



Gerontechnology Adoption in the Silver Market: Global Bibliometric Trends and Future Agenda

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ABSTRACT

Malaysia is projected to become an aged nation by 2030, creating both opportunities and challenges for the expanding silver market. Gerontechnology integrates technology and gerontology to support the independence, health, and quality of life of older adults, yet its impact depends on acceptance as much as innovation. This study conducts a bibliometric and content analysis of global gerontechnology research to identify key drivers of technology acceptance and to position Malaysia within this emerging field. Publications indexed in Scopus were analysed using VOSviewer to map publication growth, collaboration networks, and thematic clusters. The results show a gradual shift from mainly health-oriented applications toward behavioural and marketing perspectives, emphasising determinants such as perceived usefulness, ease of use, trust, and affordability. Malaysia's research contribution remains developing but demonstrates growing attention to digital health, assistive technologies, and active ageing solutions. Based on these insights, the study proposes a marketing-oriented research and innovation agenda for 2025-2035 that prioritises user-centred design, digital inclusion, and collaboration among industry, academia, and policymakers. Integrating consumer behaviour perspectives into gerontechnology development can accelerate adoption among older adults and strengthen Malaysia's role in the regional silver economy.

Keywords: Gerontechnology, Silver Market, Technology Acceptance, Technology Adoption

JEL Classifications: M13, O15, O33

1. INTRODUCTION

Population ageing has become one of the defining global transitions of the twenty-first century, with far-reaching implications for social, economic, and technological development. According to the World Health Organization (WHO), by 2050, one in six people worldwide will be aged 60 years or older, nearly doubling from 12% in 2015 (World Health Organization, 2025). This demographic milestone reflects significant advances in healthcare and living standards but also presents new challenges related to economic productivity, health management, and social participation among older adults (Cabañero-Garcia et al., 2025). As societies adapt to these changes, technology has emerged as

a crucial enabler for enhancing the quality of life and promoting independence in later years.

Malaysia is undergoing a rapid demographic transition, resulting in an ageing population. The Department of Statistics Malaysia (DOSM) projects that individuals aged 60 years and above will comprise more than 15% of the national population by 2030, officially categorising Malaysia as an ageing nation (Department of Statistics Malaysia, 2025). Unlike the gradual demographic shifts observed in many high-income countries, Malaysia's transition is occurring within a much shorter period. This trend increases pressure on the healthcare system, aged care services, and the labour market, while also generating new economic

opportunities in the expanding silver market. The silver market refers to the growing segment of consumers aged 60 and above who are potential users of digital and assistive technologies (Abdullah et al., 2024).

Gerontechnology, an interdisciplinary field that integrates technology and ageing research, offers solutions to improve autonomy, safety, and social engagement among older adults (Jumbri et al., 2025; Wider et al., 2025). Its applications range from telehealth platforms and wearable health monitors to smart home systems, robotics, and artificial intelligence-enabled diagnostics (Shi et al., 2025). As technological advancements accelerate, the successful implementation of new technologies largely depends on user acceptance, perceived value, and trust in the technology. For many older adults, factors such as affordability, digital literacy, cultural attitudes, and design usability play a decisive role in determining adoption behaviour. Understanding these factors is critical for both policymakers and marketers seeking to bridge the digital divide and ensure that innovation translates into tangible benefits for the ageing population.

From a marketing perspective, the silver market represents a promising yet underexplored domain. Elderly consumers are increasingly recognised as active decision-makers rather than passive recipients of care. Their adoption of gerontechnology depends on perceived usefulness, ease of use, and emotional comfort with digital interfaces, aligning with models such as the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT). Companies and policymakers must therefore develop strategies that address consumer trust, communication styles, and value co-creation to encourage adoption and loyalty in this expanding market.

Despite growing global attention, research on gerontechnology in Malaysia remains limited and fragmented. Previous studies have primarily emphasised healthcare policy and sustainability rather than consumer behaviour and marketing potential. A clearer understanding of international research trends can help identify where Malaysia stands in terms of innovation, collaboration, and market readiness. Bibliometric analysis offers a systematic approach for mapping global knowledge structures, identifying leading contributors, and uncovering emerging themes in this evolving field (Wider et al., 2025; Yang et al., 2022).

This study conducts a bibliometric and content analysis of global gerontechnology research to explore the key drivers of technology acceptance and the marketing implications for Malaysia's ageing population. The specific objectives are to:

- I. Map global publication trends and thematic directions related to technology acceptance among older adults
- II. Evaluate Malaysia's research position within international collaboration networks
- III. Propose a marketing-oriented research and innovation agenda for 2025-2035.

By integrating consumer behaviour perspectives with insights from bibliometric evidence, this study contributes to a better understanding of how Malaysia can strengthen its role in the

regional silver economy through innovation, inclusivity, and market responsiveness.

2. LITERATURE REVIEW

2.1. Concept and Evolution of Gerontechnology

Gerontechnology emerged in the early 1990s as an interdisciplinary response to the opportunities and pressures created by population ageing. It integrates gerontology, which examines the ageing process and later-life experiences, with technological development aimed at enhancing the health, independence, and social participation of older adults (Toros et al., 2024). From the outset, the field positioned technology not merely as a tool for clinical care but as an enabler of autonomy and quality of life across diverse living contexts.

Early gerontechnology research focused on assistive devices and healthcare technologies designed to enhance safety, alleviate functional limitations, and alleviate caregiver burden. Typical developments included mobility aids, monitoring and alert systems, and basic home-based support solutions. As digital infrastructures matured, research and practice expanded into more integrated applications that connect older adults with services and communities in real time.

Recent advances in digital health, robotics, and information and communication technologies have further broadened the scope of gerontechnology. Contemporary studies increasingly address telehealth platforms, smart home environments, wearable sensing devices, and artificial intelligence applications for screening, monitoring, and decision support (Pilotto et al., 2023). These innovations enable continuous and personalised support, particularly for individuals managing chronic conditions or ageing in place, and they also facilitate preventative approaches rather than reactive care alone.

This evolution reflects a gradual shift from a primarily biomedical orientation toward a more holistic understanding of ageing that incorporates psychological, social, and behavioural dimensions (Huang and Oteng, 2023; Wang, 2025). In this context, the WHO's concept of active ageing reinforces the importance of supportive environments that allow older adults to remain engaged, independent, and socially connected. Technologies are therefore increasingly evaluated not only by clinical outcomes, but also by how they strengthen participation and everyday functioning.

Despite the promise of gerontechnology, real-world impact depends on more than technical performance. Adoption is shaped by perceived usefulness, usability, affordability, trust, digital literacy, and the extent to which solutions align with the values and lived routines of older adults. Accordingly, research on technology acceptance and market adoption is central to translating gerontechnology innovations into sustained use and measurable benefits at scale.

