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Analysis of Co-authorship Patterns in Global e-Health Literacy Research

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Abstract

Rationale of the Study - This study investigated the co-authorship patterns in global research on e-health literacy, focusing on authors, countries, and organisations to reflect the participation of African researchers and their institutions in collaborative research on e-health literacy.

Methodology - The study period covered 2006 to 2024 and was based on publications retrieved from Scopus. VOSviewer was used to identify and map co-authored documents, uncovering valuable information about authorship.

Findings - From 2006 to 2024, a total of 7,887 authors wrote 2,027 documents on the subject, amounting to 415 authorships per annum. Leading countries in co-authorship include the US, Germany, Australia, and Canada. There were only 12 connected organisations, indicating room for growth in inter-institutional research partnerships. The University of Education, Winneba, Ghana, was the only African institution to have published four documents and established four collaborative links.

Implications - Expanding institutional partnerships, particularly with countries that have high research volumes, such as China, could help address the disparity between research quantity and citation impact. Promoting structured collaborations can facilitate resource sharing, diversify perspectives, and improve the overall quality and influence of research, driving innovation and advancing the field globally.

Originality - Many studies in this field focused on quantitative research, but this study deploys bibliometrics to reveal important insights. A unique finding of the study is a comparatively high volume of Chinese research. Conversely, previous studies have shown that China has a low research impact, highlighting disparities in global research influence.

Keywords

Collaborative networks, author impact, global research trends, institutional connections, publication metrics

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1 Introduction

Since the concept of e-health was first introduced by Mitchell in 1999, its scope and application have grown significantly, encompassing a wide range of information and communication technology (ICT) tools used to support health services. These include electronic health records, telemedicine, mobile health (mHealth), and web-based health interventions. As e-health technologies increasingly redefine healthcare delivery, a related concept - e-health literacy - has emerged as a crucial determinant of individuals' ability to effectively engage with digital health resources (Norman & Skinner, 2006; WHO, 2018).

E-health literacy is the capacity to seek, find, understand, and appraise health information from electronic sources and apply this knowledge to solve health problems. It integrates digital literacy, health literacy, and information literacy, thereby equipping individuals with the skills to make informed health decisions in a digital environment. As digital health becomes integral to achieving Universal Health Coverage (UHC), research on e-health literacy is gaining global attention, particularly regarding how populations engage with digital health tools and platforms (Kickbusch et al., 2013; Nwagwu, 2022).

Despite the increasing number of publications in this domain, little attention has been paid to understanding the collaborative dynamics - specifically co-authorship patterns - that drive research output in e-health literacy. Co-authorship is a measurable indicator of collaboration and knowledge exchange, particularly in interdisciplinary and international research. Analysing co-authorship can reveal the structure of research communities, identify influential researchers and institutions, and highlight gaps in collaboration across regions or disciplines (Glänzel & Schubert, 2004; Wang et al., 2020). This study contributes to bridging that gap by applying bibliometric methods to examine co-authorship in global e-health literacy research. The analysis focuses on three core dimensions: 1) the quantity of co-authored documents; 2) levels of co-authorship (small vs. large research teams); and 3) patterns of collaboration among authors, countries, and institutions. Special emphasis is placed on mapping the participation of African researchers and institutions to assess their visibility and integration within the global e-health research network.

Understanding these patterns is crucial for identifying knowledge hubs, fostering collaboration between high- and low-income countries, and ensuring that the global development of e-health literacy encompasses diverse and underrepresented voices, particularly those from Africa. By exploring these dynamics, this study not only highlights the structure of existing research efforts but also provides insights for enhancing global and

regional partnerships in digital health literacy research.

The research problem addressed in this study lies in the need to understand the co-authorship dynamics within e-health literacy literature using bibliometric analysis. Despite the growing importance of e-health literacy in healthcare research (Nwagwu 2022), little is known about the patterns and trends in collaborations among authors in this field. Additionally, the influence of key authors and institutions in driving advancements in e-health literacy remains understudied.

This study was conducted to investigate the quantity of co-authored documents, co-authorship levels, and co-authorship patterns in global research on e-health literacy, focusing on authors, countries, and organisations, to reflect the contributions of African researchers and their institutions to collaboration in e-health literacy research.

2 Literature review

The literature review is discussed based on the study's objectives.

2.1. Empirical studies on e-health literacy

The study of e-health literacy has evolved significantly over time, with early research laying the foundation for understanding how individuals' access, comprehend, and utilise online health information. According to Nwagwu (2022), 1176 documents were produced in the subject matter between 2006 and 2022. This review reflects on a few of these documents. Nguyen et al. (2013) focused on visual aids for communicating medical risks, concluding that icon arrays, bar graphs, and pictographs effectively aid comprehension, particularly for patients with low literacy but high numeracy skills. Mitsutake et al. (2016) demonstrated a strong correlation between e-health literacy and healthy behaviours, including physical activity, dietary choices, and preventive healthcare engagement. Diviani et al. (2015) found that individuals with low health literacy often struggled with comprehension and confidence in using online resources. This was further reinforced by Paige et al. (2017), who explored the relationship between e-health literacy and trust in online health communication, highlighting the role of data visualisation in enhancing comprehension. Expanding on this, Chang et al. (2021) found that consumers primarily relied on content-related indicators, such as credibility and source reputation, rather than their e-health literacy skills when evaluating online health information.

Recent studies have delved into demographic and contextual predictors of e-health literacy. Alzougool (2022) conducted a quantitative study in Jordan, identifying gender, occupation, perceived usefulness of the internet, and frequency of online health information-seeking as key predictors. In a similar vein, Yuce et al. (2022) examined e-health literacy among chronic patients in

Izmir, Turkey, finding that digital literacy and social media use significantly influenced literacy levels. Maggioni (2023) emphasised the role of healthcare organisations in enhancing patients' ability to navigate digital platforms for health promotion. Digital inequalities persist as a significant challenge in e-health literacy research. Khilnani et al. (2020) noted that the COVID-19 pandemic exacerbated disparities in information access, disproportionately affecting marginalised communities. Palumbo (2021) echoed this concern, arguing that the rapid expansion of telemedicine risks excluding digitally disadvantaged populations.

