

Evolution of Scientific Publishing: From Ancient Manuscripts to Digital Platforms

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ABSTRACT

Introduction: Scientific publishing has evolved significantly and is shaped by technological advancements, societal changes, and global challenges. The dissemination of knowledge has expanded dramatically from ancient manuscripts to digital platforms, thereby enhancing collaboration and accessibility. This review explores the history of scientific publishing, ethical and technological challenges, and future directions for global research.

Methods: This review utilized a comprehensive search strategy across databases, such as PubMed, Scopus, and Web of Science. Keywords related to evolution, ethical challenges, and technological advancements in scientific publishing were used in this study. Peer-reviewed articles published since 1990 were screened using predefined eligibility criteria. A thematic synthesis categorized findings into historical milestones, technological innovations, and ethical considerations, ensuring rigor through the Critical Appraisal Skills Program checklist and visual representation via a Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram.

Results: This review highlights the transition in scientific publishing from oral traditions to the digital era. Key milestones include the invention of the printing press, emergence of peer-reviewed journals, and growth of open-access publishing. Challenges such as regional biases, predatory journals, commercialization, and ethical dilemmas have been identified. Technological advancements, such as artificial intelligence (AI) and blockchain, have improved transparency and efficiency, but pose new risks. The COVID-19 pandemic has underscored the need for rapid dissemination, while exposing gaps in current systems.

Conclusion: Scientific publishing continues to evolve, balancing technological innovation with ethical practice. Addressing biases, fostering inclusivity, and adapting to generational needs, such as video-based dissemination, are crucial for maintaining relevance and credibility. Open science initiatives and citizen engagement offer promising avenues for global knowledge sharing.

Keywords: Ethical challenges, Knowledge dissemination, Open access, Scientific publishing evolution, Technological advancements.

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INTRODUCTION

Today, scientific publishing is regarded as a neutral and objective mechanism for disseminating research. However, its evolution has been influenced by various sociocultural, economic, and political factors. From early oral traditions and handwritten manuscripts to the print era and current digital age, scientific communication has undergone significant changes. Initially, scientific literature was composed of self-published books or letters shared among intellectuals and often circulated privately within exclusive groups. These early writings, passed through scholarly networks, established the foundation of modern scientific publishing systems.¹ Over time, communication methods have evolved in tandem with societal changes from handwritten manuscripts to today's extensive digital archives. The evolution of research and publication methods has been closely tied to advances in technology, societal needs, and academic collaboration. From ancient oral traditions to the digital age, research communication has significantly transformed, allowing for the faster and wider dissemination of knowledge.² Although scientific publishing is fundamentally about sharing knowledge, ideas, and discoveries, the platforms and audiences for this communication have shifted dramatically.

Understanding the history of scientific publishing provides valuable insights into the dynamics of knowledge production and dissemination, highlighting important lessons for global scientific communication.

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This review provides a narrative overview of the transformation of research and publication methods with a focus on technological, societal, and ethical impacts, and examines future directions of research dissemination.

METHODS

The eligibility criteria for the review were carefully defined, focusing specifically on articles that addressed the history of research and publication, technological innovation, and ethical considerations.

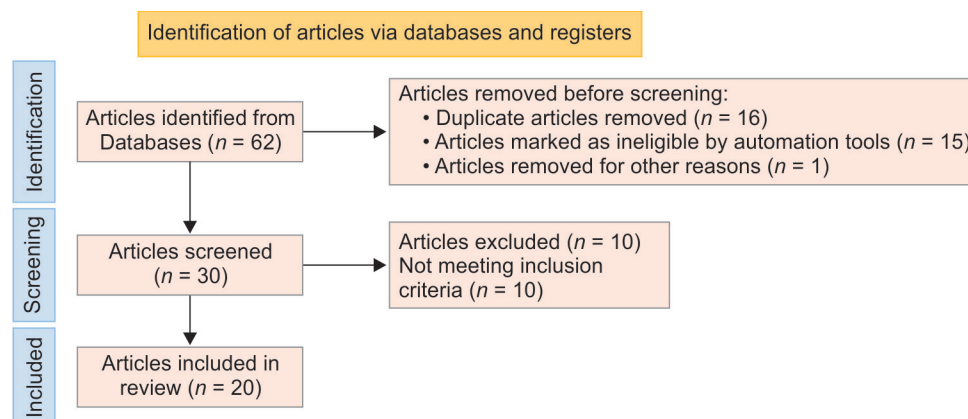


Fig. 1: PRISMA flowchart

Articles that did not relate to these core themes or lacked scholarly rigor were excluded from the analysis. To gather relevant literature, a variety of information sources were utilized, including PubMed, Scopus, Web of Science, and Google Scholar. Additionally, reference lists of the included articles were reviewed to identify further pertinent studies.

