Análisis cienciométrico de COVID-19: una base para desarrollar una teoría general de la pandemia desde la perspectiva de las comunicaciones académicas

Scientometric analysis of COVID-19: A basis for developing a general theory of pandemic from scholarly communications perspective

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Resumen

Este estudio realizó un análisis cienciométrico de la pandemia de COVID-19 con el objetivo de proporcionar una base para desarrollar una teoría general de las pandemias desde una perspectiva de las comunicaciones académicas. Para lograrlo, el estudio buscó responder a una sola pregunta: ¿Cómo se relacionan entre sí el conocimiento, la innovación y el medio ambiente durante una pandemia? Carayannis y Campbell (2010) plantearon una pregunta similar desde una perspectiva diferente, y este estudio se basa en ella al intentar proporcionar un marco en caso de que ocurra otra pandemia. Para comprender el comportamiento de publicación de los académicos durante el período de cinco años de 2019 a 2024, los autores analizaron datos extraídos de Scopus entre el 18 y el 28 de agosto de 2023. La estrategia de

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búsqueda utilizada fue "COVID-19 OR Coronavirus OR Coronaviruses OR SARS-CoV -2 O 2019-nCoV". La búsqueda arrojó 511.920 resultados, de los cuales 17.487 se utilizaron para este estudio. Se descubrió que muchos países de todo el mundo formaban seis grupos. Como resultado, los investigadores de estos países continuaron produciendo importantes resultados de investigación, lo que generó un gran número de citas y mejoró su posición dentro de las comunicaciones académicas. Un hallazgo interesante de esta investigación reveló temas nuevos y relevantes, lo que llevó a los autores a vincular estos hallazgos con la teoría de la quíntuple hélice. El estudio recomendó utilizar modelos empíricos y teóricos para desarrollar teorías que puedan definir mejor las pandemias.

Palabras clave: pandemia de COVID-19, análisis cienciométrico, comunicaciones académicas, teoría, teoría de la quíntuple hélice

Abstract

This study conducted a scientometric analysis of the COVID-19 pandemic with the aim of providing a foundation for developing a general theory of pandemics from a scholarly communications perspective. To achieve this, the study sought to answer a single question: How do knowledge, innovation, and environment relate to one another during a pandemic? Carayannis and Campbell (2010) posed a similar question from a different perspective, and this study builds on that by attempting to provide a framework in case another pandemic occurs. To understand the publication behavior of scholars over the five-year period from 2019 to 2024, the authors analyzed data extracted from Scopus between August 18 and 28, 2023. The search strategy used was "COVID-19 OR Coronavirus OR Coronaviruses OR SARS-CoV-2 OR 2019-nCoV." The search yielded 511,920 results, of which 17,487 were used for this study. It was found that many countries around the globe formed six clusters. As a result, researchers from these countries continued to produce significant research outputs, leading to a high number of citations and enhancing their position within scholarly communications. An interesting finding of this research revealed new and relevant topics, prompting the authors to link these findings with the quintuple helix theory. The study

recommended using empirical and theoretical models to develop theories that can further define pandemics.

Keywords: COVID-19 pandemic, scientometric analysis, scholarly communications, theory, quintuple helix theory

Introduction

Pandemics are a critical cornerstone that paves the way for the introduction of new knowledge and technologies, emergence of innovative methodologies or tools, and necessity to anchor new with old normal in all ramifications. That is why research in health security is continually becoming an important component in knowledge industry and healthcare sector taking into cognizance the emerging and reemerging infectious disease outbreaks globally. With the current COVID-19 scenario, many researchers and stakeholders are exceptionally becoming more inclined towards research that informs theory and practice for unraveling the uncertainties inherent thereby providing capable strategies that predict epidemics/pandemics using surveillance technologies especially through collaboration between digital and traditional infectious disease surveillance systems and communicating clearly model uncertainties (Desai et al., 2019).

This might have emanated from the fact that, humans are in a fortress—surrounded by multiple and various strains of microbes most of which desire animal or human population as a reservoir for their propagation. These microbes commonly aided by agent mobility such as human—rotate in causing afflictions in society either through direct or indirect contact—that result in endemic, epidemic or pandemic depending on the severity of the disease, type of organisms involved, prevailing conditions, response by stakeholders, among others. This is to say that, neither the human population nor microbial geochemical processes are stationary rather they are always dynamic and in transition supported by human migration. That is, the microbial world proliferates in an unprecedented way, hard to be identified, possesses different capacities to transmit diseases (Malik et al., 2020) depending on the prevalent

conditions such as physico-chemical parameters to the extent skipping the sight of most epidemiologists. This is why forecasting emerging and reemerging infectious disease outbreaks is critical for resource allocation and preparedness planning (Desai et al., 2019).

