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Impact of COVID-19 on Primary Healthcare Research: Trends and Suggestions for Better Services Approaches Via Blockchain Based Applications

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Abstract

Objective: The authors assessed how research in primary healthcare was affected by the COVID-19 pandemic and identified the potential of blockchain technology to address pandemic-related challenges.
Methods: This quantitative bibliometric research study used machine learning techniques. A comprehensive analysis of all primary healthcare (PHC) research was conducted using bibliometric data from the WOs. We examined co-authorship, co-occurrences, citation and co-citation, thematic mapping, factorial, document, and Latent Dirichlet Allocationtopic analyses. Our main dataset was 1,885 articles produced by 9,185 researchers from 3,132 institutions in 113 countries.
Results: The most cited studies in the PHC field during the pandemic related to telemedicine and remote consultation, along with clinical conditions such as mental health, diabetes, vaccinations, risks during pregnancy, and healthcare of the elderly. In addition, the impact of COVID-19 on educational outcomes, changes to the organization of care, experiences and challenges to PHC physicians and other health professionals, and the diversity of COVID-19 symptoms were prominent.
Conclusions: The PHC researchers adapted quickly to the pandemic and conducted multidisciplinary research that helped to mitigate the impact on individuals, health systems, and society. Within this context, blockchain technology can be used to facilitate the security of health data, resource management (e.g., monitoring of the vaccine supply chain), and global collaboration toward pandemic control. By providing transparency, security, and efficiency in these areas, blockchain technology might lead to more effective pandemic preparedness and management in the future.

Plain Language Abstract

The authors assessed how research in primary healthcare was affected by the COVID-19 pandemic and identified the potential for blockchain technology to address pandemic-related challenges. The main dataset included 1,885 articles produced by 9,185 researchers from 3,132 institutions in 113 countries. The PHC researchers adapted quickly to the pandemic and conducted multidisciplinary research that helped to mitigate the impact on individuals, health systems, and society. The results reveal that blockchain technology can facilitate the security of health data, resource management (e.g., monitoring of the vaccine supply chain),

and global collaboration toward pandemic control. By providing transparency, security, and efficiency in these areas, blockchain technology may lead to more effective pandemic preparedness and management in the future.

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The COVID-19 pandemic resulted in over seven million deaths and profoundly affected health systems globally.[1–3] Primary healthcare (PHC) practitioners played an important role in responding to the COVID-19 pandemic. As the initial point of contact and the 'front door' to the healthcare system,[4,5] PHC providers supported key aspects of the pandemic response, including testing, vaccination, treatment of SARS-CoV-2, communication to the public, and adapting to maintain care for other acute illnesses and chronic diseases.[6–8]

Bibliometric analysis methods are important tools for reviewing developments or prominent debates in a specific field over time.[9,10] Several bibliometric studies were conducted in the PHC literature.[11–14] Exploring the impact of the COVID-19 pandemic on PHC research through a comprehensive bibliometric evaluation may provide insights to be better prepared for future pandemics.

No previous study provides a comprehensive evaluation of the global impact of COVID-19 on PHC literature. Using bibliometric tools, our objective was to provide a comprehensive evaluation of how COVID-19 changes the PHC research landscape. We sought to identify answers to the following issues. How has the COVID-19 pandemic affected the PHC literature? What are the most highly cited COVID-19 articles in PHC? Which researchers, institutions, and in what countries conducted the most intensive research on COVID-19 in PHC. In addition, we sought to identify how blockchain technology might be used more efficiently during similar outbreaks in the future with.

Methodology

Data on articles published between January 1, 2020 and February 2, 2024, were obtained from nine different queries through the Web of Science (WoS) Core Collection (Appendix A). Bibliometric data were first obtained as Excel files and plain text, and we used VOS viewer and the Biblioshiny application in the Bibliometrix R Package.

In our analyses, we focused on research articles and reviews as the information carried by these document types is more comprehensive and relevant to the research field. Several types of content analyses were conducted to capture and reveal the impact of the COVID-19 pandemic on PHC research. The set of conducted content analysis and associated methods includes co-authorship analysis,[15,16] co-occurrence analysis (network, overlay, and density analysis),[16,17] citation and co-citation analysis,[18,19] thematic map analysis, thematic evaluation analysis, and factorial analysis (word map, words by cluster, and topic dendrogram),[19,20] document analysis (most frequent words, word cloud, treemap, word dynamics, trend topics),[19,20] and Latent Dirichlet Allocation.[21,22] The search sites used to retrieve the data for analysis from the WoS Core Collection, the research methodology, and other details are provided in Appendix A.

Topic modeling is one of the most powerful techniques for data/text mining and hidden data discovery to identify relationships between data and text documents. Among the various methods of topic modeling, Latent Dirichlet Allocation is one of the most popular.[23]

Results

General View of COVID-19 Literature in Primary Healthcare Research Area

The COVID-19 pandemic was first reflected in the PHC literature in 2020. Our bibliometric analysis accessed a total of 2,606 publications of 12 different types. The PHC research area, which has had critical importance during the pandemic outbreak period, ranked 74th among WoS research areas with 2,606 documents. We limited our main dataset to 1,885 publications by considering only research articles and reviews. Appendix B illustrates the distribution of publications according to relevant fields (COVID-19 or PHC), publication years, publication types, and research areas.

The top five WoS research areas where COVID-19 studies were conducted include general internal medicine (f:50,613, 9.72%), public environmental occupational health (f:50,162, 9.63%), immunology (f:23,126, 4.44%), infectious diseases (f:22,779, 4.37%), and multidisciplinary sciences (f:19,831, 3.81%). Interestingly, the vast majority of the relevant publications (f:1,779 out of 1,885, %94.4%) were open-access.

Authors, Institutions, and Countries

The relevant articles in the main database (f:1,885) were written by 9,185 researchers from 3,132 different institutions located in 113 different countries. The top 30 countries, the top 20 institutions, and the top 20 authors showing the most intense interest in COVID-19 topics within the PHC literature are listed in Appendices C, D, and E, respectively. The threefield-plot (journals, authors, and keyword plus) analysis

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in Appendix E shows the journals and subject headings of the researchers' publications in general.

Considering the publications in journals in the Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCI-Expanded), the University of Oxford (f:40, 5.42%), University of Toronto (f:34, 4.61%), University of London (f:33, 4.47%) stand out and make significant contributions to the field.

References, Most Cited Documents and Sources

The COVID-19 articles in the field of PHC were published in 29 different journals (see Appendix F). The most cited articles are shown in Appendix G. The 1,885 relevant articles cited 4,449 different sources (journals, theses, books, etc.) and 42,295 references. The co-citation source analysis shows the network analysis of 374 sources according to the minimum 20 works, the eight clusters with which the journals are associated, and the density map of the journals (Figure 1).

The most cited study in the main database evaluates the impact of COVID-19 on loneliness, mental health, and health service utilization with a cause-and-effect relationship for older adults.[24] That study revealed that older patients with multimorbidity in primary care experienced worse psychosocial health and an increase in missed scheduled medical appointments for chronic disease care after the start of the COVID-19 pandemic. The top cited studies in the PHC field during the relevant period considered prominent issues related to telemedicine,[3,25] remote consultation,[26,27] mental health,[24,28,29] diabetes,[30] anxiety,[28,31] vaccination,[32,33] risks for pregnant and elderly people,[28,34] the impact of COVID-19 on education,[35] organizational problems in PHC,[36,37,38] PHC physicians' and health professionals' experiences and problems,[4,25,39,40] COVID-19 symptoms,[41,42] migrants,[43] refugees,[44] COVID-19 vaccine hesitancy.[45]

Themes of the Relevant Studies Based on Keywords, Titles, Abstracts, and Research Areas Perspectives

The results of the co-occurrence analysis for researcher keywords are shown in Figure 2. Note that the keywords equivalent to COVID-19 in PHC and primary care were excluded from the analysis for clarity. In Figure 3, the size of each word is proportional to the usage frequency of that word. The words belonging to the same clusters have the same color in Figures 2a and c, while the thickness of the links between words highlights co-occurrence frequency, which implies the existence and magnitude of relationships between the keywords. In Figure 2b, from dark blue to red, the topics that were intensively studied between 2020 and 2024 are shown. Furthermore, Figure 2d shows the thematic evolution performed on the researchers' keywords.

In Figure 2a and c the words belonging to the same clusters share the same color, while in Figure 2d, the thickness of the links between words highlights co-occurrence frequency, which implies the existence and magnitude of relationships between the keywords. In addition, Figure 2d shows the thematic evolution performed on the researchers' keywords. Note that the keywords equivalent to COVID-19 in PHC and primary care were excluded from the analysis for clarity. (a) Network Analyses, (b) Overlay Analyses, (c) Density Analyses, and (d) Thematic Evolution. PHC: primary healthcare.

