Guidance List for repOrting Bibliometric AnaLyses (GLOBAL): Explanation and Elaboration

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Abstract

Background: Bibliometric analysis is a valuable approach for studying and evaluating scholarly communication, research output and impact, collaboration patterns, and knowledge flows by examining various aspects of scholarly works across different levels of actors and aggregations. Despite the strong growth in publications using bibliometrics, there is limited guidance on how to report bibliometric analyses. The lack of standardized reporting practices has led to the creation of the **Guidance List for the repOrting of Bibliometric AnaLyses (GLOBAL)**. This evidence-based guideline, developed via the EQUATOR Network's framework, aims to provide a systematic approach to reporting bibliometric analyses in scholarly literature with the ultimate goal of improving reporting quality. This Explanation and Elaboration (E&E) document is a supplementary document intended to facilitate the use of the GLOBAL.

Methods: This E&E document was modeled after similar documents prepared for other reporting guidelines, such as Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) and Consolidated Standards of Reporting Trials (CONSORT). It includes feedback from Delphi participants and steering committee members, as well as references from peer-reviewed research papers. The GLOBAL steering committee, which supervised and provided input to the GLOBAL's development, consisted of six international researchers, four with expertise in bibliometrics (LW, MSabé, MSolmi, and SH) and two with expertise in reporting guidelines (DM and JYN). This document underwent pilot-testing and iterative processes of editing to enhance its clarity and applicability.

Results: This document includes detailed explanations and examples that satisfy the checklist items. Each item has an expanded explanation where the necessary components and rationale of the checklist items are presented, alongside practical examples. These examples are extracted from published bibliometric literature and provide authors with a framework on how to approach the reporting of their analyses when following the GLOBAL.

Conclusion: The GLOBAL is designed to guide the reporting of bibliometric analyses with a particular focus on manuscript-style publications (including journal and conference papers), encouraging more transparent reporting of studies using bibliometric methods. The supplementary document aims to assist in the adoption of the GLOBAL by providing explanations and examples on its implementation.

Keywords: bibliometric analysis; checklist; citation analysis; scientometrics; meta research; journal metrics; publication science; research trends; reporting guidance; reporting guideline; scholarly communication

Introduction

Bibliometric analysis is a research method used to study and evaluate the characteristics, growth, or influence of a research area, as well as the productivity of an individual author, research group, institution, country, or geographic region; among multiple other applications (e.g., collaboration analyses, mobility studies, etc.). Bibliometric methods rely on indicators based on publication frequencies, citation counts, and collaboration patterns (Donthu et al., 2021). Data for these analyses (e.g., metadata of article/book titles, authors, journal names, abstracts, or citation information) is typically gathered from bibliographic databases and processed using popular software (or programming languages) such as SQL (Chamberlin & Boyce, 1974), Python (*Python.Org*, n.d), R (*R: The R Project for Statistical Computing*, n.d.) or specialized software (e.g., Bibliometrix: *Bibliometrix*, n.d.; CiteSpace: *CiteSpace*, n.d.; SciMAT: Cobo et al., 2012; VOSviewer: van Eck & Waltman, 2010). Bibliometric studies can be applied to a micro (e.g., documents or authors), meso (e.g., departments, institutions, or journals), and macro level (e.g., countries or disciplines) of aggregation.

Bibliometric analyses serve an important role in research by providing systematic approaches to exploring existing fields of study and uncovering trends, patterns, and characteristics apparent within published literature. They enable researchers to navigate large volumes of structured or unstructured data and build a comprehensive overview of fields, topics, and other areas of inquiry. Moreover, bibliometric analysis can highlight gaps that require further investigation (e.g., database coverage issues). Through bibliometric methods, researchers can generate evidence that can guide the

advancement of knowledge generation in more targeted and efficient ways (Kumar et al., 2022).

As bibliometric analyses become increasingly used, establishing standardized reporting guidelines is essential to ensure the transparency and completeness of the reporting of these types of studies. Reporting guidelines increase reporting quality and reduce inefficiencies in scholarly communication and research waste by encouraging authors to adhere to established and robust research practices, standards for peer review and manuscript decision-making, and to allow readers to evaluate the usefulness and reliability of a study (Donthu et al., 2021; Gagnier et al., 2013; Moher et al., 2010).

Currently, there is limited guidance on how to adequately report bibliometric analyses (Jappe, 2020). Moreover, as evidenced by our scoping review (Ng et al., 2024), most guidance relies on opinions rather than rigorous methodologies (e.g., “How to develop a reporting guideline” by the Enhancing the QUAlity and Transparency Of health Research (EQUATOR) (*EQUATOR,* n.d.). The need for evidence-based guidance on the reporting of bibliometric analyses has led to the development of the **Guidance List for the repOrting of Bibliometric AnaLyses (GLOBAL)**. The GLOBAL is intended to assist authors in reporting bibliometric studies and ultimately, promote the transparency and reliability of bibliometric research.

This Explanation and Elaboration (E&E) document is a supplementary document to the GLOBAL reporting guideline, aimed at facilitating the adoption of the GLOBAL by providing readers with explanations and examples on how to use it.

Development of the GLOBAL

The GLOBAL was created in accordance with the EQUATOR Network's methodological framework on how to develop a reporting guideline (*EQUATOR*, n.d.) and was further informed by the toolkit developed by Moher et al. (2010). First, a scoping review (Ng et al., 2024) was conducted to identify previously published guidance for the reporting of bibliometric analyses and to subsequently create a preliminary 32-item checklist for the GLOBAL. Next, a two-round modified Delphi was conducted to further develop and refine the preliminary GLOBAL items. Consensus on items was reached when at least 80% of participants agreed on their inclusion or exclusion. In Round 1, invitations were sent to individuals with varying levels of bibliometric expertise to complete an online survey using Welphi (*Welphi*, n.d.). A total of 145 participants responded, providing demographic information and rating each item's necessity using a 9-point Likert scale. Round 2 involved an in-person consensus meeting with 16 participants from Round 1. These individuals were invited to discuss items that failed to reach consensus (i.e., at least 80%) in the previous round or were newly introduced to the Delphi process following a content analysis of Round 1 participant feedback. Items that did not reach consensus by the end of Round 2 were excluded. This process resulted in a 28-item checklist, which was then pilot-tested to create the final version of the GLOBAL. Throughout this process, the GLOBAL steering committee, consisting of five bibliometrics experts (LW, MSabé, MSolmi, SH, and DS) and two reporting guideline experts (DM and JYN), aided in the development of the GLOBAL. More information on the scoping review and Delphi processes can be found at Ng et al. (2024) and the main reporting guideline publication, respectively.

This accompanying E&E document, reflective of the collaboration and input of 151 contributors, including the GLOBAL steering committee members and Delphi participants, elaborates further on the rationale for and expectations underlying each checklist item. Two research assistants (NS and DZ) identified examples and drafted explanations for the items, meeting several times alongside three other core members (JYN, HL, and MM), to further refine the document. This draft was then circulated for feedback and approval by the GLOBAL steering committee and Round 2 Delphi participants.

Scope of the GLOBAL

The GLOBAL aims to provide guidance on how to report bibliometric analyses, with the goal of enhancing the transparency and clarity of these types of studies. It is not intended to be used as a quality assessment tool, nor does it offer guidance on the suitability of a method or indicator, or methodological design, used in varying contexts (Vandenbroucke, 2009). While the GLOBAL does not directly address the quality of existing bibliometric analyses, we expect it to lay the groundwork for future improvements in this area by making methodological choices more transparent.

The GLOBAL is formatted to align with the sections commonly found in manuscripts submitted to scholarly journals. These sections include 'abstract,' 'introduction,' 'methods,' 'results,' and 'discussion.' We also have items categorized under 'other' to account for those not clearly aligned with any of the manuscript sections. Our aim with the reporting guideline and this accompanying E&E document is for them to be clear and easy to follow. As outlined by the CONSORT guideline principle (Altman, 1996), “[r]eaders should not have to infer what was probably done; they should be told explicitly.”

How to Use This Document

This document was modeled after E&E documents prepared for other reporting guidelines (Chan et al., 2013; Page et al., 2021; Logullo et al., 2024). Readers are provided with the reporting expectations and rationale behind each checklist item, referencing feedback from the Delphi participants and steering committee members, as well as peer-reviewed research papers. We also provide clear examples from published bibliometric literature that satisfy each GLOBAL item requirement. These examples provide authors with a framework on how to prepare a thorough and transparent report of their bibliometric analyses when following the GLOBAL. All of the examples used in this document are taken from papers that are open access and follow Creative Commons (CC BY) licensing. To fully understand the E&E document, we encourage readers to read this document in conjunction with the main paper that outlines the GLOBAL Delphi process.

While the GLOBAL provides a minimum list of requirements for reporting bibliometric analyses, we encourage authors to include any additional information that could enhance the transparency and completeness of their work. Additionally, while the GLOBAL presents the items numerically from 1.1 to 6.3, authors should not feel discouraged from changing the order in which the items are presented in their manuscript. Finally, we acknowledge that, although transparency is central to the GLOBAL initiative, practical considerations (e.g., journal requirements or concision) may limit the extent to which these standards are fully met.

The GLOBAL

ABSTRACT

Abstract

1.1 Abstract should be reflective of the bibliometric analysis, including scope, data collection, analysis, and results.

Explanation: A well-crafted abstract should reflect the scope, data collection, analysis, and results of a bibliometric analysis. By providing a concise overview of the study's objectives and methodologies, abstracts enable researchers to quickly assess the relevance of the research to their interests and the validity of the findings (Harbourt et al., 1995). Authors are encouraged to format their abstracts as structured summaries to increase their quality and accessibility (Hartley, 2003; Haynes et al., 1990; Taddio et al., 1994). Additionally, while authors must ensure that their abstract aligns with the submission requirements of a journal (e.g., word limit) (*JAMA Network*, n.d.; *Elsevier Policy*, n.d.), they should not omit important details that could mislead the interpretation of their findings (Gøtzsche, 2006; Harris et al., 2002; Pitkin et al., 1999; Ward et al., 2004). Altogether, these factors can enhance the use of the study and the study's visibility, especially as abstracts often serve as the first point of contact for potential readers and are frequently used in literature searches (Pottier et al., 2024).

Example: "We aim to estimate the total amount of article processing charges (APCs) paid to publish open access (OA) in journals controlled by the five large commercial publishers between 2015 and 2018. Using publication data from WoS [Web of Science],

OA status from Unpaywall, and annual APC prices from open data sets and historical fees retrieved via the Internet Archive Wayback Machine, we estimate that globally authors paid $1.06 billion in publication fees to these publishers from 2015–2018. Revenue from gold OA amounted to $612.5 million, and $448.3 million was obtained for publishing OA in hybrid journals. Among the five publishers, Springer Nature made the most revenue from OA ($589.7 million), followed by Elsevier ($221.4 million), Wiley ($114.3 million), Taylor & Francis ($76.8 million), and Sage ($31.6 million). With Elsevier and Wiley making most of their APC revenue from hybrid fees and others focusing on gold, different OA strategies could be observed between publishers.” (Butler et al., 2023)

INTRODUCTION

Context

2.1 Situate the bibliometric analysis within the context of relevant pre-existing literature, identifying the gap in literature.

