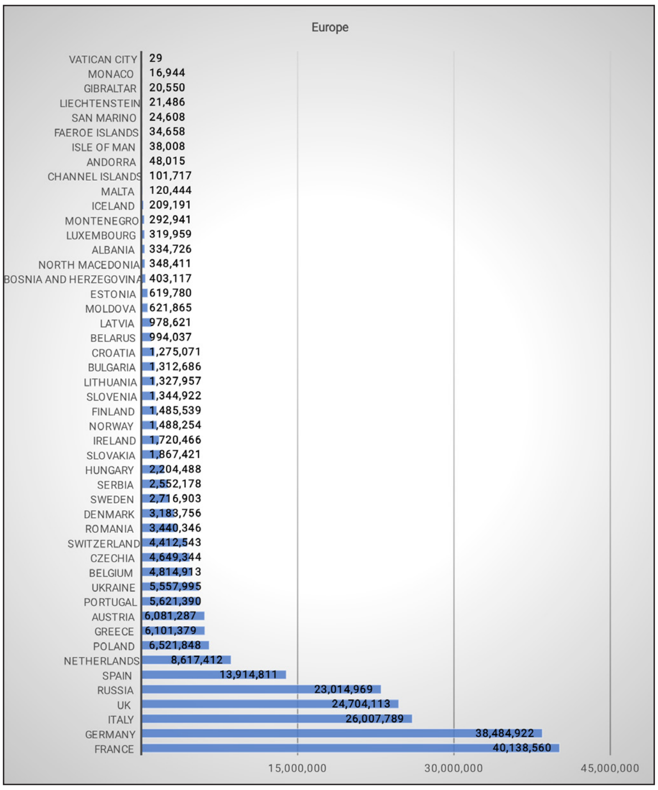
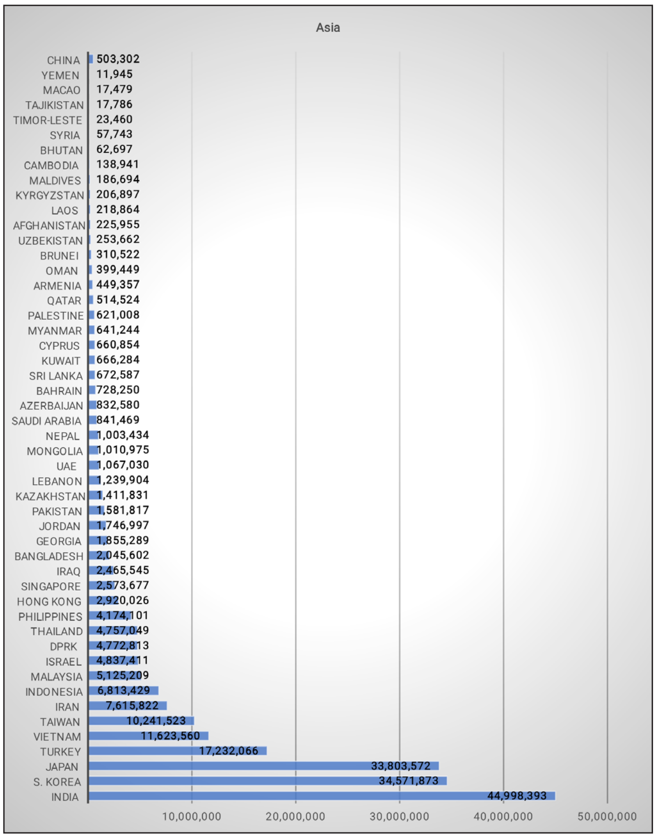


Fig 1: Global accumulative cases of laboratory-confirmed cases of 2019 coronavirus disease (COVID-19) by continents as of September 2023.