We also analyzed the relevant articles on COVID-19 in PHC literature using Latent Dirichlet Allocation topic modeling to summarize and extract article themes. These distinct themes obtained from this analysis are depicted on six different word clouds in Figure 3a–f.

Based on a topic dendrogram analysis performed on the abstracts of the articles to the main research areas, COVID-19 articles in PHC literature focus on eight main research areas (See Appendix H, Appendix I and Appendix J). The related fields are general internal medicine (Appendix Ha), endocrinology metabolism (Appendix Hb), healthcare sciences services (Appendix Ic), health policy services (Appendix Id), public environmental occupational health (Appendix Id), orthopedics (Appendix Je), sport sciences (Appendix Jf), respiratory system (Appendix Jf). COVID-19 articles in health policy services are also associated with the public environmental occupational health field (Appendix Id), and COVID-19 articles in orthopedics are also associated with the sports sciences field (Appendix Je).

Discussion and Conclusion

During the pandemic and during the following years, COVID-19-related issues have drawn significant interest in the PHC literature, for example, nearly one out of every five PHC studies published between 2021 and 2023 were related to COVID-19. This study offers a comprehensive bibliometric assessment of articles using machine learning techniques on COVID-19 in the PHC research field, providing insights into the pandemic's impact on PHC research from a holistic perspective.

Upon review of the literature, this study represents the most comprehensive investigation into the impact of the pandemic on PHC literature. In addition, the pandemic was beyond a regular health problem or disease. Thus, its multidimensional impact has been studied by experts from different fields.[46–48] However, existing studies have reviewed PHC research related to COVID-19 within specific subareas of the field.[28,29,33,49]

Our bibliometric analyses revealed that such large-scale pandemics affect a vast variety of subareas within the PHC field as well as other fields of medicine. Therefore, multidisciplinary approaches are often necessary for

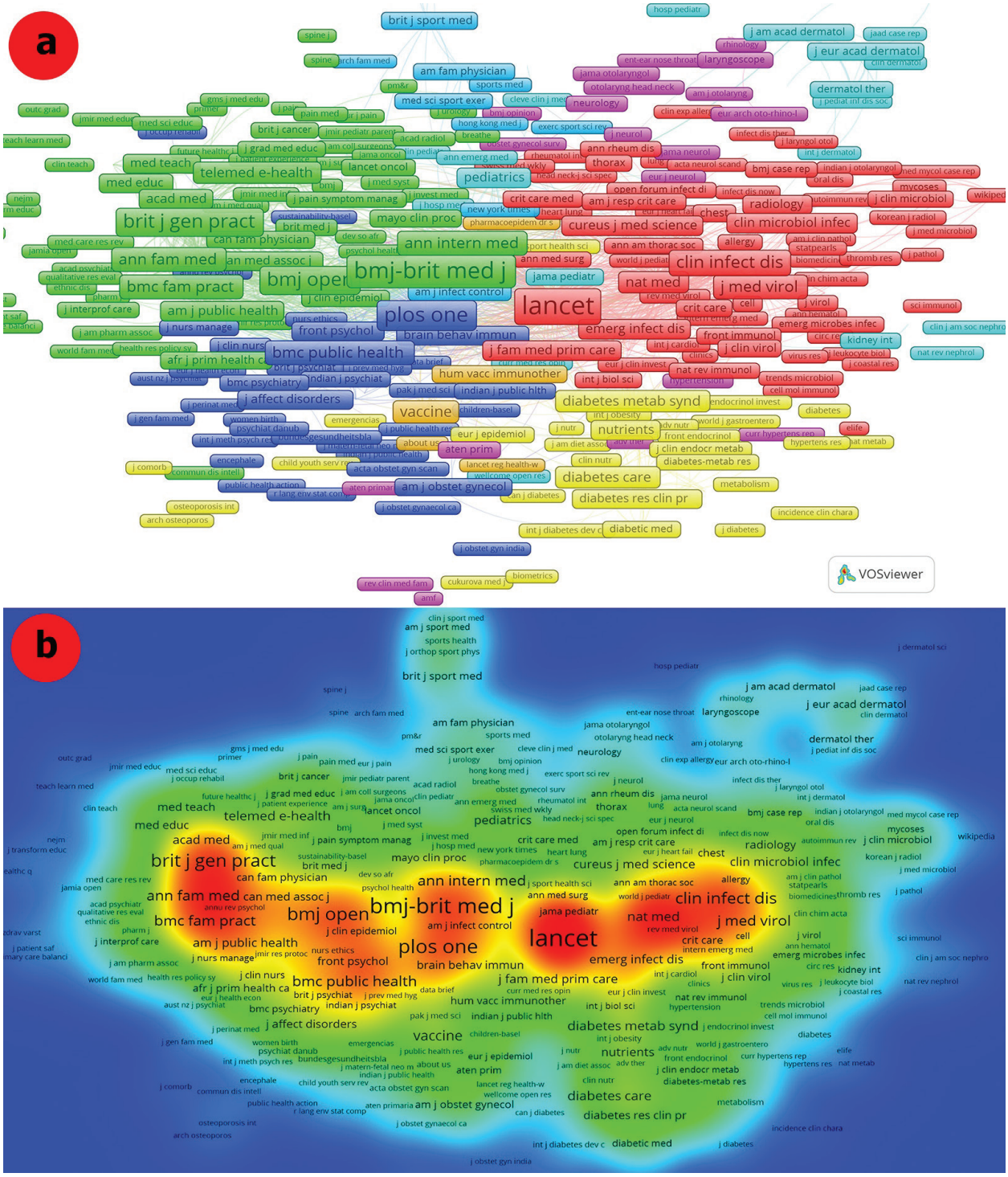

Fig. 1. Co-citation sources analyses for COVID-19 studies in PHC research area. PHC: primary healthcare.

effective problem-solving for the control and management of such large-scale pandemics.

Comorbidity, multimorbidity, stress, telemedicine, remote consultation, mental health, diabetes, anxiety, vaccination, risks for pregnant and elderly, vulnerable population, impact of COVID-19 on education, organizational problems in PHC, experiences and problems of PHC physicians and health workers, COVID-19 symptoms, migrants, refugees, COVID-19 vaccine hesitancy, and disease management were the other intensively studied topics worth mentioning. For instance, care for patients with multimorbidity emerged as an intensely questioned issue

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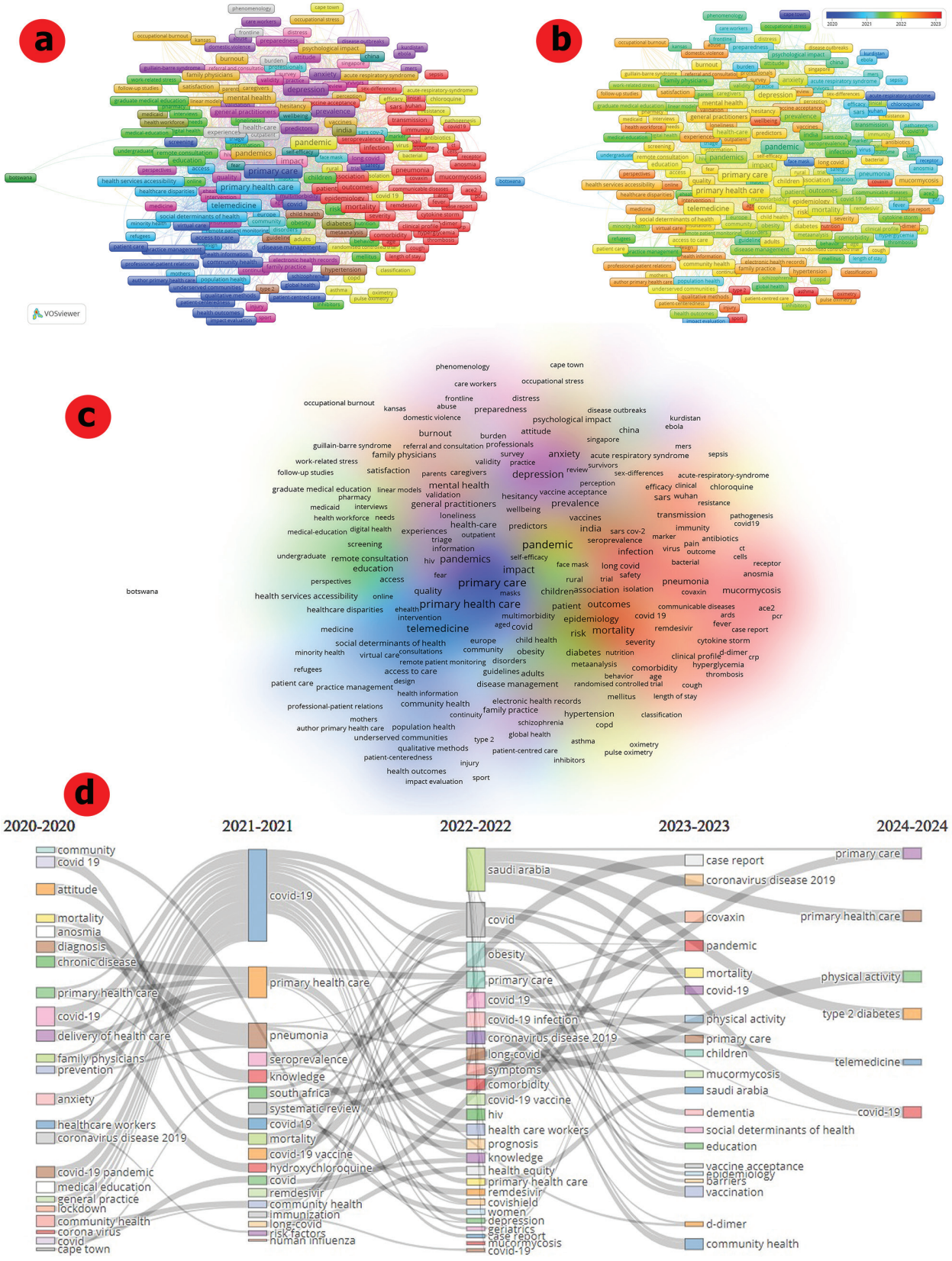