Explanation: Authors are required to provide background information on their bibliometric analysis and contributions of pre-existing literature. This helps readers understand the current state of knowledge in the field and, consequently, the scope and relevance of the bibliometric analysis at hand (Sun & Linton, 2014). Additionally, authors are encouraged to identify the gaps in previous literature and explain how the study aims to address them (Sun & Linton, 2014). In doing so, authors should also briefly articulate the significance of the gap, such as in advancing scholarly understanding or informing practical applications, to underscore the significance of the study's contribution. Altogether, this information indicates a well-grounded study, increases its outreach, and highlights its unique contribution to the field (Hashem et al., 2023), and can be used to contextualize and position findings as discussed in Item 5.2.

Example: "The author-pays model has increasingly become a popular revenue source for publishers, either in addition to the subscription model or as the sole income stream. While the 'Big 5' commercial publishers – Elsevier, Sage, Springer Nature, Taylor & Francis, and Wiley – use APCs to supplement existing revenue strategies, other publishers, such as Frontiers and MDPI, rely solely on APCs to generate revenue. APCs have proven lucrative and profitable for publishers, but highly controversial

among researchers who struggle to pay several thousand dollars per article or find they divert resources away from their research and act as a major barrier to publishing OA. Against this background, the diamond OA model has recently been favored by policy makers and researchers as neither authors nor readers are excluded on economic grounds. While diamond OA represents community-driven and academic-led and owned publishing initiatives, ensuring the financial sustainability of diamond OA journals is an ongoing challenge.

Given the prevalence of APC-based models, there is a need for reliable data that can support evidence-based decision making by institutions, funders, or consortia during negotiations with publishers or in the context of science policy making. The lack of transparency around the payment of APCs, combined with the decentralization of individual authors paying from their own funds, has limited the ability of most institutions and the global community at large to know how much is spent on OA publication fees. Studies analyzing APCs at the funder, country, institution, or disciplinary level have encountered limitations. For example, without contacting individual authors, it is difficult to identify who was responsible for paying the APC or whether waivers or discounts were in place. The commonly used APC data from the Directory of Open Access Journals (DOAJ) does not include hybrid journals and lacks historical fees. While institutions are better positioned to track their own APC expenditure, such information is typically not systematically tracked, leaving institutions to employ a range of methods to estimate their affiliated authors' spend. These estimates are not often publicly available. A notable exception is the OpenAPC initiative in Germany, which is a unique dataset on

APCs actually paid by universities, funders, and research institutions from Europe and North America. To date, OpenAPC provides APC records paid for 224,962 articles with a total amount of almost €448 million by 429 institutions from 2005 to 2024.” (Haustein et al., 2024)

Rationale

2.2 Define the aim, scope, rationale, and/or objective of the bibliometric analysis.

Explanation: Authors should define the aim, scope, rationale, and/or objective of a bibliometric analysis to provide context for their research (Klarin, 2024). The aim and objective should outline the study's intended outcomes, helping readers identify the goals of the study (Farrugia et al., 2010). The scope should define the boundaries of the analysis, allowing for a focused exploration of the data (Klarin, 2024). The rationale must justify the study's importance and relevance, explaining its contribution to the field (and beyond) and the reasoning behind the chosen data or methodology.

Example: “A different approach was taken by Butler et al., who collected annual APCs for 6,252 journals from several open datasets and historic journal website snapshots via Wayback Machine. To complement and expand upon this previous work, which was limited to journals published by the Big 5 and the 2015 to 2018 period, the present study is based on a new dataset that was created using a similar approach, but includes annual list prices for six large publishers (Elsevier, Frontiers, MDPI, PLOS, Springer Nature, and Wiley) and spans 2019 to 2023. We use this new dataset to estimate the global amount of APCs paid for OA publishing to these six publishers in recent years.” (Haustein et al., 2024)

Research Question

2.3 Define the research question.

Explanation: Well-defined research questions in bibliometric analyses are essential for steering the research focus, engaging the readership, and effectively addressing significant issues. While we acknowledge that research goals can vary in how they are expressed, ranging from a list of intended actions to explicit questions, we encourage authors to explicitly state their research question(s) or objective(s) in the introduction and ensure they are closely aligned with the aim of the paper (Linnenluecke et al., 2019). Presenting the research question(s) early in the paper not only clarifies the study's primary objective but also amplifies its research impact by immediately providing context and focus for the reader. This early disclosure allows scholars to quickly assess the relevance and rigor of the study, which can lead to higher engagement, easier integration into subsequent research, and ultimately, an increased likelihood of citation and scholarly influence (Sun & Linton, 2014).

Example: "More specifically, we aim to address six research questions (RQ):

- RQ1: What is the current development and trend in this research area?
- RQ2: What are the influential research constituents (e.g., (a) countries, (b) authors, (c) journals and (d) articles) in research related to ESG [Environmental, Social and Governance]?
- RQ3: What is the state of collaboration among countries in the ESG literature?
- RQ4: What are the most prominent themes in studies related to ESG?

- RQ5: How has research changed regarding this issue over time?
- RQ6: What are the future research areas and gaps in ESG research from a business perspective?” (Chytis et al., 2024)

Definitions

2.4 Explicitly specify relevant terms, concepts, and theoretical frameworks used in the study

Explanation: Authors should provide definitions for important terms used in their bibliometric analysis to ensure that the study is well understood, especially by those unfamiliar with the field. Definitions can vary depending on context, and authors should clearly explain these terms to reduce ambiguity (Rantala, 1991). Providing precise definitions minimizes confusion and aids readers in understanding the study's objectives, methodology, and findings. This clarity is crucial for the accurate interpretation of a study.

Concepts are foundational ideas that define the study and are often used to structure the analysis (Bordage, 2009). Theoretical frameworks, on the other hand, are structured collections of concepts, theories, and models that provide a lens for interpreting data. Authors should explain the concepts and theoretical frameworks used in their study to aid readers in understanding their findings. However, not all bibliometric analyses employ an explicit theoretical framework; in such cases, authors should state this explicitly rather than omit the item entirely, ensuring transparency for readers.

Example: “Counting method

A ‘counting method is defined by the choice of [a] basic unit [of analysis], object [of study] and score function’.

‘Objects of study,’ ‘basic units of analysis,’ and ‘score function’ are described below. Table 2 illustrates how five score functions work in counting methods, where countries are both units of analysis and objects of study. The basic units of analysis are credited, and the objects of study are scored by collecting the credits from the basic units of analysis assigned to the object of study. For the illustration, the table presents a publication with three addresses: one from Country X and two from Country Y.

[...]

Score function

A score function describes how the objects of study are scored. The basic units of analysis are credited individually before the objects of study collect the credits. Five common score functions are presented below:

- Complete

  A credit of 1 is given to each basic unit of analysis in a publication. An object of study collects the credits from the basic units of analysis assigned to the object of study.
- Complete-fractionalized

  A credit of 1/n is given to each basic unit of analysis where n is the number of basic units of analysis in a publication. An object of study collects the credits from the basic units of analysis assigned to the object of study.

- Straight

  A credit of 1 is given to the basic unit of analysis ranked first in a publication. All other basic units of analysis in the publication are credited 0. An object of study collects the credits from the basic units of analysis assigned to the object of study.

  Instead of first authors (i.e., the basic unit of analysis ranked first in the publication), last authors or reprint authors can also be credited. The review does not discuss these alternatives further.

- Whole

  A credit of 1 is given to each basic unit of analysis, assigned one-to-one to a unique object of study, in a publication. If a unique object of study is represented by more basic units of analysis in a publication, these basic units of analysis share 1 credit in whatever way. An object of study collects the credits from the basic units of analysis assigned to the object of study.

- Whole-fractionalized

  A credit of 1/m is given to each basic unit of analysis, assigned one-to-one to a unique object of study, where m is the number of unique objects of study related to a publication. If a unique object of study is represented by more basic units of analysis in a publication, these basic units of analysis share 1/m credit in whatever way. An object of study collects the credits from the basic units of analysis assigned to the object of study.

When the terminology is reduced to full and fractional counting, the differences between complete and whole score functions are not immediately visible. Both are called full counting. Neither are the differences between complete-fractionalized, straight, and whole-fractionalized score functions. All three are variations of fractional counting." (Gauffriau, 2021)

METHODOLOGY

Bibliometric Methods

3.1 Describe the bibliometric methods used.

Explanation: Bibliometric methods are techniques used to analyze scholarly literature, offering valuable insights into the structure and evolution of scholarly disciplines (Zupic & Čater, 2015). Authors should specify the bibliometric methods used in their analysis, such as citation counts for assessing article impact or co-authorship networks for identifying collaboration patterns. Authors are also encouraged to specify the rationale for selecting a particular method, helping readers understand its appropriateness for the study's objectives. Transparent reporting of these methods fosters trust in the research by enabling others to verify the processes and outcomes of the study (Haghani, 2023).

Example: "We use common variants of bibliometric analysis such as performance analysis and science mapping. The former is used to profile relevant research constituents such as authors, institutions, journals, and countries. The latter enables us to understand the relationship between these research constituents by drawing on visual tools such as those provided by VOSviewer software. While performance analysis uses quantitative indicators (e.g., number of total publications by year, publication, or country), science mapping focuses on patterns of collaboration between selected units (e.g., authors, institutions, countries) to document the social interactions shaping the intellectual structure of research on a topic within a timeframe. [...] Subsequently, we have examined the emerging themes connected to cultural heritage

by using co-occurrence analysis based on the assumption that frequently co-occurring keywords bear a strong thematic relationship and therefore, [...].” (Vlase & Lähdesmäki, 2023)

Units of Analysis

3.2 Define the units of analysis that are analysed (i.e., micro-, meso-, and macro-level) in the bibliometric analysis (e.g., countries, institutions, authors).

Explanation: In bibliometric research, the units of analysis may be distinguished at different levels: micro (e.g., individuals), meso (e.g., journals or institutions), and macro (e.g., regions, nations, or disciplines) (e.g., Herzog et al., 2020; Dorsch & Haustein, 2023). Authors should aim to explicitly state the units of analysis in their bibliometric analyses, as well as the aggregation level considered in their calculations. For example, a bibliometric analysis may use research institutions (meso-level) as the units of analysis, leading to results reported at the institutional level. These results can be obtained directly via scores from research institutions or by aggregated scores from lower levels, such as individual authors (micro-level). Both the units of analysis and the units used in the calculations should be defined. Clearly defining the units of analysis provides readers with a framework for understanding the study's scope and helps them interpret the results more accurately, as patterns and trends can vary between different levels of analysis (Herzog et al., 2020; Dorsch & Haustein, 2023).