This is true as the human population might have already been susceptible to one form or another of previous pandemic thereby developing population immunity to that etiologic agent. This means that, when another pandemic comes up, it mostly affects the immuno-compromised or suppressed fractions of the population easily. That is why, infectious diseases remain the most recurring public health hazard necessitating increased local, regional, and global health systems' surveillance for protecting health but confronted strongly by existing and emerging infectious diseases (Malik et al., 2020). The COVID-19 pandemic has reminded the contemporary society that, when a pandemic erupts, what mostly resonates within the minds of stakeholders revolve around two categories "*health, safety, treatment and economy, security, freedom of the population*" (Manca, 2022, p. 1639). This signals the structure (or its equivalent the stakeholders) to rearrange or realign its policies to tally with the requirements of meeting the pandemic at the earliest before it affects one or all of the mentioned categories. Even though, there is a general observation concerning "*a lack of continuity [in] research [on] epidemic following a disease epidemic*" (Malik et al., 2020, p. 310), COVID-19 pandemic still lingers within the realms of scholarly community. Notably, the COVID-19 pandemic has caused many prolonged emergencies in hospitals necessitating governments to call for prompt and responsible decisions. This is attributable to the fact that, at the onset of the pandemic, there was no attention paid to the outbreak dynamics rather the allocation of resources to hospital wards and ICU as "*the doubling time of infected, hospitalized, intubated, and dead individuals were unprecedented and often as short as two-three days*" (Manca, 2022, p. 1639). From another viewpoint, the virus has affected social wellbeing, society, economy the worst since World War II, and disrupted food supply with long-term consequences (Okolie & Ogundeji, 2022).

This resulted in policymakers became interested in knowing the time evolution and intensity of the outbreaks, which made information world to focus on pandemics and any information

that could assist in *predicting, quantifying, and assessing* the components of the structure. In this way, *mass media urged any updated and analyzed pandemic data* (Manca, 2022). As Giddens, (1984) cited by Gilani, (2020) posits that, "*accelerated/intensified social reflexivity may more easily affect and change the conditions imposed by social structures/structural forces around the world*".

To begin with, at the onset of the pandemic, questions asked were for short- and medium-term plans respectively focusing on probabilities, predictions, resources allocations, pressure, etc., and non-pharmaceutical protective actions, which encompassed masks, lockdowns, social distancing, to mention but a few. This prompted hospitals and governments to call for a quantitative prediction for a long-term plan to contain the virus (Manca, 2022). This also agrees with the submission of He et al., (2023, p. 2) that non-pharmaceutical interventions (NPIs) are a measure put in place "*to break infection by altering key aspects of our behavior*".

Perhaps this has to do with the fact that, when a pandemic breaks out, "*we have this kind of tunnel vision, trying to focus on one thing instead of looking more broadly and creatively*" (Gao et al., 2021 cited in Lewis, 2021). That is why many researchers from different domain perspectives—AI, economics, physics—championed in contributing to the solution of the varied clinical and societal challenges posed by the pandemic (Cunningham et al., 2021). To be precise, by January 2021, there were about 166,000 COVID-19-related research, which implies a period of scientific productivity (Allen Institute, 2021; WHO, 2021 cited in Cunningham et al., 2021).

Interestingly, Kaur and Gurnani, (2021) reported similar finding despite at a country level describing the pandemic as infodemic of publications due to the high submission of articles to several scholarly publishing outlets. Following incessant submissions and publications by researchers, COVID-19 is believed to have opened many opportunities characterized either as a boon for young researchers or, as a bane due to an increased number of publications in research world leading to publication addiction (PA) (Gurnani et al., 2022). Looking at this scenario in an AI-based medium would suggest the fact that, for AI to thrive, it requires inputs

from NI a consequence of equating increase in AI equals to increase in NI (Adakawa, 2023). This is attributable to the fact that, medical publishing is growing in digital medium in an undiminished pattern, which implies the need for medical practitioners to rank medical journals for policy or decision-making processes (Ay et al., 2022). To support this fact, "*the COVID-19 pandemic has the particularity of being the frst in which information technologies have taken a leading role in the dissemination of both useful health information and fake news calls*" (Santos et al., 2022, p. 1610).

Sequel to the announcement of COVID-19 pandemic, this signaled the UN Secretary-General to launch the UN Commission Response Initiative to regulate the widespread fake news. Due to this promulgation, misinformation that could cost lives because of the failure of populace to adhere to guidelines calling them to observe social distancing, disease management, and adherence to vaccination, rendered ineffective. In this regard, science has played a vital role in disseminating important research findings through journals and preprints to aid in containing the spread of the pandemic (Santos et al., 2022). This means that, scientific research community has tried to flatten the curve of the pandemic on most countries around the globe.

This resulted in growth of publications in majority of databases, increased research funding agencies in many countries, decreased average time to manuscript acceptance, and heightened international collaborations (Aviv-Reuven & Rosenfeld, 2021). This is to say that, this health crisis positioned global health journals at a juxtaposition playing significant roles in disseminating health-related research thus affecting their impact factors. That is, COVID-19 pandemic altered and affected the structure of publication types of global health journals particularly COVID-19 related editorial materials and letters resulting in increased Journal Impact Factor (JIF) (He et al., 2023*). In addition, there is recognition that, COVID-19-related publications have more impacts than non-COVID-19 publications. That is why, He et al.'s (2023*) findings indicated that, global health journals should not singly use JIF as the yardstick for journal development. Rather, there is the need for a balanced structure between the number of pandemic and non-pandemic-related publications (He et al., 2023*) whenever

a pandemic erupts. As a result, the scholarly community has witnessed a remarkable collaboration year-in-year-out with increased research team size across domain-specific disciplines thereby affecting research positively. That is, the advantages attached to multidisciplinary science have been recognized in bringing researchers from different disciplines despite inherent small size due to the cost in start-up and coordination, remain an enabler for conferring solutions to most complex challenges bedevilling the world (Cunningham et al., 2021).