In the African context, mobile technology has emerged as a pivotal tool for improving e-health literacy. Shabi and Oyewusi (2017) demonstrated the effectiveness of mobile health tools in promoting literacy among Nigerian adolescents. Further supporting this trend, Shiferaw et al. (2020) examined e-health literacy among chronic patients in Nigeria, identifying strong links between literacy levels and proactive health-seeking behaviours. The comprehensive scoping review by El Benny et al. (2021), which analysed 131 Digital Health Interventions (DHIs) across 26 countries, found that most initiatives focused on non-communicable diseases and mental health yet lacked comprehensive coverage of all e-health literacy domains. Li et al. (2020) underscored the importance of data visualisation in mapping regional disparities in e-health literacy in China, emphasising the utility of heat maps and bubble charts in enhancing data accessibility. These studies highlight the complexity of e-health literacy, illustrating its critical role in shaping health behaviours, reducing health disparities, and informing digital health policies. The findings underscore the need for inclusive strategies that bridge literacy gaps worldwide, ensuring that digital health interventions effectively reach and benefit all populations.

Green (2025) highlights the increasing importance of electronic health literacy in ensuring positive health outcomes, particularly among ageing populations. The study focused on validating the Hebrew version of the Electronic Health Literacy Scale (HeHEALS) for Israelis aged 65 and older, examining its psychometric properties, including content validity, construct validity, and reliability. Findings demonstrated that HeHEALS is a reliable tool for measuring eHealth literacy, with significant correlations found between literacy levels and factors such as education, income, and health status. These results align with previous research that highlights the importance of digital health literacy in achieving health equity (Chauhan et al., 2024).

Building on the connection between eHealth literacy and health-related outcomes, Hu et al. (2025) examined its influence on the return-to-work (RTW) process among young and middle-aged survivors of colorectal cancer (CRC). The study revealed that eHealth

literacy, along with RTW self-efficacy and family resilience, significantly impacted successful RTW outcomes. This research supports previous findings that underscore eHealth literacy as a determinant of health-related behaviours and social reintegration (Peimani et al., 2024). These insights further emphasise the necessity for health professionals to design targeted support programs that leverage eHealth literacy to facilitate RTW for CRC survivors.

Similarly, Peters et al. (2024) explored behavioural intentions regarding digital discharge management interventions after bariatric surgery, emphasising the role of eHealth literacy in adoption rates. Using the Unified Theory of Acceptance and Use of Technology (UTAUT), the study identified eHealth literacy as a significant predictor of digital intervention usage. These findings align with prior research that links digital literacy to the acceptance and effectiveness of health technologies (Yang et al., 2024). This highlights the need for targeted interventions that promote digital health engagement and facilitate the effective adoption of digital health solutions. Extending the discussion on digital engagement, Yang et al. (2024) investigated the role of eHealth literacy in shaping health behaviours among university students in Wuhan, China, particularly in the context of TikTok usage for health information. The study found a positive correlation between TikTok health information-seeking behaviours and preventive health actions, mediated by eHealth literacy and COVID-19 risk perception. These results contribute to the growing body of literature emphasising the impact of social media on health information dissemination and behavioural changes (Chauhan et al., 2024). This highlights the need to improve digital health literacy and promote informed decision-making among young populations.

Taking a broader approach, Chauhan et al. (2024) conducted a systematic review and meta-analysis to examine the association between health literacy and multimorbidity. Their findings revealed that individuals with lower health literacy levels were more likely to experience multiple chronic conditions, with education and income identified as key determinants of this outcome. These results reinforce the critical role of eHealth literacy in managing chronic diseases and the necessity for targeted interventions to improve health literacy among at-risk populations (Green, 2025). This interconnected relationship between eHealth literacy and health outcomes demonstrates the widespread impact of digital health engagement.

Further exploring the role of eHealth literacy in chronic disease management, Peimani et al. (2024) examined its moderating effects on the relationship between online diabetes information-seeking behaviour and self-care practices. Their findings indicated that higher

eHealth literacy levels improved self-care behaviours and medication adherence, emphasising the importance of digital literacy in chronic disease management. This research aligns with previous studies highlighting the intersection of digital health engagement and patient empowerment (Hu et al., 2025). Consequently, the study recommends increased efforts to integrate eHealth literacy training into diabetes self-management programs, thereby further strengthening the connection between digital literacy and improved health outcomes.

2.2 Co-authorship in e-health research

Co-authorship in health research plays a pivotal role in fostering collaboration across multiple disciplines, given the complex and multifaceted nature of health challenges. The field of health research often requires the integration of expertise from medicine, public health, epidemiology, psychology, social sciences, and health informatics to develop comprehensive and effective solutions (Morris et al., 2011). This multidisciplinary approach ensures that research is not only methodologically sound but also practically relevant, addressing diverse aspects of healthcare, from disease prevention and treatment to healthcare policies and patient behaviour (Börner et al., 2010).

The growing complexity of health issues, such as chronic diseases, pandemics, and mental health disorders, has increased the need for collaborative research efforts. Co-authorship facilitates the integration of diverse perspectives, methodologies, and analytical techniques, resulting in more comprehensive research outcomes (Cameron et al., 2013). For example, epidemiologists may collaborate with medical practitioners to assess disease prevalence, while social scientists contribute insights into behavioural factors influencing health outcomes (Glänzel & Schubert, 2004). This diversity of expertise strengthens the quality and applicability of health research findings.

In the domain of e-health and digital health, co-authorship fosters interdisciplinary partnerships among specialists in health informatics, artificial intelligence (AI), and computer science. These collaborations are crucial for the development and implementation of innovative healthcare solutions, including telemedicine, electronic health records, mobile health (mHealth) applications, and wearable health technologies (Mair & May 2020). The co-authorship of health informatics researchers and clinical experts ensures that digital solutions are both technologically efficient and clinically relevant, leading to improved healthcare accessibility and patient outcomes (Pagliari, Detmer, & Singleton, 2016). Moreover, co-authorship in e-health research helps address emerging challenges, including data privacy, cybersecurity, and interoperability of health information systems. Studies have shown that

interdisciplinary teams producing co-authored publications in digital health tend to generate higher citation impacts, reflecting the increasing importance of collaborative efforts in advancing medical technology (Shaw et al., 2017).

