ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

A BIBLIOMETRIC ANALYSIS OF GERONTECHNOLOGY: LITERATURE TRENDS, CITATION DYNAMICS, AND FUTURE PERSPECTIVES

GERONTEKNOLOJİNİN BİBLİYOMETRİK ANALİZİ: LİTRATÜR TRENDLERİ, ATIF DİNAMİKLERİ VE GELECEK PERSPEKTİFLERİ

Dr. Öğr. Üyesi Aysun DANAYİYEN [1]

Arş. Gör. Elem EROĞLU[2]

Dr. Öğr. Üyesi Semra BAYSAN [3]

ABSTRACT

This study examines academic trends within the gerontechnology literature by evaluating core themes, author collaborations, and scientific contributions across countries. A bibliometric analysis was conducted using data retrieved from the Web of Science database and visualized through VOSviewer software. The study identifies prominent themes and influential authors in gerontechnology research, while also mapping the structure of scientific collaborations among countries and institutions. The findings indicate that countries such as China, the United States, and Malaysia have made significant contributions to the field, with institutions like Hong Kong City University and Monash University hosting high-impact research. Keyword analysis reveals that terms such as "aging," "assistive technology," "quality of life," and "health promotion" demonstrate the strongest linkages, frequently associated with concepts like "cognitive health," "fall prevention," and "enhancing quality of life." Recent research highlights the growing multidisciplinary nature of gerontechnology, offering researchers meaningful insights and broadening its academic relevance. Moreover, studies focused on developing technological solutions to promote the independence of older adults present valuable resources for both academic and industry stakeholders. By providing a comprehensive overview of the current literature, this study aims to guide future research in gerontechnology and support the development of strategic approaches to better address the evolving needs of aging populations.

Keywords: Gerontechnology, Older Adults, Technology, Ethics, Bibliometrics

JEL Classification Codes: I10, I14, I18, O14

ÖZ

Bu çalışma, ülkeler arasında temel temaları, yazar iş birliklerini ve bilimsel katkıları değerlendirerek geronteknoloji literatüründeki akademik eğilimleri inceler. Web of Science veri tabanından alınan ve VOSviewer yazılımıyla görselleştirilen veriler kullanılarak bibliyometrik bir analiz yürütülmüştür. Çalışma, geronteknoloji araştırmalarındaki önemli temaları ve etkili yazarları belirlerken, ülkeler ve kurumlar arasındaki bilimsel iş birliklerinin yapısını da haritalamaktadır. Bulgular, Çin, Amerika Birleşik Devletleri ve Malezya gibi ülkelerin alana önemli katkılarda bulunduğunu ve Hong Kong Şehir Üniversitesi ve Monash Üniversitesi gibi kurumların yüksek etkili araştırmalara ev sahipliği yaptığını göstermektedir. Anahtar kelimeler analizi, "yaşlanma", "destekleyici teknoloji", "yaşam kalitesi" ve "sağlık promosyonu" gibi terimlerin, sıklıkla "bilişsel sağlık", "düşme önleme" ve "yaşam kalitesini artırma" gibi kavramlarla ilişkilendirilen en güçlü bağlantıları gösterdiğini ortaya koymaktadır. Son araştırmalar, geronteknolojinin giderek artan disiplinler arası doğasını vurgulayarak araştırmacılara anlamlı içgörüler sunmakta ve akademik önemini genişletmektedir. Ayrıca, yaşlı yetişkinlerin bağımsızlığını desteklemek için teknolojik çözümler geliştirmeye odaklanan çalışmalar hem akademik hem de endüstri paydaşları için değerli kaynaklar sunmaktadır. Mevcut literatürün kapsamlı bir genel görünümünü sağlayarak, bu çalışma geronteknolojideki gelecekteki araştırmalara rehberlik etmeyi ve yaşlanan nüfusların değişen ihtiyaçlarını daha iyi karşılamak için stratejik yaklaşımların geliştirilmesini desteklemeyi amaçlamaktadır.

Anahtar Kelimeler: Geronteknoloji, Yaşlı Yetişkinler, Teknoloji, Etik, Bibliyometri

JEL Sınıflandırma Kodları: I10, I14, I18, O14

[1]　University of Istanbul Sabahattin Zaim, Faculty of Health Sciences, Health Management, aysun.danayiyen@izu.edu.tr/ aysunda@hotmail.com

[2]　University of Istanbul Sabahattin Zaim, Faculty of Health Sciences, Health Management, elem.eroglu@izu.edu.tr

[3]　University of Rumeli, Faculty of Health Sciences, Health Management, semra.baysan@rumeli.edu.tr

GENİŞLETİLMİŞ ÖZET

Amaç ve Kapsam:

Giderek yaşlanan nufus ile yaşlı bireyler gündelik hayatta daha fazla teknoloji kullanmaya başlamışlardır. Yaşlı bireylerin teknoloji uyumu geronteknoloji olarak anılmaktadır. Geronteknoloji, disiplinler arası bir bilim olarak adlandırmakla birlikte yaşlılık sürecindeki bilgiyi alır analiz eder ve uygular.İlk yıllarda geronteknolojinin ana hedefi yaşlılar ve bakım verenler olarak belirlenirken ilerleyen yıllarda geronteknolojinin bakım verenler için de katkılar sunacağı ortaya atılmıştır. Ek olarak çocuksuz ailelerin, dul veya yalnız yaşayan yaşlıların sayısısnın artmasının yanında yerinde yaşlanma istediğinin doğması, yaşlılara artan bakım gereksinimlerinin olması ve giderek artan bakım maaliyetleri geronteknolojinin gelişmesine öncü olarak yeni boyutlar kazandırmış ve literatürde büyümeye neden olmuştur. Yaşlanma Türkiye litaratüründe sıkça rastalanan bir konu olmasına karşın son yıllarda yaşlı bakımı en fazla çalışılan konular arasında yer alamaktadır. Uluslararası literatürde ise geronteknoloji geçmişinin 30 yıllık bir geçmişe sahip olduğu görülmüştür. Son yıllarda özellikle Japonya, Kanada, Hollanda, Fransa, İspanya, İtalya ve İskoçya gibi ülkelerde lietratürde geronteknoloji açığının görülerek çalışmaların hızlandığı görülmekle beraber hem hükümetlerin hem de akademisyenlerin bu konuda ilgisini çekmektedir.

