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PAPER

Early Research Trends on ChatGPT: Insights from Altmetrics and Science Mapping Analysis

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ABSTRACT

In the four months following its launch in December 2022, ChatGPT, the LLM bot employing deep learning algorithms to generate human-like responses, has been the subject of numerous research articles. Identifying early attention to this research is highly intriguing. As citations for these publications may take time to accumulate, our study focused on examining the early attention of ChatGPT research using the Altmetric Attention Score (AAS), a composite attention score developed by Digital Science. Our findings from the total set of publications and the top publications according to the highest AAS scores reveal the following trends: (i) The United States, Japan, and the United Kingdom are the top countries that published most of the top research articles related to ChatGPT. (ii) The most frequently mentioned source titles include journals like Nature, Science and preprint sources like medRxiv and arXiv. (iii) Among the fields of research (FoR) to which ChatGPT publications align, 'information and computing sciences' and 'biomedical and clinical sciences' received the highest mentions. (iv) Five major clusters were identified in the network formed by the interlinkage of FoRs, and the most prominent themes discussed in top articles within these five clusters include ChatGPT usage in medical writing and determining ChatGPT's role in scientific publishing. (v) Scientists are found to be the major user category demonstrating the highest level of interest in ChatGPT research. By capturing these early trends in ChatGPT research and the early attention to this research, our work offers valuable insights for ChatGPT enthusiasts, researchers, and policymakers in fields such as education, information sciences, biomedical sciences, scientific publishing, and many others.

KEYWORDS

large language model, fields of research, bibliometrics, cluster analysis, social media

1 INTRODUCTION AND RELATED WORK

In recent years, the concurrent advancement of numerous technologies has led to significant breakthroughs in Artificial Intelligence (AI). These AI systems have demonstrated potential benefits in various domains, including skill acquisition, service democratization, accelerated production, energy usage reduction, healthcare efficiency

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improvements, real-time environmental monitoring, cybersecurity enhancement, entertainment environment innovation, real-time translation service improvements, and national output augmentation. A notable development in AI that has generated considerable interest among researchers across disciplines and the public is the introduction of ChatGPT in November 2022. This AI-powered chatbot, a Large Language Model (LLM) employing a deep learning neural network with numerous parameters trained on extensive data through self-supervised learning algorithms, can generate convincing and insightful textual responses to prompts.

Since its inception, ChatGPT has reportedly been successfully applied to various tasks across diverse fields, eliciting mixed reactions from the broader scientific community [8] [23] [17] [5] [7] [18]. In light of this, our study aims to examine the responses documented in scientific publications, including research articles, reviews, opinion pieces, and other forms of communication. Additionally, to gain insight into the early impressions of community members regarding preliminary research, we intend to analyze these initial reactions as well. Scientometrics is a field of research that uses tools, methods, and science techniques to measure Science's progress. One major way such assessments happen is by analyzing scientific publications and the citation relationship among such publications in a field or multiple fields. However, as the accumulation of citations takes some time owing to the delay in the peer review process, which is regarded as a gatekeeping mechanism, it is prudent to use altmetrics or alternative metrics (often dubbed Scientometrics 2.0) for assessing early trends in emerging topics like ChatGPT. Altmetrics comprises different metrics computed from different events about scholarly articles on social media platforms and academic, social networks. It has become extremely popular for emerging topic analysis as it is suitable to gauge initial research trends as an upsurge is found among researchers' activity on various platforms like Twitter and Facebook, as well as academic social networks like Academia, Mendeley, and ResearchGate, to share and disseminate their research results [4]. Some facts about altmetrics justify this study's choice of altmetrics-based analysis.

Driven by altmetrics' ability to capture early trends, researchers have begun employing altmetrics in studies previously reliant on citation analysis. Examples include country-level studies [2] [34] utilizing altmetrics, discipline-specific coverage studies [1] [13][33] employing altmetrics, and investigations of disciplinary variations in altmetrics [21] [28]. A study used altmetrics to analyze the online attention garnered by climate change research papers, finding that altmetrics facilitated the identification of highly-discussed and shared papers, offering valuable insights into public interest and engagement [12].

Several studies have also explored the correlation between altmetrics and citations, revealing strong correlations [26] [29] [3]. This correlation has contributed to the conjecture that altmetrics may serve as citation predictors. Another intriguing factor is the similarity in distribution characteristics between citations and altmetrics. The discovery that Twitter mentions exhibit a highly skewed distribution was supported by multiple studies, with reports on the skewed nature of altmetrics distributions further corroborating this finding [6] [27] [29]. This study demonstrated that citations and altmetrics adhere to a power law distribution, further bolstering the notion of altmetrics' predictive power [4]. While these highlight the parallelism between citations and altmetrics, some advantages of altmetric studies can claim are discussed next. One notable advantage is the rapid accumulation of altmetrics compared to traditional bibliometric indicators. This speed enables the understanding of early discussions on emerging topics, such as ChatGPT, well before the results of traditional peer review processes become available. This timeliness advantage facilitates real-time monitoring of research trends, as opposed to the time-delayed analysis offered by citation-based methods.

