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Thematic Characteristics and Research Hot-spots of China's Healthy Aging Policy : Topic Modeling Study

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Availability of data and materials.

The datasets generated and analyzed during the current study are all publicly available.

Ethics approval and consent to participate.

This study did not involve human participants, and therefore required no ethics approval or consent to participate.

Conflicts of interest.

None declared.

Consent for publication.

Not applicable.

Abbreviations

WHO: World Health Organization
NLP: Natural language processing
LDA: latent Dirichlet allocation
TF-IDF: term frequency-inverse document frequency
CNKI: China National Knowledge Infrastructure
HCR: Holsti's Reliability Coefficient

Description of authors' roles.

CZ conceived the idea and conceptualized the study questions. JH and XL participated in data cleaning and statistical analysis. BZ constructed the research model. BX and LY edited the paper. YL and XZ wrote the manuscript. CZ gave many valuable comments on the draft and polished it. All authors approved the final version.

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Background: China faces unprecedented aging challenges, with its population aged 60+ projected to exceed 310 million by 2024. To address this, China integrated "healthy aging" into national strategies like the Healthy China 2030 initiative. However, a systematic analysis of policy themes and research hot-spots was lacking. This study aims to fill this gap by examining China's healthy aging policies and academic focus areas from 2016 to 2025.

Objective: To identify core thematic characteristics of China's healthy aging policies and research hot-spots using topic modeling and content analysis, revealing national priorities and informing global aging governance.

Methods: This study employed a mixed-methods approach to analyze China's healthy aging policies and research trends. First, 14 national policy documents (2016–2025) were collected from official Chinese government portals, while 101 research papers were systematically retrieved and screened from four major Chinese academic databases. Policy texts underwent latent Dirichlet allocation (LDA) topic modeling using Python 3.11.8: after custom dictionary optimization and TF-IDF-weighted (term frequency-inverse document frequency) stop-word filtering, grid search identified the optimal topic count (K = 4) via perplexity-coherence metrics, followed by 50 iterations for model convergence. Simultaneously, research papers were analyzed through content analysis on the DiVoMiner® platform, using a predefined coding framework (4 primary themes, 15 sub-dimensions). Coding reliability was ensured via Holsti's coefficient (0.93) derived from dual human-AI coder consensus.

Results: The LDA model revealed four core policy themes: Topic 0 (Comprehensive Health Service System and Elderly Health

Monitoring, 11.4% strength), Topic 1 (Whole-Life-Cycle Health Management and Chronic Disease Prevention, 25.7%), Topic 2 (Development of Age-Friendly Industries and Public Services in Urban-Rural Contexts, 46.3%, highest strength), and Topic 3 (Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services, 16.6%). Temporal analysis showed policy evolution from single-topic dominance (2016: Topic 0 at 99.9%) to multi-topic integration. Content analysis of research papers identified divergent hot spots: "Health Promotion Strategies" (102 occurrences, 33.3% focused on community support) and "Policy Support" (83 occurrences, 74.7% national-level) dominated the literature, whereas "Health Management Technologies" were significantly underrepresented (15 occurrences, 66.7% categorized as "other" uncategorized tech). Critical gaps included minimal focus on family support (1.2%) and underutilized technologies.

Conclusions: China's healthy aging framework combines strategic governance, cultural resources, and socioeconomic integration. Strengths include tiered interventions for diverse needs and urban-rural synergy, though rural health equity and technology adoption require optimization. Future research should prioritize longitudinal policy evaluations, cross-nation comparisons, especially with developing economies, and participatory elderly-centered designs. China's model offers a cost-effective paradigm for global aging societies.

Keywords: Healthy Aging; LDA Topic Modeling; Policy Text Analysis; Health Equity; Integrated Medical-Elderly Care; Silver Economy

Thematic Characteristics and Research Hot-spots of China's Healthy Aging Policy : Topic Modeling Study

1 Introduction

The World Health Organization (WHO) defined healthy aging in its 2015 Global Report on Aging and Health as "the process of developing and maintaining the functional ability that enables well-being in older age," meaning that healthy aging refers to the functional and functional capacity process of older adults [1]. China is the country with the largest elderly population in the world and one of the countries with the fastest aging rates. By the end of 2024, the population aged 60 and above is projected to reach 310.31 million, surpassing the 300 million mark for the first time [2]. To address the challenges posed by population aging, China adopted the "Healthy China 2030" Planning Outline in 2016, fully integrating the concept of "healthy aging" into policy to improve the health status of the elderly, meet their health needs, and steadily enhance their overall health levels [3].

According to United Nations population projections, China's demographic landscape will undergo significant changes over the next three decades, with the aging population experiencing particularly notable shifts [4]. The number of people aged 60 and above is expected to increase significantly, particularly among the elderly aged 80 and above, who will see the fastest growth rate. From 1990 to 2050, the number of people aged 80 and above in China may reach 16 times the previous level, which means China faces a significant burden of aging [5]. In response, China has implemented a series of healthy aging policies, with nearly a decade of achievements in both current policies and research, as well as positive practical outcomes.

Natural language processing (NLP) focuses on human-computer language interaction and explores how to process and utilize natural language [6]. In the fields of public health and informatics, researchers have applied NLP topic modeling techniques to cross-inductive analysis of topics such as population health, epidemiology, and bioinformatics [7, 8, 9].

This study applies the latent Dirichlet allocation (LDA) model and content analysis method, focusing on domestic research in mainland China. By mining current policy texts and analyzing publicly published research papers, the aim is to extract the main themes of China's healthy aging policies and research hot-spots in the field of healthy aging, revealing China's priorities in the aging sector. This helps to deeply understand the efforts and choices China has made to address aging, with the hope of providing references for the formulation of healthy aging policies, and promote the improvement and development of the global healthy aging governance system [39,40].

2 Methods

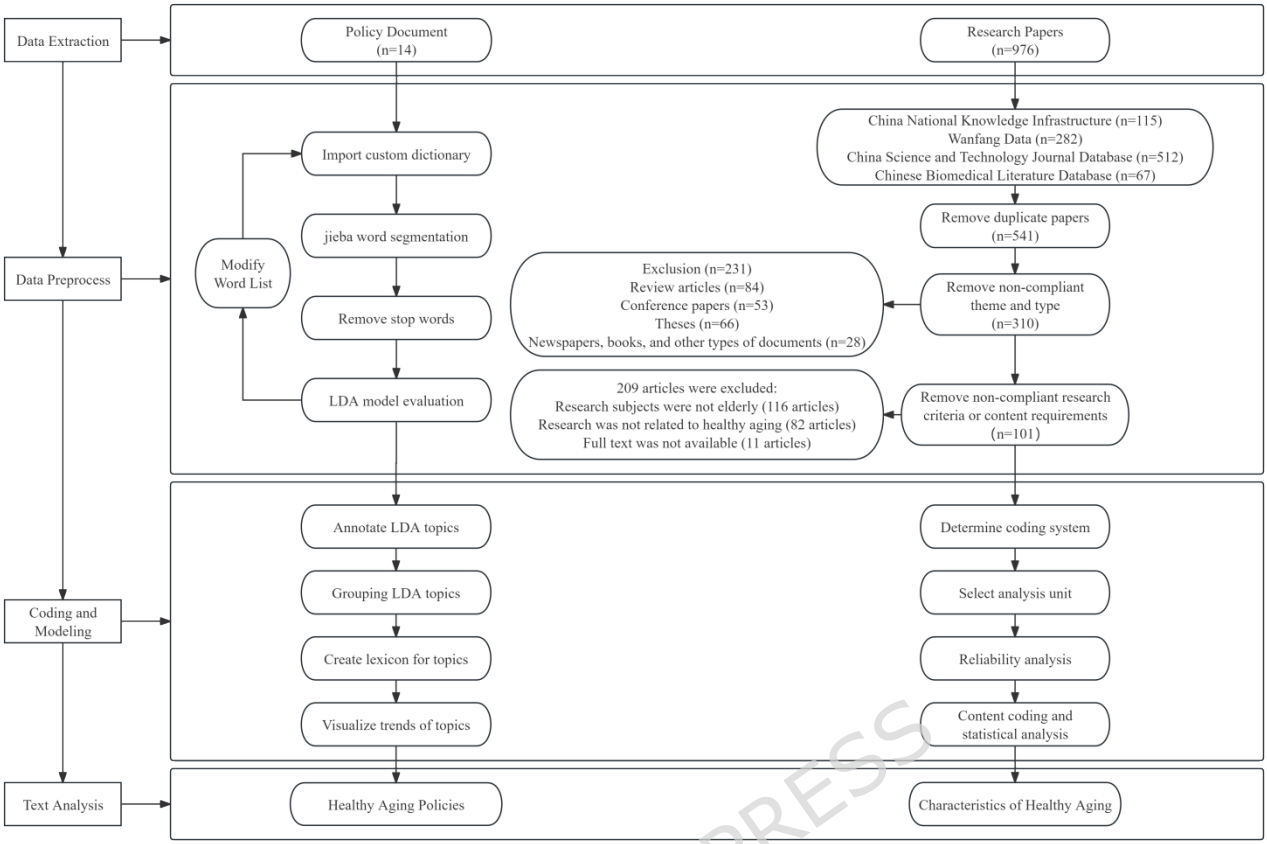
2.1 Research Design

Figure 1 shows the overall framework of this study. First, we downloaded policy documents related to healthy aging from the Chinese government website and searched for relevant research literature on healthy aging from four major Chinese literature search platforms. We then preprocessed the data, including data cleaning and text cleaning. Next, LDA topic modeling was applied to the policy texts to identify topics present in the text, dividing the research content into distinct research topics, each associated with characteristic keywords [10]; subsequently, the content indicated by each topic was clarified based on these characteristic keywords; Finally, the content was analyzed to comprehensively reflect the

characteristics of China's healthy aging policies. Content analysis was also applied to research papers, with a coding system developed specifically for healthy aging research papers. Research hot-spots in healthy aging were described in detail, with selected sentences serving as the smallest analytical units for coding, followed by reliability analysis and statistical analysis [11]. Ultimately, this approach enabled the intuitive presentation of the characteristics of China's aging policies and the hot-spots in healthy aging research.