Example 1: "A total of 4,570 publications were analyzed, with a steady increase in publications in the field of Intensive Care Unit (ICU) early mobilization. From a macro perspective, research on ICU early mobilization involves multidisciplinary involvement, including critical care medicine, neurology, and nursing; as for the meso perspective, the United States is the major contributor. Needham DM and Schweickert WD are the

key researchers in this field. Moreover, the core journal is Critical Care Medicine, with the most publications and citations. The microscopic level, dominated by references and keywords, illustrates that the hotspot and frontier of research on ICU early mobilization focus on ICU-acquired weakness, delirium, the prognosis of critical illness, and severe COVID-19." (Zhang et al., 2022)

Example 2: "To explore the interdependency of authorship and key topics in the dataset, we then made use of the VOSviewer software to visualize networks of co-authorship and co-occurrences of clustered keywords showing different patterns of research collaborations between authors, institutions, and countries, as well as prominent inter-related lines of inquiry related to cultural heritage. By employing these tools, we seek to illustrate the WOS-indexed evolution of cultural heritage research conducted in the multidisciplinary humanities over the past 20 years." (Vlase & Lähdesmäki, 2023)

Collection Method

3.3 Describe the bibliometric data collection methods, including any limitations.

Explanation: Authors should describe the data collection methods used in their bibliometric analyses. This includes detailing what and how bibliographic data from various sources (e.g., academic journals, conference proceedings, or databases) were systematically gathered, alongside the types of data collected (e.g., publication titles, authors, journals, citation counts, keywords, or publication years). This information aids in the transparency and reproducibility of a study (Pranckutė, 2021).

Additionally, authors should specify the limitations of their collection process (e.g., constraints in precision or recall or the incompleteness of the dataset). Highlighting these potential biases, gaps, or challenges allows readers to critically assess the study's findings and inspire new research. It can also explain the rationale behind each decision and the best practices within a field. This openness aids in ensuring the research process is clearly reported and can promote accessibility and spur future research (Benchimol et al., 2015).

Example 1: "[...] six databases were searched in order to identify the most highly cited motivation questionnaires in sport prior to August 2016: Academic Search Complete; Google Scholar; PsycARTICLES; PsycINFO; SPORTDiscus; Web of Science. The search was conducted using the following terms:

(motiv* OR regulat* OR behav*) AND sport* AND (questionnaire OR measur* OR instrument OR scale).

Reference lists of the obtained articles were searched by hand. The six most highly cited motivation questionnaires in sport were selected for review and are summarized in Table 1: the Sport Motivation Scale (SMS; Pelletier et al., 1995), the Intrinsic Motivation Inventory (IMI; McAuley et al., 1989), the Situational Motivational Scale (SIMS; Guay et al., 2000), the Perceptions of Success Questionnaire (POSQ; Roberts et al., 1998), the Behavioral Regulation in Sport Questionnaire (BRSQ; Lonsdale et al., 2008), and the Task and Ego Orientation in Sport Questionnaire (TEOSQ; Duda, 1989). In order to critically appraise each instrument, further searches were conducted using the questionnaire name combined with test evaluation-related terms (e.g., reliability, psychometric, factor analysis)." (Clancy et al., 2017)

Example 2: "We use data from two bibliographic databases (VABB-SHW in Flanders, the Dutch-speaking part of Belgium, and Cristin in Norway) and WoS. Data were retrieved from Cristin on March 24, 2018 and from VABB-SHW on May 23, 2017. WoS data were retrieved from the in-house WoS database maintained by ECOOM-Leuven on July 23, 2018, and from the Clarivate Analytics WoS database via the web interface on November 21, 2018. The choice to use data from these two countries is merely pragmatic. In addition, we assume that comparisons in relation to classifications are methodologically more robust if carried out using data from more than one national database. [...] The WoS data set is limited to articles from the reference data set that are indexed in the three main indices in WoS (SCI-E [Science Citation Index Expanded],

SSCI [Social Science Citation Index], AHCI [Arts and Humanities Citation Index]). While the SM [Science-Metrix] data set is limited to articles in journals that are included in the SM classification, the ERIH PLUS [European Reference Index for the Humanities and the Social Sciences] data set is confined to the journals included in ERIH PLUS. Finally, the VABB-NPU data set contains articles in the subset of journals that were identified in the reference data sets both from Flanders and Norway; journals that were identified in only one of the data sets were not considered. [...] Another minor limitation is related to the WoS data sets, the data sets limited to the articles indexed in WoS. Our bibliographic data matching approach was developed taking VABB-SHW data as the point of reference. This means that the accuracy of the approach with respect to Cristin data might be lower due to differences in bibliographic data collection and processing practices. Consequently, the number of WoS-indexed articles for Norway might be underestimated. Given that the focus of this study is not WoS coverage, we assume that the acquired level of accuracy is acceptable." (Sile et al., 2021)

Databases and Data Sources

3.4 Describe the databases and data sources used, including any limitations.

Explanation: Bibliographic databases and data sources provide structured data for bibliometric analyses. Authors should describe the databases and data sources used in their bibliometric analysis to promote transparency and reproducibility (Jappe, 2020). Clearly stating which databases and data sources were used helps readers replicate the dataset and validate the findings.

Additionally, acknowledging the strengths (e.g., wide coverage) and weaknesses (e.g., restricted database coverage or indexing issues that may affect the comprehensiveness of the dataset) of different sources helps to avoid inaccurate bibliometric evaluations. Authors should outline these limitations to help readers understand the potential biases or gaps in the data, which are crucial for an accurate interpretation of the results. Providing justification for selecting specific databases, alongside an explanation of how the limitations were overcome or could impact the results, can further strengthen the transparency and reliability of the analysis (Benchimol et al., 2015) and is strongly encouraged.

Example: “We used the three commercial databases Web of Science, Scopus, and Dimensions and the free database OpenAlex as sources of bibliometric data. The WoS data used were retrieved from an in-house WoS database developed and maintained by the Max Planck Digital Library and derived from the Science Citation Index Expanded

(SCI-E), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) provided by Clarivate (Philadelphia, Pennsylvania, USA). The database contains disambiguated and unified address information for German research institutes and universities developed by the I2SoS Bibliometrics Team at the University of Bielefeld and provided by the German “Kompetenznetzwerk Bibliometrie” (KB funded by the BMBF via grant 16WIK2101A, Competence Centre for Bibliometrics). The Scopus data derived from Elsevier were also provided by the KB. The WoS data was released in October 2021 and the Scopus data in April 2021. From Dimensions, we used a data dump from January 2022 and from OpenAlex, a snapshot from February 2022.” (Scheidsteger et al., 2025)

Search Strategy

3.5 Present the full search strategies for all databases used, including any filters and limits that were applied.

Explanation: Bibliometric analyses are often difficult to replicate as the dataset accessed for a study can change rapidly over time. This is because databases are regularly updated with new publications, edits, and removals. By providing a detailed account of the search strategy and its filters or limits, researchers enhance the reproducibility of their methods (Farooq et al., 2023). Therefore, authors are encouraged to present the full search strategies used in all the databases, specifying the search terms involved (e.g., “English”, “Bibliometrics”, “Scorpions”) and the filters or limits applied (e.g., restrictions on the time frame, languages, document types, and topics being investigated). This helps readers refine their search effectively to retrieve the same or a similar dataset and verify the findings. This thorough documentation ultimately strengthens the reproducibility of bibliometric analyses by outlining the initial stages of the data collection process.

Example: “We designed a two-step approach to retrieve all relevant publications from 2000 to 2020. The first step aimed to extract all possible keywords in varying ophthalmological subspecialties. To this end, we searched the Web of Science-Core Collection (WoSCC) database which is maintained by Clarivate Analytics using the following parameters: TS = (‘meta analysis’ OR ‘meta analyses’ OR ‘systematic review’ OR ‘systematic reviews’), time span = ’from 2000 to 2020,’ language = ’English,’ Web of

Science category = ’Ophthalmology,’ type = ’article, review or early access.’ TS here represents topic, meaning the search of the mentioned words in the title, abstract, and keyword lists. In this step, a total of 1,498 publications were obtained. We downloaded all original records and analyzed [the] frequency of author’s keywords using the R package - bibliometrix. Keywords that had an occurrence ≥3 times were arbitrarily defined as the core ophthalmology-related keywords, yielding 128 terms ([includes hyperlink to] Supplementary Material). Based on this collection, we conducted the second-round search in the WoSCC database. The retrieval strategy was set as: TS = (each of the 128 core keywords) AND TS = (‘meta analysis’ OR ‘meta analyses’ OR ‘systematic review’ OR ‘systematic reviews’). Other parameters, including publication year, language and literature type, were set identical to those in the first-round search.” (Fu et al., 2023)

Time Frame

3.6 Describe the data collection time frame.

Explanation: Authors should specify as clearly and precisely as possible the date of data collection (particularly when using online tools and databases, such as the web interfaces or the APIs of Web of Science, Scopus, Dimensions, OpenAlex, and other similar data sources), and when using dumps or versions of data sources, indicate the timestamp of these. Authors should distinguish between the date(s) of data collection and the broader timespan represented in the dataset. Moreover, specific time-related aspects involved in the analysis, such as publication windows, citation windows, specific periods, and cohorts, need to be clearly identified. Establishing a clear time frame for data collection in a bibliometric analysis is essential for ensuring the credibility of the analysis as it facilitates the replication and verification of results (Anney, 2014).

Example 1: “We designed a two-step approach to retrieve all relevant publications from 2000 to 2020… Both literature retrieval and raw data collection were performed on a single day (October 1, 2021).” (Fu et al., 2023)

Example 2: "We use the version of the dataset from July 1, 2020. This version of CORD-19 contains 169, 821 articles, of which 77, 777 are equipped with full text.... We focus on publications from the time period 1980–2019." (Colavizza et al., 2021)

