



Research design and writing of scholarly articles: new artificial intelligence tools available for researchers

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Recent advances in artificial intelligence (AI) have introduced transformative capabilities that are revolutionizing the process of scientific research and communication. AI tools can assist researchers in designing studies, analyzing data, and drafting manuscripts, enhancing both efficiency and analytical rigor. This allows researchers to focus cognitive resources on higher-level conceptualization and interpretation. Furthermore, AI holds promise for steering research towards more impactful directions by aiding in the identification of critical knowledge gaps and research questions with potential societal benefits. Collaboration platforms powered by AI facilitate connections between researchers across domains and institutions, accelerating discovery and promoting convergence around global health priorities. However, responsible development and application of AI in research is essential. Transparency, explainability, data privacy, and human oversight must remain priorities to ensure ethical AI practices. While AI offers transformative capabilities, researchers must maintain agency and responsibility over the scientific process. With thoughtful governance and participatory design, AI can become a powerful tool for advancing science in the service of society. Overall, AI ushers in new potentials for improving the rigor, relevance, and reach of scientific inquiry. Yet realization of this potential necessitates proactive efforts to address emerging risks and challenges.

Keywords AI · Research tools · Medical writing · Academic research

Introduction

The scientific landscape is undergoing a profound evolution driven by the advent of artificial intelligence (AI) tools. While concerns about potential AI misuse are valid, it remains essential to explore its multifaceted benefits for scientific workflows. Recent debate within the scientific community [1–4] highlights potential risks associated with AI tools, such as ChatGPT. These concerns encompass the potential for increased scientific fraud and the dissemination of “fake science” [5, 6]. Additionally, some researchers express anxieties about losing essential skills in traditional writing and source evaluation due to overreliance on AI [7].

There is also a fear that this could lead to cultural impoverishment [8].

Where do we stand after just more than a year since the commercial large-scale launch of ChatGPT? [9, 10] While ethical issues surrounding AI, such as bias, transparency, accountability, and privacy, are undeniably rational and should not be overlooked, they need to be addressed in a suitable manner [11]. This view point aims to highlight how generative AI, a subset of AI capable of generating novel content or predictions based on existing data, represents a significant shift that will inevitably impact various aspects of how we design and write scientific articles in the medical field. Our task is to harness this system effectively rather than prohibit or demonize it [12].

AI holds the potential to fundamentally transform the traditional scientific process, which primarily relies on an ‘analog approach’ in its methodology. This process involves conducting background research on a rational idea, formulating a hypothesis, testing it through trials or experimental observational studies, analyzing the collected data, drawing a conclusion, and ultimately writing and communicating the results to the scientific community and beyond. An impressive array of

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AI-derived tools has been generated that can assist researchers in eliminating a series of time-consuming manual tasks, thereby accelerating and primarily simplifying the steps of the procedure that are currently carried out manually. Simultaneously, those involved in disseminating science, such as editors, communicators, and mass media, can benefit from what AI currently offers [13–16].

AI driven literature review

A comprehensive literature review remains the cornerstone of thorough research articles. Traditionally, researchers have relied on established search databases such as PubMed, Google Scholar, Scopus, and the Web of Science [17]. While valuable, these tools struggle with purely *quantitative analysis* and necessitate the manual selection of relevant articles. AI-powered algorithms address these limitations, shifting the focus from quantitative toward *qualitative analysis* and uncovering hidden valuable insights from vast amounts of data.

These advanced tools are effective at identifying manuscripts directly relevant to a specific research topic, regardless of their journal impact factor. They further facilitate the extraction of specific details (e.g., number of patients included in a study, characteristics of the studied population), and the identification of manuscripts using unique methodologies, like distinguishing between NGS and Sanger analysis [18] from many publications. This offers an unprecedented opportunity to rapidly identify key elements in experimental research, fundamentally transforming the literature review process.

Large Language Models (LLMs) like ChatGPT show potential for formulating search queries, but further research is needed to demonstrate its performance relative to other tools. The introduction of GPT-4 [19] and the integration of plugins have significantly expanded ChatGPT's capabilities and versatility.

ChatGPT has been proven to be promising in automating parts of the PRISMA [20] process, a well-defined framework used in systematic reviews, thereby increasing the proportional representation of papers in these reviews. Additionally, it demonstrates potential for generating effective boolean queries, which is crucial for the systematic review creation process. As AI technologies mature, the transformative potential of LLMs in systematic reviews and broader research domains is likely to expand.

