HOTSPOTS AND VISUAL ANALYSIS OF ACADEMIC EARLY WARNING RESEARCH FOR COLLEGE STUDENTS

XiaoPeng Tang, YunLiang Jiang, HaiLong Sun*
School of Aeronautical Engineering, Civil Aviation University of China, Tianjin 300300, China.
Corresponding Author: HaiLong Sun, Email: hlsun@cauc.edu.cn

Abstract: This study used China National Knowledge Infrastructure (CNKI) as the data source and selected 385 research papers on academic warning in universities published between 2005 and 2024 for analysis. The CiteSpace analysis tool was used to visualize the literature, and the results showed that research on academic warning in China began in 2007 and has gone through stages of initial exploration, diversified explosion, and innovation deepening; The research is mainly focused on education and psychology in terms of disciplinary distribution, with computer science as a supplement; Most researchers tend to conduct research independently, with limited collaborative power and only a few small-scale collaborative teams present, resulting in relatively insufficient cooperation between different institutions; The research hotspots focus on academic difficulties, academic crises, and academic assistance, and in recent years, there has been a gradual shift towards using big data and intelligent algorithms for research; The academic warning for college students is mainly clustered into eight core topics: credit system, warning mechanism, assistance mechanism, data mining, student management, countermeasures, students with learning difficulties, and delayed graduation. The research results suggest that future research can expand the scope of disciplines, strengthen cooperation between authors and institutions, discover students with potential academic crises through mining data information and applying artificial intelligence algorithms, improve warning and assistance mechanisms, timely formulate precise tutoring strategies to support and assist students, improve their learning quality, and successfully complete academic tasks. These will become important hot topics of concern for major universities and researchers in the future.
Keywords: Academic warning; Visual analysis; CiteSpace; Knowledge graph; College students

1 INTRODUCTION

In recent years, the severity of academic difficulties faced by college students in the field of higher education has become increasingly prominent. Its manifestation has gradually evolved from a single academic problem to a complex chain that may trigger multidimensional negative effects such as mental health disorders and weakened employment competitiveness[1]. In the current era, the higher education system is undergoing a profound transformation in teaching methods and training models. At the same time, students' learning paradigms and strategies are constantly being restructured. This dual transformation has greatly intensified the complexity and diversity of factors that can trigger academic difficulties. Therefore, higher education institutions are facing unprecedented multidimensional challenges and difficulties in dealing with the academic crisis of college students. Firstly, college students generally exhibit a lack of understanding and mastery of new learning patterns during the early stages of enrollment. There are significant limitations in their understanding of the coherence of the knowledge system and the systematic connections between various disciplines, which leads to some students adopting a last-minute cramming strategy before exams. Secondly, there are several deep-seated problems in the teaching system of universities, such as the aging of professional knowledge systems, the fragmentation of teaching content and the disconnect from the development of emerging disciplines, and the difficulty of traditional teaching models in effectively attracting and meeting the learning needs of contemporary young students. The interweaving of these factors can easily lead to academic difficulties and trigger academic crises. Furthermore, the current academic community's in-depth exploration and theoretical construction of academic crisis issues are still weak. Although some university managers have started exploratory research on academic crisis warning mechanisms, most of these studies are scattered and lack systematic theoretical framework support. A professional, systematic, and scientific academic warning research system has not yet been formed [2-3]. Therefore, how to effectively address the issue of academic warning for college students has become a research hotspot in the field of higher education in recent years. However, unfortunately, there is a lack of systematic review literature on the current situation, hotspots, and future trends of academic warning research for college students in China. It is urgent to comprehensively sort out and deeply analyze the latest research results in this field to guide practice and promote further development of related research.

2 RESEARCH METHODS

2.1 Data Sources

This study used the Chinese Journal Full text Database (CNKI) as the data source and employed advanced retrieval strategies to precisely define the scope of literature sources. To ensure the reliability and accuracy of research conclusions, this study has limited the time span of literature search to between 2005 and 2024. By conducting targeted

searches by topic, 601 relevant literature were initially obtained. Subsequently, multiple rounds of screening were conducted to remove 216 articles with low relevance to the research topic, while preserving 385 highly relevant and effective literature samples. These literature information were subsequently organized and exported in a format compatible with Refworks literature management software, forming the data foundation and core source of this study.

2.2 Research Methods and Tools

CiteSpace is a visualization analysis software based on Java language [4]. It analyzes the potential knowledge hidden in literature data through visualization methods, presenting the structure, rules, and distribution of scientific knowledge [5]. It demonstrates strong superiority and accuracy in analyzing and predicting the information panorama, hot topics, research frontiers, and development history of a certain discipline and technology field [6]. Compared with traditional literature review and analysis, this bibliometric method shows the advantages of comprehensive and objective data [7]. Therefore, this article mainly uses CiteSpace 6.2.R3 information visualization analysis software and Excel to visually analyze the Chinese literature of academic journals on academic warning research included in CNKI, in order to grasp the publication volume, disciplinary distribution, research hotspots, frontiers and trends of domestic academic warning research, and provide theoretical basis for related research.