This study employs different analytical methods for policy texts and academic literature, based on the fundamental attributes of the two types of materials and the requirements of the research questions. National-level policy documents are mostly macroscopic and comprehensive strategic statements, and their core themes are often intertwined and implicitly present throughout the entire text. Therefore, we adopt the Latent Dirichlet Allocation (LDA) model, which is an unsupervised topic discovery method, suitable for systematically identifying potential, macroscopic strategic theme structures from long documents. On the contrary, academic papers (abstracts) usually have clear research objectives, methods, and conclusion statements, and are more suitable for systematic content analysis. We conduct deductive classification and coding of the literature based on a pre-established coding manual to precisely capture the explicit research focuses, methods, and orientations in the academic community, as shown in Figure 1.

Figure 1. Research Framework Diagram.



2.2 Data Collection and Preprocessing

2.2.1 Data Processing of Policy Documents

This study aims to systematically analyze the top-level strategic designs and core policy themes regarding healthy aging at the national level in China. The authoritative data source for this study is the policy document library of the Chinese government website (https://www.gov.cn/). The policy documents released in the policy document library up to 2025 have been systematically screened.

The policy text starts from 2016 because China issued the "Healthy China 2030" Planning Outline in that year. This guiding document systematically constructed the blueprint for a healthy China at the national strategic level for the first time, and explicitly included "healthy aging" as a core issue. This marked the entry of China's healthy aging policy into a brand-new and systematic national strategic advancement stage.

Firstly, the documents must explicitly mention the core concept of "healthy aging", or focus on topics such as the maintenance and improvement of the intrinsic abilities of the elderly, functional performance, geriatric medicine, prevention and rehabilitation, as well as the fairness of elderly health. Secondly, the documents must be labeled as "published" and have produced actual normative and guiding effects. This ensures that the analyzed objects are texts with real binding force or guiding significance. Finally, the documents must be national-level and comprehensive policy documents directly promulgated by the highest administrative organ (the State Council) or core ministries (such as the National Health Commission). These texts constitute the policy foundation in the field of healthy aging in China, establishing a strategic framework, basic principles, and priority development areas that are uniformly followed nationwide.

Based on the above principles, this study finally selected 14 national-level core policy documents on healthy aging as the analysis samples, as shown in Table 1., as shown in Table 1.

Table 1. Summary of sample data

Release Annual	Policy Documents
2016	"Healthy China 2030" Planning Outline
2019	Healthy China Action (2019-2030)
2019	National Medium-and Long-term Plan for Proactively Responding to Population Aging
2021	The Outline of the 14th Five-Year Plan for Economic and Social Development and Long-Range Objectives Through the Year 2035 of the People's Republic of China
2021	Opinions on Strengthening the Work on Aging in the New Era
2021	Guidelines on Comprehensively Strengthening Elderly Health Services
2022	The 14th Five-Year Plan for Healthy Aging
2022	The 14th Five-Year Plan (2021-2025) for the Development of National Undertakings for the Aged and the Elderly Care Service System
2023	Opinions on Promoting the Construction of the Basic Elderly Care

	Service System
2024	Opinions on Developing the Silver Economy to Improve the Well-being of the Elderly
2024	Guiding Opinions on Promoting High-Quality Development of Medical Care and Elderly Care Integration Services
2024	Opinions on Deepening the Reform and Development of Elderly Care Services
2024	National Action Plan on Dementia (2024–2030)
2025	Notice on Improving the Delivery of Basic Public Health Services in 2025

To ensure the accuracy and topic discrimination of LDA topic modeling, this study implemented a systematic text preprocessing and post-processing procedure. Firstly, the policy texts were cleaned to remove punctuation, numbers, and irrelevant characters. Then, the Jieba word segmentation tool (set to the exact mode, cut_all=False) was used, along with a user-defined dictionary specifically constructed for the field of healthy aging, which included core compound terms such as "medical-nursing integration", "silver-haired economy", "long-term care insurance", and "smart health care for the elderly", to ensure that they were accurately identified as independent semantic units [13]. Subsequently, a comprehensive list of stop words was applied, integrating both general stop words and policy-related frequent auxiliary words like "strengthen" and "improve", for filtering, and only words longer than 1 character were retained, thereby constructing a high-quality bag-of-words model input. Based on this, LDA modeling was carried out to enhance the purity of the topics. A term probability threshold was set to filter out widely occurring broad terms, thereby sharpening the boundaries between topics [14]. The model finally outputs the "topic-word" probability distribution and the "text-topic" attribution. Based on this, the study extracted the set of feature words with the highest probability weights under each topic for in-depth analysis. This not

only completed the identification and description of macro-strategic topics but also made it possible to conduct in-depth analysis of specific focuses [12].

By manually reading representative policy documents, core terms, compound words, and institutional names were manually extracted. The initial word segmentation results were then subjected to term frequency-inverse document frequency (TF-IDF) to identify high-frequency compound words that were not correctly recognized, such as "medical and elderly care integration" being split into "medical," "elderly care," and "integration." Simultaneously, we used the jieba tokenization tool to adjust word frequencies [12]. Based on this, we created an initial custom dictionary and invited experts in public health policy and elderly care services to review and supplement it. During the trial run of the analysis process, we continuously added newly discovered terms based on the model's output of keywords and manual document reviews to ensure that professional terms, compound words, institutional names, and policy names in the policy texts were not incorrectly split, thereby obtaining the custom dictionary [13].

Based on the standard Chinese stop word list, add policy-specific stop words, such as overly generalized policy terms, high-frequency verbs with no thematic meaning, and structural words in documents. Then, perform simple word frequency statistics on the segmented policy text corpus, manually review high-frequency words, and add words with high frequency but extremely broad and vague meanings to the stop word list [14]. Based on the custom dictionary and stop word list, an LDA model is constructed for testing, observing theme coherence, theme word distinguishability, and whether the themes align with domain

knowledge, followed by iterative optimization of the dictionary.

2.2.2 Data Processing for Research Papers

The literature sources are four Chinese databases: China National Knowledge Infrastructure (CNKI), Wanfang Data, China Science and Technology Journal Database, and the Chinese Biomedical Literature Service System. Search terms: TI=(Healthy Aging OR Healthy Aging Strategy OR Promoting Healthy Aging OR Healthy Aging System OR "Healthy Aging" OR Active Healthy Aging OR Rural Healthy Aging). The literature search and data collection for this study were conducted in 2025. The search period was set from the beginning of each database's establishment until 2025.

The study population includes older adults aged 60 years and above; the research content focuses on the current status of healthy aging; the research language is Chinese. Excluded are duplicate literature, reviews, conference papers, theses, patents, Chinese and foreign standards, scientific achievements, scientific reports, local annals, and literature for which the full text is unavailable.

The literature was imported into the EndNote literature management software, and two researchers independently screened the literature based on the inclusion and exclusion criteria. The screening focused on the research design, hypotheses, and methods of the literature, with particular emphasis on the current state of healthy aging research and its future-oriented characteristics. The specific manifestations and measures of healthy aging research were identified and extracted into an Excel spreadsheet.

2.3 Topic Model Training and Evaluation

2.3.1 LDA Model Construction for Policy Texts

The LDA model is an unsupervised machine learning text mining technique that can be used to identify latent hidden thematic information in large document sets or corpora [10,54]. The core principle of the model is based on a three-layer probabilistic generation process, where each policy document is treated as a probabilistic mixture of K latent themes. Each theme is represented as a probability distribution of terms, with the Dirichlet prior distribution controlling theme sparsity and term focus [11], as shown in Table 2.