Fig. 2. Co-occurrence analyses for COVID-19 studies keywords in PHC research area. PHC: primary healthcare

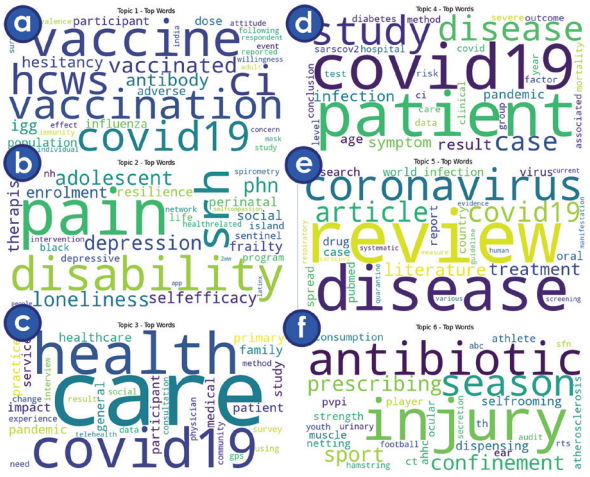

Fig. 3. Latent Dirichlet Allocation topic modeling analysis (Fields: Abstracts and Titles).

for PHC services during the COVID-19 pandemic given their vulnerability against COVID-19.[6,7] In addition, as the pandemic progressed, vulnerable groups were more susceptible to COVID-19 infection and had worse health outcomes compared to others.[6]

Refugees, migrants, the homeless population, children, pregnant women, elderly people, veterans, people with chronic diseases (e.g., diabetes, cancer, cardiovascular problems, neurological diseases, chronic respiratory diseases), and rural populations are other outstanding keywords for vulnerable populations. Keeping an up-to-date database for patients with multimorbidity and vulnerable patients is vital to be better prepared for such pandemics in the future and minimize the adverse outcomes among these individuals.

In our study, stress and anxiety emerged as very intensively studied topics in the PHC field. This situation is reasonable considering the burden of the pandemic.[24] Mental health, anxiety, depression, stress, and burnout were among the keywords and themes captured by our topic modeling applications. These topics were discussed in the context of problems faced by doctors, nurses, and other health professionals, as well as by patients and medical students. Quality of life, health equity, health service accessibility, social determinants of health, and gender differences were other topics discussed in relation to PHC services. These topics were discussed in the PHC literature in conjecture with disease management, triage, risk factors, and health management.[50–53]

The most important COVID-19 measures for mitigating the pandemic propagation were social distancing[3] and the use of masks, herd immunity, personnel protective equipment, quarantine, and the management and coordination of the outbreak in PHC services.[54] In addition to these, telemedicine digital technology has been a relevant and necessary technology for the COVID-19 pandemic process.[55,56] Telemedicine has supported the delivery of health services when severe social-distancing and isolation measures were in place, especially for public health, disease prevention, and clinical practices.[3,25] Telemedicine was the most intensively studied useful technology in our study. A properly implemented telemedicine service can integrate with health services.[56]

Nurses and other allied health professionals performing important tasks on the frontline are affected as much as family doctors, physicians, or medical students globally[38,40,57–59] and the technology developed must be planned with the needs of all health stakeholders in mind. Therefore, being a useful technology, especially considering the importance of social distance in the way the virus is transmitted, it has been used in the pandemic process as a critical technology for diagnosis, treatment, and monitoring, and even for the training of doctors and doctor candidates.[26] This has also significantly impacted the educational processes of these professions.[60,61] Therefore, it can be suggested that education processes should be ready for such outbreaks. In general, patients have reported high satisfaction with telehealth in general practice during quarantine, and integrating telemedicine into the healthcare system as a natural component is considered beneficial for being better prepared for future pandemics.[62]

Strengths and Limitations of Our Study

It can be said that the dataset analyzes publications in journals indexed by WoS, but most of the relevant journals with PHC are also indexed by Scopus.[63] In addition, many analyses were performed on the data obtained, and only part of them are presented here due to limitations in the number of figures, tables, and text. Additional findings are presented as Appendices, as they may be useful for researchers and strengthen the article.

Future Studies

For future studies it might be useful to discuss PHC and the pandemic process with computer science, artificial intelligence, information systems, interdisciplinary applications, software engineering, medical informatics, robotics, respiratory systems, public administration, psychology, social, psychiatry, and economics. This contribution stems from the critical value and importance of the PHC field in COVID-19-like outbreaks. Experiences gained from pandemics should not be lost, lessons should be learned and used to create new approaches for PHC in the future. Singapore is a successful example.[64] Contemporary technologies such as the metaverse play a significant role in the healthcare field.[65] During the COVID-19 pandemic, PHC services have been virtualized, and the use of virtual technologies has become widespread.[66] In particular, virtual visits in Canada are considered an alternative

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healthcare service for those with chronic illnesses.[67] For future pandemics, it is necessary to thoroughly investigate virtual healthcare services and reorganize PHC to incorporate remote technologies.

Given the likelihood of encountering similar epidemics in the future due to global climate change, population growth, and deteriorating living conditions, the study emphasizes the importance of distance services (telehealth, distance education, remote consultation, etc.) in connecting patients, healthcare providers, and health services remotely during epidemic periods. It recommends that policymakers and governments integrate relevant systems into national health frameworks, prioritizing epidemic preparedness for future outbreaks and addressing integration-related challenges promptly.

Many countries faced challenges in accessing protective equipment, masks, and respiratory systems crucial for pandemic control. To prevent similar issues in future outbreaks, the results published here advise countries to develop strategic pandemic plans urgently and ensure sufficient stock and distribution of pandemic-fighting materials during COVID-19-like crises. It also underscores the importance of prioritizing PHC, particularly in densely populated countries such as India, Indonesia, Pakistan, and Bangladesh. Developing nations must utilize their limited resources more effectively, with PHC offering significant potential in reducing health inequalities and providing critical health services during pandemics. For these countries, investing in PHC services is deemed essential and strategic to ensure more equitable access to healthcare services for citizens.

What Blockchain Technology Can Provide for Future Pandemics

The COVID-19 is transmitted to humans through zoonosis, which can occur again in the future.[68] Therefore, the global community should invest in potential technologies that can be helpful for future pandemics. Blockchain is among such a critical technology and its applications such as Hashlog, VeChain, the Public Health Blockchain Consortium (PHBC) platform, and Hyperchain have been used during COVID-19 pandemic for various purposes.[69]

Blockchain is a technology that attracts attention with its decentralized, transparent, secure, and immutable data storage and transaction features.[70] These features can facilitate pandemic control through early detection of outbreaks, accelerating drug delivery, and protecting user privacy during treatment.[69] During pandemics, rapid access to accurate and reliable health data is vital. Blockchain technology provides real-time information to all strategic partners and traceability in the disease control process, which can ensure secure and transparent management of health data.[71] The blockchain technology can be used to globally track the spread of coronavirus infections by placing a blockchain network on citizens' mobile devices.[69] It also facilitates the use of international vaccination certificates and health status monitoring.[72]

The transparent structure of blockchain enables tracking of how health data are used at each step of care delivery. For example, during pandemics, efficient and proper production, transportation, and distribution of vaccines, therapeutic drugs, masks, and hygiene products is critical to combat the pandemic. Various significant problems have been experienced in these processes during the COVID-19 pandemic.[73–76] With blockchain technology, the vaccine and drug production processes can be made transparent and secure and the processes can be monitored in real-time. In this way, definitive traceability of transported and stored vaccines and drugs can be achieved. This could also reduce the risk of counterfeiting in vaccines and other protective products. Sharing of research and development data during the pandemic has also been critical in the drug development process and early pandemic response.[77] In vaccine development processes, sharing data from different research organizations on the blockchain can enable faster research progress as a part of their pandemic preparedness plans.