2.2. Global Research Landscape in Gerontechnology

Over the past two decades, gerontechnology research has expanded rapidly, propelled by demographic ageing and the accelerating

pace of digital transformation. Research leadership has been concentrated in the United States, Japan, and several European countries, including the Netherlands and Germany, which have advanced both foundational concepts and applied solutions in this domain (Chien et al., 2025). Across these regions, scholarly and industrial activity has been supported by mature innovation ecosystems and sustained investment in health and assistive technologies, enabling the faster translation of prototypes into real-world deployment.

The dominant research streams have centred on smart home environments, telehealth services, wearable sensing technologies, and assistive robotics, each designed to strengthen autonomy, safety, and continuity of care for older adults (Pilotto et al., 2023). In parallel, more recent developments increasingly emphasise data-driven approaches, including the use of artificial intelligence for early disease detection, monitoring, and decision support. Robotics has also gained prominence in dementia care, rehabilitation, and daily assistance, reflecting a shift toward more interactive and adaptive systems that can respond to the complex needs of older adults (Chen, 2020).

At the same time, global publication patterns suggest a gradual transition from predominantly engineering-oriented studies toward research that foregrounds behavioural, social, and market determinants of adoption. This shift is often framed through established acceptance models such as the TAM, which highlights perceived usefulness and perceived ease of use, and the UTAUT, which extends the explanation to include social influence and facilitating conditions (Ren and Zhou, 2023). In addition, Diffusion of Innovation Theory has been used to clarify how gerontechnology spreads within ageing populations, emphasising perceived relative advantage, social networks, and communication pathways as mechanisms shaping uptake (Zhou et al., 2024).

Large-scale collaborative initiatives illustrate how multi-stakeholder partnerships can accelerate innovation and dissemination. Europe's Ambient Assisted Living Joint Programme is frequently cited as an example of coordinated effort among academia, government, and industry to develop and validate solutions that support independent living and well-being (Khaksar et al., 2025). Such programmes demonstrate the strategic value of shared standards, user involvement, and cross-sector funding in moving beyond isolated pilot studies toward scalable applications.

Despite these advances, scholarships from low and middle-income countries remain comparatively limited. Moreover, the international literature still tends to underexamine context-specific factors such as affordability constraints, digital literacy gaps, infrastructure readiness, and cultural preferences. These considerations are crucial in diverse socioeconomic settings, where adoption decisions are shaped not only by the performance of technology but also by perceived value, accessibility, and trust. Addressing these gaps is crucial for developing a more comprehensive and inclusive evidence base that accurately reflects the realities of the silver market across various national and regional contexts.

2.3. Research Gaps and Rationale for the Present Study

The existing literature highlights several persistent gaps that constrain the understanding of gerontechnology adoption and its commercial potential. First, a substantial proportion of studies prioritise technological development and system performance, while giving less attention to consumer acceptance, user experience, and behavioural intention. This imbalance limits the ability to explain why technically feasible solutions may fail to achieve sustained use among older adults in real-world settings.

Second, contextual influences remain insufficiently examined. Socioeconomic status, educational background, digital literacy, and rural-urban disparities significantly influence access, perceived relevance, and willingness to adopt; however, these variables are often treated as peripheral rather than integral determinants of adoption (Oh et al., 2021). As a result, evidence is frequently challenging to generalise across diverse communities and service environments, particularly in countries with uneven infrastructure and income distribution.

Third, the marketing dimensions of gerontechnology are still underdeveloped. Topics such as value proposition design, pricing affordability, branding, trust formation, and risk perceptions among older consumers receive limited systematic attention. Similarly, governance and ethical considerations, including data privacy, informed consent, algorithmic transparency, and digital equity, are commonly acknowledged but remain underexplored in empirical research and practical implementation studies (Sundgren et al., 2020). These issues are increasingly central as gerontechnology solutions rely on continuous monitoring, data sharing, and platform-based service delivery.

Bibliometric evidence further suggests that Malaysia and several neighbouring countries remain underrepresented in global publication and collaboration networks (Ahmad et al., 2022). This underrepresentation reduces regional visibility, constrains knowledge exchange, and limits opportunities for coordinated innovation and policy learning. Addressing these gaps requires more than additional studies; it calls for interdisciplinary approaches that integrate technology design with behavioural science, marketing strategy, and regulatory perspectives.

Against this background, the present study conducts a bibliometric and content analysis of global gerontechnology research to identify emerging themes, influential contributors, and patterns of collaboration. It also situates Malaysia within the global landscape and evaluates how marketing and consumer behaviour insights can inform national strategies for an ageing society. By synthesising bibliometric evidence with acceptance and market-oriented frameworks, the study proposes a research and innovation agenda for 2025-2035 aimed at strengthening Malaysia's competitiveness, inclusivity, and readiness for the regional silver economy.

3. METHODOLOGY

3.1. Study Design

This study employed a bibliometric research design, guided by the preferred reporting items for systematic reviews and meta-analyses (PRISMA) framework, to examine global research trends in gerontechnology systematically. The approach aimed to identify thematic developments, key contributors, and emerging focus areas related to technology acceptance and marketing implications for older adults. Bibliometric analysis was selected because it enables a quantitative and visual exploration of publication growth, citation impact, and collaboration patterns, which collectively provide insights into the intellectual structure and evolution of a research field (Muda et al., 2024). This design has been widely applied in previous bibliometric studies on digital health, consumer technology, and innovation adoption, making it well-suited for analysing the emerging intersection of gerontechnology and the silver market.

3.2. Data Source and Search Strategy

The Scopus database was selected as the primary data source because it offers comprehensive coverage of peer-reviewed journals and multidisciplinary research across the social sciences, engineering, and health domains (Lwin et al., 2023). A structured search strategy was developed using a combination of keywords related to ageing, technology, and user acceptance. The search terms included “gerontechnology,” “ageing population,” “assistive technology,” “elderly consumers,” “technology adoption,” and “digital health for older adults.” Boolean operators (AND/OR) were used to refine the query and ensure comprehensive retrieval of relevant literature.

The search was conducted in September 2025, covering publications from 1990 to 2026 to capture the field’s development over time. Only journal articles, review papers, and conference proceedings published in English were included. The search was limited to subject areas related to health sciences, social sciences, engineering, and business management, reflecting the interdisciplinary and marketing-oriented nature of gerontechnology research.

3.3. Inclusion and Exclusion Criteria

Publications were included if they explicitly addressed the use, development, or evaluation of technologies designed for older adults, with a particular focus on health, social participation, or consumer adoption. Studies focusing on general digital health or technology without a clear connection to ageing or user acceptance were excluded. Editorials, letters, book chapters, and non-indexed materials were also removed. The inclusion process prioritised research that examined both technological and behavioural aspects of adoption, including perceived usefulness, trust, accessibility, and market readiness. Duplicates were identified and removed through a systematic data-cleaning process to ensure the integrity of the dataset.