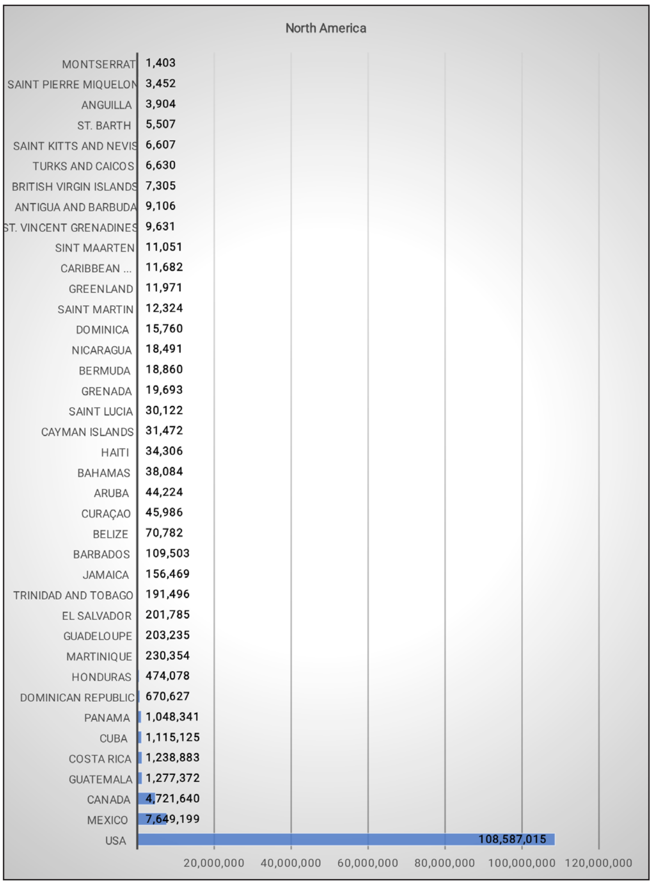
(A)


Europe
VATICAN CITY 29
MONACO 16,944
GIBRALTAR 20,550
LIECHTENSTEIN 21,486
SAN MARINO 24,608
FAEROE ISLANDS 34,658
ISLE OF MAN 38,008
ANDORRA 48,015
CHANNEL ISLANDS 101,717
MALTA 120,444
ICELAND 209,191
MONTENEGRO 292,941
LUXEMBOURG 319,959
ALBANIA 334,726
NORTH MACEDONIA 348,411
BOSNIA AND HERZEGOVINA 403,117
ESTONIA 619,780
MOLDOVA 621,865
LATVIA 978,621
BELARUS 994,037
CROATIA 1,275,071
BULGARIA 1,312,686
LITHUANIA 1,327,957
SLOVENIA 1,344,922
FINLAND 1,485,539
NORWAY 1,488,254
IRELAND 1,720,466
SLOVAKIA 1,867,421
HUNGARY 2,204,488
SERBIA 2,552,178
SWEDEN 2,716,903
DENMARK 3,183,756
ROMANIA 3,440,346
SWITZERLAND 4,412,543
CZECHIA 4,649,344
BELGIUM 4,814,913
UKRAINE 5,557,995
PORTUGAL 5,621,390
AUSTRIA 6,081,287
GREECE 6,101,379
POLAND 6,521,848
NETHERLANDS 8,617,412
SPAIN 13,914,811
RUSSIA 23,014,969
UK 24,704,113
ITALY 26,007,789
GERMANY 38,484,922
FRANCE 40,138,560
15,000,000
30,000,000
45,000,000

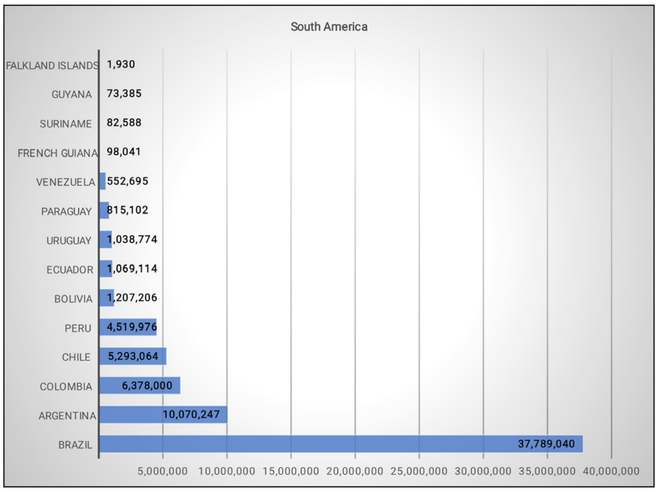
(C)


