

Detecting the Major Trends of Information Systems in the COVID-19 Research Landscape

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Abstract

As the volume and diversity of COVID-19 manuscripts grow, trend topic detection has become a more crucial issue to utilize information from pandemic-specific literature. Latent Dirichlet Allocation (LDA) and bibliometric analysis are common ways of detecting trend topics. In this study, a hybrid approach is suggested by combining both techniques as a novelty perspective to attain comprehensive information. The topics studied in the COVID-19 literature were outlined with the LDA analysis, and then the COVID-19 studies were examined specifically in the field of information systems (IS) with bibliometric analysis. As an outcome of LDA analysis, it has been determined that the topics studied on COVID-19 are concentrated under the categories of clinical studies, epidemiology and transmission of COVID-19, national and global policy responses to the COVID-19 pandemic, and the impacts of the COVID-19. Infodemiology in social media, computer-aided detection methods for diagnosis, information systems for contact tracing and health systems, distance learning solutions, data analytics for modeling and forecasting COVID-19, epidemiology, molecular docking of COVID-19 are primary topics of IS literature in COVID-19 era. This paper assists researchers in providing a comprehensive view of the compatibility of COVID-19 literature at a macro level and in the scope of IS and also offers suggestions for future work by IS researchers.

Keywords: Bibliometric Analysis, COVID-19, Information Systems, Latent Dirichlet Allocation, Topic Modeling.

Introduction

The presence of a novel health threat (Coronavirus disease 2019 (COVID-19)) has declared a global pandemic by the World Health Organization (WHO) on March 11, 2020 (WHO, 2020). As the first mortal case in China on January 11, 2020, the virus has begun crossing China's boundaries by January 23, 2020, and expanded to other countries rapidly (Taylor, 2020). COVID-19 has become a focal point in the last few months because millions worldwide have been affected by COVID-19 (Tran & et al., 2020). It enormously impacts different areas such as society, security, economy, politics, and tourism worldwide (Etyang, 2020). Being a new health threat, scientific studies on COVID-19 have tremendously increased (Tran & et al.,

2020). On February 11-12, 2020, many scientists came together to create, share, and discuss COVID-19-related issues in Geneva for a project WHO called R&D Blueprint. The main objectives of this project are to produce remedies for the treatment of the disease and to encourage global research platforms to prepare for a possible new pandemic. Moreover, the WHO has created a regularly updated database for researchers who want to work on COVID-19 (WHO, 2020). As of September 2021, there are 87,694 publications in ScienceDirect, 184,018 in Web of Science, and 179,810 in PubMed databases with the keyword "COVID-19".

A significant percentage of COVID-19 studies focuses on medical interventions to diagnose, treat, and prevent this disease (Usman & Ho, 2021). As the pandemic progresses, technological applications and initiatives are deployed to surveillance and detection, prevent the spread of the disease in the community, maintain essential services, and develop new, effective vaccines. The IS is vital in combating COVID-19 by drastically modifying the dynamics of sectors such as education, healthcare, businesses, and more, besides offering effective communication. Many governments have incorporated modern technologies such as artificial intelligence (AI), robots, and drones addressing planning, testing, clinical care, surveillance, quarantine, and contact tracing to reduce COVID-19 cases and deaths into their pandemic policies (Fisher & Sang-Hun, 2020; Ting, Carin, Dzau & Wong, 2020; Kulkarni, Kodad, Mahadevappa & Kulkarni, 2020). Researchers have proposed new IS subject areas representing solutions to the pandemic by offering telehealth technologies, 3D printing, blockchain applications, and so on (Pan & Zhang, 2020; He, Zhang & Li, 2021; Sinclair, 2020).