During future pandemics, citizens do not only need to be provided with the right medicine or equipment but also with the most accurate information. During the COVID-19 process, many problems have been experienced in social media and other platforms, rendering access to accurate information.[78] The most appropriate way to combat this is to share information with citizens through social media communication channels where content can be monitored.

Khurshid[79] suggested a nationally coordinated partnership (consisting of academia, researchers, the business world, and industry) to accelerate the adoption of blockchain and their national/international use in accurately disseminating information, which can prevent disinformation and manipulation, especially in social media. On a global scale, the need for pandemic research collaboration, and thus, secure data-sharing channels is even greater. Global collaboration efforts require quick and secure transfer of large-scale data between different countries, organizations, and health authorities. At this point, blockchain technology is a real, applicable, and secure technology. Therefore, it would be appropriate to carry out such processes and initiatives through and under the leadership of the World Health Organization.

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Conflicts of Interest

None

Contributors

Muhammet Damar: Conceptualization, methodology, software, validation, formal analysis, data curation, writing—original draft, writing—review and editing, visualization.

Andrew David Pinto: Conceptualization, validation, investigation, writing—review and editing, supervision.

Fatih Safa Erenay: Conceptualization, investigation, writing—review and editing, supervision.

Ömer Aydın: Conceptualization, writing—review and editing, supervision.

Data Availability Statement (DAS), Data Sharing, Reproducibility, and Data Repositories

The data that support the findings of this study are available from the corresponding author upon reasonable request. Also, we retrieve our bibliometric data from WoS Core Collection Database and this database is open for everyone.

Application of AI-Generated Text or Related Technology

No AI tools were used for content creation in this manuscript (e.g., drafting, rewriting, or generating ideas).

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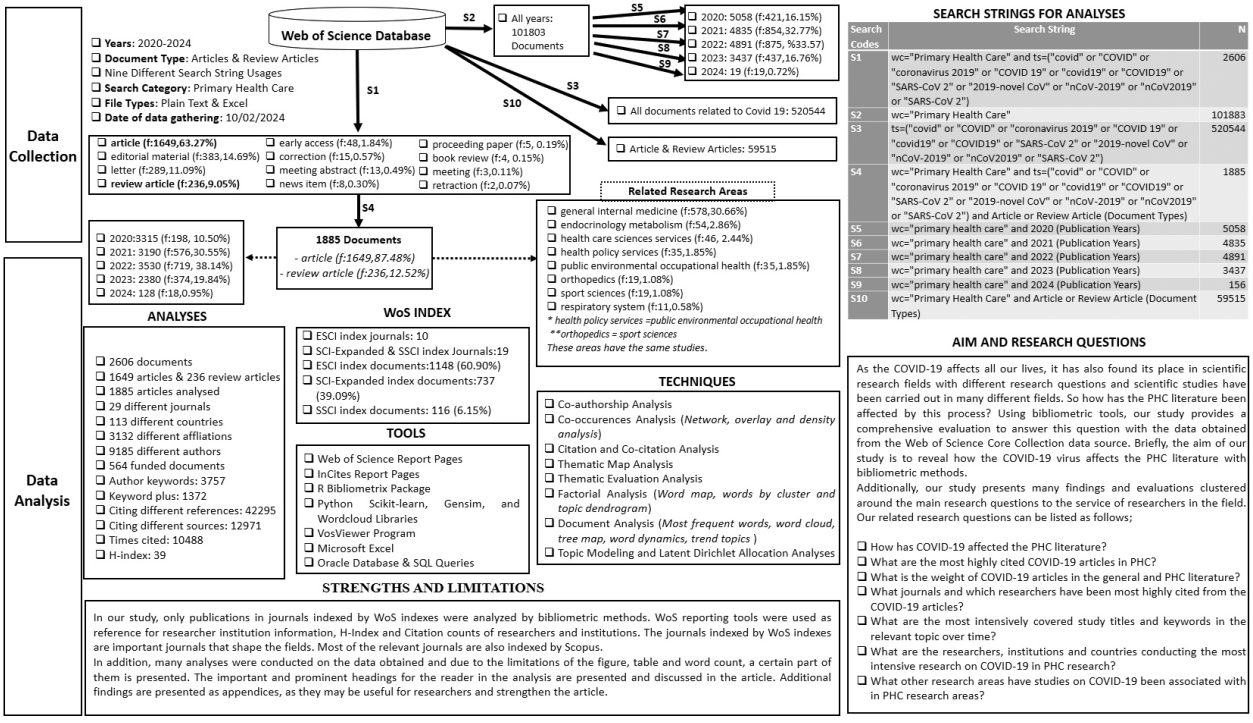
Appendix A. Research methodology and study descriptions. PHCA; primary health care



SEARCH STRINGS FOR ANALYSES

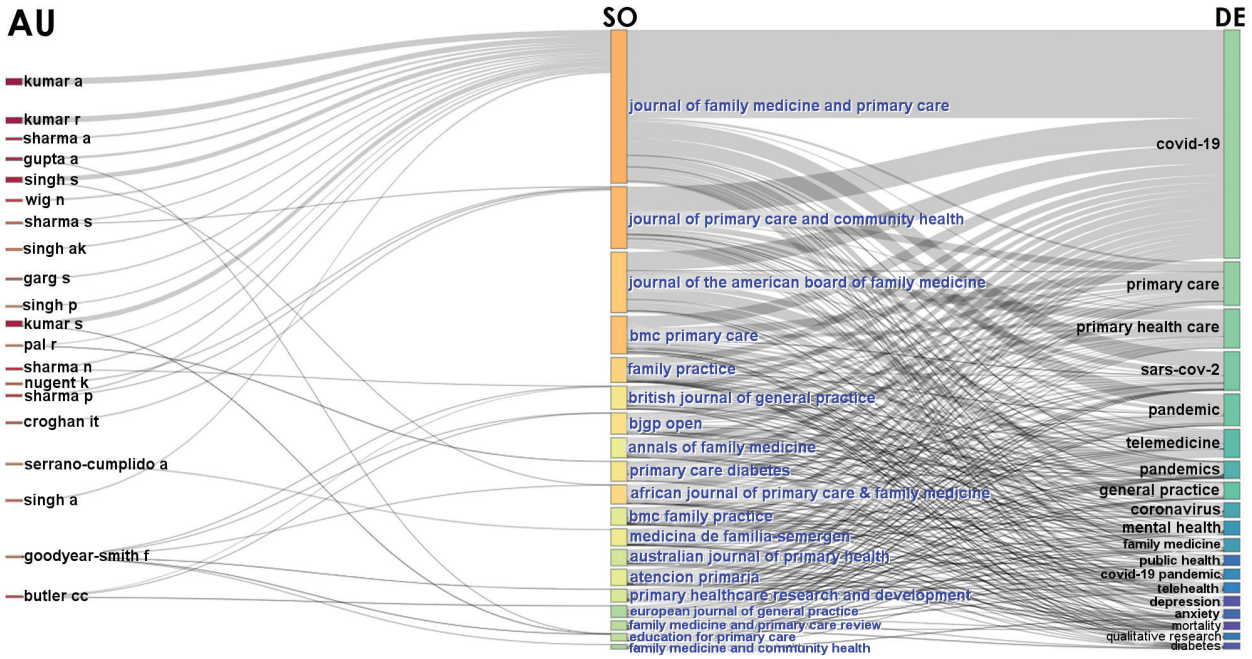
Search Codes	Search String	N
S1	wc="Primary Health Care" and ts=("covid" or "COVID" or "coronavirus 2019" or "COVID 19" or "covid19" or "COVID19" or "SARS-CoV 2" or "2019-novel CoV" or "nCoV-2019" or "nCoV2019" or "SARS-CoV 2")	2606
S2	wc="Primary Health Care"	101883
S3	ts=("covid" or "COVID" or "coronavirus 2019" or "COVID 19" or "covid19" or "COVID19" or "SARS-CoV 2" or "2019-novel CoV" or "nCoV-2019" or "nCoV2019" or "SARS-CoV 2")	520544
S4	wc="Primary Health Care" and ts=("covid" or "COVID" or "coronavirus 2019" or "COVID 19" or "covid19" or "COVID19" or "SARS-CoV 2" or "2019-novel CoV" or "nCoV-2019" or "nCoV2019" or "SARS-CoV 2") and Article or Review Article (Document Types)	1885
S5	wc="primary health care" and 2020 (Publication Years)	5058
S6	wc="primary health care" and 2021 (Publication Years)	4835
S7	wc="primary health care" and 2022 (Publication Years)	4891
S8	wc="primary health care" and 2023 (Publication Years)	3437
S9	wc="primary health care" and 2024 (Publication Years)	156
S10	wc="Primary Health Care" and Article or Review Article (Document Types)	59515