Bu çalışma, ülkeler arası temel temaları, yazar işbirliklerini ve bilimsel katkıları değerlendirerek geronteknoloji literatüründeki akademik eğilimleri incelemektedir.

Yöntem:

Bu çalışma, geronteknoloji baz alınarak yapılan niceliksel ve teorik olarak incelenmesinden elde edilen literatür bulgularını içermektedir. 1989 ile 2024 yılları arasında yayınlanmış çeşitli disiplinlerden 275 dergi makalesi, 23 başyazı, 28 kitap bölümü, 4 kitap incelemesi, 404 konferans bildirisi, 4 erken erişim makalesi, 49 derleme makalesi ve 1 kitap olmak üzere toplam 760 yayın analiz edilmiştir.

Yayınların disiplinler arası dağılımının analizi, en sık temsil edilen alanların palyatif bakım (117 kayıt), yönetim (108), bilgisayar görüntüleme ve grafikleri (54), beslenme ve diyetetik (36), robotik (36), fizyoterapi (31), sosyal psikoloji (47), telekomünikasyon (18), hemşirelik (17), nörogörüntüleme (17), sağlık okuryazarlığı ve telemedikal (16) ve iletişim (12) olduğunu ortaya koydu. Bibliyometrik veriler, yazarlık, atıflar, dergiler, ülkeler, kurumlar ve anahtar sözcüklerin analizleri yoluyla incelenmiştir.

Web of Science veritabanından alınan ve VOSviewer yazılımıyla görselleştirilen veriler kullanılarak bibliyometrik bir analiz yürütüldü. Çalışma, geronteknoloji araştırmalarında öne çıkan temaları ve etkili yazarları belirlerken, ülkeler ve kurumlar arasındaki bilimsel iş birliklerinin yapısını da haritalamaktadır.

Bulgular:

Bulgular, Çin, Amerika Birleşik Devletleri ve Malezya gibi ülkelerin alana önemli katkılarda bulunduğunu ve Hong Kong Şehir Üniversitesi ve Monash Üniversitesi gibi kurumların yüksek etkili araştırmalara ev sahipliği yaptığını göstermektedir. Anahtar kelime analizi, "yaşlanma", "destekleyici teknoloji", "yaşam kalitesi" ve "sağlık promosyonu" gibi terimlerin, sıklıkla "bilişsel sağlık", "düşme önleme" ve "yaşam kalitesini artırma" gibi kavramlarla ilişkilendirilen en güçlü bağlantıları gösterdiğini ortaya koymaktadır. Son araştırmalar, geronteknolojinin büyüyen çok disiplinli doğasını vurgulayarak araştırmacılara anlamlı içgörüler sunmakta ve akademik önemini genişletmektedir. Dahası, yaşlı yetişkinlerin bağımsızlığını desteklemek için teknolojik çözümler geliştirmeye odaklanan çalışmalar, hem akademik hem de endüstri paydaşları için değerli kaynaklar sunmaktadır.

Sonuç ve Tartışma:

Bu çalışmanın bulguları yaşlı bireylerin yaşam kalitesini arttırmayı amaçlayan bir çok disiplinden faydalanan bir araştırma makalesidir. Geronteknoloji kavramı bağımsızlığı teşvik etme, kazaları ve sağlık tehditlerini önleme, fiziksel ve bilişsel sınırlamaları telafi etme ve hem resmi hem de gayri resmi bakıcıları destekleme üzerine odaklanmaktadır. Geronteknolojinin işlevsel rolleri konusunda literatürde bir fikir birliği bulunmaktadır ve bu, disiplinler arası yapısı göz önüne alındığında daha net bir kavramsal tanımı da gerekli kılmaktadır Mevcut literatürün kapsamlı bir genel görünümünü sunan bu çalışma, geronteknoloji alanındaki gelecekteki araştırmalara rehberlik etmekte ve yaşlanan nüfusun değişen ihtiyaçlarını daha iyi karşılamak için stratejik yaklaşımların geliştirilmesini desteklemektedir. Gelecektekti çalışmaların etik boyutlarına vurgu yapılarak eğitim programları, kampanyalar ve tanıtım faaliyetleri de dahil olmak üzere kamu farkındalığı stratejilerinin etkinliği, kültürel ve demografik çeşitliliğe dikkat eçkerek değerlendirmeye alınmalıdır. Literatürdeki bir çok çalışma karşılaştırılarak eksik yönler vurgulanmalı ve çalışmalar eksik gönler baz alınarak yapılmalıdır.

1. INTRODUCTION

The increasing proportion of the elderly population today necessitates the development of technologies aimed at improving their quality of life. Technology offers significant benefits in various domains, such as enhancing the independence of older adults, facilitating their access to healthcare services, and supporting their social interactions.

Old age represents a critical turning point in maintaining individual autonomy, performing daily living activities, and improving overall health status. In this context, *Activities of Daily Living* (ADL) and *Instrumental Activities of Daily Living* (IADL) are among the key factors directly influencing the quality of life in older adults. These activities include tasks such as household chores, shopping, money management, proper medication intake, transportation arrangements, and communication. They are essential for sustaining independent living and also serve as indicators of cognitive and physical health. Instrumental Activities of Daily Living, which require a higher level of cognitive control, are defined as complex tasks that respond to environmental and social needs, and they are strongly associated with cognitive functioning (Marshall et. al,2011; Reppermund, et al. 2011). The inability of older individuals to perform these activities may result in a decline in quality of life, an increase in psychological problems such as loneliness and depression, and a greater likelihood of institutionalization. In this regard, technological advancements play a vital role in supporting the independence of older adults and enhancing their quality of life. Technological innovations offer critical tools to address challenges associated with aging. Emerging technologies such as mobile health applications, remote monitoring systems, and augmented reality provide practical solutions to facilitate daily activities, encourage physical activity, and reduce social isolation among the elderly. A systematic review by Valenzuela et al. (2018) demonstrated that technology-based exercise programs significantly and sustainably increased physical activity in older adults, showing high levels of adherence. (Valenzuela et. al. 2018). Moreover, augmented and virtual reality technologies can enhance shopping experiences by supporting healthy decision-making, thereby fostering greater independence (Valenzuela et. al. 2018; Yousaf, et al. 2020).