Determining research trends and hot topics is one of the methods for representing scientific papers (Panahi, Lotfi & Ouchi, 2022). Investigators have used bibliometric analysis (Brika, Chergui, Algamdi, Musa & Zouaghi, 2022; Ozyurt & Ayaz, 2022; Syed & Bawazir, 2021) and LDA (Ayele & Juell-Skielse, 2019; Griffiths & Steyvers, 2004; Moro, Cortez & Rita, 2015) for specifying the trend topics in a wide range of scientific domains. Bibliometric analysis (Abd-Alrazaq & et al., 2021; Andersen, Bramness & Lund, 2020; Usman & Ho, 2021) and LDA method (Älgå, Eriksson & Nordberg, 2020; Gupta, Aeron, Agrawal & Gupta, 2021; Tran & et al., 2020) were also employed to analyze the COVID-19 scientific literature. Researchers use different databases for obtaining the publications, such as PubMed (Abd-Alrazaq & et al., 2021; Älgå, Eriksson & Nordberg, 2020), Web of Science (Usman & Ho, 2021), and more than one database (Andersen, Bramness & Lund, 2020; Cheng, Cao & Liao, 2020; Tran & et al., 2020). They generally prefer to use the data from 2020 since it was the beginning of the pandemic (Andersen, Bramness & Lund, 2020; Gupta, Aeron, Agrawal & Gupta, 2021; Tran & et al., 2020; Usman & Ho, 2021).

Additionally, some of the research that applies bibliometric analysis to the COVID-19 literature address specialized domain like business (Verma & Gustafsson, 2020), environmental studies (Usman & Ho, 2021), and education (Brika, Chergui, Algamdi, Musa & Zouaghi, 2022). However, there are no studies analyzing the COVID-19 literature in the domain of IS despite its significance.

A review of prior, relevant literature is essential for identifying gaps and demonstrating current knowledge. Researching and analyzing academic studies on COVID-19 is critical to mitigate the impact and prepare for a possible new epidemic. Because of the increased number of COVID-19 publications, reviewing and analyzing the publications' content and manually extracting information from many texts are very difficult. The literature indicates that no studies combine LDA and bibliometric approaches to identify the trend topics of COVID-19 literature.

Furthermore, there are no studies analyzing the COVID-19 literature in the domain of IS, despite its importance.

This article analyzes the topics of COVID-19 studies at a macro level using a topic modeling method. Then it uses bibliometric analysis to reveal the themes of COVID-19 studies in the scope of IS. Thus, by comparing the COVID-19 literature at a macro level and the IS context, this work defines the academic gaps, offers recommendations for future studies of IS researchers, and extracts valuable information from these studies by automating the analysis of the texts. In this regard, there are two research questions in this study:

- What are the main research topics of COVID-19 literature?
- What are the trend topics for establishing and maintaining engagement with COVID-19 literature in the context of IS studies?

Materials and Method

Two separate analyses, LDA and bibliometric analysis, were conducted on the COVID-19 publications in this research. Articles scraped from the Web of Science database to gain insights into the research questions. Web of Science was chosen as the independent global citation database because of its comprehensive platform, which has over 171 million entries and 1.9 billion references (Web of Science, 2022)

Considering searching keywords of the studies in the literature for the LDA analysis ("COVID-19" OR "SARS-CoV-2" OR "severe acute respiratory syndrome coronavirus 2" OR "coronavirus" OR "coronavirus disease" OR "2019-nCoV") were chosen as the keywords. Designing a study around the framework of COVID-19 studies in the context of IS helps to constrict the scope of analysis. Searching COVID-19 keywords in IS-related journals would yield more meaningful findings. Therefore, specific journals are selected related to IS by examining the journal list of the Web of Science database. A search was done with the keywords ("COVID-19" OR "SARS-CoV-2" OR "severe acute respiratory syndrome coronavirus 2" OR "coronavirus" OR "coronavirus disease" OR "2019-nCoV") in these journals, such as medical informatics, computer science information systems, computer science interdisciplinary applications, information science library science, computer science artificial intelligence, computer science cybernetics and computer science software engineering for the bibliometric analysis. Categorization limits were not applied, and each dataset covers the 2019-2020 period, which included state-mandated lockdowns and various detrimental effects, but also closed with the arrival of vaccines. This period is notable for examining how pandemic-related studies evolved and developed. In the end, LDA was conducted over the abstraction of the 42,037 articles, and the keywords of the 1,305 articles were analyzed for the bibliometric analysis.

Preprocessing and Data Analysis Process

To simplify analysis and provide more reliable results, the first step of the preprocessing stage was data cleaning and preparation. LDA analysis was done in Python programming language. Firstly, the retrieved data files as .csv was converted to Python's acceptable format. After that, preprocessing steps were applied. The whole methodological process for the LDA analysis is given in Figure 1. Figure 1 shows tokenization, removing the stop words, converting the lower-case, N-Gram Processing, and Part of the Speech Tagging (PoS) were conducted in the preprocessing step.

