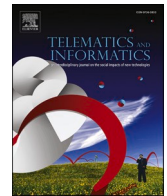




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Analytical mapping of information and communication technology in emerging infectious diseases using CiteSpace

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ABSTRACT

The prevalence of severe infectious diseases has become a major global health concern. Currently, the COVID-19 outbreak has spread across the world and has created an unprecedented humanitarian crisis. The proliferation of novel viruses has put traditional health systems under immense pressure and posed several serious issues. Henceforth, early detection, identification, rapid testing, and advanced surveillance systems are required to address public health emergencies. However, Information and Communication Technology (ICT) tackles several issues raised by this pandemic and significantly improves the quality of services in the health care sector. This paper presents an ICT-assisted scientometric analysis of infectious diseases, namely, airborne, food & waterborne, fomite-borne, sexually transmitted illnesses, and vector-borne illnesses. It assesses the international research status of this field in terms of citation structure, prolific journals, and country contributions. It has used the CiteSpace tool to address the visualization needs and in-depth insights of scientific literature to pinpoint core hotspots, research frontiers, emerging research areas, and ICT trends. The research finding reveals that mobile apps, telemedicine, and artificial intelligence technologies have greater scope to reduce the threats of infectious diseases. COVID-19, influenza, HIV, and malaria viruses have been identified as research hotspots whereas COVID-19, contact tracing applications, security and privacy concerns about users' data are the recent challenges in this field that need to address. The United States has produced higher research output in all domains of infectious diseases. Furthermore, it explores the co-occurrence network analysis and intellectual landscape of each domain of infectious diseases. It provides potential research directions and insightful clues to researchers and the academic fraternity for further research.

1. Introduction

The proliferation of novel viruses has accelerated significant health threats and become a global problem in a very short period. Infectious illnesses are growing every year due to globalization, urbanization, and the spread of dangerous pathogens (Bloom et al., 2017). The dissemination of infections is a severe problem causing social consequences, economic loss and significant mortality around the globe. According to the World Health Organization (WHO) (Organization et al., 2015), more than 7 million people lose their lives due to infectious diseases every year, and at least 30 new diseases have been grown in last two decades. Moreover, several deadly

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illnesses have shaped human history; unfortunately, this trend still continues in the twenty-first century. Currently, COVID-19 has spread to almost every country and affects the lives of millions of people around the world. As of 21 January 2022, there has been 343.396594 million confirmed COVID-19 cases, including 5.59401 million deaths, are reported globally. On 26 November 2021, WHO designated a new variant of COVID-19, named Omicron, first detected in South Africa. This variant has several mutations and assumes that it is more contagious than other variants. Like COVID-19, several viral infectious diseases such as ebolavirus, HIV/AIDS, and middle east respiratory syndrome coronavirus provoked disease severity and humanitarian catastrophes in most countries. Such novel infections have created several complex health challenges for researchers.

The widespread of COVID-19 and other infectious diseases have significantly emphasized the importance of Information and Communication Technology (ICT) for timely detection, prevention, and control of viral infections. Also, ICT has increasingly been used to address several challenges posed by this pandemic and helps to improve the quality of services in the healthcare field. ICT brings several health advancements and undertakes conventional diagnostic methods to assist health practitioners in the treatment process (Zhang et al., 2022). In contemporary situation, ICT tools are used to access a wide range of technological solutions such as home hospitalization systems, on-site detection of infectious viruses, rapid and accurate testing of suspects, online survey for an immediate public response, participatory disease surveillance systems to curtail the spread of virus, deployment of cost-effective and more portable point of care diagnostic testing, and location-based contact tracing applications to notify its users if they were in close proximity to an infected person. Also, ICT has been used to address many critical social issues like enabling people to continue work from home, reducing the threats of infodemic and sharing of fake news (Su, 2021; Apuke and Omar, 2021), establishing remote education programs for students during public health crisis time (Yuan et al., 2021), enabling online booking for COVID-19 vaccination (Luo et al., 2021), surveillance public places during lockdown period, and predicting the next hotspot of the pandemic (Sood and Rawat, 2021). Despite this excellent ICT advancement in healthcare, many challenges still have to be faced. The novel coronavirus has attracted researchers' attention because current research is not enough in front of this pandemic. For this reason, researchers from various disciplines, including computer science and engineering, have contributed significantly to controlling the COVID-19 pandemic and other viral infections.

Towards the contribution, this research conducts a scientometric analysis on the literature of viral infectious diseases published in the knowledge of science and technology. This work aims to identify the current state of ICT and global research dynamics in this field. The scientometric analysis investigates the quantitative aspects of the science disciplines using various bibliometrics approaches to evaluate the development of research, impact, and social relevance in science and technology (Rawat and Sood, 2020). In general, it is an essential statistical analysis to detect important topics of research and explain evolutionary pathways in a specific field of science.

This paper classified most infectious diseases into five domains for the sake of conciseness. The classification of five domains is based on two existing studies. These two studies (Dicker et al., 2006; Alemayehu, 2004) have covered the most contagious diseases that significantly affect human health in the past. Fig. 1 represents the classification of all five domains of infectious diseases. These infectious diseases are divided into two broad categories: Direct contact and Indirect contact (Dicker et al., 2006). Direct contact includes sexually transmitted infections (STI) or direct physical touch. STIs include Candidiasis, herpes genitalia, gonorrhoea, ebola, and HIV/AIDS. Indirect contact contains those diseases that can be spread from one host to another through various modes like air, water, food. Airborne diseases spread through in the air and vector-borne diseases can be transmitted from animal to human. Airborne diseases include COVID-19, influenza, mumps, measles, and whooping cough. Similarly, chikungunya, dengue, zika virus, lymphatic filariasis, and malaria represents vector-borne diseases. The two main types of vehicle-borne diseases are 1) Food & waterborne diseases 2) Fomite-borne diseases. Food & waterborne diseases can spread through contaminated food and water, and fomite-borne diseases can transmit from fomite or inanimate objects to host. Food & waterborne diseases include shigellosis, brucellosis, anthrax, hepatitis, cholera, and diarrhoeal diseases. Likewise, cold sores, zoonoses, respiratory syncytial virus, hantavirus, rhinovirus, and middle east respiratory syndrome represents fomite-borne diseases.

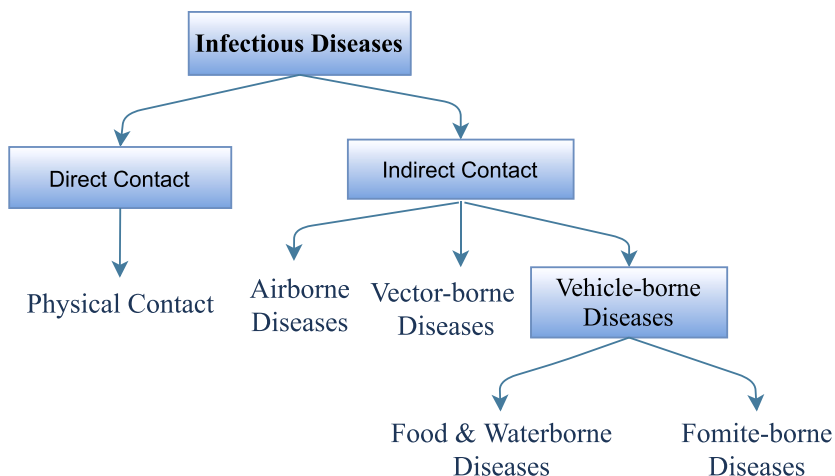


Fig. 1. Classifications of Infectious Diseases.

1.1. Research gap

This work has explored recent scientometric studies conducted on infectious diseases. It has obtained 25 relevant scientometric papers in the discipline of computer science and engineering from which eighteen documents are related to COVID-19 and seven studies have addressed other infectious diseases. In 25 publications, a few articles have assessed the role of technology in the specific domain of infectious diseases. [Rodríguez-Rodríguez et al. \(2021\)](#) explored the applications of artificial intelligence and other emerging techniques associated with intelligent data analysis for the management of the COVID-19 pandemic. [Mahajan and Shrivastava \(2018\)](#) conducted scientific research on the H1N1 influenza virus to extract evidence-based searching mechanisms for administrative decisions in the information science discipline. [Rahimi et al. \(2021\)](#) explored machine learning models used to forecast the COVID-19 outbreak globally. Besides scientometric studies, some papers have developed frameworks and models to address infectious diseases using ICT. [Calderon-Gomez et al. \(2020\)](#) proposed a telemonitoring system based on microservices architecture for detecting, monitoring, and assisting clinical diagnosis of infectious diseases. [Jenner et al. \(2020\)](#) outlined the recent findings in computational and mathematical models on HIV and other communicable diseases related to food & waterborne diseases. In addition, this research study suggested the collaboration of researchers from medicine and molecular biology and computer science disciplines to understand infectious diseases better. [Lin et al. \(2020\)](#) have explored how information technologies control the covid-19 pandemic. This paper also describes the role of ICT-based testing kits to detect the virus in Taiwan.

After the careful examination of scholarly literature, it observed that a significant number of infectious disease-related articles are published in international journals. From which, the majority of recent scientometric papers have addressed COVID-19 and the influenza virus in the knowledge of science and technology. As per exhaustive searching on the Scopus database, this research has not found a single paper that provides broad coverage of infectious diseases from the perspective of ICT. As a result, this scientometric paper is performed to fill this research gap and explore the current state of ICT in the various domains of infectious diseases.