Table 2. Three-layer probability framework at the core of LDA model

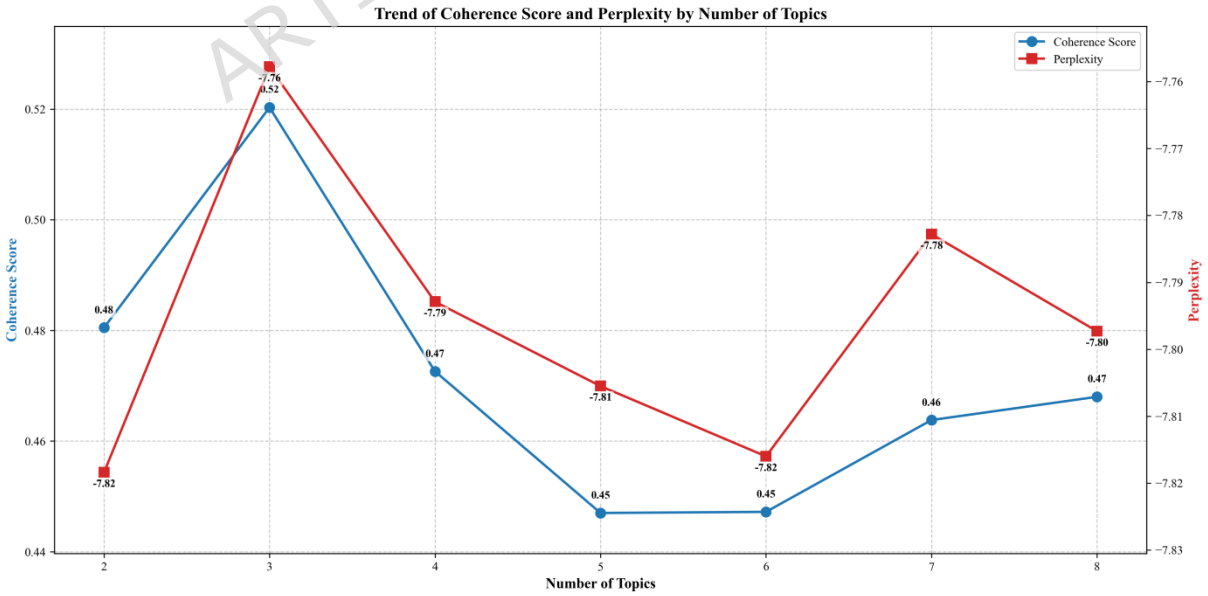
Document layer	Each policy document is regarded as a probability mixture of K potential topics ($\theta_d \sim \mathrm{Dir}(\alpha)$)
Topic layer	Each topic is represented as a probability distribution in the term space ($\Phi_k \sim \mathrm{Dir}(\beta)$)
Term layer	The Dirichlet prior distribution controls topic sparsity (α) and term focus (β)

This study implements the LDA topic model using the gensim library [41]. To ensure the robustness of the model and the reproducibility of the results, both the document-topic distribution prior (Alpha) and the topic-word distribution prior (Beta) are set to 'auto', allowing the model to learn asymmetric priors from the data. This is usually more capable of generating more interpretable topics, especially for professional corpora such as policy texts [42]. The number of model training iterations is set to 50, and the log-likelihood tends to stabilize during the training process, indicating that the model has fully converged. Additionally, a fixed random seed (random_state=42) is used to ensure the complete reproducibility of the experimental results [43]. Grid search is employed to determine the optimal number of topics, and the perplexity and coherence scores for topic numbers 2-8 are calculated.

The coherence score reaches its peak at K=3, indicating that

the three-topic model is slightly superior in terms of internal word co-occurrence consistency. However, the coherence score of the K=4 model still remains at a high level, and its perplexity is highly close to the optimal value, indicating that there is a minor difference in statistical performance between the two, both falling within the feasible range. When the number of topics is 3, although the quantitative indicators are slightly better, the generated topics are relatively broad, tending to merge the domains with independent policy significance in this study, reducing the value of independent analysis of key policy dimensions; when the number of topics is greater than 4, new topics show significant overlap or content fragmentation, the interpretability decreases, and some topics are supported by only a few documents, resulting in insufficient policy representativeness [15]. Therefore, the optimal number of topics for this study is determined to be 4, as shown in Figure 2.

Figure 2. Trend of Coherence Score and Perplexity by Number of Topics.

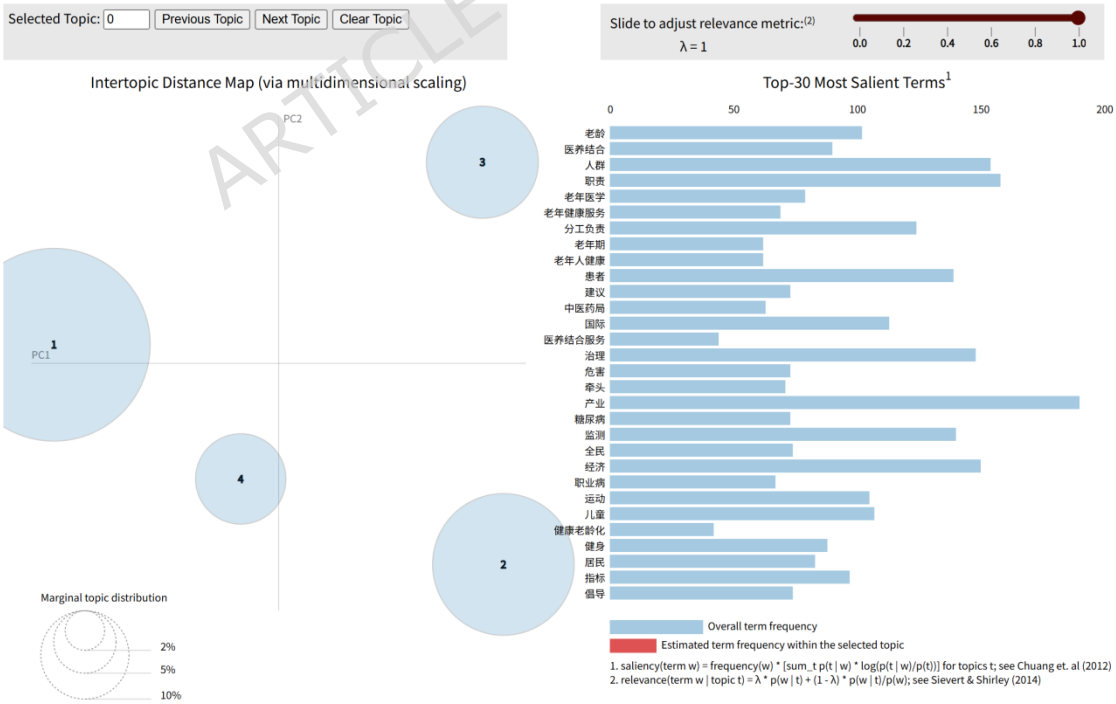


Subsequently, the topic and keywords associated with each paragraph were output, and the original policy text was annotated

with topics. "Topic-word" and "text-topic" analyses were then conducted [16]. Finally, feature word analysis was performed based on different policy topics to identify the main themes and complete the topic analysis.

To better present the theme modeling results, data visualization is performed using pyLDAvis.gensim_models. To enhance the interpretability of the model results, this study employed the pyLDAvis tool for visual analysis. This visualization method maps the topics in a two-dimensional space to show the relative distances between them, which helps in determining the degree of dispersion of topic distributions; at the same time, it can interactively present the distribution of keywords under specific topics and their association strength with the topics, thereby assisting researchers in semantic interpretation and label definition of the topics, as shown in Figure 3.

Figure 3. Modeling Keyword Relationship Diagram.



2.3.2 Content Analysis Method for Research Papers

To systematically analyze the key characteristics of academic

research on healthy aging, this study employed the content analysis method. The content analysis method is a research approach that obtains conclusions through the analysis of "content" [17]. Based on qualitative analysis, it conducts a quantitative analysis of the content of the literature, describes the results using statistical figures, and thereby discovers connections and patterns that are difficult to find from qualitative analysis alone [18]. This study completed coding and data analysis using the DiVoMiner® platform.

By studying policy texts and related literature [19–21], a coding system covering four dimensions: health promotion strategies, elderly social participation, policy support, and health management technologies was initially drafted, as shown in Table 3. Subsequently, a pre-coding test was conducted on 10% of the literature to revise and refine the coding categories and rules, resulting in the final coding manual (a selection of the manual is provided in Supplementary Material 1); a three-party independent coding team was formed, consisting of two human coders and the AI coding module of DiVoMiner® (AI configuration is provided in Supplementary Material 2)[53]. The three parties independently coded 20% of the literature samples first. The Holszt Index was calculated to evaluate the initial reliability: the inter-human coder reliability was 0.91, the average inter-human-AI reliability was 0.93, indicating an acceptable level of consistency.

Table 3. Coding classification system for characteristics of healthy aging research

Primary Code	Secondary Code	Specific measures
Health Promotion Strategies	Community Support	Specific measures and strategies taken to improve the health of older adults
	Physical Exercise	
	Mental Health Education	

	Other	
	Healthy Diet	
	Policy Advocacy	
Forms of Social Participation for the Elderly	Community Activities	Specific ways for older adults to participate in social activities
	Volunteer Services	
	Other	
	Fitness Activities	
	Cultural and Recreational Activities	
Policy Support for Healthy Aging	National Policies	National, local, and social policies and measures to promote healthy aging
	Local Policies	
	Community support	
	Family support	
Health management technologies for the elderly	Other	Various technical means used in the health management of older adults
	Health management apps	
	Telemedicine	
	Health monitoring devices	
	Smart home devices	

For the 5 discrepant items in the independent coding, the human coders and the researchers held a consensus meeting to review the AI's coding logic and compare it with the coding manual, and reached a consensus through discussion (discrepancy handling is provided in Supplementary Material 3); based on the consensus standards, one human coder completed the coding of the remaining literature, and another human coder reviewed 20% of it. Finally, the coding results of all 101 literature were integrated, and frequency statistics and cross-analysis were mainly used to quantitatively reveal the distribution and characteristics of research hotspots.