AIM AND RESEARCH QUESTIONS

As the COVID-19 affects all our lives, it has also found its place in scientific research fields with different research questions and scientific studies have been carried out in many different fields. So how has the PHC literature been affected by this process? Using bibliometric tools, our study provides a comprehensive evaluation to answer this question with the data obtained from the Web of Science Core Collection data source. Briefly, the aim of our study is to reveal how the COVID-19 virus affects the PHC literature with bibliometric methods.
Additionally, our study presents many findings and evaluations clustered around the main research questions to the service of researchers in the field. Our related research questions can be listed as follows;

- How has COVID-19 affected the PHC literature?
- What are the most highly cited COVID-19 articles in PHC?
- What is the weight of COVID-19 articles in the general and PHC literature?
- What journals and which researchers have been most highly cited from the COVID-19 articles?
- What are the most intensively covered study titles and keywords in the relevant topic over time?
- What are the researchers, institutions and countries conducting the most intensive research on COVID-19 in PHC research?
- What other research areas have studies on COVID-19 been associated with in PHC research areas?

Appendix B. Three fields plot with authors, journals, and keywords for COVID-19 studies in PHC research area. (AU: author, DE: author keyword, PHC: primary healthcare, SO: Source/Journal/Conference)



Appendix C. Top 30 countries where studies of COVID-19 were at PHC research areas. (ACPA: Avarage Citation Per Article HI: H-Index PHC: primary healthcare, TC: Total Cited)

#	Countries	TC	HI	ACPA	*n*	%
1	India	1,592	17	2.91	547	29.01
2	USA	2,756	21	6.75	408	21.64
3	England	1,765	20	10.09	175	9.28
4	Spain	703	12	5.49	128	6.79
5	Canada	399	10	4.75	84	4.45
6	Australia	540	9	6.84	79	4.19
7	Saudi Arabia	178	7	2.70	66	3.50
8	South Africa	510	11	8.95	57	3.02
9	Iran	224	8	4.48	50	2.65
10	Germany	430	11	9.15	47	2.49
11	Turkiye	299	10	8.54	35	1.85
12	Netherlands	486	9	13.89	35	1.85
13	New Zealand	270	6	8.71	31	1.64
14	Belgium	237	6	8.78	27	1.43
15	France	146	6	5.41	27	1.43
16	Scotland	346	8	13.31	26	1.37
17	China	419	8	17.46	24	1.27
18	Egypt	82	5	3.73	22	1.16
19	Poland	142	6	6.45	22	1.16
20	Sweden	134	5	6.09	22	1.16
21	Ireland	157	5	7.48	21	1.11
22	Japan	33	3	1.65	20	1.06
23	Denmark	56	4	2.95	19	1.00
24	Italy	115	6	6.05	19	1.00
25	Norway	47	4	2.76	17	0.90
26	Israel	130	7	8.13	16	0.84
27	Indonesia	55	4	3.67	15	0.79
28	Pakistan	127	6	9.07	14	0.74
29	Switzerland	113	6	8.07	14	0.74
30	Wales	106	5	7.57	14	0.74

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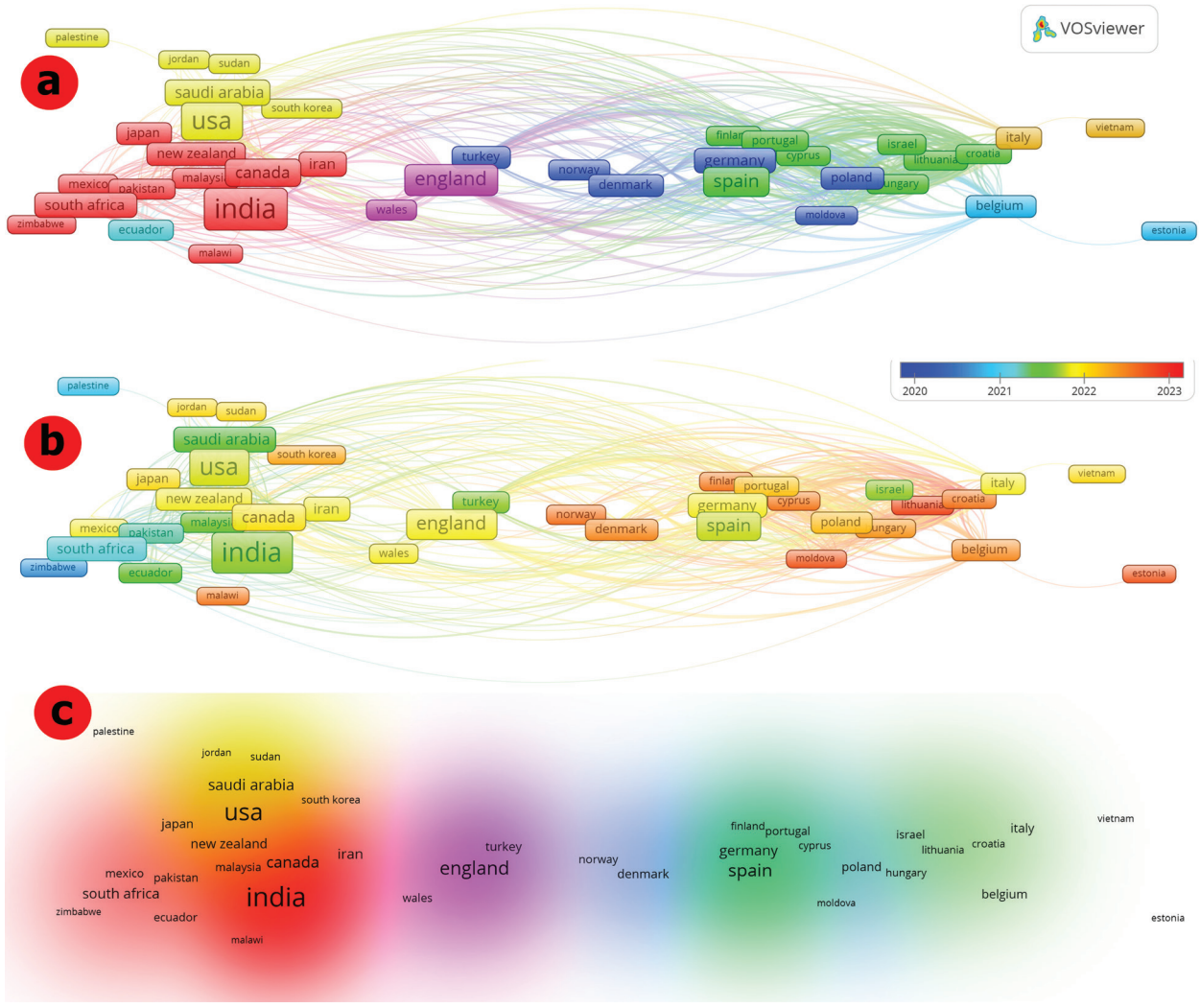
Country collaborations (co-authorship country analyses)



Appendix D. Top 20 institutes where COVID-19 was studied at PHC research areas. PHC: primary healthcare

Rank	Institutes	Country	HI	TC	ACPA	*n*	%
1	University of London	England	13	407	8.48	48	2.54
2	University of Oxford	England	13	635	13.51	47	2.49
3	All India Institute of Medical Sciences (AIIMS) New Delhi	India	8	162	3.95	41	2.17
4	University of Toronto	Canada	8	287	7.18	40	2.12
5	All India Institute of Medical Sciences (AIIMS) Rishikesh	India	8	130	3.94	33	1.75
6	University of California System	USA	7	241	8.31	29	1.53
7	Post Graduate Institute of Medical Education Research (PGIMER) Chandigarh	India	6	136	4.86	28	1.48
8	University System of Ohio	USA	6	119	4.25	28	1.48
9	All India Institute of Medical Sciences (AIIMS) Jodhpur	India	6	119	4.76	25	1.32
10	Mayo Clinic	USA	8	183	7.32	25	1.32
11	Government Medical College	India	4	40	1.82	22	1.16
12	University of Colorado System	USA	7	220	10.00	22	1.16
13	Egyptian Knowledge Bank	Egypt	5	82	3.90	21	1.11
14	Imperial College London	England	7	324	15.43	21	1.11
15	Headquarters of the Catalan Institute of Health	Spain	7	309	14.71	21	1.11
16	All India Institute of Medical Sciences (AIIMS) Patna	India	5	71	3.55	20	1.06
17	University of Colorado Anschutz Medical Campus	USA	7	218	10.90	20	1.06
18	All India Institutes of Medical Sciences	India	4	38	2.11	18	0.95
19	King's College London	England	8	216	12.00	18	0.95
20	All India Institute of Medical Sciences (AIIMS) Raipur	India	5	48	2.82	17	0.90
21	State University System of Florida	USA	6	112	6.59	17	0.90
22	Stellenbosch University	South Africa	9	193	11.35	17	0.90
23	King George S Medical University	India	4	68	4.25	16	0.84
24	University of California Los Angeles (UCLA)	USA	6	194	12.13	16	0.84
25	Harvard University	USA	6	134	8.93	15	0.79

Affiliations Collaborations (Co-Authorship Affiliations Analyses).