Another aspect highlighting the value of altmetrics is their inclusivity, particularly for interdisciplinary topics. Altmetrics ensure visibility for interdisciplinary research

by reaching diverse audiences across various platforms, thus capturing trends that might be more reliable than early trend analysis using citation data. As ChatGPT attracts researchers from different disciplines, early analysis with altmetric platforms can better reflect emerging trends. Altmetrics' ability to reflect the societal impact of research is also noteworthy. Although some argue that altmetric attention is not equivalent to impact, some studies [10] suggest that altmetrics are better suited for early analysis and interdisciplinary topics than traditional bibliometric indicators. An additional advantage of altmetric analysis is the potential for identifying and facilitating collaborations between academia and industry. By examining influential researchers and organizations (both academic and industrial) actively promoting scientific research, altmetrics can help foresee and foster partnerships. This aspect becomes increasingly relevant as academic researchers recognize the importance of transforming scientific results into practical technological products for society. Governments are also implementing Scientific Social Responsibility (SSR) in their National Science, Technology, and Innovation Policies, emphasizing the value of these connections.

Recent examples, particularly from epidemic and pandemic response efforts, demonstrate the value of altmetric analysis. During the 2015–2016 Zika virus outbreak, altmetrics were crucial for monitoring the evolving research landscape and public interest, enabling researchers to identify prominent papers and understand the public's concerns and priorities [19]. Similarly, in the early stages of the COVID-19 pandemic, altmetrics assisted researchers and policymakers in tracking and comprehending the rapid development of scientific knowledge, identifying influential papers, spotting emerging trends, and assessing the public's response to various aspects of the pandemic [15].

Despite the advantages of altmetric studies over traditional bibliometric methods, some limitations exist. These include the lack of gatekeeping mechanisms like peer review, lack of standardization leading to potential inconsistencies in assessment, the possibility of manipulating score computation sources, and the influence of factors such as catchy titles on a work's popularity rather than its inherent merit. Some limitations may not significantly impact our goal of providing an early trend report on ChatGPT research. Altmetric analysis is more suitable than citation-based analysis due to the previously discussed advantages. This information can benefit various stakeholders, including researchers and policymakers from different disciplines interested in ChatGPT. The specific questions we aim to address in this research are as follows:

1. What is the geographic breakdown of mentions for the top ChatGPT research articles based on their attention scores?
2. What are the most frequently mentioned source titles for ChatGPT research?
3. How does ChatGPT research align with different Fields of Research (FoR), and which FoRs receive the highest number of mentions?
4. Based on the mapping to Fields of Research, what are the thematic clusters of ChatGPT research?
5. Which Twitter users, such as scientists, practitioners, or science communicators, are interested in ChatGPT?

2 EARLY IMPACT ANALYSIS OF CHATGPT RESEARCH

As the major objective is oriented towards identifying the early impact/response of the early research related to ChatGPT, we used altmetrics or alternative metrics for our analysis, as the importance of altmetrics in reflecting societal impact was discussed in the study [35]. Our major data source to collect publications data related to

ChatGPT is the Dimensions database. We used the search term "(ChatGPT) OR (chat GPT)", and the search was conducted in the fields 'title' and 'abstract' of publications. Data collection was done on March 16, 2023. Publications published in 2022 and those in 2023 up to that day were covered.

Out of 385 publications (168 articles, 215 preprints, one book chapter, and one monograph) retrieved from the search using the above query, only 227 (99 articles and 128 preprints) had altmetric scores. Of 227 publications with altmetric scores, 183 (99 articles and 84 preprints) had DOI. We collected the altmetric details of these 183 publications using DOI from Altmetric.com. For these 183 publications, the total mentions found in altmetric.com amounts to 22159, of which 20854 are social media mentions (almost 94%). The split up of 20854 social media mentions was found to be: Twitter: 20678 mentions, Facebook: 142 mentions, and Reddit: 34 mentions. Apart from social media mentions, ChatGPT research has 1267 mentions in news and blogs.

Firstly, the articles about ChatGPT that received the top AAS (Altmetric Attention Score) are identified. The altmetric attention score is a composite score of mentions (that represent attention) in social media and other platforms' mentions. Then, the most prolific countries regarding posts about ChatGPT research articles were examined. We also identified the most frequently mentioned source titles for ChatGPT research. Next, we identified how publications related to ChatGPT align with different fields of Research (FoR). Then, the FoRs that got the highest AAS are also identified. The thematic clusters within in FoRs are identified using keyword co-occurrence maps using VOSviewer software which enables the visualization and analysis of scientific landscapes, revealing patterns and relationships within research fields [32]. We also determined the extent to which different types or categories of Twitter users, such as scientists, practitioners, or science communicators, are interested in ChatGPT. We also analyzed the articles with the top 10 AAS, identified the FoRs they belong to, and did the content analysis.

3 RESULTS AND DISCUSSION

3.1 Prolific countries based on posts

The countries leading in posts about ChatGPT include those with a strong research focus on artificial intelligence, such as the United States, Japan, and the United Kingdom. These are shown in Figure 1 China may be among the top countries for tweets related to ChatGPT research despite Twitter being banned in China. However, other social media platforms popular in China, such as Weibo and WeChat, may also be used to discuss ChatGPT research. The social media pattern of ChatGPT's mentions reveals that Twitter is the platform with the most mentions (94% total mentions).