Beyond ChatGPT, other AI tools, such as Elicit [21] and Research Rabbit [22] leverage natural language processing (NLP) algorithms to accelerate the literature reviews. These tools automatically extract key phrases, sentences, and paragraphs from research papers, significantly reducing the time spent on manual searches.

Benefits of AI-powered literature reviews

- *Quickness and efficiency*: traditional literature reviews could be time-consuming, requiring weeks or months of meticulous effort. AI tools revolutionize this process by swiftly processing and analyzing vast amounts of data in seconds or minutes, significantly reducing time commitments.
- *Widespread analysis*: AI tools possess the unparalleled ability to scan and dissect millions of research articles, ensuring that no pertinent piece of literature is overlooked. Their expansive reach transcends the boundaries of a single discipline, allowing researchers to uncover relevant articles from diverse fields, fostering a more holistic perspective.
- *Improved keyword and semantic search*: AI tools move beyond the limitations of traditional keyword searches by comprehending the context in which words are employed. This semantic understanding results in more accurate and pertinent results, ensuring that the literature review captures the essence of the research topic. Additionally, AI tools can identify and integrate results that utilize different terminology but address the same subject matter, broadening the scope and depth of the literature review.

Beyond Elicit and Research Rabbit, the landscape of AI-powered literature review tools is rapidly expanding.

While a comprehensive table is included for reference [see Table 1], it's important to note that new tools are constantly emerging, each offering unique functionalities and focusing on specific aspects of the literature review process. This dynamic environment fosters healthy competition and continuous improvement within the field.

Automated data analysis

Data analysis, the core of any scientific research, has undergone a profound transformation due to the rise of AI. Powerful tools like Python libraries (Pandas, NumPy) and R packages empower researchers to efficiently manage and analyze complex datasets, unlocking deeper insights. Choosing the right tool depends on the specific dataset and research goals: Python libraries are effective in data manipulation, while R packages often hold the advantage in statistical analysis.

Effective data visualization is paramount for clear communication and accessibility. AI-powered tools transform complex data into compelling visuals (graphs, charts and maps) using libraries like Matplotlib, Seaborn (Python), or ggplot2 (R) [23]. These visualizations effectively highlight key findings, fostering understanding and engagement with

Table 1 Table review: AI-powered research tools and AI for academic research

Activity type	Product/service Name	Free, freemium or paid	Privacy terms and conditions	Description
1. Writing assistance, bibliographic research and collaborative writing tools				
Writing assistance	Chat with Llama 2	Freemium	YES https://mbasic.facebook.com/privacy-policy/printable/version/7122790421067234/#1	Meta's Large Language Model
Writing assistance	ChatGPT (free version)	Free	YES https://openai.com/policies/privacy-policy/	Free version, does not browse the internet
Writing assistance	ChatGPT Plus	Paid	YES https://openai.com/policies/privacy-policy/	OpenAI's paid version of LLM; browses the internet
Bibliographic Research	ChatPDF	Freemium	YES https://chat-pdf.notion.site/ChatPDF-Privacy-Policy-45fa3cf8bac8483896eb09b108f0c0f2	An AI-powered app that simplifies reading and analyzing journal articles by providing summaries and answering questions about research papers.
Writing Assistance	Citation Machine	Freemium	YES https://www.chegg.com/en-US/privacy-policy	Helps generate accurate citations in various formats (APA, MLA, Chicago, etc.), particularly useful for citing sources correctly in research papers.
Writing Assistance	CiteSmart	Freemium	NO	An AI tool that assists with proper citation formatting, ensuring consistency in citation styles (APA, MLA, Chicago) throughout your paper.
Writing assistance	Claude	Freemium	YES https://www.anthropic.com/legal/privacy	Anthropic's Large Language Model
Bibliographic Research	Connected Papers	Freemium	YES https://www.connectedpapers.com/privacy	Research for scientific articles and maps
Collaborative Writing	Consensus	Freemium	YES https://consensus.app/home/blog/privacy-policy/	An AI-powered tool that assists with collaborative writing and helps authors achieve agreement on content, ensuring consistency and coherence in manuscripts with multiple authors.
Bibliographic Research	Elicit.org	Freemium	YES https://elicit.com/operations/privacy	An AI tool designed for conducting literature reviews and mapping. It performs searches using semantic queries and promptly pinpoints pertinent papers, extracting key information.
Reference Management	EndNote	Paid	YES https://endnote.com/privacy	Widely used for managing references and creating bibliographies.
Writing assistance	Google Gemini	Freemium	YES https://policies.google.com/privacy	Google's LLM, integrated with Google Suite
Bibliographic Research	Litmaps	Freemium	YES https://www.litmaps.com/privacy-policy	Research of scientific articles connected through citations with visual maps.

