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Research on Covid-19 in Europe from 2020-2024: A Citation Analysis Approach for Funded by The National Institute for Health and Care Research, United Kingdom

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Abstract
The COVID-19 pandemic has impacted so many people's everyday lives worldwide, and it is still threatening our society as a whole. The COVID-19 pandemic is unprecedented in several ways that make it particularly challenging and threatening: it is still largely unknown of its origin and transmission routes; there may be months or even longer before COVID-19 vaccines can be expected to be a powerful line of defense; and the prolonged pandemic continues to pose social, economic, and political challenges to businesses and entire industries such as airlines and international travel as well as schools and many other areas. This paper adopts a systematic literature review approach to understand past studies from 2020 to 2024 funded by the National Institute of Health and Care Research in Europe related to COVID-19. This paper summarises the most contributing authors, countries, and journals in the field of COVID-19 by analysing recently published articles from different publishers. Also, with the help of VOS viewer software, the researcher visualized the authors and co-authors and instituted network visualization. The total number of papers was 1,457, which was efficient for conducting the review dated between 2020 and 2024. Publications have decreased steadily from 423 in 2021 to 201 in 2024. SARS-CoV-2 and COVID-19 research topics dominate the dataset, with 124 entries, followed closely by long-term effects (121) and clinical research (111). COVID-19's healthcare impacts (107) and mental health implications (91) represent a significant but smaller portion of the research. University of London is the dominant institution, contributing 35.8% of the total metric means of the top five institutions' publications. The article published in the New England Journal of Medicine entitled Dexamethasone in Hospitalized Patients with COVID-19 by Peter Horby, Wei Shen Lim, *et al* has received the maximum number of citations with 7,626.

Keywords: COVID-19, Research Publications, VOS Viewer, Pandemic, Citation Analysis, Bibliographic Coupling, Cluster, United Kingdom (UK), NIHCRE

Introduction

The emergence of the COVID-19 pandemic served not only as a challenge to the resilience of humanity but also as a rigorous examination for scientists. As a new virus, there was initially a scarcity of literature to support the medical community; thus, it became imperative for scientists to rapidly contribute to the evidence base to guide the management of ill patients appropriately. Treatments that were newly proposed, often based on anecdotal evidence, were being implemented globally; however, policy-makers and healthcare professionals on the 'front-line' could not solely depend on such data to assure that these innovative treatments would be optimal for patient care. Certain countries, like the UK, which follows NICE guidelines, emphasize validated and peer-reviewed evidence to develop treatment protocols and regimens. A major obstacle to clinical confidence in the swiftly published 'COVID-19' articles is the evident lack of high hierarchical levels of evidence. While this may primarily stem from the urgency and immense pressure to publish research, there may also be a widespread misunderstanding that results from case studies with small sample sizes cannot be generalized to represent entire populations.

The swift expansion of the COVID-19 research literature has resulted in a growing number of bibliometric and scientometric studies, such as those by Chahrour *et al*. (2020), Colavizza *et al*. (2020) [4], and Deng *et al*. (2020). Additionally, there have

been systematic reviews and meta-analyses addressing various facets of the COVID-19 pandemic, including the risk factors associated with severe and fatal COVID-19 cases (Zheng *et al*., 2020) [18] and the potential high risk for patients with asthma (Morais-Almeida *et al*., 2020) [13]. Our research distinguishes itself from other pertinent studies within the COVID-19 literature by contributing to the creation of a flexible and extensible visual analytic framework. Our objective is to empower individual researchers, enabling them to investigate a rapidly expanding body of scientific literature by constructing a representative dataset tailored to their specific interests through their queries. Moreover, we illustrate how diverse exploratory and analytic workflows can seamlessly integrate within the visual analytic framework. In this article, we will present a generic and reproducible method based on meta-analysis for conducting visual analytic studies of the COVID-19 literature. Notably, this method is also applicable to literature on other subjects. This approach contributes to the exploration of a research field in several ways: 1) it allows anyone interested in the topic to create their own CORD-19-like dataset, enriched with cited references and citation contexts; 2) it removes obstacles to performing scientometric studies using citation-enriched data; 3) it broadens the scope of existing visual analytic studies of research literature by incorporating citation contexts and enhances network-based analyses with deeper insights identified at a more granular level; 4) it enables analysts to interactively investigate the uncertainties related to the citations of a reference; and 5) by facilitating analyses within an integrated visual analytic environment, it improves the application of a widely utilized science mapping tool, CiteSpace (Chen, 2004; Chen, 2006; Chen *et al*., 2010; Chen, 2017).

A citation is an article (citation) that cites another (cited citation) as a reference. The number of citations is not only a measure of an article's impact on the scientific community but is also the basis for generating a journal's impact factor (IF). Eugene Garfield introduced the term “citation classics” in 1955 to identify the most cited scientific articles in the Institute for Scientific Information (ISI) Web of Knowledge (now known as Web of Science) database. Most fields consider an article cited more than 100 times a citation classic. Reviewing the most cited articles (the so-called “citation classics”) can provide interesting information about scientific progress and research trends in a particular subject area.

Review of Literature

Mohamad Chahrour *et al* (2020) explored the PubMed and the World Health Organization (WHO) databases for publications about COVID-19 from December 2019 until March 18, 2020. Only relevant observational and interventional studies were included in our study. Data on COVID-19 incidence were extracted from the WHO situation reports. Research output was assessed concerning each country's gross domestic product (GDP) and population. They found that only 564 publications met our inclusion criteria. These articles came from 39 countries, constituting 24% of all affected countries. China produced the most significant publications, with 377 (67%). Concerning continental research activity, Asian countries had the highest research activity with 434 original publications (77%). Regarding publications per million persons (PPMPs), Singapore had the highest number of publications with 1.069 PPMPs. In terms of publications per billion-dollar GDP, Mauritius ranked first with 0.075.