1.2. Focus and objectives

The purpose of this research is to conduct scientometric analysis of scholarly publications of viral infectious disease for 2012–2021 to systematically investigate various domains, emerging research areas, prominent sources, and technology trends in this field. This work intends to analyze the recent status of ICT and its potential applications in infectious diseases. More specifically, The key objectives of this research are as follows:

1. To identify the research status quo, such as analyzing the scientific growth pattern of publications, prolific journals, and citation structure of documents.
2. To analyze co-citation and co-occurrence networks for deducing the intellectual landscape, research frontiers, and ICT trends in infectious diseases.
3. To identify critical research topics, research outputs of influential articles, and potential possibilities for future work.

This paper makes a significant contribution to the discipline of Science and Technology. It provides an essential takeaway about disruptive technologies in life-threatening infectious diseases and helps researchers and academic fraternity around the world to understand the intellectual structure, various research dynamics, and evolving trends in active pursuit of this domain.

1.3. Structure of paper

This paper is structured as follows: Section 1 Introduction: presents the background study of infectious diseases and explores use of ICT along with Research gap and Objectives of this paper. Section 2 Methodology: outlines the Data sources, Visualization tool-CiteSpace, and Searching strategy. Section 3 Results and discussion: this section presents the result of the following analyses: Publication pattern analysis, Geographical distribution, Citation structure analysis, Prominent journal analysis, Intellectual structure of infectious diseases derived from Document co-citation analysis, and Keyword co-occurrence network analysis. Section 4 Conclusion and future work.

2. Methodology

Sample and data

Google Scholar, Web of Science, Scopus are three primary databases mainly used for bibliometric studies [63]. Google scholar is simple to use and provides free access to scholarly literature. It offers a broader range of publications as compared to prior databases. Web of Science offers online subscription-based scientific citation indexing for researchers. Web of Science and Scopus data sources are considered as the best alternatives to each other because both databases prefer various convenient features for researchers. This research has exported all data from the Scopus database. It provides 20% more coverage than the Web of Science from the citation analysis point of view [25]. Scopus provides various on-site analyses such as year-wise, subject-wise, document type, publication type, source type, keyword occurrence, affiliations, country-wise analysis on searched results [46]. It also provides an online-analytical tool for visualizing the searched results in terms of graphs and tables.

Measures of variables

Several tools are used to analyze and visualize the scientific literature such as CiteSpace, VOSviewer, and Gephi ([Sood and Rawat,](#)

2021). These tools are used to extract and visualize scholarly information from massive data collection. CiteSpace is the best visualization tool that offers rich features to researchers for identifying the intellectual links among the publications. It is a free open software tool that provides different insights to analyze the bibliometric data. It enables the users to analyze the data by reference, authors, source, country, and keywords. CiteSpace is best compatible with the Web of Science data format. If users want to use the CiteSpace tool with other data formats, they need to convert it into a CiteSpace-friendly format. It is best compatible with the Web of Science data format. If the user wants to employ the CiteSpace tool with another data format, they need to convert it into a CiteSpace-friendly format. However, CiteSpace provides built-in functionality for transforming data into its format. In this paper, CiteSpace version 5.8.R2 is used to explore the document co-citation network and Keywords co-occurrence network analysis. Furthermore, Microsoft Excel version 2019 is used in this research to perform statistical analysis. In addition, Fig. 2 represents the analysis and tools adopted for this research.

Data analysis procedure with searching strategy

A collection of scientific publications was exported from the Scopus database using the advanced query: (TITLE-ABS-KEY (“infectious diseases”) AND TITLE-ABS-KEY (“information communication technology”)) AND PUBYEAR > 2011 AND PUBYEAR < 2022 AND (LIMIT-TO (SRCTYPE,“j”)) AND (LIMIT-TO (DOCTYPE,“ar”) OR LIMIT-TO (DOCTYPE,“re”)) AND (LIMIT-TO (LANGUAGE,“English”)). Fig. 3 represents the searching strategy and different restriction parameters applied to obtain more relevant and quality publications in this research domain. We repeated the same query by changing the diseases keywords. On the other hand, the general ICT terms are: “information communication technology”, “Intelligent technology”, “mobile technology”, “health information technology” in the Title-Abstract-Keyword search field. This research obtained a total of 4,980 records for further scientometric analysis as shown in Table 1.

3. Results and discussion

3.1. Publication pattern analysis

The analysis represents the growth pattern of publications over the years to reflect the academic progress in a specific research field. Fig. 4 depicts the total number of articles received from 2012 to 2021. The trending line in the chart signifies the growth rate of publications. It is observed that the growth rate of papers has accelerated after 2019. It indicates a surge of publications have received from the disciplines of science and technology in recent two years. In contrast, Fig. 5 represents the segregation of publications based on classifications of infectious diseases. In this line chart, each line represents a single domain of infectious diseases. The X-axis of the Fig. 5 shows the years from 2012 to 2021 whereas Y-axis denotes the number of publications. Airborne and food & waterborne follow the primary axis (0 to 1800) whereas fomite-borne, vector-borne, and STI follow the secondary axis (0 to 240). The analysis depicts that researchers have been paying more attention to the STI area from its beginning. It obtained a comparatively steady growth in the number of publications till 2018. It shows that this field has consistently received research articles with any substantial downturn in the last ten years. It indicates STI is a critical field in the healthcare domain. In airborne diseases, the growth of publications was not stable at first, but lately, an expeditious growth has been observed after 2019. A share of 95.13% of total publications of airborne diseases has been received in the last two years. From which most publications are related to the COVID-19 outbreak. In contrast, Fomite-borne and vector-borne diseases received publications with fluctuating growth rates from 2012 to 2021. Consequently, a significant downfall in the growth rate of fomite-borne illnesses records was observed in 2019. Food & waterborne literature received a comparatively lesser number of publications. Furthermore, there has been no significant change in the growth rate of publications have noted in food & waterborne area throughout the period.

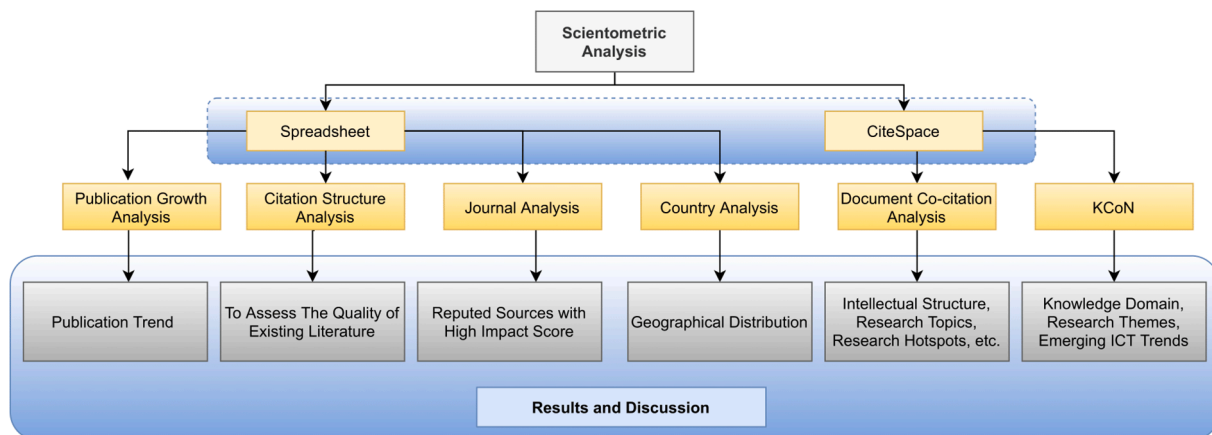


Fig. 2. Research Framework.



Fig. 3. Inclusion and Exclusion Criteria for Literature Selection.

Table 1
Representation of Disease Classifications and Filtered Research Publications.

| Diseases | Publications |
|-------------------|--------------|
| Airborne | 2548 |
| Fomite-borne | 277 |
| STI | 1282 |
| Vector-borne | 444 |
| Food & waterborne | 429 |

3.2. Geographical distribution analysis

Geographical distribution analysis represents the contribution of different nations in a specific research field. This analysis is based on the frequency of publications received from the top-5 countries in each domain of diseases shown in Table 2. This table depicts the list of top countries along with their produced publications and share of documents in each category. The United States has produced the maximum number of publications in all domains of infectious illnesses. From which, STI domain has received 47.81% a share of total publications only from this nation. The United Kingdom has taken the second highest lead in all domains except in food & waterborne diseases, where Pakistan has taken the lead with a share (5.82%) of total publications. India has produced the third-highest number of papers in the domains of airborne (195) and vector-borne (57), whereas Canada and China have produced the maximum number of publications in the fields of fomite-borne (22), STI (80), and food & waterborne (49) respectively. China has made the fourth-highest lead in the domain of airborne (191) and fomite-borne (18) whereas Australia, Brazil and the United Kingdom have produced a higher number of documents in the field of STI (78), Vector-borne (52), and food & waterborne (30) respectively. Italy has taken the fifth-highest lead in the airborne research domain with a share (6.51%), whereas France in fomite-borne (6.49%), Canada in



Fig. 4. Overall Growth of Scientific Publications From 2011–2021.