Table 1 (continued)

Activity type	Product/service Name	Free, freemium or paid	Privacy terms and conditions	Description
Writing assistance	Microsoft Copilot	Freemium	YES https://privacy.microsoft.com/en-us/privacystatement	Microsoft's LLM; navigates with BING; DALL-E is integrated.
Writing assistance	MistralAI	Freemium	YES https://mistral.ai/terms/#privacy-policy	The first European LLM (French), in partnership with Microsoft.
Writing Assistance	Paper Wizard	Freemium	NO	An AI-powered writing assistant that uses NLP technology to help create high-quality, well-researched documents and provide content improvement suggestions.
Bibliographic Research	PaperPal	Freemium	YES https://cactusglobal.com/privacy-policy/	Research of scientific articles.
Writing assistance	Perplexity	Freemium	YES https://www.perplexity.ai/hub/legal/privacy-policy	Anthropic's LLM.
Writing Assistance	Plagscan	Freemium	YES https://www.plagscan.com/en/data-protection	A plagiarism checker that scans documents for similarities with existing content, widely used by researchers and educators to ensure originality.
Writing Assistance	ProWritingAid	Freemium	YES https://prowritingaid.com/en/Home/Privacy	An AI-powered writing tool that helps perfect written work before submission. Features include a rephrasing tool for sentence improvement and a grammar checker.
Writing Assistance	QuillBot	Freemium	YES https://quillbot.com/privacy	An AI-powered writing tool that uses advanced algorithms and machine learning to assist with writing tasks. Useful for improving writing quality, saving time, and avoiding plagiarism.
Writing Assistance	Ref-N-Write	Freemium	YES https://www.ref-n-write.com/privacy-policy/	An AI tool that provides suggestions for academic phrases and vocabulary to improve the clarity and coherence of writing.
Bibliographic Research	Research Rabbit	Freemium	NO	Research of scientific articles connected through citations with visual maps.
Bibliographic Research	Scholarcy	Freemium	YES https://www.scholarcy.com/privacy-policy	An AI tool that summarizes academic articles, highlights key parts, and offers quick insights into the relevance of articles for scholars and researchers.
Publishing Support	SciSpace	Freemium	YES https://typeset.io/privacy	An AI-powered platform that supports researchers in publishing their work, providing services from manuscript submission to peer review to publication.
Bibliographic Research	Scite.ai	Freemium	YES https://scite.ai/policy	An AI-powered platform that helps you discover and evaluate scientific articles. It uses smart citations to show how a paper has been cited, assessing the quality and relevance of references.
Bibliographic Research	Semantic Scholar	Free	YES https://allenai.org/privacy-policy	An AI-powered search engine that streamlines your search for pertinent academic papers by employing advanced algorithms to extract essential information from a wide array of PDFs.
Writing Assistance	Trinka	Freemium	YES https://www.trinka.ai/privacypolicy	An AI-powered English grammar and plagiarism checker designed specifically for academic and technical writing. It also serves as a language enrichment writing assistant.

Table 1 (continued)

