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Bibliometric Analysis of the Application of the Behavior Change Wheel in the Medical Field

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Abstract

Objective: This study employs bibliometric analysis to examine the current state, popular topics, and trends in the application of the Behavior Change Wheel (BCW) within the medical field, aiming to provide a reference framework for further research endeavors in this domain. Methods: The Web of Science core collection database was searched, and relevant literature was collected from March 29, 2024, according to the inclusion and exclusion criteria. CiteSpace was applied for visual analysis. Results: A total of 1000 articles were finally included, and the number of articles showed an upward trend year by year, reaching a peak in 2023. England, Australia, and the United States and their research institutions had the largest number of publications, but the overall cooperation between countries, institutions, and authors was relatively sparse. Behavior change, health promotion, digital health, mobile health, mental health, and qualitative research were the research hotspots, frontiers, and future directions. Conclusion: Current research on the application of the Behavior Change Wheel (BCW) in the medical field lacks empirical evidence tailored to China's unique national context. It is recommended that future studies integrate China-specific realities, designing intervention strategies that cater to the distinct characteristics of different population groups, thereby facilitating health behavior change and enhancing individual capacity for self-health management. Such efforts are poised to bolster the implementation of the "Healthy China" initiative.

Keywords

Behavior Change Wheel, COM-B Model, CiteSpace, Visual Analysis, Bibliometrics

1. Introduction

The "Healthy China Action (2019-2030)" explicitly states that "each individual is

the primary responsible entity for their own health" (The State Council of the People's Republic of China, 2019), highlighting the crucial role of personal behavioral alterations in reducing the burden of chronic diseases and enhancing the health level of the nation. Nevertheless, the transformation of health behaviors is influenced by a multiplicity of factors, encompassing personal (Reid et al., 2022) and environmental aspects (Mather et al., 2022). Hence, it is of paramount importance to develop behavioral intervention models guided by theoretical frameworks (Cane et al., 2012).

The Behavior Change Wheel (BCW), put forward by Michie in 2011, is an intervention model that consolidates 19 related theories of behavior change (Michie et al., 2011). Its core lies in the Capability, Opportunity, Motivation-Behavior (COM-B) model, which analyzes the factors influencing patients' health behaviors to guide the formulation of intervention measures (Cai et al., 2019). It aims to transform individual health behaviors, enhance self-management capabilities, and facilitate the improvement of health conditions (Liu et al., 2021). The BCW has significant applications in the medical field, including medication adherence management (Chiang et al., 2018), smoking cessation (Gould et al., 2017), the intervention of unhealthy lifestyles (Cavalheri et al., 2016), and chronic disease management (Yin et al., 2020; Martín-Payo et al., 2021; Stanton-Fay et al., 2021). It has emerged as an international research hotspot in recent years and merits in-depth exploration.

However, the BCW fails to incorporate specific factors and technical contents for behavior change, and due to individual differences and the disconnection between theory and practice, the maintenance of research subjects' behaviors is not optimistic (Madigan et al., 2021). Additionally, most related research is concentrated abroad, with insufficient localization. Before better integrating it with the actual situation in China and developing more scientific, operational, and scalable specific behavior change intervention plans, it is necessary to have a comprehensive understanding of the international research status.

To this end, this study is the first in China to adopt bibliometric methods, utilizing CiteSpace software to conduct a visual analysis of BCW-related literature in the medical field from the Web of Science Core Collection database. The objective is to uncover the international research status, hotspots, and trends through bibliometric indicators such as the annual distribution, international cooperation networks, and keyword clustering. This is expected to offer reference experience for Chinese scholars to explore more deeply and to provide practical guidance for health professionals in promoting patient behavior change at the grassroots level.

2. Materials and Methods

2.1. Materials

This study utilizes the Web of Science Core Collection database from the Institute for Scientific Information (ISI) as the primary source for literature retrieval. The search period spans from the inception of the database to March 29, 2024. Em-

ploying a subject-based search strategy, the search query included the following terms: "behavior change wheel" OR "Behavior Change Wheel" OR "BCW" OR "Capacity Opportunity Motivation-Behaviour" OR "capacity opportunity motivation-behaviour" OR "COM-B". The citation index selected was "All", resulting in a total of 3919 documents retrieved for the study.

2.2. Methods

Bibliometric analysis is a quantitative research method that maps the structural characteristics, evolutionary trends, and knowledge landscape of a specific research field by analyzing bibliographic data such as publication output, citations, and keywords.