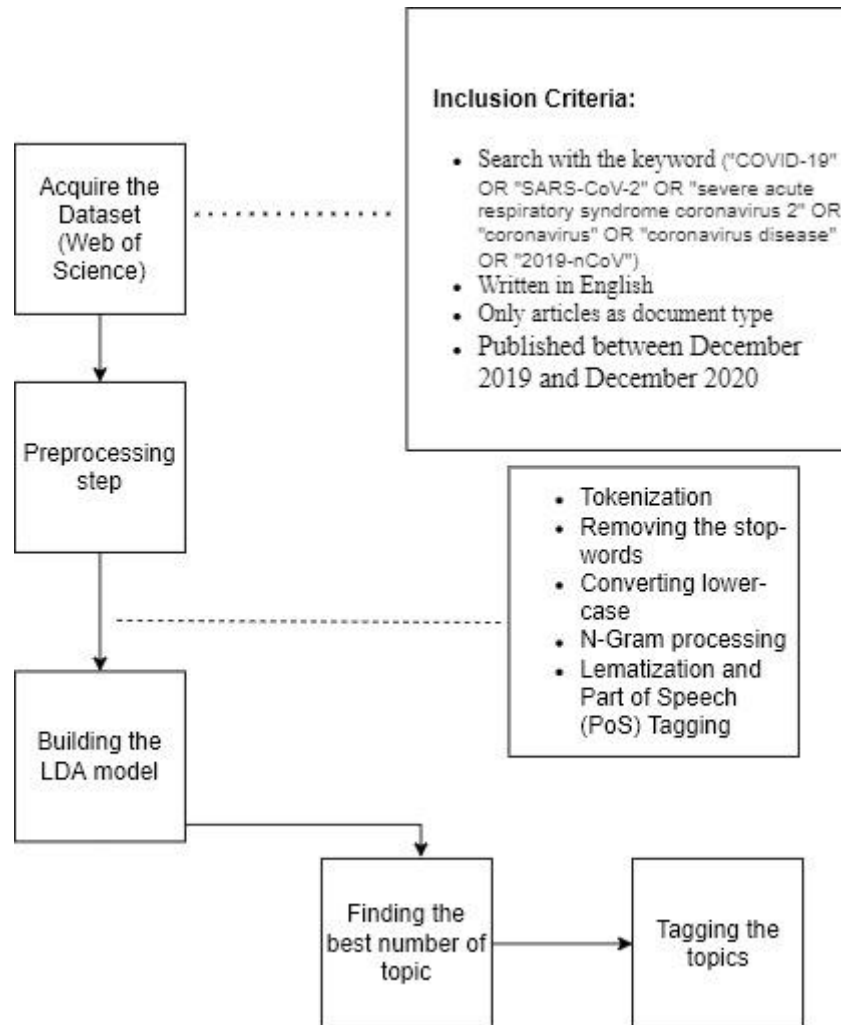


Figure 1: Methodological Process for LDA Analysis

LDA, a probabilistic model used to derive hidden information from textual data, achieves successful information retrieval, classification, and annotation results (Bellegarda, 2008; Liu, 2013). In LDA, each document consists of topics of different weights, and each topic is seen as an element of the different weights of words. Although there are many topic modeling approaches, we chose LDA, because it is the most preferred topic modeling due to its many advantages. Thanks to mature probability algorithms, direct training models are more stable than non-hierarchical models, and presenting quality semantic conditions and descriptive power are among strong advantages (Girolami & Kabán, 2003; Masada, Kiyasu & Miyahara, 2008).

After the preprocessing steps, a dictionary and corpora were generated with Python's Gensim library for building the LDA model. Gensim is a Python library that works effectively even in large datasets in topic modeling, similarity detection, and indexing of documents (Rehürek, 2020). The document finally became available for the LDA analysis. LDA mallet package was employed in this analysis. “*MALLET is a Java-based package for statistical natural language processing, document classification, clustering, topic modeling, information extraction, and other machine learning applications to text*”(Mallet, 2002). An extremely scalable and fast implementation of Gibbs sampling is included in the MALLET kit. Specifying the topic number is a challenging issue in LDA. While deciding on the topic number, we used the coherence score measure. Topic coherence is a metric that assesses the degree of semantic

similarity between high-scoring terms in a single topic. This metric aid in distinguishing between semantically interpretable topics and those that are statistical inference objects. The coherence measure is the sum of the pair-wise distribution similarity scores on the group of topic words (Stevens, Kegelmeyer, Andrzejewski & Buttler, 2012). The coherence score is calculated for different combinations and 20 topics and 15 words yielded the highest coherence score, therefore topic number was specified as 20. The program gives only the relevant words in a topic as an output, the topics were tagged with the views of three researchers.