Activity type	Product/service Name	Free, freemium or paid	Privacy terms and conditions	Description
Writing Assistance	Wisio	Freemium	YES https://www.wisio.com/policy	Focuses on scientific writing and editing, helping authors improve manuscripts by providing suggestions for clarity, coherence, and style.
Writing Assistance	Wordtune	Freemium	YES https://www.wordtune.com/privacy-policy	An AI-driven writing assistant that offers suggestions for alternative phrasing to aid in articulating ideas with greater clarity and brevity.
Writing Assistance	Writefull	Freemium	YES https://www.writefull.com/privacy	Helps improve writing by suggesting alternative phrases and providing context-based feedback. Offers language translations and checks for academic phrases.
Reference Management	Zotero	Freemium	YES https://www.zotero.org/support/privacy	A reference management tool that integrates with your web browser to help collect, organize, and cite research materials.
Activity type	Product/service Name	Free, freemium or paid	Description	
2. Tools for data management, analysis and visualisation				
Data visualization	Flourish	Freemium		An online tool and platform for creating and sharing data visualizations. It allows users to turn data into appealing and interactive graphics without needing to code.
Data visualization	Google Data Studio	Free		A free data visualization tool that integrates with various data sources to create interactive dashboards, reports, and charts. User-friendly interface for designing visually appealing figures and tables.
Data organization and visualization	Google Sheets	Free		A platform for organizing and visualizing data in tables and charts. Functions and tools to transform raw data into structured tables and graphical representations suitable for scientific manuscripts.
Data visualization	GraphMaker.ai	Freemium		Allows the creation of various types of charts and diagrams from data.
Data visualization	Highcharts	Freemium		A JavaScript charting library for creating interactive and responsive charts for web applications. Wide range of chart types and customization options.
Data visualization	Infogram	Freemium		A data visualization tool that allows creating infographics, charts, and maps from raw data. Templates and design tools to customize visualizations for scientific communication.
Data visualization	Matplotlib (Python library)	Free		A plotting library for creating static, animated, or interactive visualizations. Used for generating various graphical representations of data in scientific research.
Data analysis	Pandas (Python library)	Free		A powerful data manipulation and analysis library in Python that provides tools for cleaning, transforming, and analyzing data. It can be used to organize data into tables and prepare it for visualization in scientific manuscripts.
Data visualization	Plotly	Freemium		A versatile data visualization library for creating interactive plots and graphs. Integrates with programming languages like Python, R, and Julia for customized scientific reporting.
Data management	Rivery	Paid		A fully-managed DataOps platform that automates and manages data transformation processes. Automates data management from various databases and SaaS platforms.
Data analysis & visualization	Statsomat (EDAR)	Freemium		A web platform designed to provide automated guidance and applications for statistical data analysis. Offers apps for automated exploratory data analysis with R and Python, generating a PDF report with numerical/graphical outcomes and the code to reproduce results. Includes univariate descriptive statistics and graphics.

Table 1 (continued)

Activity type	Product/ service Name	Free, freemium or paid	Privacy terms and conditions	Description
Data engineering and wrangling	Trifacta	Paid		A visual data engineering and data wrangling cloud platform that aids in preparing, cleaning, transforming, and visualizing raw data efficiently. Enhances data organization and quality.

AI-powered tools can significantly enhance the academic writing process by providing valuable support to researchers and students. Here are some key AI tools that can boost academic research and writing.

Disclaimer: these tools are continually evolving, and new ones may emerge. Choose the ones that best suit your needs and enhance your academic writing experience. We invite potential users to thoroughly check the privacy terms and conditions of the above mentioned tools before using them.

Since when this manuscript was finalized Springer Nature and most scholarly publishers did not allow the use of Images generated through Artificial Intelligence tools, we deliberately excluded other dedicated Gen AI tools for images.

Appendix - crafting effective prompts for AI-driven research

Writing precise prompts is crucial for harnessing the power of AI in research. Clear instructions ensure the AI accurately understands your needs, leading to tailored and relevant outputs. Detailed prompts help the AI focus on the specific information, saving time and effort.

Effective *prompt engineering* is akin to crafting a precise language guiding AI's cognitive processes. Well-constructed prompts act as blueprints, dictating the nature and quality of the AI's responses. It goes beyond mere instructions, requiring consideration of context, tone, and semantic nuances. This ongoing process involves refining prompts through strategic adjustments to phrasing and contextual cues, enhancing the model's ability to comprehend and generate accurate, relevant outputs.

AI prompts are diverse, each serving distinct purposes and requiring specialized approaches. Whether guiding a chatbot towards empathetic responses or fine-tuning a language model for specific domains, effective prompt engineering lays the foundation for seamless human-AI interaction and unlocks the full potential of AI.

Key principles for effective prompts include:

- *Clarity and concision:* use clear, unambiguous language to avoid misinterpretation by the AI model.
- *Contextualization:* provide relevant background information to establish the scope of the task and guide the AI's understanding.
- *Objective specificity:* clearly define the desired outcome, whether it be simplifying medical terminology, adapting content for specific audiences, formatting citations, or enhancing comprehension of medical concepts.
- *Audience awareness:* tailor prompts to the intended audience, using appropriate language complexity for patients versus healthcare professionals.
- *Iterative refinement:* continuously evaluate and refine prompts based on the AI's output to achieve optimal performance.

By adhering to these principles, medical writers can leverage the power of AI tools to streamline workflows, enhance content quality, and ensure targeted communication across diverse audiences.

the research. Additionally, advanced AI visualization tools like Tableau, Bold BI, and Qlikview generate interactive dashboards and graphs, employing techniques like heat-maps and scatter plots to reveal hidden patterns and trends (e.g., time series for cyclic patterns, spatial mapping for geographic clusters) [24].