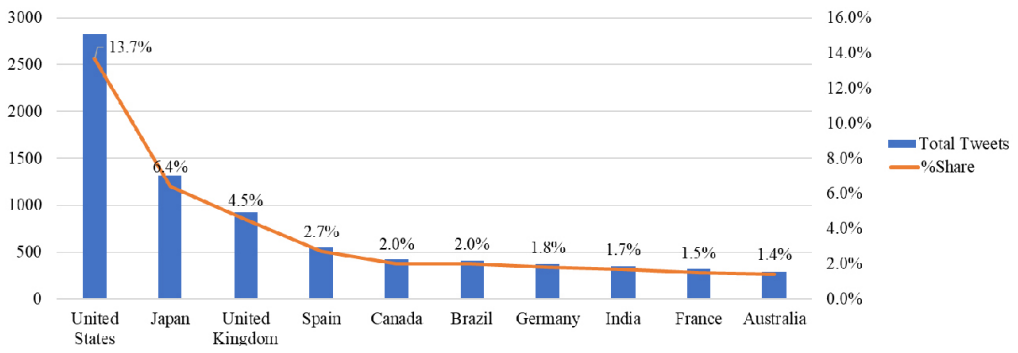

Fig. 1. Leading countries in terms of posts about ChatGPT

3.2 Highly mentioned articles – geographical analysis based on AAS

Table 1 presents the top ten articles based on AAS, sorted by the top five countries for each article. The Table displays the percentage of mentions from each country for each article. We observe that the United States and Japan are the top two countries with the highest percentages of mentions. The United Kingdom and Spain also have a considerable number of mentions, and their percentages are consistently high across the top ten combinations. While developing economies like India and Brazil have a relatively lower percentage of mentions in the top ten list, their presence in some combinations indicates their contributions to the ChatGPT research field and their potential for further growth and collaboration.

Table 1. Top ten articles ranked according to Altmetric Attention Score

Article Title	Top 5 Countries				
Performance of ChatGPT on USMLE: Potential for AI-Assisted Medical Education Using Large Language Models (AAS)	United States	Japan	United Kingdom	India	Canada
	14%	7%	3%	2%	2%
ChatGPT listed as author on research papers: many scientists disapprove	United States	Spain	United Kingdom	Germany	France
	14%	7%	5%	4%	4%
Abstracts written by ChatGPT fool scientists	Brazil	United States	United Kingdom	Germany	Spain
	11%	10%	5%	4%	3%
Tools such as ChatGPT threaten transparent Science; here are our ground rules for their use	Japan	United States	United Kingdom	Spain	Canada
	12%	12%	4%	2%	2%
Comparing scientific abstracts generated by ChatGPT to original abstracts using an artificial intelligence output detector, plagiarism detector, and blinded human reviewers	United States	Japan	Spain	United Kingdom	Canada
	12%	12%	3%	3%	3%
ChatGPT is fun, but not an author	Japan	United States	Spain	United Kingdom	Germany
	15%	12%	4%	3%	2%
AI bot ChatGPT writes smart essays—should professors worry?	United Kingdom	United States	Spain	Japan	Korea, Republic of
	11%	11%	4%	3%	3%
What ChatGPT and generative AI mean for Science	United States	United Kingdom	Japan	India	Spain
	19%	7%	3%	3%	2%
ChatGPT: five priorities for research	United States	Spain	United Kingdom	Netherlands	Canada
	15%	6%	5%	5%	3%
How Does ChatGPT Perform on the United States Medical Licensing Examination? The Implications of Large Language Models for Medical Education and Knowledge Assessment	United States	Spain	Germany	India	Nigeria
	22%	9%	7%	4%	2%

3.3 Top source titles based on mentions

Table 2 displays the source titles that received the most mentions in tweets, news, blogs, and Facebook posts related to ChatGPT and the number of research outputs

associated with each source. Nature had the highest total mentions, accounting for 43% of all mentions, followed by medRxiv at 34% and arXiv at 23%. Science received 4% of the total mentions, while PLOS Digital Health accounted for 2%. Radiology, JMIR Medical Education, Cureus, Accountability in Research, Patterns, and the Journal of Educational Evaluation for Health Professions received 1% or less of the total mentions in the Table.

The Table suggests that Nature, medRxiv, and arXiv were the most prominent sources of research related to ChatGPT, with a significant percentage of the total mentions across all social media platforms. Approximately 98% of the total mentions in the Table came from Twitter, indicating that it was the most popular platform for discussing articles related to ChatGPT. The remaining 2% of mentions were split between news, blog, and Facebook mentions. This suggests that Twitter is the primary social media platform for individuals to share and discuss content related to ChatGPT.

Table 2. Analysis of top source titles according to total mentions

Source Title	Total Mentions	Twitter Mentions	News Mentions	Blog Mentions	Facebook Mentions	Number of Research Outputs
Nature	9495 (43%)	8879	383	80	109	17
medRxiv	7102 (32%)	6903	184	10	4	18
arXiv	4655 (21%)	4547	76	4	1	87
Science	881 (4%)	823	36	17	2	2
PLOS Digital Health	417 (2%)	252	152	12	0	2
Radiology	199 (1%)	176	15	5	0	3
JMIR Medical Education	178 (1%)	65	111	2	0	2
Cureus	44 (< 1%)	44	0	0	0	5
Accountability in Research	28 (< 1%)	28	0	0	0	4
Patterns	16 (< 1%)	15	1	0	0	2
Journal of Educational Evaluation for Health Professions	2 (< 1%)	2	0	0	0	2

The top source title with a high Altmetrics Attention Score is Nature (AAS = 8192), known for its research in artificial intelligence and natural language processing, followed by Preprints medRxriv (AAS = 4206), arXiv (AAS = 3299), and PLOS Digital Health (AAS = 1233).

3.4 Most mapped Fields of Research (FoR) by total mentions

Table 3 displays the percentage of total mentions for the top five fields of research related to ChatGPT. Information and computing sciences had the highest percentage of total mentions with 73%, followed by biomedical and clinical sciences with 38%, and language communication and culture with 18%. Philosophy and religious studies had 11% of total mentions, while education had the lowest percentage with 5%.