3.4. Data Extraction and Processing

All bibliographic records were exported from Scopus in both RIS and CSV formats for further processing. Extracted metadata included publication year, author names, institutional affiliations,

country of origin, document type, source title, citation counts, and author-supplied keywords. Data cleaning was performed using a combination of manual screening and automated scripts to standardise author names, merge duplicate entries, and correct typographical inconsistencies.

The PRISMA workflow was followed throughout the identification, screening, and inclusion stages to ensure methodological transparency and reproducibility. Figure 1 illustrates the PRISMA flow diagram summarising the data selection process.

3.5. Bibliometric Analysis and Tools

Three complementary tools were employed for bibliometric analysis. VOSviewer (version 1.6.20) was used to construct and visualise co-authorship, co-citation, and keyword co-occurrence networks, revealing intellectual and thematic relationships among studies. Publish or Perish (version 8) was used to calculate citation-based metrics, including the h-index, g-index, and average number of citations per year. Biblioshiny, an R-based graphical interface for the Bibliometrix package, was utilised to perform trend analysis, thematic evolution mapping, and country-level collaboration analysis.

The integration of these tools enabled both descriptive and relational analyses, facilitating a deeper understanding of how gerontechnology research has evolved from a health policy focus toward a market- and consumer-oriented paradigm. Keyword co-occurrence analysis played a crucial role in identifying emerging themes related to technology acceptance, user experience, and marketing strategies in the silver market.

3.6. Ethical Considerations

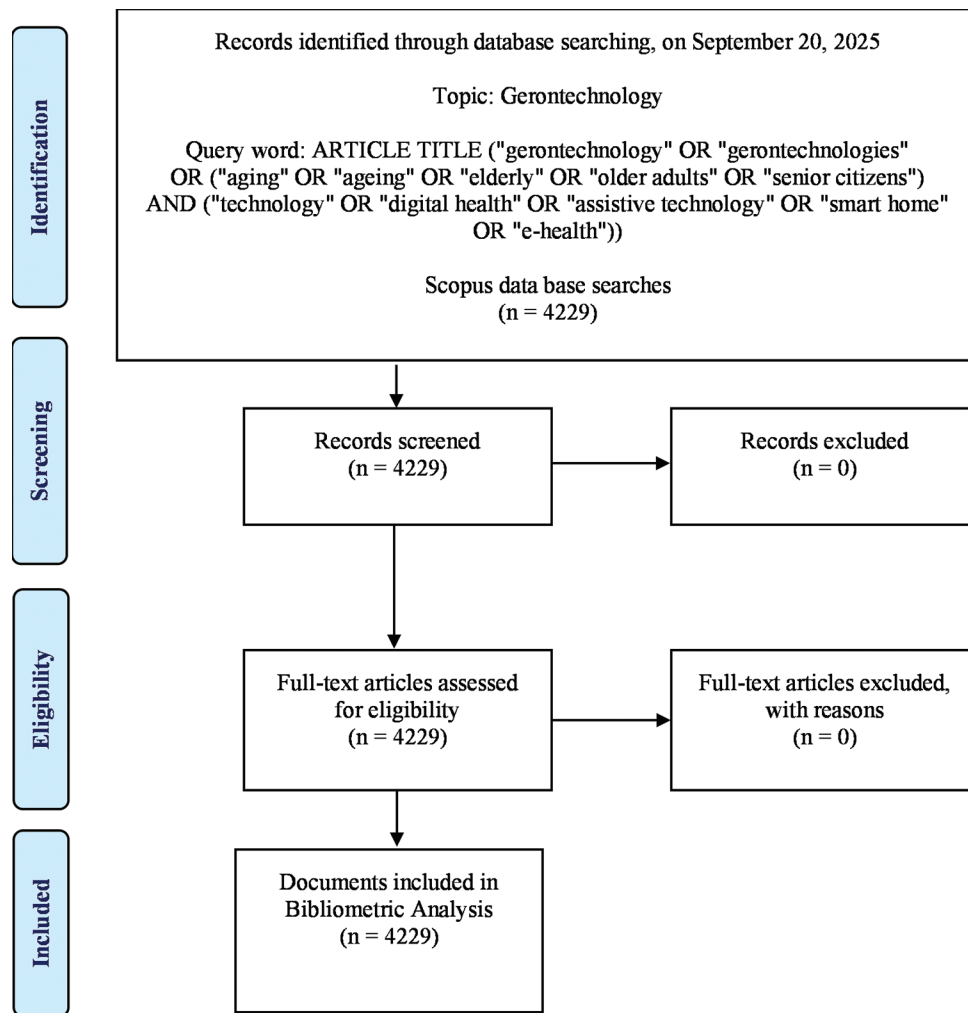
This study relied entirely on secondary bibliometric data obtained from the Scopus database. As no human participants or primary data collection were involved, ethical approval was not required. All procedures were carried out in accordance with established guidelines for bibliometric research and transparent scientific reporting. The analytical process emphasised reproducibility and data integrity to ensure credible and verifiable outcomes.

4. RESULTS

4.1. Document Type Distribution

A total of 4,216 documents related to gerontechnology were retrieved from the Scopus and Web of Science databases for the period 1990-2026. Table 1 summarises the document type distribution. Journal articles constituted the largest share (51.00%), followed by conference papers (26.13%) and review papers (10.05%). Other contributions included book chapters (6.60%), editorials (1.56%), and smaller categories such as notes, conference reviews, and letters.

This distribution demonstrates that gerontechnology has matured into a well-established academic domain characterised by both conceptual and empirical scholarship. The strong representation of journal articles and conference papers reflects the field’s dual emphasis on theoretical exploration and the dissemination of technological innovations relevant to ageing and user adoption.

Figure 1: Preferred reporting items for systematic reviews and meta-analyses flow diagram**Table 1: Document type distribution**

Document type	No. of publication	Percentage
Article	2157	51.00
Conference paper	1105	26.13
Review	425	10.05
Book chapter	279	6.60
Editorial	66	1.56
Erratum	59	1.40
Note	38	0.90
Book	28	0.66
Letter	27	0.64
Conference review	24	0.57
Short survey	14	0.33
Retracted	7	0.17

Table 2: Source type distribution

Document type	No. of publication	Percentage
Journal	2792	66.02
Conference proceeding	720	17.03
Book Series	429	10.14
Book	271	6.41
Trade journal	17	0.40

The combination of journal and conference outputs reflects a dynamic knowledge ecosystem where scientific validation and market-oriented innovation intersect.

4.3. Language of Publication

Language analysis (Table 3) revealed that English overwhelmingly dominates gerontechnology publications (94.82%), followed by Chinese (1.92%) and Spanish (0.78%). Other languages, such as French, German, and Portuguese, accounted for <1% each. The predominance of English underscores its role as the global medium for scientific communication, enabling international collaboration and visibility in ageing and technology research.