Yuetian Yu *et al* (2020) [17] analysed a total of 3,626 publications on the topic of COVID-19, and "COVID-19" with a total link strength of 2,649 appeared as the most frequent keyword, which had a strong link to "pneumonia" and "epidemiology". The mean citation count of the top 100 most cited articles was 96 (range, 26-883). Most of them were descriptive studies and concentrated on the clinical features. The highest-ranking journal was the British Medical Journal with 211 publications, and the most cited journal was The Lancet with 2,485 citation counts. Eleven articles written by Christian Drosten from the Berlin Institute of Virology have been cited 389 times, and 40 articles from the Chinese Academy of Sciences have been cited 1,597 times, making them the most cited author and organization. The number of collaborators with China is 44, and the total link strength is 487. The main partners of China are the USA, England, and Germany. The published literature has focused on three topics: disease management, clinical features, and pathogenesis.

Peijing Yan *et al* (2020) visualized the mapping and keyword cluster graphs to illustrate the research topics and hotspots. We included 14,141 CoV-related publications for the bibliometric analysis and 16 (12 articles) CoV-related bibliometric analyses for the systematic review. Both the systematic review and bibliometric analysis showed (1) the number of publications showed two steep upward trajectories in 2003–2004 and 2012–2014; (2) the research hotpots mainly focused on the mechanism, pathology, epidemiology, clinical diagnosis, and treatment of the coronavirus in MERS-CoV and SARS-Cov; (3) the USA, and China; the University of Hong Kong; and Yuen KY, came from the University of Hong Kong contributed most; (4) the *Journal of Virology* had the most significant number of CoV related studies. More studies should focus on prevention, diagnosis, and treatment in the future.

Jingchun Fan *et al*. (2020) [7] conducted a Bibliometric Analysis on COVID-19: A Comparison of Research Between English and Chinese Studies. They found that a total of 143 original English and 721 Chinese research articles and reviews on COVID-19 were included in our study. Most of the authors and institutions of the papers were from China before March 1st, 2020; however, the distribution of authors and institutions was mainly in developed countries or wealthier areas of China. The range of the keywords in English publications was more extensive than that in Chinese. Traditional Chinese Medicine was seen more frequently in Chinese papers than in English. Of the 143 articles published in English, 54 were published by Chinese authors only, and 21 were published jointly by Chinese and other overseas authors. They concluded that English publications have enabled medical practitioners and scientists to share/exchange information. On the other hand, publications in the Chinese language have provided complementary educational approaches for local medical practitioners to understand the essential information needed to manage COVID-19 in the relatively remote regions of China, for the general population with a general level of education.

Objective of the study

- To determine the total number of COVID-19 research publications in Europe funded by the National Institute for Health and Care Research, United Kingdom, from 2020 to 2024.
- Identify the five most significant types of publications, key topics of these publications, leading organizations or institutions, and sources of COVID-19 research.
- Extract the top ten COVID-19 research articles by citation count.
- The goal is to analyze documents' citations, including their authors, sources, institutions, and countries.
- To examine the bibliographic coupling of documents, authors, sources, institutions, and countries.

Methodology

This paper adopts a systematic literature review approach to understand past studies from 2020 to 2024 funded by the National Institute of Health and Care Research in Europe related to COVID-19. This paper summarises the most contributing authors, countries, and journals in the field of COVID-19 by analysing recently published articles from different publishers. Also, with the help of VOSviewer software, we visualized the authors and co-authors and instituted network visualization. The distance between the two authors in the visualization indicates the authors' relatedness regarding co-citation links. The closer the two authors are to each other, the stronger their relatedness is. Lines also represent the strongest co-citation links between authors. Search technology as follows in Title and Abstract includes "Covid 19", AND Year range 2020-2024, AND Funder is "National Institute of Health and Care Research", AND continent is "Europe", like that 'search' keywords were used in the OpenAlex database. The total number of papers was 1,457, which was efficient for conducting the review dated between 2020 and 2024.

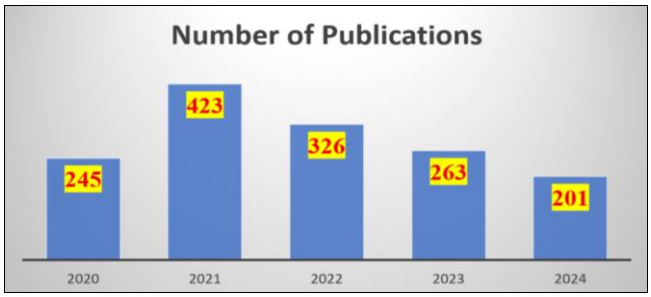

Fig 1: Number of publications year-wise

The figure shows that 1,457 research articles related to COVID-19 research publications in Europe funded by the National Institute for Health and Care Research, United Kingdom, from 2020 to 2024, have decreased steadily from 423 in 2021 to 201 in 2024. The peak year was 2021, with the maximum number of publications about COVID-19, and there has been a consistent downward trend since then. Yearly Decline: 2021 to 2022: ~23% drop, 2022 to 2023: ~19% drop, 2023 to 2024: ~23.6% drop.

Top Five Topics and Types of Publications

Table 1: Top Five types of publications & Topics on COVID-19

Type of publications	Count	Topic	Count
Article	1,110	SARS-CoV-2 and COVID-19 Research	124
Review	167	Long-Term Effects of COVID-19	121
Preprint	91	COVID-19 Clinical Research Studies	111
Letter	79	COVID-19 and healthcare impacts	107
Editorial	11	COVID-19 and Mental Health	91

SARS-CoV-2 and COVID-19 research topics dominate the type of publication in topic-wise, with 124 entries, followed closely by long-term effects (121) and clinical research (111). COVID-19's healthcare impacts (107) and mental health implications (91) represent a significant but smaller portion of the research. The data suggests a strong emphasis on the immediate and long-term consequences of the pandemic across various medical and psychological domains. Further statistical analysis could explore the relative proportions of research within each category and identify potential areas for future investigation.