Beyond visualization, AI offers powerful techniques for exploration and analysis. Advanced algorithms like principal component analysis, clustering, and correlation matrices automate the exploration of large datasets, identifying associations, interactions, and groupings that may suggest significant relationships between variables. For example, clustering can classify samples based on shared traits, revealing distinctive phenotypes.

AI modeling techniques like regression, decision trees, random forests, and neural networks construct predictive models from historical data. These models identify key predictors and model complex relationships, enabling them to forecast outcomes (disease risk, treatment response and survival rates [25]).

Furthermore, NLP allows AI systems to extract key information from unstructured text data. Additionally, AI automates repetitive tasks like data cleaning and normalization, freeing researchers for higher-level analysis and discovery [26]. By minimizing human error, AI enhances the accuracy and efficiency of data interpretation and analysis.

In conclusion, AI empowers researchers with intuitive visualizations, hidden pattern discovery, predictive modeling, text mining, and automation, leading to more accurate, insightful, and efficient data analysis. Recent trends explore the potential of generative AI and LLMs to assist in specific analysis tasks, data exploration, and even hypothesis generation [27]. Together, AI's automation and quality assurance capabilities enable researchers to achieve higher quality results with increased efficiency.

The use of digital and AI tools in checking the accuracy and appropriateness of statistical tests and methods

The integration of digital and AI in statistical analysis marks a significant transformation in researchers' approaches to data interpretation and validation in scientific studies. AI technologies, including machine learning algorithms and AI-driven software, offer unprecedented support in scrutinizing the statistical methods employed in research.

This technological advancement ensures that the selected statistical approaches align with the data, thereby enhancing the reliability and validity of the research findings. One notable tool in this domain is Statcheck [28], an R package

designed to detect statistical errors in peer-reviewed psychology articles. By automatically reviewing APA-formatted statistical outputs, Statcheck can identify inaccuracies in p-value reporting, degrees of freedom, and the consistency of statistical results, thereby aiding in the identification of potential errors in the statistical analysis. However, it has several limitations. For instance, it can only detect results reported completely and in exact accordance with APA guidelines. It cannot detect statistics that are only included in tables in the paper [28] and have been used mainly in psychology literature.

Furthermore, AI-driven tools for statistical analysis review not only enhance accuracy but also significantly expedite the research validation process. Traditional manual reviews of statistical methods are time-consuming and prone to human error, especially in complex datasets. In contrast, AI can process and analyze vast amounts of data at speeds unattainable by human reviewers. This proactive approach can guide researchers toward more robust analytical strategies, ensuring that their findings are both accurate and statistically sound.

AI tools are revolutionizing scholarly manuscript writing

The realm of research writing is undergoing a transformative shift with the advent of intelligent AI tools that are empowering researchers to craft their manuscripts with greater efficiency and effectiveness.

The use of AI tools in medical writing can have a positive impact on efficiency, allowing writers more time to focus on creativity and accuracy. These tools can streamline the workflow, improve accuracy, and reduce the time required for writing and editing.

AI-powered assistants are also poised to enhance the quality of scientific writing for researchers. While some apprehension exists regarding the potential use of systems like ChatGPT to directly author texts, it is arguable that this should not be a concern. On the contrary, the assistance of AI is beneficial if it enhances the interpretation and integration of data into an article. Many scientific papers suffer from poor structure, redundant text, and the need for language editing due to a lack of proficiency in English. The clarity and quality of these papers could be significantly enhanced using AI.

Abstracts [29, 30], the crux of research articles, encapsulate the core findings and takeaways of a study. AI algorithms like QuillBot [31] are revolutionizing abstract generation, enabling researchers to produce comprehensive and engaging summaries with minimal effort. These AI tools can handle both factual and creative writing styles, catering to diverse research domains.

AI-driven tools like Grammarly [32] and Hemingway Editor [33] are becoming increasingly important companions for researchers, meticulously scrutinizing manuscripts for stylistic consistency, grammar errors, and typos. These tools provide insightful feedback, ensuring that manuscripts meet the stringent standards of target journals and showcase the researcher's expertise.

AI tools to find the most appropriate target journal

The integration of AI into the academic publishing process has changed how researchers identify suitable journals for their manuscripts. AI-driven tools, like Enago's Journal Finder [34] and AJE's Journal Recommendation Service [35] (part of Springer Nature), offer an advanced approach navigating the academic publishing. These tools utilize advanced AI algorithms to analyze manuscripts and match them with appropriate journals.

These AI tools extend beyond than just keyword matching; they assess the manuscript's overarching theme, research methodology, and target audience to suggest journals where the work could have the greatest impact.