Asia
CHINA 503,302
YEMEN 11,945
MACAO 17,479
TAJIKISTAN 17,786
TIMOR-LESTE 23,460
SYRIA 57,743
BHUTAN 62,697
CAMBODIA 138,941
MALDIVES 186,694
KYRGYZSTAN 206,897
LAOS 218,864
AFGHANISTAN 225,955
UZBEKISTAN 253,662
BRUNEI 310,522
OMAN 399,449
ARMENIA 449,357
QATAR 514,524
PALESTINE 621,008
MYANMAR 641,244
CYPRUS 660,854
KUWAIT 666,284
SRI LANKA 672,587
BAHRAIN 728,250
AZERBAIJAN 832,580
SAUDI ARABIA 841,469
NEPAL 1,003,434
MONGOLIA 1,010,975
UAE 1,067,030
LEBANON 1,239,904
KAZAKHSTAN 1,411,831
PAKISTAN 1,581,817
JORDAN 1,746,997
GEORGIA 1,855,289
BANGLADESH 2,045,602
IRAQ 2,465,545
SINGAPORE 2,573,677
HONG KONG 2,920,026
PHILIPPINES 4,174,101
THAILAND 4,757,049
DPRK 4,772,813
ISRAEL 4,837,411
MALAYSIA 5,125,209
INDONESIA 6,813,429
IRAN 7,615,822
TAIWAN 10,241,523
VIETNAM 11,623,560
TURKEY 17,232,066
JAPAN 33,803,572
S. KOREA 34,571,873
INDIA 44,998,393
10,000,000
20,000,000
30,000,000
40,000,000
50,000,000

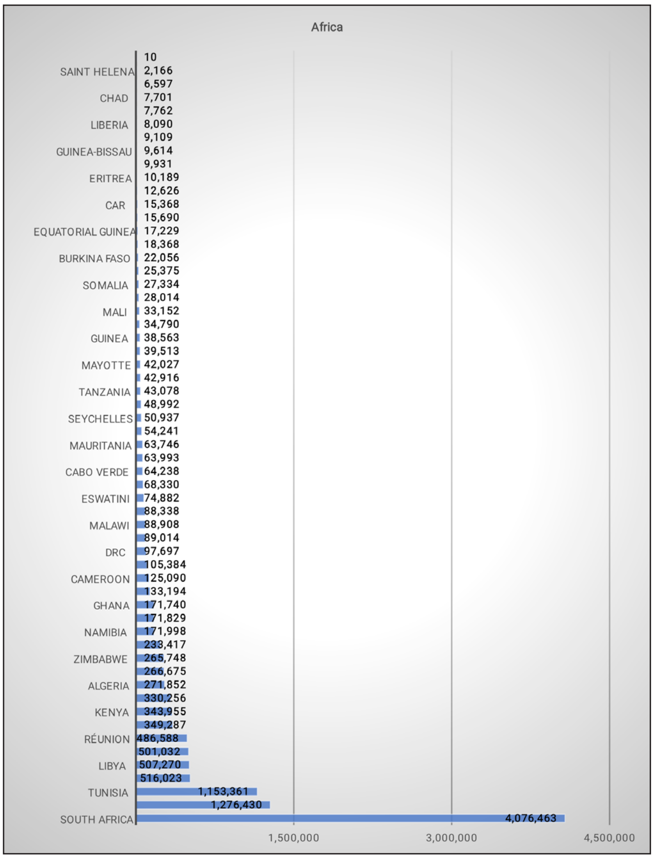
(B)


North America
MONTSERRAT 1,403
SAINT PIERRE MIQUELON 3,452
ANGUILLA 3,904
ST. BARTH 5,507
SAINT KITTS AND NEVIS 6,607
TURKS AND CAICOS 6,630
BRITISH VIRGIN ISLANDS 7,305
ANTIGUA AND BARBUDA 9,106
ST. VINCENT GRENADINES 9,631
SINT MAARTEN 11,051
CARIBBEAN ... 11,682
GREENLAND 11,971
SAINT MARTIN 12,324
DOMINICA 15,760
NICARAGUA 18,491
BERMUDA 18,860
GRENADA 19,693
SAINT LUCIA 30,122
CAYMAN ISLANDS 31,472
HAITI 34,306
BAHAMAS 38,084
ARUBA 44,224
CURAÇAO 45,986
BELIZE 70,782
BARBADOS 109,503
JAMAICA 156,469
TRINIDAD AND TOBAGO 191,496
EL SALVADOR 201,785
GUADELOUPE 203,235
MARTINIQUE 230,354
HONDURAS 474,078
DOMINICAN REPUBLIC 670,627
PANAMA 1,048,341
CUBA 1,115,125
COSTA RICA 1,238,883
GUATEMALA 1,277,372
CANADA 4,721,640
MEXICO 7,649,199
USA 108,587,015
20,000,000
40,000,000
60,000,000
80,000,000
100,000,000
120,000,000