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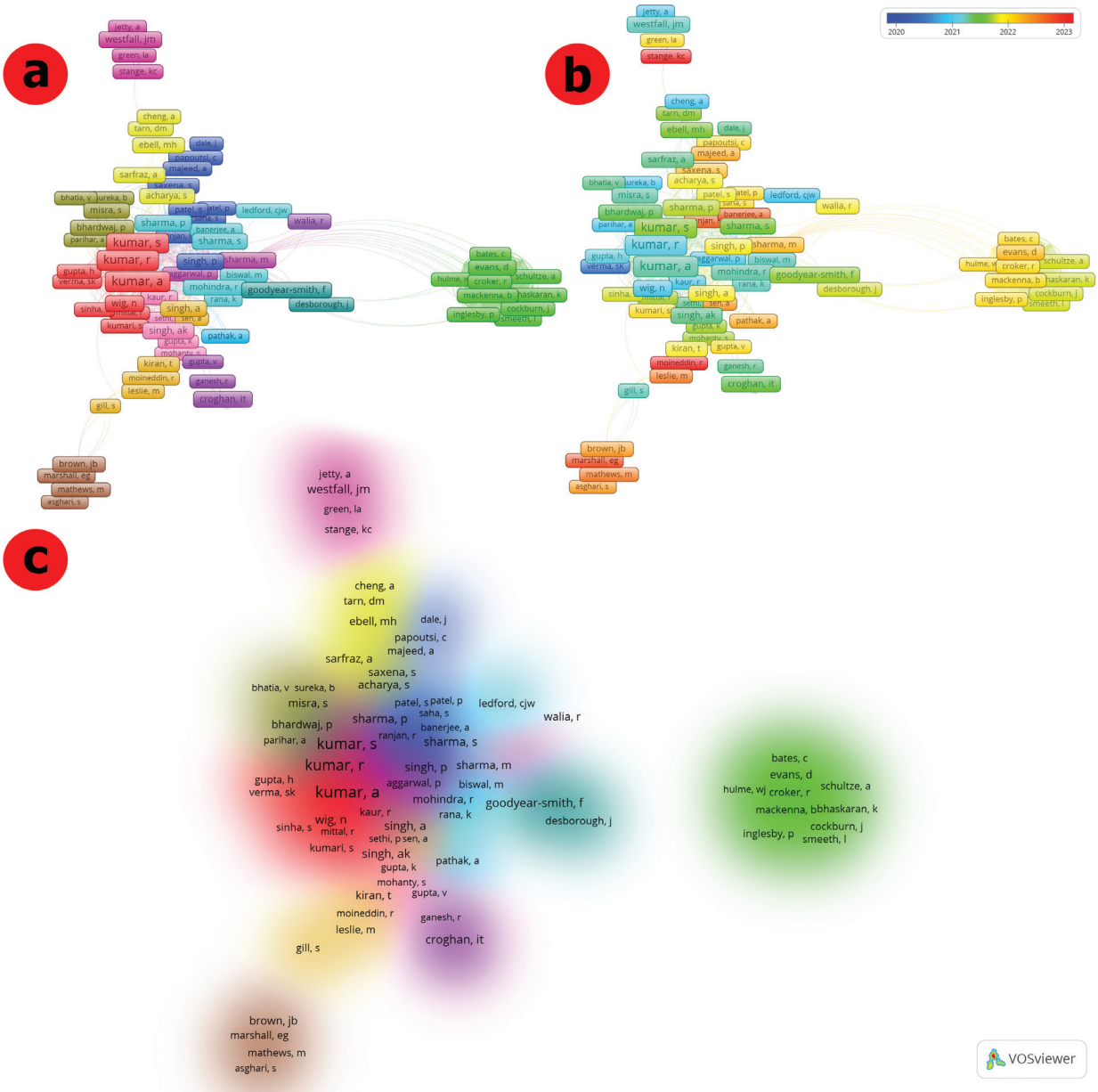
Appendix E. Top 20 authors who studied COVID-19 at PHC research areas F. PHC: primary healthcare

Rank	Authors	Country	Institutions (From WoS Profile)	TC	ACPA	*n*	%
1	Kumar A	India	All India Institute of Medical Sciences (AIIMS) New Delhi	82	2.93	28	1.48
2	Kumar R	India	Vardhman Mahavir Medical College & Safdarjung Hospital	110	4.07	27	1.43
3	Kumar S	India	All India Institute of Medical Sciences (AIIMS) New Delhi	78	3.12	25	1.32
4	Singh S	India	Sharda University	73	3.32	22	1.16
5	Gupta A	India	Tufts University	43	3.31	13	0.69
6	Sharma A	India	Department of Dentistry | SHKM, Goverment Medical College	21	2.10	10	0.53
7	Sharma P	India	Faculty of Medicine, Uttar Pradesh University of Medical Sciences	34	3.40	10	0.53
8	Wig N	India	All India Institute of Medical Science	25	2.50	10	0.53
9	Butler CC	England	University of Oxford	100	11.11	9	0.47
10	Croghan IT	USA	Mayo Clinic	108	12.00	9	0.47
11	Garg S	India	Maulana Azad Medical College	19	2.11	9	0.47
12	Nugent K	USA	Texas Tech University Health Sciences Center	63	7.00	9	0.47
13	Sharma N	India	Post Graduate Institute of Medical Education & Research, Chandigarh	27	3.00	9	0.47
14	Singh A	India	KGMC Department of Physical Medicine Orthopaedic	17	1.89	9	0.47
15	Singh AK	India	All India Institute of Medical Sciences (AIIMS) New Delhi	51	5.67	9	0.47
16	Goodyear-smith F	New Zealand	University of Auckland	81	10.13	9	0.47
17	Pal R	India	College of Nursing, AIIMS, Bhubaneswar	64	8	8	0.42
18	Serrano-cumplido A	Spain	Board of Retired Doctors	27	3.38	8	0.42
19	Singh P	India	The George Institute for Global Health	9	1.13	8	0.42
20	Westfall JM	USA	Robert Graham Center: Policy Studies in Family Medicine	71	8.88	8	0.42

Authors' Collaborations (Co-Authorship Authors Analyses).

Citation: Blockchain in Healthcare Today 2025, **8**: 400 - https://doi.org/10.30953/bhty.v8.400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Appendix F. Journals that are published most often on COVID-19 at a PHC Research Area