Background of the Study

One of the interesting facts about the research outputs on COVID-19 pandemic is that, any or most of the research conducted seems to be a continuous and linking chain of the previous research. This chain can provide a clue on the pattern of scientific progression as regard the pandemic and serves as a platform for theory-generating or policymaking endeavors. For instance, at the onset of the pandemic, researchers have been trying to figure our virus functions to stop its spread where support provided by AI and other emerging technologies for speedily processing large amount of data and extracting valuable information remains indisputable.

These technologies assist in providing efficiency thereby generating new solutions and dimensions of new research (Rodríguez-Rodríguez et al., 2022). That is, in most cases, AI together with many technological methodologies such as wearables with biosensors supported the growth of scientific research in detecting, treating, developing vaccines, managing exceptional situations thereby stopping the transmission routes taken by the virus.

As a result, there is a huge number of research, which challenged scholarly community to keep abreast with regards to areas in which research progresses and who are the prominent researchers or countries contributing such a leading work. Among the technological methodologies that allow observing patients from distant places is IoMT leading to telemedicine serving as solutions to most of the infected individuals by the pandemic. Looking

at these examples of AI and its associated technological methodologies will reveal a rather important fact that, the scientific studies are diffused and uncountable making it difficult for researchers to have a structured and well elucidated view of the current trends (Rodríguez-Rodríguez et al., 2022). This is true, as during the pandemic, clinicians specifically dentists were restricted from providing dental care services except emergency cases. In this respect, teledentistry was found to perform excellent roles in treating patients digitally using tools such as telemedicine for ensuring patient safety, minimizing frequent contact with patients in order to limit the spread of virus (Mahdavi et al., 2022).

In medicine, telemedicine including teledentistry has found a permanent niche to stay. This is because, it is one of the major sources of income in medical practice with probable increase in its utilization by 20% in the next 5 years and its revenue generation of $38 billion in 2018 and projected to account for $130 billion in 2025. The main reason for its progression is associated with the fact that, it has tendency of reduced risk of COVID-19, enables proper communications between patients and dentists, allowing access to dental care quickly and effectively, and saving the time and money of the patients (Mahdavi et al., 2022).

Among the consequences of the pandemic as observed by Lewis, (2021) is that, there is a decrease of 14% on number of hours spent by researchers per week, and 15% decrease in number of projects initiated by workers. Similarly, many researchers demonstrated that, there is sudden downturn of research output compared to 2019. For those researchers who did not work on COVID-19-related projects, their publications and submissions respectively dropped by 9% and 15% during 2020. Furthermore, researchers launched fewer projects with an average drop of 26% especially if compared with 2019 projects. While researchers who collaborated on COVID-19-related research witnessed 15% increase in newer collaborations in 2020 compared to 2019, other researchers saw a decline of 32% (Lewis, 2021). This implies the need to encourage scholars to use opportunities and time during pandemic for finding an everlasting solution to the pandemic and increasing their academic reputation and productivity linearly.

Statement of the Problem

The COVID-19 pandemic is one of the biggest challenges of healthcare systems that resulted in the healthcare organizations to change the patient care approaches instantly (Mahdavi et al., 2022). For instance, it was observed that, human and microbial activities are not static. It is not always possible to indicate clearly, which of these activities hastens the process of selectivity of microbial world to attack human race. It is available in the literature that, because of human disturbance of the planet earth, some species from microbial world pays the price through causing unprecedented diseases on human race (Adakawa et al., 2023). Antimicrobial resistance is another important issue coupled with mutagenesis of the entire genetic makeup or change in the surface receptor molecules where antibiotics, antiviral, antifungal, etc. can no longer function effectively. This shows that, the entire process of controlling microbes is rendered inefficient.

Critical look at the pandemic will reveal that, it can be equated with a quintuple complex comprising of patients-medical-workfroce-stakeholders-researchers-technologies with each one requesting the inputs from the other urgently to help in understanding, overcoming or becoming freer form the pandemic. This means that, the pandemic is like a component of the whole that detaches itself from the complex thereby challenging the whole structure. That is, when a pandemic escalates, it firsts affects individuals (agency/micro) where it restricts them from partaking in carrying out routine activities. They begin to voice out and their outcries propagated through media (i.e. mass and social media) reach the local authorities, which then signal the hierarchical structure (macro) in the complex. Developing a drug is not an easy task, as it requires billions of dollars and long time to prepare (Adakawa & Harinarayana, 2022). With AI in place, it can be presumed that, all the necessary data required to classify genetic sequencing of disease-causing pathogens is possible. However, this procedure is threatened by rapid changes of the pathogens from already known species that function in a certain way following a pathway to a newly differently recombinant strain. This implies the inadequacy of neural networks, tree, forestry, etc. algorithmic data, which exemplifies the need continuously updating and feeding the algorithms for a fruitful and safer future.

Previous research on scientometric analysis have not captured ingredients required to predicate COVID-19 pandemic within the macrosociology underpinning. The current study is an attempt to predicate the pandemic within the realm of macrosociology perspective for its propagation to be discerned effectively. It is hoped that, the findings will add to the value of the literature.