3 Methodology

Data was sourced from the Scopus database. Schotten et al. (2017), Nwagwu and Onyancha (2024) and Nwagwu (2023) have elaborated on the significance of focusing bibliometric research on Scopus, the world's largest abstract and citation database of scientific literature. The search terms used are:

(("E-Health Literacy") Or ("E-Health Literacy") Or ("Digital Health Literacy") Or ("Online Health Literacy") Or ("Electronic Health Literacy") Or ("Tele-Health Literacy") Or ("Mhealth Literacy") Or ("M-Health Literacy") Or ("Web Based Health Literacy") Or ("Tele-Health Literacy") Or ("Web-Based Health Literacy")).

The search was conducted on January 20, 2025, and covered the period from 2006 to 2024. Scopus automatically determined the start date based on the publication date of the first document related to the subject. The data was downloaded and saved in CSV format. It is worth acknowledging that Scopus has certain limitations. For instance, its coverage of publications from low- and middle-income countries may be incomplete, which could introduce bias favouring research from more developed regions. Furthermore, the platform tends to prioritise English-language publications, potentially leading to the underrepresentation of research published in languages other than English. Nevertheless, Scopus remains a highly valuable tool for accessing scientific literature and conducting research analyses, providing a broad and diverse repository of scholarly works.

VOSviewer software was utilised for the analysis and visualisation of the dataset. According to Van Eck and Waltman (2019), VOSviewer is specifically designed for creating maps based on network data and for visualising and exploring these maps. It is capable of handling three types of data: network data, bibliographic data, and text data. In this study, the analysis focused on bibliographic data. The bibliographic data was analysed to understand co-authorship by authors, sources, organisations, countries, and journals. This enabled a more comprehensive examination of the bibliographic data from various perspectives.

The study employed the fractional counting method as a means of analysis. The fractional counting method, recommended by Perianes-Rodriguez et al. (2016), ensures that the weight of each paper is equalised. This method takes into account the fact that papers with multiple authors may have different contributions from each author. When describing the citations, the study took a holistic view of the results and sorted them repeatedly by different fields in

order to gain an understanding of the situation. By exploring the data from different angles, latent information and patterns could be unveiled, revealing deeper insights. The study also discussed the meaning of clusters, links, and total link strength, drawing on the work of Nwagwu and Williams (2022).

4 Findings of the study

The study findings are discussed hereunder:

4.1 Quantity of co-authored documents

Between 2006 and 2024, a total of 2,027 documents were generated, up from 1,176 in 2022, indicating the relatively recent emergence of e-health literacy as a field of study. Over the 19 years, the average number of documents co-authored per year was 106, indicating a substantial rate of document production within this sub-discipline. The 2027 documents were written by 7887 authors, amounting to 415 authorships per annum. The average number of authors per paper is 3.89.

4.2 Authorship levels

Table 1 reveals a strong preference for small research teams, with the majority of published papers involving between one and four authors. Single-author publications, while present, account for a relatively small portion of the total output, with 140 papers produced by individual researchers. This suggests that while independent research remains relevant, collaboration is the dominant approach to scholarly publishing in e-health literacy research.

Table 1: Co-authorship levels of e-health literacy research 2006-2024

Author counts	Paper counts
1	140
2	333
3	340
4	304
5	219
6	194
7	152
8	105
9	80
10	42
11	25
12	22
13	27
14	9
15	6
16	7
18	2
19	2
20	3
21	3
22	2
24	1
25	1
26	2
29	1
34	1
36	1
38	1
68	1
75	1

The most common co-authorship structure is three authors, with 340 papers, followed closely by two-author and four-author collaborations, contributing 333 and 304 papers, respectively. This trend suggests that small research teams are the preferred model for academic collaboration, likely due to the ease of coordination, efficient workload

distribution, and institutional structures that encourage limited yet effective partnerships.

As the number of co-authors increases beyond four, the frequency of co-authored papers begins to decline. Teams of five to ten authors still contribute a substantial number of papers; however, as the group size expands further, there is a noticeable decline in the number of publications. Very large research teams involving more than ten authors are relatively rare, suggesting that large-scale collaborations, such as those involving multiple institutions or international networks, are not yet a common feature of Nigerian research output. Nevertheless, a few instances of extensive collaboration exist. Papers with 15 or more authors are infrequent, appearing only sporadically in the dataset. The largest co-authored paper involves 75 authors, evidently representing a major international research collaboration project. Such large-scale collaborations, while uncommon, highlight Nigeria's growing engagement in global scientific networks. The data suggests that Nigerian researchers predominantly work in small, focused teams, balancing collaboration with manageability. While independent research still has its place, the preference for teams of two to four authors reflects a culture of cooperative scholarship; however, large-scale collaborations remain relatively limited.

4.3 Co-authorship by authors

Placing the minimum number of documents of an author to 5 and the minimum number of citations to 5, 101 out of the 7887 authors were included in the analysis, and only 22 of these authors were connected. The co-authorship map is shown in Figure 1, while Table 2 presents the indices of co-authorship by subject matter. The analysis of co-authorship in e-health literacy literature reveals a vibrant and interconnected research landscape, with key scholars making significant contributions across various collaborative networks.

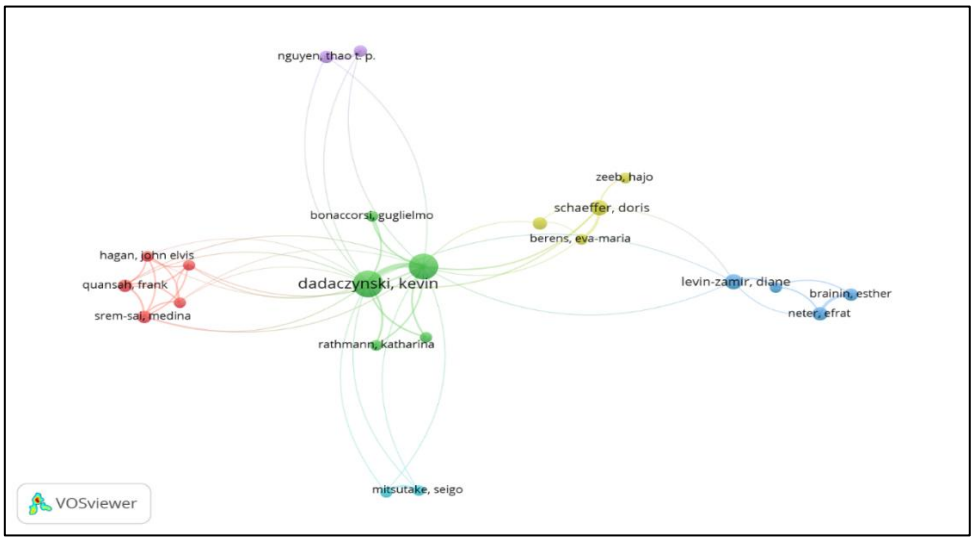

Figure 1: Visualisation map of co-authorships in e-health literacy literature by authors