Most publications are original research articles (1,110), strongly focusing on generating new scientific knowledge. Review articles (167) reflect efforts to synthesize existing research, showing maturity in the field. Preprints (91) suggest an openness to rapid, pre-peer-reviewed results sharing. Letters (79) indicate active scholarly communication, while editorials (11), being few, serve their usual role of offering perspectives or commentary. The distribution reflects a research-driven field with balanced support for discussion, synthesis, and rapid dissemination.

Top Five Institutions

Table 2: Top Five Institutions on COVID-19 Research

Top Five Institutions	Publications
University of London	663
University of Oxford	354
University College London	333
Imperial College London	253
National Institute for Health Research	252

The University of London is the dominant institution, contributing 35.8% of the total metric of the top five publications. This could suggest its prominence or larger scale compared to the others. The University of Oxford has a significant contribution (19.1%), more than double that of UCL. University College London and Imperial College London are relatively close in value (333 vs. 253), contributing 17.9% and 13.6% respectively. The National Institute for Health Research has the lowest contribution, just slightly below Imperial College London's (13.6% vs. 13.6%). There seems to be a substantial

disparity between the University of London and the other institutions. The University of London's value is almost double that of the closest institution, which could reflect its unique status in this metric. The other institutions, especially those based in London (Oxford, UCL, Imperial), have close values, suggesting a possible similarity in size, influence, or focus area. The University of London stands out as the key player, while the other institutions have made more similar contributions, with Oxford leading the rest.

Top ten articles based on citations

Table 3: Top Ten Research Articles based on the number of citations

S. No	Title	Year	Author	Journal	Citations
1	Dexamethasone in Hospitalized Patients with COVID-19.	2020	Peter Horby, Wei Shen Lim, *et al.*	New England Journal of Medicine	7,626
2	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts.	2020	Joel Hellewell, Sam Abbott, *et al.*	The Lancet Global Health	2,744
3	Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19.	2020	Maria Loades, Eleanor Chatburn, *et al.*	Journal of the American Academy of Child & Adolescent Psychiatry	2,548
4	Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: a systematic review and meta-analysis compared to the COVID-19 pandemic.	2020	Jonathan Rogers, Edward Chesney, *et al.*	The Lancet Psychiatry	2,374
5	6-month neurological and psychiatric outcomes in 236,379 survivors of COVID-19: a retrospective cohort study using electronic health records.	2021	Maxime Taquet, John Geddes, *et al*	The Lancet Psychiatry	1,972
6	Interleukin-6 Receptor Antagonists in Critically Ill Patients with COVID-19.	2021	Anthony Gordon, Paul Mouncey, *et al.*	New England Journal of Medicine	1,762
7	The COVID-19 pandemic and health inequalities	2020	Clare Bambra, Ryan Riordan, *et al.*	The Lancet Psychiatry	1,762
8	Suicide risk and prevention during the COVID-19 pandemic.	2020	David Gunnell, Louis Appleby, *et al.*	The Lancet Psychiatry	1,450
9	Bidirectional associations between COVID-19 and psychiatric disorder: retrospective cohort studies of 62,354 COVID-19 cases in the USA.	2020	Maxime Taquet, Sierra Luciano, *et al.*	The Lancet Psychiatry	1,401
10	Longitudinal observation and decline of neutralizing antibody responses in the three months following SARS-CoV-2 infection in humans	2020	Jeffrey Seow, Carl Graham, *et al.*	Nature Microbiology	1,322

The study *"Dexamethasone in Hospitalized Patients with Covid-19"* (Horby *et al.*, 2020) is the most cited (7,626 citations), underscoring its significance in shaping global treatment protocols. Its findings likely influenced hospital management worldwide by demonstrating the effectiveness of a low-cost corticosteroid in reducing mortality. Multiple highly cited papers focus on the psychological and psychiatric consequences of the pandemic:

- *Loades et al.* explored the effects of social isolation on children and adolescents.
- *Rogers et al.*, *Taquet et al.*, and *Gunnell et al.* delved into psychiatric and neurological complications, suicide risk, and bidirectional links between COVID-19 and mental illness.

This concentration highlights the immense mental health burden tied to the pandemic, a topic that has gained significant academic attention. *Hellewell et al.*'s modeling on outbreak control through isolation (2,744 citations) emphasizes the urgent need for fast, proactive public health measures early in the pandemic. *Seow et al.*'s study on antibody decline reflects crucial concerns about waning immunity and potential reinfections, informing vaccine design and booster strategies. Studies on *IL-6 receptor antagonists* (Gordon *et al.*) also gained traction (1,762 citations), reflecting global exploration of immunomodulatory treatments in critically ill patients. *Bambra et al.* highlighted health inequities, showing how COVID-19 amplified social vulnerabilities. The equal number of citations here and in the IL-6 study (1,762) reflects that biomedical and socio-structural factors received critical scholarly focus.

Most of the top-cited studies were published in the first year of the pandemic, reflecting the immediate global rush to understand and respond to the crisis. The range of journals—from clinical medicine to psychiatry and global health—demonstrates the multifaceted nature of the COVID-19 research landscape. Though citation count doesn't always equal quality, it strongly suggests that these papers were foundational or frequently referenced in subsequent research.