1. Theoretical Background

The COVID-19 pandemic remains a phenomenon in the history of humankind on the planet earth as it touched every single aspect of human endeavor in unprecedented way. This resulted in diffused views as regards its occurrence, progression, and transmission especially taking into cognizance its pathogenesis, virulence, morbidity, mortality, etc. from subjective and objective approaches. As a known fact, if a man drowns in water or the unknown, any helpful substratum that can provide support to be afloat, balanced or to remain submerged physically, cognitively, etc. instead of being entangled, is highly needed. This is why during the pandemic, man tried to grasp any information (reliable or otherwise) deemed capable of providing him a clue as a substantive component of making sense of his situations to regain equilibrium. Scholarly community was not immune to such discussions, which brought about a plethora of research outputs from different perspectives. In order to explain a simple or complex attribute of the pandemic, many researchers employed the use of theories. To start with, some authors noted that, conspiracy theories are the main barriers that hindered the control mechanisms of the spread of the COVID-19 (Romer & Jamieson 2020). In this sense, social media skepticism and belief in conspiracy theories about COVID-19 (Ahadzadeh et al., 2023) rose beyond grip. This gave rise to different conspiracy theories about the pandemic.

This is to say that, the COVID-19 has left the world unlike before affecting every facet of economies, social life, etc., thereby ushering in conspiracy theories concerning its origin, scope, prevention, and management including links to 5G network development (Achem & Ani, 2022). This is to the extent that, there was a prevalence of misinformation escalating

through social media where the feedback raises attention to affect the strategy of a user to share misinformation intentionally (Agarwal et al., 2023). The conspiracy theories can be both at individual and collective or national level that transformed into a global scale. In this regard, some scholars are of the view that, national narcissism was a determiner to the belief and dissemination of conspiracy theories using 56 countries as an evidence (Sternisko et al., 2023). Many studies have employed conspiracy theories. Notably, among the studies that used conspiracy theories include conspiracy theory on 5G (Ahmed et al., 2020), conspiracy theories on Instagram (Alassad et al., 2020), conspiracy theories (Douglas, 2021), anti-Semitic conspiracy theory (Gannuscio, 2022), conspiracy theories and underlying psychosocial and criminological factors (Groicher et al., 2022).

The pattern of how international community responds to the pandemic throws more light on understanding the social behavior at the place. As indicated by many researchers such as Jones and Karsten, (2003), Giddens' structuration theory aims at "*tell[ing] us what sort of things are out there in the world, not what is happening to, or between, them*". This owes to the fact that, the theory deals with phenomenon *at a high level of abstraction rather than their particular instantiation in a specific context,* which tries to indicate how to see a world rather than explanations of its mechanisms (Jones & Karsten, 2003, p. 5). From a strategy-as-practice perspective, Giddens has the notions that, "*understanding people's activity is the central purpose of social analysis*" In other words, "*practice needs studying because it makes a difference to outcomes*", which can be possible only through "*understanding activity, [to the extent reaching] to institutional embeddedness*" (Whittington, 2015, p. 145). To begin with, from social theory, there are two views one supporting the idea that structure has influence on the agency and another school of thought arguing that, agent has the ability to negotiate, challenge, or transform, shape the structure itself. As captured by Gilani, (2020), it was Giddens, (1984), who came with idea that, to transform social theory in such a way to break structure-agency dualism is normal, reconcilable, and this led to the formulation of structuration theory. According to this theory, there is a dynamic relationship between structure and agency. That is, structuration theory recognizes that, there is:

Interaction and dynamic relationship between structure and agency (different facets of society that always work together), instead of describing the capacity of human action as being constrained by powerful stable societal structures (such as political institutions, religious, or educational ones) or as a function of the individual expression of will. (Gilani, 2020, p. 1)

From structuration theory, three stratification model is available among the agency, which encompasses discursive consciousness, practical unconsciousness, and unconsciousness (Elliot, 2014 cited in Gilani, 2020). From this perspective, it is eminent that, multidisciplinary researchers have demonstrated discursive consciousness in knowing that, without investing into research on the pandemic, it would have done too much damage than never imagined. Perhaps this has relation with the fact that, stakeholders (social structures) have demonstrated readiness to fund and coordinate research in all directions that signalled other components of the quintuple complex to do the same in a similar proportion. In effect, by making research to be a norm within the framework of scholarly community, that what made it possible for the researchers to consciously and unconsciously develop a habit to venture into conducting research thereby reinforcing stakeholders commitments. While these structures reside within human action, "*the rules and resources of social action are at the same time the means of systems reproduction*" (Elliott, 2014, p. 150 cited in Gilani, 2020).

Through social reflexivity, conducting research deals with having some organizing principles that guide researchers on what to write and investigate. From Giddens' perspective, this can be referred to as social reflexivity that deals with ratioanlizing the actions of humans to monitor, think, reflect on actions and their consequences. Globalization, media, and technology play vital roles in conditioning the behaviors of humans in the modern society. In this way, pandemic served as a stimulus that motivated social actors (researchers) to think cogitatively about the pandemic globally thereby allowing them to come up with thought-provoking findings that inform practice. Borrowing from the work of Whittington, (2015), for a pandemic to be under control, the stakeholders (structure) have some responsibilities. First, they should use proper communication channel (mass and social media, technology, etc.,

research outputs) to facilitate adherence to a good behavior among knowledgeable and capable human agents, community at large (such as wearing a mask, social distancing, etc.) for a pandemic to be under control.