Search Results and Selection

3.7 Describe the search results and selection processes (e.g., inclusion/exclusion). If applicable, use a flow diagram.

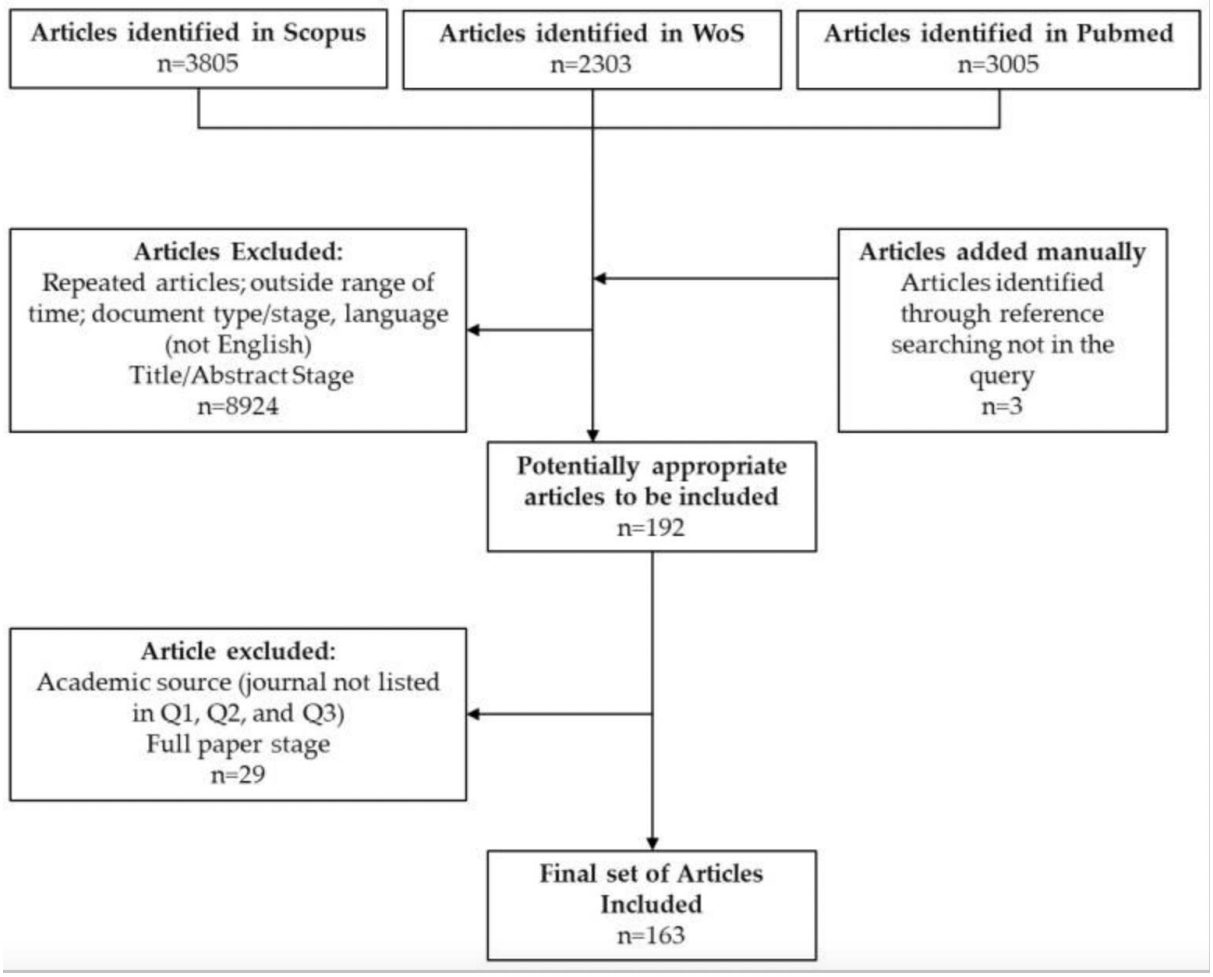
Explanation: In bibliometric analyses, the process of selecting relevant publications involves systematically identifying and selecting documents based on predefined inclusion and exclusion criteria. This includes searching bibliographic databases using keywords and filters to narrow the search to relevant studies, followed by screening the results to ensure alignment with the criteria (Artsin et al., 2024). Authors should describe the search strategy results, including a summary of the data characteristics, and the selection process guided by the inclusion and exclusion criteria. If additional reasons for inclusion or exclusion exist, these should be indicated. Authors are also encouraged to include diagrams, as seen in Example 3, to further enhance the clarity of these processes and make the methodology easier to follow (Rohwer et al., 2021). Clearly outlining this process and its results helps define the scope of the analysis, contextualizes the results, and facilitates the replication of the study.

Example 1: “We designed a two-step approach to retrieve all relevant publications from 2000 to 2020. The first step [was] aimed to extract all possible keywords in varying ophthalmological subspecialties. [...] In this step, a total of 1,498 publications were obtained. [...] Based on this collection, we conducted the second-round search in the WoSCC database. [...] Raw metadata comprising 5,063 records in the 2nd round of literature search were downloaded from WoSCC. [...] Reports meeting any of the

following criteria were excluded: (1) non-English publication; (2) publication year beyond 2000–2020; (3) retracted article.” (Fu et al., 2023)

Example 2: “[...] The keyword Instagram was searched for in the title, abstract, and keyword fields. No time restrictions were applied in the search regarding the starting year. To ensure the academic nature and high quality of the retrieved publications, only journal articles indexed in the WoS with complete bibliographic data were considered for the analysis. We restricted our analysis to papers in the English language, which is the dominant language in this field of research, due to its use in WoS and to ensure comparability with previous studies.” (Rejeb et al., 2022)

Example 3:



Flowchart of items included in the review. Figure from Aboelkhir et al. (2022)

Data Cleaning

3.8 Describe the data cleaning methods, including any limitations.

Explanation: Data cleaning improves the quality and accuracy of a dataset for analysis. This process may involve correcting errors or inconsistencies, determining the exclusion criteria, and/or handling missing data. This often applies particularly to author or institutional address disambiguation and aggregation. Authors should explicitly state and outline their chosen data cleaning method. Transparency in this process is essential for assessing the reliability of the study and the verification of the dataset.

Additionally, the limitations of the data-cleaning process should be communicated clearly. For instance, biases introduced during cleaning, such as those favouring certain geographical areas, should be discussed alongside their possible influence on the analysis. Such limitations allow readers to contextualize the results, determine their generalizability, and avoid inaccurate or misleading conclusions from being reported (Guo et al., 2023).

Example 1: “In order to build a network of the Italian academic community, we started from the Cineca dataset, which provides reliable information about the Italian faculty members, enriching it with details about their publication record obtained from Semantic Scholar. We describe in this section our data linkage approach, where we faced many challenges due to the aforementioned noise in the data sources. Figure 1 illustrates the

methodology for constructing a bibliometric network using data from the Cineca and SemS datasets.

[...]

Overall, we were able to match 62.3% of the Cineca names, which correspond to 38,220 authors. These names are the nodes in our co-authorship network, and sum up both Cineca information and publication and bibliometrics metadata obtained from Semantic Scholar, as described in the Data Records section.

More details on the nature of 37.7% unmatched full names from the Cineca dataset are provided in Figure 2. This figure shows that the research areas with a high percentage of unmatched names are primarily in law, social sciences, and humanities. This is largely because their corresponding SemS profiles contain a significant amount of non-English content." (Finocchi et al., 2025)

Example 2: "Author names, institutions, and countries were cleaned to combine various spellings and variants of the same entity into one (e.g., UCSF was combined with University of California, San Francisco). This was done using the VOSviewer thesaurus function. For author names we changed 58 spellings of author names for 53 authors to merge them with alternative spelling variants. The majority of changes affected first name initials only (e.g., "driessen, e" to "driessen, ew"). Author name disambiguation reduced the total number of distinct authors from 1285 to 1227. We also cleaned

institution names, reducing the total number of institutions from 423 to 333. We found 955 keywords and, for ease of analysis, selected only those that appeared at least three times in our dataset, which reduced the keywords most frequently found to 101.” (Maggio et al., 2022)

Data Analysis

3.9 Describe the bibliometric data analysis methods used.

Explanation: Bibliometric methods focus on analyzing metadata and the relationships between publications rather than raw experimental or survey data, which distinguishes them from traditional data analysis approaches. Authors should explicitly state the tools (e.g., Python: *Python.Org*, n.d.; R: *R: The R Project for Statistical Computing*, n.d.; Excel: *Excel | Microsoft 365*, n.d.; VOSviewer software: van Eck & Waltman, 2010; CiteSpace: *CiteSpace*, n.d.) and techniques (e.g., citation analysis, network analysis) employed in their bibliometric analyses. They should further specify the metrics used (e.g., publication counts, citation counts, or co-authorship network) and the aspects of scholarly communication quantified (e.g., the impact of research, collaboration networks, or the evolution of scientific fields). This information provides clarity on the scope of the analysis and how the data was processed, and aids in the interpretation of the results (Jackson, 2014). This transparency helps readers to understand, replicate, and verify the findings and build upon credible research.

Example 1: “Citation analysis was one of the parameters for assessing the quality of research published in scientific, technology, and social science journals. The bibliometric data show that there were 15,400 keywords involved in this research. To illustrate the research hotspots in smart city area, keywords co-occurrence was analyzed with VOSviewer. The co-occurrence threshold of the keywords was set as 10 and 431 items were brought into visualization (Figure 3).” (Guo et al., 2023)

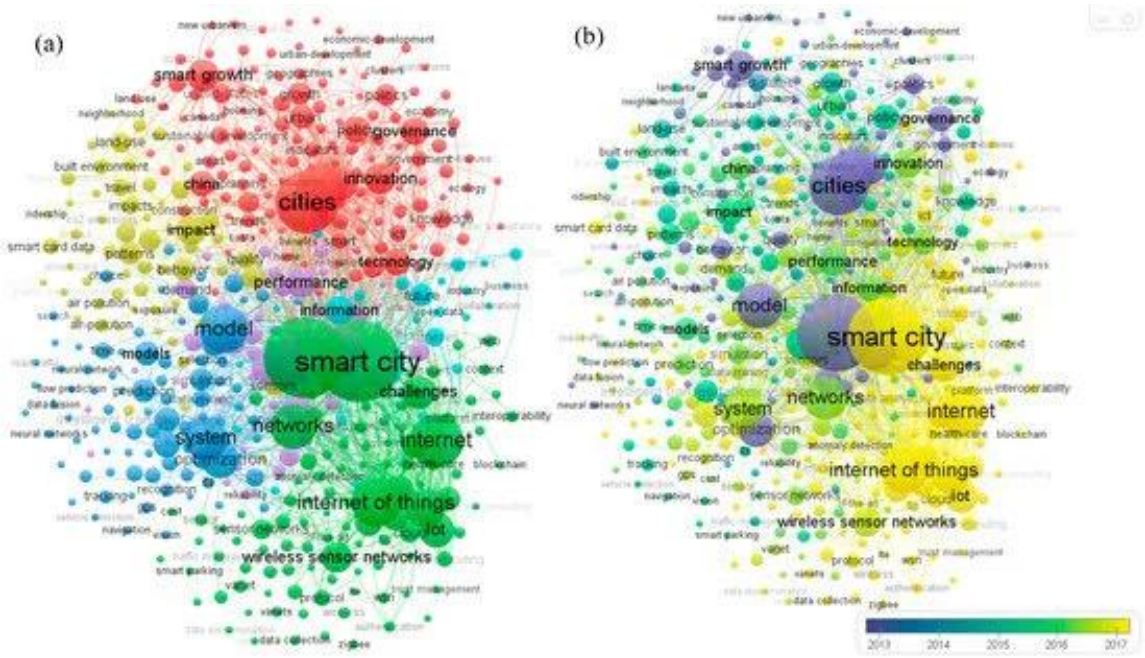


Figure 3. Co-keyword network visualization on smart cities research. Note: (a) co-keyword network visualization was based on occurrences; (b) co-keyword overlay visualization was based on the occurrences and average publications per year scores. Figure from Guo et al. (2023)

Example 2: “VOSviewer (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands) and CiteSpace (Chaomei Chen, China) were used to make visualization mapping in this paper. CiteSpace is effective in information visualization. It is used to obtain […] quantitative and visual information in specific fields. In this paper, we use CiteSpace to make keywords timeline picture[s].” (Liao et al., 2018)

Analytical Software

3.10 Specify the analytical software used and the parameter settings selected.

Explanation: Authors should explicitly state the analytical software used in their bibliometric analyses, as well as the parameter settings applied. For instance, when using VOSviewer (van Eck & Waltman, 2010), authors should specify the types and units of analysis conducted, the normalization method applied, the clustering density used, and the visualization scale configured during the analysis. The authors should explain why they decided to set certain parameters. Ideally, they should share their analytical workflows, scripts, and procedures. Detailing the software and its set parameters enhances transparency, giving readers a clearer understanding of how the data was processed and analyzed. Where possible, the software tools and packages used should be cited correctly, including the version number (Smith et al., 2016). Without clear documentation of these factors, variations in software or settings could lead to inconsistent results, particularly in mapping exercises, making verification difficult. Overall, this transparency is crucial for evaluating the rigor and validity of the study's methods and findings (Maher et al., 2018).