4.4. Subject Area Classification

The subject area classification (Table 4 and Figure 2) illustrates the interdisciplinary structure of gerontechnology research. The largest

share of publications falls within the field of Medicine (41.62%), followed by Computer Science (31.00%), Engineering (23.76%), and Social Sciences (20.22%). Notably, Business, Management, and Accounting (3.45%) also emerged as a growing subfield, indicating an increasing focus on the economic and marketing aspects of technology adoption among older adults.

This interdisciplinary pattern reinforces that gerontechnology operates at the intersection of health innovation, engineering

design, and social systems. Its growing inclusion in business and management disciplines further signals an evolving recognition of the silver market as an emerging area of research and practice.

4.5. Temporal Publication Trends

The temporal distribution of publications from 1973 to 2026 (Table 5 and Figure 3) shows a gradual evolution followed by exponential growth. Publications were scarce before the 1990s but began increasing steadily from 2000 onwards. The most significant acceleration occurred after 2012, coinciding with growing global attention to digital transformation, smart ageing, and technology-enabled healthcare.

The period from 2021 to 2025 marked the most productive phase, accounting for over 45% of total publications. This surge reflects heightened scholarly and industry interest in the acceptance of technology, user experience, and digital inclusion among older adults. The sustained upward trajectory and increasing citation frequency confirm the consolidation of gerontechnology as an influential and rapidly expanding research domain bridging health, innovation, and marketing.

4.6. Geographical Distribution

The global distribution (Table 6 and Figure 4) identifies the United States as the leading contributor (25.99%), followed by China (12.63%), the United Kingdom (7.47%), Canada (7.00%), and Italy (4.54%). These countries dominate the research landscape, driven by advanced innovation systems and substantial investments in digital health and ageing technology.

Table 3: Language of publication

Document type	No. of publication	Percentage
English	4010	94.82
Chinese	81	1.92
Spanish	33	0.78
French	29	0.69
German	25	0.59
Portuguese	21	0.50
Russian	20	0.47
Italian	11	0.26
Japanese	7	0.17
Korean	6	0.14
Persian	5	0.12
Slovenian	5	0.12
Greek	3	0.07
Dutch	2	0.05
Polish	2	0.05
Bosnian	1	0.02
Finnish	1	0.02
Norwegian	1	0.02
Swedish	1	0.02

Table 4: Subject area

Document type	No. of publication	Percentage
Medicine	1760	41.62
Computer science	1311	31.00
Engineering	1005	23.76
Social sciences	855	20.22
Nursing	514	12.15
Health professions	362	8.56
Mathematics	333	7.87
Biochemistry, genetics, and molecular biology	274	6.48
Psychology	226	5.34
Physics and astronomy	168	3.97
Materials science	159	3.76
Business, management, and Accounting	146	3.45
Environmental science	132	3.12
Arts and humanities	125	2.96
Decision sciences	102	2.41
Energy	99	2.34
Agricultural and biological sciences	84	1.99
Neuroscience	72	1.70
Chemical engineering	68	1.61
Chemistry	63	1.49
Economics, econometrics, and finance	57	1.35
Multidisciplinary	44	1.04
Earth and planetary sciences	37	0.87
Immunology and microbiology	34	0.80
Pharmacology, toxicology, and pharmaceuticals	25	0.59
Dentistry	6	0.14
Veterinary	3	0.07

Figure 2: Documents by subject area

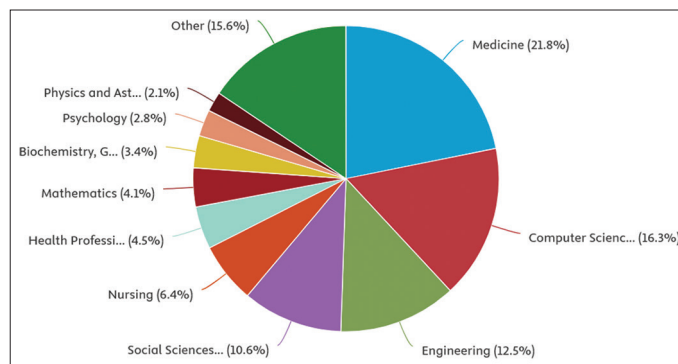


Figure 3: Temporal trends in gerontechnology publications (1973-2026)

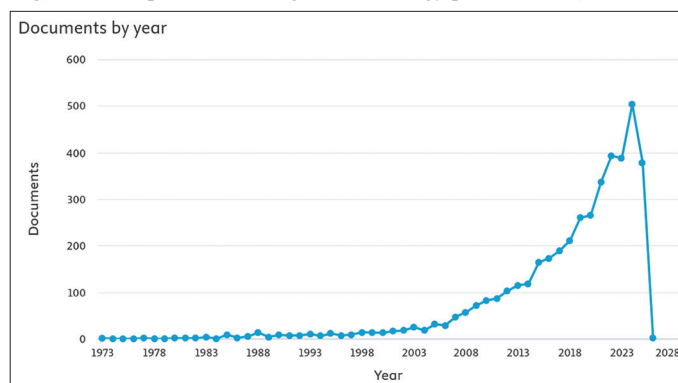


Table 5: Year publication trends

Year	No. of publication	Percentage
2026	2	0.05
2025	378	8.94
2024	504	11.92
2023	388	9.17
2022	393	9.29
2021	337	7.97
2020	265	6.27
2019	260	6.15
2018	211	4.99
2017	189	4.47
2016	173	4.09
2015	164	3.88
2014	118	2.79
2013	115	2.72
2012	103	2.44
2011	87	2.06
2010	82	1.94
2009	72	1.70
2008	57	1.35
2007	47	1.11
2006	29	0.69
2005	31	0.73
2004	18	0.43
2003	25	0.59
2002	18	0.43
2001	16	0.38
2000	13	0.31
1999	13	0.31
1998	14	0.33
1997	9	0.21
1996	7	0.17
1995	11	0.26
1994	6	0.14
1993	10	0.24
1992	7	0.17
1991	7	0.17
1990	8	0.19
1989	4	0.09
1988	13	0.31
1987	5	0.12
1986	2	0.05
1985	9	0.21
1983	4	0.09
1982	1	0.02
1981	1	0.02
1980	1	0.02
1977	1	0.02
1973	1	0.02

Table 6: Top 20 Countries contributed to publication

Country	No. of publication	Percentage	Continent
United States	1099	25.99	North America
China	534	12.63	Asia
United Kingdom	316	7.47	Europe
Canada	296	7.00	North America
Italy	192	4.54	Europe
Germany	190	4.49	Europe
Australia	178	4.21	Oceania
Spain	165	3.90	Europe
Sweden	128	3.03	Europe
South Korea	126	2.98	Asia
Netherlands	119	2.81	Europe
Japan	118	2.79	Asia
France	116	2.74	Europe
Taiwan	96	2.27	Asia
Portugal	94	2.22	Europe
India	86	2.03	Asia
Hong Kong	80	1.89	Asia
Ireland	66	1.56	Europe
Malaysia	66	1.56	Asia