Citation analysis for the documents

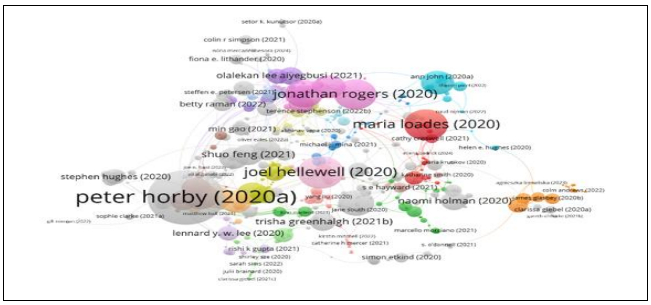

Fig 2: Citation analysis for the documents

Of 1457 documents, 1343 meet thresholds and are connected with a maximum of 711 items; the largest connected items consist of 250 items. The cluster number likely represents a categorization or grouping of documents based on specific criteria, such as topics, themes, or research areas. The dataset contains 294 entries, with authors from various years, predominantly between 2020 and 2024. The

data includes 42 unique cluster numbers ranging from 1 to 42. The distribution of documents across clusters varies significantly. For example, the cluster with the highest count is cluster 34, which has six papers, while clusters 1 and 2 have multiple documents but are not as populous as cluster 34.

The following clusters have the most documents: Cluster 34: 6 documents, Cluster 31: 6 documents, Cluster 37: 5 documents, Cluster 22: 5 documents, Cluster 30: 5 documents.

The dataset spans from 2020 to 2024, with most documents published in 2020 and 2021. The number of documents decreases significantly for 2022 and 2023, suggesting a potential decline in submissions or publication frequency over the years. Notably, 2020 has the highest number of records, indicating it may have been a pivotal year for research in the relevant fields. Particular clusters are more popular than others, indicating specific research areas that may receive more attention or funding. For instance, clusters 34, 31, and 37 suggest focused research on particular themes. Clusters with fewer documents (e.g., 1, 2, 3) may indicate niche areas or emerging topics just beginning to be explored. The concentration of documents in 2020 and 2021 might correlate with global events such as the COVID-19 pandemic, which spurred significant research across various disciplines, particularly in health and epidemiology. The decline in submissions in subsequent years may reflect a shift in research focus or the completion of initial studies. Authors like Maxime Taquet and Clarissa Giebel have multiple entries, which may indicate their influence in the field. Their works could be pivotal for further studies and should be highlighted in any literature review. The decline in publications from 2021 onwards could suggest a research gap or a shift in focus that may need to be addressed by future studies. This could also allow new researchers to explore these less populated clusters. The statistical breakdown reveals trends in author contributions, cluster popularity, and temporal changes in research output.

Citation analysis for the sources

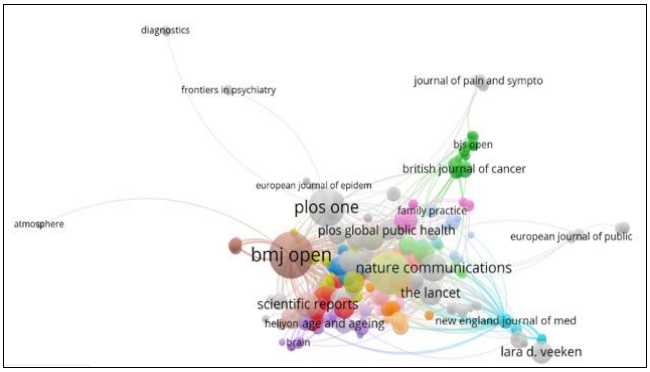

Fig 3: Citation analysis for the sources

Out of 526 total sources, only 59 meet the minimum threshold of having at least five documents cited. This indicates that a small fraction (approximately 11.2%) of the sources significantly contribute to the dataset's citations. The distribution of journals across clusters is uneven, with Cluster 1 having the highest count (12 journals) and Cluster 10 the lowest (3 journals). Most clusters (Clusters 1-5) contain a significant number of journals, while Clusters 6-10 show a decrease in quantity, indicating a possible specialization or niche focus within these clusters. The average number of journals per cluster is approximately 6.1 (total of 55 journals across 10 clusters). Clusters 1, 2, and 3 contain many journals, suggesting these areas may be broader fields of study or have higher publication activity. Clusters 1, 2, and 3 likely represent high-impact research areas, as they contain the most significant number of journals. These clusters encompass a variety of health-related topics, indicating a robust interest in public health, epidemiology, and infectious diseases. Clusters 4 through 10, while smaller, may represent emerging areas of research or specialized niches. For instance, Cluster 4 includes journals focusing on public health, while Cluster 5 contains journals that may address computational biology and its applications in health. The presence of journals like "Social Science & Medicine" in Cluster 6 and "The Lancet Healthy Longevity" in Cluster 8 suggests an interdisciplinary approach to health research, incorporating social sciences and geriatric studies. High-impact journals such as "The Lancet," "New England Journal of Medicine," and "Nature Medicine" are included in the higher clusters (3 and 4), indicating their relevance and contribution to significant health research discussions. The wide range of topics covered by the journals—from infectious diseases to public health and social science—highlights the complexity of health research and the need for collaboration across different fields. Reveals significant insights into the landscape of academic journals related to health research. Clusters 1 to 3 are prominent, reflecting broad and impactful research areas, while subsequent clusters indicate emerging or specialized fields.

Citation analysis for the authors

The dataset contains a significant number of authors (7,647) who meet the criteria of having at least five documents and one citation. This indicates a robust academic output and suggests diverse research topics. The minimum citation requirement implies that these authors have received recognition for their work, which can indicate the quality or impact of their research. The mention of 277 thresholds suggests categorizing authors or documents based on citation metrics.