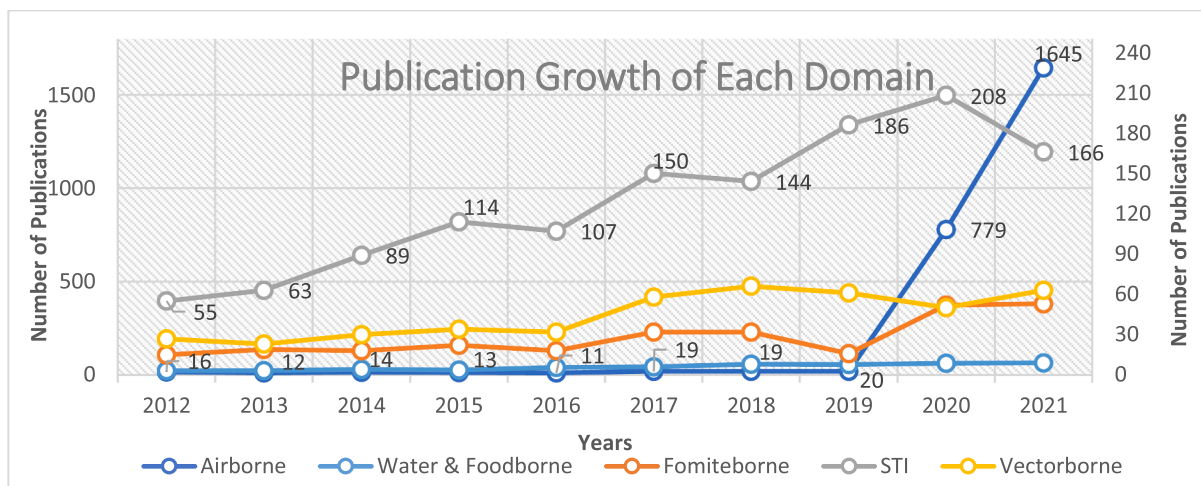


Fig. 5. Growth of Scientific Publications in Each Domain of Infectious Diseases.

Table 2
Top-5 Most Productive Nations.

| Domain | Top 1 | Top 2 | Top 3 | Top 4 | Top 5 |
|-------------------|----------------------------|-----------------------------|-------------------|---------------------------|----------------------|
| Airborne | United States (605, 23.74) | United Kingdom (281, 11.02) | India (195, 7.65) | China (191, 7.49) | Italy (166, 6.51) |
| Fomite-borne | United States (93, 33.57) | United Kingdom (33, 11.91) | Canada (22, 7.94) | China (18, 6.49) | France (18, 6.49) |
| STI | United States (613, 47.81) | United Kingdom (119, 9.28) | China (80, 6.24) | Australia (78, 6.08) | Canada (70, 5.46) |
| Vector-borne | United States (134, 30.18) | United Kingdom (66, 14.86) | India (57, 12.83) | Brazil (52, 11.71) | Australia (27, 6.08) |
| Food & waterborne | United States (125, 29.13) | Pakistan (25, 5.82) | China (49, 11.42) | United Kingdom (30, 6.99) | Brazil (27, 6.29) |

STI (5.49%), Australia in vector-borne (6.08%), and Brazil in food & waterborne (6.29%), produced a maximum share of publications in prior domains.

3.3. Citation structure analysis

The citation analysis is used to assess the quality and impact of the research articles in an academic field. Table 3 represents the disease classifications and the number of citations ranging from 0 to 100 and greater than 100. The numbers (%) in the table represents the share of publications in each domain of infectious diseases. The analysis depicts that a share of 13–20% of the total publications has received zero citation count in all domains except airborne (39.29%). The primary reason behind the most zero citation count of airborne research publications is that the major share (95.13%) of airborne literature has been received in 2020 and 2021. Fomite-borne, on the other hand, has received the least zero-citation count. All domains of infectious diseases possess 8–12% papers having one citation only except for airborne (15.19%). A share of 4–7% publications of all categories has received 3 and 4 citations only. It has been that 17–24% of publications have received 5–10 citations in all categories of diseases except airborne diseases (12.44%). A share (14–18)% of documents have gained 11–20 citation counts whereas 10–13% of publications have received 21–50 citations in all domains except for airborne.

It has been found that 1–3% share of documents of all disease categories has obtained citations scores between 50 and 100 except for food & waterborne (6.06%). Similarly, a share of 1–3% publications of all domains of diseases has crossed more than 100 citation count. From which, the highest share (3.26%) of publications with more than 100 citations come from the food & waterborne domain.

3.3.1. Prominent journals analysis

The research investigates the top five prominent journals in each domain of infectious diseases. This analysis aims to identify the leading journals in this research field. Table 4 shows the list of highly cited journals with total citation count, the number of publications (np), Average Citation Per Publication (ACPP), share of publications (np%), and the impact factor (IF) of journals. After careful examination of Table 4, it found that the ACS nano has a higher number of citations in airborne diseases (946) followed by The Lancet in vector-borne diseases with citations (887). The Journal of Medical Internet Research is having the maximum number of publications (93) followed by JMIR mHealth and uHealth with publications of 48 in airborne research. In domain analysis, ACS nano and The Lancet Public Health are dominant journals in airborne diseases whereas Nature Medicine and Annals of Oncology have a greater influence in fomite-borne diseases.

In contrast, PLoS ONE, AIDS and Behavior have a greater impact in the STI domains. Likewise, The Lancet and Plos Neglected Tropical Diseases have made notable contributions in Vector-borne diseases. The lancet has also made a significant impact in the realm of food & waterborne followed by Biosensors and Bioelectronics with citations of 524. with the highest impact factor (79.321) in all domains of infectious diseases. In terms of the Impact factor, The Lancet (79.321), Nature Medicine (53.44), and Science (47.728) have a higher impact than the others.

3.4. The intellectual structure of infectious diseases

CiteSpace represents the literature of infectious diseases in terms of scientific collaboration networks to describe the dynamic structure of research development. The collaboration network synthesized from a series of high cited publications published in the one-year time interval ranges from 2012 to 2021. The references used by these high-cited papers are portrayed as nodes in the co-citation network. The connectivity among the nodes is represented by links in the collaborative networks. It indicates that these nodes are associated in some ways. The validation of the collaboration network can be measured using temporal and structural properties. These are some following key parameters used to validate the quality of the network: Silhouette score (-1, 1) measure the homogeneity of the clustering result. A value close to 1 indicates high precision in clustering whereas a value close to -1 indicates weak connectivity between cluster members. Modularity (0,1) measures the quality of the clustering result. A value of 1 suggests high quality of clustering results. It shows that the network is perfectly broken down into discrete clusters. Betweenness centrality measures the strength of links established between the nodes and reflects the influence of nodes in the connected network. High betweenness represents the high impact of the node in the network. Similarly, Citation burst indicates the expeditious growth in the citation counts of publications.

Fig. 6 represents the timeline view of document co-citation networks of all domains of infectious diseases. It shows five document co-citation networks, namely, airborne diseases, fomite-borne, STI, vector-borne, and waterborne respectively. This research has adopted g-index selection criteria with different scale factors (K) for each domain. The g-index gives more weightage to high cited papers. The different colour layers on the right bottom side corner represent the time domain of the nodes by year from 2012 to 2021 as

Table 3
Citation Distribution of Research Publications Over Infectious Disease Domains.

| Domains | 0 | 1 | 2 | 3 | 4 | 5–10 | 11–20 | 21–50 | 51–100 | >100 |
|-------------------|-------|-------|------|------|------|-------|-------|-------|--------|------|
| Airborne | 39.29 | 15.19 | 7.77 | 5.97 | 4.43 | 12.44 | 7.22 | 4.79 | 1.81 | 1.10 |
| Fomite-borne | 13.72 | 11.55 | 7.22 | 4.69 | 2.89 | 23.83 | 18.77 | 10.83 | 3.97 | 2.53 |
| STI | 17.16 | 10.53 | 8.42 | 6.79 | 3.67 | 19.97 | 16.61 | 12.09 | 3.20 | 1.56 |
| Vector-borne | 17.34 | 9.23 | 9.46 | 5.86 | 4.28 | 24.10 | 14.19 | 10.36 | 3.15 | 2.03 |
| Food & Waterborne | 20.28 | 8.62 | 6.99 | 4.66 | 3.03 | 17.72 | 16.32 | 13.05 | 6.06 | 3.26 |

Table 4
Top-Five Most Influential Journals in Each Domain of Infectious Diseases.