Table 7: Top 20 most influential institutions

Institution	No. of publication	Percentage
University of Toronto	61	1.44
University of Illinois Urbana-Champaign	54	1.28
Georgia Institute of Technology	51	1.21
University of Washington	45	1.06
Karolinska Institutet	38	0.90
University of Montreal	32	0.76
University of Miami Leonard M. Miller	30	0.71
School of Medicine		
Harvard Medical School	29	0.69
The Hong Kong Polytechnic University	29	0.69
University of Ottawa	29	0.69
Rheinisch-Westfälische Technische	28	0.66
Hochschule Aachen		
University of Miami	28	0.66
National University of Singapore	27	0.64
Simon Fraser University	25	0.59
The University of British Columbia	24	0.57
Peking University	24	0.57
University of Michigan, Ann Arbor	24	0.57
University of Missouri	23	0.54
University of Florida	23	0.54
Michigan State University	23	0.54

In Southeast Asia, Malaysia contributed 66 publications (1.56%), positioning it among the top 20 countries. Although its output remains modest, Malaysia's growing engagement highlights its emerging role in integrating gerontechnology into national ageing strategies and exploring technology adoption among older consumers. This momentum presents opportunities for Malaysia to expand its marketing and behavioural research on technology acceptance within the regional silver economy.

4.7. Institutional Contributions

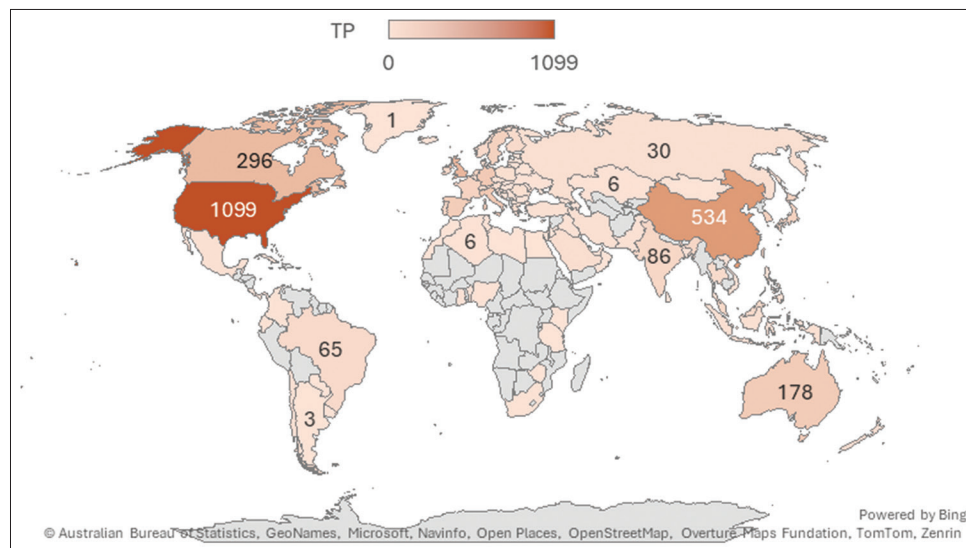
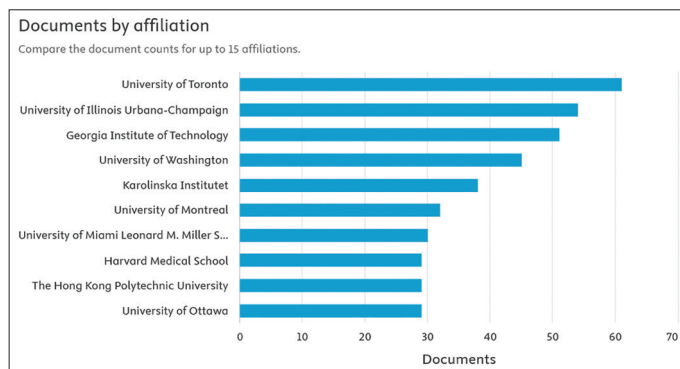
Institutional analysis (Table 7 and Figure 5) reveals that the University of Toronto, the University of Illinois at Urbana-Champaign, and the Georgia Institute of Technology are the most productive institutions globally. These centres have made significant

contributions to human-technology interaction and ageing-related design. European and Asian institutions, such as Karolinska Institutet, The Hong Kong Polytechnic University, and the National University of Singapore, also exhibit firm research profiles.

While Malaysian universities are not yet among the global top 20, institutions such as Monash University Malaysia and Multimedia University are emerging contributors. Their growing involvement reflects Malaysia's increasing capacity to lead regional collaborations in gerontechnology, particularly in research on user acceptance and market development for elderly consumers.

4.8. Most Productive Authors

Author productivity analysis (Table 8) identified W.A. Rogers, G. Demiris, and S.J. Czaja as leading contributors, all of whom

Figure 4: Geographical distribution of publications**Figure 5:** Document by affiliation**Table 8: Most productive authors**

Author name	No. of publication	Percentage
Rogers, W.A.	52	1.23
Demiris, G.	38	0.90
Czaja, S.J.	31	0.73
Kottorp, A.	27	0.64
Nygård, L.	23	0.54
Charness, N.	20	0.47
Mitzner, T.L.	19	0.45
Ziefle, M.	19	0.45
Skubic, M.	17	0.40
Malinowsky, C.	15	0.35

are recognised for advancing human–technology interaction and ageing-related usability frameworks. Other key authors, such as A. Kottorp, L. Nygård, and N. Charness, have contributed to studies on user-centred design and cognitive aspects of adoption. Emerging Malaysian authors, such as P.L. Teh, represent a growing voice in regional scholarship linking gerontechnology adoption with public health and consumer behaviour.

4.9. Active Source Title

Analysis of publication outlets (Table 9) shows that Lecture Notes in Computer Science (and its subseries) remains the most prolific source, followed by Gerontechnology and JMIR Aging. These journals and conference proceedings bridge the gap between technology innovation, human–computer interaction, and health applications. Notably, interdisciplinary journals such as Frontiers in Public Health, Digital Health, and the Journal of Applied Gerontology demonstrate increasing integration of marketing and social science perspectives.

This trend suggests that gerontechnology research is expanding beyond medical and technical domains to encompass consumer-focused and market-oriented investigations related to the acceptance, usability, and diffusion of ageing technologies.

4.10. Citation Analysis

The 4,229 documents retrieved between 1973 and 2026 accumulated a total of 83,714 citations, averaging 19.80 citations per paper (Table 10). The overall h-index of 129 and g-index of 205 reflect substantial scholarly influence and intellectual maturity. The continuous increase in citation counts parallels the global growth of gerontechnology research, underscoring its growing importance in promoting active ageing, consumer empowerment, and the design of inclusive technology.