The co-authorship map of e-health literacy literature provides a view of the collaborative dynamics within the field. At the centre of the network is Kevin Dadaczynski, who emerges as the most prominent and influential researcher. His position, marked by the largest node and extensive connections, underscores his critical role in fostering collaboration and linking diverse research groups. The map reveals several tightly knit groups of researchers. One group includes John Elvis Hagan, Frank Quansah, and Medina Srem-Sai, who frequently collaborate and form a significant hub of activity. This group's focus might be thematic or regional, as evidenced by their strong connections to one another and fewer links to the broader network. Another key group consists of Doris Schaeffer, Hajo Zeeb, and Eva-Maria Berens, who appear to work closely together. Their interconnectedness suggests a specialisation in specific areas of e-health, potentially related to health systems or policy-oriented research.

Table 2: Co-authorship by authors

S/N	Label	Cluster	Links	Total link strength	Docs	Citations
1	Dadaczynski, Kevin	2	15	29	30	831
2	Okan, Orkan	2	17	29	29	800
3	Levin-Zamir, Diane	3	5	4	10	256
4	Schaeffer, Doris	4	6	8	10	70
5	Neter, Efrat	3	3	8	8	731
6	Brainin, Esther	3	2	7	7	729
7	Fischer, Florian	4	3	1	7	98
8	Nguyen, Thao	5	3	6	7	74
9	Quansah, frank	1	6	7	7	38
10	Srem-Sai, Medina	1	6	7	7	38
11	Duong, Tuyen van	5	3	6	6	73
12	Agormedah, Edmond Kwesi	1	6	5	5	25
13	Baron-Epel, Orna	3	3	5	5	21
14	Berens, Eva-Maria	4	3	5	5	43
15	Bonaccorsi, Guglielmo	2	2	3	5	38
16	Hagan, John Elvis	1	6	5	5	25
17	Mitsutake, Seigo	6	3	5	5	377
18	Oka, Koichiro	6	3	5	5	377
19	Rathmann, Katharina	2	3	4	5	218
20	Ros Rio, Rafaela	2	3	4	5	293
21	Schack, Thomas	1	6	5	5	32
22	Zeeb, Hajo	4	1	1	5	46

Figure 1 and Table 2 further demonstrate that Diane Levin-Zamir, Esther Brainin, and Efrat Neter form another notable collaborative group, operating somewhat independently of the central clusters. This indicates a specialised or emerging research focus that may differ from the more interconnected parts of the network. Smaller, more independent groups, such as those involving Thao T.P. Nguyen or Seigo Mitsutake, represent localised collaborations or niche research areas. While their connections to the broader network are less extensive, they may contribute to emerging or less mainstream topics within the e-health field. What stands out in this map is the role of Kevin Dadaczynski as a central connector. His collaborations span multiple groups, enabling the exchange of knowledge and ideas across distinct research domains. The map reflects a well-integrated yet diverse research landscape, where prominent figures connect various teams, and specialised groups contribute to specific aspects of e-health research. This visualisation emphasises the central role of key individuals and the contributions of smaller, focused research teams. Also, it underscores opportunities for future collaborations, particularly in connecting independent or emerging groups with the broader research community.

The list of contributors to e-health research includes notable African scholars who have made significant strides in this field. Among these contributors are Frank Quansah, affiliated with the Department of Educational Foundations at the University of Education, Winneba, and Medina Srem-Sai, a member of the Department of Health, Physical Education, Recreation, and Sports at the same university. John Elvis Hagan Jr. is affiliated with the Department of Health, Physical Education, and Recreation at the University of Cape Coast, Cape Coast. Similarly, Edmond Kwesi Agormedah works within the Department of Business and Social Sciences Education at the University of Cape Coast, Ghana.

These scholars form a cohesive network within Cluster 1, and this demonstrates active collaboration and shared research goals. Taken together, they contributed seven documents to the body of e-health literature, with a total link strength of six to seven, indicating their engagement with both local and international research networks. While their citation counts are relatively modest compared to some other authors, their work underscores the growing presence of African perspectives in global e-health discourse. Their contributions are particularly significant given the context of digital health challenges in Africa. By addressing issues unique to the continent, these scholars are helping to advance the understanding and implementation of e-health solutions, ensuring that the needs of African communities are represented in global research. This highlights the important role of

Ghanaian institutions in fostering research excellence in e-health.

4.4 Co-authorship by country

A total of 119 countries contributed documents on e-health literacy. At a threshold of five documents per country and five citations per country, 59 met the threshold, and 58 countries have co-authored documents. Figure 2 and Table 3 show the linkages. The table on co-authorship of e-health literacy research by countries reveals a fascinating global landscape of scholarly collaboration and contribution. At the forefront, the United States emerges as the dominant force in this field, with the highest number of documents, totalling 449, and an impressive citation count of 11,277. This suggests not only prolific output but also a significant global influence, as evidenced by its considerable link strength and extensive collaboration with other countries. The US is a major player in shaping the direction of e-health literacy research across borders.