To conduct a thorough search, a comprehensive strategy was employed using keywords such as “evolution of scientific publishing,” “scientific publication,” “open access (OA),” “ethical challenges in research,” “technological innovations,” “Course of Scientific Publishing,” “challenges to scientific publication,” and “Scientific Databases” with Boolean operators (AND, OR) to combine terms, adjusting to each database’s indexing system. Filters were applied to ensure that only peer-reviewed articles published from 1990 onward were considered. The selection process involved the independent screening of titles and abstracts by two authors, followed by a thorough assessment of the full texts of eligible articles. Any disagreements were resolved through discussion to ensure a consensus.

During the data extraction, the focus was on publication timelines, technological advancements, and key ethical considerations. The resulting data synthesis categorizes information into thematic areas, including historical milestones, technological advancements, and ethical challenges. This thematic analysis allowed the identification of patterns, trends, and gaps in the literature. To ensure reliability and validity of the findings, the quality of the included studies was assessed using the Critical Appraisal Skills Program checklist. Finally, the study selection process was visually represented in a Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram that outlined the number of articles that were identified, screened, excluded, and ultimately included in the study (Fig. 1). In total, 62 articles were initially screened, and after applying the inclusion and exclusion criteria, 20 articles were selected.

RESULTS

Humans have engaged in research and knowledge sharing since early times, as evidenced by cave drawings, primitive writings, and seals. In particular, Indian culture holds a rich tradition of scientific wisdom, as seen in ancient texts such as the Vedas, Vedangas, Puranas, Nyaya, Mimamsa, and Dharmashastra. The Vedas—Rigveda, Yajurveda, Atharvaveda, and Samaveda—are

among the oldest scriptures, dating back to over 3,000 years.² These texts reflect an early understanding of science, wisdom, and culture, with Rigveda being the oldest and composed of 10 books or mandalas. These early writings, transcribed by disciples and scholars, have laid the groundwork for future scientific literature.³ The term “author” originates from the Latin word *auctor*, meaning “creator,” while “journal” was derived from the French word *journal*, meaning “day.” Initially, journals referred to daily records or logs that later evolved into periodicals. The word “science” comes from the Latin word *scientia*, meaning “knowledge.” By the 19th century, the term “scientist” replaced the term “natural philosopher,” which was first used in 1834.

Before the 20th century, scientific publishing was limited and financially lucrative, with many prominent scientists publishing infrequently and often refraining from signing their names.² For instance, Andreas Vesalius, a famous anatomist, was embroiled in a scandal in 1564, where he faced accusations after performing a dissection on a nobleman. Johann Gutenberg’s invention of the movable printing press in 1452 significantly advanced text production, initially dominated by religious works.

By the late 17th century, scientific journals emerged, with *Le Journal des Sçavans* (France) and *Philosophical Transactions* (England) becoming two of the first. In 1896, following Wilhelm Roentgen’s discovery of X-rays, the first radiology journal, *Archives of Clinical Skiagraphy*, was launched. Peer-reviewed journals expanded rapidly throughout the 19th and 20th centuries, with the number of medical journals growing due to influences from peer review practices in the Islamic world, as exemplified by Ishaq Bin Ali Al-Rahawi’s 9th-century work on medical ethics.⁴ By the 18th century, peer review had become a key component of scientific publishing, particularly in the medical field, with journals such as the *Edinburgh Medical Journal* (1733) setting an early precedent.³ Despite wars and political upheaval, the number of scientific publications continued to grow, especially during the world wars and pandemics of the 20th century. The rise of scientific journals represents a fundamental shift in the communication of knowledge, emphasizing collaboration within academic and professional communities.⁵

In 1971, Michael Hart’s Project Gutenberg began the first digitization project, transforming the *Declaration of Independence* into the first free online text.⁶ By the late 20th century, digital books and journals proliferated alongside the expansion of the World Wide Web, allowing for quicker dissemination, easier storage, real-time updates, and enhanced collaboration.⁷ In 2010, Encyclopedia

Britannica ceased print editions after 244 years. Digital-only and hybrid models have emerged, with search engines, such as Google Scholar and Scopus, making citation and data metrics more transparent.^{8,9}

Open access emerged as a revolutionary force in scientific publishing, making research freely available.¹⁰ From 2000 to 2010, OA journals grew by 18%, with a 30% increase in the number of published articles. However, OA's success has also spurred the rise of predatory publishers using deceptive practices. Sci-Hub, founded in 2011, challenged traditional publishing by providing free access to research behind paywalls, prompting debates on the sustainability of the current publishing model.¹¹ Open science initiatives are increasingly gaining traction and are crucial for accelerating research progress as they emphasize the principles of transparency, data sharing, and collaboration among researchers. Additionally, citizen science initiatives play a vital role in expanding the scope of research by actively engaging the public in data-collection efforts. This engagement bridges the gap between science and society by fostering a collaborative environment in which scientific inquiry benefits from diverse perspectives and contributions.

The peer review process has evolved from traditional single-blind reviews to more transparent models such as double-blind and open-peer reviews. Artificial intelligence (AI) tools are now being integrated to streamline peer reviews and identify errors, although concerns about privacy and bias remain.¹²

Ethical challenges, such as predatory journals and data commercialization, threaten the integrity of research dissemination. Ensuring ethical practices and robust regulatory frameworks are essential for maintaining credibility in academic publishing.