| Classification | Source title | Total Citation | np | ACPP | np% | Impact Factor |
|-------------------|---|----------------|----|--------|------|---------------|
| Airborne | ACS nano | 946 | 4 | 236.5 | 0.16 | 15.881 |
| | The Lancet Public Health | 781 | 3 | 260.33 | 0.12 | 21.648 |
| | Journal of Medical Internet Research | 775 | 93 | 8.33 | 3.65 | 5.428 |
| | JMIR mHealth and uHealth | 571 | 48 | 11.89 | 1.88 | 4.773 |
| | Nature | 569 | 8 | 71.12 | 0.31 | 49.962 |
| Fomite-borne | Nature Medicine | 472 | 1 | 472 | 0.36 | 53.44 |
| | Annals of Oncology | 254 | 2 | 127 | 0.72 | 32.976 |
| | Cancer Immunology, Immunotherapy | 247 | 1 | 247 | 0.36 | 6.968 |
| | Journal of Clinical Oncology | 209 | 1 | 209 | 0.36 | 44.544 |
| | International Materials Reviews | 164 | 1 | 164 | 0.36 | 19.599 |
| STI | PLoS ONE | 792 | 27 | 29.33 | 2.11 | 3.24 |
| | AIDS and Behavior | 688 | 25 | 27.52 | 1.95 | 3.895 |
| | JMIR mHealth and uHealth | 551 | 41 | 13.43 | 3.20 | 4.773 |
| | Journal of Medical Internet Research | 480 | 36 | 13.33 | 2.81 | 5.428 |
| | Sexually Transmitted Infections | 421 | 17 | 24.76 | 1.33 | 3.519 |
| Vector-borne | The Lancet | 887 | 3 | 295.66 | 0.68 | 79.321 |
| | PLoS Neglected Tropical Diseases | 645 | 43 | 15 | 9.68 | 4.411 |
| | American Journal of Tropical Medicine and Hygiene | 289 | 19 | 15.21 | 4.28 | 2.345 |
| | Parasites and Vectors | 287 | 21 | 13.66 | 4.73 | 3.876 |
| | Lymphology | 281 | 2 | 140.5 | 0.45 | 1.286 |
| Food & Waterborne | The Lancet | 844 | 2 | 422 | 0.47 | 79.321 |
| | Biosensors and Bioelectronics | 524 | 7 | 74.85 | 1.63 | 10.618 |
| | Science | 403 | 1 | 403 | 0.23 | 403 |
| | Food Research International | 253 | 3 | 84.33 | 0.70 | 6.475 |
| | Food Control | 234 | 4 | 58.5 | 0.93 | 5.548 |

shown in Fig. 6. It signifies the nodes and citations in purple color (light to dark) happen closely to 2012 whereas yellowish ones occur in close years to 2021. The labels of clusters with their IDs are on the right side of figure. Cluster IDs are labelled with '#' and the number in the IDs imply the size of clusters. For instance, #0 is the largest cluster whereas #7 is the smallest cluster in the airborne network. The labels of clusters are retrieved using the LLR algorithm. LLR (Log-Likelihood Ratio) provides unique labels to the clusters with adequate coverage of core literature than other labelling extraction algorithms. The solid timeline of clusters shows the activeness of the cluster whereas clusters with dotted lines depict the inactive span of the cluster. The timeline legend on the top of Fig. 6 shows a clearer understanding of trends and magnitude of the bursts of references on a specific cluster timeline. Citespace characterized the reputed literature through the use of a variety of visual attributes. For example, the larger the node size signifies that the article has received a good amount of citations. Similarly, a node with yellow tree rings represents the most recent citation relationships in the network and indicates the current research hotspots. A node with purple citation tree rings imply that the articles were established in early period. The red nodes are the bursts nodes that represent the most active research areas in this knowledge domain. Likewise, the nodes having an outer pink ring represent the betweenness centrality. It signifies the importance of the node and its impact other connected nodes in the network map.

3.4.1. Core literature of airborne diseases

The document co-citation network of airborne diseases consists of 393 nodes and 993 links with an overall density of the entire network is 0.0129. The density of network signifies the clarity and influence of the network. The highest possible density is 1.00, which represents a highly centralized and connected network. The weighted mean silhouette score is 0.9355 and modularity is 0.8374 of this network. These values signify that the clustering result of this network map is highly reliable. This network is divided into seven different clusters having sizes greater than or equal to 15. Table 5 shows the different attributes of each cluster such as ID number, size, silhouette value, mean year, LLR label of clusters. The size of the cluster indicates the presence of a total number of citing articles. The mean year represents the recentness of the cluster. The LLR labels of the clusters reflect the research frontiers in this knowledge domain. Consequently, artificial intelligence, information systems success model, tracing app, COVID-19 outbreak, rapid review, and participatory disease surveillance system are the main research areas in this knowledge domain.

Cluster #0 labelled "Artificial intelligence" is the first largest cluster having a size of 42. The silhouette value of 0.897 and the mean year of this cluster is 2019. The active duration of the cluster starts from year 2004 and lasts up to 2020. This cluster contains numerous nodes with yellow citation rings signify that this research area is a recent research hotspot in this discipline's development. This cluster includes the following top research topics: vascular medicine, digital contact, and cas13-based detection. Furthermore, the most cited work in this cluster by Gerotziafas and Catalano (2020). The work demonstrates the management of patients with cardiovascular disease risk factors and COVID-19. Also, it provides the assessments for the foundation of home treatment and hospitalization with the

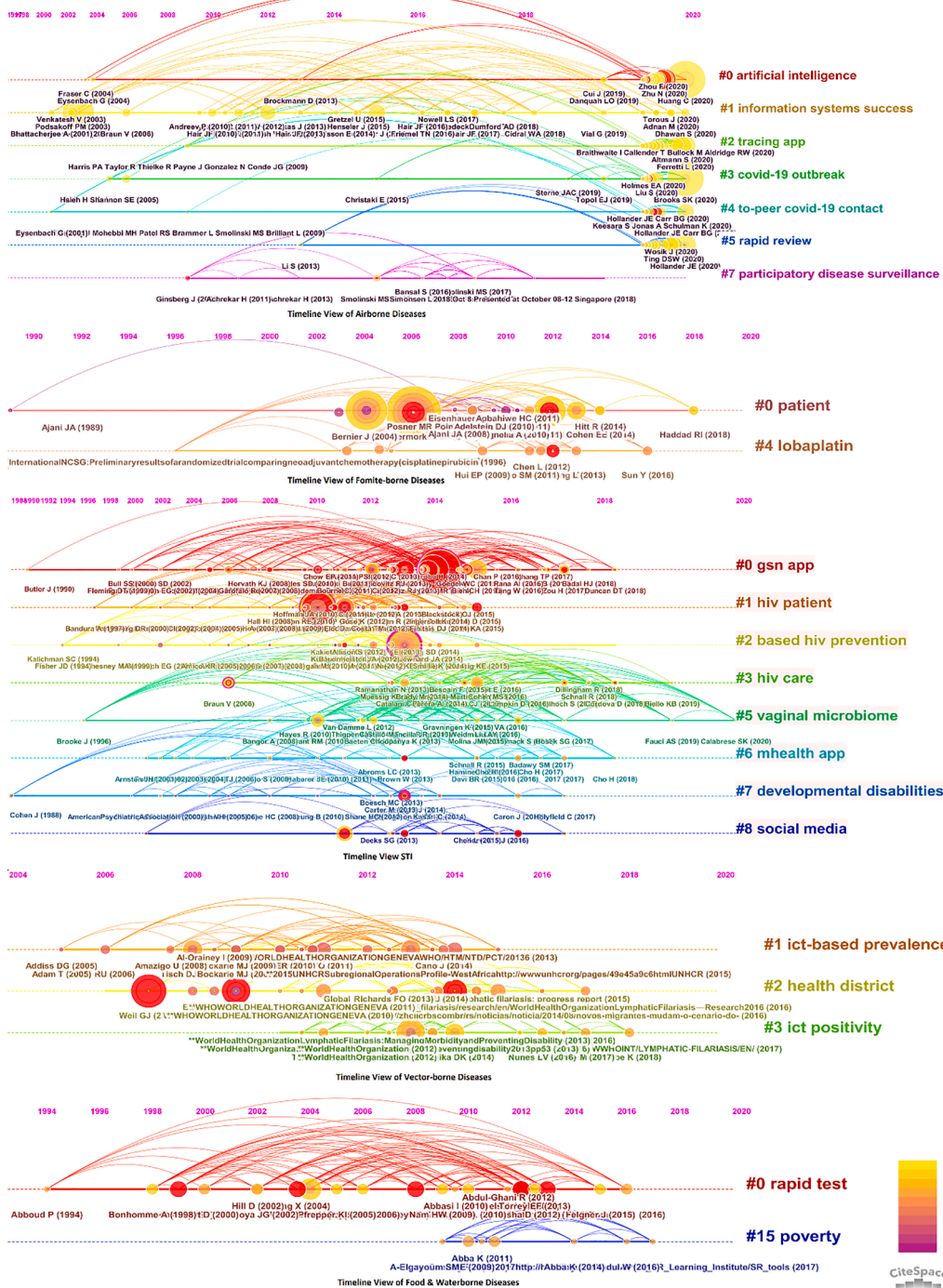


Fig. 6. Timeline View of Each Domain of Infectious Diseases.

use of eHealth technology.

Cluster #1 labelled “Information systems success” is the second-largest cluster containing 35 citing references. The mean year and silhouette score of this cluster are 2014 and 0.921 respectively. This cluster starts from year 2001 and lasts up to 2020. This cluster includes the following main research topics: e-learning context, McLean model, education institutions, and social distancing. McLean is an information systems success model used to assess complex dependent variables in information systems research (McLean, 2003). The most cited article in this cluster by Jang et al. (2021). This work examines the impact of information literacy on the intention to use digital technologies for learning.