For the second part of the methodology, bibliometric analysis was performed with COVID-19 publications accessed by keywords defined in the IS research. Bibliometric analysis is a mathematical method that explains the analysis of scientific publications. It is utilized to specify the number of citations, author name, journal title, country, institution, article type, and research fields (Kurtuluş & Bilen, 2021). VOSviewer, a computer program for creating and visualizing bibliometric analysis, contains a citation, bibliographic coupling, co-citation, or co-authorship relations. Moreover, VOSviewer proposes text mining features that can be used to create and visualize essential words extracted from scientific studies in co-occurrence networks (VOSviewer, 2020). In Vosviewer, three options are creating a map based on network data, creating a map based on bibliographic data, and creating a map based on text data. We chose the creating a map based on the bibliographic data option. At this point, extracted .csv files were transformed to .txt, Vosviewer acceptable file format. The type of analysis was chosen as co-occurrence analysis. The unit of analysis is all keywords (including both author and index keywords), and whole counting was selected as the counting method. The keywords with frequencies of ≥ 10 were entered into software for generating a topic map. The created clusters based on co-occurrence analysis were also labeled with the three researchers' views.

Results

Table 1 lists the twenty research topics linked to COVID-19 and their corresponding top fifteen most frequent terms found by LDA analysis.

Table 1

The Topics Linked to COVID-19, their Corresponding Most Frequent Terms

Topics	Top fifteen most frequent words
1. The emerging complication of SARS-CoV-2 infection	severe, respiratory, acute, disease, syndrome, infection, covid, present, lung, develop, associate, inflammatory, increase, function, complication
2. Social works during the COVID-19 Crisis	research, article, crisis, community, life, social, issue, author, society, state, offer, focus, context, form, work
3. Economic impacts of the COVID-19 pandemic	impact, economic, policy, pandemic, crisis, country, government, food, global, effect, economy, sector, financial, business, affect
4. Treatment of COVID-19	treatment, covid, clinical, study, therapy, effect, include, treat, trial, receive, drug, improve, evidence, group, effective
5. Laboratory diagnostics and clinical examination on COVID-19 patients	case, symptom, report, infection, covid, positive, day, present, confirm, test, result, negative, asymptomatic, clinical, diagnosis
6. COVID-19 virus structure and vaccines	cell, protein, virus, vaccine, viral, target, human, drug, host, potential, response, interaction, bind, infection, expression

Topics	Top fifteen most frequent words
7. The impact of online learning on students' mental health	student, online, participant, mental, anxiety, survey, psychological, stress, health, impact, depression, physical, pandemic, learn, respondent
8. COVID-19 Restrictions impacts on case numbers	increase, period, change, time, decrease, lockdown, compare, significant, reduction, level, week, state, result, activity, datum
9. Modeling for forecasting the dynamics of the COVID-19	model, base, datum, system, develop, propose, network, process, result, design, predict, set, application, performance, apply
10. Public response and social measures in response to COVID-19	public, health, social, people, information, measure, medium, response, relate, pandemic, covid, individual, behavior, government, source
11. Global strategies for coping with the pandemic-related challenges	pandemic, current, global, role, world, strategy, important, emerge, present, challenge, highlight, research, future, outbreak, discuss
12. Outcomes and Mortality trends among hospitalized COVID-19 patients	patient, outcome, hospital, day, admission, mortality, year, clinical, death, age, admit, median, intensive, covid, cohort
13. Epidemiological situation of COVID-19	case, number, country, spread, epidemic, measure, control, outbreak, model, death, transmission, rate, population, estimate, disease
14. Health Care Management During Covid-19	care, health, service, system, worker, healthcare, medical, resource, staff, work, community, professional, support, resident, response
15. Effectiveness of Mask Wearing to Control Spread of COVID-19	mask, reduce, transmission, prevent, control, protection, face, virus, exposure, high, material, measure, design, pressure, result
16. COVID-19 and Surgical Procedures	patient, pandemic, emergency, covid, management, cancer, perform, procedure, risk, surgery, surgical, method, recommendation, guideline, care
17. Evaluation of clinical features of COVID-19 patient	patient, group, covid, clinical, result, finding, show, score, method, significantly, image, feature, compare, severe, evaluate
18. Diagnostic Methods for Detection of COVID-19	virus, sample, test, positive, detect, viral, antibody, result, infection, detection, covid, testing, diagnostic, respiratory, human
19. Home Visiting Services during COVID-19	child, face, experience, family, home, visit, program, person, practice, change, pandemic, support, virtual, telemedicine, including
20. Risk stratification of COVID-19 cases	high, risk, factor, covid, level, associate, age, low, population, increase, rate, significantly, result, mortality, compare