Rank	Journals	Research domain	5YIF	ESCI	HI	TC	ACPA	*n*	%
1	*Journal of Family Medicine and Primary Care*	Primary Healthcare	-	Yes	14	1,557	2.46	634	33.63
2	*Journal of Primary Care and Community Health*	Primary Healthcare	-	Yes	23	1,870	8.90	210	11.14
3	*BMC Primary Care*	Primary Healthcare; Medicine, General & Internal	-	No	7	233	2.31	101	5.35
4	*Journal of The American Board of Family Medicine*	Primary Healthcare; Medicine General & Internal	3.024	No	14	695	6.95	100	5.30
5	*Family Practice*	Primary Healthcare; Medicine, General & Internal	2.652	No	10	469	7.22	65	3.44
6	*African Journal of Primary Healthcare Family Medicine*	Primary Healthcare	-	Yes	10	424	6.84	62	3.28
7	*BJGP Open*	Primary Healthcare	-	Yes	10	269	4.34	62	3.28
8	*Primary Care Diabetes*	Endocrinology & Metabolism; Primary Healthcare	2.644	No	13	518	9.59	54	2.86
9	*British Journal of General Practice*	Primary Healthcare Medicine, General & Internal	6.916	No	15	1,068	20.15	53	2.81
10	*Medicina De Familia Semergen*	Primary Healthcare	-	Yes	7	154	2.91	53	2.81
11	*Annals of Family Medicine*	Primary Healthcare; Medicine, General & Internal	6.697	No	11	454	9.27	49	2.59
12	*Atencion Primaria*	Primary Healthcare; Medicine, General & Internal	1.982	No	9	346	7.36	47	2.49
13	*BMC Family Practice*	Primary Healthcare; Medicine, General & Internal	3.301	No	15	818	20.45	40	2.12
14	*Primary Healthcare Research and Development*	Primary Healthcare	1.947	No	6	121	303	40	2.12
15	*Australian Journal of Primary Health*	Healthcare Sciences & Services; Health Policy & Services; Primary Healthcare; Public, Environmental & Occupational Health	1.764	No	4	112	3.20	35	1.85
16	*Family Medicine*	Primary Healthcare; Medicine, General & Internal	1.957	No	5	78	2.23	35	1.85
17	*Education for Primary Care*	Primary Healthcare	-	Yes	7	158	4.79	33	1.75
18	*Family Medicine and Primary Care Review*	Primary Healthcare	-	Yes	3	51	1.59	32	1.69
19	*European Journal of General Practice*	Primary Healthcare; Medicine, General & Internal	5.654	No	6	318	10.60	30	1.59
20	*Family Medicine and Community Health*	Primary Healthcare	-	Yes	7	190	7.31	26	1.37
21	*Journal of Primary Healthcare*	Primary Healthcare	-	Yes	4	71	2.96	24	1.27
22	*Canadian Family Physician*	Primary Healthcare; Medicine, General & Internal	3.899	No	5	70	3.50	20	1.06
23	*Physician and Sportsmedicine*	Primary Healthcare; Orthopedics; Sport Sciences	2.883	No	8	182	9.58	19	1.00
24	*American Family Physician*	Primary Healthcare; Medicine, General & Internal	7.361	No	4	40	3.33	12	0.63
25	*Korean Journal of Family Medicine*	Primary Healthcare	-	Yes	2	16	1.33	12	0.63
26	*NPJ Primary Care Respiratory Medicine*	Primary Healthcare; Respiratory System	3.706	No	4	53	4.82	11	0.58
27	*Scandinavian Journal of Primary Healthcare*	Healthcare Sciences & Services; Primary Healthcare; Medicine, General & Internal	3.227	No	2	2	2.00	11	0.58
28	*Primary Care*	Primary Healthcare Medicine, General & Internal	3.602	No	3	130	16.25	8	0.42
29	*Journal of Family Practice*	Primary Healthcare Medicine; General & Internal	0.837	No	1	1	0.14	7	0.37

*5YIF: Five Year Journal Impact Factor, ESCI: Emerging Sources Citation Index, HI:H-Index, TC: Times Cited, APCD: Average Citation Per Articles, N: Record Count.

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Appendix G. Top 30 most cited articles on COVID-19 in PHC Research Area: PHC: primary healthcare

Rank	Title	Journal	Authors	Year	ACPY	Times cited
1	Impact of COVID-19 on loneliness, mental health, and health service utilisation: a prospective cohort study of older adults with multimorbidity in primary care	British Journal of General Practice	Wong, SYS; Zhang, DX; (…); Mercer, SW	2020	38.80	194
2	Implementation of remote consulting in UK primary care following the COVID-19 pandemic: a mixed-methods longitudinal study	British Journal of General Practice	Murphy, M; Scott, LJ; (…); Horwood, J	2021	48.25	193
3	Lessons on the COVID-19 pandemic, for and by primary care professionals worldwide	European Journal of General Practice	Rawaf, S; Allen, LN; (…); van Weel, C	2020	35.40	177
4	Telemedicine in the face of the COVID-19 pandemic	Atencion Primaria	Vidal-Alaball, J; Acosta-Roja, R; (…); Segui, FL	2020	34.00	170
5	Implementation and Usefulness of Telemedicine During the COVID-19 Pandemic: A Scoping Review	Journal of Primary Care and Community Health	Hincapie, MA; Gallego, JC; (…); Escobar, MF	2020	29.00	145
6	Telehealth consultations in general practice during a pandemic lockdown: survey and interviews on patient experiences and preferences	BMC Family Practice	Imlach, F; McKinlay, E; (…); McBride-Henry, K	2020	26.20	131
7	Redesigning Primary Care to Address the COVID-19 Pandemic in the Midst of the Pandemic	Annals of Family Medicine	Krist, AH; DeVoe, JE; (…); Jones, SM	2020	25.40	127
8	Post-acute and long-COVID-19 symptoms in patients with mild diseases: a systematic review	Family Practice	van Kessel, SAM; Hartman, TCO; (…); van Jaarsveld, CHM	2022	41.67	125
9	A Qualitative Study of Primary Care Physicians' Experiences with Telemedicine During COVID-19	Journal of The American Board of Family Medicine	Gomez, T; Anaya, YB; (…); Tarn, DM	2021	29.25	117
10	A Mixed-Methods Pilot Study of Perinatal Risk and Resilience During COVID-19	Journal of Primary Care and Community Health	Farewell, CV; Jewell, J; (…); Leiferman, JA	2020	22.20	111
11	The impact of COVID-19 on chronic care according to providers: a qualitative study among primary care practices in Belgium	Bmc Family Practice	Danhieux, K; Buffel, V; (…); van Olmen, J	2020	19.20	96
12	Mental Health Burden of the COVID-19 Outbreak in Germany: Predictors of Mental Health Impairment	Journal of Primary Care and Community Health	Bauerle, A; Steinbach, J; (…); Skoda, EM	2020	18.00	90
13	Clinicopathological characteristics of 8697 patients with COVID-19 in China: a meta-analysis	Family Medicine and Community Health	Zhu, JY; Zhong, ZM; (…); Zhao, CL	2020	17.20	86
14	The Effects of the Face Mask on the Skin Underneath: A Prospective Survey During the COVID-19 Pandemic	Journal of Primary Care and Community Health	Techasatian, L; Lebsing, S; (…); Kosalaraksa, P	2020	15.40	77
15	Impact of COVID-19 on migrants' access to primary care and implications for vaccine roll-out: a national qualitative study	British Journal of General Practice	Knights, F; Carter, J; (…); Hargreaves, S	2021	18.25	73
16	Primary care in the time of COVID-19: monitoring the effect of the pandemic and the lockdown measures on 34 quality of care indicators calculated for 288 primary care practices covering about 6 million people in Catalonia	BMC Family Practice	Coma, E; Mora, N; (…); Medina, M	2020	14.60	73
17	Reorganisation of primary care for older adults during COVID-19: a cross-sectional database study in the UK	British Journal of General Practice	Joy, M; McGagh, D; (…); de Lusignan, S	2020	14.40	72
18	The State of Telehealth Before and After the COVID-19 Pandemic	Primary Care	Shaver, J	2022	23.67	71
19	Spiritual care—'A deeper immunity'—A response to Covid-19 pandemic	African Journal of Primary Healthcare & Family Medicine	Roman, NV; Mthembu, TG and Hoosen, M	2020	13.40	67

(continued)

Appendix G. (Continued)

Rank	Title	Journal	Authors	Year	ACPY	Times cited
20	The effect of isolation on athletes' mental health during the COVID-19 pandemic	Physician and Sports Medicine	Senisik, S; Denerel, N; (…); Tunc, S	2021	12.40	62
21	A Multidisciplinary NHS COVID-19 Service to Manage Post-COVID-19 Syndrome in the Community	Journal of Primary Care and Community Health	Parkin, A; Davison, J; (…); Sivan, M	2021	15.25	61
22	The effectiveness of teleconsultations in primary care: systematic review	Family Practice	de Albornoz, SC; Sia, KL and Harris, A	2022	20.00	60
23	Impact of lockdown COVID-19 on metabolic control in type 2 diabetes mellitus and healthy people	Primary Care Diabetes	Karatas, S; Yesim, T and Beysel, S	2021	15.00	60
24	Sociodemographic Determinants of COVID-19 Vaccine Hesitancy, Fear of Infection, and Protection Self-Efficacy	Journal of Primary Care and Community Health	McElfish, PA; Willis, DE; (…); Selig, JP	2021	14.50	58
25	Recommendations for the recognition, diagnosis, and management of long COVID: a Delphi study	British Journal Of General Practice	Nurek, M; Rayner, C; (…); Delaney, BC	2021	14.25	57
26	Transformation of primary care during the COVID-19 pandemic: experiences of healthcare professionals in eight European countries	British Journal of General Practice	Wanat, M; Hoste, M; (…); Tonkin-Crine, S	2021	13.75	55
27	Physician Burnout in Primary Care during the COVID-19 Pandemic: A Cross-Sectional Study in Portugal	Journal Of Primary Care And Community Health	Baptista, S; Teixeira, A; (…); Duarte, I	2021	12.50	50
28	What should primary care look like after the COVID-19 pandemic?	Australian Journal of Primary Health	Duckett, S	2020	10.00	50
29	Telehealth challenges during COVID-19 as reported by primary healthcare physicians in Quebec and Massachusetts	BMC Family Practice	Breton, M; Sullivan, EE; (…); McAlearney, AS	2021	12.25	49
30	Insulin resistance in COVID-19 and diabetes	Primary Care Diabetes	Govender, N; Khaliq, OP; (…); Naicker, T	2021	12.25	49

ACPY: average citations per year, TC: times cited.