2.2.1. Inclusion and Exclusion Criteria for Literature

Inclusion criteria for literature: 1) The type of literature is research articles; 2) The research topic pertains to the application of the BCW and COM-B in the medical field. Exclusion criteria for literature: 1) The type of literature is reviews; 2) The research topic has low relevance to BCW and COM-B, or is related to BCW and COM-B but not within the medical field; 3) Duplicate literature.

2.2.2. Literature Screening Process

To ensure the scientific and effective nature of the sample literature, a screening process was conducted based on the inclusion and exclusion criteria, as follows: 1) A search was performed in the Web of Science Core Collection database using the search query, yielding a total of 3919 documents; 2) The documents were imported into the Endnote software and duplicates were removed, excluding 3 duplicate documents; 3) Based on the relevant criteria, a total of 2856 documents were excluded (180 of which were reviews, and 2676 were unrelated or of low relevance to the research topic), with a preliminary inclusion of 1060 documents; 4) The documents were sorted by citation frequency from high to low, and ultimately, the top 1000 highly cited documents were included. Selecting the top 1000 highly cited articles was intended to focus the analysis on the most influential and impactful literature in the field. Highly cited papers typically represent seminal works, core theories, or pivotal empirical studies that have shaped the development of BCW applications in medicine, thereby enhancing the validity and significance of the bibliometric findings.

2.2.3. Research Method

This study employs CiteSpace, a research tool developed in 2004 by Professor Chaomei Chen of Drexel University using the Java language (Chen et al., 2015), to identify and visually present high-frequency keywords, popular literature, research hotspots, trends, and frontiers in a scientific field (Ding & Chen, 2014). First, the EndNote database records were exported in plain text format, with the output style set as RefMan (RIS) Export. After data conversion, they were imported into CiteSpace 6.3.R1 software, and then a bibliometric method was used to conduct a visual analysis of the research status, hotspots, and trends of the ap-

plication of the Behavior Change Wheel in the medical field for the final 1000 included documents. Parameter settings: Time range from 2008 to 2024, with a time slice of 2 years, using g-index, K = 15. Although the foundational BCW paper by Michie et al. (2011) was published in 2011, the time range was set to start in 2008 to capture early literature on precursor behavior change theories (e.g., social cognitive theory, transtheoretical model) and preliminary studies that laid the groundwork for the development and application of BCW, ensuring a comprehensive understanding of the field's evolutionary context.

3. Results

3.1. Visualization Analysis of Research Status

3.1.1. Annual Distribution of Literature

The number of published papers in a certain period can visually show the research status (Gong et al., 2021) and research topic popularity (Li et al., 2022), and also reveal the characteristics of the development trend of the research field (Zhou et al., 2020). As shown in **Figure 1**, the number of documents on the behavior change wheel in the medical field shows an overall upward trend year by year, with a significant increase starting in 2015, a slight decline in 2017, a significant increase again in 2018, and reaching 246 in 2023, indicating that with the deepening of research, it has received continuous attention.

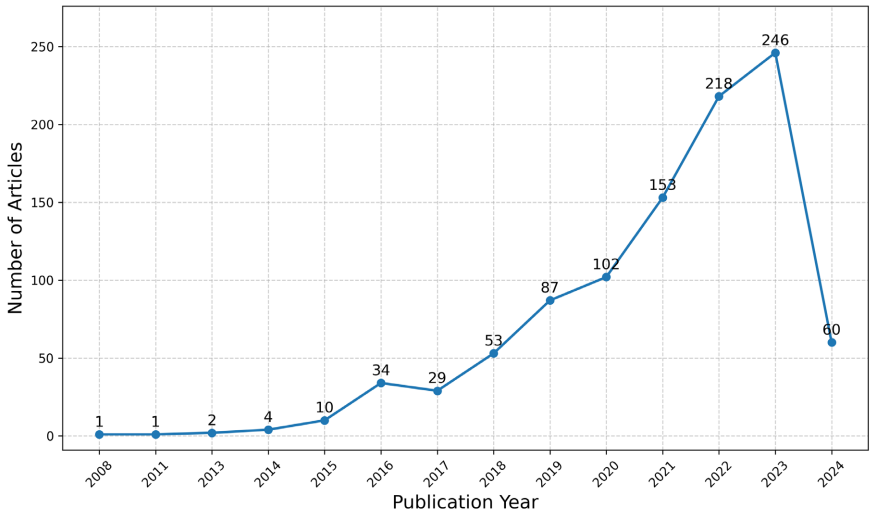

Figure 1. Annual distribution of literature.