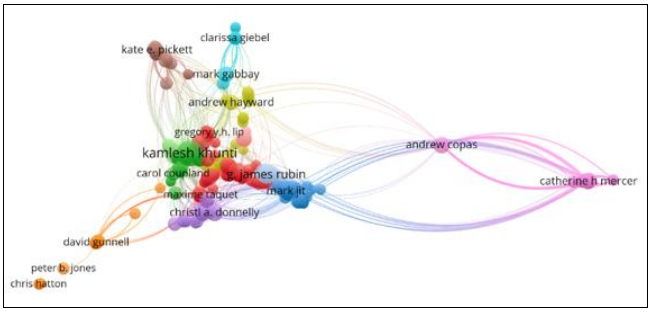

Fig 4: Citation analysis for the authors

Cluster 1: 66 authors - Cluster 2: 39 authors - Cluster 3: 34 authors - Cluster 4: 30 authors - Cluster 5: 30 authors - Cluster 6: 30 authors - Cluster 7: 15 authors - Cluster 8: 15 authors - Cluster 9: 15 authors - Cluster 10: 11 authors - Cluster 11: 11 authors - Cluster 12: 7 authors

Cluster 1 has the highest number of authors (66), indicating it may represent a broad or popular area of research. Cluster 12 has the fewest authors (7), suggesting a more niche or

specialized research area. Clusters 2, 3, and 4 have a moderate number of authors (ranging from 25 to 40), indicating these may represent emerging or focused research areas. The distribution of authors across clusters shows a significant concentration in Cluster 1, which may suggest that this area is either well-established or has garnered considerable interest from researchers. Smaller clusters indicate diversity in research topics, with some clusters representing specialized fields that might not have as many researchers. Clusters with more authors could present opportunities for collaboration, networking, and sharing of resources and findings. The authors in the largest cluster (Cluster 1) could be examined further to understand the specific themes or topics they are addressing, which may provide insights into current trends in research. Analyzing the relationships between clusters could reveal interdisciplinary research opportunities. For instance, authors from Cluster 1 could collaborate with those in Cluster 2 or 3 if their research interests overlap.

Citation analysis for the organization

The requirement of at least five documents per organization indicates a baseline level of engagement. Organizations meeting this threshold may be more actively contributing to their fields, indicating their influence or reputation. The relatively low average of 5.25 citations per organization could indicate varying levels of impact among organizations. Some may have numerous citations, while others may have few, leading to a skewed distribution. The 292 thresholds could indicate specific benchmarks or standards organizations are expected to meet. This could be a measure of quality or relevance in their contributions.

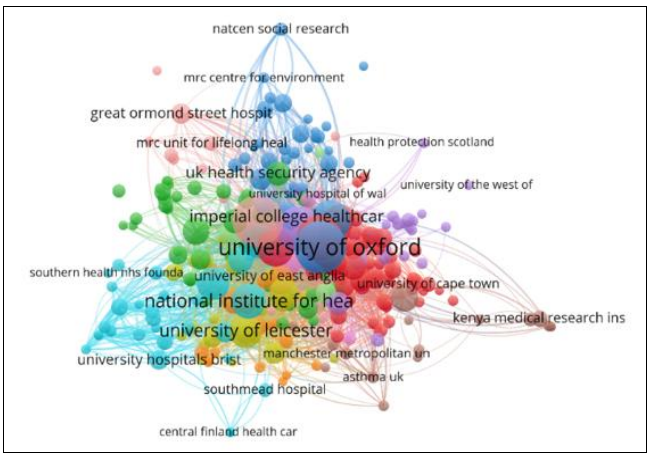

Fig 5: Citation analysis for the organization

Most organizations fall within clusters 1 and 2 (129 out of 186, approximately 69.4%). This suggests that most entities included in the dataset are likely smaller or less specialized organizations than those in higher clusters, which may represent more established or larger research institutions. As we move from cluster 1 to cluster 11, there is a noticeable decline in the number of organizations. For example, cluster 11 has only 11 organizations compared to cluster 1's 68. This indicates a potential stratification in the field, where fewer organizations meet the criteria for higher clusters, possibly due to funding, research output, or specialization. Many organizations are based in the UK, particularly clusters 1 and 2. This may point to a concentration of healthcare and biomedical research efforts within specific regions, particularly in major cities like London, Birmingham, and Edinburgh. The organizations span various healthcare and biomedical research fields, including hospitals, universities, public health institutions, and research councils. This diversity may reflect the interdisciplinary nature of modern healthcare research, where collaboration across different fields is essential for addressing complex health challenges. Well-known institutions such as Harvard University, Johns Hopkins University, and the University of Oxford are included. These institutions may play a significant role in shaping research agendas and influencing healthcare practices globally. The clustering suggests potential for collaboration among organizations within the same cluster. For example, organizations in cluster 5 could collaborate on cancer research, while those in cluster 3 may focus on public health initiatives. The presence of organizations related to mental health (e.g., the Centre for Mental Health, Mental Health Research UK) and public health (e.g., Public Health England) in the higher clusters may indicate a growing focus on these areas, particularly in response to recent global health challenges such as the COVID-19 pandemic. The clustering may also reflect differences in funding and resource allocation, with higher clusters potentially receiving more significant funding or being associated with larger, more impactful research projects. The rich landscape of organizations involved in health research and education, with a clear hierarchical structure, is reflected in the clustering. The analysis reveals a concentration of institutions in foundational clusters, indicating their significance in the field. The trends suggest a collaborative environment with a growing emphasis on specialized areas of health research.