Table 3. Fields of research, their mentions, and AAS values

Fields of Research	% Total Mentions	AAS
information and computing sciences	73%	14970
biomedical and clinical sciences	38%	5876
language communication and culture	18%	3295
philosophy and religious studies	11%	1946
education	5%	661

3.5 Fields of research linkages

Next, we analyzed the linkages between the Fields of Research. The network formed by fields of research linkage based on citations is shown in Figure 2. This resulted in 5 clusters, as described in Table 4.

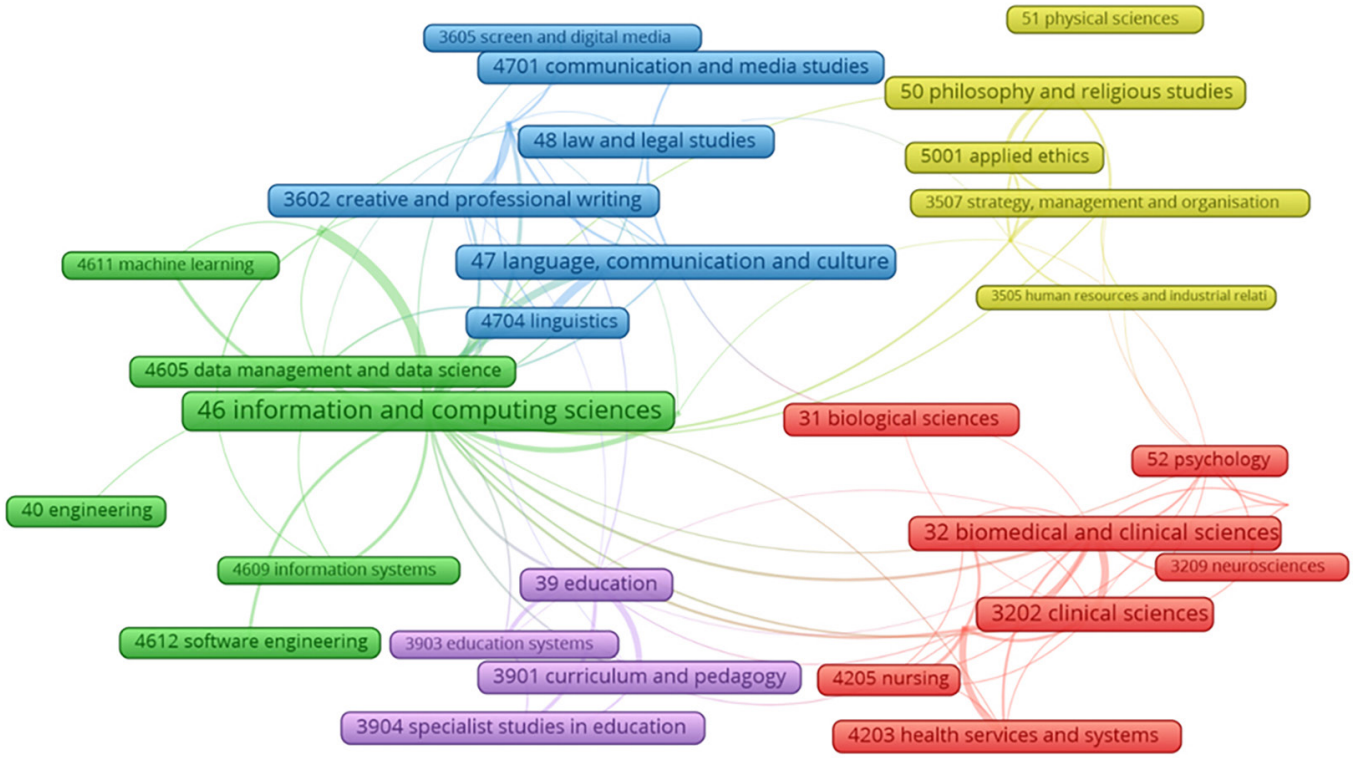

Fig. 2. Linkages between Fields of Research (FoR) due to the publications related to ChatGPT

Cluster 1 (red) predominantly focuses on biomedical, clinical, and health sciences and has a cumulative AAS of 6347 from 87 articles. Its AAS/TP is 73. Cluster 2 (green) has the highest cumulative AAS score of 15278 from 317 articles and is mapped to information and computing sciences. It has the highest TC of 317 and AAS/TP of 81.3. Cluster 3 (blue) articles are mapped to language, communication, and culture with a total AAS of 6546 from 84 articles and an AAS/TP of 77.9. Cluster 4 (yellow) articles are mostly mapped to philosophy and religious studies, with an AAS of 558 from 33 articles and a modest AAS/TP of 16.9. Finally, Cluster 5 (violet) is mapped to education and has an AAS of 1203 from 35 articles and an AAS/TP of 34.4.

Early trends show that ChatGPT research articles are most mapped to Information and Computing Sciences and Engineering (TC = 317, AAS = 15278) and Biomedical and Clinical Sciences and health sciences (TC = 240, AAS = 6347). Five clusters of articles emerge based on the mapping of ChatGPT research articles to FoR.