3 Results

3.1 Topic Summary

After completing the LDA topic clustering, four core topics were identified: Comprehensive Health Service System and Elderly Health Monitoring (Topic 0), Whole-Life-Cycle Health Management and Chronic Disease Prevention (Topic 1), Development of Age-Friendly Industries and Public Services in Urban-Rural Contexts (Topic 2), and Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services (Topic 3). Each topic generates 15 key terms. These key terms reflect the core content of each topic, with their corresponding relationships shown in Table 4.

Table 4. Correspondence table of topics and words

Topic Summary	Topic Explanation	Topic Keywords
Comprehensive Health Service System and Elderly Health Monitoring (Topic 0)	This topic focuses on building a nationwide health service system aligned with the goal of healthy aging. It emphasizes elderly health monitoring, optimization of medical insurance systems, and promotion of national fitness initiatives to provide lifelong health security for older adults, supporting the implementation of the Healthy China Initiative.	Aging period, Monitoring, National population, Fitness, Pharmaceuticals, Populations, Industry, Healthy China Initiative, Governance, International, Medicine, Diagnosis and treatment, Indicators, Medical insurance, Service system.
Whole-Life-Cycle Health Management and Chronic Disease Prevention (Topic 1)	Centered on the needs of healthy aging, this topic addresses health interventions across the lifespan from childhood to old age. It strengthens prevention and control of chronic diseases (e.g., diabetes), occupational disease management, and multi-departmental division of responsibilities to mitigate the negative health impacts of population aging.	Populations, Patients, Responsibilities, Exercise, Children, Recommendations, Collaborative division of responsibilities, Expectations, Diabetes, Leading department, Residents, Health advocacy, Health hazards, Indicators, Occupational diseases.
Development of Age-Friendly Industries	Serving the societal support system for healthy aging, this topic	Industry, Economy, Governance, Conservation, Urban areas,

Topic Summary	Topic Explanation	Topic Keywords
and Public Services in Urban-Rural Contexts (Topic 2)	coordinates industrial economic development with age-friendly renovation of urban and rural public services (e.g., medical-care integrated facilities). It fosters livable environments for the elderly through ecological conservation and international cooperation.	Ecology, International, Market, Rural areas, Public services, Cultivation, A cohort of, Agriculture, Renovation, Service facilities.
Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services (Topic 3)	Directly addressing core challenges of healthy aging, this topic explores innovative service models for integrated medical and elderly care (e.g., pilot programs for disability care), geriatric medicine, and Traditional Chinese Medicine applications. It aims to enhance the quality of elderly health services through tiered diagnosis/treatment systems and policy innovation.	Aging population, Integrated medical and elderly care, Geriatric medicine, Elderly health services, Responsibilities, Health of older adults, Division of responsibilities, Traditional Chinese Medicine Bureau, Integrated medical and elderly care services, Healthy aging, Patients, Pilot programs, Secondary (healthcare), Disability, Models.

Subsequently, the distribution probability of each paragraph of text across different topics is calculated. The higher the probability, the more significant the relevance of the paragraph text to that topic. Additionally, the annual and data intensity jointly reveal the dynamic replacement patterns of policy texts. Probability thresholds: when the probability of a topic exceeds 50%, it dominates absolutely; 40%-50% indicates a significant association; and <10% indicates negligible relevance. Based on this, the development trend of policy texts is as follows: early single-topic dominance → mid-term dual-topic competition → recent multi-topic integration. Topic 2 and Topic 3 form the core axis over the past five years, while the revival of Topic 0 (2024) and the cyclical activity of Topic 1 (2019/2025) constitute secondary threads, in Table 5.

Table 5. Distribution probability table of text topics

Release Annual	Topic0	Topic1	Topic2	Topic3	Max_topic
2016	0.99	0.00	0.00	0.00	0
2019	0.00	0.50	0.48	0.02	1
2021	0.00	0.00	0.58	0.42	2
2022	0.00	0.00	0.39	0.61	3
2023	0.00	0.05	0.95	0.00	2
2024	0.12	0.00	0.47	0.41	2
2025	0.00	0.35	0.00	0.65	3

3.2 Topics Identified by the Topic Model

Based on this study, we mined policy texts, extracted high-frequency keywords, calculated their weights, and generated word clouds for each topic keyword. The font size in the word cloud directly reflects the weight of the term; the higher the weight, the larger the font, See Figure 4.

Figure 4. Word clouds for each of the topics: (A) Topic0, (B) Topic1, (C) Topic2, (D) Topic3.

(A) (B)

(C)

(D)

Comprehensive Health Service System and Elderly Health Monitoring (Topic 0) focuses on the national health governance system, with the core terms "Healthy China Initiative" (0.0062) and "Governance" (0.0061), "Service System" (0.0047) form a policy triangle, highlighting the synergistic mechanism between institutional design, service provision, and "Medical Insurance" (0.0048) coverage. Meanwhile, "National Population" (0.009) and "Coverage" (0.0046) reflect the goal of universality.

Whole-Life-Cycle Health Management and Chronic Disease Prevention (Topic 1) exhibits a pronounced responsibility-oriented focus, with "Responsibilities" (0.0116) and "Collaborative Division of Responsibilities" (0.0088) occupying the visual center. Target audience terms such as "Patients" (0.012), "Children" (0.0093) reflect a hierarchical management logic. In disease prevention, "Diabetes" (0.0084) and "Cancer" (0.0063) have a much higher priority than "Diet" (0.0059), suggesting a policy bias toward intervention for severe conditions.

In the development of age-friendly industries and public services in urban-rural contexts (Topic 2), economic factors dominate, with the font sizes of "Industry" (0.0104) and "Economy"

(0.0097) significantly larger than those of ecological terms. The spatial planning term chain "Urban areas" (0.0071) → "Rural areas" (0.0053) → "Layout" (0.0043) reveals the path toward urban-rural integration, while technological empowerment is reflected through the equally weighted terms 'Intelligence' (0.0041) and "Digital" (0.0041), embodying a dual-drive strategy.

Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services (Topic 3) with elderly health as the core, the weight of "Integrated medical and elderly care" (0.0168) exceeds that of the second-ranked "Geriatric medicine" (0.0136) 23%, with its policy characteristics highlighted by the prominent role of the "Traditional Chinese Medicine Bureau" (0.01), while the alignment of 'Responsibilities' (0.0118) and "Leading Department" (0.0082) underscores the design of management mechanisms.

There is significant overlap between the topics. "Responsibilities" is prominently featured in both topic 1 (0.0116) and topic 3 (0.0118), confirming the need for cross-domain collaboration. "Monitoring" appears repeatedly in topic 0 (0.0098) and topic 3 (0.0065).

3.3 Trends in LDA Topic Groups

Topic strength is an indicator that describes the degree of attention a topic receives within a certain time window. The more documents containing that topic within a given time window, the greater its topic strength, indicating that it is more likely to be a hot topic [22]. The formula for calculating topic strength is:

$$\theta_z^t = \frac{\sum_{d=1}^{D_t} \theta_z^t}{D_t}$$

In the formula, D is the set of documents in the text collection, $d \in \{1, 2, \ldots, D\}$; θ^1_2 is the proportion of topic z in document d; D is

the text collection in time window *t*.

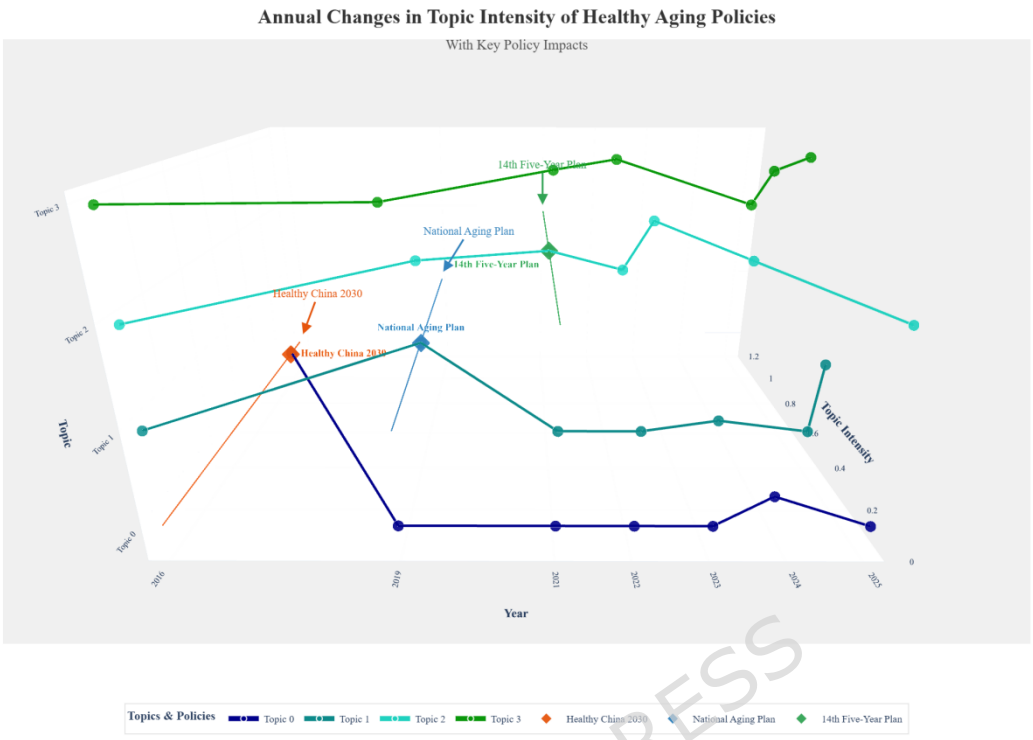
The topic strengths for Topics 0 to 3 were calculated, as shown in Table 6. Topic 2 (Development of Age-Friendly Industries and Public Services in Urban-Rural Contexts) had the highest topic strength, with a value of 0.46. The remaining topics were ranked in descending order of strength as follows: Topic 1 (Whole-Life-Cycle Health Management and Chronic Disease Prevention), Topic 3 (Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services), and Topic 0 (Comprehensive Health Service System and Elderly Health Monitoring).