In Table 1, the right side gives the program outputs and the words, and the left side indicates the manual labels conducted by researchers. The order of the words in each topic is proportional to their importance in the topics. For example, in Topic 1, the most important words are "severe", "respiratory", "acute," and "disease". The least weighted word in Topic 1 is "complication".

We categorized the topics as follows: clinical studies (Topic 1, 4, 5, 6, 9, 12, 16, 17, 18, 20), epidemiology and transmission of COVID-19 (Topic 8, 13, 15), impacts of COVID-19 pandemic (Topic 3, 7, 19), national and global policy responses to the COVID-19 pandemic (Topic 2, 10, 11, 14).

The category of clinical studies is an umbrella term that includes the structure of the virus, its dynamics, diagnosis and treatment methods, and clinical research. The epidemiology and transmission category covers topics related to restrictions, epidemiological situations, and the spread of COVID-19. The impacts of COVID-19 category refers to the impacts of COVID-19 on different domains such as economics, education (online learning), and health (home-visiting services). The public response, social measures, and global strategies to cope with COVID-19 are evaluated under the national and global policy responses to the COVID-19 pandemic category.

The second section attempts to gather valuable information by studying the COVID-19 literature in the context of IS by using bibliometric analysis. Seven clusters are presented with clusters' words based on network structure in Figure 2.

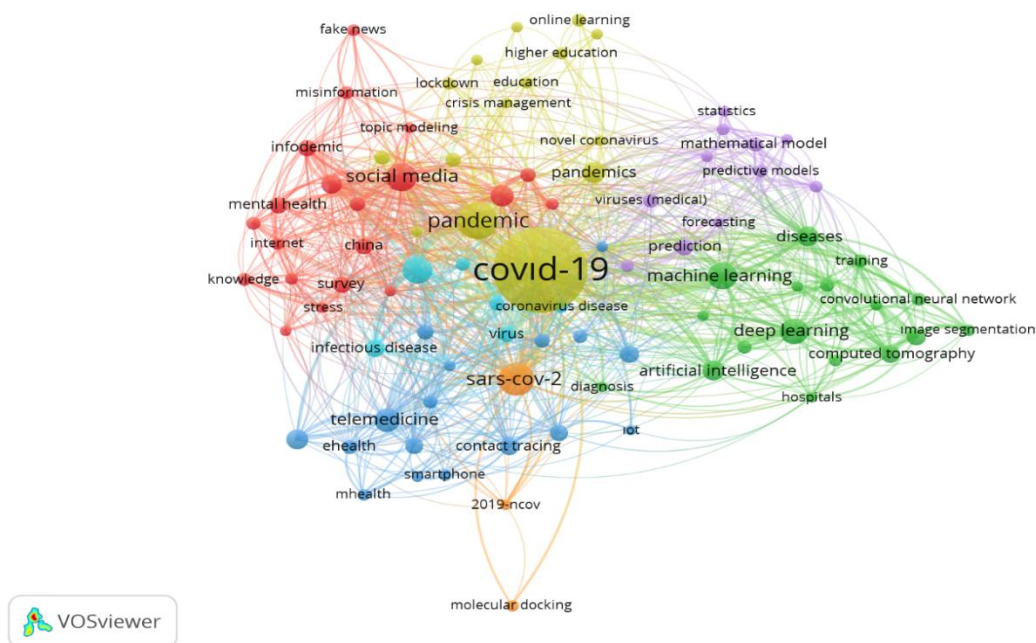


Figure 2: The keyword co-occurrence analysis of COVID-19 Literature in the Information Systems Area