Table 4. Cluster analysis of FoR linkage network

Cluster	Major FoR	AAS	TC	TP	AAS/TP
Cluster 1 (red)	**32 biomedical and clinical sciences** 3202 clinical sciences 42 health sciences 4203 health services and systems 31 biological sciences 52 psychology 4205 nursing 4206 public health 3209 neurosciences 5202 biological psychology	6347	240	87	73.0
Cluster 2 (green)	**46 information and computing sciences** 4610 library and information studies 4608 human-centred computing 4605 data management and data science 4602 artificial intelligence 4612 software engineering 40 engineering 4611 machine learning 4609 information systems	15278	317	188	81.3
Cluster 3 (blue)	**47 language, communication, and culture** 48 law and legal studies 4701 communication and media studies 36 creative arts and writing 3602 creative and professional writing 44 human society 4704 linguistics 3605 screen and digital media	6546	157	84	77.9
Cluster 4 (yellow)	**50 philosophy and religious studies** 5001 applied ethics 35 commerce, management, tourism, and services 3507 strategy, management, and organisational behaviour 51 physical sciences 3505 human resources and industrial relations	558	67	33	16.9
Cluster 5 (violet)	**39 education** 3904 specialist studies in education 3901 curriculum and pedagogy 3903 education systems	1203	77	35	34.4

3.6 Cluster analysis with major themes

Cluster 1: Biomedical and clinical sciences. The top 3 articles based on AAS in cluster 1 are further analyzed, as seen in Table 5. The highest altmetric attention scored article [17] evaluated the performance of ChatGPT on the three staged United States Medical Licensing Exam (USMLE). Without any specialized training or reinforcement, ChatGPT performed well and scored almost or near the passing score.

The display of concordance and insights in answers was the key highlight of ChatGPT and implied the potential of large language models to assist medical education and clinical decision-making.

Table 5. Top 3 works in Cluster 1 (which is dominated by biomedical and clinical sciences)

Altmetric Attention Score (AAS)	Title (Year)	Application	Authors	Research Organizations	Times Cited	Source
4061	Performance of ChatGPT on USMLE: Potential for AI-Assisted Medical Education Using Large Language Models (2022)	Medical writing/ Education	Kung, Tiffany H et al. [17]	Massachusetts General Hospital; Brown University	21	medRxiv
78	ChatGPT and the Future of Medical Writing. (2023)	Medical writing/ Education	Biswas, Som [5]	The University of Tennessee Health Science Center	5	Radiology
35	Generating scholarly content with ChatGPT: ethical challenges for medical publishing (2023)	Medical writing/ Education	Liebrenz, Michael et al. [18]	University of Bern; University of Zurich; King's College London	6	The Lancet Digital Health

An attempt was made to prove by example that medical writing will heavily depend on AI and chatbots. The experiment involved posing an essay question about radiology training to ChatGPT, and the bot provided a confident, human-like answer reflecting on how good training it has received in radiology [5]. The work concludes by providing some cautions related to ethics, legal issues (including medico-legal issues), innovation, accuracy, bias, and transparency for using ChatGPT to move forward with medical writing.

A study [18] found that ChatGPT's usage in overcoming the language barrier of publishing relieves non-native speakers. ChatGPT's ability to produce misleading and inaccurate content may place medical research at risk of spreading misinformation. Another major challenge comes from Open AI's prospects of monetizing the product after an initial period of free access, as this may widen the existing international inequalities in publishing. Elsevier group of publications' decision to not allow ChatGPT as an author and to demand proper acknowledgment of its use is judiciously based on the apprehension about 'originality' and 'accuracy' of AI-generated text and on the grounds of 'accountability' of the content produced by ChatGPT.

Cluster 2: Information and computing sciences. The analysis of the top 3 articles based on AAS in cluster 2 is presented in Table 6. The article [24], with the second highest AAS score, reported that some scientific manuscript submissions listed ChatGPT as an author in the byline information, causing concern to journal editors and publishers. This forces editors and publishers to devise suitable policies to restrict the use of ChatGPT in scientific authorship.

Nature's editorial piece, "Tools such as ChatGPT threaten transparent Science; here are our ground rules for their use" [20] is the fourth most AAS-scored work. It draws inputs from articles published in Nature about the AI-LLM bot's efficiency in publishing feel-genuine research manuscripts, and editors are already receiving submissions crediting authorship to ChatGPT. In this work, two principles were introduced by Nature and Springer Nature journals (some other journals are on their way to adopting these). These are: (i) No LLM tool will be used as a credited author on a research paper (as AI tools cannot be held accountable while accountability is a primary characteristic

of authorship), and (ii) researchers should properly acknowledge the use of LLM tools in methods, acknowledgment, introduction, or any other suitable sections.

Table 6. Top 3 works in Cluster 2 (which is dominated by information and computing sciences)

Altmetric Attention Score (AAS)	Title (Year)	Application	Authors	Research Organizations	Times Cited	Source
	ChatGPT listed as author on research papers: many scientists disapprove (2023)	Scientific publishing	Stokel-Walker, Chris [24]	Freelance journalist in Newcastle, UK.	27	Nature
	Tools such as ChatGPT threaten transparent Science; here are our ground rules for their use (2023)	Scientific publishing		Editorial	24	Nature
	Comparing scientific abstracts generated by ChatGPT to original abstracts using an artificial intelligence output detector, plagiarism detector, and blinded human reviewers (2022)	Medical writing/ Education & Scientific publishing	Gao, Catherine A. et al.	University of Chicago	14	bioRxiv

The paper [11] found that scientists failed to differentiate between abstracts written by ChatGPT and original abstracts. Upon a test by researchers at Northwestern University, Chicago, led by Professor Gao, the AI output decoder successfully distinguished original abstracts from ChatGPT-generated abstracts while Plagiarism detectors drastically failed. Also, medical researchers correctly identified 68% of abstracts written by ChatGPT and 86% of original abstracts. This outlined the ability of AI-LLM bots to generate convincing medical research articles.