This ensures alignment between the manuscript and the journal scope, increasing acceptance likelihood. Additionally, these AI-powered tools provide valuable insights into journal metrics, such as impact factors, acceptance rates, and the publication average time, crucial for researchers aiming to maximize their work's visibility and citation potential.

Peer review: a crucial mechanism for scientific quality assurance

Peer review is vital for scientific quality assurance, safeguarding research integrity. This unbiased evaluation by field experts maintains the credibility of scientific publications. The advent of AI has led to significant advancements in the peer review process. AI-powered tools like Snapp [36], developed by Springer Nature, have transformed the identification and reviewer recruitment processes for journal submissions.

Using advanced algorithms and databases, Snapp matches manuscripts with reviewers based on their expertise, research interests, and past contributions. This innovative approach speeds up the review process, ensuring timely assessment and timely publication of research findings. AI's incorporation into the peer review process [37] has addressed long-standing challenges, including reviewer recruitment, bias prevention, and timely feedback. Additionally, AI-powered tools can analyze reviewer performance and detect potential biases, ensuring a fair and objective review process.

AI and digital tools to disseminate research

The dissemination of research findings is crucial for scientific advancement and collaboration. AI is a powerful tool for extending the reach of scholarly articles beyond academic boundaries. AI-driven platforms optimize article diffusion through digital channels, making research findings accessible to a broader audience, including academics, industry professionals, and the general public, thereby maximizing the potential for citation and real-world application. Tools like Altmetric [38] track online activity surrounding scholarly literature, providing researchers with insights into the social media presence and discussion about their work. ResearchGate [39] uses AI to recommend articles based on users' interests and research activity. Similarly, Publons, tracks publications, citations, peer reviews, and journal editing work, aiding researchers in claiming credit for their contributions [40]. ORCID provides a unique identifier for each researcher, facilitating connections between individuals and their professional activities [41]. These tools ensure research findings are shared broadly and effectively, enhancing the visibility and impact of scientific research in the digital era.

Research integrity and plagiarism check

The advent of artificial intelligence in the realm of academic writing has ushered in a transformative era for maintaining academic integrity. AI-driven paid tools like iThenticate and Turnitin [42] are at the forefront of combating plagiarism, a pervasive issue that undermines the credibility of scientific publications. These technologies employ advanced algorithms to scan vast databases of published work, comparing documents to identify potential instances of plagiarism.

The role of AI extends beyond mere detection. It includes offering corrective suggestions, thereby aiding authors in enhancing the originality and integrity of their manuscripts. The integration of AI in plagiarism detection has also been pivotal in addressing the challenges posed by the subtleties of self-plagiarism and improper citation.

However, let's remark that while information technologies and AI have significantly strengthened efforts to address sentence-level plagiarism, the challenge of dealing with the subtleties of meaning-based plagiarism remains ongoing and complex. The ever-changing intricacies of language nuances, combined with contextual complexities, create formidable obstacles to achieving thorough detection of semantic plagiarism. Furthermore, the emergence of generative AI exacerbates the complexity by undermining traditional plagiarism detection methods at the sentence structure level. For instance, consider the use of paraphrasing tools powered by generative AI.

These tools can subtly rephrase sentences, making it difficult for conventional syntax-based plagiarism detectors to identify instances of copied content. In essence, generative AI introduces a new dimension of evasion, challenging established approaches to plagiarism prevention. This underscores the essential need for continuous advancements in AI-powered tools and methodologies to effectively navigate the enduring intricacies of this significant issue.

Addressing privacy concerns with AI tools

The use of AI tools in academic research and writing raises important data privacy criticalities that should be carefully considered. While AI tools offer remarkable capabilities in assisting researchers, there are valid concerns about the potential use of unpublished data for fine-tuning and further training of commercial AI models. Some AI tools may not provide sufficient transparency or control over the use of submitted files, which could be used for purposes beyond the intended research application.

To mitigate these privacy concerns, we recommend the following:

- Carefully review the terms of service and privacy policies of any AI tools used in the research process (Table 1).
- Ensure that the policies clearly outline how the submitted data will be handled and protected.
- Consider using AI tools that provide more transparency and control over data usage, if available for the specific research tasks.
- Avoiding the use of tools with low transparency and unclear data usage policies for sensitive or unpublished research data.
- Update the knowledge of the tools regarding the policies, as terms of use can change over time.

By taking these proactive steps, researchers can maintain responsible practices when using AI tools in their work. Prioritizing data privacy and transparency is crucial for upholding the integrity of the research process and maintaining public trust in the scientific community.