The COVID-19 pandemic has once again underscored the importance of technology for older adults. During emergency lockdowns, individuals became increasingly reliant on digital technologies to carry out daily activities such as communicating with friends and family or shopping through online platforms (Woolf and Schoomaker, 2019). In this period, technology played a critical role in alleviating feelings of loneliness and strengthening social connections (Bilotta et al., 2011). The use of smart technologies has enabled older adults around the world to maintain meaningful relationships, engage in physical activity, and support their psychological well-being (US Census, 2018)

Addressing the challenges associated with aging and enhancing the quality of life for older adults has become a central focus of developments in the field of gerontechnology. Gerontechnology is a multidisciplinary field that aims to improve physical and cognitive health by providing solutions that support the continued independence of older individuals. In this context, technology-based interventions facilitate daily living activities, improve access to healthcare services, and help reduce social isolation (Yousaf, et al. 2020; Woolf and Schoomaker, 2019).

This study aims to present a systematic overview of the existing literature on the concept of gerontechnology through a bibliometric analysis. It seeks to identify prevailing research trends and highlight potential gaps in the field. By revealing the evolution of gerontechnology-related scholarship, the analysis intends to contribute to a deeper understanding of current research directions and provide a foundation for future investigations in this growing domain.

2. LITERATURE REVIEW

Gerontechnology is a comprehensive interdisciplinary field that combines scientific research, ergonomics, gerontology, and technology to develop solutions tailored to the needs of older adults, with the overarching goal of enhancing their quality of life. This field encompasses a variety of functions aimed at supporting the independence of older individuals, compensating for physiological and cognitive limitations, preventing accidents, and assisting informal caregivers. Gerontechnology not only seeks to improve the physical and mental health of older adults but also aims to increase their social participation and ensure safer living environments.

This discipline incorporates a wide range of technologies designed to facilitate the daily lives of elderly individuals. For instance, home health monitoring systems, smart home technologies, wearable health devices, and robotic assistance systems enable older adults to maintain their independence and continue living in their own homes for longer periods. Additionally, gerontechnology offers tools that reduce social isolation by enhancing interaction with one's surroundings. These technologies help older adults build stronger connections with their families and communities, thereby preventing psychological issues such as loneliness and depression. Moreover, gerontechnological solutions provide substantial support to caregivers. Specifically, technologies have been developed to ease the burden on informal caregivers—typically family members or close relatives—through education modules, monitoring systems, and remote care services. These tools improve the efficiency of caregiving processes and offer emotional and logistical support to those providing care. In conclusion, gerontechnology serves as a crucial tool not only in promoting healthy and secure aging for individuals but also in increasing the overall efficiency of healthcare services, thereby alleviating the social and economic burdens associated with elderly care. As such, it is a field that strives to enhance individual well-being while contributing to the broader societal goal of sustainable aging.

Gerontechnology, as a field dedicated to enhancing the quality of life for older adults, has been examined from various perspectives across different geographical regions and has been the focus of numerous academic studies addressing its economic, social, and environmental impacts. For instance, Delello and McWhorter (2017) emphasize that with individuals aged 65 and over in the United States living longer and experiencing a range of life changes, issues such as loneliness, depression, and a decline in overall health have contributed to increased social isolation (Delello and McWhorter, 2017). In their mixed-methods study, they explored whether information and communication technologies (ICT), particularly iPads, improve the quality of life of older adults. Their findings revealed that technology contributes positively by increasing knowledge, strengthening family ties, and enhancing social connectivity. Portet et al. (2013), in their research on the acceptance and fear of new technologies, demonstrated that voice interfaces hold significant potential for easing the daily lives of older and frail individuals and may be more widely accepted than more intrusive solutions (Portet et. al, 2013). Fang et al. (2018) examined the impact of ICT use on the psychological well-being of older adults, considering factors such as age, frailty, and social connectedness (Fang et al., 2018). Their findings indicated that ICT use can improve psychological well-being in adults aged 75 and older by facilitating contact with family members and highlighted the importance of improving access to and literacy in ICT for this age group. Similarly, Blackman et al. (2016), in their study on environment-assisted living technologies for improving aging, emphasized the need for strong interdisciplinary collaboration between health sciences, rehabilitation, gerontology, and social sciences, along with technical fields such as engineering, computer science, and robotics (Blackman et al, 2016). Such collaboration is deemed essential for developing technologies that address the multifaceted needs of a heterogeneous older population, ranging from independent devices to more complex environmental systems. This study is particularly important for framing gerontechnology as a multidisciplinary R&D field.

In another study, Chen and Chan (2014) proposed the Senior Technology Acceptance Model (STAM) to understand the acceptance of gerontechnology among elderly Chinese individuals in Hong Kong (Chen and Chan, 2014). Their model revealed that individual factors such as age, gender, education level, self-efficacy, and anxiety related to technology, as well as health status and functional abilities, significantly affect technology acceptance. Liu et al. (2016), in their research on smart homes and home health monitoring technologies, found that technological readiness among older adults remains low (Liu et. al,2016). Nonetheless, their findings supported the use of home-based health technologies for monitoring daily living activities and managing health in older adults with complex needs. Majumder et al. (2017), in evaluating the advantages and future challenges of smart homes, stressed the importance of developing affordable, unobtrusive, and easy-to-use healthcare solutions to address the health needs of the elderly (Majumder et al. (2017). Smart homes, equipped with environmental and wearable medical sensors, actuators, and modern communication technologies, allow for the continuous and remote monitoring of older adults' health, enabling them to live comfortably at home rather than in costly healthcare facilities. Peek et al. (2016), through a qualitative field study involving 53 older adults aged 68–95 in the Netherlands, identified six key factors influencing technology adoption: challenges in independent living environments, personal attitudes toward technology, social network influences, institutional roles, and the physical environment (Peek et al. 2016). Their findings suggest that both psychological and contextual factors must be considered to support aging in place through technology use. Huisman et al. (2012), in their review of 65 articles, investigated how the physical environment affects recovery processes and overall well-being. Their study

recommended design considerations such as single-patient rooms and adequate lighting and concluded that future research should focus on aligning staff needs with physical environmental design (Huisman et al. 2012). Wang et al. (2020), in their study on the adoption of wearable technologies, demonstrated that factors such as performance expectancy, effort expectancy, facilitating conditions, social influence, and task-technology fit significantly influence consumer behavior regarding wearable technology use. Collectively, these factors explained 68.0% of the variance in usage intention, highlighting the critical role of user perceptions and task-technology alignment in adoption (Wang et al. 2020).