3.1.2. National Cooperation Network Analysis

The circle formed by the nodes of the national cooperation network represents the number of published papers from the corresponding country. The larger the area, the more published papers, and the connection between nodes represents the cooperative relationship. The thicker the connection, the closer the cooperation between countries, and strengthening mutual cooperation is conducive to continuously improving the level of scientific research and influence (National Natural Science Foundation of China, 2021). **Figure 2** shows that there are 82

countries and 159 instances of cooperation, and the cooperation between countries is relatively loose (network density = 0.0123). Notably, this sparse collaboration is consistent with characteristics of emerging interdisciplinary fields like BCW application in medicine, which integrates behavioral science, public health, and clinical medicine. Cross-disciplinary collaboration often faces barriers such as divergent research paradigms, communication gaps, and uneven resource allocation across regions—factors that hinder the formation of stable large-scale cooperation networks.

The top 10 countries in the number of published papers on the behavior change wheel in the medical field from 2008 to 2024 are England, Australia, the USA, Canada, the People's Republic of China, the Netherlands, Ireland, Germany, Denmark, and Wales (or Belgium). Among them, the UK has the largest number of published papers, reaching 371, and China ranks fifth, with a total of 98. Wales or Belgium has the lowest number of published papers. The UK, Australia, the US, and Canada are developed countries with a high level of economic development and occupy an important position, which may further widen collaboration gaps due to unequal access to research funding and international partnerships.

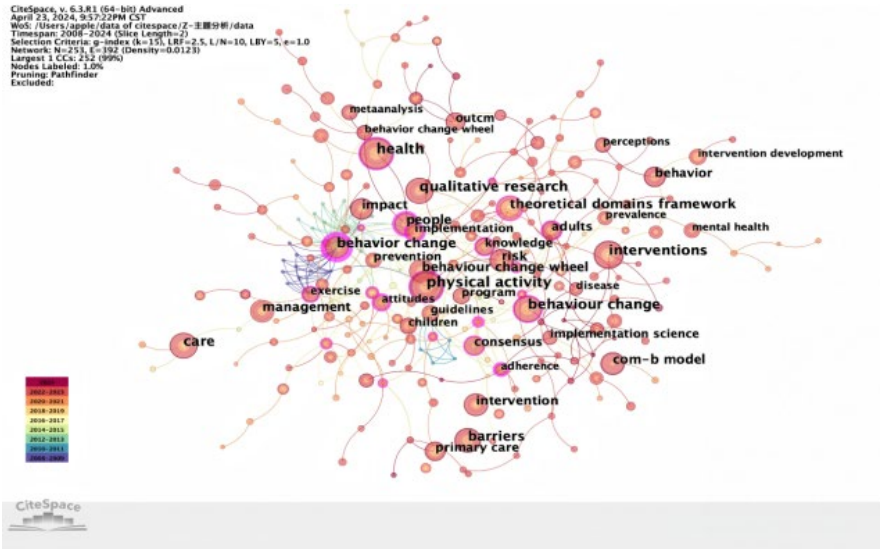

Figure 2. National cooperation network.

3.1.3. Research Institution Cooperation Network Analysis

A visual analysis was performed with the node type set as "Organization", and the results are shown in Figure 3. Among them, universities are the main research institutions, and the top 5 institutions with the highest number of published papers are University College London (99), University of Sydney (60), Monash University (46), University of Manchester (37), and University of Queensland (29). It can be seen that research institutions in the UK and Australia are in a leading position, which is consistent with the results of the national cooperation network analysis, but because the density is 0.0151, it represents relatively few institutional collaborations.