Citation analysis for the country

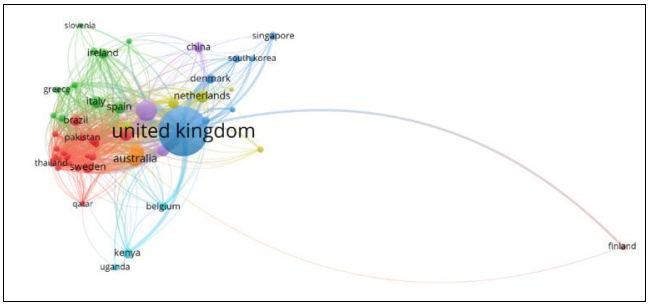

Fig 6: Citation analysis for the country

Out of 109 countries, 54 meet thresholds. Cluster 1 comprises a diverse range of countries from different continents, including Asia (Bangladesh, Japan), Africa (Ghana, Nigeria), Europe (Germany, Bulgaria), and the Americas (Brazil, Mexico). This indicates that the characteristics defining Cluster 1 are broadly applicable across various regions. Cluster 2 includes predominantly European countries, suggesting that the metrics or characteristics here may be more relevant to developed or transitioning economies. Clusters 1 and 2 contain a mix of developing and developed countries, while higher clusters (3 to 8) appear to include more developed nations, particularly in Cluster 8 (Finland). This suggests a potential correlation between cluster number and the level of economic development, with lower clusters possibly representing emerging markets. The high number of countries in Cluster

1 indicates a wide range of characteristics that could indicate economic, social, or political factors commonly shared among these nations. The sparsity of countries in Clusters 7 and 8 may suggest that the defining characteristics for these clusters are more stringent or specialized, or that fewer countries meet these criteria. The data could benefit from additional context regarding what each cluster represents. Understanding the underlying metrics could provide insights into trends like economic growth, social development, or geopolitical stability among the countries. The analysis of the offered country-cluster data reveals significant insights regarding the distribution of countries across clusters, potential geographical trends, and the relationship between cluster number and economic development.

Bibliographic coupling analysis for documents

Out of the 1,457 documents, 1,343 have at least one citation. This suggests a high level of engagement with the literature, as most documents are cited. The minimum citation threshold of 1 indicates that even the least cited documents are considered in the analysis, allowing for an inclusive view of the literature landscape.

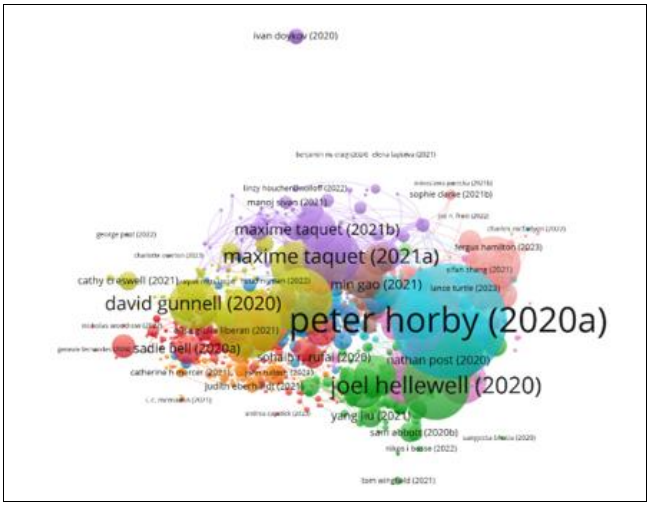

Fig 7: Bibliographic coupling analysis for documents

Out of 1,457 documents, 1,343 are connected through bibliographic coupling. This indicates that a significant majority (approximately 92%) of the papers share at least one citation with another document. This high level of connectivity suggests a robust network of scholarly communication within the dataset. With a minimum citation threshold of 1, the analysis indicates that even the least cited documents contribute to the network. This may imply that there are many foundational or introductory works that, while not heavily cited, still play a role in linking different research areas. The number of connected items (1,303) is slightly lower than that of connected documents (1,343). This discrepancy could suggest that some documents are cited multiple times across various other documents, indicating the presence of a few highly influential works that serve as central nodes in the network. This bibliographic coupling analysis reveals a rich and interconnected landscape of academic documents, highlighting the importance of citation networks in understanding scholarly communication.

- Cluster 1: 126 documents - Cluster 2: 90 documents - Cluster 3: 58 documents - Cluster 4: 68 documents
- Cluster 5: 54 documents - Cluster 6: 63 documents - Cluster 7: 50 documents - Cluster 8: 55 documents
- Cluster 9: 39 documents - Cluster 10: 38 documents - Cluster 11: 20 documents

Cluster 1 is significantly larger than all other clusters, indicating it may represent a primary theme or area of research that is highly populated with authors. The authors in this cluster span multiple years, suggesting ongoing study or interest in the topics represented. The dataset includes documents from 2020 to 2024, with a notable contribution increase from 2021 onwards. 2020 appears to be the starting year for many authors, with a gradual rise in subsequent years, indicating a growing interest in the subject matter. Clusters 2 through 4 contain fewer authors, suggesting they may represent more specialized or niche research areas. Some authors appear multiple times across different years or clusters, indicating their active engagement in research and possibly their contributions to various aspects of the field. A noticeable increase in publications from 2020 to 2021 suggests a growing interest or activity in the field during that period. This trend appears to plateau slightly in 2022 and then decline significantly in 2023 and 2024. The decline in 2023 and 2024 may indicate a natural decrease in research output or could reflect external factors affecting publication rates. Cluster 1 has the most publications across all years, indicating it may encompass a broad range of topics or themes that attract more researchers. Clusters 2 and 3 also show significant activity but are less populated than Cluster 1. This could suggest specialization in these areas. Clusters 10 and 11, with the fewest documents, might need further investigation to determine the specific focus or barriers to publication in these areas. Some authors appear multiple times, indicating a trend of individuals contributing to different clusters or over numerous years. This could signify active researchers in the field or those exploring varied topics. The analysis reveals a significant activity concentration in Cluster 1, with a peak in publications in 2021. The decline in later years suggests the need for further investigation into the factors affecting research output. The diversity of authors and the presence of repeat contributors highlight a collaborative research environment.