Table 6. Overall Strength of Each Topic

Topic	Topic0	Topic1	Topic2	Topic3
Strength	0.11	0.26	0.46	0.17

By setting the topic, publication year, and topic intensity as three distinct dimensions, a 3D line chart was constructed to illustrate the annual trends in the intensity of policy topics related to healthy aging. This reveals that, overall, Topic 0 has the highest intensity and spans the entire cycle, reaching a peak during the National Medium-and Long-term Plan for Proactively Responding to Population Aging period, indicating that this topic is the core focus of policy; Topic 1 has moderate intensity, with a significant increase during the 14th Five-Year Plan period, potentially related to directions such as integrated medical and elderly care or chronic disease management; Topic 2 shows fluctuating increases in intensity, with stronger presence during the later stages of Healthy China 2030 and the early stages of the 14th Five-Year Plan, potentially involving areas such as health technology innovation or health environment construction; Topic 3 has the lowest intensity, with only minor increases in certain years, potentially pointing to emerging fields such as smart aging, see Figure 5.

Figure 5. Annual changes in topic intensity of healthy aging policies with key policy impacts.



3.4 Trends in LDA Topic Groups

Among the characteristics of healthy aging research, "health promotion strategies" was the most frequently mentioned topic (102 times), followed by "policy support for healthy aging" (83 times). "Health management technologies for the elderly" was the least frequently mentioned theme (15 times).

Within each primary theme, in "health promotion strategies," "community support" had the highest proportion (33.3%), while "policy advocacy" had the lowest proportion (6.9%); Within "Forms of Social Participation for the Elderly," "Community Activities" had the highest proportion (39.5%), while "Fitness Activities" and "Cultural and Recreational Activities" had the lowest proportions (both 5.3%); Within "Policy Support for Healthy Aging," "National Policies" dominated with the highest proportion (74.7%), while "Family Support" had the lowest proportion (1.2%); In "health management technologies for the elderly," the "other" category had

the highest proportion (66.7%), while specific technologies: apps, telemedicine, monitoring devices, smart home devices had relatively low proportions (6.7–13.3%), indicating a diverse range of health management technologies for the elderly. The specific distribution of coding characteristics is shown in table 7.

Table 7. Distribution of health aging coding characteristics

Primary Code	Secondary Code	Frequency	Percentage (%)
Health Promotion Strategies	Community Support	34	33.3%
	Physical Exercise	27	26.5%
	Mental Health Education	16	15.7%
	Other	10	9.8%
	Healthy Diet	8	7.8%
	Policy Advocacy	7	6.9%
Forms of Social Participation for the Elderly	Community Activities	15	39.5%
	Volunteer Services	10	26.3%
	Other	9	23.7%
	Fitness Activities	2	5.3%
	Cultural and Recreational Activities	2	5.3%
Policy Support for Healthy Aging	National Policies	62	74.7%
	Local Policies	14	16.9%
	Community support	6	7.2%
	Family support	1	1.2%
Health management technologies for the elderly	Other	10	66.7%
	Health management apps	2	13.3%
	Telemedicine	1	6.7%
	Health monitoring devices	1	6.7%
	Smart home devices	1	6.7%

4 Discussion

4.1 Principal Findings

In this study, we used the LDA model to analyze the main topic of policy texts and content analysis to extract research hot-spots in the field of healthy aging. We identified four topics related to healthy aging in China, namely "Comprehensive Health Service System and Elderly Health Monitoring (Topic 0)"、"Whole-Life-Cycle Health Management and Chronic Disease Prevention (Topic 1)"、"Development of Age-Friendly Industries and Public Services in Urban-Rural Contexts (Topic 2)"、"Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services (Topic 3)".

One of the core and significant findings of this study is that, in the process of pursuing healthy aging in China, a clear gap has been identified between policies, research, and practice. For instance, there is significant heterogeneity among the elderly in their utilization of digital technologies to cope with daily life, and the differences in their attitudes and skills have exacerbated the inequality at the access and usage levels [51]. The adoption of new technologies is often influenced by the "digital divide" and specific acceptance barriers [52]. Although national policy documents actively advocate for "smart" solutions and industrial innovation in the "silver economy", our analysis shows that there is a significant lag in academic research related to the implementation of technical aspects. Specifically, the emphasis of policies on digital empowerment, intelligent health management, and technology-driven home-based elderly care models has not yet received a deep academic research response that matches it. The adoption of new technologies by the elderly is often affected by the "digital divide" and specific acceptance barriers. The insufficient research in this field by the Chinese academic community may partly reflect that in the research design, an in-depth examination of the unique acceptance factors of elderly users has not been fully

incorporated, resulting in a gap between technology and actual needs. This disconnection indicates that the research agenda of the academic community has not fully synchronized with the national strategic priorities. This provides an important opportunity for future research to directly address these technical and implementation challenges that have not been fully explored, thereby bridging the gap between strategic vision, academic research, and actual impact.

China's policy framework for healthy aging demonstrates distinct local characteristics and innovative approaches. Its core strength lies in the deep integration of national strategic leadership, traditional cultural resources, and modern governance tools, forming a practical model with Chinese characteristics [23]. Policy evolution has consistently centered on systematic integration: on the one hand, leveraging the advantages of the national mobilization system, it has driven interdepartmental collaboration through top-down design, such as establishing a "division of responsibilities" mechanism among health, education, and community sectors in chronic disease prevention and control (Topic 1), and assigning specialized responsibilities to the Traditional Chinese Medicine Bureau in medical-care integration (Topic 3), thereby addressing the challenge of fragmented governance across sectors; on the other hand, it activates cultural genes, incorporating family support into the policy pillars (Table 1 coding system), and developing a distinctive "integrated medical care and elderly care + traditional Chinese medicine" model (a high-frequency term in Topic 3), transforming traditional filial piety ethics into modern service resources. More importantly, China has creatively linked healthy aging with socioeconomic development: the introduction of the "silver economy" policy cluster in 2024

marks a paradigm shift from "addressing burdens" to "creating momentum," fostering elderly-friendly industries, upgrading urban and rural service facilities, and forming a closed-loop system where health investments yield economic returns [24,25].

The uniqueness of China's approach is further reflected in its tiered and tailored intervention logic. In response to the challenges posed by its massive population and rapid aging, policy design precisely distinguishes between three tiers: at the basic security tier, it relies on the universal health service system to build a monitoring network and medical insurance safety net [38]; at the core tier, it focuses on the pain points of disability care and launches local pilot programs for medical and nursing care integration; at the frontier exploration tier, it lays out a national action plan for cognitive impairment and smart health management technology. This tiered advancement strategy avoids the rigid expansion of welfare while enabling concentrated breakthroughs in key areas.

Notably, China has adopted a creative approach to addressing the urban-rural dichotomy. Rather than pursuing a simplistic egalitarian approach, policies have instead implemented differentiated interventions through Topic 2 (46.3%), which consistently ranks highest in terms of policy intensity: in urban areas, the focus is on upgrading public services to accommodate the aging population and fostering the smart elderly care industry; in rural areas, the emphasis is on strengthening county-level medical and elderly care consortiums, with county hospitals serving as the hubs of village-level networks [26]. This three-tiered response system—urban innovation, county-level hubs, and village-level foundations—offers a new paradigm for developing countries to address aging populations.

4.2 Comparison with Prior Research

Compared to current policies in other countries, China's healthy aging policy has taken a unique path in the field of public health. Western countries often rely on well-established primary healthcare systems. Many developed countries have established key points of their aging policies through specific legislation or national strategies. For instance, the "Elderly Persons Act" system and the "National Alzheimer's Disease Plan" in the United States focus on community support and specialized disease management [27,28]; the "National Aging Strategy" in Australia [47,48] and the "Outline for Measures for a Society with an Aging Population" in Japan [49,50] emphasize social participation and preventive healthcare. These frameworks generally rely on relatively mature primary healthcare and community service systems. China, however, has adopted a more systematic "nationally driven strategy-service network restructuring" model: on one hand, it has incorporated elderly health into national priorities through the "Healthy China 2030" Planning Outline; on the other hand, it is actively building a comprehensive elderly health service system covering both urban and rural areas, and extensively promoting family doctor contract services to strengthen primary healthcare management.