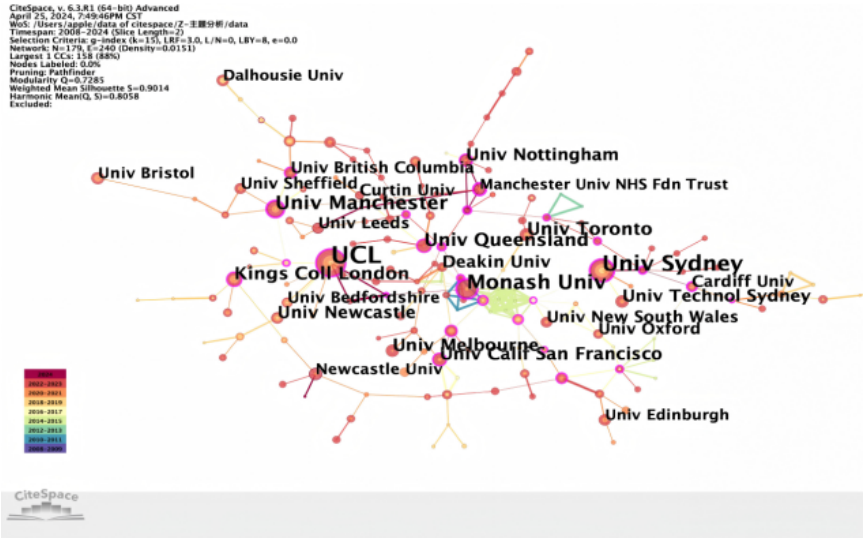

Figure 3. Research institution cooperation network.

3.1.4. Research Author Cooperation Network Analysis

After performing a visual analysis with the node type set as "Author", a total of 182 authors and 231 collaborations were found. The overall connection between research authors is not close, but because S = 0.9014, it indicates a good clustering effect, and there is a significant local aggregation phenomenon in the collaboration network, forming a small group of close collaborations in the local area, such as Fisher A. and Burton A., Michie S. and Atkins L., Armitage C. J., Chater A. M., Courtenay M., McNulty C. A. M., etc. in Figure 4.

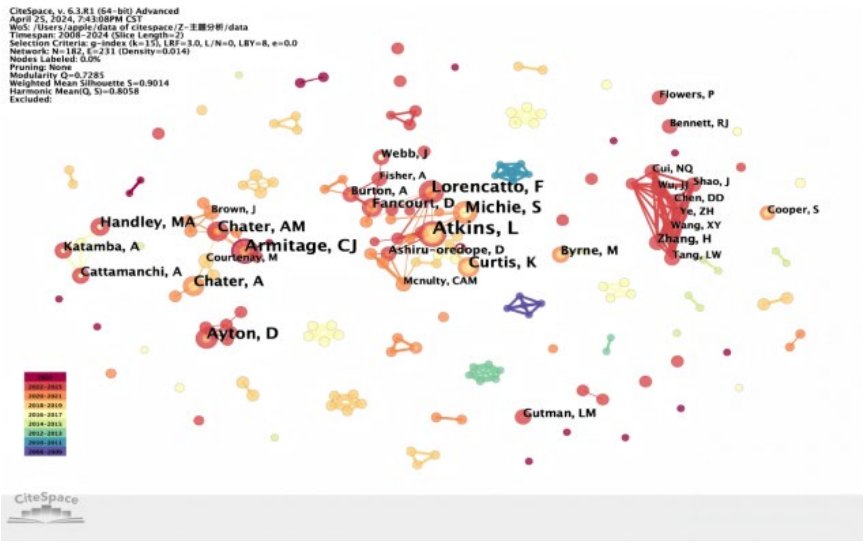

Figure 4. Research author cooperation network.

3.2. Visualization Analysis of Research Hotspots

3.2.1. Keyword Cluster Analysis

Keywords are a high-level summary and overview of the full text, reflecting the central idea of a document (Wang & Guo, 2021). By performing clustering oper-

ations, statistically significant keywords with high centrality and frequency can help researchers understand the research hotspots that are generally of concern in the corresponding academic field, grasp the trend of the discipline, and guide future research directions (Ren & Liao, 2021). The results found that there were 253 nodes and 392 connections, the network density was 0.0123, the Q value was 0.7258 (> 0.3), and the S value was 0.7285 (> 0.4), indicating that the connection between nodes was relatively sparse, but with significant modular characteristics and a good clustering effect.

Figure 5 shows 14 major clustering results, namely "behavior change", "theoretical domains framework", "qualitative study", "qualitative research", "community of practice", "behaviour change", "infection control", "general practice", "medication adherence", "depression", "quality in health care", "sedentary behavior", "opportunity and motivation" and "mobile phone".