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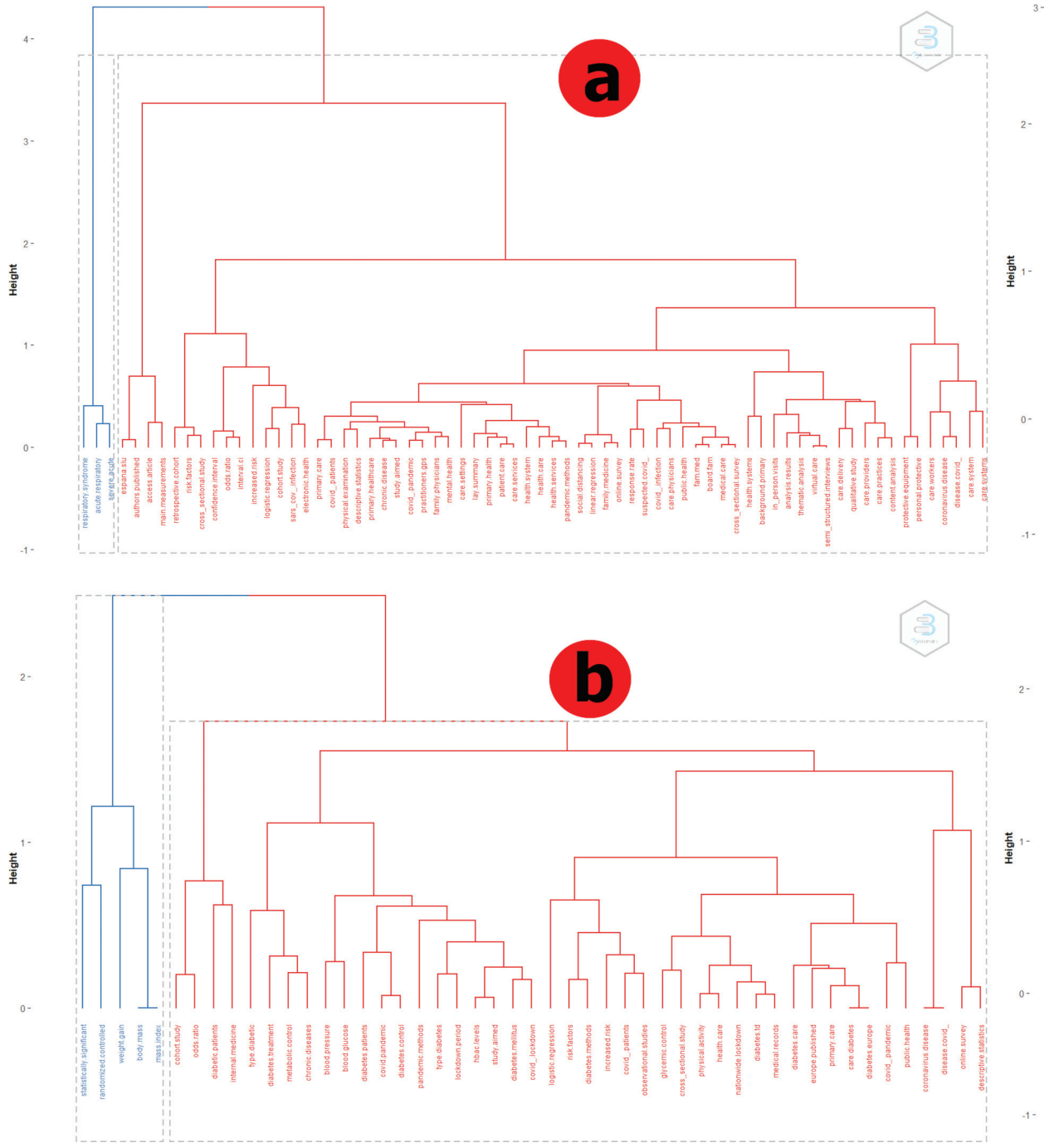
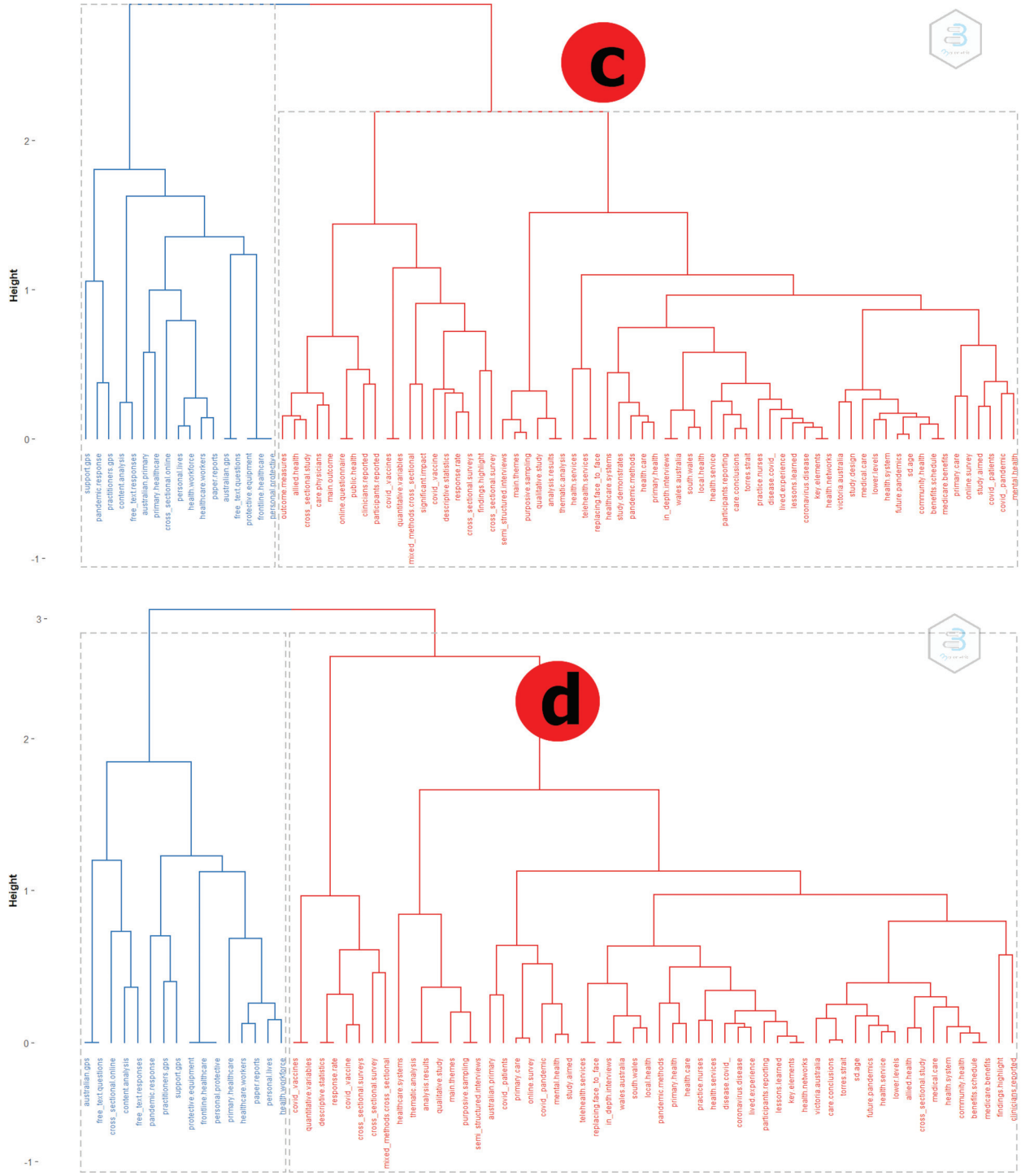
Appendix H. Conceptual structure topic dendrogram factorial analysis (Field: Abstract) Part 1



Appendix I. Conceptual structure topic dendrogram factorial analysis (Field: Abstract) Part 2



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Appendix J. Conceptual structure topic dendrogram factorial analysis (Field: Abstract) Part 3