Cluster 3: Language, communication, and culture. The top 3 articles according to AAS in cluster 3 have been analyzed in more detail, as presented in Table 7. The editor's note from Science [31] declared the updating of license and editorial policies of the journal so that not only the text but also the figures, images, or graphics generated by ChatGPT cannot be used in submissions. It also specified that violating these policies will invite actions for scientific misconduct equivalent to altering images or plagiarism of existing works. However, AI's intentional production of legitimate datasets is excluded from such actions.

Table 7. Top 3 works in Cluster 3 (which is dominated by language, communication and culture)

Altmetric Attention Score (AAS)	Title (Year)	Application	Authors	Research Organizations	Times Cited	Source
	ChatGPT is fun, but not an author (2023)	Scientific publishing	Thorp, H Holden [31]	Editor-in-Chief, Science journals.	25	Science
	AI bot ChatGPT writes smart essays – should professors worry? (2022)	Education	Stokel-Walker, Chris [25]	Freelance journalist in Newcastle, UK.	15	Nature
	Abstracts written by ChatGPT fool scientists (2023)	Scientific publishing Education	Else, Holly [8]	A reporter with Nature in London	14	Nature

The news piece in Nature titled "AI bot ChatGPT writes smart essays – should professors worry?" [28] is mainly based on the opinions expressed by Lilian Edwards (New Castle University, UK), Dan Gillmor (Arizona State University, United States), Thomas Lancaster (Imperial College, UK), Aravind Narayanan (Princeton University, United States), and Sandra Wachter (Oxford Internet Institute, UK). Edwards observed that ChatGPT is so good that there is no point in using essays for assessment. Upon Gillmor's test on ChatGPT by feeding a homework question that he often assigned his students, ChatGPT produced a response that would have earned a good grade. Lancaster found no 'game changer potential' in ChatGPT as, according to him, it is trained to generate a new pattern of words based on the pattern of words used it has seen before. Narayanan opined that the 'essays for assignment' problem could be tackled by reworking the assessment priority to encourage critical thinking and reasoning. Wachter found ChatGPT exciting and worrying simultaneously, as students might be outsourcing their writing and thinking. But the challenges are not insurmountable.

And finally, the news [8] published in Nature is mainly about the experiment conducted by Professor Gao and his team. It mainly reports the opinions of Sandra Wachter (University of Oxford), Aravind Narayanan (Princeton University), and Irene Solaiman (Hugging Face, an AI Company). Wachter cautioned of dire consequences to researchers as they might be misled by flawed research and society, as scientific research plays a huge role in society. Narayanan opined that those who are into serious research are unlikely to use ChatGPT and added that the focus should be more on the incentives that lead to 'publication pressure' that forces desperate measures like usage of ChatGPT and mentioned practices like hiring and promotions based on mere counting of publications should be checked. Solaiman insisted that fields like medical science, where misinformation can be fatal, should adopt a more rigorous approach to ensure information accuracy and people's safety.

Cluster 4: Philosophy and religious studies. The top 3 articles according to AAS in cluster 4 have been analyzed in more detail, as presented in Table 8. The article "Rapamycin in the Context of Pascal's Wager: generative pre-trained transformer perspective" [30] has ChatGPT as the first author. It explored the benefits of taking Rapamycin in the context of the philosophical argument 'Of Pascal's Wager'. ChatGPT successfully picked up its pros, like anti-aging effects and life-extension capabilities in animals. Drawbacks of the medicine, especially long-term risks like potential increase in cholesterol and chances for developing diabetes, were also correctly retrieved by ChatGPT. Notably, a wise recommendation to consult health care professionals is also given by ChatGPT.

According to the study [7], the assessment of ChatGPT for the research process at all four stages, from idea creation to testing, is carried out. It found that with the addition of private data (rather than public data) and the researcher's expertise, ChatGPT's results are likely to become more impressive. This work favored the usage of ChatGPT as a research assistant. Regarding the ethical concern of authorship, it draws an analogy to the Banarama Conjecture, where the extent of usage (of ChatGPT in research and level of human supervision) matters most to deciding authorship. This approach can be more suitable than plain acceptance of ChatGPT's authorship or a blanket ban on its authorship.

Table 8. Top 3 works in Cluster 4 (which is dominated by the FoR 'philosophy and religious studies')

Altmetric Attention Score (AAS)	Title (Year)	Application	Authors	Research Organizations	Times Cited	Source
	Rapamycin in the context of Pascal's Wager: generative pre-trained transformer perspective (2022)	Medical writing/ Education	Transformer, ChatGPT Generative Pre-trained; Zhavoronkov, Alex [30]	OpenAI (United States)	11	Oncoscience
	ChatGPT for (Finance) research: The Bananarama Conjecture (2023)	Scientific Publishing	Dowling, Michael; Lucey, Brian [7]	Trinity College Dublin; the University of Economics Ho Chi Minh City; Dublin University	1	Finance Research Letters
	The moral authority of ChatGPT (2023)	Decision Making/ Judgemental aid	Krugel, Sebastian et al. [16]	Technische Hochschule Ingolstadt, The University of Southern Denmark,	0	arXiv

[16] remarked that though the assistance of ChatGPT is beneficial for many purposes, it turns out highly inconsistent as a moral advisor, mainly when different codes of morality exist in society. Despite this, its influence on the user's judgment is predominant. This work views ChatGPT as a threat that corrupts users' judgment. It highlights the need for responsible use of ChatGPT and similar AI and recommends training to improve digital literacy to ensure that.

