Research Trends in Virtual Assistants: An Integrated Scientometric and Topic Modeling Study (2014-2024)

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ABSTRACT

Virtual assistants have become integral to personal and professional spheres, demonstrating their utility in various domains such as e-commerce, social media, and administrative tasks. This study examines research trends and new themes in virtual assistant research from 2014 to 2024 using a scientometric technique in conjunction with Latent Dirichlet Allocation (LDA). It analyses global publication trends, prominent authors, prolific sources, and important study subjects like artificial intelligence, conversational agents, and human-centered studies based on 8,079 Scopus-indexed papers. An annual publication growth rate of 33.87 % reflects rising interest in this domain. Four main themes emerged from topic modeling: healthcare applications, user-centric conversational AI, educational technology, and AI-driven information systems and chatbots. Terms like "chatgpt", "education" and "patients" indicate a variety of applications, and the Inter-topic Distance Map and saliency-based analysis highlight theme similarities and contrasts. The report offers a thorough analysis of the changing field of virtual assistant research, providing insightful information for further investigation and advancement in this ever-evolving area.

Keywords: Virtual assistants; Scientometric; Topic modeling; Latent dirichlet allocation (LDA); Artificial intelligence

1. INTRODUCTION

In basic terms, a virtual assistant is an application program that can comprehend natural language and carry out activities for the user[1,2,3]. Virtual assistants, or VAs, are becoming more and more common in practically every industry, including government, business, and people's personal and professional lives. An intelligent application called a virtual assistant can help a user by providing services or support when they are giving directions or placing orders. VAs comes in a variety of forms, including administrative, book keeping, social media, real estate, and e-commerce[4]. It has been recognised that virtual assistants have been included into both personal and professional realms[5,6,7,8]. The vast array of scholarly literature in trendy domain like virtual assistants poses challenges in identifying trends and topical foci. It can be difficult to pinpoint trends and topical themes in a wide range of scholarly literature in cutting-edge fields like virtual assistants. In order to find hidden patterns in literature from academia, researchers have shifted to computational techniques like topic modeling, particularly Latent Dirichlet Allocation[9,10,11,12]. In this study, a topic modeling-based scientometric analysis will be conducted to identify the leading topics and emerging trends in the field of virtual assistants. Topic models are widely used in exploratory data analysis to find latent "topics" in a set of documents by analysing word distributions to find semantic trends. Different themes are presented in different proportions in each document. By enabling direct comparisons between various data and document kinds, topic models provide flexibility. The underlying latent semantic structure inside big text collections is revealed by automatically clustering frequently co-occurring words across documents to discover unique subjects. Meanwhile, scientometric analysis provides a broader perspective by monitoring global research trends, analysing publications, evaluating author, source, and affiliation citations, and examining the cognitive structure of science.

Therefore, in order to obtain both a macro-level comprehension of publication patterns and a micro-level investigation of subject structures, a combined scientometric and topic modeling method is necessary. Researchers can track changing themes, find hidden trends, and more precisely map the field's trajectory thanks to this integration. Together, these methodologies offer a comprehensive approach to understanding the evolving landscape of virtual assistant research[13,14].

2. LITERATURE REVIEW

Li[15], *et al.* in their 2024 study examined the publication trends and evolution of the International