(D)


South America
FALKLAND ISLANDS 1,930
GUYANA 73,385
SURINAME 82,588
FRENCH GUIANA 98,041
VENEZUELA 552,695
PARAGUAY 815,102
URUGUAY 1,038,774
ECUADOR 1,069,114
BOLIVIA 1,207,206
PERU 4,519,976
CHILE 5,293,064
COLOMBIA 6,378,000
ARGENTINA 10,070,247
BRAZIL 37,789,040
5,000,000
10,000,000
15,000,000
20,000,000
25,000,000
30,000,000
35,000,000
40,000,000

(E)



(F)

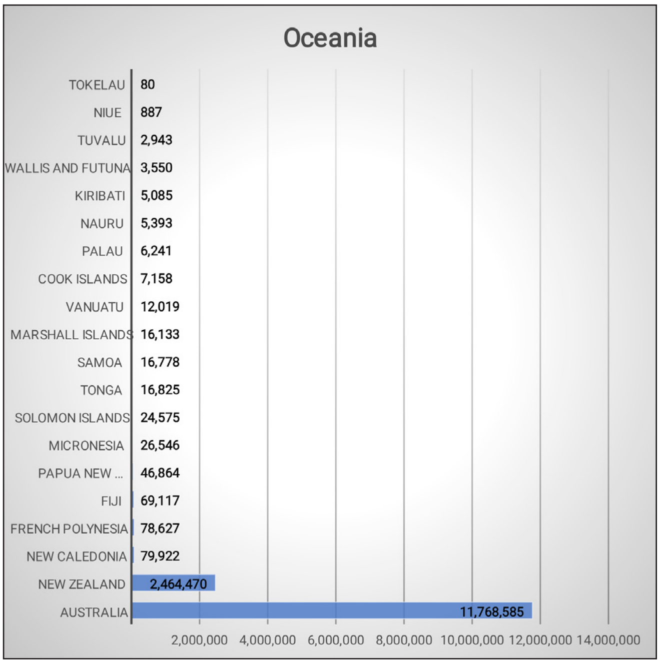


Fig 2: Accumulative cases of laboratory-confirmed cases of COVID-19 in different continents as of September 23, 2023 (A) Europe (B) north America (C) Asia (D) South America (E) Africa (F) Oceania

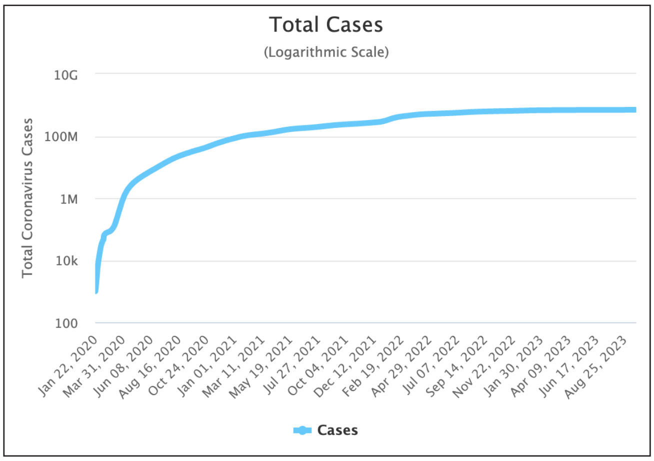


Fig 3a: Logarithmic scale of total confirmed cases of COVID-19 from January 22, 2020, to August, 2023 (Source: Worldometers.info)

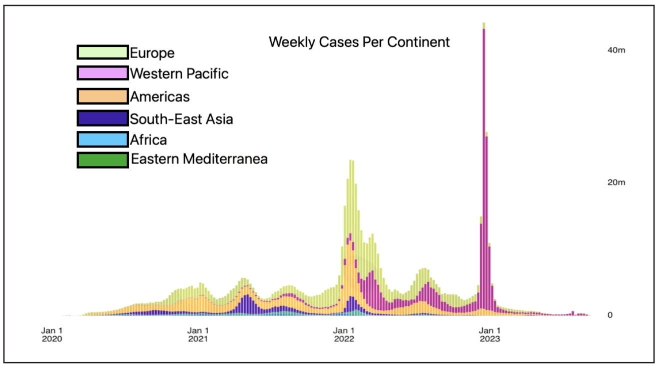


Fig 3b: Number of confirmed COVID-19 cases by month of report and WHO region (2020 to 2023)