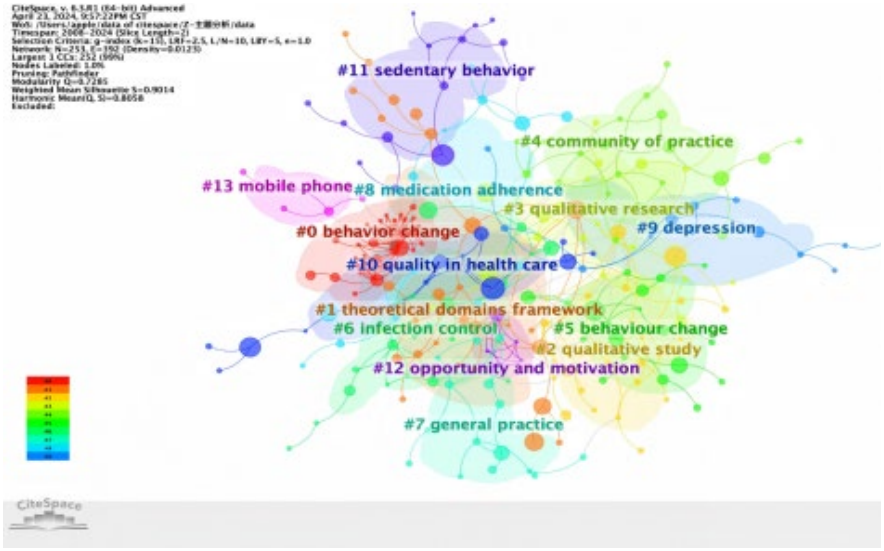

Figure 5. Keyword cluster analysis.

3.2.2. Keyword Co-Occurrence Analysis

Keyword co-occurrence is a keyword that appears simultaneously in a document. Through analysis, the relevance and theme distribution between different keywords can be revealed. The nodes in the keyword co-occurrence analysis diagram represent keywords, and the larger the node, the higher the frequency of the keyword in the document, indicating greater academic attention (Ni, 2020). Two hundred fifty-three nodes and 392 connections were obtained; the network density was 0.0123, and the larger the node, the greater the research hotspot.

Classifying high-frequency keywords, it can be found that 1) research fields: "physical activity" (physical activity), "health" (health), "obesity" (obesity), "care" (care), "behavior change" (behavior change), "smoking cessation" (smoking cessation), etc.; 2) Key research directions: "interventions" (interventions), "barriers" (barriers), etc.; 3) Research methods: "qualitative research" (qualitative research), "theoretical domains framework" (theoretical framework), "meta-analysis" (meta-

analysis); 4) Research groups include "adults" (adults), "children" (children), "women" (women), "patients" (patients), "older adults" (elderly); 5) Health policies: "primary care" (primary care), "prevention" (prevention), "mental health" (mental health), "health care" (health services), "public health" (public health), "health promotion" (health promotion), etc. (See Figure 6)

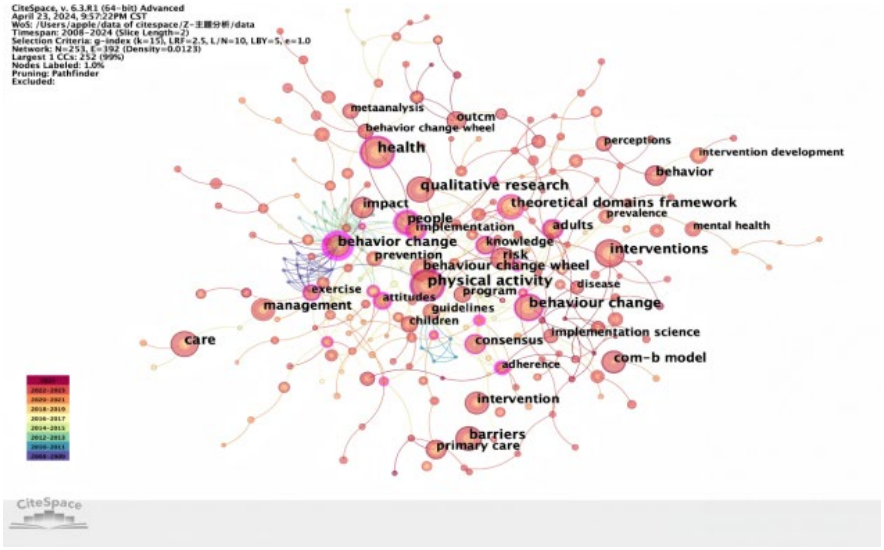

Figure 6. Keyword co-occurrence analysis.