Collectively, these studies reflect a growing body of research in gerontechnology focused on developing technologies to enhance the quality of life for older adults, support their independence, compensate for cognitive and physical limitations, reduce social isolation, and provide tools for caregivers. Although several systematic reviews have been conducted in this field, there is a noticeable lack of bibliometric analyses. Therefore, this study adopts a bibliometric analysis approach to examine the trends within the gerontechnology literature, identify shifts over time, and measure the intensity of research activity in this area.

3. Methodology

Research Objective

The primary aim of this study is to present a comprehensive overview of the existing academic literature on the concept of gerontechnology through bibliometric analyses based on quantitative data and numerical indicators. The study seeks to provide researchers with a holistic understanding of the field by identifying key publication trends, thematic focuses, and collaborative networks.

Data and Analysis

Bibliometric analysis offers valuable insights into prevailing research trends and encourages scholars to explore emerging and underexplored topics. Generally, bibliometric methods are employed to statistically examine the citations of scholarly articles and other publications. In most cases, the aim is to summarize research patterns and visualize academic networks (Zhang, et. al, 2019).

Various tools are available for conducting bibliometric analysis; however, in this study, VOSviewer software was selected due to its robust functional capabilities. Designed by Jan van Eck and Ludo Waltman, VOSviewer facilitates the creation and visualization of bibliometric maps (Van Eck et al. 2019). It is widely used for generating, mapping, and analyzing bibliometric data, offering multidimensional visualizations that help researchers explore the evolution of literature identify conceptual relationships, and discover new thematic clusters.

In May 2024, a search was conducted in the Web of Science database using the keyword "gerontechnology" within "All Fields" to ensure a focused and precise dataset. All searches were conducted in English to ensure consistency and comparability across records, and since only one database (Web of Science) was used, there were no duplicate publications. The use of quotation marks limited the results to publications explicitly using this term, thereby reducing the likelihood of retrieving unrelated research and enhancing the specificity of the inquiry toward this subdomain of technology. The search yielded a total of 760 publications spanning from 1989 to 2024. These included 275 journal articles, 23 editorial materials, 28 book chapters, 4 book reviews, 404 conference proceedings, 4 early access articles, 49 review articles, and 1 book.

Only records indexed in the Web of Science database were included, as this platform provides advanced search indicators, rigorous quality control mechanisms, and access to a diverse and reliable collection of scholarly literature from multiple disciplines. Its credibility in academic publishing ensures the inclusion of ethically sound and high-quality studies.

An analysis of the disciplinary distribution of the publications revealed that the most frequently represented fields include palliative care (117 records), management (108), computer imaging and graphics (54), nutrition and dietetics (36), robotics (36), physiotherapy (31), social psychology (47), telecommunications (18), nursing (17), neuroimaging (17), health literacy and telemedicine (16), and communication (12). The bibliometric data were examined through analyses of authorship, citations, journals, countries, institutions, and keywords.

For network visualization and mapping, VOSviewer (version 1.6.18) was used to conduct a co-occurrence analysis of author keywords. The normalization method was set to LinLog/modularity, and the clustering resolution was fixed at 1.0. A minimum threshold of 1 keyword occurrences was applied to focus the analysis on terms with sufficient frequency. These settings were chosen based on established practices in the bibliometric literature and aimed to balance cluster granularity with interpretability. Parameter selection was informed by previous studies (e.g., Van Eck & Waltman, 2010), ensuring methodological transparency and allowing for reproducibility by other researchers.

Ethical Statement

Because this study utilized secondary data, ethics committee approval was not required. However, no unethical behavior was observed throughout the study.

4. RESULT

Co-authorship of Authors

The Co-authorship Network Map Illustrating Author Collaborations depicts the collaborative relationships between authors, where each node represents an individual author, node size indicates publication output, and the thickness of the connecting lines reflects the strength and frequency of co-authored works, highlighting research partnerships and collaborative clusters. Based on the co-authorship analysis of authors, a network map was generated to identify the most collaborative and interconnected researchers in the field. The analysis was conducted by applying a minimum threshold of one publication and at least one citation per author. As a result, 16 authors grouped into four clusters were identified, with a total of 90 co-authorship links. Each author within this network was found to have 49 total link strength units, indicating a relatively dense level of collaboration among the most active contributors.

In terms of citation impact, *Chen Ke* received 512 citations from 3 links in 2014, *Chan Alan* recorded 173 citations across 28 links in 2016, and *Teh Pei Lee* obtained 66 citations from 22 links in 2018. These findings highlight not only the academic influence of these researchers but also their central roles in collaborative networks within gerontechnology scholarship.
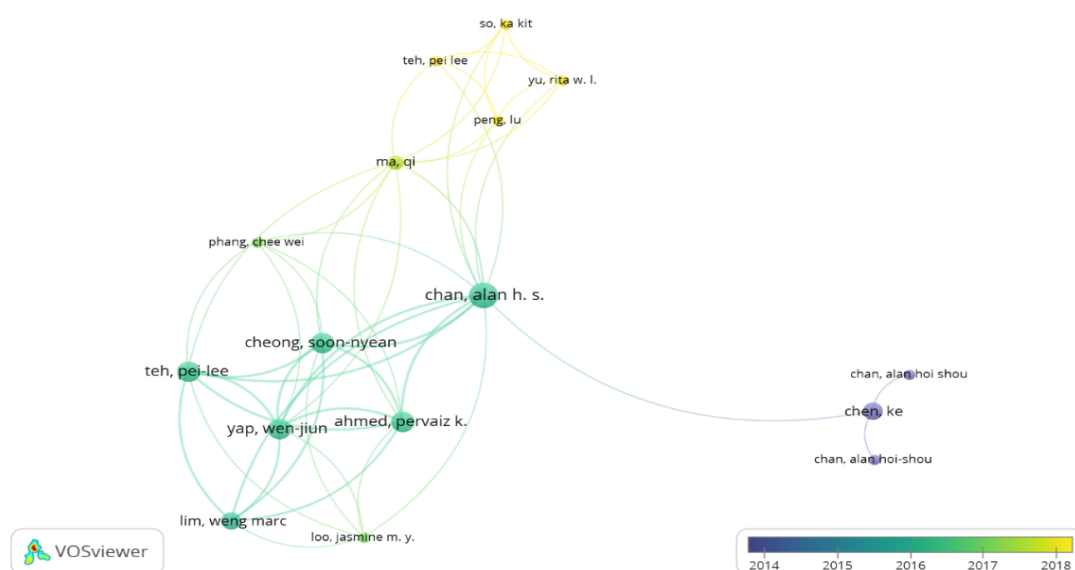