2. Materials and Methods

For understanding the publication behavior of scholars during the five (5) year period from 2019-2024, the authors analyzed the data extracted from Scopus from 18-28 August 2023. The search strategy used was "COVID-19 OR Coronavirus OR Coronaviruses OR SARS-CoV-2 OR 2019-nCoV". The search yielded 511, 920 results. Out of this number, 17, 487 results were used for the purpose of this study. The graphs of scientometric relation of countries were constructed in such a way to allow searching for individual clusters that represent the cooperation among countries through group. This is done with the aim of determining the average citation level of each country. Similarly, authors used visualization of scientific literature to build graphical networks to identify thematic clusters and trends based on topics used, most current topics, keyword used in publications.

3. Findings

3.1 Countries by cluster (cooperation)

There is a peculiar pattern of cooperation among countries during the pandemic. To understand and maintain this type of cooperation is of immense importance for globally recognized health agencies such as World Health Organization, UNICEF, etc., and other related organizations such as World Bank, OECD, to mention but a few. Based on the patterning of cooperation, authors have categorized these countries into six (6) groups. Even though there are no apparently clear reasons why such cooperation took place, it can be deduced that, some countries collaborated because of territorial positions, similar problems encountered at the onset of the pandemic, similar languages spoken, diplomacy, among others. In this sense, because of the inter-country mobility, the researchers might have recognized the

increasing necessity to understand some important variables as regard the pandemic. This is especially important considering its effects or consequences on populace, how research could affect practice to bring the pandemic to the barest minimum. In other words, the governments of these countries might have decided to use their resources in addition to the one received from the World Bank and other research-related funders to finance pandemic-related research for finding an everlasting solution to the problems brought by the pandemic.

Country group №1: Austria, Belarus, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Lithuania, Luxembourg, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine

Country group №2: Bangladesh, Benin, Botswana, Burkina Faso, Cameroon, Congo, Democratic Republic Congo, Ethiopia, Ghana, Kenya, Laos, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Nepal, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Thailand, Uganda, Zambia, Zimbabwe

Country group №3: Algeria, Australia, Cuba, Egypt, Finland, India, Indonesia, Iran, Iraq, Jordan, Kazakhstan, Kuwait, Malaysia, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, Taiwan, United Arab Emirates, Uzbekistan, Viet Nam, Yemen

Country group №4: Argentina, Bahrain, Bolivia, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Gabon, Lebanon, Malta, Mexico, Panama, Peru, Philippines, Tunisia, Uruguay, Venezuela

Country group №5: China, Hong Kong, Japan, Macao, Puerto Rico, Singapore, South Korea, United States

Country group №6: Canada, New Zealand, Sri Lanka, United Kingdom

Figure 1. Clusters of countries by number of common publications
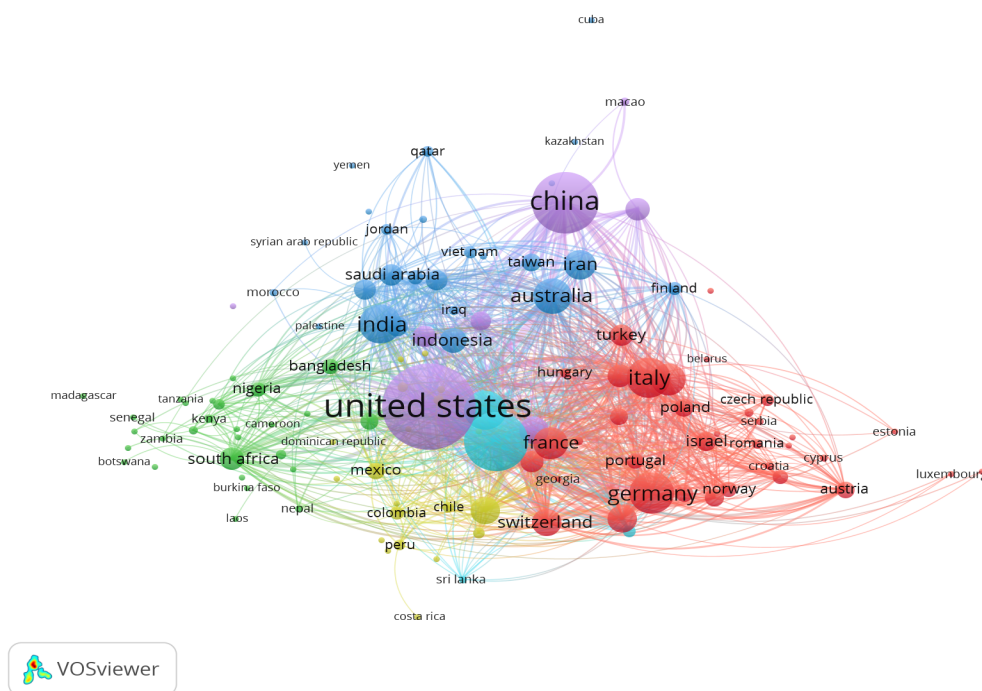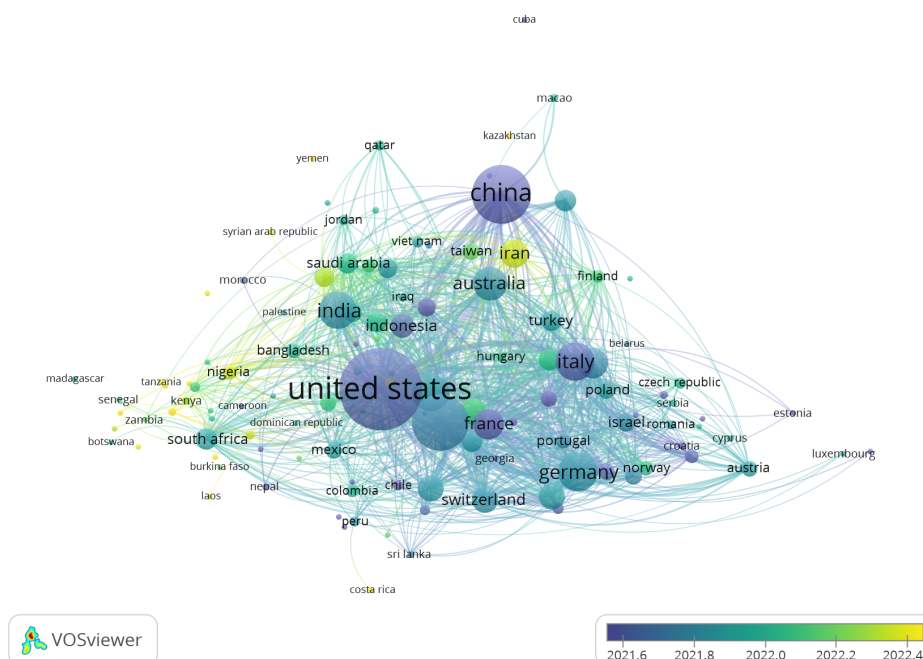