3.3. Visualization Analysis of Research Frontiers and Trends

3.3.1. Keyword Cluster Timeline Analysis

To more clearly show the research frontiers and topics of the application of the behavior change wheel in the medical field, based on the co-line of keywords, a view for analyzing the evolution of different clusters over time is constructed with the publication year as the x-axis, and the frequency or importance of the clusters is ranked to form a cluster number. Based on this, a timeline analysis is performed, which can help researchers capture the trend characteristics of keywords over time. The results showed that 14 clusters appeared, and the smaller the number, the more documents in the cluster. It was found that the earliest keywords were Behaviour Change, and they repeatedly appeared in multiple clusters with keywords such as Health Promotion, Digital Health, Mental Health, qualitative study, and Mobile Health, indicating that it is not only currently at the research frontier but is also likely to continue to be a trend in future research and development. (See Figure 7)

3.3.2. Keyword Burst Analysis

Burst words can reflect the research hotspots and frontiers of a discipline in various periods and reflect the research trends (Li & Chen, 2016). Figure 8 shows that implementation, strategy, and the theoretical domains framework have high burst intensities, reaching 5.34, 5.04, and 5.05 respectively, indicating that their frequency and importance of citation in the corresponding year are relatively high,

suggesting that they are the research hotspots and trends in the field of behavior change wheels in medical application research in the next period and have received significant attention. Mobile health, depression, the United States, and therapy are the latest keywords from 2022 to 2014, and research has begun to explore the application of behavior change wheels in topics such as mobile health, depression, and treatment.

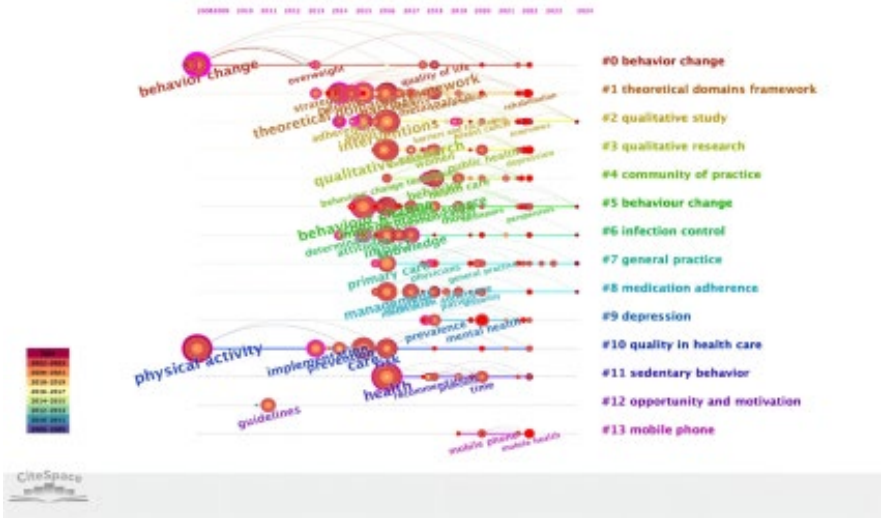

Figure 7. Keyword cluster timeline analysis.

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2008 - 2024
implementation	2013	5.34	2013	2017	
strategy	2013	5.04	2014	2019	
framework	2014	3.92	2014	2017	
taxonomy	2014	3.33	2014	2017	
behavior change techniques	2014	3.25	2014	2017	
prevention	2014	2.34	2014	2017	
protocol	2014	2.04	2014	2015	
theoretical domains framework	2015	5.05	2016	2019	
care	2015	3.28	2016	2019	
interventions	2016	2.85	2016	2017	
individuals	2016	2	2016	2017	
socioeconomic status	2016	1.9	2016	2017	
physicians	2018	2.56	2018	2021	
older people	2018	2.21	2018	2019	
reliability	2018	2.05	2018	2019	
sedentary behaviour	2020	2.66	2020	2021	
sedentary behavior	2020	2.66	2020	2021	
focus groups	2020	2.66	2020	2021	
food	2020	2.22	2020	2021	
quality in health care	2020	2.22	2020	2021	
symptoms	2020	2.22	2020	2021	
mobile health	2022	2.71	2022	2024	
depression	2022	2.48	2022	2024	
united states	2022	2.03	2022	2024	
therapy	2022	2.03	2022	2024	

Figure 8. Keyword burst analysis.

4. Discussion

4.1. Research Status and Evolutionary Path

The application of the Behavior Change Wheel (BCW) in the medical field can be divided into three stages, revealing the evolution from initial exploration to rapid growth. The initial germination phase (2008-2014) saw an average annual publication of 8 articles, marking the gestation period of the BCW theory. During this phase, Professor MICHIE officially proposed the BCW model in 2011 (Michie et al., 2011), laying the theoretical foundation.