Figure 1. Co-authorship Network Map Illustrating Author Collaborations

Citation of Authors

The Author Citation Network Map shows how authors are connected based on citation relationships, where the size of each node reflects the total number of citations an author has received, and the thickness of the connecting lines indicates the frequency with which one author cites or is cited by another, revealing key contributors and citation dynamics within the field. To identify citation networks among authors, a citation analysis was conducted using a threshold of at least one publication and one citation per author. Based on these criteria, a citation network map was generated to visualize inter-author citation relationships. The analysis revealed a total of 73 nodes, organized into 8 clusters, with 388 citation links and a total link strength of 559.

Among the most frequently cited authors, Chen Ke stands out with 512 citations, followed by Chan Alan with 173 citations, and Ahmed Pervaiz with 66 citations. These three authors not only lead in citation counts but also hold the highest positions in terms of total link strength within the citation network. Their central roles indicate a significant influence on the scholarly development of the gerontechnology field.
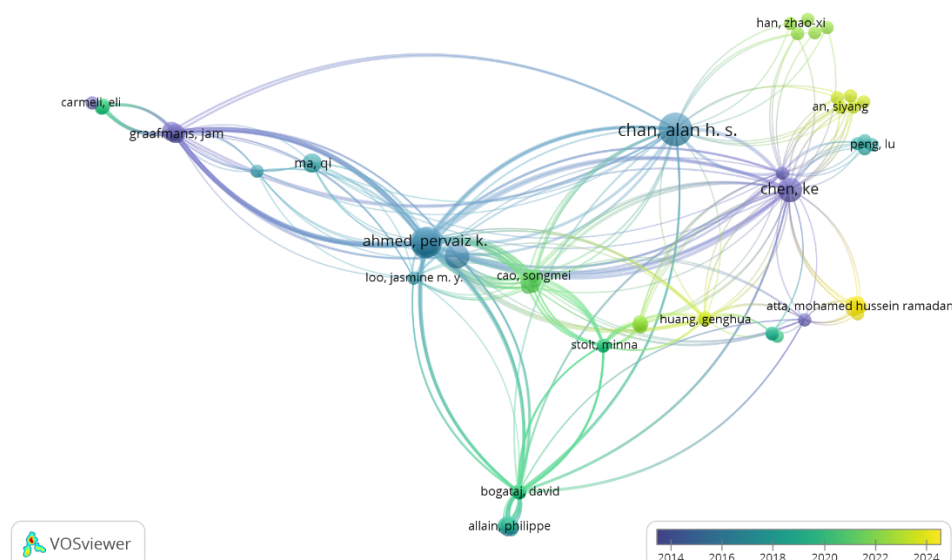

Figure 2. Author Citation Network Map

Citation of Countries

The Country Citation Network Map illustrates the citation relationships between countries, with node size indicating the total number of citations received by each country and line thickness representing the strength of citation links, thereby revealing global research influence and international scholarly connections. To visualize the citation impact of countries based on the origin of publications, a citation network map was generated using the criteria of at least one publication and one citation per country. The analysis was conducted on 15 observation units, revealing 5 clusters, 24 links, and a total link strength of 53.

The countries with the highest citation counts were the People's Republic of China with 616 citations, followed by the United States with 139 citations, and Malaysia with 82 citations. These three countries also ranked highest in terms of total link strength, reflecting both the volume and influence of their contributions in the field of gerontechnology. The distribution of publications by country mirrored the citation rankings, indicating consistent research productivity and academic impact.

In recent years, countries such as Germany (159), Egypt (1), and Bahrain (1) have also emerged with noteworthy publications, signaling a broader global engagement in gerontechnology research.
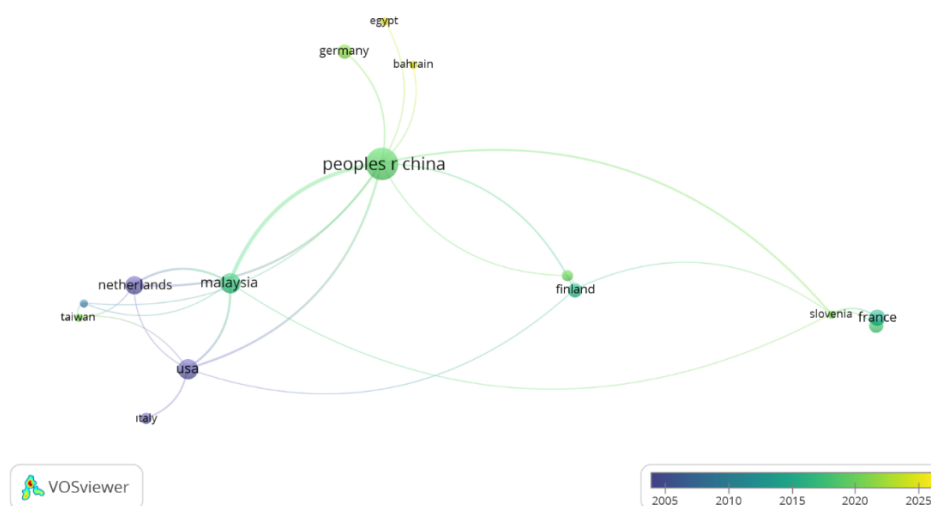

Figure 3. Country Citation Network Map

Citation of Organizations

To examine inter-institutional citation relationships, a citation network map was created using the criteria of at least one publication and one citation per organization. The Institutional Citation Network Map displays the citation relationships between institutions, where node size represents the total number of citations received and the thickness of the connecting lines indicates the frequency of citation links between institutions, highlighting influential academic hubs and collaborative networks. The analysis was carried out across 40 organizational units, resulting in the identification of 11 clusters, 91 links, and a total link strength of 132.