Limitations and challenges of AI tools

While AI tools offer remarkable efficiency in generating summaries, they also present certain limitations that warrant consideration by researchers. A notable challenge is their restricted contextual understanding, which can lead to misinterpretations or misleading summaries. To mitigate

this, researchers can provide additional context or use AI tools with more advanced training models.

AI summaries may not fully encapsulate the essence of research papers or accurately interpret complex concepts, underscoring their role as supportive tools rather than replacements for human analysis. Another concern is that AI tools trained on biased data may introduce inherent biases into the summaries, demanding the careful selection of diverse and representative training sets. Lastly, the quality of the input research article significantly influences the accuracy of the generated summary, emphasizing the need for researchers to select high-quality papers to ensure reliable and informative summaries.

While AI summarization tools are valuable for streamlining the literature review process and keeping researchers updated on advancements, it is crucial to be aware of their limitations and use them carefully [42].

LLMs and “hallucinations”

AI and LLMs [43] have advanced NLP, demonstrating capabilities in text generation, translation, and comprehension. However, a phenomenon termed “hallucination” [44] has been identified, where an LLM generates text that contradicts or is inconsistent with the given input.

The occurrence of LLM hallucinations can be attributed to several factors, including:

- Incomplete or noisy training data: LLMs are trained on massive datasets, which may contain errors or inconsistencies, leading to hallucinations [45].
- Jailbreak prompts: formulating specific prompts (“jailbreak prompts”) that exploit their tendencies to generate creative text can encourage the LLMs to produce nonsensical or even harmful content [46].
- Overfitting: overfitting occurs when an LLM becomes too closely aligned with the training data, leading it to struggle with generalization. In some cases, this can lead the LLMs to hallucinate when presented with new or unfamiliar input [47].
- Procedural reasoning over factual accuracy: LLMs trained on vast amounts of text data develop a model of language. However, they may prioritize procedural reasoning over factual accuracy when generating text, focusing on creating text that conforms to learned patterns and structures, even if it contradicts reality [48].
- Invented bibliographic references: a particularly alarming aspect of LLM hallucinations is their ability to invent bibliographic references. By mimicking the style and structure of actual bibliographic entries, LLMs can create seemingly credible citations that support their fabricated claims. This can have severe consequences for scholarly

- research and publishing, as it can lead to the propagation of misinformation and the inaccurate attribution of ideas.
- Even the latest versions of ChatGPT 4 (paid version), which is able to navigate the web through the search engine Bing or Google Bard, continue to invent non-existent bibliographic references or – worse – can create fraudulent references that link to real articles pointing to real DOIs and Pubmed records (which actually refer to other articles) or produce randomly linked links to accurate and reliable content and fraudulent outputs [49]. However, this effect, present in “generalist” products, is significantly reduced, if not entirely absent, in AI products specifically designed for bibliographic research.

To mitigate the issue of LLM hallucinations, several strategies can be employed:

- Improved training data: ensuring the quality and accuracy of training data is vital. This involves meticulous management of the dataset and the removal of any erroneous or fabricated information.
- Prompt refinement: researchers are developing techniques to refine prompts in a way that encourages LLMs to generate more accurate and reliable content. This may involve using more specific prompts or providing additional context to guide the LLM’s understanding.
- Enhancing generalization: addressing overfitting can improve LLMs ability to generalize better to new or unfamiliar input, reducing the likelihood of hallucinations. This could involve strategies such as data augmentation or the inclusion of diverse training data.

The phenomenon of LLM hallucinations underscores the inherent challenges of AI and highlights the need for thorough evaluation and validation when deploying LLMs in real-world applications. By addressing these challenges, we can ensure that LLMs are developed and used responsibly, minimizing the risk of misinformation and material inaccuracies [49].

LLMs and languages other than English: implications for authors and users

LLMs have shown impressive capabilities in tasks such as translation, text generation, expanding communication, research, and education. However, the dominance of English in LLM datasets and training methodologies raises concerns about the marginalization of non-English languages.

Most LLMs are trained on extensive English datasets, leading to challenges for other languages:

- *Competitive disadvantage*: English-centric LLMs may struggle with the nuances of other languages, leading to

inaccurate translations and misinterpretations [50]. This can hinder the dissemination of research and scholarship in non-English languages.

- *Limited datasets*: The lack of large, high-quality datasets in non-English languages hampers the development of specialized LLMs for these languages, restricting their potential applications.
- *Cultural misrepresentations*: LLMs trained primarily on English data may struggle to comprehend the cultural references, idioms, and nuances embedded in non-English texts, leading to misinterpretations and miscommunications.
- *Prompt in English*: initiating prompts in English is generally recommended when interacting with LLMs due to their extensive training on English data.