The 1st (red) cluster corresponds to terms related to infodemiology in social networks, such as fake news and misinformation in social networks. The 2nd (green) cluster represents computer-aided methods for virus diagnostics (artificial intelligence, convolutional neural networks, deep learning, machine learning, image segmentation, and computed tomography). The 3rd (dark blue) cluster focuses on digital health technologies and contact tracing (smartphones, apps, contact tracing, e-health, internet of things, telemedicine). The 4th (yellow) cluster emphasizes IS-based distance learning solutions. Next, the 5th (purple) cluster contains analytic data items for forecasting COVID-19 (forecasting, mathematical model, modeling, predictive models, SIR models, and statistics). The 6th (light blue) and 7th (orange) are general themes of the COVID-19 literature, and no keywords directly refer to IS. In Table 2, clusters are given with all their related words.

The density of the topics in the document reduces as you move from the red to the orange cluster. As a result, infodemiology in social networks, which is the red cluster, is the most discussed topic, followed by computer-aided detection methods for COVID-19 diagnosis.

Clusters 6 and 7 in Table 2 have the lowest density because IS researchers concentrated on data analytics methods and digital technologies. They used these technologies as solution partners in different fields rather than focusing exclusively on the COVID-19 virus structure and epidemiology.

Table 2

The Topics and all Related Words of COVID-19 Literature in the Field of Information Systems

Topics of Clusters	Related Words
1. COVID-19 and infodemiology in social media	Anxiety, behavior, china, cross-sectional, fake news, health information, infodemic, infodemiology, infovillance, internet, knowledge, mental health, misinformation, natural language processing, sentiment analysis, social media, Twitter, stress, survey
2. Computer-Aided Detection Methods for Diagnosis of COVID-19	Artificial intelligence, classification, computed tomography, convolutional neural network, deep learning, diagnosis, diseases, feature extraction, hospitals, image segmentation, lung, machine learning, neural network, optimization, pneumonia, training, transfer learning
3. Information systems for contact tracing and health systems during the COVID-19 period	The app, big data, contact tracing, digital health, eHealth, government, internet of things, mhealth, iot, mobile phone, monitoring, privacy, smartphone, surveillance, symptom, telehealth, telemedicine
4. Distance learning solutions based on information systems	Academic libraries, communication, covid-19, crisis management, digital transformation, e-learning, education, higher education, lockdown, novel coronavirus, online learning, pandemic, pandemics, risk social distancing
5. Data analytics for modeling and forecasting COVID-19	Analytical models, data models, forecasting, mathematical model, modeling, prediction, predictive models, sir models, sociology, statistics, viruses(medical)
6. COVID-19 epidemiology	Coronavirus disease, epidemiology, infectious disease, outbreak, public health, virus
7. Molecular docking of COVID-19	2019-nCov, molecular docking, sars-cov-2

Discussion

The findings of this study are in line with other COVID-19 literature investigations. Älgå, Eriksson and Nordberg (2020) found that the most common topics in the COVID-19 literature are healthcare responses and clinical manifestations. Danesh, Dastani and Ghorbani (2021) also identified the trends of COVID-19 literature as the structure of the virus, clinical presentation and detection, and epidemiology and transmission-related topics. Genetic, epidemiological, zoonotic, and other biological topics associated with COVID-19 are significant concerns, according to Hossain (2020). Dehghanbanadaki and et al. (2020) highlighted the focused topics as pathogenesis, epidemiology, transmission, diagnosis, treatment, prevention, and complications of COVID-19. As seen in the references, clinical and epidemiological studies have been essential research since the beginning of the epidemic. The diagnosis and treatment of COVID-19 are the most critical subjects identified by many researchers (Cunningham, Goh & Koh, 2020; Dai & et al., 2020; Feng & et al., 2020). It has changed the direction of clinical

studies, and researchers, governments, and organizations have concentrated on discovering the structure of COVID-19 and seeking a cure, developing a vaccine for the virus (Haleem, Javaid, Vaishya & Deshmukh, 2020; Sathian & et al., 2020). The destructive effects of COVID-19 led many researchers to work on reducing the transmission rate, studying medical treatment and risk factors (Tang, Schmitz, Persing & Stratton, 2020).