Example 1: "Frequency-based textual data analysis was conducted to create textual networks and identify sub-themes and decipher the recent trends in social sciences research attending to the pandemic. Keyword co-occurrence analysis has been performed after extracting clusters from CiteSpace software and validating the pattern in Bibliometrix package of R studio using Co-occurrence network tool and Thematic Map

tool. Keyword co-occurrence analysis was performed to map the existing knowledge structure of the research field. The keyword co-occurrence network was created using Louvain clustering algorithm with top 50 frequently used keywords. The Louvain algorithm is an agglomerative hierarchical clustering approach that utilizes the modularity measure. Equation 1 shows the calculation of the modularity measure, where nc is the number of clusters, lc is the number of intra-cluster edges, dc is the sum of degrees of all nodes in c and m is the number of edges in the graph. [...] The network analysis tool from VOS viewer and Collaboration World Map from Bibliometrix package was useful in interpreting and visualizing research collaboration and intrinsic networks among authors, countries and institutions. Here, the Bibliometrix tool uses networkPlot() tool from VOSviewer software to plot a network and collaboration graph and conceptualStructure() function from R software to sketch out the conceptual structure map of a scientific field using Multiple Correspondence Analysis and Cluster Analysis." (Roychowdhury et al., 2022)

Example 2: "This research uses the bibliometric software VOSviewer®, version 1.6.20, supported by the Centre for Science and Technology Studies of Leiden University (The Netherlands) [...] A co-occurrence cluster visualization analysis of high-frequency keywords was performed. The type of analysis selected was 'co-occurrence', the unit of analysis 'keywords', and the counting method 'full counting', instead of the 'fractional counting' approach, as suggested. In the keyword co-occurrence clustering graph, each circular node represents a keyword, with the node's size indicating its frequency of occurrence. Lines indicate co-occurrence relationships between two keywords, with line

thickness and length correlating with the strength of the relationship. The node color indicates the cluster to which a keyword belongs. A keyword occurrence timeline analysis was conducted to observe the evolution of the research topics, where blue node colors indicate earlier keyword appearances and yellow node colors denote recent research tendencies.

[…] a hybrid similarity measure combining bibliographic coupling and textual information to create bibliometric networks and cluster the literature on IM [innovation management] is used. The search query strings used as a parameter in the software code have been formulated as follows: TITLE-ABS-KEY (‘innovation management’) and TITLE-ABS-KEY (‘innovation management’) AND (LIMIT-TO (SUBJAREA, ‘BUSI’) OR LIMIT-TO (SUBJAREA, ‘ECON’). The search focused exclusively on identifying ‘MI’ [‘IM’] in the title, abstract, and keywords. As a result, the preliminary research sample of 6778 documents (all 27 research fields) was compared to 4902 documents after being limited to the BMA (Business, Management, and Accounting), EEF (Economics, Econometrics, and Finance), and SOC (Social Sciences) areas to enrich the analyses, as IM is essentially a multidisciplinary research area. We used only the term ‘Innovation Management’ to capture all possible results without limiting the findings to aspects related explicitly to IM.” (Saiz-Alvarez, 2024)

Indicators

3.11 Describe the bibliometric indicators used.

Explanation: Bibliometric indicators (e.g., the mean-normalized citation score, number and share of top 10% highly cited publications, number and share of publications in international collaboration, etc.) are used to measure publication output, the citation impact of research, and/or the collaboration patterns among researchers and institutions (Merigó et al., 2015). Authors should explicitly state the bibliometric indicators used in their study. They should also include the rationale behind their choice(s) and demonstrate why the indicators used are the most suitable ones. Disclosing this information helps readers to assess the methodology and reproduce the results, thereby validating the study.

Example: "We performed a specific analysis focusing on the 24 most productive authors identified, calculating the following indicators.

- Scientific activity:
    - Number of documents published and indexed on the WoS.
    - Number of articles and percentage of this document type with regard to the total documents published.
- Collaboration:
    - Average author signatures per article.
    - Percentage of articles produced in international collaboration.

- Impact indicators:
    - Number of citations received.
    - Average citations per article.
    - H-index (number h articles that have been cited at least h times each).
    - Mean percentile in subject area.
    - Mean normalized citation impact.
- Visibility indicators:
    - Percentage of articles published in journals ranked in the first (Q1) and second (Q2) quartile according to their impact factor in Journal Citation Reports (JCR).

We selected these indicators from the numerous potential measures that could have been used due to their ease of calculation, accessibility and reproducibility or because they are standardized indicators that can be consulted through the WoS by non-bibliometricians. The indicators also measure the main dimensions of research activity—including collaboration, an aspect that is not covered in the proposed evaluation methodologies that we identified during our literature review. With regard to scientific activity, the quantification of the number of documents published can help to determine the degree of researchers' contributions to advancing knowledge in a particular discipline or topic. The focus on the number of articles responds to the fact that this document type constitutes the preferred medium for disseminating original research work. The collaboration indicators are intended to capture the extent to which cooperative practices (particularly at an international level) are integrated in research

collaborations, reflecting their increasingly acknowledged importance in advancing knowledge. The impact indicators based on citations aim to measure the repercussions of the studies and visibility indicators aim to measure the importance of the media through which they have been disseminated, understood as the degree to which researchers' publications are concentrated in journals occupying the highest positions in impact ratings.” (Alcaide & Gorraiz, 2018)

Calculations/Formulas

3.12 If applicable, define the calculations/formulas used for indicators in the bibliometric analysis.

Explanation: When applicable, authors should outline the calculations and/or formulas used for the indicators in their bibliometric analyses, either within the main text or in the appendix. Including the specific formulas and/or calculations involved in the analysis assists others in accurately reproducing it. This is especially true when introducing new methods or indicators, and when modifying existing ones (Bornmann & Daniel, 2009). If including widely used indicators, calculations and formulas may not be necessary for understanding the methods. However, referencing these indicators is strongly encouraged (Rutterford et al., 2015).

Example: “The growth analysis was also presented as relative growth rate (RGR) which was defined as the increase in number of publications per unit of time. The RGR was calculated based on the following equation: RGR = [log e W2 - log e W1]/(T2 - T1) where log e W1: log of initial number of articles; log e W2: log of final number of articles after a specific period of interval; and T2 - T11: the unit difference between the initial time and the final time. [...] Analysis of overall collaboration in the field of m-Health was calculated using the following equation: Degree of collaboration = C = Nm / Nm + Ns where Nm = number of multi-authored papers and Ns = number of single-authored papers.” (Sweileh et al., 2017) Please note that we believe the writers of the paper above meant to write T2 - T1 instead of T2 - T11.

Replicability/Transparency

3.13 Provide sufficient detail in the bibliometric analysis manuscript to ensure full replicability/transparency of methods.

Explanation: Authors should provide a comprehensive and detailed breakdown of their methods to maximize replicability and transparency (Serghiou et al., 2021). Simply reporting methods within the paper is generally insufficient for full replication; therefore, whenever possible, links to data sources and/or code should be included (Colavizza et al., 2024). While the level of methodological detail may vary depending on the study, authors should aim to report enough information, including access to data and code, to enable independent replication, thereby setting a standard for openness and reproducibility in the field.

Example: "A comprehensive search was performed online using the English language databases Embase (15) and Scopus (16) on March 1, 2020, and simultaneously the Chinese databases Chinese Biomedical Database (SinoMed), CNKI, VIP and Wanfang were searched. The search terms were COVID-19, COVID 19, 2019-nCov, SARS-CoV-2, 2019 novel coronavirus, coronavirus disease 2019 and coronavirus disease-19. A detailed search strategy is presented in Supplementary Figure 1. The time period of publication was from 2019 to 1st March 2020. The search was performed on a single day to avoid bias caused by daily database updates. In the present study, only original articles and reviews published in either Chinese or English were included. The search

retrieved 721 or 143 items in Chinese or English, respectively, that met the inclusion criteria.” (Fan et al., 2020)

RESULTS

Results of Study

4.1 Describe the results and key findings.

Explanation: When possible, authors should provide a comprehensive list of the data gathered through their search strategy, along with the quantitative and qualitative results of the bibliometric analysis. This ensures research transparency, allowing readers to identify errors and variations in the data, assess the findings, and determine the study's credibility (Colavizza et al., 2024). Authors are also encouraged to summarize key findings, such as the most impactful and/or frequently cited studies, to enhance clarity. Such summaries can help readers easily identify the study's contributions, trends in the literature, and potential areas for future research (Conway et al., 2017). Providing supplementary materials and additional calculations is encouraged to support readers in their understanding of the results.

Example: "The counts of SRMA [Systematic review and meta-analyse] in various ophthalmological subspecialties were listed in Figure 4A. Retina/vitreous (n = 986), glaucoma (n = 411), cornea/external diseases (n = 303), cataract/anterior segment (n = 189), and pediatric ophthalmology/strabismus (n = 183) were top five represented subspecialties. Approximately half of SRMAs were published in ophthalmology journals in most subspecialties, with an exception of Oncology/Pathology and Neuro−ophthalmology/Orbit, where SRMAs were more frequently published in non-ophthalmology journals. Year wise publication in various subspecialties was shown in

Figure 4B. The number of publications in most subspecialties show a rising trend in general, especially after 2011. We then analyzed the proportion of different types of study content in major subspecialties. Treatment related SRMA accounted for about a half in each subspecialty, followed by those on epidemiology, genetics, and diagnosis. A Sankey plot revealed the relationship between subspecialties and various bibliometric properties." (Fu et al., 2023)