Cluster 5: Education, curriculum, pedagogy. The top 3 articles according to AAS in cluster 5 are shown in Table 9. The work [22] laid out the implications for higher education and discussed the future of learning, teaching, and assessment. It is observed that ChatGPT can be beneficial in providing conceptual explanations and applications. However, AI is deemed less competent for content that requires higher-order thinking (critical, analytical thinking). It also provided separate recommendations to students, faculty, and higher education institutions in the context of ChatGPT and other AI tools.

The position paper by [14] presented LLMs' potential benefits and challenges from students' and teachers' perspectives. It then discussed how these models could be used to create educational content, improve student engagement and interaction, and personalize learning experiences. It also highlighted that clear strategies within educational systems with a strong emphasis on critical thinking and fact-checking strategies are required to reap the full benefit of these models. It also provided recommendations on addressing these challenges to ensure responsible usage of these models for education.

Table 9. Top 3 works in Cluster 5 (which is dominated by the FoR 'education, curriculum and pedagogy')

Altmetric Attention Score (AAS)	Title (Year)	Application	Authors	Research Organizations	Times Cited	Source
	ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? (2023)	Education	Jürgen Rudolph et al. [22]	Kaplan, Singapore Civica Asia Pacific, Singapore	1	Journal of Applied Learning & Teaching
	ChatGPT for Good? On Opportunities and Challenges of Large Language Models for Education (2023)	Education	Kasneci, Enkelejda et al. [14]	Technical University of Munich, Germany Ludwig-Maximilians-Universitat Munchen, Germany University of Tubingen, Germany	1	EdArXiv

(Continued)

Table 9. Top 3 works in Cluster 5 (which is dominated by the FoR 'education, curriculum and pedagogy') *(Continued)*

Altmetric Attention Score (AAS)	Title (Year)	Application	Authors	Research Organizations	Times Cited	Source
	Mathematical Capabilities of ChatGPT (2023)	Mathematical Education	Frieder, Simon et al. [9]	University of Oxford, UK TU Wien, Austria University of Cambridge, UK University of Vienna, Austria Institute for Advanced Study, Princeton, US	0	arXiv

The preprint [9] investigated the mathematical capabilities of ChatGPT by testing it on publicly available datasets and newly developed benchmark datasets. Upon evaluation of ChatGPT on a benchmark dataset that covers graduate-level mathematics, ChatGPT's mathematical abilities are significantly below that of an average mathematics graduate student. ChatGPT understands the question but fails to provide the right solutions due to a lack of ability for mathematical comprehension.

3.7 Who is tweeting?

Altmetric analyzed the top categories of Twitter users who tweeted about ChatGPT articles by examining their profile descriptions and the types of journals they linked to. The categories of users were divided into three groups: scientists who were familiar with the literature, practitioners who were clinicians or researchers working in clinical sciences, and science communicators who frequently linked to scientific articles from various journals and publishers. The resulting Table provided insights into the demographics of Twitter users engaging with ChatGPT content.

Table 10 shows that scientists had the highest percentage of tweets for the top eight ChatGPT articles, ranging from 21% to 26%. Science communicators had the second-highest percentage of tweets, ranging from 3% to 4%, while practitioners had the lowest percentage of tweets, ranging from less than 1% to 9%. This indicates that scientists are the most engaged group when tweeting about ChatGPT articles, followed by science communicators, while practitioners are the least engaged group. Overall, the Table suggests that individuals primarily discuss ChatGPT articles with a scientific background or an interest in science communication.

Table 10. Types of users on Twitter and the pattern of the mentions by these users concerning publications related to ChatGPT

Article Title	Scientists	Science Communicators	Practitioners
What ChatGPT and generative AI mean for Science	26%	4%	2%
ChatGPT: five priorities for research	26%	3%	2%
AI bot ChatGPT writes smart essays—should professors worry?	24%	3%	< 1%
ChatGPT listed as author on research papers: many scientists disapprove	23%	4%	4%
Tools such as ChatGPT threaten transparent Science; here are our ground rules for their use	23%	3%	3%
ChatGPT is fun, but not an author	23%	2%	4%

(Continued)

Table 10. Types of users on Twitter and the pattern of the mentions by these users concerning publications related to ChatGPT *(Continued)*

Article Title	Scientists	Science Communicators	Practitioners
Comparing scientific abstracts generated by ChatGPT to original abstracts using an artificial intelligence output detector, plagiarism detector, and blinded human reviewers	22%	3%	3%
Abstracts written by ChatGPT fool scientists	21%	3%	3%
How Does ChatGPT Perform on the United States Medical Licensing Examination? The Implications of Large Language Models for Medical Education and Knowledge Assessment	11%	2%	9%
Performance of ChatGPT on USMLE: Potential for AI-Assisted Medical Education Using Large Language Models	6%	3%	1%

4 IMPLICATIONS FOR VARIOUS STAKEHOLDERS

Implications of the findings of this study for some major stakeholders are given below:

4.1 International policymakers

1. As there is ethical concern about the usage of AI LLM bots like ChatGPT in various fields like education, medical diagnosis, etc., and overall use of AI for a multitude of applications, an ethical framework should be formed (possibly under the UN) with experts from different fields all over the world as members.
2. Setting up of legal framework to determine legal limits of the usage of AI in general and AI LLM bots in fields like education, medical writing and diagnosis, law, business and industrial practices etc., and to fix various litigation aspects against breaches violations or crimes should follow the establishment of ethical framework.
3. This should follow the formation of an international body of standardization and regulation to design standards, protocols, and regulation policies for AI in general and AI LLM bots per the international legal framework.
4. Regulation policies, standards, and protocols should be periodically evaluated and revised with time, subjected to the technological advancement of AI in general and improved capabilities with the introduction of newer versions of AI LLM bots like ChatGPT.
5. Concern over the possible loss of jobs once AI in general and AI LLM chatbots might take over many fields should be properly addressed to provide an internationally applicable solution to this problem.