Journal of Surgery over its 20-year history (2004-2024). It pinpoints prolific contributors, institutions, and countries, along with thematic trends in surgical research. The research emphasises the incorporation of AI and deep learning as a prospective area of focus for progress in surgery. Another study conducted by Dymkova[16], *et al.* investigates how technology influences the analysis of scientometric indicators related to scientists and universities, with particular emphasis on its effects on the peer-review process. It investigates the outcomes of peer-reviewed articles from the TIRVED-2024 conference, which is backed by IEEE, and scrutinizes conference materials according to the Hirsch index distribution of the authors and organisations. Yumnam[17], *et al.* analysed global research trends in bioactive compounds from 1989 to 2023, utilising Web of Science data and bibliometric tools such as Biblioshiny and VOSviewer. The results indicate a noteworthy increase in publications, with Brazil at the forefront of contributions and King Saud University generating the highest volume of research. Limitations include dependence on one database, indicating the necessity for wider data exploration. Yun[18], *et al.* assessed public awareness and the policy challenges encountered by nurses during the COVID-19 pandemic through an analysis of nurse-related news articles published before and after the "Thanks to You Challenge" campaign (December 2019–July 2020). It identified changes in prevailing topics before and after the campaign using keyword analysis, latent Dirichlet allocation topic modeling, and keyword network analysis. The campaign focused on themes of gratitude and sacrifice, but critical issues that nurses faced during the crisis were not adequately represented in media coverage. The research highlighted the necessity of tackling genuine policy challenges and promoting public-nursing initiatives that benefit both parties. Negara*19*, *et al.* examined tweets as big data through the Latent Dirichlet Allocation technique to produce topic modeling, topic similarity assessments, and visualisations of topic clusters. Tweets in Indonesian were classified into four primary topics: Economic, Military, Sports, and Technology, each having a different number of tweets. The LDA method exhibited superior effectiveness in topic extraction and word indexing, attaining an accuracy of 98 % for the Sports topic-this surpassed the performance of the Latent Semantic Indexing method. The research emphasises LDA's capability in handling extensive tweet data and illustrating topic clusters.

3. OBJECTIVES

- To examine the trends in research output from 2014 to 2024.
- To identify the leading and the most globally cited sources.
- To evaluate the research themes and word frequency trends over time.

- To visualise and interpret the distribution of the top 30 prevalent topics in virtual assistant research using 2D topic modeling techniques.
- To identify latent topics and assess their significance by analyzing beta values and word frequency.

4. SCOPE AND LIMITATIONS

This study analyzes Virtual Assistant research from 2014 to 2024 using Scopus data, employing bibliometric, scientometric, and topic modeling methods to identify trends, leading authors, and emerging themes. The focus is limited to peer-reviewed articles, relying solely on Scopus, and excludes other document types. The study is constrained by its timeframe from 2014-2024, LDA's algorithmic limitations, and potential terminological gaps in the query.

5. MATERIALS AND METHODS

Research on virtual assistants has been tracked using the scientometric & bibliometric method, which has recently become a very prominent application in business research[20,21]. The topic modeling approach has also been used to find latent topics in the literature. Bibliometric techniques are used to quantify the productivity of scientific production. "The application of mathematical and statistical methods to books and other media of communication" is how Pritchard[22] described bibliometrics.

5.1 Data Source

For this study, the Scopus database, which hosts an extensive library of over 94 million records[23], was utilised to gather bibliographic data. To collect information relevant to virtual assistants, an advanced query was formulated (TITLE-ABS-KEY ("Virtual Assistant" OR "Virtual Assistance" OR "Conversational Agent" OR "AI Assistant" OR "Intelligent Assistant" OR "Chatbot" OR "Digital Assistant" OR "Voice Assistant")). The search was restricted to the time period from 2014 to 2024 and limited to documents classified as articles. A total of 8,079 records were retrieved and exported in both CSV and BibTeX formats for further analysis.

5.2 Data Analysis

Microsoft Excel 2021 was used for basic data analysis, while the Biblioshiny package in RStudio was employed for scientometric analysis, including tasks such as analyzing publication trends, identifying leading authors and sources, assessing word frequency, and generating visualisations like three-field plots. Biblioshiny provides a user-friendly web interface for Bibliometrix, enabling academics to easily access its core functionalities, such as data filtering, importing, converting data to data frames, and collecting data using Dimensions, PubMed, and Scopus APIs[24].

For topic modeling analysis, the Latent Dirichlet Allocation algorithm was implemented on the R platform,

supported by key packages such as 'topicmodels', 'dplyr', 'LDAVis', 'LDAshiny' and 'ggplot'[25].