Examining the virus's epidemiology and clinical aspect is necessary to cope with COVID-19. Epidemiological studies of COVID-19 summarize transmission dynamics, the burden of infection, and other related epidemiological features (Chowdhury & Oommen, 2020). In the fight against any disease, epidemiology is crucial. Research into how and why the virus spreads is essential in the fight to understand and contain COVID-19. Therefore, epidemiological studies have attracted the attention of many researchers (Liu, Yang, Zhao, Xie & Si, 2020; Ma & et al., 2020).

Our findings are strikingly similar to those of Abd-Alrazaq and et al. (2021) and Haghani and Bliemer (2020). Haghani and Bliemer (2020) have gathered the topics in the COVID-19 literature under three cluster titles: public health response and epidemic control, the chemical constitution of the virus, and treatment, vaccine, and clinical care of COVID-19. Abd-Alrazaq and et al. (2021) discovered the dominant topics as public health response, clinical care practices during COVID-19, its clinical characteristics and risk factors, and epidemic models for its spread. They found a novel trend topic called "public health response". It resembles our "national and global policy responses to the COVID-19 pandemic" category. Researchers have performed studies to assess and improve the preparedness of society and healthcare organizations for a pandemic (Moriarty & et al., 2020). Furthermore, many studies have analyzed and compared government policies of different countries in coping with the COVID-19 challenges (Dewi & et al., 2020; Hale & et al., 2021; Hu & Liu, 2022). Consequently, this category has become a hot topic in the COVID-19 literature.

A novel category, "impacts of COVID-19 pandemic," was discovered in this investigation. "Home visiting services during COVID-19", "the impact of online learning on students' mental health", and "economic impacts of the COVID-19 pandemic" are the topics covered in this category. The emergence of this category shows that early pandemic research concentrated on clinical aspects, followed by a considerable increase in studies evaluating the impact of the virus in different domains such as economic, health-related, and education. COVID-19, as a highly contagious disease, changes the daily life of people and the processes of many different sectors. It has halted economic activity as countries adopt rigorous movement restrictions to slow the transmission of the virus. Many publications explore how the production of goods and services has decelerated, and the supply has been interrupted (Paul & Chowdhury, 2020; Pu & Zhong, 2020). In addition to its economic impacts, COVID-19 also harms education. The educational systems in many countries have maintained their practices by moving from traditional ways to digital forms of learning. Institutions adopt online teaching, and digital technologies are becoming increasingly important in education worldwide (Lischer, Safi & Dickson, 2021). The literature highlights this sudden shift to digital education (Abdulrahim & Mabrouk, 2020; Händel, Stephan, Gläser-Zikuda, Kopp, Bedenlier & Ziegler, 2020; Nuere & de Miguel, 2020).

Another area negatively impacted by COVID-19 is health. Face-to-face health services, such as case management, family support, and counseling, have become complicated due to the pandemic. Health departments provide these essential services through remote services, such

as virtual home visits, telemedicine, and telehealth (Platt, 2020). As seen in the examples, digital solution partners are used to reduce the adverse effects of the pandemic. In the pandemic era, they have become a critical enabler of productivity regarding personal and professional life. Governments and corporations have adapted their systems to implement emerging technologies such as big data, the Internet of Things (IoT), AI, machine learning, blockchain, and digital trade (Panigutti, Perotti & Pedreschi, 2020). Home-visiting services and online learning topics in our results are intriguing, and they show that IS-related topics have recently gained prominence in the COVID-19 literature. However, no study has been found examining the COVID-19 literature in the context of IS, and there is a lack of research in this area. This present study analyzes the COVID-19 literature in the context of IS, besides analyzing the holistic level.

As in the general literature, COVID-19 studies in the IS context highlighted health-related topics (Clusters 2, 3, and 5 in Table 3), virus structure (Cluster 7 in Table 3), epidemiology (Cluster 6 in Table 3), and online learning related topic (Cluster 4 in Table 3). Advanced methods such as AI, deep learning, big data, and machine learning are among the words that appear in the results of bibliometric analysis. AI has many applications and attributes that can detect and diagnose COVID-19. Researchers have emphasized using AI techniques, machine learning, and deep learning models to analyze, diagnose, and treat COVID-19 cases and contact tracing (Ting, Carin, Dzau & Wong, 2020; Vafea & et al., 2020).