The subsequent preliminary development phase (2015-2017) saw an acceleration of research activities, with the annual number of publications jumping from 18 to 72, indicating a significant increase in academic interest and attention to the application of BCW in the medical field. During this period, domestic research was relatively lagging, and it was not until 2017 that Li Fuxia and colleagues (Li, 2017) applied the BCW theory for the first time in the domestic nursing field, marking the initial exposure of China's attention and practice to this theory.

Since 2018, BCW research has entered a rapidly developing mature phase, reaching a peak annual publication volume of 246 articles in 2023, with a total of 859 articles published during this period, at an average annual rate of about 143 articles. The growth momentum during this phase stems not only from the widespread international demand for behavior change strategies but also reflects the global emphasis on promoting healthy behaviors, reducing the burden of chronic diseases, and improving public health levels. The prosperity of research during this period is closely related to the widespread international attention to health behavior science and the application of BCW in various medical practice fields.

However, from the analysis of the cooperation network, the network density at the national, research institution, and author levels is relatively low (national: 0.0123; institutional: 0.0151), indicating that although the research enthusiasm has increased, the cooperation mode in the field is still relatively dispersed, lacking stable and close international or inter-institutional collaboration. This pattern is not uncommon for emerging interdisciplinary fields: BCW research requires expertise in both behavioral theory and clinical practice, and aligning research goals across different disciplines and institutions often requires significant coordination. Additionally, the local cooperation aggregation observed in the author network (e.g., Fisher A. & Burton A., Michie S. & Atkins L.) suggests that small-scale collaborative clusters may serve as building blocks for future large-scale networks—for example, by expanding existing clusters through international joint projects.

Notably, the United Kingdom, Australia, and their related research institutions and authors have a significant lead in the number of publications in the BCW field, which is closely related to the economic strength and scientific research investment of these countries, and also implies the positive impact of economic conditions on promoting BCW research.

4.2. Research Hotspots

High-frequency keywords show a wide range of research content, including various subjects such as "adults", "children", "women", "patients", and "elderly"; various fields such as "physical activity", "behavior change", and "smoking cessation"; and various methods such as "qualitative research" and "theoretical domain framework", reflecting the high representativeness, comprehensiveness, and coverage of the included literature in this study.

Cluster analysis can further clarify hot research topics. These include 1) Health Behavior Intervention: Intervention strategies are the core of BCW-related strategies applied in the medical field. Multiple studies have shown the use of BCW and COM-B to promote the formation of healthy behavior changes in reducing sedentary behavior (Hall et al., 2020), helping to quit smoking (Gould et al., 2017), and changing diet (McEvoy et al., 2018; Johnson et al., 2018); 2) Lifelong and Disease Population Management: It is used for life cycle groups such as children (Creaser et al., 2023), healthy adults (Kaur et al., 2022), pregnant women (Saarikko et al., 2021), and the elderly (Kwok et al., 2021), as well as for health management of disease populations such as cardiovascular disease (Yin et al., 2020), stroke (Hall et al., 2020), and diabetes (Stanton-Fay et al., 2021), promoting behavior change, stimulating patients to actively and consciously manage health issues, and enhancing self-management capabilities, reflecting the broad application potential of BCW in different populations and health states; 3) Innovation and Diversification of Research Methods: The differences in methodology between domestic and international research highlight the diversification of research methods. Compared with the domestic research mainly focused on interventional research, the methods used in international research are more diverse (Qin, 2022), including systematic reviews (Paton et al., 2021), qualitative research (Leenen et al., 2022), and in-depth analysis of the core components of BCW—COM-B using the theoretical domain framework (Kourouche et al., 2019), enriching the application of BCW in the medical field and promoting the design of more refined behavior intervention plans, providing new perspectives and tools for future research.

4.3. Research Frontier Trends

Keyword clustering timeline analysis and burst word analysis provide a unique perspective for understanding the research frontier trends of the Behavior Change Wheel in the medical field. Timeline analysis reveals that "Behavior Change" as a core concept is closely related to keywords such as "Health Promotion", "Digital Health", "Mental Health", "Qualitative Study", and "Mobile Health", confirming the foundational status of behavior change strategies, health promotion, digital health technology, mental health research, and qualitative methods, and indicating that these fields will continue to lead the mainstream direction of future research. These findings emphasize the importance of interdisciplinary integration, especially in technology-driven health behavior interventions and the deepening of mental health research.