The most highly cited institutions were Hong Kong City University with 580 citations, followed by Monash University with 68 citations, and Multimedia University with 66 citations. These institutions also ranked among the highest in terms of total link strength, indicating their prominent role and scholarly influence in gerontechnology research.
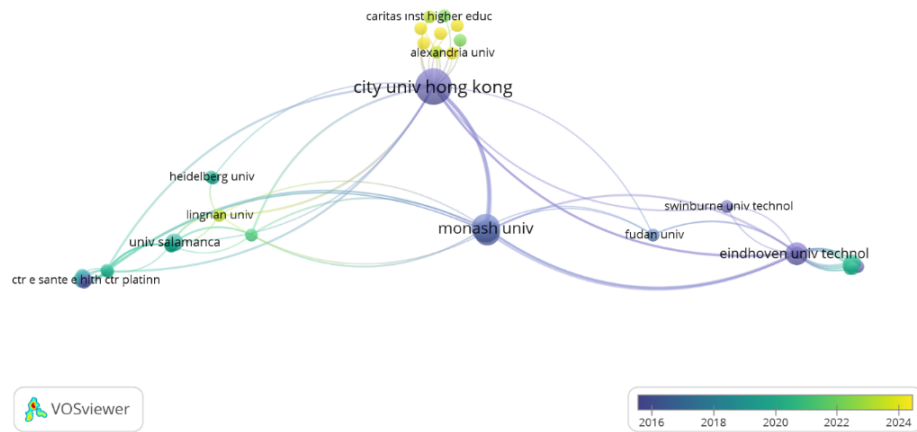
Figure 4. Institutional Citation Network Map

Co-occurrence of All Keywords

The Keyword Co-occurrence Network Map visualizes the relationships between frequently appearing keywords, where node size reflects keyword frequency and line thickness indicates the strength of co-occurrence, revealing major thematic clusters in the literature. An analysis of keywords used in gerontechnology-related publications was conducted to identify the most frequently occurring terms and their co-occurrence relationships. Among the most prominent keywords were "gerontechnology" with 33 occurrences, "older adults" with 9 occurrences, "technology" with 5 occurrences, and "ethics" with 3 occurrences.

In terms of total link strength, the keywords *"gerontechnology," "older adults,"* and *"technology"* emerged as the most influential, indicating their central role in the thematic structure of the literature.

The analysis, conducted on 133 nodes representing keywords that appeared at least once and demonstrated a relational connection, revealed 23 clusters, 411 links, and a total link strength of 452. These findings highlight the diverse conceptual landscape of gerontechnology research and the interconnectedness of its core themes.

Figure 5. Keyword Co-occurrence Network Map

Bibliographic Coupling of Documents
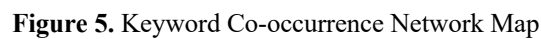
Bibliographic coupling refers to the relationship between two independent documents that cite the same third source. The Bibliographic Coupling Network Map of Documents illustrates how individual publications are linked based on shared references, where thicker lines indicate stronger bibliographic coupling, reflecting a closer intellectual relationship between the documents. In this study, an analysis was conducted on 34 documents that met the criterion of having at least one citation and demonstrated inter-document connections. The results revealed 7 clusters, 150 links, and a total link strength of 402.

The publications with the highest number of bibliographic couplings were *Chen (2014b)* with 315 citations, *Merkel (2019)* with 107 citations, and *Chen (2014a)* with 105 citations. In terms of total link strength, the most strongly coupled documents were *Chen (2014b)* with 82, *Cheng (2023)* with 77, and *Chen (2014a)* with 73. These results indicate that these publications share a strong intellectual connection with other works in the field and play a significant role in shaping the gerontechnology literature.

Figure 6. Bibliographic Coupling Network Map of Documents

Bibliographic Coupling of Authors

The bibliographic coupling analysis of authors was performed using the criteria of having published at least one work and received at least one citation. Among the 111 connected author units included in the analysis, a total of 11 clusters, 1,848 links, and a total link strength of 21,142 were identified.

The authors with the highest bibliographic coupling were Chan Alan, with 173 citations and a link strength of 2,265, followed by Ahmed Pervaiz and Cheong Soon Nyean, each with 66 citations and a link strength of 1,680. These results highlight the strong intellectual connections these authors share with other researchers in the field, suggesting that their works are frequently grounded in similar bodies of literature.
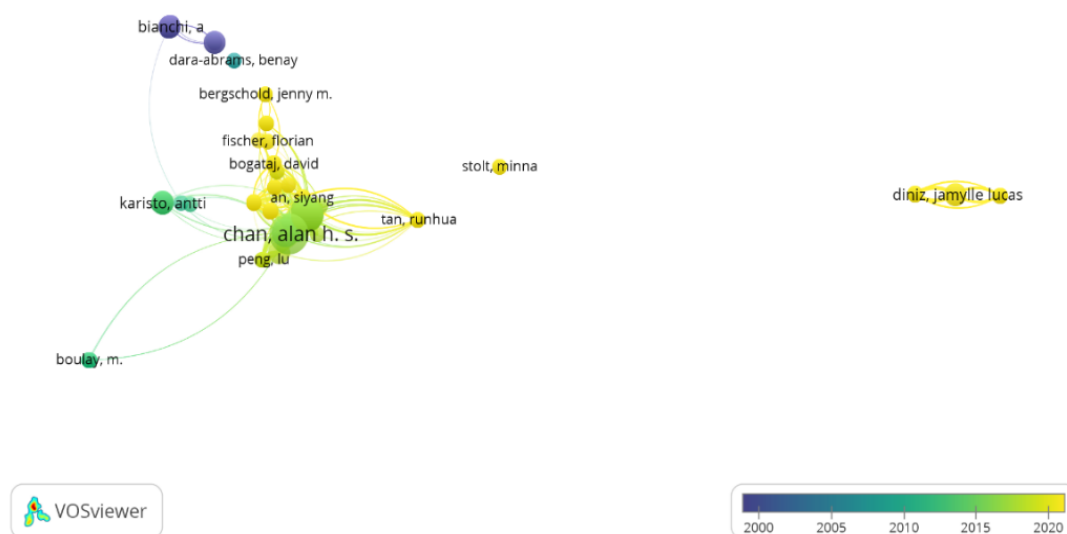