Source: Unknown

3.2 Countries by average year of publication

As it can be seen, those authors who have chosen to continue to write about the pandemic are from developed and developing countries. That is, these authors are predominantly found in Asia, Middle East, Africa, and Europe. Perhaps the large number of authors emanating from developing countries might be attributable to the fact that, they were more affected by the pandemic. This necessitated them to strategize in understanding the pattern of propagation of the virus and putting in place measures that could annul the impacts of such pandemics in the future. In addition, most of these developing countries are in economic havoc and when the pandemic erupted, they were taken aback as it came without proper planning. Similarly, there was no available infrastructure in place in most developing countries, which might be linked with the fact that, they could not produce a large number of research outputs compared to

many developed countries around the globe. To be precise, an interesting finding indicates the pattern of authors' research productivity that continues without stoppage since 2022 to the present time on the COVID-19-related research. The countries whose authors have relatively recently started publishing papers on the topic and have not stopped (average year of publication is 2022 onwards) include the following:

Benin, Democratic Republic Congo, Yemen, Sierra Leone, Kazakhstan, Puerto Rico, Syrian Arab Republic, Laos, Uganda, Malawi, Lesotho, Tanzania, Costa Rica, Lebanon, Iran, Nigeria, Ethiopia, Namibia, Egypt, Kenya, Taiwan, Burkina Faso, Gabon, Tunisia, Uruguay, Zambia, United Arab Emirates, Zimbabwe, Finland, Ghana, Senegal, Japan, Thailand, Botswana, Congo, Sweden, Hungary, Norway, Saudi Arabia, South Korea, Czech Republic, Bosnia and Herzegovina, Slovakia, Bangladesh, Kuwait, Dominican Republic, Malta.

Figure 2. Countries by average year of publication of articles

Source: Unknown

3.3 Countries by average number of citations

Especially in terms of the average number of citations among active countries, the following stand out: Argentina, China, Singapore, Hong Kong, Austria, South Africa, New Zealand, United Kingdom, Belgium, Switzerland, Israel, United States, Netherlands, Denmark, France

Figure 3. Countries by average number of citations
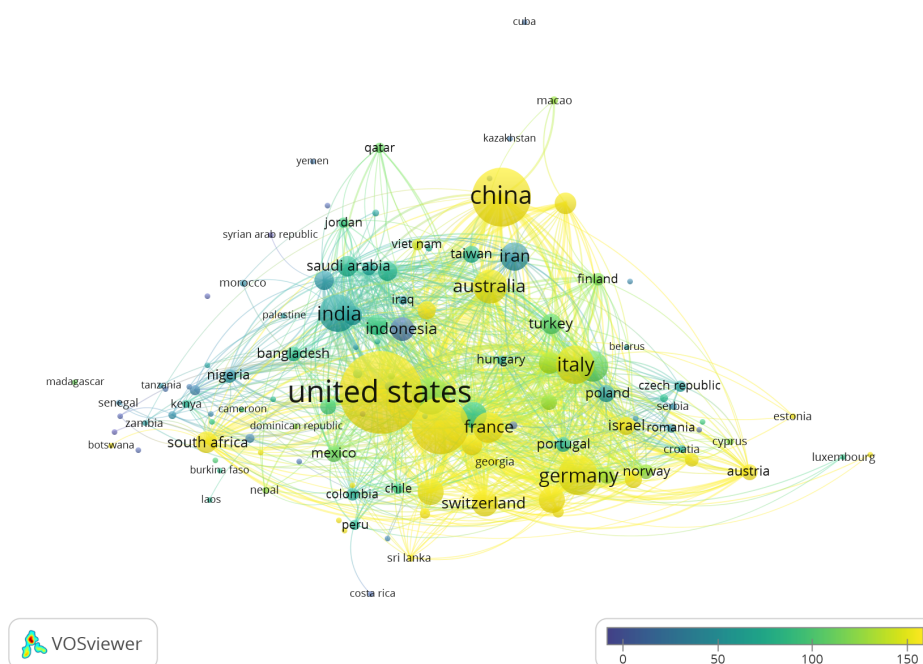
Source: Unknown