In terms of research priorities, the international academic community continues to focus on the management of multiple coexisting conditions, community interventions for cognitive impairment, and the quality of end-of-life care, such as the application of the PACE model in the United States [29]. Chinese research, however, highlights two distinct features: first, it emphasizes the integration of medical care and elderly care as a core innovation, exploring diversified integration models involving

medical institutions, elderly care facilities, communities, and families. Studies on the effectiveness of such models—such as reducing the incidence of disability and minimizing unplanned hospitalizations—provide practical examples for countries with limited resources; Second, there is a strong emphasis on health equity, particularly focusing on the accessibility of health services for vulnerable elderly groups such as rural residents, the elderly living alone, and those with disabilities. Related research has thoroughly examined the role of decentralizing primary healthcare resources, telemedicine, and "internet-plus nursing services" in bridging the health gap between urban and rural areas [30].

However, Chinese research still has room for improvement in terms of evaluating the effectiveness of community-based long-term interventions. Referring to the WHO's "Decade of Healthy Aging" monitoring framework [32], there is still room for continuous optimization in terms of detailed analysis of health-related social determinants. In the future, it is necessary to strengthen the application of longitudinal cohort data in policy evaluation and deepen research on the localized mechanisms of how cultural contexts affect the effectiveness of policy implementation.

Compared with Germany, it emphasizes the construction of a stable multi-pillar security system through social consultation [31]. The iconic long-term care insurance system, as a part of the legal social insurance, has achieved near-universal coverage. At the same time, its pension insurance system presents a distinct three-pillar structure: statutory pension insurance, enterprise pension insurance, and private pension insurance. While the government ensures regulatory uniformity, it also encourages the market to provide diversified pension financial products to meet different needs [33]. This reflects a model of addressing the

pressure of aging through "social consultation for joint construction and multi-level risk sharing" [34]. China, on the other hand, places more emphasis on the integration of medical communities led by the government, strengthening the public welfare nature. By strengthening the coverage of hardware facilities and digital empowerment, it narrows the urban-rural gap at the system level. China places greater emphasis on comprehensive hardware infrastructure coverage and digital empowerment, aiming to narrow the urban-rural gap from a systemic perspective.

In addition, China has taken the lead in developing the world's first global standard for age-friendly digital technology, the ISO Standard for Age-Friendly Digital Economy (ISO 25556:2025) [35]. This standard proposes solutions such as voice navigation and one-click ride-hailing for scenarios like online shopping and smart transportation, integrating technologies developed by Shenzhen-based companies—including intelligent voice interaction and age-friendly modifications for online education—into international standards [36]. The core of China's healthy aging strategy lies in resource integration and technological governance innovation driven by national strategy. In the future, it is necessary to deepen the assessment of the long-term effects of interventions and strengthen sustainable mechanisms for health equity in rural areas.

4.3 Limitations/ Implications for Public Health and Future Studies

This study has certain limitations: firstly, in terms of research methods, this study employed the LDA topic model to analyze 14 national policy documents. Although we optimized the process through meticulous text preprocessing, custom dictionaries, strict hyperparameter settings, and model stability checks, it must be

acknowledged that the relatively small text corpus may pose inherent challenges to the statistical robustness of topic modeling. Probabilistic models like LDA typically generate more stable and detailed topic structures on large-scale text sets. Although the core objective of this study was to identify macro-strategic themes, and the model results demonstrated good consistency across multiple runs, the limited sample size implies that the four themes extracted should be regarded as a powerful depiction of the most prominent and core policy priorities at the national level, rather than an exhaustive coverage of all policy nuances. This methodological trade-off was made as a clear choice between focusing on the "top-level design" research objective and the availability of data. Future research can further validate and deepen the findings of this study by incorporating more policy texts (such as local documents or longer-term longitudinal data); secondly, the literature search strategy of this study focused on academic research centered on the theme of "healthy aging", which enabled it to effectively depict the overall knowledge structure of this field. However, this focused design also meant that this study did not exhaustively cover all the subfields within the category of elderly health (such as specialized research on specific diseases); finally, cultural context differences and translation losses may lead to interpretive biases [11]. This study employs thematic modeling, whose core advantage lies in leveraging big data and computational methods to efficiently, objectively, and systematically depict the macro-level landscape and dynamic evolution of China's health aging policy framework and research field, providing valuable overview insights and a structured knowledge map. However, its core limitation lies in the method's inherent limitations in analyzing the deep semantics, context,

policy processes, and implementation realities of texts, and it is completely unable to assess the motivations, effects, and problem-solving capabilities of policies [7]. The research results are highly dependent on the quality and comprehensiveness of the data sources, and the generation and interpretation of themes involve subjectivity [11].

To achieve technological innovation centered around the elderly and bridge the current gap between practice and research, future studies on the "silver economy" must systematically adopt the participatory co-design approach, treating the elderly as active co-creators [44]. Based on the continuous feedback from the elderly, the elderly-friendly technologies and policies should be optimized to ensure they truly meet the users' habits and needs [45]. This process not only leads to more usable products but also empowers the elderly to participate in shaping their living environment, directly promoting their social participation, autonomy, and well-being, thereby forming a strong response to the core policy goals of healthy aging [46].

This study provides important foundational and descriptive insights, serving as a powerful tool for understanding the "topography" of China's healthy aging field. However, to gain a deeper understanding of the logic behind policy formulation, evaluate policy effectiveness, identify issues in implementation, and propose practical improvement recommendations, it is essential to combine in-depth qualitative research, quantitative assessment studies, and an examination of the broader context. Thematic modeling serves as a starting point for understanding the key themes of China's healthy aging policies and research hot-spots in the field of healthy aging, rather than an endpoint.

Future research could further explore the following directions:

first, conducting cross-national comparative studies on healthy aging, particularly comparisons with emerging economies and developing countries, to explore the paths to healthy aging in countries at different stages of development; second, strengthening the integration of natural science research and social science research, such as the combination of brain science, gene technology, and healthy aging; third, developing participatory research methods, treating the elderly as research subjects rather than mere objects, and truly embodying the research concept of "elderly-centered."

4.4 Conclusions

China's research on healthy aging is undergoing a profound transformation, shifting from a problem-oriented approach to a solution-oriented one, from a single-discipline focus to interdisciplinary integration, and from theoretical exploration to practical innovation. Based on the analysis of the themes of national policies, this study not only reveals the disconnect between them and the academic research focus, but also further transforms this "policy-research-practice" gap into a specific and testable empirical research agenda. China's healthy aging policies have now entered a "period of deepening characteristics," and future efforts should further leverage existing strengths: deepening the application of traditional Chinese medicine in chronic disease management to reduce costs, promoting mechanisms like "time banks" to transform younger seniors into volunteer service forces, and developing dialect-based voice interaction health management tools to bridge the digital divide. These innovations rooted in China's social and cultural DNA are transforming healthy aging from a national strategy into vibrant practice, offering an Eastern solution for global demographic transitions. As the national

strategy for actively addressing population aging is implemented in depth, this field will continue to contribute wisdom and solutions to the governance of aging societies in China and globally. "Healthy aging is the most cost-effective and beneficial approach to implementing the national strategy for actively addressing population aging." [37] Exploring this path will remain a long-term mission for academic research and practical innovation.

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Figure 1. Research Framework Diagram.