6. RESULTS AND DISCUSSION

The first research output on Virtual Assistants indexed in the Scopus database was published in 1971. Within the field of Virtual Assistants, a total of 8,079 articles were published between 2014 and 2024, following a restriction to document type "articles". The annual growth rate of publications was found to be an impressive 33.87 %, with an average document age of 3.5 years. Additionally, the average citation per document stood at 19.69, reflecting the scholarly impact of this domain. The detailed bibliographic information is presented in Table 1.

6.1 Publication Trend and Sources

Figure 1 illustrates the year-by-year trend in the number of publications. The trend demonstrates that growth was relatively slow until 2018, with gradual increases observed in earlier years, such as 2014 to 2017. However, starting from 2018, the gowth rate became more pronounced. A noticeable surge in publication output occurred from 2018 (322 publications) to 2019 (524 publications). This rapid growth continued consistently in subsequent years, with the number of publications rising dramatically, particularly between 2022 (903 publications) and 2023 (1505 publications). By 2024, the publication

Table 1. Basic information about the documents

Main information about data	
Description	**Results**
Timespan	2014:2024
Sources	3055
Documents	8079
Annual growth rate %	33.87
Document average age	3.5
Average citations per document	19.69
Author's keywords	17849
Keywords plus (Id)	22235

count reached 2496, marking an exponential increase. This trend highlights a significant rise in interest and research activities in the subject area, especially in recent years.

Figure 2 visualises the top 10 most relevant sources for publications in the field of Virtual Assistants. The analysis of publication sources revealed the most prolific outlets contributing to research in this domain. The top three sources include the Journal of Medical Internet Research, which leads with 115 publications, followed by the International Journal of Human-Computer Interaction with 107 publications, and IEEE Access with 105 publications. These journals serve as the primary platforms for disseminating significant research findings in the field.

Table 2 showcases the top globally cited documents in the field of Virtual Assistants, emphasising their Total Citations (TC), citations per year (TCP), and Normalised Total Citations (NTC). The most cited document is by Dwivedi YK (2023), published in International Journal of Information Management, with 1663 total citations, 554.33 citations per year, and a normalised TC of 80.84. This is followed by Fitzpatrick KK (2017), published in JMIR Mental Health, with 1221 citations, 135.67 citations per year, and an NTC of 37.23. The third is Sung YT (2016), featured in Computers & Education, with 1044 total citations, 104.40 citations per year, and an NTC of 29.78. These metrics highlight the remarkable impact and influence of these studies in shaping Virtual Assistant research globally.

6.2 Research Themes and Word Frequency

Figure 3 classifies research themes into four quadrants according to density and centrality, a thematic map created from the analysis of author keywords in the study area reveals the spatial organisation and connections within the field[26-27]. The basic themes in the lower right quadrant include large language models, natural language processing, and machine learning, representing fundamental ideas that guide research and implementation. In the motor theme section of the upper right quadrant, highly influential and interconnected topics such as artificial intelligence, ChatGPT, mental health, and human-centered studies are highlighted, indicating their pivotal role in advancing the field and
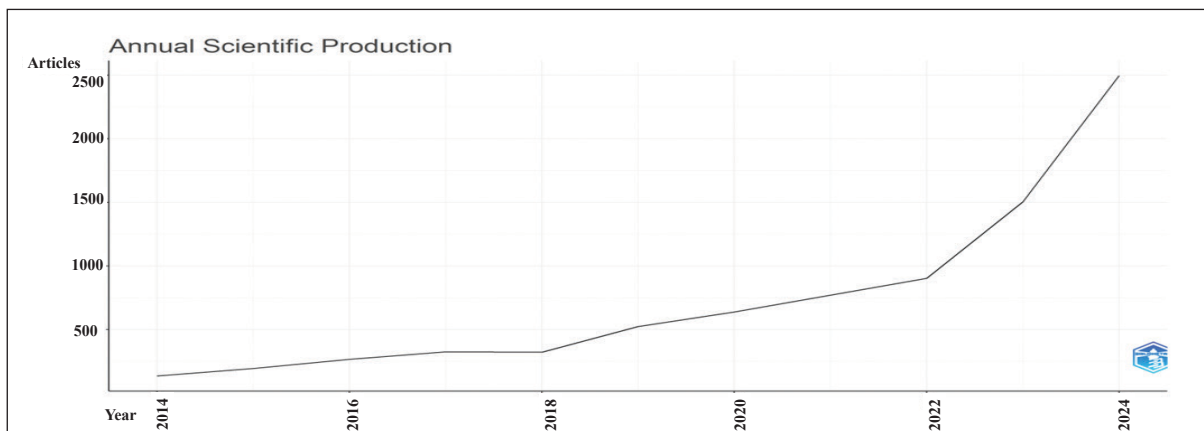