3.4 Topics: The most relevant and new

From the analysis carried out, a number of topics that are new and relevant emanated from the study, which cut across different perspectives. From the surface, the topics could be related with patients, medical workforce, stakeholders, researchers, and technologies. These topics are:

. The effectiveness of the combined drug nirmatrelvir/ritonavir in the treatment of COVID-19.

. Forecasting the course of COVID-19 and optimal epidemic management.

. Multiple medical conditions and their management in the context of COVID-19.

. The influence of psychological capital on the symptoms of anxiety and depression during the COVID-19 pandemic.

. Evaluation of the cost-effectiveness of infection control measures and emergency department visits during the COVID-19 period.

. Infection control and preventive measures in the context of migration and refugees.

. The impact of COVID-19 on physical fitness and possible recovery measures.

. Emergency preparedness in the context of the COVID-19 pandemic.

. Pandemic preparedness and preparation.

. Patient safety and care in the context of the COVID-19 pandemic.

. Access to health and social services during the COVID-19 period.

4. Discussion of Findings

The fact that scientometric analysis is a subfield of bibliometrics that measures the impacts of manuscripts, journals, etc., which serves as a basis for policy formulation/implementation thereby affecting managerial dealings (Kaur & Gurnani, 2021) gave the authors of this paper to use it as a lens to guide the study. This is because, when a pandemic erupts, provided that, international community—countries, healthcare agencies, NGOs, multidisciplinary researchers, doctors, pharmacies, politicians, media, citizens—aligns in a single plain and responds quickly and appropriately, the pandemic would be contained shortly with lesser morbidity and mortality. This implies the importance of measuring the contributions of structures in terms of their impacts to understand the ways they followed to bring the pandemic under control. From the figures provided above, it is apparent that, countries contributed immensely towards bringing the pandemic under control. In addition, based on the topics, with respect to both newness and relevance, it is evident that, the COVID-19 pandemic has witnessed a remarkable number of innovations from five (5) key perspectives.

The five key elements interacted even though not necessarily in a direct proportion manner. Borrowing from the study of Carayannis and Campbell, (2010), it follows that, they attempted to answer a single question: How do knowledge, innovation, and environment relate with one another? Through comparing knowledge, innovation, and environment, they integrated triple helix theory developed by Etzkowitz and Leydesdorff, (2000), quadruple helix theory (Carayannis & Campbell, 2009) who showed the interaction and reciprocity of innovation with university, corporations, governments and culture-based and media-based public respectively. Instead to dwell more on quintuple theory discussed by Carayannis and Campbell, (2010), a slight defection is necessary not in opposing the theory per se but in including certain elements that are important as regard pandemic. That is, it appears to the authors of the current study that, Carayannis and Campbell's (2010) research is a general theory that touches aspects of knowledge, innovation, and environment. However, the current study focuses on the pandemic alone.

Ideally, a pandemic comes along with the emergence of new knowledge about the causing organism, evolution of innovation employing different types of technologies to synthesize drugs or equipment, tools, etc. aimed at or geared towards bringing the pandemic under control. That is, there are interactions between and among stakeholders (knowledge industry, medical workforce (such as pharmaceutical industries, physicians, allied health professionals, etc.,) funding agencies (such as governments, NGOs, Not-for-Profit Organizations, etc.,), media both conventional and social media), patients, researchers, and manufacturing industries. All these components interact reciprocally and sometimes the functions of elements are performed by one another with a view to developing efficient and effective pharmaceutical and non-pharmaceutical agents that can best describe the pathways to neutralize or weaken the progression of the pandemic in society.

The synthesis of knowledge and innovations depends largely on the accuracy of data received from patients, the speed of genetic sequencing of the etiologic agent, dissemination of accurate, reliable, precise, and simple information reaching the public and the trust the public has in their governments. This is very critical as this brought the media to the equation to

perform excellent functions in ensuring dissemination of unambiguous information to guard against misinformation, fake news or conspiracy theories. In addition, depending on the immune condition of patients; patients can be symptomatic or asymptomatic or availability of vaccines differentiating population into those willing to receive vaccines and those who do not. Based on the topics obtained from the analysis of this study, even though account of all cannot be possible because of the large corpus of data, a brief account of the general overview is given with a view to providing clue and drawing the attention of stakeholders to develop interest as regard tackling the issues of pandemics as they emerge.

To begin with, innovation involving drug manufacturing is time-, energy-, and resource consuming. This might have to do with difficulty in isolating, identifying, characterizing, etc., the organism responsible for the pandemic and developing its associated drugs that can impede its progression in a limited timeframe with least effort and resources. To agree with this statement, according to Galli et al., (2024), the COVID-19 pandemic necessitated scientists around the world to dive into the ocean of looking for novel molecules that exhibit antiviral properties for bringing the COVID-19 under control. That is, researchers from academia and industries, such as Pfizer, indulged in experimenting the previously tested molecules with antiviral efficacy, which include but not limited to remdesivir, favipiravir, umifenovir.