However, to ensure the equitable development of LLMs, it is crucial to support non-English languages. One strategy is to expand datasets. By enhancing the availability of large, high-quality datasets in non-English languages, the performance of LLMs across a wider range of languages can be improved.

Allocating resources to develop specialized LLMs for specific non-English languages is a crucial step towards accommodating these languages’ unique linguistic and cultural nuances [51]. Alongside this, there’s an urgent requirement to formulate standardized evaluation metrics for these multilingual LLMs. These metrics enable fair language comparisons and guide the development of advanced models. By addressing these challenges and promoting multilingualism in LLMs, we can extend their benefits to global researchers, fostering inclusivity and advancing science.

Guidelines for researchers and authors in using AI in Scholarly Publishing

As discussed in previous paragraphs, AI’s introduction raises ethical challenges requiring guidelines for responsible use. The Scientific, Technical and Medical Publishers Association (STMA), has issued guidelines for the responsible use of AI in scholarly publishing, emphasizing transparency, fairness, and accountability in AI applications [52]. The World Association of Medical Editors (WAME) and the International Society for Medical Publication Professionals (ISMPP) have provided valuable insights and recommendations [53, 54].

WAME advocates for transparency and accountability in AI’s in medical publishing, demanding for a clear disclosure of the involvement of AI in research and publication processes, and ensuring that the AI’s use does not damage research’s integrity or the readers’ trust. WAME also

stresses the importance of maintaining human supervision of AI-generated outputs [53].

Similarly, ISMPP has released a position statement on AI in medical publishing. The statement outlines key principles and best practices for AI's appropriate use. ISMPP encourages professionals to commit to appropriate AI utilization, disclosure, and education [54].

Given these recommendations, it is clear that AI's responsible integration into medical publishing demands adherence to strict ethical and professional standards. Transparency, accountability, and academic integrity are key. Publishers should disclose the use of AI tools to authors and readers, ensuring that AI-generated content is appropriately labeled and attributed. Additionally, publishers should establish robust quality control measures to mitigate potential biases and errors in AI-produced outputs. Authorship guidelines, such as those provided by Nature journals [55–58] also play a crucial role in addressing the challenges posed by AI in scholarly publishing. While AI can aid various aspects of the research process, it should not be considered sufficient grounds for authorship. Authors retain ultimate responsibility for their work's accuracy, originality, and ethical integrity.

The Committee on Publication Ethics (COPE) and the International Committee of Medical Journal Editors (ICMJE) have also released guidelines on AI's use in scholarly publishing, emphasizing the need for transparency and ethical considerations [59, 60]. COPE guidelines recommend that publishers provide clear policies on the use of AI, including disclosure requirements and quality control procedures [59]. ICMJE guidelines emphasize the importance of human oversight and intervention in AI-assisted research, ensuring that AI is used to augment, not replace, human expertise [60].

The introduction of AI into scholarly publishing presents a complex landscape of opportunities and challenges. By adhering to guidelines established by STMA [52], Nature journals [61], COPE, and ICMJE, publishers, authors, and researchers can responsibly navigate this evolving landscape and ensure the integrity and quality of scholarly communication.

Conclusions

AI can transform clinical research by moving the focus to more relevant concerns, preventing the continuation of “useless research.” This is achieved through AI's ability to scan massive amounts of data and identify patterns and trends that human researchers may overlook. AI can optimize resource allocation and accelerate scientific development by eliminating ineffective research initiatives.

Furthermore, AI can stimulate collaboration among researchers through new platforms, leading to a large

consortium of scientists capable of addressing large-scale challenges. This could significantly influence the study of a variety of topics, including the consequences of climate change on health, the impact of pollution and environmental degradation, and the study of uncommon diseases, among others.

However, the transformational potential of AI in clinical research must be properly managed. We must ensure that AI is developed and implemented ethically, prioritizing ethical issues, data protection measures, and transparency in AI-driven research processes. By embracing AI potential while tackling its obstacles, we can foster a more efficient, collaborative, and effective clinical research environment.

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Compliance with ethical standards

Conflict of interest S.F., Editor in Chief of Endocrine, recused himself from the peer review process for this article. A different Editor handled the review. The views and opinions expressed in this article are solely those of the authors and do not necessarily reflect the official position of Springer Nature, the publisher. The authors disclose that they utilize Quillbot in the final revision of the manuscript, particularly for the native English check, technical editing, spelling, and grammar correction.

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