4.2 National policymakers

1. The national-level ethical framework should be developed, bodies should handle ethical issues related to AI in general, and AI LLM bots to ensure congruence

with the international ethical framework to maintain country-specific and region-specific ethos.
2. The national legal framework should be expanded by incorporating general AI and AI LLM bots-related legal aspects.
3. National standardization and regulation bodies should be expanded to cover the usage of AI in general and AI LLM bots in agreement with the national legal framework and in compliance with international standards, regulations, and protocols.
4. Periodical evaluation and revision of regulation policies, standards, and protocols should be practiced to synchronize with international revisions and should consider the legal and ethical framework (that handles country-specific and region-specific ethos).
5. Concern over the possible loss of jobs once AI in general and AI LLM chatbots might take over many fields should be properly addressed to provide a nationally applicable solution to this problem. If an international solution is not viable due to country or region-specific ethos, solutions can be properly modified to suit such ethos.

4.3 Industrial players

1. Current industrial players (in the AI market and AI LLM domain) should envision the possibilities of upcoming international level ethical and legal frameworks as well the possible upgradations in national level ethical and legal frameworks to incorporate aspects related to AI in general and AI LLM to formulate their policies and strategies to develop their AI products and services to make the best out of it.
2. Current industrial players can attempt to attend and have a say in stakeholder meetings to establish international ethical and legal frameworks, get their genuine concerns addressed properly, and oppose any possible manipulation attempts by competitors or other players.
3. Industrial players are planning to enter the AI market in general, and AI LLM bots can plan for their entry as soon as possible because this is the right time for their entry. But whether to enter now can be based on the foresight exercise to list out the challenges they face in doing so related to the characteristics of the market and also in the backdrop of possible challenges posed by upcoming international and national level ethical and legal frameworks and various standardization and regulatory policies and operation protocols.
4. It is high time industrial players in various fields that may face the takeover of AI applications choose whether to go for AI or continue with their product or process innovations for more years.
5. As concerns over ChatGPT's potential to pose a threat to human employees in different fields mount, and if international or national solutions are not available, human resource departments of industrial players have to consider the best ways to retain human employees effectively and to train AI compatible skills properly to them to cope with a possible shift towards a work environment that includes AI in general and AI LLM bots.

5 CONCLUSIONS

A remarkable gold rush was witnessed post the launch of ChatGPT, the most successful AI large language model chatbot created so far. In this context, we attempted

to determine how the scientific community responded to this technology product in its early stage. As three-four months is a very early stage to assess the impact through citation analysis (citations take a somewhat more extended period to accumulate to conduct any serious research study), we used altmetrics or alternative metrics to get an idea about the early impact of the early response from the scientific community through various publications. Specifically, we attempted to identify/determine (i) the source titles that got the most aggregated altmetric attention and the pattern of attention garnered by these source titles, (ii) the countries that got the most aggregated altmetric attention via the early publications, (iii) the attention obtained by early ChatGPT publications in different social media platforms that constitutes the altmetric attention score (aggregated score), (iv) field-wise mapping of ChatGPT publications and top FoRs that gained most altmetric attention and (v) type or category of tweeters who recorded their early response to early ChatGPT research.

Apart from this, cluster analysis of FoR mappings among themselves is also analyzed. There were five clusters in the FoR interlinkage network. Information and computing sciences, language communication and culture, and biomedical and clinical sciences are the most attention-scored representative FoRs from the top three clusters. Further, we analyzed the top three publications from each cluster. Most works in different clusters discussed apprehension and excitement related to ChatGPT's potential to revolutionize education, especially medical writing and education. Different arguments in favor of and against the game-changing potential of ChatGPT are discussed in various works. The stringent stance of leading publishers of leading sources, like Nature, Science, and the Lancet, etc., about the authorship of ChatGPT and acknowledgment of its usage in science writing is also revealed in clusters focussed on scientific publishing and medical writing/education. The pros and cons of ChatGPT usage in education are also discussed in clusters focussing on education. Also, the ineffectiveness of ChatGPT as a moral advisor, its limitations in solving mathematical problems of undergraduate level and above, and its inability to develop content related to topics that require critical thinking and analytical reasoning were made into the content of most altmetric scores works.

As altmetrics is being debated as a foreteller of citations since altmetric scores correlate highly with citations, the power law behavior of altmetrics (just like citations) is recently revealed [4]; these works should be earning commendable citations too. FoRs in these clusters are anticipated to grow remarkably as publications accumulate citations. Thus, this work provides a sense of direction to researchers in various FoRs looking to dive into research on or related to ChatGPT. Also, institutions and educational policymakers weighing on whether to embrace ChatGPT can understand where to look and what to do at this initial stage as implications to various stakeholders are discussed in this work.

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The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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