Through developing several analogs, Nirmatrelvir received approval of FDA in December 2021. The target validation of the Nirmatrelvir has to do with its broad-spectrum activity and inhibition capacity of M^{PRO} (Galli et al., 2024). To agree with this submission, Reis et al., (2023, p. 1) observed that, the main reason for developing the oral nirmatrelvir/ritonavir (Paxlovid) was to *avoid severe COVID-19 in asymptomatic patients or people with mild symptoms for decreasing hospitalization and death*.

To support this view, the COVID-19 Treatment Guidelines Panel, (2024, p.186).

> Nirmatrelvir is an oral protease inhibitor that is active against M^{PRO}, a viral protease that plays an essential role in viral replication by cleaving the 2 viral polyproteins. It

has demonstrated antiviral activity against all coronaviruses that are known to infect humans. Nirmatrelvir is packaged with ritonavir (as Paxlovid), a strong cytochrome P450 (CYP) 3A4 inhibitor and pharmacokinetic boosting agent that has been used to boost HIV protease inhibitors. Coadministration of ritonavir is required to increase nirmatrelvir concentrations to the target therapeutic range. Ritonavir-boosted nirmatrelvir is approved by the Food and Drug Administration (FDA) for the treatment of mild to moderate COVID-19 in adults who are at high risk of progressing to severe COVID-19. The Emergency Use Authorization (EUA) for ritonavir-boosted nirmatrelvir will continue to authorize the use of the EUA-labeled product for the treatment of nonhospitalized adolescents aged 12 to 17 years and weighing ≥40 kg who are at high risk of progressing to severe COVID-19.

Interestingly, a study by Mesfin et al., (2024) has provided a systematic review and meta-analysis based on observational evidence on the effectiveness of nirmatrelvir/ritonavir and molnupiravir in pre- and post-Omicron variant tested against vaccinated and unvaccinated patients. Does this imply the need to continue testing drugs until the best one is confirmed to be used against the pandemic? If this continues in this direction, it means that, many lives will be lost and health of population weaken, which calls for forecasting and preparedness prior to the emergence of infectious diseases. Fortunately, Sun et al., (2020) noted that, forecasting the long-term trend of pandemics help healthcare professionals understand the transmission pathways of the virus with a view to developing appropriate prevention and containment strategies. To assist in this direction, the study by Nikolopoulos et al., (2020) is very relevant. In their study, the authors realized that progression of COVID-19 across the globe brought about changes in the actual needs (health and food) and corresponding effects in the consumer behavior especially looking at it from bullwhip effect. In order to ensure a healthy supply chain, the authors provided a concrete review on the previous instances that necessitated forecasting for the short- and long-term assessment for the policymakers.

Forecasting for the evolution of pandemics is paramount and can include time-series methods, compartmental epidemiological models, agent-based models, meta-population models, ML,

deep learning, among others (Nikolopoulos et al., 2020). While these methods are important, other researchers such as Sun et al., (2020) questioned the insufficiency of most models as they based their judgments on the retrospective analysis or over-fitting, under-fitting, etc. For instance, in order to improve the problem inherent in one of the models used in epidemiological methods such as SIR or SEIR i.e. Susceptible, Infective, Recover or Susceptible, Exposed, Infective, Recovery; they proposed D-SEIQ model i.e. Dynamic-Susceptible-Exposed-Infective-Quarantined through integrating it with ML optimization using reasonable constraints. Fortunately, prior to the widespread of the COVID-19 pandemic, many researchers such as Desai et al., (2019) have provided detailed account of the challenges that impede global, real-time epidemic forecasting thereby raising the awareness in this regard. The challenges include updated data, model uncertainties occasioned by lack of information regarding transmissibility of the pathogen or structural issues such as connectivity in relation to environment susceptibility.

In addition, there is data need issues that encompass case counts, mobility, host and environmental susceptibility, healthcare capacity, population and thus called for open data sharing, integration of digital and traditional disease surveillance as well as collaboration between Global Outbreak Alert and Response Network (GOARN) and other health agencies (Desai et al., 2019). On the other hand, all these measures are taken to guard against the spread of the virus among population. That is, patients are important components of the disease prevention and control.

Conclusions

When a pandemic erupts, five (5) key structures function in bringing it to the barest minimum or total eradication. These five key elements interact in a reversible fashion not necessarily as indicated but reciprocity among them is a common factor. These elements are patients-medical-workforce-stakeholders-researchers-technologies. These interactions yield new knowledge about the causative disease agents, evolution of innovations employing different types of technologies for synthesizing drugs and equipment for bringing the pandemic under

control. The COVID-19 pandemic has shown the relevance of health security in the contemporary society that signals the burden stakeholders to take to forecast, integrate, collaborate, communicate clear models, and ensure open data for researchers globally to contribute their quota towards solving the problem of the pandemic. The topics highlighted are important as they provide important platform for the international community to tackle any emerging or reemerging pandemics in the near future. There is a need for using empirical and theoretical models to develop theories that can further define pandemics and forecast the lingering conditions that can evoke their occurrence in society.

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