Figure 7. Bibliographic Coupling Network Map of Authors

Co-citation of Authors

Co-citation refers to the occurrence of two or more authors being cited together within the same publication. In a *Bibliographic Coupling Network Map of Authors*, the **nodes** represent individual authors, and the **connecting lines (edges)** illustrate the degree of bibliographic coupling between them—that is, how many references they have in common. The **thicker the connecting line**, the greater the number of shared references, indicating a stronger intellectual or thematic connection in their work. The **size of each node** typically reflects the author's total citation count, signaling their influence within the field. In this analysis, a minimum threshold of 10 citations was set, and 7 author units that met this criterion and showed interconnections were included in the network. The analysis revealed 2 clusters, 19 links, and a total link strength of 176.

The most frequently co-cited authors were Chen K. with 26 co-citations, followed by Fozard J.L. with 15, and Peek S.T.M. with 12. These authors are commonly referenced together in gerontechnology literature, indicating that their work is considered foundational and complementary within the scholarly discourse.
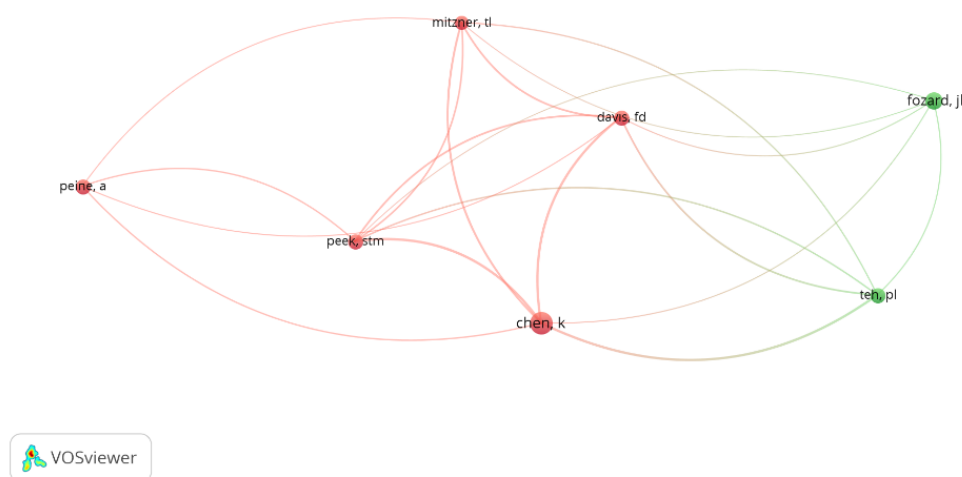
Figure 8. Co-citation Network Map of Authors

5. DISCUSSION AND CONCLUSION

This study evaluates a range of findings derived from both quantitative analysis and the theoretical examination of scholarly works on gerontechnology. A total of 760 publications from various disciplines—comprising 275 journal articles, 23 editorials, 28 book chapters, 4 book reviews, 404 conference papers, 4 early access articles, 49 review articles, and 1 book—published between 1989 and 2024 were analyzed. The findings highlight *gerontechnology* as an emerging multidisciplinary Research and Development domain aimed at enhancing the quality of life for older adults. The concept centers on promoting independence, preventing accidents and health threats, compensating for physical and cognitive limitations, and supporting both informal and formal caregivers. A consensus exists in the literature on the functional roles of gerontechnology, which also necessitates a clearer conceptual definition given its interdisciplinary nature.

The field merges scientific research with ergonomics, gerontology, and technological innovation, positioning itself as a vital platform for responding to the diverse needs of the aging population. Academic contributions from countries such as China, the United States, and Malaysia, and institutions like Hong Kong City University and Monash University, demonstrate the international scope and growing impact of the field. In recent years, emerging contributions from Germany, Egypt, and Bahrain have also gained attention.

Technological solutions—such as vital sign monitoring systems, fall detection devices, medication reminders, and smart home technologies—have been developed to support older adults' mobility, personal care, and daily activities. Despite their benefits, adapting to rapidly evolving technologies can be challenging for older adults due to cognitive and physical limitations; however, they tend to more easily adopt devices similar to technologies they have previously used. The World Health Organization's guidelines on age-friendly cities highlight the importance of accessible housing, transportation, social participation, and healthcare, aiming to foster active aging and inclusion. These approaches position older adults not only as service recipients but as active contributors to society.

Keyword trends show a temporal shift: earlier studies emphasized *"aging", "assistive technology", "silver economy",* and *"aging policy"* while recent work has increasingly focused on *"life quality", "emerging technology", "co-creation"* "mental wellbeing*" "accident prevention",* and *"health promotion".* These evolving themes reflect the growing complexity and relevance of gerontechnology. The frequent co-occurrence of keywords such as *"ethics"* and *"older adults"* may be interpreted through the lens of the Senior Technology Acceptance Model (STAM), particularly in relation to dimensions such as *technology-related anxiety* and *perceived usefulness,*

indicating that ethical concerns and user characteristics significantly shape the acceptance of gerontechnological innovations.

Looking forward, research in gerontechnology must further investigate its individual, societal, political, economic, and cultural impacts. The rise of artificial intelligence and its symbiosis with user-generated data online offers new opportunities at the intersection of AI and gerontechnology. The steady growth of literature from 53 studies in 1992 to 105 in 2021 demonstrates increasing scholarly interest, supported by accumulated global experience and academic output. Periodic literature reviews will continue to serve as essential tools for informing both experts and the broader public from a scientific perspective.

Future research should also explore the diffusion, usage potential, and ethical dimensions of AI-integrated Geron technological products. Additionally, the effectiveness of public awareness strategies—including education programs, campaigns, and outreach activities—should be evaluated with attention to cultural and demographic diversity. Comparative studies may yield actionable insights for implementation across various sectors.