4.11. Highly Cited Articles

The ten most cited publications Table 11. forms the intellectual foundation of gerontechnology. The most cited work (Czaja et al., 2006) identified predictors of technology use among older adults, followed by Heerink et al. (2010), who developed the Almere Model for assessing acceptance of assistive technologies. Peek et al. (2014) offered a systematic review on technology acceptance for ageing in place. Collectively, these seminal works emphasise perceived usefulness, usability, and trust as key drivers of adoption.

Their high citation rates reveal the academic community's sustained interest in understanding the psychological and social mechanisms behind technology acceptance and diffusion among elderly users, which are core principles for developing effective marketing and engagement strategies within the silver market.

Table 11: Highly cited articles

No.	Authors/year	Title	Source	Cites	Cites per year	Cites per author
1	Czaja et al. (2006)	Factors predicting the use of technology: Findings from the centre for research and education on aging and technology enhancement (CREATE)	Psychology and aging	1587	83.53	227
2	Heerink et al. (2010)	Assessing acceptance of assistive social agent technology by older adults: The Almere model	International Journal of Social Robotics	908	60.53	227
3	Peek et al. (2014)	Factors influencing acceptance of technology for aging in place: A systematic review	International Journal of Medical Informatics	880	80	147
4	Mitzner et al. (2010)	Older adults talk technology: Technology usage and attitudes	Computers in Human Behaviour	812	54.13	81
5	Vaportzis et al. (2017)	Older adults' perceptions of technology and barriers to interacting with tablet computers: A focus group study	Frontiers in psychology	626	78.25	209
6	Chen et al. (2016)	The effect of information communication technology interventions on reducing social isolation in the elderly: A systematic review	Journal of Medical Internet Research	615	68.33	308
7	Demiris et al. (2004)	Older adults' attitudes towards and perceptions of 'smart home' technologies: A pilot study	Medical Informatics and the Internet in Medicine	576	27.43	82
8	Lee and Coughlin (2015)	PERSPECTIVE: Older adults' adoption of technology: an integrated approach to identifying determinants and barriers	Journal of product innovation management	564	56.4	282
9	Liu et al. (2016)	Smart homes and home health monitoring technologies for older adults: A systematic review	International Journal of Medical Informatics	549	61	110
10	Chen et al. (2014)	Gerontechnology acceptance by elderly Hong Kong Chinese: A senior technology acceptance model (STAM)	Ergonomics	490	44.55	245
11	Barnard et al. (2013)	Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability	Computers in Human Behaviour	488	40.67	122
12	Selwyn et al. (2003)	Older adults' use of information and communications technology in everyday life	Ageing and Society	482	21.91	121
13	Majumder et al. (2017)	Smart homes for elderly healthcare - Recent advances and research challenges	Sensors	466	58.25	67
14	Charness et al. (2009)	Aging and information technology use: Potential and barriers	Current Directions in Psychological Science	457	28.56	229
15	Pollack et al. (2005)	Intelligent technology for an ageing population: The use of AI to assist elders with cognitive impairment	AI Magazine	433	21.65	433

Table 12: Keywords in gerontechnology research

Keyword	No. of publication	Percentage
Gerontechnology	439	65.13
Human	199	29.53
Aged	146	21.66
Humans	129	19.14
Aging	113	16.77
Article	106	15.73
Older adults	101	14.99
Technology	96	14.24
Female	84	12.46
Male	81	12.02
Quality of life	57	8.46
Adult	52	7.72
Aged, 80 and over	48	7.12
Very elderly	46	6.82
Independent living	44	6.53

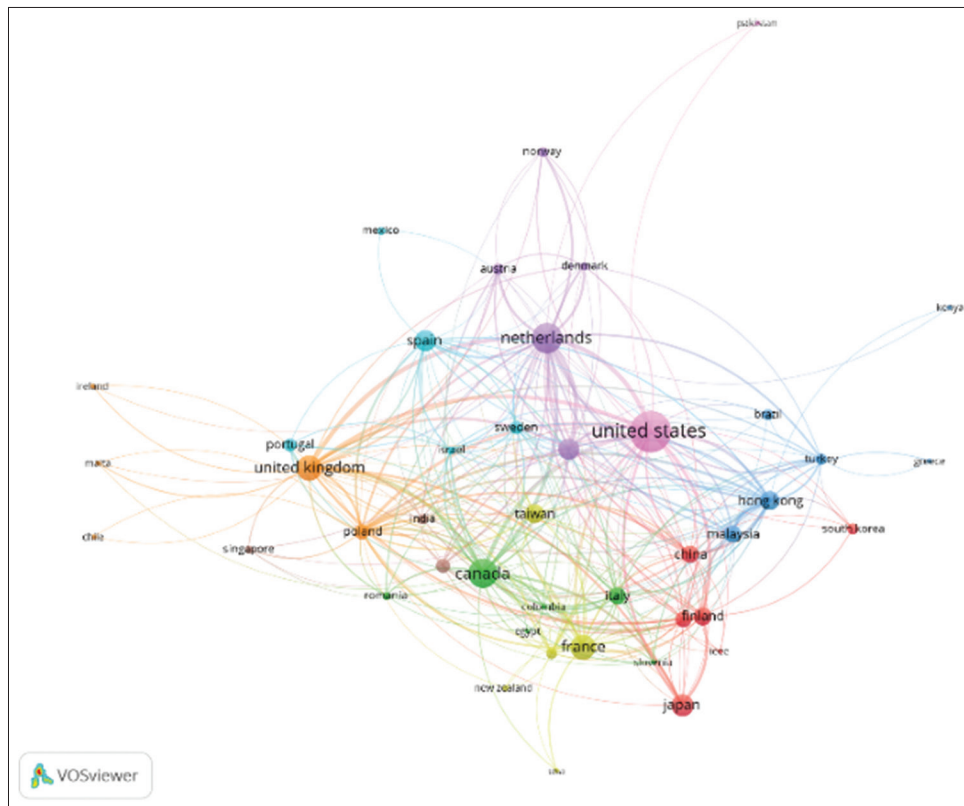
China, Japan, and South Korea, are increasingly visible but remain more regionally clustered. Malaysia appears at the periphery with a modest linkage density, which suggests that targeted international collaboration, especially with institutions at the forefront of behavioural and marketing research, could accelerate knowledge transfer and elevate Malaysia's contribution to silver-market scholarship. Partnerships that pair local ageing contexts with established expertise in consumer

analytics and user-experience design are likely to yield high marginal impact.