Burst word analysis further points out the new direction of research. "Implementation", "Strategy", and "Theoretical Domains Framework" have high mutation intensity, indicating that future research will focus more on the implementation effects of behavior change strategies, the scientific rigor of strategy formulation, and in-depth analysis of theoretical frameworks. In particular, the emergence of "Mobile Health", "Depression", "United States", and "Therapy" marks that the application of mobile health technology in depression treatment, mental health intervention, and even broader medical fields has become an emerging research frontier. This not only highlights the broad application potential of the BCW in the field of mobile health but also reflects the deepening global attention to mental health issues, especially depression, and the significant leadership role of the United States in this research field.

Global trends such as the integration of mobile health with BCW present unique opportunities for China's healthcare context. China has a high penetration rate of mobile internet (over 1 billion users in 2024) and widespread use of super-applications (e.g., WeChat, Alipay) that already integrate healthcare services (e.g., appointment booking, medication reminders). These platforms can be leveraged to deliver BCW-based mobile health interventions—for example, a WeChat mini-program that uses the COM-B model to tailor physical activity prompts for elderly patients with hypertension. Such interventions directly align with the "Healthy China" initiative's goal of improving population health literacy and reducing the chronic disease burden. However, challenges exist in regional disparities in healthcare access (e.g., limited digital literacy in rural areas) that require localized adaptation, and data privacy regulations (e.g., China's Personal Information Protection Law) must be integrated into intervention design to ensure compliance.

The research frontier of integrating mobile health with BCW has direct practical implications for both clinical practice and public health policy. For clinical interventions, mobile tools can bridge gaps in continuous care: wearable devices (e.g., smartwatches) can track sedentary behavior (a key cluster in **Figure 5**) and send real-time BCW-guided feedback (e.g., motivational messages based on the "opportunity" component of COM-B) to patients with stroke—aligning with studies on post-stroke behavior change. For public health policy, investing in mobile health infrastructure can scale BCW interventions to underserved areas: for example, training community health workers to assist rural residents in using BCW-based apps reduces reliance on in-person visits.

The high burst intensity of "implementation" and "strategy" (**Figure 8**) also highlights a critical practical need: translating BCW theory into routine practice requires clear operational guidelines. For China, this could involve developing national standards for BCW intervention design (e.g., for diabetes self-management) and integrating BCW training into medical education curricula—ensuring that healthcare providers have the skills to apply BCW in clinical settings.

5. Conclusion

In summary, this study, with the help of CiteSpace software for visual analysis of

the Web of Science Core Collection database, not only reveals the research status, hotspots, and frontier trends of the Behavior Change Wheel in the medical field but also highlights several key contributions and practical values:

1) Identifying hotspots and trends: Through keyword co-occurrence and burst analysis, this study reflects the core research hotspots of BCW and COM-B models, such as innovation in behavior change strategies (e.g., digital health, mobile health technology), expansion of health promotion activities (e.g., community participation), intervention in the mental health field, and the rise of qualitative research methods, providing specific directions for future research; 2) Perspective on international cooperation patterns: The constructed international cooperation network map clearly shows the global cooperation ecology of BCW and COM-B research, providing intuitive guidance for promoting cross-border cooperation; 3) Methodological innovation: This study is the first in China to use bibliometrics and CiteSpace technology for in-depth analysis of international medical field behavior change wheel literature, not only filling the methodological gap but also providing new tools and research paths for domestic scholars.

However, this study also has several limitations, mainly reflected in the following two aspects: 1) Limitations of literature inclusion criteria: Although the top 1000 highly cited articles were selected based on citation frequency ranking to ensure the influence of the research, some potentially innovative literature that has not been fully cited may have been overlooked; 2) Data timeliness: Although the literature data retrieval was completed by March 29, 2024, recent research results may not have been included in this analysis.

In light of the above limitations, future research can be deepened and expanded in the following directions: 1) Expand literature sources and cross-cultural analysis: Integrate Chinese databases such as CNKI and Wanfang Data for cross-language and cross-cultural comparative studies to fully understand the application differences and effects of BCW in different cultural backgrounds around the world; 2) Continuously update data and dynamic monitoring: Establish a regular data update mechanism to track the latest progress of BCW-related research to ensure the cutting-edge nature and practicality of research results; 3) Comprehensive assessment of literature quality and impact: Adopt multidimensional literature assessment standards to ensure the comprehensiveness and depth of research, while exploring innovative studies that have not been fully cited to enrich research perspectives; 4) Strengthen practical application and localization strategies: Combine specific practices in China and the Asian region to design and verify BCW application models that fit local characteristics, providing a more solid scientific basis and practical guidance for achieving the "Healthy China" goal.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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