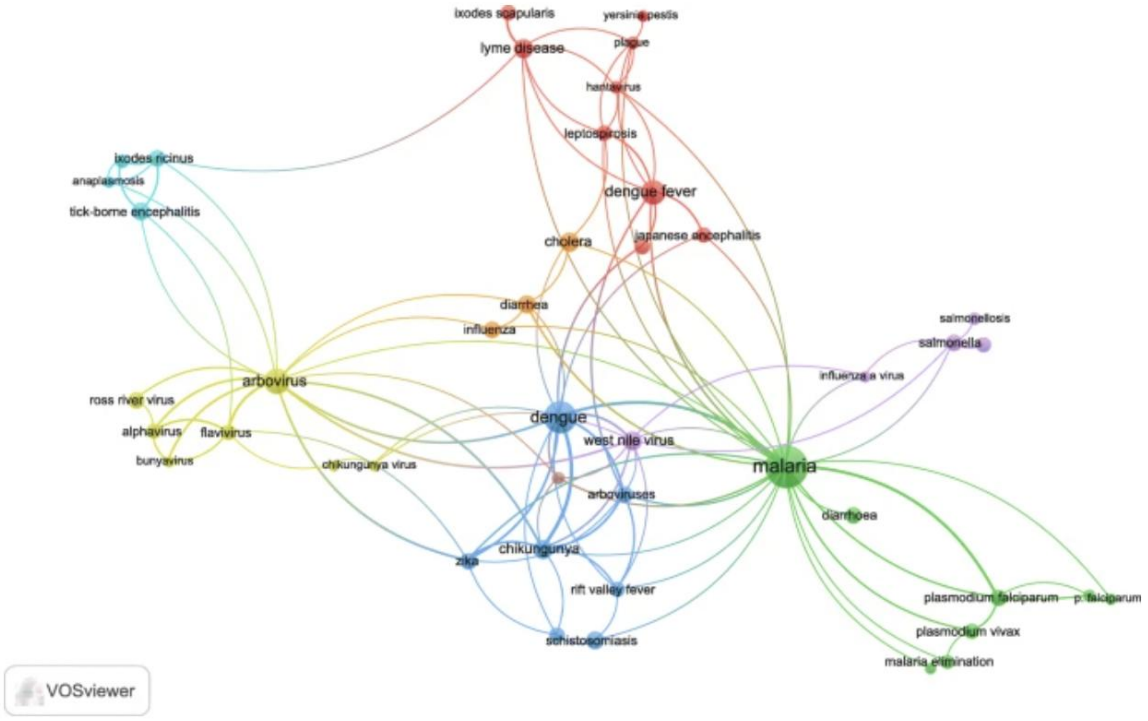
Results of Techniques

4.2 Describe the results of bibliometric analysis techniques used.

Explanation: Authors should provide a clear and detailed description of the results from each analytical technique used. Results can include quantitative results (e.g., percentages, counts) and qualitative outcomes (e.g., observed trends, emerging patterns) (Dixon-Woods et al., 2005). If multiple techniques were used, outlining each result can explain how these different perspectives support or contradict each other. Similar to the previous item, results should be completely reported, while key findings can be summarized to enhance clarity.

Example: “Analysis of author keywords in infection-related literature indicated that malaria (112 occurrences), dengue (76 occurrences), and arboviruses (arthropod-borne viruses) (33 occurrences) were the most frequent infectious diseases/pathogens encountered (Table 2 and Fig. 3). Infection-related literature included 32 documents that discussed climate change and emerging infectious diseases such as malaria, dengue, Chikungunya, Lyme disease, West Nile virus, zika virus, arboviruses, flavivirus, hantavirus, tick-borne encephalitis, bluetongue virus, Cryptosporidiosis, rift valley fever, alpha virus and others.” (Sweileh, 2020)

Fig. 3



Network visualization map of author keywords in documents in the infection-related literature. Node size represents frequency of occurrence of the keyword. Larger node size represents keywords that are most frequent in the retrieved literature. The map was created by VOSviewer

Figure from Sweileh (2020)

Tables/Graphs

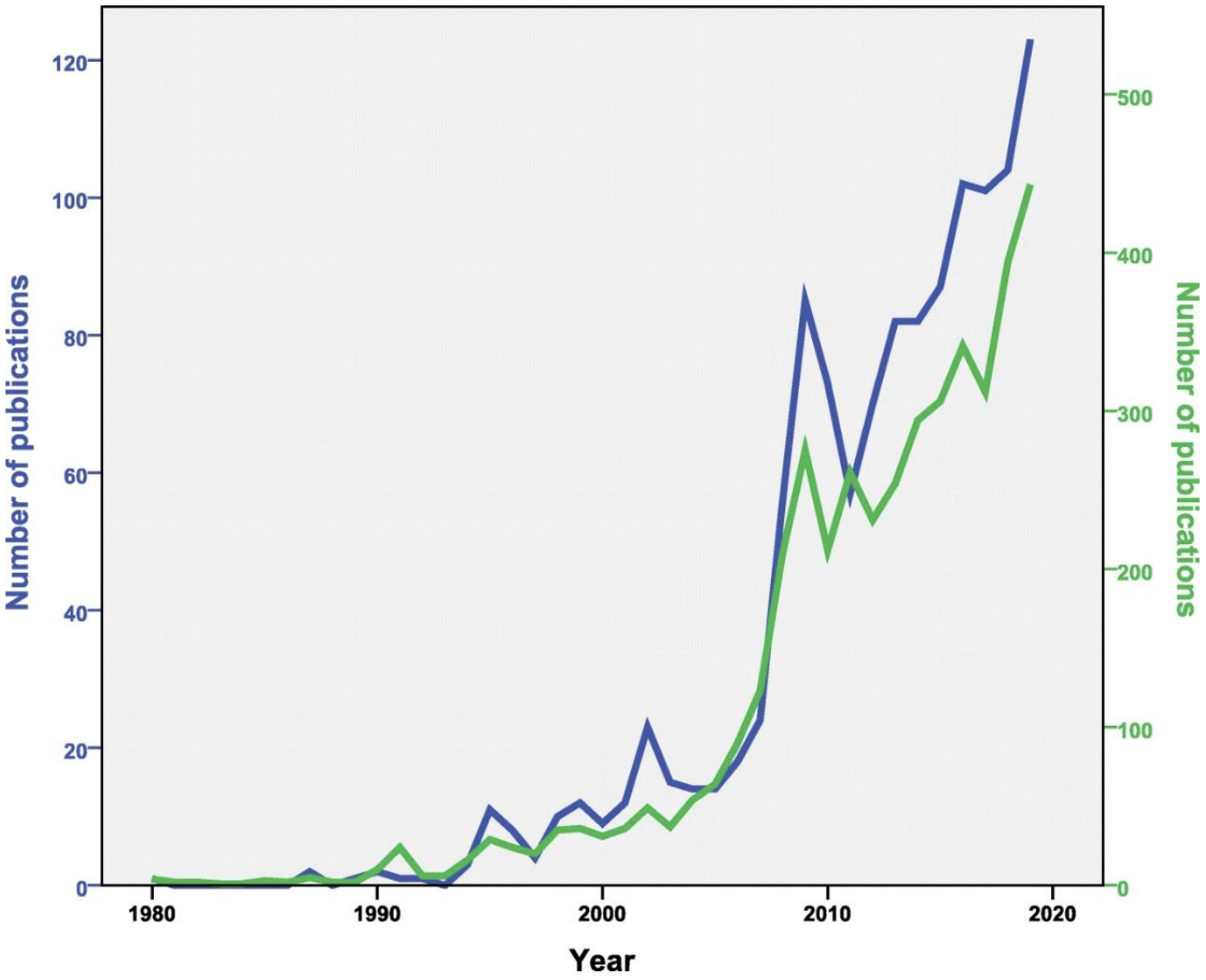
4.3 Ensure figures, tables and visualizations clarify and/or facilitate the interpretation of the results without misleading.

Explanation: Figures, tables, and visualizations (ranging from quantitative graphs to quantitative or qualitative diagrams) should facilitate the interpretation of results, with the addition of legends where applicable. They improve the clarity and comprehension speed of complex concepts, enhancing information communication (Eberhard, 2023). Diagrams should supplement data analysis and be as detailed as possible to aid in interpretation while ensuring easy comprehension of the results. Authors are encouraged to select the most appropriate format to summarize and display their data based on their research questions, methods, analyses, and/or data. They should ensure that their chosen table, graph, or visualization aligns with its intended use (e.g., using a scatter plot to describe correlation instead of a bar chart) to prevent confusion or inaccuracies in data representation (Eberhard, 2023). Additionally, the addition of colour in visualizations can reduce the time spent on understanding the visuals and can improve data comprehension (Eberhard, 2023). Diagrams should accurately reflect the results without modifying or omitting data, preventing readers from misunderstanding the results (Baker, 2016; Dwan et al., 2008). Patterns and characteristics of citation maps, such as clusters or distances, should be interpreted carefully, as they may result from the visualization algorithm (Venturini et al., 2021) or underlying base mappings (see Rafols et al., 2010), rather than the data itself.

Example 1:

Fig. 1

From: Bibliometric analysis of peer-reviewed literature on climate change and human health with an emphasis on infectious diseases



Annual growth of documents in the health- and infection-related literature (1980–2019). Green line represents the annual growth of documents in the health-related literature while the blue line represents the annual growth of documents in the infection-related literature. The graph was created by SPSS program using dual y-axis for comparative purposes.

Figure from Sweileh (2020)

Example 2:

Table 1 Types of documents on health- and infection-related literature (1980–2019)

From: Bibliometric analysis of peer-reviewed literature on climate change and human health with an emphasis on infectious diseases