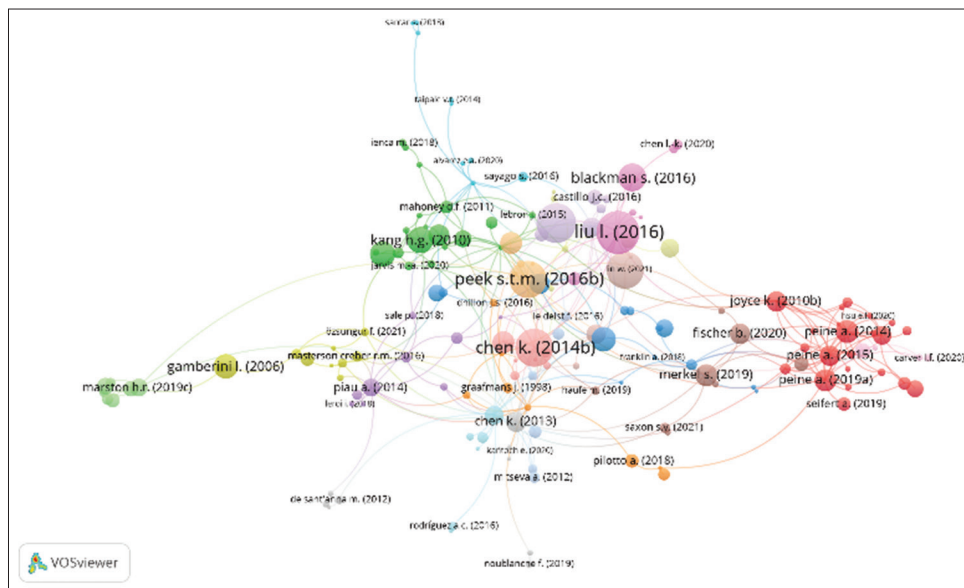
The document co-citation network (Figure 8) positions foundational acceptance studies at the centre of the field. Highly co-cited works by Chen and Chan, Peek et al., and Liu et al. anchor the map, connecting health technologies with adoption theory, user experience, and smart-home integration.

Their centrality suggests that contemporary research is increasingly interpreting gerontechnology through the lens of perceived usefulness, ease of use, facilitating conditions, social influence, and risk perception. This pattern aligns with evidence-based research that marketing strategists can operationalise, for example, by segmenting elderly consumers by readiness, tailoring communication to address trust and privacy concerns, and designing onboarding processes that reduce cognitive and financial barriers.

The author citation network (Figure 9) further consolidates this orientation. Scholars such as Chen, Peek, Bouma, and Peine form influential hubs that bridge engineering design with user-centred theory and market adoption. Surrounding clusters include human-factors researchers and critical gerontology scholars whose work on usability, cognition, and ethics informs product positioning

Figure 7: Network visualisation map of the citation by countries

Minimum number of documents of an author = 1; Minimum number of citations of an author = 5

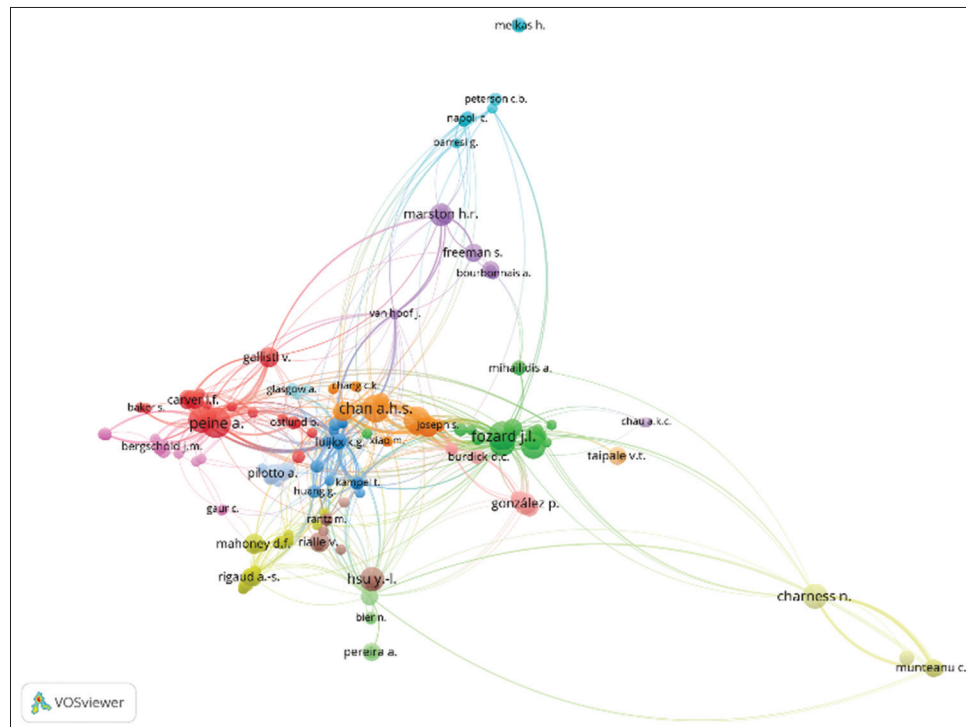
Figure 8: Network visualisation map of the citation by documents

Minimum number of citations of an author = 5

and responsible marketing. The configuration of these author communities suggests a converging research frontier where technical performance, service design, and consumer behaviour are studied together to improve uptake and sustained use among older adults.

Taken together, the four networks demonstrate that gerontechnology has evolved from a predominantly technical

field to a multidisciplinary domain centred on consumer behaviour, usability, and market diffusion. For Malaysia, the implication is clear. Advancing from policy aspiration to measurable adoption will require research programs and industry partnerships that integrate behavioural modelling, market segmentation, and value co-creation with older users. This integration can help translate technological promise into actual purchase, adherence, and long-term engagement in the regional silver economy.

Figure 9: Network visualisation map of the citation by author

Minimum number of citations of a document = 3

5. DISCUSSION

5.1. Global Overview of Gerontechnology Research

This study offers an in-depth examination of global trends in gerontechnology, situating Malaysia within the context of a rapidly evolving international research landscape. Over the past three decades, gerontechnology has evolved from a narrow technical field into a mature, interdisciplinary domain that integrates health sciences, engineering, behavioural studies, and marketing. The steady growth of scholarly output, particularly after 2015, reflects the global recognition of technology's role in supporting the physical, cognitive, and social well-being of older adults. This aligns with the WHO's framework for active and healthy ageing, which emphasises lifelong health and social participation.

High-income countries, such as the United States, the Netherlands, Japan, and Canada, continue to dominate gerontechnology research due to their well-established innovation ecosystems and ageing policies (Czaja et al., 2006; Peek et al., 2014). Malaysia, by contrast, is still building institutional capacity but has demonstrated a positive upward trend in publication activity, reflecting greater awareness of the potential for technology to address demographic change (Abdullah et al., 2024). Strengthening cross-sector collaboration and increasing publication in high-impact international outlets will be essential for enhancing Malaysia's global research visibility.