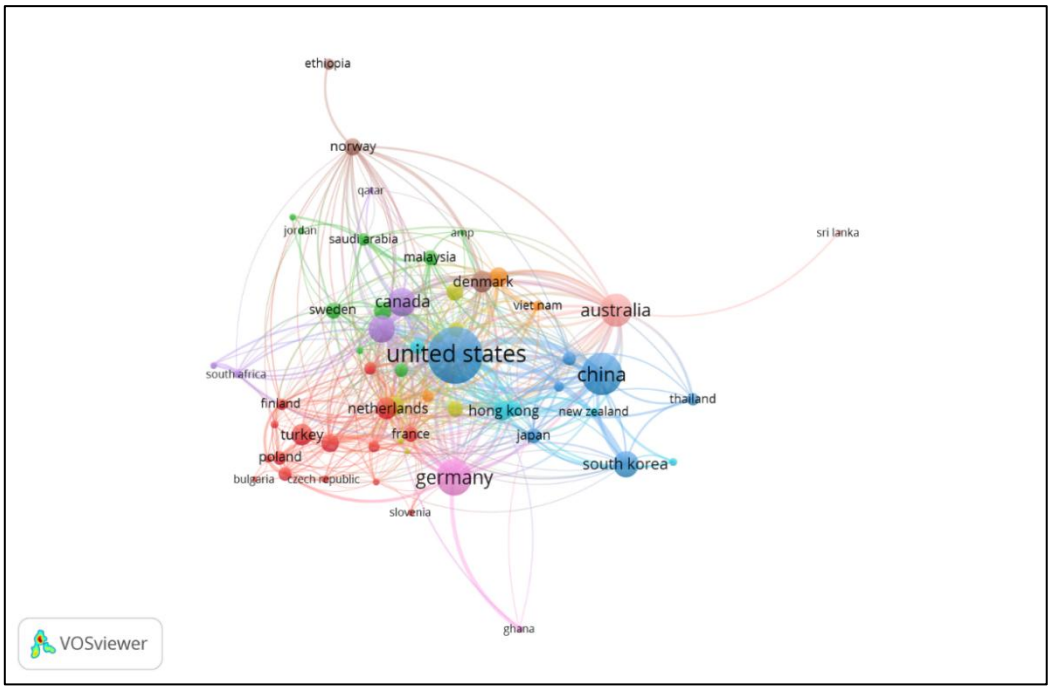

Figure 2: Visualisation map of co-authorships in e-health literacy literature by countries

Following the US, China is the second-largest contributor, with 250 documents. Despite having fewer citations (2,557) than the US, China has made a substantial mark in this field, indicating a growing body of research, particularly within its regional context. Its solid network of collaboration further emphasises this, reflected in its 79 links. Germany and Australia also show strong involvement in e-health literacy, contributing 186 and 156 documents, respectively. Both countries have achieved substantial citation counts—3,050 for Germany and 3,803 for Australia, indicating that their research is not only productive but also widely recognised. The high link strength of Germany (71) suggests it

plays a key role in fostering international research collaborations, while Australia's robust participation also highlights its centrality in advancing the field.

Table 3: Co-authorship by country

S/N	Label	Cluster	Links	Total link strength	Documents	Citations
1	United States	3	42	111	449	11277
2	China	3	28	79	250	2557
3	Germany	9	38	71	186	3050
4	Australia	10	34	74	156	3803
5	Canada	5	29	45	116	5644
6	United Kingdom	5	43	77	111	1677
7	South Korea	3	15	27	101	1528
8	Netherlands	1	32	48	71	2053
9	Denmark	8	26	36	67	1487
10	Turkey	1	21	8	66	340
11	Hong Kong	6	28	42	57	1271
12	Taiwan	7	21	28	54	1134
13	Spain	4	31	29	53	630
14	Italy	1	24	22	50	543
15	Iran	2	20	18	47	491
16	Norway	8	25	27	43	657
17	Indonesia	4	14	11	41	133
18	Switzerland	6	26	35	40	1139
19	Sweden	2	19	16	39	463
20	Brazil	4	23	15	36	290
21	India	4	26	17	35	406
22	Israel	6	19	12	34	1249
23	Malaysia	2	19	14	34	315
24	France	1	28	22	33	619
25	Japan	3	22	13	33	621
26	Portugal	2	13	11	28	543
27	Singapore	3	19	21	28	527
28	Poland	1	13	8	27	307
29	Greece	1	21	15	26	155
30	Austria	1	32	15	25	183
31	Saudi Arabia	2	14	11	25	317
32	Thailand	3	7	9	24	244
33	Finland	1	18	15	20	368
34	Belgium	1	19	16	18	369
35	Ethiopia	8	1	2	18	257
36	Hungary	7	19	13	18	353
37	Pakistan	3	12	10	17	345
38	Philippines	4	17	9	16	266

S/N	Label	Cluster	Links	Total link strength	Documents	Citations
39	Vietnam	7	12	15	16	241
40	New Zealand	6	8	10	12	227
41	Czech Republic	1	13	4	11	106
42	Ireland	1	8	4	11	80
43	South Africa	5	13	10	11	29
44	Cyprus	1	16	10	10	103
45	Macao	6	4	7	9	133
46	Ghana	9	4	8	8	89
47	Jordan	2	5	3	8	142
48	Nigeria	5	5	6	8	16
49	Lebanon	2	3	4	7	74
50	Romania	1	19	4	7	64
51	Slovenia	1	6	2	7	135
52	United Arab Emirates	2	15	5	7	109
53	Argentina	4	16	5	6	108
54	Peru	4	4	2	6	26
55	Sri Lanka	10	1	1	6	68
56	Amp	2	7	5	5	7
57	Bulgaria	1	4	1	5	9
58	Qatar	5	7	3	5	45

On the other hand, countries like Canada, the United Kingdom, and South Korea contribute moderately in terms of documents, with Canada producing 116 and South Korea contributing 101. However, their citation impact varies, with Canada's citation count (5,644) reflecting a more widespread influence, while South Korea's citations (1,528) are notably lower. In contrast, countries from Africa and the Middle East exhibit an emerging yet modest presence in e-health literacy research. South Africa, for example, has contributed 11 documents, which is relatively small compared to other countries, but it remains an important part of the global research network. The Ghanaian contribution is similarly modest, with only eight documents published. However, it has garnered 89 citations, indicating that the research produced in Ghana may be niche yet impactful in certain areas of e-health literacy.