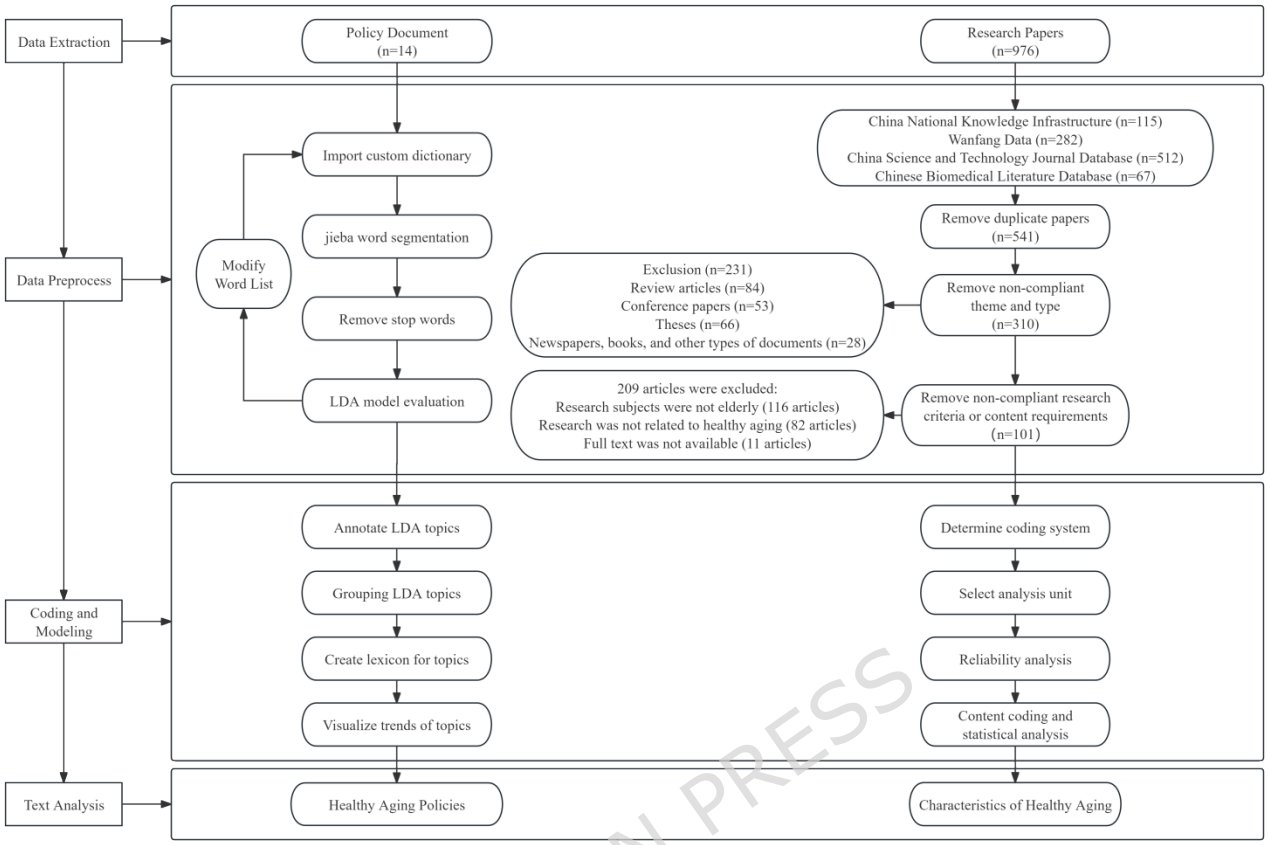


Figure 2. Trend of Coherence Score and Perplexity by Number of Topics.

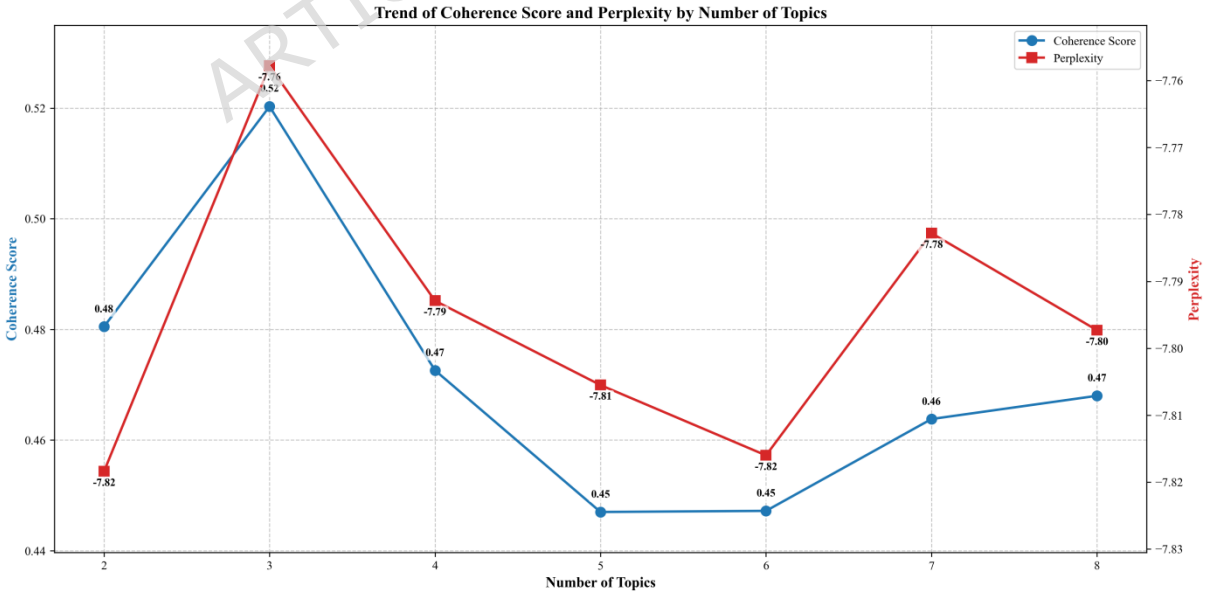


Figure 3. Modeling Keyword Relationship Diagram.

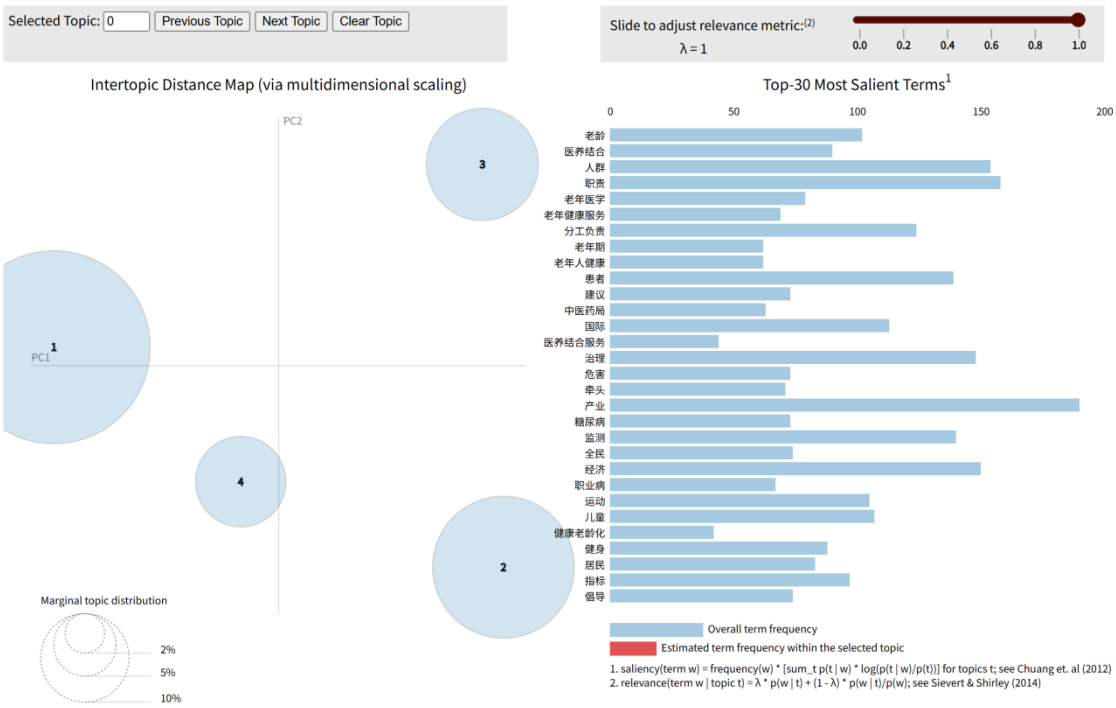
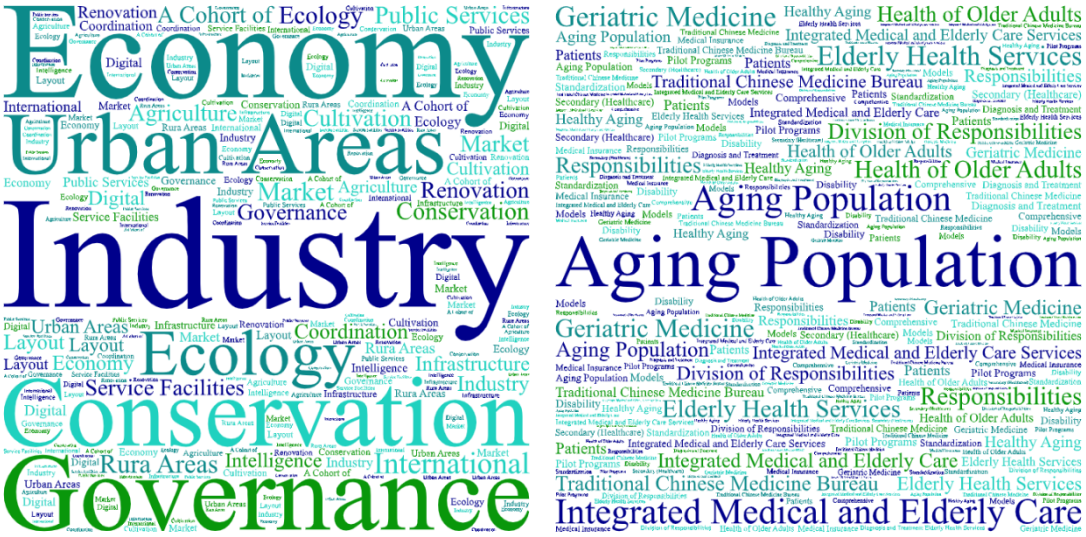


Figure 4. Word clouds for each of the topics: (A) Topic0, (B) Topic1, (C) Topic2, (D) Topic3.