Historically, male researchers have dominated publications; however, gender parity has improved. However, regional disparities persist, with researchers from low-income countries facing significant barriers to publication. Efforts to promote OA and inclusivity address these inequities.¹³ Scientific publishing is influenced by cultural and social contexts. For example, the *New England Journal of Medicine* initially supported Nazi medical policies, later revising its stance after the 1964 Helsinki Declaration.^{14,15} In Colombia, Rodolphe Meyer de Schauensee's work on bird species led to globally recognized publications despite financial constraints. Gender disparities persist in fields such as Physics and Computer Science, although growing female representation in academia has led to greater publication parity in other fields, such as psychology.¹⁶

English is the preferred language for scientific publications, but this has led to the neglect of the rich scientific contributions made by non-English-speaking scientists. Germany has suffered the most, partly due to politics but primarily because of language barriers. Prof. Edgar Biemer from Berlin, who, while delivering an oration in India, lamented that English-speaking doctors have often, either out of ignorance or intent, presented ideas that were already published in German journals decades ago. With digitization today, translation is no longer an issue.

The COVID-19 pandemic has led to a surge in scientific papers, as rapid research has focused on prevention, treatment, and the effects of the virus. This was facilitated by fast-track peer review, publication waivers, and free access to articles. The pandemic also accelerated the use of preprints, allowing for quicker dissemination of research findings. Post pandemic, publication rates have continued to grow exponentially, aided by AI tools that enable quicker data analysis and manuscript creation.¹⁷⁻¹⁹

The commercialization of research data, or "data capitalism," has led to concerns regarding the commodification of scientific knowledge. Publishers profit from the data collected through article downloads, citations, and user behavior. While commercialization has spurred growth, it has also led to inequities, particularly regarding authorship and career advancement.²⁰ The pressure to publish in high-impact journals has contributed to plagiarism and questionable research practice. Tools such as iThenticate help manage plagiarism, but emphasis on publication metrics often compromises research integrity.²¹

PubMed, launched in 1971 by the US National Library of Medicine, has revolutionized access to biomedical literature. Initially made available through institutional facilities, PubMed became fully accessible to the public in 1997. Currently, PubMed holds over 37 million citations, with millions of searches conducted daily. The database adhered to strict protocols for journal selection and indexing, ensuring the accuracy of its content.

There is a clear bias against journals published in developing countries, but this does not imply that we should disregard the treatment of populations facing unique challenges. These challenges include different disease profiles, stages of detection, rehabilitation priorities, and issues such as limited insurance coverage and compromised access to advanced treatment. However, this does not mean that we should stop treating these populations nor does it suggest that we should avoid documenting the treatments provided. The documentation of treatment in such settings is essential, even if it does not meet the rigorous standards of Western journals, as they contribute valuable insights into healthcare delivery in resource-limited settings. Therefore, standards for publication should recognize and respect the diverse realities of healthcare systems globally.

Similarly, there is bias in traditional medicine. Western journals have set rigid standards and indices to which all scientists must adhere for international recognition. However, traditional medical systems, such as Ayurveda, Chinese medicine, Unani (ancient Greek), and Arabic medicine, which remain widely practiced in many parts of the world owing to affordability and cultural familiarity, effectively address healthcare needs. However, they lack opportunities for dissemination and cross-pollination, which is comparable to modern medical practices.

Journals must evolve to keep pace with changing generations. The Gen-Z audience lacks the attention span for reading long articles and often does not possess patience or inclination to fully extract their value. They require a different style of presentation, and perhaps a video journal. Visual depictions leave a lasting impression and enable students to carry key insights from the video directly into their practice. Currently, journals face serious competition from platforms such as YouTube, which, despite being biased and lacking peer review, is far more appealing to Gen-Z audiences. To remain relevant, journals must acknowledge this shift and adapt it accordingly.

Blockchain technology has the potential to significantly enhance transparency in various aspects of the research process, including authorship verification, data provenance, and peer review. The integration of AI into scientific research has transformed how researchers handle large datasets, perform complex computations, and generate new research questions. While AI facilitates improved research communication, it also poses challenges such as the risk of misuse and threats to the integrity of publishing. Artificial intelligence tools have become instrumental in assisting researchers with tasks such as writing and translation, thereby increasing the

accessibility for non-English speakers. However, the adoption of AI carries risks, including the potential propagation of biases, misinformation, and plagiarism. To maximize the benefits of AI in research, it is essential for researchers to adhere to ethical practices and ensure access to necessary computational resources.

CONCLUSION

The history of scientific publishing has evolved along with technological advancements, societal changes, and global challenges. From ancient manuscripts to digital and open-access publishing, scientific communication has expanded, enabling rapid knowledge dissemination. However, challenges such as data commercialization, predatory publishing, and ethical concerns regarding AI remain. The COVID-19 pandemic has highlighted the need for timely information sharing, revealing the strengths and weaknesses of publishing models. Addressing these challenges while promoting transparency, ethics, and inclusivity will shape global knowledge dissemination.

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