Bibliographic coupling for the sources

Bibliographic coupling is a method of measuring the relationship between documents based on their shared references. Out of 526 sources, only 59 met the threshold criteria (a minimum of 5 papers and at least 1 citation). This indicates a substantial drop-off, suggesting that many sources either have fewer than five documents or are not cited enough to meet the threshold. The ratio of sources meeting the threshold (59) to total sources (526) is approximately 11.2%. This low percentage indicates that only a few sources are sufficiently robust regarding document volume and citation.

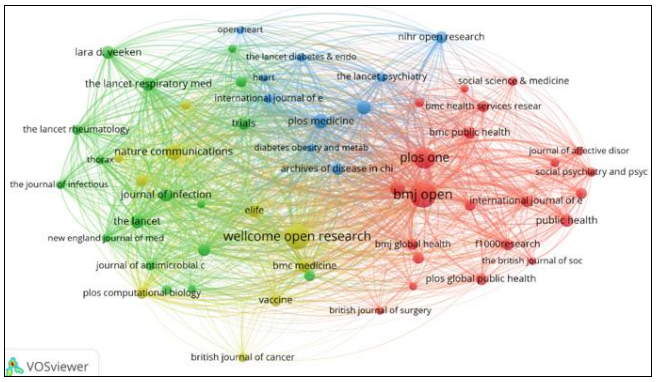

Fig 8: Bibliographic coupling analysis for the sources

Cluster 1 contains various journals, including public health and medical journals. The prevalence of sources in this cluster suggests that many journals may not have high-impact factors or rigorous peer-review processes. Cluster 2 has a balanced representation of journals, including several focusing on infectious diseases and public health. The presence of journals like "Clinical Infectious Diseases" and "Journal of Infection" indicates a focus on essential health issues. Cluster 3 includes generally more respected journals, such as "diabetes, obesity and Metabolism" and "International Journal of Epidemiology". These journals suggest a trend towards more specialized and impactful research. Cluster 4 contains some of the most prestigious journals, including "The Lancet," "Nature Medicine," and "Vaccine." The limited number of sources in this cluster indicates a high barrier to entry for journals to achieve this level of recognition. High-impact journals highlight the importance of these sources in driving significant research and clinical advancements. It reveals a diverse range of journals across different clusters, with many lower-impact journals. The mean cluster rating indicates that while there are many sources, the overall quality leans toward the lower end of the spectrum. High-impact journals in Cluster 4 highlight the competitive nature of publishing in prestigious outlets.

Bibliographic coupling for authors

Out of 7,647 authors, only 277 meet certain thresholds for bibliographic coupling. This suggests that a small proportion of authors are significantly interconnected through shared references, indicating a potential concentration of research interests among a few key authors. The total number of links (22,405) relative to the number of authors (7,647) gives a link density of approximately. This indicates that, on average, each author has about 2.93 connections based on shared references, suggesting a moderate level of interconnectivity among the authors. The total link strength of 394,919 suggests that the connections among authors are numerous and substantial, indicating that the authors share a significant number of standard references. This implies that the average strength of each link (or shared reference) is notable, indicating robust relationships among the coupled authors.

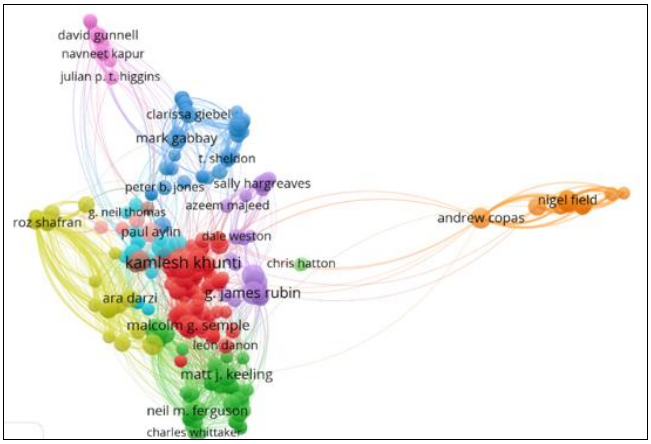

Fig 9: Bibliographic coupling analysis for authors

Cluster 1: 78 authors, Cluster 2: 54 authors, Cluster 3: 38 authors, Cluster 4: 29 authors, Cluster 5: 30 authors, Cluster 6: 17 authors, Cluster 7: 14 authors, Cluster 8: 11 authors, Cluster 9: 10 authors, Cluster 10: 6 authors, Cluster 11: 3 authors

Cluster 1 is the largest, containing 56.1% of the authors. The subsequent largest cluster is Cluster 2, with 38.8% of the total. Clusters 3 through 11 show a decreasing trend in size, with Cluster 11 being the smallest, containing only 2.2% of the total authors. The significant number of authors in Cluster 1 suggests it may represent a specific category or type of authors. This warrants further investigation into the characteristics of authors in this cluster. The rapid decrease in authors from Cluster 1 to Cluster 11 indicates a sharp drop-off in cluster sizes. This may suggest that the authors in the smaller clusters are either more specialized or represent niche areas of expertise. Cluster 1 contains many authors, which may indicate a commonality among these individuals, such as shared research interests, professional backgrounds, or affiliations. The subsequent clusters (2-11) may represent increasing specialization or diversity in expertise, as indicated by their smaller sizes. This could reflect a hierarchical structure in fields of study or professional practice.