Interestingly, countries such as Nigeria and Ethiopia also show up with fewer documents - 6 and 2, respectively - but Ethiopia stands out with a comparatively higher citation count (257). This suggests that while these countries may not yet be producing a large volume of e-health literacy research, the work they do contribute is relevant and gaining recognition. Smaller contributors, such as Sri Lanka and Peru, have limited outputs in terms of documents. However, their presence in the

table underscores the growing global interest in e-health literacy across diverse regions. Sri Lanka's six documents and Peru's 6 reflect regional engagement, albeit on a smaller scale compared to leading nations.

The co-authorship data paints a picture of an evolving global research network, where traditional powerhouses such as the US, China, Germany, and Australia continue to lead, while countries from Africa, South America, and the Middle East are gradually increasing their involvement. Although the citation impact varies significantly, with some countries receiving greater recognition of their research than others, the inclusion of diverse regions, particularly those from emerging markets such as South Africa, Ghana, and Nigeria, indicates the broadening scope of e-health literacy research. This growing participation is crucial for ensuring that e-health literacy research reflects the global, multi-dimensional challenges faced in the healthcare and digital literacy sectors.

4.5 By organisations

The researcher set the threshold for the number of organisations to 3 and the number of citations to 3, resulting in 80 organisations meeting the threshold out of 6075 organisations that contributed to e-health literacy. Of these 80 organisations, only 11 were involved in the co-authorship of documents. Figure 3 and Table 4 display the result. The Department of Health Science at Fulda University of Applied Sciences, Germany, is represented by five collaborative links and a total link strength of 3. This department has co-authored five documents, which have collectively received 72 citations. While the institution's collaboration is relatively modest, its publications have gained significant attention, as indicated by the citation count, suggesting meaningful contributions to the health literacy field despite a lower number of documents. The Centre for Applied Health Science at Leuphana University Lueneburg, Germany, emerges as one of the more prominent institutions in the table, with six collaborative links and a higher link strength of 4. It has published four documents, which have garnered 255 citations. This demonstrates the high impact and academic visibility of its research output. The combination of strong collaboration and high citation count indicates that the centre's work is highly regarded in the academic community.

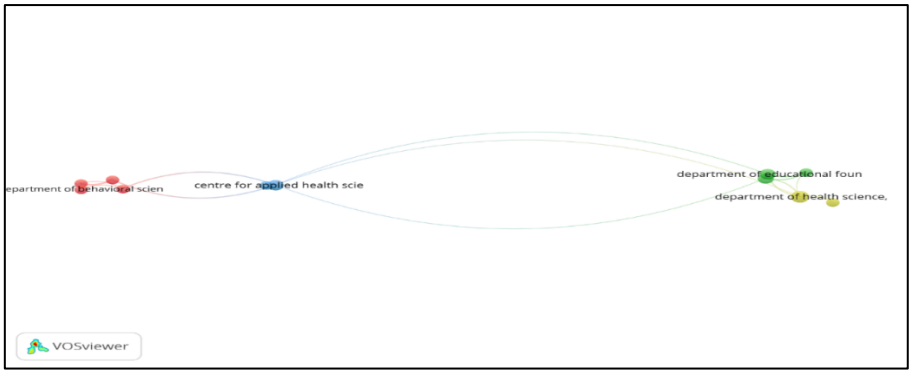

Figure 3: Visualisation map of co-authorships in e-health literacy literature by authors

The Department of Educational Foundations at the University of Education, Winneba, Ghana, and the Department of Health, Physical Education, Recreation, and Sports at the same university each have four documents and four collaborative links, both with a link strength of 4. However, these departments have accumulated only 30 citations each, indicating that while they are active participants in health literacy research, their publications have not been as widely cited, suggesting that their impact may be more localised or emerging in the global academic context. The Department of Behavioral Sciences at Ruppin Academic Center, Israel, while having only two collaborative links and a link strength of 1, has co-authored three documents that have collectively received 65 citations. Although its collaborative network is smaller, the department's research still holds significant academic weight, as evidenced by the citation count, indicating that its work has found resonance within certain sectors of the health literacy community.

Table 4: Co-authorship by organisations

S/N	Label	Cluster	Links	Total link strength	Documents	Citations
1	Department of Health Science, Fulda University of Applied Sciences, Fulda, Germany	4	5	3	5	72
2	Centre for Applied Health Science, Leuphana University Lueneburg, Lueneburg, Germany	3	6	4	4	255
3	Department of Educational Foundations, University of	2	4	4	4	30

S/N	Label	Cluster	Links	Total link strength	Documents	Citations
	Education, Winneba, Ghana					
4	Department of Health, Physical Education, Recreation and Sports, University of Education, Winneba, Ghana	2	4	4	4	30
5	Department of Behavioral Sciences, Ruppin Academic Center, Emeq Hefer, Israel	1	2	1	3	65
6	Department of Education and Psychology, University of Cape Coast, Cape Coast, Ghana	2	3	3	3	20
7	Department of Health Education and Promotion, Clalit Health Services, Tel Aviv, Israel	1	3	2	3	10
8	Institute For Community Health Research, University of Medicine and Pharmacy, Hue University, Hue, Viet Nam	1	2	3	3	37
9	School of Nursing, the Hong Kong Polytechnic University, Hong Kong	4	1	1	3	48
10	School of Nursing, University of Minho, Braga, Portugal	3	1	1	3	222
11	School of Nutrition and Health Sciences, Taipei Medical University, Taipei, Taiwan	1	3	3	3	6

The Institute for Community Health Research at the University of Medicine and Pharmacy, Hue University, Vietnam, shows two links and a link strength of 3. This institution has co-authored three documents, which have accumulated 37 citations. While it has fewer

links compared to other institutions, the documents co-authored have still attracted attention, contributing to the global body of research on health literacy. The School of Nursing at The Hong Kong Polytechnic University, Hong Kong, is represented with one link and a link strength of 3. This institution has published 1 document, which has received 48 citations. Despite its limited collaboration, the high citation count for a single document indicates the research's significant impact on the academic community. The School of Nursing at the University of Minho, Braga, Portugal, also has one link with a link strength of 3 and has co-authored 1 document that has garnered 222 citations. Although the publication count is low, the high citation count suggests that the research has had a significant impact, possibly due to its quality or relevance within the field of health literacy.