Table 5
Clusters Information in Each Domain of infectious Diseases.

| Domains | ID | Size | Silhouette | Mean year | LLR |
|-------------------|----|------|------------|-----------|---|
| Airborne | 0 | 42 | 0.897 | 2019 | Artificial Intelligence |
| | 1 | 35 | 0.921 | 2014 | Information Systems Success |
| | 2 | 30 | 0.986 | 2019 | Tracing App |
| | 3 | 27 | 0.879 | 2018 | Covid-19 outbreak |
| | 4 | 26 | 0.979 | 2018 | To-peer COVID-19 Contact |
| | 5 | 25 | 0.936 | 2019 | Rapid Review |
| | 7 | 15 | 0.999 | 2015 | Participatory Disease Surveillance System |
| Fomite-borne | 0 | 18 | 0.977 | 2008 | patient |
| | 4 | 10 | 1 | 2007 | lobaplatin |
| STI | 0 | 61 | 0.79 | 2011 | GSN app |
| | 1 | 52 | 0.855 | 2010 | HIV patient |
| | 2 | 32 | 0.891 | 2009 | based HIV prevention |
| | 3 | 26 | 0.903 | 2014 | HIV care |
| | 5 | 21 | 0.97 | 2013 | Vaginal Microbiome |
| | 6 | 19 | 0.951 | 2011 | mhealth app |
| | 7 | 18 | 0.997 | 2008 | developmental disabilities |
| | 8 | 16 | 0.867 | 2013 | Social media |
| Vector-borne | 1 | 31 | 0.885 | 2011 | ICT-based prevalence |
| | 2 | 28 | 0.986 | 2012 | health district |
| | 3 | 23 | 0.976 | 2013 | ICT positivity |
| Food & Waterborne | 0 | 21 | 0.983 | 2006 | Rapid Test |
| | 15 | 7 | 0.994 | 2012 | Poverty |

Cluster #2 labelled “Tracing app” is the third-largest cluster containing 30 citing references. The mean year and silhouette score of this cluster are 2019 and 0.986 respectively. This cluster starts from year 2009 and lasts up to 2020. This cluster includes the following primary research topics: COVID-19 tracing app, national health insurance, and uncertainty reduction. The most cited article in this cluster by [Kolasa et al. \(2021\)](#). This work reviewed 21 contact tracing apps and demonstrates how tracing apps with high-level data privacy standards tends to maximize public health benefits.

Cluster #3 labelled “COVID-19 outbreak” is the fourth largest cluster having a size of 27. The silhouette value of 0.879 and the mean year of this cluster is 2018. The active duration of the cluster starts from year 2004 and lasts up to 2020. This cluster includes the following top research topics: supportive technologies, covid-19 quarantine, emergency management, and digital applications. The most cited work in this cluster by [Kumaravel et al. \(2020\)](#). The work explores various preventive measures and technology employed to maintain the situation under control during the COVID-19 period.

Cluster #4 labelled “To-peer COVID-19 contact” is the fifth-largest cluster having 26 citing references. The mean year and silhouette score of this cluster are 2018 and 0.979 respectively. This cluster starts from year 2002 and lasts up to 2020. This cluster includes the following main research topics: digital health solutions, high disease prevalence, rapid deployment, health systems, and smartphone apps. The most cited article in this cluster by [Nakamoto et al. \(2020\)](#). This article introduces a bluetooth- based mobile contact-confirming application. This application provides detailed notifications related to COVID-19 without losing the compliance and standards of data privacy.

Cluster #5 labelled “Rapid review” is the sixth largest cluster having a size of 26. The silhouette value of 0.936 and the mean year of this cluster is 2019. The active duration of the cluster starts from year 2013 and lasts up to 2020. The majority of top citing references of this cluster are based on the significance of medical 4.0 and the role of telemedicine technologies in the healthcare domain from the context of an outbreak. The most cited work in this cluster by [Bahl et al. \(2020\)](#). This work provides a comprehensive review of telemedicine technology. It demonstrates how telemedicine technologies have great potential to provide the best treatment.

Cluster #7 labelled “Participatory disease surveillance system” is the seventh-largest cluster having 15 citing articles. The mean year and silhouette score of this cluster are 2015 and 0.999 respectively. This cluster starts from year 2009 and lasts up to 2019. This cluster includes the following main research topics: ethical framework, participatory influenza surveillance, and complementing conventional infectious disease surveillance. The most cited article in this cluster by [Geneviève et al. \(2019\)](#). This article delineates several ethical issues raised by public health surveillance systems. Furthermore, this work used the Influenzanet digital system as a case study to exhibit ethical challenges associated with this digital platform.

Most Active Research Areas in Airborne Knowledge Domain: Burst references reflect the most active research topics evolving for a certain time duration. These references have received a surge of citations in a very short period of time. It signifies that the researchers have paid more attention towards the underlying work. The purpose of citation burst references is to trace the development of research focus. [Fig. 7](#) represents the list of references with the strongest citation bursts in airborne literature. The first top-most reference by burst is [Ginsberg et al. \(2009\)](#). This reference belongs to cluster #7 participatory diseases surveillance system. The citation burst

Top 5 References with the Strongest Citation Bursts in Airborne Literature

| References | Strength | Begin | End | 2012 - 2021 |
|---|----------|-------|------|-------------|
| Ginsberg J, 2009, Detecting influenza epidemics using search engine query data @ Nature, V457, P1012-1014 | 2.62 | 2018 | 2019 | |
| Smolinski MS, 2015, Flu near you, V105, P2124-2130 | 2.59 | 2019 | 2021 | |
| McCall B, 2020, COVID-19 and artificial intelligence, V2, P0 | 3.19 | 2020 | 2021 | |
| Hollander JE Carr BG, 2020, Virtually Perfect?, V382, P1679-1681 | 3.19 | 2020 | 2021 | |
| Zhu N, 2020, A novel coronavirus from patients with pneumonia in China, 2019 @ N Engl J Med, V382, P727-733 | 3.12 | 2020 | 2021 | |

Top 5 References with the Strongest Citation Bursts in Fomite-borne Literature

| References | Strength | Begin | End | 2012 - 2021 |
|--|----------|-------|------|-------------|
| Pignon JP, 2009, Meta-analysis of chemotherapy in head and neck cancer (MACH-NC), V92, P4-14 | 1.64 | 2012 | 2013 | |
| Starr PA, 2014, Interventional MRI-guided deep brain stimulation in pediatric dystonia, V14, P400-408 | 1.96 | 2017 | 2018 | |
| Al-Sarraf M, 1998, Chemoradiotherapy versus radiotherapy in patients with advanced nasopharyngeal cancer, V16, P1310-1317 | 1.66 | 2017 | 2017 | |
| Fountzilias G, 2012, Induction chemotherapy followed by concomitant radiotherapy and weekly cisplatin versus the same concomitant chemoradiotherapy in patients with nasopharyngeal carcinoma, V23, P427-435 | 1.66 | 2017 | 2017 | |
| Holloway K, 2013, A quantitative assessment of the accuracy and reliability of O-arm images for deep brain stimulation surgery @ Neurosurgery, V72, P47-57 | 1.61 | 2018 | 2018 | |

Top 5 References with the Strongest Citation Bursts in STI Literature

| References | Strength | Begin | End | 2012 - 2021 |
|---|----------|-------|------|-------------|
| Pop-Eleches C, 2011, Mobile phone technologies improve adherence to antiretroviral treatment in a resource-limited setting, V25, P825-834 | 3.81 | 2013 | 2016 | |
| Winetrobe H, 2014, Associations of unprotected anal intercourse with Grindr-met partners among Grindr-using young men who have sex with men in Los Angeles @ AIDS Care, V26, P1303-1308 | 3.72 | 2016 | 2019 | |
| Phillips G, 2014, Use of geosocial networking (GSN) mobile phone applications to find men for sex by men who have sex with men (MSM) in Washington, DC @ AIDS Behav, V18, P1630-1637 | 5.18 | 2018 | 2019 | |
| Beymer MR, 2014, Sex on demand, V90, P567-572 | 4.17 | 2018 | 2019 | |
| Zou H, 2017, Characteristics of men who have sex with men who use smartphone geosocial networking applications and implications for HIV interventions, V46, P885-894 | 3.93 | 2019 | 2021 | |

Top 5 References with the Strongest Citation Bursts in Vector-borne Literature

| References | Strength | Begin | End | 2012 - 2021 |
|---|----------|-------|------|-------------|
| Wongsrichanalai C, 2007, A review of malaria diagnostic tools, V77, P119-127 | 2.33 | 2012 | 2013 | |
| Gillet P, 2009, Assessment of the prozone effect in malaria rapid diagnostic tests @ Malar J, V8, P271 | 2.32 | 2012 | 2013 | |
| Boelaert M, 2008, Diagnostic tests for kala-azar, V102, P32-40 | 1.90 | 2013 | 2014 | |
| Michael E, 2004, Mathematical modelling and the control of lymphatic filariasis @ Lancet Infect Dis, V4, P223-234 | 2.31 | 2015 | 2017 | |
| Maia Z, 2012, Comparative study of rK39 Leishmania antigen for serodiagnosis of visceral leishmaniasis, V6, P0 | 2.07 | 2019 | 2021 | |

Fig. 7. Top-5 Burst References in Airborne, Fomite-borne, STI, and Vector-borne Domains.

started in 2018 and ended in 2019 as shown in Fig. 7. This work illustrates how to early detect infectious diseases like the influenza virus by analyzing a large number of google search queries. Authors have developed a model that takes google-searched data submitted by different users who are experiencing influenza-like symptoms.

The second top-most reference by burst is [Smolinski et al. \(2015\)](#). This reference also belongs to cluster #7 participatory diseases surveillance system. The citation burst started in 2019 and ended in 2021. This article represents a Flue Near You (FNY) framework to analyze the symptoms of influenza by online survey technology that directly engaging the people to public health reporting. FNY is a public health disease surveillance system that leverage digital communication technologies to achieve rapid response.