Figure 1. Year-wise publication trend of virtual assistants research.

addressing key societal needs. The emerging or declining themes in the lower left quadrant include natural language processing systems, natural languages, user interfaces, chatbots, conversational agents, language models, and deep learning. These topics exhibit different patterns, with some gaining traction and others possibly losing their significance. The upper left quadrant's niche themes such as learning systems, sales, and customer service, represent narrow but developing fields of interest that are underrepresented but have room to grow and find use in targeted fields.

Table 3 presents the frequency trends of the top 10 keywords over time, reflecting the evolving focus in research. Words like "human", "female", and "male"

dominate consistently, showing their central relevance to studies, with notable growth after 2019. Terms like "artificial intelligence" and "personal digital assistant" show a sharp rise, particularly from 2020 to 2024, highlighting the increasing prominence of AI-driven technologies. Similarly, "humans", "article", and "adult" steadily increase, showcasing a broader exploration of human-centered research topics. Keywords like "computers" and "handheld" also demonstrate consistent growth, reflecting technological advancements and their role in the field. The peak in 2024 across all terms signifies the rapid expansion and diversification of research in this domain.
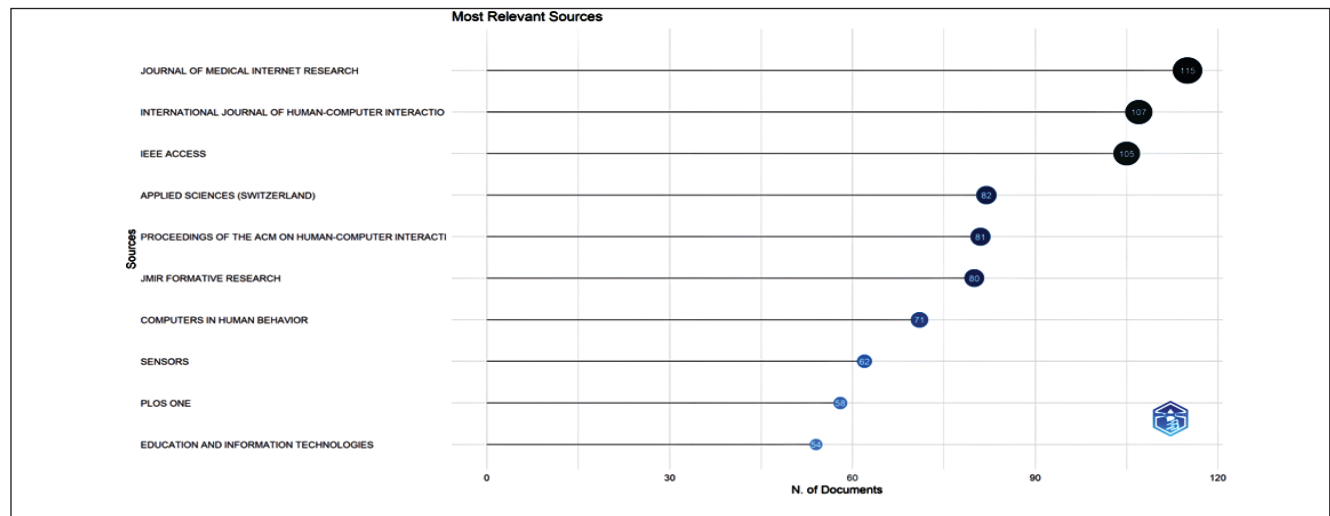

Figure 2. Top 10 publication sources.