Even though digital technology tools such as AI, big data analytics, blockchain technology, robotics, and drone technology play a vital role in the pandemic, only data-centric technology-related words such as AI, convolutional neural network, deep learning, machine learning, big data, and data analytics more involved in clusters.

None of the human-centric technologies (3D printing and robotics) and some of the system-centric technologies (blockchain) are not mentioned in clusters' words. However, these technologies have been used effectively in many areas to cope with the pandemic (He & et al., 2021). Drones are employed to deliver essential items and medicines to people in quarantine and protect transportation workers from virus exposure (Obeidat, 2020). Also, law enforcement routinely utilizes drones to impose lockdowns, monitor lawbreakers, and detect people not wearing face masks (Kulkarni, Kodad, Mahadevappa & Kulkarni, 2020). Another technology deployed in this outbreak is robotic, intended to help sanitation workers and healthcare workers lower their chances of contracting the virus during the pandemic (Kulkarni, Kodad, Mahadevappa & Kulkarni, 2020).

Moreover, 3D printing can create face masks and other personal protective equipment (PPE) for healthcare workers. (He & et al., 2021). Blockchain technology enables mobile applications to give each participant a "digital identity"; these digital identities are personal and used to distinguish people who have the disease (Sinclair, 2020).

Apart from these parallels, there are notable variances as well. When looking at the COVID-19 literature as a whole, there is no trending topic connected to infodemiology, as seen in Table 1, but when looking at the literature within the framework of the IS, infodemiology is the most discussed topic. It means that the topic of infodemiology is mainly studied by IS researchers. Infodemic, also called misinformation (Zarocostas, 2020) involves deliberate efforts to distribute false information to disrupt the public's reaction and encourage alternate goals of groups or individuals. During the COVID-19 pandemic, there has been a rise in the volume of infodemiology publications (Springer, Zieger & Strzelecki, 2021). Infodemic has

mainly been categorized as the creator and origin of COVID-19, its spread dynamics and symptoms, treatments and healing, and government interventions against COVID-19 (Krause, Freiling, Beets & Brossard, 2020); Verma & Gustafsson, 2020). The economic impacts of COVID-19 are trend topics in the general literature, but there is no economic finding in the COVID-19 literature in the IS context. Although the IS applications in health and education come to the fore (Cluster 2, 3, 4), IS research is lacking in the field of economy.

Conclusion

This article is valuable as it is the first study examining the COVID-19 literature in the context of information systems, and it reveals trend topics of COVID-19 literature at a macro level and in the scope of IS. Afterward, researchers can use this study to adapt their wisdom towards further pandemic-related studies, enhance disciplinary collaboration, and find novel solutions by analyzing IS themes.

According to the findings, the trend topics in the COVID-19 literature are categorized under the titles of “clinical studies”, “epidemiology and transmission of the COVID-19”, “impacts of COVID-19 pandemic”, and “national and global policy responses”. The IS researchers that have conducted COVID-19 research are concentrated in the health and education area and intensively studied technologies such as AI, machine learning, conventional neural networks, big data, remote health care systems, and contact tracing. IS research can be expanded in different areas affected by the pandemic, such as the economy, transportation, business, and supply chain in addition to the domains of health and education. In future studies, IS researchers can engage with new sophisticated technologies utilized in the COVID-19 era, such as drones, robotics, and blockchain. The challenges caused by digital technologies used in the pandemic, such as privacy and ethics, are another issue that IS researchers can examine.

There are some limitations, which are language bias resulting from the exclusion of languages other than English. The language barrier demonstrates a lack of ability to analyze studies written in different languages. The study was intended to be performed on two datasets using the same method, LDA. IS-based COVID-19 literature was unsuitable for LDA analysis due to the low number of publications. Therefore, two different methods were applied. The optimum number of topics was found for the accuracy of the results; however, the number of topics for the two analyses was different.

In future studies, COVID-19 studies based on information systems can be increased by adding more databases and keywords, and LDA analysis can be applied to extensive IS literature. Moreover, a multilingual analysis can be made by removing the language restriction, and more comprehensive and global results can be obtained.

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