The third top most reference by burst is [McCall \(2020\)](#). This reference belongs to cluster #3 COVID-19 outbreak. The citation burst of this reference started in 2020 and ended in 2021. This article explores the role of artificial intelligence in COVID-19 pandemic. Many applications of artificial intelligence have used in health care against COVID-19 pandemic such as predicting the next location of the outbreak, monitoring the social media, artificial intelligence based cameras for surveillance suspects to maintain lockdown policies during pandemic periods.

The fourth top-most reference by burst is [Hollander and Carr \(2020\)](#). This reference belongs to cluster #4 to-peer COVID-19 contact. The citation burst of this reference started in 2020 and ended in 2021. The article delineates the use of telemedicine technology for covid-19 outbreak. The work focused on number of feasible solutions that enable the treatment of patients at home using telemedicine technologies.

The fifth top-most reference by burst is [Zhu et al. \(2020\)](#). This reference belongs to cluster #0 artificial intelligence. The citation burst of this reference started in 2020 and ended in 2021. This article demonstrates different members (seven) of the coronavirus family. This work distinguishes serious acute respiratory syndrome-coronavirus, middle east respiratory syndrome coronavirus, and Coronavirus 2019. It also explores viral diagnostic methods, genome sequencing, and the transability mode of viruses.

3.4.2. Core literature of fomite-borne diseases

The document co-citation network of fomite-borne diseases consists of 263 nodes and 429 links with an overall density of the entire network is 0.0125. This network has a weighted mean silhouette score of 0.9851 and modularity is 0.9373. This network is divided into two clusters as shown in [Table 5](#). The LLR labels of the clusters reflect the research frontiers in this knowledge domain. Patient, Lobaplatin are the two main research areas in the knowledge field of fomite-borne. Both research areas are more related to the biomedical field. From the view of computer science discipline, imaging and radiological technologies are on the front topics in fomite-borne. At present, clusters have an inactive status as shown in the timeline view of fomite-borne. It indicates that there is no any landmark research has been done in recent years from the field of computer science.

Most Active Research Areas in fomite-borne Domain: [Fig. 7](#) represents the list of references with the strongest citation bursts in fomite-borne literature. These are following most active research topics deduced from top burst references viz; chemotherapy, radiotherapy and magnetic resonance imaging. The first top-most reference by burst is [Pignon et al. in 2014](#). This reference belongs to cluster #0 patient with burst 1.64. The citation burst of this reference started in 2012 and ended in 2013. The second top-most reference by burst is [Starr et al. in 1998](#). This reference belongs to cluster #0 patient with burst 1.96. The citation burst started in 2017 and ended in 2018. This work developed interventional magnetic resonance imaging to achieve accurate lead placement in anaesthesia patients. The third top reference by burst is [Al-Sarraf et al. in 1998](#). This reference belongs to cluster #4 lobaplatin with burst 1.66. The citation burst started and ended in 2017. The fourth top reference by burst is [Fountzilias et al. in 2012](#). This reference belongs to cluster #4 lobaplatin with burst 1.66. The citation burst started and ended in 2017. The fifth top reference by burst is [Holloway et al. in 2014](#). This reference belongs to cluster #0 patient with burst 1.61. The citation burst started and ended in 2018.

3.4.3. Core literature of STI

The document co-citation network of STI domain consists of 390 nodes and 1165 links with an overall density of the entire network is 0.0154. The weighted mean silhouette score is 0.8889 and modularity is 0.7011 of this network. These values indicate that the clustering result of this network map is reasonable. This network is divided into eight different clusters having size is greater than 15 as shown in [Table 5](#). The main research areas in this research domain are; GSN app, HIV patients, based HIV care, vaginal microbiome, mhealth app, development disabilities, and social media. Cluster #0 labelled "GSN app" is the first largest cluster having a size of 61. The silhouette value of 0.790 and the mean year of this cluster is 2011. The active duration of the cluster starts from year 1990 and lasts up to 2018. GSN app stands for GeoSocial Networking applications. These are locations-based social networking applications used for online dating. This cluster includes the following top research topics: gsn apps users, recreational drugs, sexual health, and behavior tracking. The most cited work in this cluster by [Xu et al. \(2018\)](#). This work examines the features of geosocial networking and determines their increased effect on HIV incidence.

Cluster #1 labelled "HIV patient" is the second-largest cluster having a size of 52. The silhouette value of 0.855 and the mean year of this cluster is 2010. The active duration of the cluster starts from year 1990 and lasts up to 2018. The most relevant research topics of this cluster are; mobile phone technology, digital medicine, real-time care testing, patient monitoring, and data collection. The most cited work in this cluster by [Devi et al. \(2015\)](#). This article elicits the several uses of mobile technology to manage HIV/AIDS and tuberculosis patients. This work explores how mobile technology can be employed to treat such STI diseases.

Cluster #2 labelled "Based HIV prevention" is the third-largest cluster having a size of 32. The silhouette value of 0.891 and mean year of this cluster is 2009. The active duration of the cluster starts from year 1994 and lasts up to 2018. The most relevant research topics of this cluster are; digital innovations, clinical trials, and clinic attendance. The most cited work in this cluster by [Holloway et al. \(2017\)](#). This article discusses mobile-based HIV prevention among black young men who have sex with men. It describes the utilization of digital innovations to reduce the spread and improve treatment adherence in healthcare.

Cluster #3 labelled "HIV care" is the fourth-largest cluster having a size of 26. The silhouette value of 0.903 and the mean year of this cluster is 2014. The active duration of the cluster starts from year 1994 and lasts up to 2018. This cluster's most relevant research topics are; intervention group, health care setting, and depressive symptoms. The most cited work in this cluster by [Maloney et al.](#)

(2020). This article explores the recent interventions of eHealth for HIV care. This work preliminarily focuses on new media technologies used to prevent STI diseases.

Cluster #5 labelled “Vaginal microbiome” is the fifth-largest cluster having a size of 21. The silhouette value of 0.970 and the mean year of this cluster is 2013. The active duration of the cluster starts from year 1997 and lasts up to 2020. This cluster’s most relevant research topics are; odds ratio, pre-exposure prophylaxis conservatives, medication adherence, and discrete choice experiments. The most cited work in this cluster by [Liu et al. \(2020\)](#). This article developed an automated directly observed therapy platform to support pre-exposure prophylaxis use for control and prevent HIV infection.

Cluster #6 labelled “Developmental disabilities” is the sixth-largest cluster having a size of 19. The silhouette value of 0.951 and the mean year of this cluster is 2011. The active duration of the cluster starts from year 2001 and lasts up to 2018. This cluster’s most relevant research topics are; usability evaluation framework, heuristic evaluation, cognitive walkthrough, and eye-tracking retrospective think-aloud. The most cited work in this cluster by [Cho et al. \(2018\)](#). This article introduced an evidence-based methodological approach to assess the usability of mHealth applications. This work also describes the future scope of mHealth applications development.

Cluster #7 labelled “mhealth app” is the seventh-largest cluster having a size of 18. The silhouette value of 0.997 and the mean year of this cluster is 2008. The active duration of the cluster starts from year 1988 and lasts up to 2017. This cluster’s most relevant research topics are; autism program, visual support, and alternative communication. The most cited work in this cluster by [Donato et al. \(2014\)](#). This work represent the views of stakeholders on the challenges and opportunities to the implementation of visual language in autism program for children with developmental disabilities.

Cluster #8 labelled “Social media” is the eighth-largest cluster having a size of 16. The silhouette value of 0.867 and the mean year of this cluster is 2013. The active duration of the cluster starts from year 2002 and lasts up to 2017. This cluster’s most relevant research topics are; testing-related social media use, multifunctional platforms and social media engagement. The most cited work in this cluster by [Muessig et al. \(2017\)](#). This work explores the recent interventions of mHealth in antiretroviral therapy adherence among HIV patients.

Most Active Research Areas in STI Knowledge Domain: [Fig. 7](#) elicits the top five burst references with the strongest citation bursts in STI literature. After carefully evaluating burst references, it has been observed that all references belong to cluster #0 geosocial networking application except the first reference in the list belonging to cluster #1 HIV patient research area. It signifies that geosocial networking is a research hotspot in the domain of STI. The first top-most reference by burst is [Pop-Eleches et al. \(2011\)](#). This reference belongs to cluster #1 HIV patient with burst 3.81. The citation burst started in 2013 and ended in 2016. This article assessed the efficacy of short message service reminder for patients attending a rural clinic to promote antiretroviral therapy. The second top-most reference by burst is [Winetrobe et al. \(2014\)](#). This reference belongs to cluster #0 gsn app with burst 3.72. The citation burst started in 2016 and ended in 2019. This work demonstrated how the geosocial smartphone app, Grindr- dating app for gay, is associated with sexual risk-taking behavior. Furthermore, this paper conducted an online questionnaire survey on sexual behavior with their last Grindr-met partners. The third top-most reference by burst is [Phillips et al. \(2014\)](#). This reference belongs to cluster #0 gsn app with burst 5.18. The citation burst started in 2018 and ended in 2019. This work explored the same as prior burst reference, that is, the recent advancements in gsn applications that promote homosexuality and increase HIV cases. The fourth top-most reference by burst is [Beymer et al. \(2014\)](#). This reference belongs to cluster #0 gsn app with burst 4.17. The citation burst started in 2018 and ended in 2019. This article described how gsn apps are increasing the incidence of STIs. This work recognized that most gsn app users were infected with gonorrhoea, chlamydia, HIV, and syphilis. The fifth top-most reference by burst is [Zou and Fan \(2016\)](#). This reference belongs to cluster #0 gsn app with burst 3.93. The citation burst started in 2019 and ended in 2021. This paper conducts a comprehensive review on literature of HIV infection and location-based social networking applications. This work determined the scientific research gap in HIV literature and provides significant research directions to researchers belonging to this field.