It is crucial for professionals from a wide range of fields—including engineers, health administrators, urban planners, social workers, technology developers, policymakers, legislators, and care providers—to develop an understanding of gerontechnology. The field offers not only solutions to facilitate daily living for older adults but also strategies to mitigate the broader social and economic consequences of population aging. Thus, increasing interdisciplinary awareness and collaboration is essential to meet the evolving needs of older populations effectively.

Limitations of the study must also be acknowledged. First, while the Web of Science database is a leading source, incorporating additional databases in future research could broaden the scope. This may introduce database bias by excluding relevant studies in other indexing services (e.g., Scopus, PubMed), particularly non-English literature, thereby limiting generalizability. Second, the findings reflect the state of the literature as of the date of data retrieval and may not account for very recent developments. Lastly, although VOSviewer was chosen for its strong visualization capabilities, future studies could benefit from using alternative bibliometric software to explore additional analytical dimensions.

AUTHORS' STATEMENT

REFERENCES

Bilotta, C., et al. (2011). Older people's quality of life (OPQOL) scores and adverse health outcomes at a one-year follow-up: A prospective cohort study on older outpatients living in the community in Italy. *Health and Quality of Life Outcomes,*9, 72. https://doi.org/10.1186/1477-7525-9-72

Blackman, S., Matlo, C., Bobrovitskiy, C., Waldoch, A., Fang, M. L., Jackson, P., ... & Sixsmith, A. (2016). Ambient assisted living technologies for aging well: A scoping review. *Journal of Intelligent Systems, 25*(1), 55-69. https://doi.org/10.1515/jisys-2015-0061

Chen, K., & Chan, A. H. S. (2014). Gerontechnology acceptance by elderly Hong Kong Chinese: A senior technology acceptance model (STAM). *Ergonomics,* 57(5), 635-652. https://doi.org/10.1080/00140139.2014.907356

Delello, J. A., & McWhorter, R. R. (2017). Reducing the digital divide: Connecting older adults to iPad technology. *Journal of Applied Gerontology, 36*(1), 3-28. https://doi.org/10.1177/0733464814544047

Fang, Y., Chau, A. K., Wong, A., Fung, H. H., & Woo, J. (2018). Information and communicative technology use enhances psychological well-being of older adults: The roles of age, social connectedness, and frailty status. *Aging & Mental Health,* 22(11), 1516-1524. https://doi.org/10.1080/13607863.2017.1362784

Huisman, E. R., Morales, E., Van Hoof, J. & Kort, H. S. (2012). Healing environment: A review of the impact of physical environmental factors on users. *Building and Environment*, 58, 70-80. https://doi.org/10.1016/j.buildenv.2012.07.013

Liu, L., Stroulia, E., Nikolaidis, I., Miguel-Cruz, A. & Rincon, A. R. (2016). Smart homes and home health monitoring technologies for older adults: A systematic review. *International Journal of Medical Informatics,* 91, 44-59. https://doi.org/10.1016/j.ijmedinf.2016.04.003

Majumder, S., Aghayi, E., Noferesti, M., Memarzadeh-Tehran, H., Mondal, T., Pang, Z. & Deen, M. J. (2017). Smart homes for elderly healthcare—Recent advances and research challenges. *Sensors,* 17(11), 2496. https://doi.org/10.3390/s17112496

Marshall, G. A., Rentz, D. M., Frey, M. T., Locascio, J. J., Johnson, K. A., & Sperling, R. A. (2011). Executive function and instrumental activities of daily living in MCI and AD. *Alzheimer's Dementia: The Journal of the Alzheimer's Association 7*(3), 300–308. https://doi.org/10.1016/j.jalz.2010.04.005

Peek, S. T., Luijkx, K. G., Rijnaard, M. D., Nieboer, M. E., Van Der Voort, C. S., Aarts, S., ... & Wouters, E. J. (2016). Older adults' reasons for using technology while aging in place. *Gerontology,* 62(2), 226-237. https://doi.org/10.1159/000441271

Portet, F., Vacher, M., Golanski, C., Roux, C., & Meillon, B. (2013). Design and evaluation of a smart home voice interface for the elderly: Acceptability and objection aspects. *Personal and Ubiquitous Computing, 17*, 127-144. https://doi.org/10.1007/s00779-012-0576-3

Reppermund, S., et al. (2011). The relationship of neuropsychological function to instrumental activities of daily living in mild cognitive impairment. *International Journal of Geriatric Psychiatry,* 26(8), 843–852. https://doi.org/10.1002/gps.2612

US Census. (2021). The U.S. joins other countries with large aging populations. 2018 Census.gov. https://www.census.gov/library/stories/2018/03/graying-america.html (accessed Dec. 20, 2021).

Valenzuela, T., Okubo, Y., Woodbury, A., Lord, S. R., & Delbaere, K. (2018). Adherence to technology-based exercise programs in older adults: A systematic review. *Journal of Geriatric Physical Therapy,*41(1), 49–61. https://doi.org/10.1519/JPT.0000000000000095

Van Eck, Nees Jan, & Ludo Waltman. (2014). Visualizing bibliometric networks. *Measuring scholarly impact: Methods and practice*. Cham: Springer International Publishing, 285-320.

Wang, H., Tao, D., Yu, N., & Qu, X. (2020). Understanding consumer acceptance of healthcare wearable devices: An integrated model of UTAUT and TTF. *International Journal of Medical Informatics,* 139, 104156. https://doi.org/10.1016/j.ijmedinf.2020.104156

Woolf, S. H. & Schoomaker, H. (2019). Life expectancy and mortality rates in the United States, 1959-2017. *JAMA,* 322(20), 1996–2016. https://doi.org/10.1001/jama.2019.16932

Yousaf, K., et al. (2020). A comprehensive study of mobile-health based assistive technology for the healthcare of dementia and Alzheimer's disease (AD). *Health Care Management Science*, 23(2), 287–309. https://doi.org/10.1007/s10729-019-09486-0

Zhang, X., Estoque, R.C., Xie, H., Murayama, Y., & Ranagalage, M. (2019). Bibliometric analysis of highly cited articles on ecosystem services. *PLoS ONE,* 14(2), 1-16. https://doi.org/10.1371/journal.pone.0210707