Finally, the School of Nutrition and Health Sciences at Taipei Medical University, Taiwan, is linked to three other institutions, with a link strength of 3, and has published three documents. However, these documents have received just six citations, indicating that the research co-authored by this institution, while contributing to the field, has not yet achieved widespread recognition or impact. The data reveals a diverse range of contributions to health literacy research, with some institutions like Leuphana University and Fulda University leading in terms of collaboration and citation impact, while others, such as Winneba University and Taipei Medical University, are making valuable contributions but may benefit from enhancing their collaborative networks and increasing the visibility of their research. The document field plays a crucial role in showcasing the quantity of research co-authored by these institutions, highlighting the varying levels of output alongside their citation counts.

At the African regional level, the Department of Educational Foundations at the University of Education, Winneba, Ghana, has published four documents and established four collaborative links, resulting in a total link strength of 4. The documents have garnered 30 citations, indicating that the institution is making significant contributions to the field of health literacy research. However, the citation impact is relatively modest compared to that of some other institutions. Additionally, the Department of Health, Physical Education, Recreation, and Sports at the University of Education, Winneba, Ghana, like the previous department, has four documents, four collaborative links, and a link strength of 4, with 30 citations. This exhibits a similar pattern of active research output, albeit with a relatively lower citation impact.

5 Discussion

This study was conducted to investigate the quantity of co-authored documents, co-authorship levels, and co-authorship patterns

in global research on e-health literacy, focusing on authors, countries, and organisations to reflect the contributions of African researchers and their institutions to collaboration in e-health literacy research. The findings from the co-authorship analysis of e-health literacy research reveal a complex and dynamic network of scholarly collaboration, with distinct clusters of researchers contributing to the advancement of the field. The results underscore the highly interconnected nature of e-health literacy research, with some key scholars playing a central role in facilitating cross-disciplinary collaboration. In contrast, others operate within more specialised, focused research domains. This highlights the importance of both central figures and smaller research groups in the development of this area of study.

This study was conducted to investigate the co-authorship patterns in global research on e-health literacy, focusing on authors, countries, and organisations. The findings from the co-authorship analysis of e-health literacy research reveal a complex and dynamic network of scholarly collaboration, with distinct clusters of researchers contributing to the advancement of the field. This aligns with Glänzel and Schubert (2004), who highlighted the value of co-authorship networks in mapping the collaborative structures of scientific disciplines. The results underscore the highly interconnected nature of e-health literacy research, with some key scholars playing a central role in facilitating cross-disciplinary collaboration. In contrast, others operate within more specialised, focused research domains (Börner et al., 2010). This highlights the importance of both central figures and smaller research groups in the development of this area of study.

Kevin Dadaczynski emerges as the most influential scholar in the co-authorship network. His central position in the network, indicated by the largest node and the highest number of links, emphasises his significant role in shaping the trajectory of e-health literacy research. Dadaczynski's extensive collaborations across various research groups underscore his ability to bridge different areas of research within e-health literacy, thereby facilitating the exchange of knowledge and ideas between diverse academic communities. This central role suggests that fostering collaborative networks around prominent scholars such as Dadaczynski can further enhance the cohesion and productivity of the research community.

Beyond the central figures, the analysis also reveals several tightly knit research groups that contribute significantly to e-health literacy. For example, the collaboration between John Elvis Hagan, Frank Quansah, and Medina Srem-Sai within Cluster 1 suggests a focus on thematic or regional issues, possibly specific to health education or e-health challenges in the African context. This smaller group, with its relatively

modest citation counts, illustrates the growing significance of African scholars in the global e-health discourse (Shiferaw et al., 2020; Shabi & Oyewusi, 2018). Their work, while perhaps still emerging, addresses critical issues in digital health that are unique to the African continent, particularly in the face of widespread challenges in healthcare access and infrastructure.

Similarly, the collaboration between Doris Schaeffer, Hajo Zeeb, and Eva-Maria Berens in Cluster 4 reflects a specialised focus, possibly on health systems or policy-oriented research (El Benny et al., 2021). Their well-defined area of interest indicates that smaller, highly specialised research groups play a crucial role in addressing specific issues within the broader e-health literacy field. These groups often work independently but contribute niche knowledge that enriches the overall research landscape.

Several researchers, including Diane Levin-Zamir, Esther Brainin, and Efrat Neter, represent another key collaboration group within the field of e-health literacy. Their work, somewhat independent from the central clusters, signals a potentially emerging area of focus within e-health literacy (Green, 2025). This highlights the diverse directions in which the field is developing, with scholars exploring new topics or refining existing ones. Smaller, less interconnected groups, such as those led by Thao T.P. Nguyen and Seigo Mitsutake, further illustrate the growth of niche research areas within the e-health domain.

The role of African scholars in this research landscape is significant, especially as they represent essential contributions from Nigerian and Ghanaian institutions. Researchers such as Frank Quansah, Medina Srem-Sai, and John Elvis Hagan are central to the collaborative efforts within Cluster 1, and their contributions underscore the growing prominence of African perspectives in global e-health research. Their work, although not as highly cited as that of their counterparts in Europe or the United States, brings valuable insights into the unique challenges and opportunities surrounding e-health in Africa. These researchers are helping to contextualise digital health solutions within the African setting, ensuring that the continent's health needs and digital literacy gaps are considered in the broader global discourse (Becerra-Posada, 2015). In addition, the modest citation counts of these African scholars, compared to those of their global peers, may reflect the nascent stage of e-health research in Africa. However, their active engagement in the field signals a promising future for African-led research in digital health. The fact that they are part of an international network of researchers indicates a growing collaboration between African institutions and the global e-health research community.

Countries such as the United States, China, Germany, and Australia have emerged as the dominant contributors to the field. The US, with its substantial output of 449 documents and over 11,000 citations, not only leads in volume but also influence, fostering widespread international collaborations (Pagliari et al., 2016). The high citation counts and extensive linkages of countries like Germany and Australia emphasise the central role of these nations in shaping e-health literacy research, with their contributions being widely recognised and influential globally. China, although trailing the US in citations, has become a formidable force in e-health research with 250 documents. This highlights China's growing significance in the field, particularly within its regional context (Li et al., 2020). The high number of links (79) reflects an active, albeit somewhat regionally focused, collaboration network that is increasing its presence on the global stage.