3.4.4. Core literature of vector-borne diseases

The document co-citation network of Vector-borne diseases consists of 534 nodes and 1041 links with an overall density of the entire network is 0.0073. This network map has a weighted mean silhouette value of 0.9451 and modularity is 0.9228. This network is divided into three clusters with size greater than 20 as shown in [Table 5](#). ICT-based prevalence, health district, and ICT positivity are three research areas in the knowledge field of vector-borne. Here, ICT stands for immunochromatographic card test used to detect filarial antigens from serum or blood samples. At present, all clusters have an inactive status as shown in the timeline view of this domain. It indicates that there is no significant research in the domain of ICT-assisted healthcare has been performed in recent years.

Cluster #1 labelled “ICT-based Prevalence” is the first-largest cluster having a size of 31. The silhouette value of 0.885 and the mean year of this cluster is 2011. The active duration of the cluster starts from year 2005 and lasts up to 2015. The most relevant research topics of this cluster are; microfilaraemia prevalence, requiring treatment, analytical procedures, and solid-phase separation techniques. The most cited work in this cluster by [Moraga et al. \(2015\)](#). This article combined the geostatistical and mathematical modelling approach to predict the prevalence and spread of lymphatic filariasis.

Cluster #2 labelled “Health district” is the second-largest cluster having a size of 28. The silhouette value of 0.986 and the mean year of this cluster is 2012. The active duration of the cluster starts from year 2006 and lasts up to 2017. The most relevant research topics of this cluster are; urban areas, Culex mosquitoes, and pre-enrichment purification. The most cited work in this cluster by [Njenga et al. \(2017\)](#). This paper tracks the recent status of lymphatic filariasis disease in Kenya’s coastal region before the reimplementations of annual mass drug administration.

Cluster #3 labelled “ICT Positivity” is the smallest cluster in this network having a size of 28. The silhouette value of 0.976 and the mean year of this cluster is 2012. The active duration of the cluster starts from year 2010 and lasts up to 2018. This cluster’s most

relevant research topics are; canopy height, severe adverse event, and high risk. The most cited work in this cluster by Brant et al. (2018). This paper surveyed the literature of two highly infectious diseases: loiasis and lymphatic filariasis. Furthermore, this study examines the risk factors and landscape features associated with these two infectious diseases.

Most Active Research Areas in Vector-borne Knowledge Domain: Fig. 7 represents the top five burst references with strongest citation bursts in the literature of vector-borne diseases. These are following research areas deduced from top burst references viz; rapid diagnostic tests and tools for malaria and visceral leishmaniasis infections, deterministic mathematical solutions to control vector-borne diseases. The first top-most reference by burst is Wongsrichanalai (2007). This reference belongs to cluster #1 ICT-based Prevalence with burst 2.33. The citation burst started in 2012 and ended in 2013. This paper evaluates quality issues in Giemsa microscopy and rapid diagnostic tests significantly used to control the malaria infection. The second top-most reference by burst is Gillet et al. (2009). This reference belongs to cluster #2 health district with burst 2.32. The citation burst started in 2012 and ended in 2013. This article evaluates the effect of high dose-hook phenomenon in malaria diagnostic tests.

The third top-most reference by burst is Boelaert et al. (2008). This reference belongs to cluster #2 health district with burst 1.90. The citation burst started in 2013 and ended in 2014. This article examined the three diagnostic methods such as freeze-dried direct agglutination test, rK39 dipstick, and a urine latex antigen test to detect visceral leishmaniasis infection.

The fourth top-most reference by burst is Michael et al. (2004). This reference belongs to cluster #1 ICT-based Prevalence with burst 2.31. The citation burst started in 2015 and ended in 2017. This work discussed the recent advancement in mathematical models based on filariasis infection control. It demonstrates how deterministic models are beneficial to prevent the transmission of this vector-borne disease.

The fifth top-most reference by burst is Maia et al. (2012). This reference belongs to cluster #1 ICT-based Prevalence with burst 2.07. The citation burst started in 2019 and ended in 2021. This article described the meta-analysis of the literature to assess the accuracy of rK39 antigen using serological assays to treat visceral leishmaniasis.

3.4.5. Core literature of food & waterborne diseases

The document co-citation network of food & waterborne diseases consists of 429 nodes and 907 links with an overall density of the entire network is 0.0099. This network map has a weighted mean silhouette value of 0.9855 and modularity is 0.9509. This network is divided into two clusters with size greater than 5. Table 5 represents the details of clusters such as ID number, size, silhouette value, mean year, LLR label of cluster. Rapid test and poverty are two main research areas in the knowledge field of food & waterborne. Currently, both clusters have an inactive status as shown in the timeline view of this domain.

Cluster #0 labelled "Rapid test" is the largest cluster in this network having a size of 21. The silhouette value of 0.983 and the mean year of this cluster is 2006. The active duration of the cluster starts from year 1994 and lasts up to 2016. The most relevant research topics of this cluster are; urban area, rapid diagnostic test, and serological detection. The most cited work in this cluster by Ybañez et al. (2020). This article examines the potency of immunochromatography test using the use of GRA7 to detect toxoplasmosis infection in limited number of cats. Cluster #15 labelled "Poverty" is the smallest cluster in this network having a size of 7. The silhouette value of 0.994 and mean year of this cluster is 2012. The active duration of the cluster starts from year 2009 and lasts up to 2017. The most cited work in this cluster by Osorio et al. (2018). This article provides a comprehensive overview of infectious diseases including vector-borne diseases. This work assessed the availability of rapid diagnostics tests of infectious diseases in the urban context.

3.4.5.1. Most Active Research Areas in Food & Waterborne Knowledge Domain. Fig. 8 represents the top five burst references with strongest citation bursts. All references having the same burst value (1.65), and citation burst started and ended in the year 2020 and 2021 respectively. Furthermore, all top burst references belong to cluster #0 rapid testing. SAG1 GRA7 sequences, toxoplasma gandii infection, serological detection, and rapid immunochromatographic test are the most active research areas deduced from burst references as shown in Fig. 8. The first top refence by burst is Kotresha in 2012. The second top reference by burst is Dubey and Jones in 2008. The third top reference by burst is Selseleh et al. in 2012. The fourth top reference by burst is Terkawi et al. in 2013. The fifth top reference by burst is Huang X et al. in 2004.

| References | Strength | Begin | End | 2012 - 2021 |
|---|----------|-------|------|-------------|
| Kotresha D, 2012, Recombinant proteins from new constructs of SAG1 and GRA7 sequences and their usefulness to detect acute toxoplasmosis @ Trop Biomed, V29 | 1.65 | 2020 | 2021 | |
| Dubey JP, 2008, Toxoplasma gondii infection in humans and animals in the United States @ Int J Parasitol, V38, P1257-1278 | 1.65 | 2020 | 2021 | |
| Selseleh M, 2012, Production and evaluation of Toxoplasma gondii recombinant GRA7 for serodiagnosis of human infections @ Korean J Parasitol, V50, P233-238 | 1.65 | 2020 | 2021 | |
| Terkawi MA, 2013, Development of an immunochromatographic assay based on dense granule protein 7 for serological detection of Toxoplasma gondii infection @ Clin Vaccine Immunol, V20, P596-601 | 1.65 | 2020 | 2021 | |
| Huang X, 2004, Rapid immunochromatographic test using recombinant SAG2 for detection of antibodies against Toxoplasma gondii in cats @ J Clin Microbiol, V42 | 1.65 | 2020 | 2021 | |

Fig. 8. Top-5 Burst References in Food & Waterborne Diseases.

3.5. Keywords co-occurrence network

Prior literature analysis of this paper reflects intellectual base, active research area, thematic concentrations of each domain of infectious diseases. Furthermore, this research explores the keyword co-occurrence network (KCoN) analysis of published literature. This analysis aims to deduce meaningful information in terms of emerging trends, core content, research focus, and potent research directions in this field. Fig. 9 and Fig. 10 represent the co-occurrence network of airborne, STI, food & waterborne, fomite-borne, and vector-borne diseases, respectively. Likewise, Table 6 elicits top keywords by frequency value and degree in each domain of infectious diseases. This table categorized into two parts: the left side of the table represents ICT keywords, right side of the table represents diseases related keywords. These keywords are arranged in descending order according to their frequency value. It noted that this research ignored some keywords not relevant to this study, even having high-frequency values-for example, adult, male, female, article, etc. Frequency value signifies the number of occurrences in selected literature. Moreover, bigger node size is an indicator of a high-frequency value. In contrast, the degree value represents the number of co-citation links connected with the node. It means these terms are used together in a paper.