Table2. Top globally cited documents

Paper	Total citations	TC per year	Normalised TC
Dwivedi YK, 2023, Int J Inf Manage	1663	554.33	80.84
Fitzpatrick KK, 2017, Jmir Ment Heal	1221	135.67	37.23
Sung YT, 2016, Comput Educ Gig Sanit	1044	104.40	29.78
Gilson A, 2023, Jmir Med Educ	945	315.00	45.94
Ayers JW, 2023, Jama Intern Med	866	288.67	42.10
Lee P, 2023, New Engl J Med	745	248.33	36.22
Rudolph J, 2023, J Appl Learn Teach-A	725	241.67	35.24
Tlili A, 2023, Smart Learn Environ	709	236.33	34.47

6.3 Topic Modeling and Latent Topics

Topic modeling using Latent Dirichlet Allocation (LDA) was applied to uncover latent semantic structures in the Virtual Assistant (VA) literature corpus from 2014-2024. An optimal number of k = 4 topics was selected based on coherence scores and iterative model evaluation.

Fig 4 presents the Inter-topic Distance Map (left) and Top-30 Most Salient Terms (right). The map uses Multidimensional Scaling (MDS) to spatially visualise the relationship between topics. Each blue circle represents a topic, and its size reflects the topic's proportional presence in the overall dataset. Topics closer together

share semantic overlap, while those further apart are more distinct. Topic 3 appears isolated in the top-left quadrant, indicating a concentrated and unique thematic area-likely technical research on conversational systems. In contrast, Topics 2 and 4 overlap, showing thematic proximity, possibly related to user experience and domain-specific applications (e.g., education and healthcare). Topic 1, being central and large, reflects a broad and dominant theme encompassing keywords such as "chatgpt," "intelligent," and "information." These observations confirm the model's ability to separate major clusters while recognising overlap where appropriate. The bar chart to the right

displays the Top-30 Most Salient Terms, with blue bars representing total frequency and red bars indicating their prominence within specific topics. High-saliency terms such as "study," "participants," "assistant," "artificial," and "customer" illustrate the multifaceted focus of VA research. The chart also validates the chosen topic granularity and term coherence.

Together, these visualisations not only highlight the topical diversity in VA research but also justify the structural composition of the selected topic model. The findings offer valuable insight into the evolution and focus areas of the field and set a foundation for further investigation.