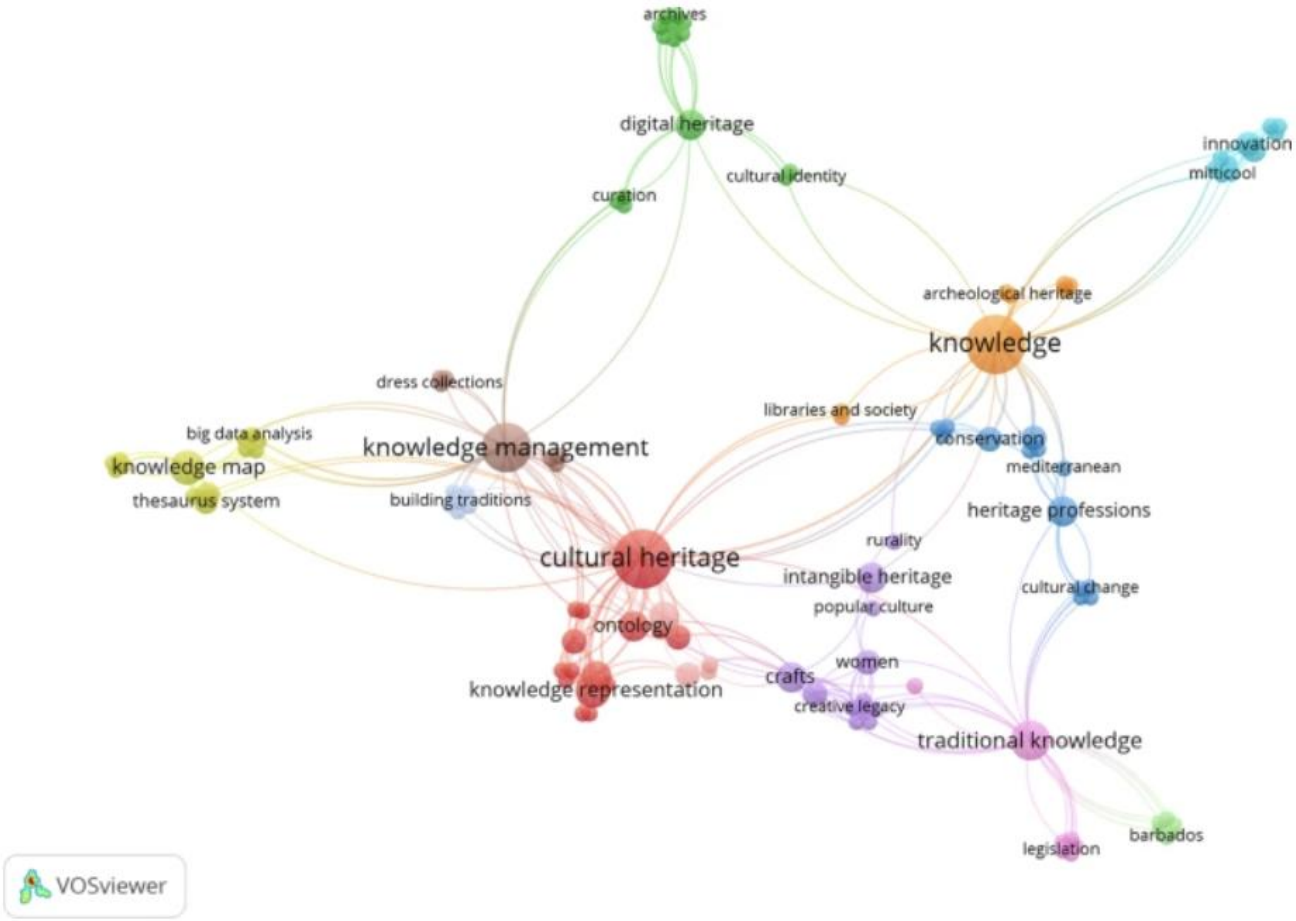
Health-related documents			Infection-related documents		
Type of document	**Frequency**	**%** ***N*** **= 4247**	**Type of document**	**Frequency**	**%** ***N*** **= 1207**
Article	2657	62.6	Article	821	68.0
Review	677	15.9	Review	225	18.6
Editorial	303	7.1	Note	44	3.6
Note	263	6.2	Editorial	37	3.1
Letter	204	4.8	Letter	32	2.7
Conference Paper	68	1.6	Conference Paper	26	2.2
Short Survey	67	1.6	Short Survey	21	1.7
Undefined[a]	8	0.2	Undefined	1	0.1

Infection-related documents: documents on climate change and infectious diseases
Health-related documents: documents on climate change and health
[a]Undefined documents represent documents that are not yet categorized by Scopus

Table from Sweileh (2020)

Example 3:

Fig. 6: Clusters of co-occurring keywords related to knowledge.



Note: VOSviewer co-occurrence analysis of 119 author keywords present in the articles containing terms referring to knowledge. Node size reflects the number of occurrences of keywords. Nodes are connected through links that mark the co-occurrence of their attendant keywords, while the thickness of links signals the frequency of co-occurrences between keywords (i.e., the more frequently they appear together in articles, the thicker the link between two keywords).

Figure from Vlase & Lähdesmäki (2023)

Report Error Values

4.4 If appropriate, report the uncertainty/dispersion/heterogeneity depending on the type of data and analysis, and error values of bibliometric indicators.

Explanation: When applicable, the dispersion or uncertainty of bibliometric indicators should be outlined, and error values should be provided. By detailing measures of uncertainty, authors allow readers to assess how robust and representative the reported indicators are. While we acknowledge that not all uncertainty measures (e.g., standard errors or p-values) may be appropriate if calculating bibliometric indicators based on the population instead of samples, authors should select the most suitable approach to convey this information effectively (Waltman, 2016).

Example: “Figure 1 displays the density distributions of log-transformed citation scores for the matched sets of papers with female first authors and male first authors (Sample 1), female last authors and male last authors (Sample 2), and female first and last authors and other gender combinations of first and last authors (Sample 3). For all distributions, the absolute uncertainty of the mean is between 0.001 and 0.005. On average, papers with female first authors are cited 8.7% less than papers with male first authors (Sample 1. Female first authors: n = 509,330; $\bar{x}$ = 1.16; σ = 1.83; $\tilde{x}$ =0.73. Male first authors: n = 509.335; $\bar{x}$ = 1.27; σ = 2.00; $\tilde{x}$ =0.76); however, the overlap between the two distributions is extensive (Cohen's d = −.06; Weitzman's Δ = 95.4%; Weitzman, 1970). Papers with female last authors are cited 6.5% less than papers with male last authors (Sample 2. Female last authors: n = 326,611; $\bar{x}$ = 1.16; σ = 1.93; $\tilde{x}$ =0.72. Male

first authors: n = 326,622; $\bar{x}$ = 1.24; σ = 1.93; $\tilde{x}$ =0.76); again, the overlap between the two distributions is extensive (Cohen's d = −.04; Weitzman's Δ = 95.6%). Finally, papers in which both the first and last authors are female are cited 12.6% less than papers with other gender combinations (Sample 3. Female first and last authors: n = 184,183; $\bar{x}$ = 1.11; σ = 1.75; $\tilde{x}$ =0.71. Other combinations: n = 184,191; $\bar{x}$ = 1.27; σ= 2.28; $\tilde{x}$ =0.76); again, the overlap between the two distributions is extensive (Cohen's d = −.08; Weitzman's Δ = 93.1%).” (Andersen et al., 2019)

DISCUSSION

Discuss Results

5.1 Summarize and discuss study findings.

Explanation: Authors are encouraged to include key quantitative (e.g., percentages, counts) and qualitative (e.g., observed trends, emerging patterns) summaries of the results in their bibliometric analyses, as well as the error values or limitations of their data. Reporting in the form of these summaries makes it easier for others to interpret the results and determine how they contribute to the research goal, without misinterpretation.

Example: “The present study aimed to construct the scientometric landscape of SRMA [systematic reviews and meta-analyses] publications in ophthalmology over the period 2000 to 2020. Our data revealed the annual output gradually increased in ophthalmology as a whole, and also in most ophthalmological subspecialties, particularly in the domains of retinal/vitreous, glaucoma and cornea/external disease. China and the United States were the most productive countries, whereas Singapore was the country having the most prolific and influential scholar and institution. International collaboration was intense among high-impact authors. Finally, we found that the rates of pre-registration and reporting guideline compliance in ophthalmology SRMAs have been steadily increasing since 2012, yet leaving room for improvement.

The number of published SRMAs in ophthalmology has substantially increased over the past two decades. The average annual growth rate of publication was 21.26%, approximately 5-fold greater than the growth of overall scientific publication (4.10%). We observed a striking 47-fold longitudinal increase of literature indexed in WoSCC from 2000 to 2020. The reasons for such increase are to be determined, but may in part attribute to the proliferation of SRMAs conducted by more researchers worldwide, especially those in China, as commonly seen in other medical specialties.

Geographically, around 70% of SRMAs in ophthalmology were published by scholars in top five productive countries (i.e., China, the United States, the United States, Australia, and Canada). Of note, China ranked first in output of articles, making China the most productive country on SRMA research in ophthalmology. In parallel, five out of top 10 productive affiliations were from China. Compared to rank 3rd of China in 2010, one can readily discern that China has experienced a rapid growth of production within the latest decade (2010–2020), exceeding any other countries. Similar findings were also observed in several other medical specialties than ophthalmology. However, increased research output in China did not lead to simultaneous increase in international collaboration and the academic influence, as explicitly indicated by low percentage of MCP (15%) and low average citation per publication. In terms of the impact of country-level, a noteworthy country is Singapore. It has the most productive institution, numerous high-yield and high-impact scholars, and a close network of collaborations among these scholars, altogether making outstanding contributions to the application of evidence-based medicine in ophthalmology.” (Fu et al., 2023)

Situate Results

5.2 Provide context for and situate the study findings in the literature.

Explanation: As authors are encouraged to contextualize their contribution to previous research (Item 2.1), they are encouraged to contextualize their findings within the framework of previous literature. This involves comparing their results with other studies to highlight similarities and differences or explain how their analysis complements or contradicts existing research (Sun & Linton, 2014). This contextualization is essential to help readers understand the study's significance, relevance to the field, and implications for new research (Sun & Linton, 2014).

Example 1: “Roughly 0.31% of all citances in our dataset are instances of disagreement, a share that has remained relatively stable over time. However, this number is much smaller than in past studies—such as the 2.4% for so-called “negative” references (Catalini et al., 2015), and the estimated 0.8% for “disputing” citations (Nicholson et al., 2021). This is explained by our operationalization of disagreement, which although conceptually broader than negative or disputing citations, is narrowed to only 23 queries to prioritize precision. Moreover, studies differ in corpus used, most often covering only one journal or field, compared to our large multidisciplinary corpus. The strength of our analysis is not the absolute incidence of disagreement, but its relative differences across disciplinary and social contexts.” (Lamers et al., 2021)

Strengths/Limitations

5.3 Discuss the strengths, limitations, and potential biases of the bibliometric analysis.

Explanation: Authors are expected to report the strengths, limitations, and potential biases of their bibliometric analyses. Doing so helps readers contextualize the findings and assess the credibility of the conclusions (Ioannidis, 2007) and may increase the usefulness of the research for other researchers (Sun & Linton, 2014). Authors should highlight the key strengths and limitations of how they have applied the methods within their study. They should also differentiate between the strengths and limitations of a methodological approach (e.g., considering a limited number of databases may result in a dataset that is not comprehensive or representative of the field) from those of bibliometric analyses themselves (e.g., bibliometric analyses cannot directly evaluate the quality of research and offer short-term perspectives on the growth of a research field) (Donthu et al., 2021). Additionally, biases, like overrepresenting specific groups (e.g., due to algorithm choices or indicators), should be transparently discussed to ensure accurate interpretations of the results (Thelwall et al., 2023).

Example 1: “Our study naturally has its limitations. We have focused our analysis on peer-reviewed journal articles, albeit many humanities scholars still consider monographs and edited volumes as the most respectable way of publishing research results. Furthermore, we limited our analysis to articles written in English or including a title, keywords, and/or abstract in English. Even though English is the contemporary lingua franca in academia, many non-English-speaking scholars in cultural heritage research want to publish their results in their mother tongue, particularly when

researching local, regional, or national case studies in order to serve the researched communities.” (Vlase & Lähdesmäki, 2023)

Example 2: “Several limitations of this study should be addressed. First, one should note that some studies might have actually been compliant with guidelines regardless of no mention of using any specific statements in their full texts. Conversely, studies that stated use of particular guidelines may not necessarily satisfy all specific domains of its statement.” (Fu et al., 2023)

Example 3: “The second limitation was the method for counting the number of documents for each country or author or institution. Scopus makes all analysis based on the number of different affiliations in the documents. Therefore, a document with several authors having the same country affiliation was counted once for that country. However, a document with two authors having two different country affiliations were counted once for each country. This has increased the research output of certain countries with greater international research collaboration even if the authors from that country was [sic] not the main or corresponding author. The citation analysis did not take into consideration the self-citations which could create a bias in the number of citations for countries, journals, and authors. Finally, the search query was built to focus on climate change and human health. The definition and scope of human health and climate change are broad and complex. Therefore, it is difficult to ensure a 100% inclusion of literature on both topics.” (Sweileh, 2020)

OTHER

References

6.1 Use references to support statements and methods used.

Explanation: References play a key role in signifying the quality and reliability of a study, as they outline the sources referenced in a paper and its connections to other research. Beyond typical referencing standards, authors of bibliometric analyses are encouraged to reference the software tools and datasets they used in their methodology. References to these resources provide transparency about the tools that facilitated the analysis, allowing readers to validate the study (Divecha et al., 2023). Moreover, authors need to consistently use a referencing style (e.g., APA: *American Psychological Association (APA)*, n.d.) that aligns with the selected publication venue.