Keyword frequency signifies the total number of papers in which that term or keyword appears in title, abstract, keyword field of the paper. For example, the frequency value of mobile application keyword is 771 as shown in Table 6. It indicates that this keyword is presented in 771 research papers. In airborne diseases, COVID-19 (1524), e-learning (114), and mental health (108) are the top frequently occurred keywords that signify the research theme of most of the high cited publications. It indicates core research content in this knowledge structure. Similarly, mobile applications (771), telemedicine (370), social media (151), artificial intelligence (149), internet of things (46), and big data (22) are the top ICT keywords in this domain.

In fomite-borne diseases, diarrhea (135), dyspnea (23), and drug safety (19) are the top keywords in this research field. In contrast, mobile applications (75), telemedicine (15), and computer-assisted tomography (4) are the top ICT terms in this knowledge domain.

In STI, human immunodeficiency virus infection (384), HIV infection (361), and homosexuality (180) are top disease-related keywords whereas mobile application (560), mHealth (102), telemedicine (139), and social networking (58) are the top ICT terms used to diagnose STI.

In vector-borne diseases, malaria (137), immunoaffinity chromatography (117), and parasitology (73) are the top keywords in this knowledge structure. Whereas mobile applications (74), point of care testing (16), diagnostic testing kits (6), and machine learning (6) are the top ICT keywords in this field of infectious diseases.

In food & waterborne, hepatitis C (70), enzyme-linked immunosorbent assay (64), and hepatitis B (6) are the top keywords in this field. On the other side, mobile application (74), information technology (27), and telemedicine (11) are the top ICT terms in the domain of infectious diseases.

4. Conclusion and future work

In conclusion, the examination of the scholarly literature of severe infectious diseases and citation-based expansion has delineated the evolutionary trajectory of collective knowledge over the period 2012–2021. This research paper outlined the number of contributions made by researchers and acknowledged that there is no quantitative assessment of ICT in this field has yet been encountered. This work systematically explores the following analyses: publication trend, country analysis, citation analysis, prolific journals, intellectual structure of infectious diseases, and KCoN analysis.

In publications pattern analysis, it identifies that the use of ICT for controlling infectious diseases was minimal before 2020. Subsequently, the literature of airborne diseases has been increasing very fast due to the COVID-19 pandemic. As a consequence, this field aroused the attention of the entire world and greatly emphasized the importance of ICT in almost all domains of infectious diseases. STI is a specific domain of infectious diseases where researchers had paid comparatively more attention till 2018 from the perspective of ICT whereas, on the other side, researchers need to put more effort into fomite-borne and food & waterborne domains. It indicates that there is a quality scope of research in corresponding domains of illnesses.

In geographical distribution analysis, the USA has produced higher research output in all domains of infectious diseases. According to reports, the USA has spent comparatively a major part of its GDP in research and development. In addition, the recent ranking of Scimago Institute revealed that the National Institute of Health is the world's top medical research centre in the USA that makes substantial contributions to the healthcare field. In prolific journals analysis, it observed that ACS nano in airborne, Nature medicine in fomite-borne, PLoS ONE in STI, The Lancet in vector-borne and food & waterborne are the leading journals in this field. These journals have contributed quality work and acquired significant citations from the research community.

In intellectual structure analysis, COVID-19 and influenza viruses have been identified research frontiers in the airborne domain where substantial research is being conducted. Several papers have used artificial intelligence and tracing applications to tackle various challenges raised by these infectious diseases. However, researchers focus on security and privacy concerns in tracing applications. These applications require more and more user data for accurate results. But, due to security and privacy concerns, these applications obtained very less data input from the users that compromising the accuracy of the decision. HIV infection is a research hotspot in STI domain where many influential papers have significantly correlated HIV incidence with GSN applications. Similarly, in vector-borne diseases, most of the high cited papers indicate that malaria illness raises the need for advanced surveillance systems and rapid diagnostic testing kits.

In KCoN analysis, mobile applications, telemedicine, artificial intelligence, and social media are the evolving ICT trends in most infectious diseases. It indicates that these technologies have significantly used to reduce the threats of infectious diseases. In category wise analysis, some prominent technologies identified that have greater scope to prevent deadly infectious diseases, such as IoT and big

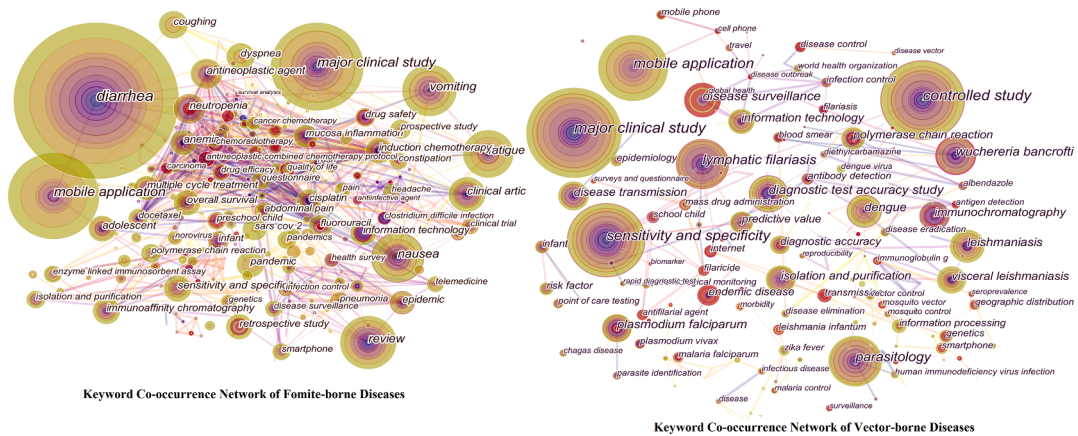


Fig. 10. Keyword Co-occurrence Network of Fomite-borne and Vector-borne Diseases.

Table 6
Most Active ICT Keywords and Domain Keywords in Infectious Disease Literature

| Domains | ICT Keywords | | | Domain Keywords | | |
|-------------------|--------------|--------|------------------------------|-----------------|--------|--|
| | Freq | Degree | Keywords | Freq | Degree | Keywords |
| Airborne | 771 | 12 | Mobile Application | 1524 | 2 | COVID-19 |
| | 370 | 5 | Telemedicine | 114 | 2 | e-Learning |
| | 151 | 1 | Telehealth | 108 | 2 | Mental Health |
| | 149 | 0 | Social Media | 67 | 1 | Risk Assessment |
| | 115 | 3 | Artificial Intelligence | 61 | 3 | Vaccination |
| | 46 | 5 | Internet Of Thing | 59 | 6 | Influenza |
| | 22 | 3 | Big Data | 32 | 2 | Home Quarantine |
| Fomite-borne | 75 | 12 | Mobile Application | 135 | 23 | Diarrhea |
| | 15 | 9 | Telemedicine | 23 | 17 | Dyspnea |
| | 4 | 3 | Computer Assisted Tomography | 19 | 20 | Drug Safety |
| | 4 | 0 | Social Media | 18 | 9 | Polymerase Chain Reaction |
| | 4 | 3 | Internet | 14 | 31 | Chemotherapy Protocol |
| STI | 560 | 3 | Mobile Application | 384 | 5 | Human Immunodeficiency Virus Infection |
| | 102 | 2 | mhealth | 361 | 3 | HIV Infection |
| | 139 | 2 | Telemedicine | 180 | 5 | Homosexuality |
| | 58 | 3 | Social Networking | 29 | 3 | Gonorrhoea |
| | 28 | 4 | Electronic Health Record | 26 | 1 | Syphili |
| | 22 | 1 | Telehealth | 24 | 8 | Chlamydia |
| | 16 | 2 | Artificial Intelligence | 9 | 7 | Ebola Fever |
| Vector-borne | 91 | 3 | Mobile Application | 137 | 2 | Malaria |
| | 16 | 3 | Point Of Care Testing | 117 | 2 | Immunoaffinity Chromatography |
| | 6 | 1 | Diagnostic Kit | 73 | 7 | Parasitology |
| | 6 | 0 | Machine Learning | 72 | 8 | Lymphatic Filariasis |
| | 4 | 0 | Telemedicine | 56 | 6 | Wuchereria Bancrofti |
| | 2 | 1 | Artificial Intelligence | 50 | 8 | Leishmaniasis |
| Food & Waterborne | 74 | 4 | Mobile Application | 70 | 5 | Hepatitis C |
| | 27 | 6 | Information Technology | 64 | 8 | Enzyme-Linked Immunosorbent Assay |
| | 11 | 5 | Telemedicine | 51 | 6 | Hepatitis B |
| | 5 | 5 | Biosensor | 30 | 5 | Salmonella |
| | 3 | 3 | X ray Computed Tomography | 30 | 4 | Food Safety |
| | 3 | 4 | teleconsultation | 28 | 4 | Polymerase Chain Reaction |

data in airborne diseases, medical imaging in fomite-borne, mhealth and telehealth in STI domain, point of care testing and machine learning in vector-borne diseases, biosensor and teleconsultation in food & waterborne discipline.

In conclusion, this paper provides a general overview of ICT in various infectious diseases. It observed that technology is

increasingly used to control and diagnose viral infections. Mobile applications, telemedicine, and artificial intelligence technologies have been widely used to address various infectious diseases. This research paper sheds light on important research topics in each infectious disease domain that engage researchers to identify unexplored applications areas in this knowledge discipline. For future work, the authors will explore the ICT trends in the literature of airborne diseases for more in-depth knowledge. Also, this work will explore emerging research areas and research frontiers that are delineated in the airborne domain.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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