Figure 5 illustrates the primary terms associated with four distinct topics identified by the LDA model, each topic representing a specific thematic focus. The red panel (Topic 1) includes terms like "information," "use," "chatgpt," and "model," indicating a wide-ranging inquiry into artificial intelligence and chatbots, particularly their utility and roles regarding information. Terms such as "chatbots", "health", "patients", and "language" are highlighted in the green panel (Topic 2), signifying the application of chatbots in healthcare, especially in relation to patient interaction, language use, and results analysis. Marked by phrases like "conversational", "study", "participants", and "health", the blue panel (Topic 3)
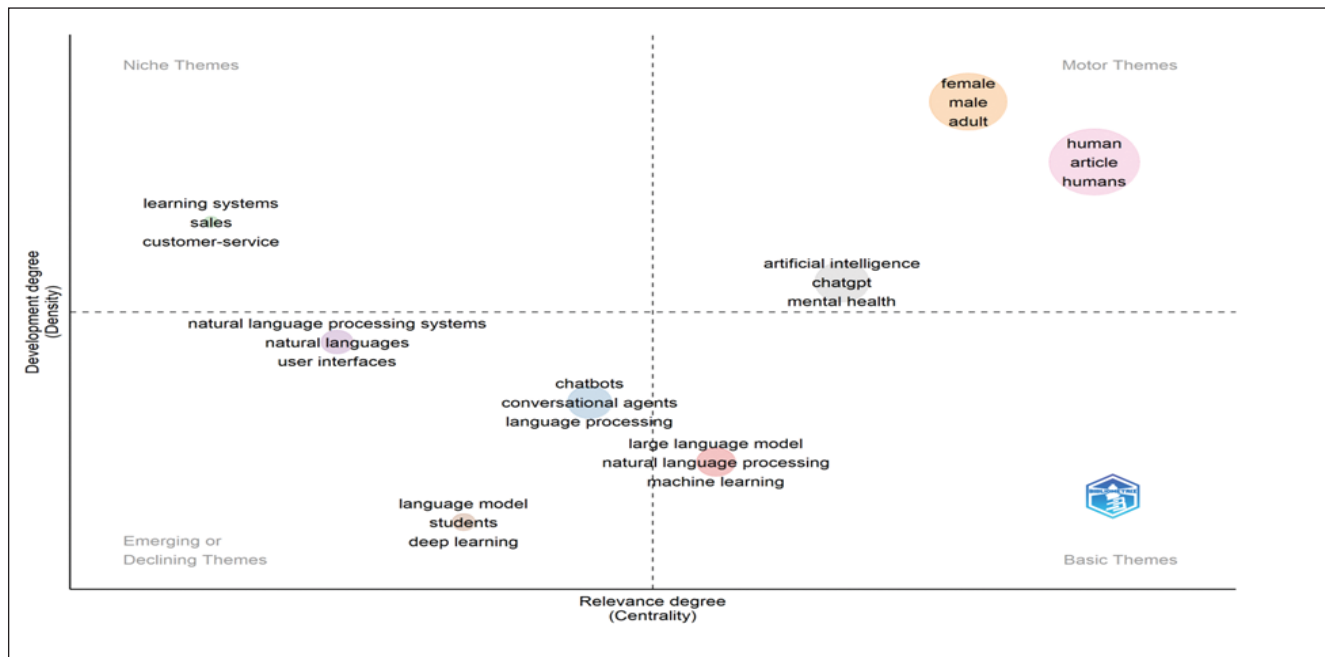

Figure 3. Thematic map.

Table 3. Word frequency over Time

Year	Human	Female	Male	Humans	Article	Adult	Artificial intelligence	Personal digital assistant	Computers	Handheld
2014	55	61	50	44	42	45	11	39	30	27
2015	194	241	215	183	119	157	15	164	151	145
2016	412	499	457	386	226	313	19	368	343	329
2017	637	800	756	601	349	504	33	570	535	519
2018	817	1038	1000	766	458	644	58	715	681	664
2019	1057	1368	1318	982	615	855	92	896	869	845
2020	1310	1659	1600	1204	774	1033	162	1037	1011	986
2021	1546	1843	1763	1388	939	1179	292	1134	1112	1083
2022	1755	1972	1869	1551	1062	1279	396	1206	1189	1155
2023	2115	2142	2017	1817	1335	1413	803	1227	1210	1176
2024	2770	2636	2479	2308	1843	1756	1547	1284	1269	1234

indicates an emphasis on user-centric research involving conversational AI that may explore interactions and health-related outcomes.

The terms "study", "chatbot", "education" and "technology" on the purple panel (Topic 4) indicate a strong connection between AI tools and advancements in educational and learning technologies. The terms within each panel are arranged based on their probabilistic relevance, reflecting the nuanced associations inherent to each topic. This visualisation offers a more profound understanding of the discussions about AI and chatbots in various domains such as healthcare, education, and conversational systems, emphasising their diverse applications and theoretical underpinnings.