Impact of the virus

During the heat of the coronavirus pandemic, so many sectors of the economy were affected, resulting from the stay-at-home directives declared in different countries across the world to reduce the spread of the virus. This directive greatly affected various sectors including the sport industry, aviation, entertainment industry etc., since people were not allowed to gather in mass (Elliot, 2020; Horowit, 2020), a consequence of social distancing directives. as- As COVID-19 concerns grew and increased beyond China, travel restrictions to other countries affected by the COVID-19 were imposed by government and this affected not only the tourism industry but also the aviation industry. The tourism industry worldwide alone recorded more than $200 billon loss (excluding the loss of revenue for tourism travel) while a loss of $113 billion was foretold by the International Air Transportation Association (IATA) Ozili and Arun (2020).

The pandemic which brought about the stay-at-home order also led to the temporary closure of restaurant, resulting to laying off some staff and an estimated job loss of 24.3 million (with 3.9 million alone in the US) recorded globally. Many hotels in the US, UK and European countries announced the temporary hold of normal operations (Ozili and Arun, 2020).

Similarly, the decline in economic activity and constraints on people's movements because of the lockdown had an impact on both manufacturing and services. Global and regional supply chains were disrupted. For instance**,** in China, data shows that the total value added of industrial enterprises in China declined by 13.5 percent during the first two months of 2020 (Randewich, 2020). In financial markets, global stock markets erased about US$5 trillion in wealth in one week from 24 to 28 of February. Randewich (2020) reported that the rapid spread of coronavirus and its impact on the global economy deepened in March 2020 with the collapse of oil prices which evaporated over $5 trillion of the S&P 500's market value (Randewich, 2020).

Not left out in the impact of the pandemic was the supply chain across the globe, which was greatly hampered, preventing circulation of goods from the production centers or country to where they are needed. A case of this was seen in the disruption in the flow of raw materials from Chinese plants to several parts of the world and to China from other countries. The European countries were not left out in the disruption of the supply chain because of various measures put in place to control the spread of the virus (Zhu *et al.,* 2020). Consequently, medical and food supplies which are of utmost importance during the pandemic were in shortage in various parts of the world, especially developing African countries which are import-dependent, hence, witnessed shortages of crucial supplies like pharmaceutical supplies, spare parts, and finished goods from China.

As part of the impact of the pandemic, sports activities ranging from football, Formula One, hockey, golf, snooker, and rugby were suspended or postponed since people could not gather as sports spectators due to the stay-at-home directives, resulting in a huge loss in the sports industry as well as for the sponsors and organizers of the games canceled (Ozili and Arun, 2020).

In the academic sector, in response to the declaration of coronavirus as a pandemic, colleges and higher institutions of learning were directed to shut down. This occurred in part in the US and Australia and completely in Israel, Nigeria, Italy, France, and Spain among other countries. The consequence of the shutdown was however more severe for schools that lacked the capacity to set up a platform for online learning, and an estimated 290.5 million student learning was affected because of the outbreak worldwide according to UNESCO (Ozili and Arun, 2020).

Areas for global research focus

The following chemotherapeutic measures were suggested at the early stage of the pandemic to be promising in mitigating the pathology of the virus and other future viral pandemics that focus on the lung/cardiovascular system.

The use /delivery of an excessive soluble form of recombinant ACE-2 protein

The use of the excessive soluble form of recombinant ACE-2 protein may competitively bind to SARS-CoV2 (Zhang *et al*., 2020), thereby neutralizing the virus and thus rescuing the cellular ACE 2 activity as well as making it available to negatively regulate the RAS system to protect the lung from injury (Zhang *et al*., 2020; Zhou et al., 2020).

The use of drugs that aid vasodilation:* Angiotensin II (*ANG II*) *inhibitors/AT1 receptor blockers.

Since vasoconstriction of the blood vessels in the infected tissue seems to be a challenge resulting from the downregulation of the ACE-2 receptors on the targeted host cell and upregulation of ANG II by ACE, drugs that aid/enhance vasodilation or reduce the ANG II levels can be put in place. This may likely improve the blood flow rate into and out of the lungs and also reduce vasoconstriction of the blood vessels which could have (if not put in place) triggered the seepage of fluid from it into the surrounding tissue causing edema and impairing lung function (Imai *et al*., 2005). This can be achieved using ANG II suppressor/inhibitor or AT 1 receptor inhibitor (ANG II type 1 receptor) (the AT 1 receptor is found on ANG II) (Imai *et al*., 2005), since ANG II is a vasoconstrictor, if it is suppressed, it favors the treatment and consequently vasodilation.