5.2. Thematic Clusters and National Relevance

The keyword and thematic cluster analysis identified three principal domains in gerontechnology research: healthcare integration, social and functional support, and governance and policy frameworks. These areas collectively represent the

intellectual and applied structure of the field and have significant implications for Malaysia's ageing strategy.

The healthcare integration cluster underscores the importance of telemedicine, remote monitoring, and digital health systems in improving disease management and preventive care. These technologies align closely with Malaysia's Twelfth Malaysia Plan, which emphasises healthcare innovation and digital transformation.

The social and functional support cluster reflects a growing emphasis on user acceptance and market adaptation. Studies such as Charness and Boot (2009) and Chen and Chan (2014) emphasise the significance of perceived usefulness, ease of use, and trust in influencing technology acceptance among older adults. In the Malaysian context, affordability and cultural appropriateness remain critical factors influencing adoption (Huang and Oteng, 2023).

The governance and policy cluster emphasises the role of ethical regulation, standardisation, and stakeholder collaboration. These factors are fundamental to implementing the Shared Prosperity Vision 2030, which aims to ensure equitable access to technology across diverse social groups (Ministry of Economic Affairs, 2019). Coordinated policy frameworks that link health, science, and social welfare will be vital to sustaining gerontechnology innovation.

5.3. Research Gaps and Institutional Capacity

Despite growing interest, Malaysia's research landscape in gerontechnology remains fragmented and concentrated within a few academic institutions. Current bibliometric evidence indicates a limited number of interdisciplinary projects that combine

engineering, social science, and health expertise. Areas such as robotics, artificial intelligence, and predictive analytics remain underexplored, despite their proven transformative impact in other contexts (Chen, 2020; Asgharian et al., 2022). Additionally, longitudinal and participatory studies focusing on technology adoption among older Malaysians are still scarce.

Building a sustainable research ecosystem requires national coordination and targeted investment. Establishing a National Gerontechnology Research Consortium could help integrate academic, industrial, and community stakeholders to develop scalable and culturally sensitive solutions that address the needs of older adults. Government incentives, postgraduate funding schemes, and innovation grants can accelerate capacity building and attract multidisciplinary talent. Encouraging collaboration with the Association of Southeast Asia Nations (ASEAN) and global partners would also strengthen Malaysia's international research visibility and knowledge exchange.

5.4. Public Health, Sustainability, and Social Inclusion

Although interest in gerontechnology is growing, research in Malaysia remains fragmented, with limited integration of behavioural science, marketing, and engineering perspectives. Previous studies have shown that the successful diffusion of innovation among older adults depends not only on functionality but also on emotional engagement and perceived value (Barnard et al., 2013; Peek et al., 2014). However, longitudinal and participatory research on Malaysian seniors' adoption behaviours is still lacking.

Emerging technologies such as robotics and artificial intelligence offer promising solutions for elder care but are underexplored in local research (Chen, 2020; Asgharian et al., 2022). Establishing a National Gerontechnology Research Consortium could consolidate resources, support interdisciplinary collaboration, and promote the development of culturally appropriate products. Government-led incentives, postgraduate scholarships, and innovation grants could accelerate this process and attract cross-sectoral partnerships, particularly within the ASEAN region.

5.5. Research and Policy Agenda for 2025-2035

The results of this study support a forward-looking research and policy agenda for the next decade. Three interrelated priorities should guide Malaysia's progress: behavioural research, market-driven innovation, and governance development.

First, behavioural research must deepen understanding of how older adults evaluate, adopt, and sustain technology use. Applying models such as the TAM and the UTAUT can elucidate the roles of perceived ease of use, social influence, and trust (Heerink et al., 2010; Chen and Chan, 2014). Cross-cultural and longitudinal studies focusing on older Malaysians could reveal how familial and cultural factors shape acceptance behaviour.

Second, innovation should integrate marketing insights and user co-design. Collaboration between engineers, designers, and marketers can produce affordable and emotionally engaging technologies tailored to the preferences of older consumers. This

approach will also foster new opportunities in the emerging silver economy, contributing to Malaysia's digital transformation agenda.

Third, governance should ensure the ethical, inclusive, and secure application of gerontechnology. Policies must safeguard data privacy, establish product quality standards, and promote public trust. Cross-ministerial coordination among the Ministries of Health, Communications, and Social Welfare is necessary to sustain coherent and ethical innovation. International partnerships, especially within ASEAN, can enhance Malaysia's research capacity and position it as a regional leader in ageing technology and marketing research.

5.6. Toward a Sustainable Future for Malaysia's Ageing Society

As Malaysia approaches aged-nation status by 2030, gerontechnology must be recognised as a strategic driver of sustainable and inclusive development. The findings of this study reveal that Malaysia is well-positioned to adapt global knowledge while nurturing local innovation. Through cohesive policies, capacity building, and public engagement, the country can convert the challenges of ageing into opportunities for innovation and social progress.

Gerontechnology is viewed as both a catalyst for healthcare and a driver of the market. It not only improves health and independence but also stimulates industry growth and technological competitiveness. Continued investment, ethical governance, and inclusive education will ensure that longevity is matched by improved quality of life and active participation for all generations.

6. CONCLUSION

This study offers a comprehensive evaluation of global trends in gerontechnology research, positioning Malaysia within the evolving international landscape of this field. By employing bibliometric and content analysis, the study effectively mapped the intellectual structure of gerontechnology, identified its key thematic domains, and assessed Malaysia's emerging contribution to this domain. The results underscore a shift in global research emphasis from purely technological development to behavioural, marketing, and policy dimensions that address the acceptance and integration of technology in ageing societies.

The analysis confirms that while high-income countries continue to dominate global research output, Malaysia is steadily building its research capacity, and its visibility in the field is growing. This trend reflects the growing recognition of the strategic importance of gerontechnology in addressing the challenges of population ageing. To solidify its position, Malaysia must foster greater interdisciplinary collaboration, invest in research infrastructure, and integrate gerontechnology within national ageing and digital transformation agendas. This is essential for advancing the nation's role in the regional silver economy and enhancing its competitive edge in gerontechnology innovation.

From a scholarly perspective, this study makes a significant contribution to a deeper understanding of how technology

acceptance, perceived usefulness, and social inclusion influence the adoption of innovations among older adults. Furthermore, the study lays the foundation for future empirical research that focuses on user behaviour, marketing dynamics, and technology design tailored to local cultural contexts.

Looking forward, the findings offer a practical framework to shape Malaysia's research and policy agenda from 2025 to 2035. By emphasising behavioural research, co-designed innovation, and ethical governance, Malaysia has the opportunity to transform the demographic challenge of ageing into a driver of sustainable development. Strengthening collaboration between academia, industry, and government will be critical for driving innovation and ensuring that gerontechnology enhances the quality of life, independence, and well-being of older adults. Such collaboration will not only promote digital inclusion but also foster the growth of the silver market, enabling Malaysia to become a regional leader in gerontechnology adoption and market development.

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