Canada, the United Kingdom, and South Korea, while contributing fewer documents compared to the top players, still play crucial roles in global e-health literacy research. For example, Canada, despite its lower document count (116), boasts an impressive citation count (5,644), indicating the widespread influence of its work. This suggests that while these nations are not leading in terms of volume, their research is recognised and cited globally, further reinforcing their importance in the network (Wagner et al., 2011).

The participation of countries from Africa and the Middle East in e-health literacy research is noteworthy, although it remains limited compared to that of leading nations. South Africa, Ghana, and Nigeria, despite their modest document outputs, are part of a growing network of research contributors from the Global South. South Africa's inclusion with 11 documents, alongside Ghana's modest output but higher citation count (89), points to the emerging relevance of these regions in addressing the unique e-health challenges faced by developing nations. Ghana's research, though niche, appears to be gaining recognition, underscoring the importance of localised e-health literacy studies that cater to specific regional needs. The involvement of smaller contributors from regions such as South America, South Asia, and the Middle East reflects the growing global interest in e-health literacy. Ethiopia, Sri Lanka, and Peru may have lower document outputs, but their work is being recognised, particularly in the case of Ethiopia, which has a relatively high citation count (257) (Chauhan et al., 2024). This signifies that, even in regions with limited production, the research conducted may have a highly impactful effect on the global discourse.

A significant aspect of this analysis is the varying citation counts across countries. While the US, Germany, and Australia lead in both publication and citation counts, countries such as Nigeria and South Africa produce fewer

documents and have modest citation totals. This disparity in citation may suggest barriers such as limited access to international research networks, language differences, or resource constraints, which affect the visibility and impact of research from these regions. The relatively lower but growing involvement of countries from the Global South provides an opportunity for future collaborations. The data highlights the potential for emerging countries, such as those in Africa and South Asia, to connect with established research hubs. These collaborations could enhance the inclusivity and diversity of e-health literacy research, ensuring that the unique challenges faced by low and middle-income countries are addressed.

The data on co-authorship by organisations in the e-health literacy field reveals both dominant and emerging players in the research landscape. A clear pattern emerges from the institutions that contribute to this field, with some universities exhibiting high levels of collaboration and significant citation impact, while others, particularly from regions such as Africa, are expanding their involvement but with more modest outcomes (European Commission, 2019). The institutions in Germany, particularly the Department of Health Science at Fulda University of Applied Sciences and the Centre for Applied Health Science at Leuphana University Lueneburg, stand out in terms of both collaborative activity and citations. The Department of Health Science at Fulda University, although contributing fewer documents, has made a notable impact with 72 citations. Similarly, Leuphana University's Centre for Applied Health Science, with fewer documents but much higher citations (255), showcases how impactful research can be even with limited output. This indicates that research from these institutions is highly regarded within the field of health literacy, with high-quality studies garnering significant attention and respect.

On the African front, institutions such as the University of Education, Winneba (Ghana), are making meaningful contributions, although the citation impact remains modest. Both the Department of Educational Foundations and the Department of Health, Physical Education, Recreation, and Sports from Winneba University have published four documents each and established four collaborative links, but with only 30 citations each. This suggests a growing but emerging presence in the global e-health literacy research community, with the potential for increased visibility through expanded networks and partnerships.

6 Conclusion

The co-authorship analysis presents a clear picture of a dynamic and interconnected e-health literacy research landscape. The central role of key figures, such as Kevin Dadaczynski, facilitates the exchange of ideas across different research domains. In contrast,

smaller, specialised research groups contribute important insights into niche areas of e-health literacy. The presence of African scholars underscores the growing influence of African research institutions in the global e-health community. As the field continues to grow, further collaboration between both established and emerging researchers will be crucial for advancing the understanding and implementation of e-health solutions, particularly in addressing the diverse health needs of global populations.

The co-authorship patterns by country underscore the central role of major research powerhouses, such as the United States and China, in driving the field forward while simultaneously highlighting the increasing participation of countries from the Global South. As the research network expands, these emerging contributors could play an increasingly significant role in shaping global discussions on e-health literacy, ensuring that the diverse needs of different regions are well-represented in future research agendas. The next steps involve fostering greater collaboration between established and emerging research hubs, as well as promoting international partnerships that bridge knowledge gaps, address resource shortages, and align with research priorities.

The diversity in institutional contributions illustrates the importance of fostering global research collaborations. While leading institutions, such as those in Germany and Israel, maintain strong networks, countries in Africa and emerging markets are gradually establishing their presence. For institutions in these regions to increase their research visibility and citation impact, expanding collaborative ties and focusing on the quality of their research will be key. Additionally, for institutions in emerging regions like Ghana, increasing the citation count will likely require both enhancing the visibility of their research through international collaborations and improving the quality of their publications to resonate within the global academic community. This shift can elevate their status and ultimately enhance the global understanding of health literacy challenges.

7 Recommendations for policy and practice

Policymakers and academic institutions should support funding mechanisms, research grants, and networking platforms that encourage scholars, particularly those from underrepresented regions, to engage with global research networks. This can be achieved through joint research projects, conference sponsorships, and exchange programs that connect researchers from the Global South with leading institutions in North America, Europe, and Asia. Additionally, enhancing the visibility and impact of African and Global South scholars is crucial to achieving a more inclusive global research landscape. Governments and health policymakers should actively support research that contextualises

digital health solutions for local populations. This includes integrating e-health literacy initiatives into public health strategies, funding research that addresses digital literacy gaps in rural and underserved communities, and collaborating with international organisations to tailor global best practices to local needs.

8 Future studies

Building on the insights from the analysis of global co-authorship patterns in e-health literacy research, a study focusing on enhancing African scholarly collaboration in e-health literacy research will be required**.** The study will examine barriers, including limited access to funding, research infrastructure, and global publishing networks, that may hinder greater participation. Additionally, a study is needed that focuses on bridging the digital health divide by contextualising e-health literacy for African healthcare systems. This study will examine the distinct challenges and opportunities associated with the adoption of e-health literacy in African healthcare systems, particularly in low-resource settings.

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