7. MAJOR FINDINGS

This research provides important insights into the growth trajectory, trends, and gaps in the field. The research output has increased rapidly, with an annual growth rate of 33.87 % over the past decade, indicating widespread interest and technological progress in VAs. Major factors driving this momentum include advancements in artificial intelligence, especially natural language processing, conversational AI, and adaptive machine learning systems. This trend is evident in the average citation rate of 19.69 per document, which indicates the academic significance of VA-related studies when compared to the findings of Singh & Yadav[28]. Influential journals such as the Journal of Medical Internet Research and Computers in Human
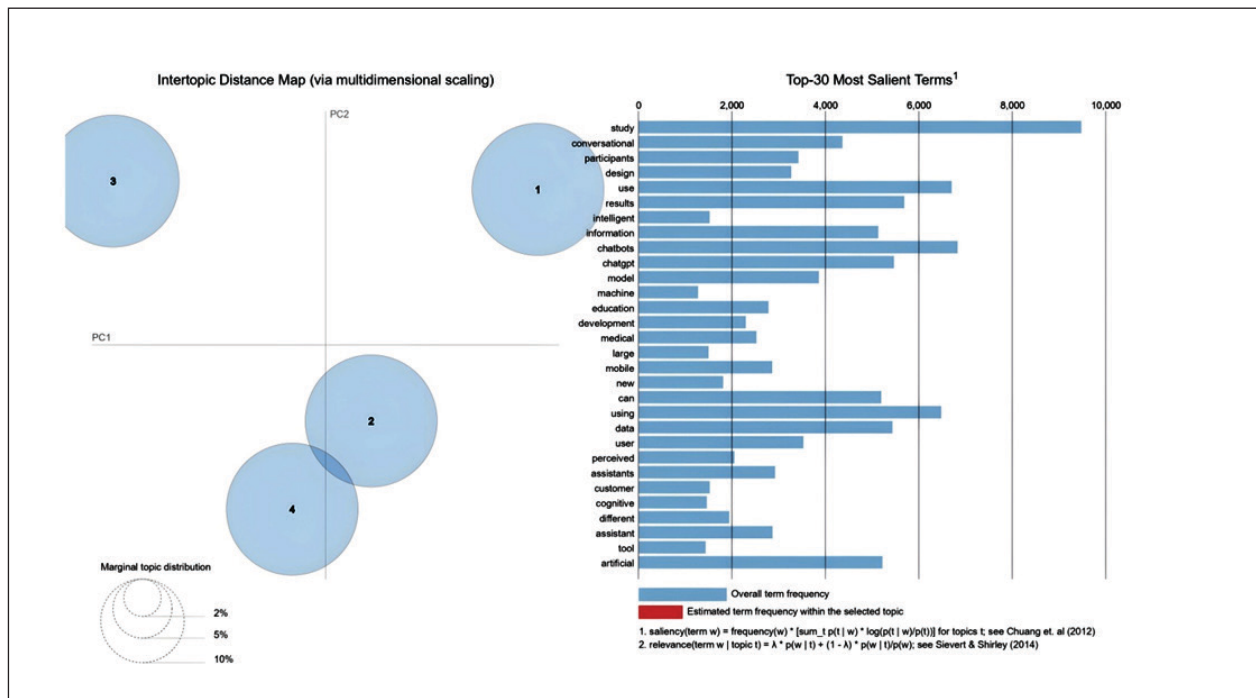