Bibliographic coupling for the organization

Bibliographic coupling occurs when two documents reference the same third document. In this context, it helps to identify how closely related different organizations are based on their shared references. The presence of 7 clusters indicates that distinct groups of organizations share similar bibliographic references. This suggests potential thematic or research areas that overlap among the organizations. The total link strength of 2,354,798 signifies the cumulative strength of connections among the bibliographically coupled organizations. This metric can be interpreted as the intensity of collaboration or thematic alignment. This indicates that, on average, each link between organizations has a strength of approximately 63.9, suggesting a moderately strong connection. The high average number of links per

organization indicates a robust network of collaboration or shared research interests among the organizations that met the bibliographic coupling threshold. The existence of 7 clusters suggests diversity in research themes or areas of focus. Investigating the specific organizations within each cluster could provide insights into predominant research trends. The data indicates that organizations will likely benefit from collaboration, especially within clusters with standard references. The relatively low percentage of organizations (19.2%) meeting the threshold may indicate that many organizations either have less collaborative research output or that their research focus is too divergent. The average link strength and number of links suggest that while the network is extensive, organizations may be central to multiple clusters, bridging different research areas.

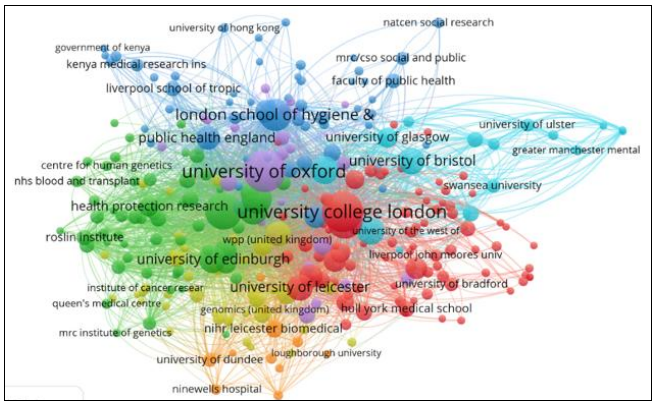

Fig 10: Bibliographic coupling analysis for organizations

1525 org – 292 meet thresholds
Cluster 1: 82 organizations, Cluster 2: 53 organizations, Cluster 3: 54 organizations, Cluster 4: 36 organizations, Cluster 5: 26 organizations, Cluster 6: 12 organizations, Cluster 7: 10 organizations

Cluster 1 has the highest number of organizations, indicating many entities engaged in foundational or preliminary research and healthcare initiatives. This could imply a strong base of institutions focusing on basic research or local healthcare services. As we move from Cluster 1 to Cluster 7, there is a consistent decline in the number of organizations. This suggests that fewer institutions are engaged in more advanced or specialized research areas, which could be due to resource constraints, expertise requirements, or the nature of the research focus. Clusters 2 and 3 have nearly equal representation, indicating a robust mid-tier of organizations that likely focus on applied research and more significant healthcare initiatives. This could reflect a growing interest in translational research, bridging the gap between basic research and clinical applications. Clusters 4 to 7 organizations represent a small fraction of the total, suggesting that advanced research and highly specialized institutions are less common. This could highlight the selective nature of high-tier research funding or the need for extensive collaboration and resources to operate at these levels.

Many organizations are NHS trusts and hospitals, particularly in Clusters 1 and 2. This indicates a strong focus on healthcare delivery and research within the UK, which is vital for public health and medical advancements. It includes universities, research institutes, and health organizations, showcasing a diverse landscape of contributors to health research. This diversity is crucial for interdisciplinary collaboration and innovation. Several international institutions (e.g., the University of Toronto and Harvard University) in the higher clusters indicate a global cooperation in health research, essential for addressing worldwide health challenges. The significant number of organizations in the lower clusters suggests the potential for growth and development in research capabilities. Institutions in Cluster 1 may evolve into higher clusters as they develop expertise and resources.

The significant presence of institutions in the lower clusters suggests a strong foundation for health research in the UK. In comparison, the decline in numbers at higher clusters highlights the need for continued support and development in advanced research initiatives. Further analysis could provide valuable insights into collaboration, funding, and the overall impact of these organizations on public health.

Findings & Suggestions

The study reveals that from 2020 to 2024, 1,457 COVID-19-related research publications were produced in Europe with funding from the National Institute for Health and Care Research, UK. The publication output peaked in 2021 and has since shown a steady decline, with only 201 publications in 2024. Original research articles (1,110) dominated, focusing on new scientific evidence, followed by reviews, preprints, letters, and editorials. The major topics studied include SARS-CoV-2 and COVID-19, long-term effects, clinical research, healthcare impacts, and mental health. The University of London emerged as the leading institution, contributing 35.8% of the top five institutions' output. Highly cited articles, such as "Dexamethasone in Hospitalized Patients with COVID-19" (7,626 citations), played crucial roles in influencing global treatment protocols. Citation and bibliographic coupling analyses show strong research networks among documents, authors, and institutions, but also reveal a concentration of impactful studies within a limited cluster of sources and organizations. Future COVID-19 research should diversify its thematic focus beyond clinical and immediate health impacts to address emerging gaps such as pandemic preparedness, vaccine equity, public health policy, and socio-economic recovery. More comparative and cross-country analyses could provide valuable insights into effective health systems responses. The declining publication trend suggests a need for renewed funding incentives and collaborations to sustain momentum. Encouraging interdisciplinary studies by bridging biomedical, psychological, and socio-economic dimensions could enrich the evidence base. Institutions should support open-access publishing, preprint sharing, and data transparency to enhance global knowledge exchange. Lastly, underrepresented clusters and organizations should receive targeted support to promote balanced research development and wider international collaboration.

Conclusion

This citation analysis confirms that Europe's COVID-19 research community, particularly under the support of the National Institute for Health and Care Research, contributed significantly to global scientific understanding during a critical period. Despite a notable surge in high-impact publications, output has tapered in recent years, indicating a possible shift in research priorities or resource allocation. The dominance of a few institutions and topics highlights

strengths and concentration risks. Sustained, diversified, and collaborative research efforts are essential to address ongoing and future public health challenges. Strengthening bibliometric tracking and visualization tools will empower researchers and policymakers to navigate large volumes of scientific evidence, ensuring informed decisions for future pandemic resilience and strengthening of health systems.

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