Thoracentesis

Thoracentesis which is a procedure to remove fluid or air as the case may be from the lungs can be carried out on those with pulmonary edema to reduce the lung fluid (drain the pleural effusions). This drainage appears to improve oxygenation (this will increase airflow into the alveolar and aids gas exchange) and is safe in mechanically ventilated patients (Goligher *et al*., 2011). This process can however not be done in isolation since the most effective treatment of pulmonary edema is treatment of the underlying cause and the approaches reveal ways by which this can be achieved, without which a recurrence of pulmonary edema will persist.

Use of Transmembrane serine protease 2 (TMPRSS2) Inhibitor

The TMPRSS2 inhibitor will also help to reduce the chances of successful virus entry into the target host cell since the TMPRSS2 is involved in the initial priming of the spike protein of the virus (Hoffman *et al*., 2020) without which, viral entry and even spread from cells to cells in the affected tissue via interaction with ACE2 protein (Iwata-Yoshikawa *et al*., 2019) becomes impossible.

Sustainability

The COVID-19 pandemic brought about a strutting economy, bringing the world to a verge of recession greater than that of the financial crisis that occurred in 2008 leading to the suspension of different activities both economic and social (Masters, 2020). This consequently affected different sectors including the sports industry, aviation, and entertainment industry, since people were not allowed to gather in mass (Elliot, 2020; Horowit, 2020), a consequence of social distancing directives. However, the effect of the outbreak, the global spread of the coronavirus, and the adverse effect on the economy worldwide have varying degrees of impact across the countries. This is because of the sustainability measures adopted by such countries, aided by the structural factors on the ground in different countries represented on the globe.

There was an outset of some economic activities in some parts of the world where prompt proactive measures were taken to limit the spread of the coronavirus as well as countries where sustainable measures were put in place, even though they've recorded a high number of confirmed cases. Despite the pandemic challenge, technological solutions have been used as a tool for policy adaptation to keep the wheels of the economy rolling in some developed countries.

Despite the pandemic, innovations were quickly budding both technologically and business-wise. Companies such as L'Oréal and Coty among others started the production of hand sanitizers by diverting facilities that were meant for fragrances and hair gels. This move was however bi -functional such that they were not only producing materials that could save lives but also maintaining jobs since workers were involved.

In the area of production of medical equipment, production of hospital beds, personal protective equipment (PPE), ventilators, etc. by companies with limited experience, there were also measures for sustainability during the period. The production of locally made equipment (such as face masks) which can be used in preventing the spread of the virus as well as treatment of infected persons was produced by governments of various countries and companies around the world. Examples include low-cost locally-made ventilators produced by engineering students in Kenya which were done in collaboration with the medical department at Kenyatta University with an estimated price of $10,000 (Wanjiku and Wanyua, 2020). In Germany, donation of medical equipment across Germany including gloves, thermometer, protective googles, and breathing masks were reported to be about £40 million in worth by Volkswagen Group who were also engaged in the production of medical equipment for areas that have need of them using their company facilities including 3D printing mountings for face shields among others (Clift and Court, 2020).

Furthermore, shopping malls and high streets were re-strategized to limit the impact of the pandemic by changing from multi-channel/omni-channel delivery (Wollenburg *et al*., 2018) to entirely digital (online) trading by employing digital technologies as well as in logistics service providers to make home deliveries. This was however not limited to malls but automobile companies also adopted online trading activities (i.e., virtual means to satisfy the needs of their buyers since many showrooms were also closed and low foot traffic was experienced).

The long-distance learning approach was reinforced mostly by the governments of developed countries to reduce the impact of the pandemic on the educational system, and according to Li and Lalani (2020), it led to several e-learning platforms being made accessible, one of which was a Bangalore-based educational technology and online tutoring firm called BY JU'S which was established in 2011 and other video conferring platform which saw the light of the day, such as Zoom and Microsoft Teams. In the United States (which had the highest number of confirmed cases as at then), Europe and some parts of Asian, online platforms were being used to keep students academically active while conferences and workshops were been held in the virtual world. This was easily achieved because of their robust digital economy coupled with cheap and easy access to the World Wide Web by the general citizens unlike in developing countries where the cost can only be afforded by the minority. Therefore, this should call the attention of the developing nations to prioritize e-learning and robust digital investment. Consequently, after the COVID-19 pandemic ended, online education fully came to stay (Li and Lalani, 2020).