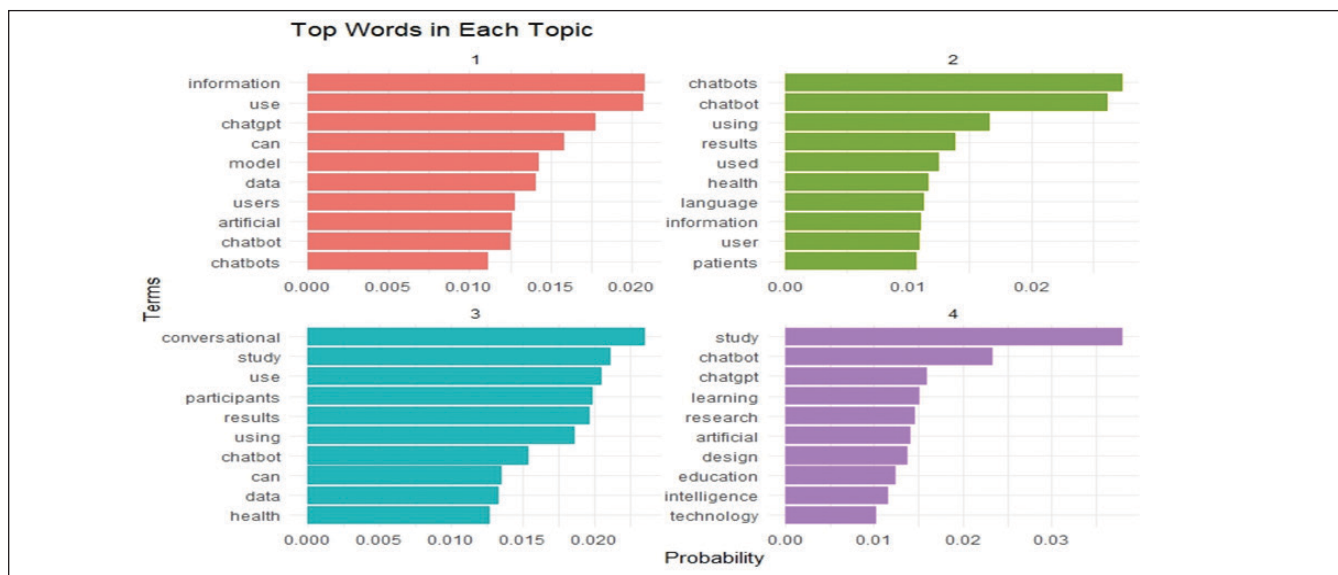**Figure 4. 2D topic visualisation and top 30 prevalent terms.**

Figure 5. Identified latent topics with beta values.

Behavior have been crucial in spreading high-quality research and promoting interdisciplinary collaborations.

The 2D topic analysis conducted on the research unveils a developing thematic landscape. Initial studies of a foundational nature concentrated on essential technological frameworks like speech recognition, semantic search, and user interfaces. With the passage of time, themes that are tailored to applications-especially in the areas of individualised education, health management, and business automation-have become more prominent. This development shows a transition from theoretical foundations to practical applications. By revealing concealed research trends and clarifying the emergence of subfields, latent topic analysis provides additional insights. VA-based assistive technologies for individuals with disabilities, the use of VAs for emotional support, and ethical dilemmas surrounding data privacy and algorithmic bias are underrepresented yet critical areas that require further investigation.

The findings further highlight considerable deficiencies in the area. Topics such as cultural adaptability, multilingual support in VAs, and the creation of inclusive AI systems for marginalised populations are still in their early stages and require more academic focus.

To summarize, the evolution of research themes, as demonstrated by 2D and latent topic analyses, highlights the field's development from technical advancements to a variety of applications. To guarantee that VA technologies are accessible, equitable, and beneficial worldwide, it is crucial to address the gaps in geographical representation, interdisciplinary collaboration, and ethical considerations. These findings offer a roadmap for future research, promoting initiatives to tackle these crucial challenges while maintaining innovation within this transformative field.

8. CONCLUSION

Providing a scientometric analysis of Virtual Assistant research from 2014 to 2024, this study employs topic modeling to investigate growth patterns, thematic trends, and research collaborations. Driven by advancements in artificial intelligence, machine learning, and natural language processing technologies, the analysis highlights the rapid development of VA research. Over the past ten years, the research identifies important authors, institutions, and nations that have made significant contributions to the advancement of the field. Additionally, it highlights significant publications and thematic trends, such as human-computer interaction, natural language understanding, voice recognition systems, and the use of VAs in areas like education, healthcare, and e-commerce.

This research offers a more profound insight into the thematic emphasis and development of VA studies by combining scientometrics with topic modeling. By providing a structured analysis of research trends over the past ten years and mapping the trajectory of this field, it addresses significant deficiencies in the current literature. The study's conclusions provide academics, decision-makers, and developers with a strategic roadmap.

Better budget allocation and research emphasis are made possible by emphasising new areas of study and collaborative trends. Institutions are able to find understudied theme areas and significant contributors. By highlighting important areas for advancement in the discipline, it also helps build curricula for LIS and AI education. The results serve as a guide for scholars and professionals, inspiring further research into new topics and the long-term viability of VAs in the face of swift technological change.

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