Example: “Climate change refers to long-term statistical shifts of the earth’s climate system that result in new climate patterns [1]. Over the past century, industrial activities have led to long-term changes in the climate system that included global warming, flooding, and drought [2].

1. United Nations Framework Convention on Climate Change (UNFCC): Fact sheet: Climate change science - the status of climate change science today [https://unfccc.int/files/press/backgrounders/application/pdf/press_factsh_science.pdf]. Accessed 15 Apr 2020.

2. Khazalah M, Gopalan B. Climate Change—Causes, Impacts, Mitigation: A Review. In: Global Civil Engineering Conference: 2017. Malaysia: Springer; 2017. p. 715–21.” (Sweileh, 2020)

Data Availability

6.2 Describe the availability and accessibility of data by providing a statement about whether study materials, data, and/or code are shared, and if so, where and how it can be accessed.

Explanation: In bibliometric analyses, making study materials, data, and code accessible enhances the transparency, credibility, and reproducibility of studies. Accessible data allows readers to validate findings and replicate methods, while also supporting future research and collaboration by enabling others to build upon the work (Colavizza et al., 2020). Study materials include search strategies, while data involve both raw and processed forms. Code includes scripts used for visualization or analysis in software tools such as VOSviewer (van Eck & Waltman, 2010) or Python (*Python.Org*, n.d.).

Following the FAIR Guiding Principles (Wilkinson et al., 2016), authors should ensure that their data is findable (e.g., through unique identifiers or indexing), accessible and retrievable, interoperable (via standardized formats and references), and reusable (with proper licensing, clear provenance, and high-quality documentation). Additionally, authors should specify the platform where materials, data, or code are stored, such as Zenodo or the Open Science Framework, and include a unique identifier (e.g., DOI), citation details in the reference list, and hyperlinks to improve accessibility (Colavizza et al., 2020). However, we recognize that it is not always feasible to share the full raw data, particularly when working with proprietary bibliometric sources. In such cases,

authors should clearly disclose these limitations. Similarly, if no data, materials, or code were generated during the study, this should be explicitly stated to maintain transparency and clarify the scope and reproducibility of the research.

Example 1: “The data analyzed in this study is subject to the following licenses/restrictions: Original data were sourced where indicated from the Web of Science, which is accessible to academic researchers in the United Kingdom under licence from the Joint Information Services Committee and in other countries through separate licensing agreements. Requests to access these datasets should be directed to https://clarivate.com/webofsciencegroup/solutions/web-of-science/contact-us/.” (Szomszor et al., 2021)

Example 2: “In this study, we were fortunate to have access to the Editorial Manager’s internal report system; we also had permission from Springer to use those [sic] data. Notwithstanding this access and permission, we currently do not have standing, guaranteed, real-time access to our own data—data that are generated by our readers and editors. This lack of access is a policy hurdle, not a technical hurdle.” (Maggio et al., 2022)

Example 3: “The cleaned and anonymized survey data is published in the Zenodo repository under a CC-BY 4.0 license. A citation to the data set is listed in the reference list.” (Gregory et al., 2024)

Conflict of Interest, Support

6.3 Disclose any existing or potential conflicts of interest and/or sources of financial or non-financial support.

Explanation: Authors should detail all sources of financial support (e.g., funding for the purchase of bibliometric software or data) and non-financial support (e.g., a librarian or organization providing access to an internal database not publicly accessible) involved in conducting and reporting their bibliometric analyses. The extent of funder(s) involvement, such as in study design, data analysis, or reporting, should be clearly explained. If no external funding or support was involved, this should also be explicitly stated. This level of transparency enables readers to evaluate any potential impact of the funder(s) on the study, such as biased influences on the paper or altering its research goals (Álvarez-Bornstein & Bordons, 2021). Any restrictions imposed by funders, such as limiting access to data or influencing the interpretation of results, should also be disclosed, as such limitations may impact the objectivity of the study and compromise academic freedom (ICMJE, 2025).

Authors should also declare any real or perceived conflicts of interest, such as if an author is affiliated with a database provider included in the analysis. If no conflicts exist, a clear statement should be provided. Perceived conflicts of interest can be just as significant as actual ones in shaping the trust of readers and the broader scientific community. Even if a relationship or activity does not directly affect the study's outcomes, failing to disclose it may lead to skepticism and diminish the perceived

credibility of the research (ICMJE, 2025). This helps readers assess the reliability and credibility of the study's conclusions (Álvarez-Bornstein & Bordons, 2021).

Example 1:

"Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest." (Haustein et al., 2020)

Example 2:

"Funding

Toby Pillinger is supported by the National Institute for Health Research (NIHR) and Maudsley Charity.

Conflict of interest

Christoph U. Correll has been a consultant and/or advisor to or has received honoraria from AbbVie, Acadia, Alkermes, Allergan, Angelini, Aristo, Axsome, Damitsa, Gedeon Richter, Hikma, Holmusk, IntraCellular Therapies, Janssen/J&J, Karuna, LB Pharma, Lundbeck, MedAvante-ProPhase, MedInCell, Medscape, Merck, Mitsubishi Tanabe Pharma, Mylan, Neurocrine, Noven, Otsuka, Pfizer, Recordati, Relmada, Rovi, Seqirus, Servier, SK Life Science, Sumitomo Dainippon, Sunovion, Supernus, Takeda, Teva, and Viatris. He provided expert testimony for Janssen and Otsuka. He served on a Data Safety Monitoring Board for Lundbeck, Relmada, Rovi, and Teva. He has received grant

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Heidi Taipale reports personal fees from Janssen-Cilag and Otsuka.fan

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Stefan Kaiser received royalties for cognitive tests and training software from Schuhfried.

Toby Pillinger has participated in educational speaker meetings organized by Lundbeck, Otsuka, Sunovion, Schwabe Pharma and Recordati.

Chaomei Chen and Michel Sabe report no conflicts of interest.” (Sabe et al., 2022)

Additional Considerations

The GLOBAL and this E&E document primarily focus on the reporting of bibliometric analyses in scholarly literature. However, a bibliometric analysis may be one part of a broader study, such as systematic reviews (Rojas-Sánchez et al., 2023). Bibliometric reports may vary in methodology, particularly in areas like data collection and analysis, which may entail different reporting requirements. Moreover, while the current focus of the GLOBAL is on academic-style reporting, such as journal articles or conference papers, it may also apply to other formats commonly used by researchers, librarians, governments, and institutions. Similarly, other ‘metrics’ related to bibliometrics, such as scientometrics, webometrics, and altmetrics, were not considered when creating this guideline but may still be reported as prescribed by the GLOBAL. Further refining the checklist or developing extensions of the GLOBAL for formats or ‘metrics’ that differ significantly may be valuable.

Discussion and Conclusion

The GLOBAL is a 28-item guideline aimed at ensuring more thorough and transparent reporting of bibliometric analyses. The current E&E document is intended to support the understanding, adoption, and dissemination of the GLOBAL by offering a minimal framework for reporting bibliometric analyses. It follows a format similar to other E&E documents (Grant et al., 2018; Page et al., 2021; Logullo et al., 2024).

We believe the evidence-based approach used to develop the GLOBAL, including a scoping review and a two-round Delphi process, will ensure its effectiveness and practical value in promoting transparent reporting of bibliometric analyses. Additionally, we envision the GLOBAL to be a catalyst for generating evidence that could inform revisions of the checklist. For example, researchers could explore facilitators and barriers to the use of the GLOBAL in practice, develop interventions to address them, and evaluate their effectiveness through randomized trials. Think-aloud studies on the GLOBAL could also help identify how items are interpreted, while reliability (or consistency) studies could determine where the items are interpreted differently (Charters, 2003). These approaches could lead to more focused revisions, resulting in a more robust and impactful guideline for reporting bibliometric analyses.

We plan to disseminate the GLOBAL widely, targeting the bibliometrics and reporting guideline communities, journal editors and editorial boards, scholarly communication librarians, research managers conducting bibliometric analyses, and publishers and related organizations. We further encourage journal editors and publishers to promote

the GLOBAL (e.g., by mentioning it in their journal's “Instructions to Authors” page), endorse its use, advise editors and peer reviewers to assess submitted bibliometric analyses against the GLOBAL, and make adjustments to journal policies to take into account the new reporting recommendations. Additionally, we encourage multiple translations of the GLOBAL, which will further enhance the guideline’s accessibility.

As the bibliometrics field continues to evolve, the GLOBAL, as well as this supplementary E&E document, will require continuous updates to stay relevant to the best practices and trends for bibliometric analyses. We therefore consider it the first version of a living document.

List of Abbreviations

E&E: Explanation and Elaboration

EQUATOR: Enhancing the QUAlity and Transparency Of health Research

GLOBAL: Guidance List for the repOrting of Bibliometric AnaLyses

Declarations

Ethics Approval and Consent to Participate

Research ethics approval was obtained by the Ottawa Health Science Network Research Ethics Board (REB ID #20230527-01H). The final protocol was registered on January 12, 2023, on the Open Science Framework (OSF) at https://osf.io/nvu6w (Ng et al., 2023).

Consent for Publication

All authors consent to this manuscript's publication.

Availability of Data and Materials

All relevant data are included in this manuscript or posted on the Open Science Framework: https://doi.org/10.17605/OSF.IO/MTXBF (Ng et al., 2024).

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

JYN: designed and conceptualized the study, collected and analysed data, co-drafted the manuscript, and gave final approval of the version to be published.

NS: collected and analysed data, co-drafted the manuscript.

DZ: collected and analysed data, co-drafted the manuscript.

MM: assisted with data collection and analysis.

HL: assisted with data collection and analysis.

MSabé: provided input for the design and methodology, made critical revisions to the manuscript, and gave final approval of the version to be published.

MSolmi: provided input for the design and methodology, made critical revisions to the manuscript, and gave final approval of the version to be published.

DS: provided input for the design and methodology, assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

JPA: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

LB: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

RC: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

MG: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

WG: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

SHinze: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

CN: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

NRG: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

AS: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

GS: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

SS: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

TVL: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

VW: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

SW: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

EY: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

AZ: assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

DM: designed and conceptualized the study, assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

LW: provided input for the design and methodology, assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

SHaustein: designed and conceptualized the study, assisted with the collection and analysis of data, made critical revisions to the manuscript, and gave final approval of the version to be published.

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