(A)

(B)



□C□ □D□

Figure 5. Annual changes in topic intensity of healthy aging policies with key policy impacts.

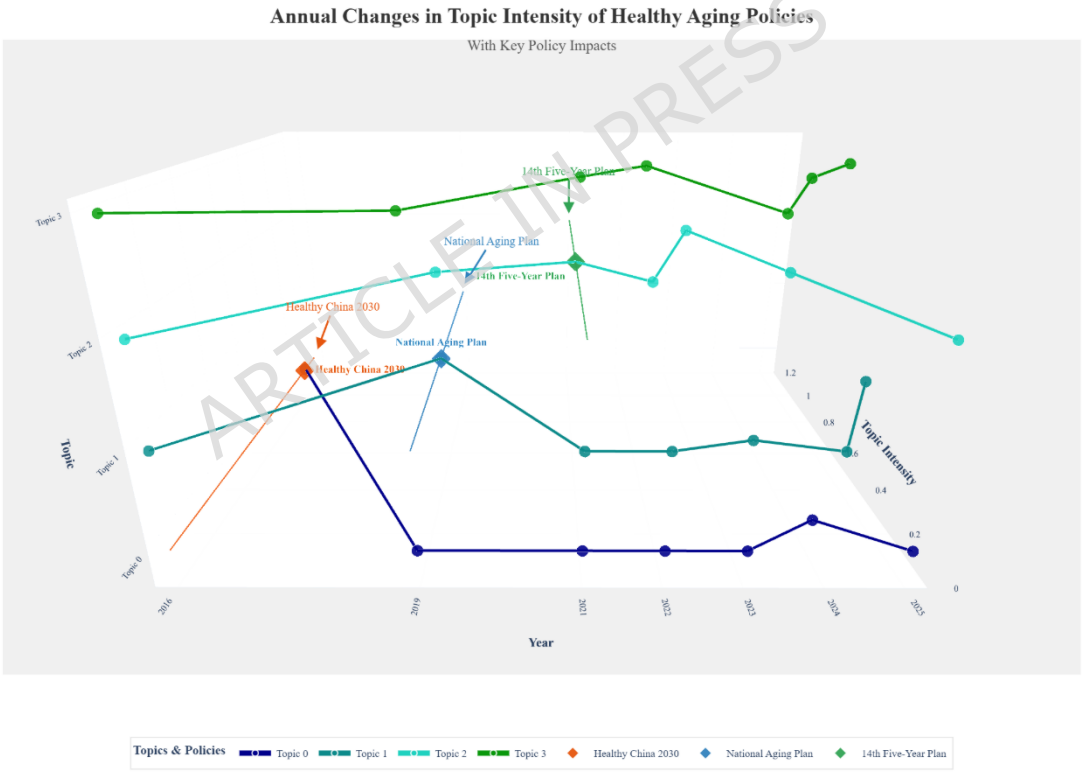


Table 1. Summary of sample data

Release Annual	Policy Documents
2016	"Healthy China 2030" Planning Outline
2019	Healthy China Action (2019-2030)
2019	National Medium-and Long-term Plan for Proactively Responding to Population Aging
2021	The Outline of the 14th Five-Year Plan for Economic and Social Development and Long-Range Objectives Through the Year 2035 of the People's Republic of China
2021	Opinions on Strengthening the Work on Aging in the New Era
2021	Guidelines on Comprehensively Strengthening Elderly Health Services
2022	The 14th Five-Year Plan for Healthy Aging
2022	The 14th Five-Year Plan (2021-2025) for the Development of National Undertakings for the Aged and the Elderly Care Service System
2023	Opinions on Promoting the Construction of the Basic Elderly Care Service System
2024	Opinions on Developing the Silver Economy to Improve the Well-being of the Elderly
2024	Guiding Opinions on Promoting High-Quality Development of Medical Care and Elderly Care Integration Services
2024	Opinions on Deepening the Reform and Development of Elderly Care Services
2024	National Action Plan on Dementia (2024–2030)
2025	Notice on Improving the Delivery of Basic Public Health Services in 2025

Table 2. Three-layer probability framework at the core of LDA model

Document layer	Each policy document is regarded as a probability mixture of K potential topics ($\theta_d \sim \mathrm{Dir}(\alpha)$)
Topic layer	Each topic is represented as a probability distribution in the term space ($\Phi_k \sim \mathrm{Dir}(\beta)$)
Term layer	The Dirichlet prior distribution controls topic sparsity (α) and term focus (β)

Table 3. Coding classification system for characteristics of healthy aging research

Primary Code	Secondary Code	Specific measures
Health Promotion Strategies	Community Support	Specific measures and strategies taken to improve the health of older adults
	Physical Exercise	
	Mental Health Education	
	Other	
	Healthy Diet	

Forms of Social Participation for the Elderly	Policy Advocacy Community Activities Volunteer Services Other Fitness Activities Cultural and Recreational Activities	Specific ways for older adults to participate in social activities
Policy Support for Healthy Aging	National Policies Local Policies Community support Family support	National, local, and social policies and measures to promote healthy aging
Health management technologies for the elderly	Other Health management apps Telemedicine Health monitoring devices Smart home devices	Various technical means used in the health management of older adults

Table 4. Correspondence table of topics and words

Topic Summary	Topic Explanation	Topic Keywords
Comprehensive Health Service System and Elderly Health Monitoring (Topic 0)	This topic focuses on building a nationwide health service system aligned with the goal of healthy aging. It emphasizes elderly health monitoring, optimization of medical insurance systems, and promotion of national fitness initiatives to provide lifelong health security for older adults, supporting the implementation of the Healthy China Initiative.	Aging period, Monitoring, National population, Fitness, Pharmaceuticals, Populations, Industry, Healthy China Initiative, Governance, International, Medicine, Diagnosis and treatment, Indicators, Medical insurance, Service system.
Whole-Life-Cycle Health Management and Chronic Disease Prevention (Topic 1)	Centered on the needs of healthy aging, this topic addresses health interventions across the lifespan from childhood to old age. It strengthens prevention and control	Populations, Patients, Responsibilities, Exercise, Children, Recommendations, Collaborative division of responsibilities, Expectations,

Topic Summary	Topic Explanation	Topic Keywords
	of chronic diseases (e.g., diabetes), occupational disease management, and multi-departmental division of responsibilities to mitigate the negative health impacts of population aging.	Diabetes, Leading department, Residents, Health advocacy, Health hazards, Indicators, Occupational diseases.
Development of Age-Friendly Industries and Public Services in Urban-Rural Contexts (Topic 2)	Serving the societal support system for healthy aging, this topic coordinates industrial economic development with age-friendly renovation of urban and rural public services (e.g., medical-care integrated facilities). It fosters livable environments for the elderly through ecological conservation and international cooperation.	Industry, Economy, Governance, Conservation, Urban areas, Ecology, International, Market, Rural areas, Public services, Cultivation, A cohort of, Agriculture, Renovation, Service facilities.
Innovative Models for Integrated Medical and Elderly Care and Elderly Health Services (Topic 3)	Directly addressing core challenges of healthy aging, this topic explores innovative service models for integrated medical and elderly care (e.g., pilot programs for disability care), geriatric medicine, and Traditional Chinese Medicine applications. It aims to enhance the quality of elderly health services through tiered diagnosis/treatment systems and policy innovation.	Aging population, Integrated medical and elderly care, Geriatric medicine, Elderly health services, Responsibilities, Health of older adults, Division of responsibilities, Traditional Chinese Medicine Bureau, Integrated medical and elderly care services, Healthy aging, Patients, Pilot programs, Secondary (healthcare), Disability, Models.

Table 5. Distribution probability table of text topics

Release Annual	Topic0	Topic1	Topic2	Topic3	Max_topic
2016	0.99	0.00	0.00	0.00	0
2019	0.00	0.50	0.48	0.02	1
2021	0.00	0.00	0.58	0.42	2
2022	0.00	0.00	0.39	0.61	3
2023	0.00	0.05	0.95	0.00	2
2024	0.12	0.00	0.47	0.41	2
2025	0.00	0.35	0.00	0.65	3

Table 6. Overall Strength of Each Topic

Topic	Topic0	Topic1	Topic2	Topic3
Strength	0.11	0.26	0.46	0.17

Table 7. Distribution of health aging coding characteristics

Primary Code	Secondary Code	Frequency	Percentage (%)
Health Promotion Strategies	Community Support	34	33.3%
	Physical Exercise	27	26.5%
	Mental Health Education	16	15.7%
	Other	10	9.8%
	Healthy Diet	8	7.8%
	Policy Advocacy	7	6.9%
Forms of Social Participation for the Elderly	Community Activities	15	39.5%
	Volunteer Services	10	26.3%
	Other	9	23.7%
	Fitness Activities	2	5.3%
	Cultural and Recreational Activities	2	5.3%
Policy Support for Healthy Aging	National Policies	62	74.7%
	Local Policies	14	16.9%
	Community support	6	7.2%
	Family support	1	1.2%
Health management technologies for the elderly	Other	10	66.7%
	Health management apps	2	13.3%
	Telemedicine	1	6.7%
	Health monitoring devices	1	6.7%
	Smart home devices	1	6.7%