The healthcare system also came under a lot of stress following the coronavirus pandemic (Clift and Court, 2020), however, several sustainability approaches were reported to be explored in different countries across the continents to handle the sudden stress on the healthcare system. These include the building of pop-up clinics and make-shift hospitals in different countries across the continents in a bid to accommodate more patients, an example is London's Excel exhibition center in the United Kingdom which was converted to a 4000-capacity makeshift hospital supported with both ventilators and oxygen (Clift and Court, 2020). As many doctors, nurses, disinfectants, and medical equipment were needed, connection of the medical facilities to the internet became vital as many life-saving equipment relies on wireless connectivity to function. Thus, safe, and secure Wi-Fi connection became important and vital to the healthcare system to deliver healthcare services effectively (Clift and Court, 2020).

The Hewlett Packed Enterprise (HPE), a networking framework that saw to Wi-Fi connection need in health care system not only donated a secure connectivity kit worth 50 million US dollars for use in the US, Canada, some European countries, and in Asia but also actuated a group of more than 200 infrastructure engineers who volunteered their time to building the networking infrastructure needed in the health care facilities fighting COVID-19 (Clift and Court, 2020). Top manufacturers in 3D printing that were leading globally including but not limited to HP, Johnson & Johnson, General Electric and Royal DSM also responded to the increasing medical demands, joining hands together via the forum's rapid Response Initiative to meet the global needs to address the issue of inadequate equipment. It ranged from manufacturing personal protective equipment (PPE) for medical staff and patients, sample swabs, 3D printing and medical equipment, valves, adapters, connectors, splitters, face shields, and durable thermoforming tools which facilitate quicker production of N95 masks required more by medical staff treating COVID-19 patients to fight the coronavirus pandemic (Clift and Court, 2020).

Due to the restrictions on traveling in some parts of China, a drone delivery system was engaged and an e-commerce giant was involved in the delivery of essential goods across China using drones (Hsu, 2022). For example, in Hebei province where boat was the routine means of delivery to the village, drone service vis the drone route developed by JD. Com was employed to drop packages for customers at designated points so they could come for their goods, thereby preventing human-human contact (Clift and Court, 2020). These drones were also employed to enhance the disinfection process in inner Mongolia where High-Tech Industrial Development zones were sprayed (disinfected). The advent of the drone also reduced long-hour drives as many drone delivery corridors were put in place, thus enhancing the possibility for a 2km drive to be completed in ten minutes (Clift and Court, 2020).

The effect of the pandemic on the economy was padded by the government of different countries using monetary and fiscal policy measures which include: One, flexibilities in loans being serviced by extending the duration and reducing the interest rate. Two, providing fund support to some economic sectors to reduce the degree of business shutting down. Furthermore, the enforcement of the WHO guidelines on safety precautions by the government on companies, banks, and small-scale businesses was employed by some African countries which include Nigeria, to keep them passively running.

Also, different humanitarian organizations by individuals, families, and companies provided various sustainable approaches during the pandemic. Refugee camps threatened by the pandemic were not left out. One of such is the €1 million donation by Volkswagen Group to the refugees faced with the pandemic. The fund was been managed by the German Red Cross to cater for funds needed to attend to emerging needs in Syria, Turkey, and Greece, as well as to source, transport and share relief materials and food (Clift and Court, 2020).

There was a network of cooperation, more than ever before between various companies and governments in such countries, and between countries to fight the coronavirus pandemic with various entities contributing their quota to fight this pandemic, recognizing that the fight was not just left to the health sector to deal with.

CONCLUSION

This article has provided a global review of the COVID-19 pandemic, including the aetiological agent, the epidemiology, pathogenesis, diagnosis, and the global distribution among others. We also suggested areas of research focus to moderate the effect of the virus on the lung/cardiovascular system, the information which if worked upon could provide a significant impact on the public health system. Considering the impact of COVID-19 globally, this paper provides a review of the global distribution, impact, and means of sustainability explored during the pandemic, and suggests areas for global research focus that could be adapted by different countries and help in policy-making decisions.

Funding: None.

Conflicts of interests: We declare no conflicts of interest.

Ethical approval: Not required.

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