3 DATA ANALYSIS AND GRAPH INTERPRETATION

3.1 Basic Information on Publication

The dynamic changes in the number of publications serve as a direct indicator of the development trend and direction of a specific research field, and their evolutionary trajectory profoundly reveals the evolution process of that field. Figure 1 shows the annual distribution trend of research results on academic warning for college students. Through this figure, it can be systematically analyzed that from 2005 to 2014, although there were a small number of research outputs, the overall quantity was limited, indicating that academic warning research was still in the preliminary exploration and foundation stage. The research results during this period laid the foundation for further in-depth research; From 2015 to 2020, research activities have significantly increased, not only reflected in the continuous growth of the number of publications, but also in the extensive expansion of research fields and the deepening of research content. This transformation demonstrates that the field has attracted widespread academic attention and become a research hotspot. However, due to the comprehensive influence of various uncertain factors, the growth path of the number of publications in this stage showed a certain degree of volatility, reaching the peak of research activities in 2020, marking the outbreak of diversified and high-speed development in academic warning research; Entering the period from 2021 to 2024, although the number of publications has shown a slight downward trend, it still remains at a high level and tends to stabilize. This trend reflects the sustained interest and high attention of the academic community in the research of academic warning for college students, indicating that the field is entering a stable and in-depth development stage, namely the stable deepening period.
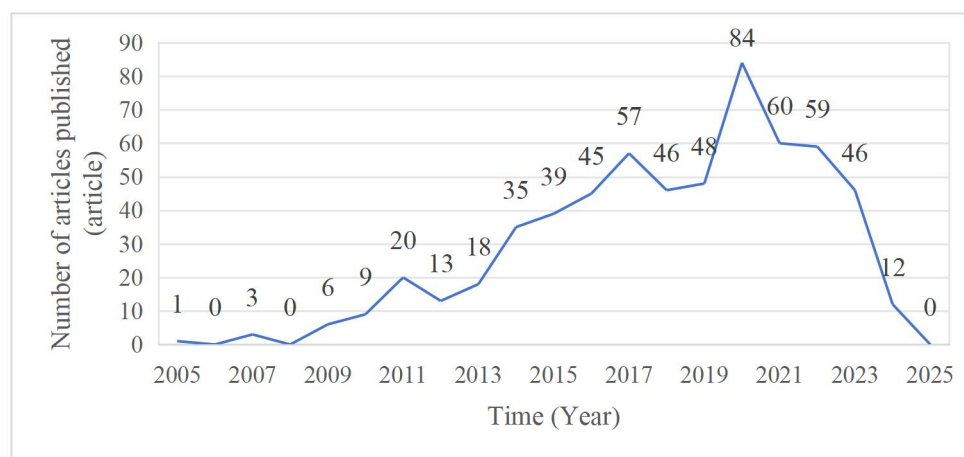
Figure 1 Distribution of Academic Early Warning Results for College Students

3.2 Visualization Analysis based on CiteSpace

This article aims to use the visualization graph analysis function of CiteSpace software platform to conduct a comprehensive and systematic statistical analysis of 385 literature on academic warning research for college students. Through this method, the aim of this study is to explore in depth the collaborative networks among authors in this academic field, the collaborative models of research institutions, and identify and analyze current research hotspots, cutting-edge dynamics, and future development trends, in order to provide scientific basis and reference for further in-depth research in this field.

3.2.1 Analysis of author collaboration graph

Author co-occurrence analysis is a method used to identify core authors in a specific academic field and their level of collaboration. In the diagram, the size of the nodes reflects the number of articles published by the authors, the thickness of the lines represents the density of collaboration between authors, and the depth of the node colors represents the order of publication time. Taking Figure 2 as an example, a network consisting of 365 authors and 183 connections has a density of 0.0028. The figure shows four significant large nodes, namely Zhang Dajun, Liu Guirong, Li Meijuan, and Zhou Dongbin. According to Price's law, these authors have published more than or equal to three articles and are therefore recognized as high-yield authors. The analysis results show that only these four authors meet the criteria for high productivity authors. The figure also shows many collaborative author groups and some small collaborative teams, with only one connection between their nodes, indicating that the collaborative network is not fully developed and the collaborative power is relatively limited. At the same time, core authors such as Zhang Dajun, Liu Guirong, Li Meijuan, and Zhou Dongbin began to engage in research on academic warning for college students earlier, while there are relatively few authors from the emerging forces. Overall, the diagram shows many relatively isolated nodes with a lack of network connections between various groups, especially emerging authors such as Chen Heng, Hou Zhoubo, Zhao Jing, and Zhang Wei, who lack close academic collaboration in this field. In summary, the author co-occurrence network shown in Figure 2 reveals the formation and distribution of the core author group in the field of academic warning research for college students, and also points out the dispersion and limitations in current research cooperation, providing directional inspiration for future research cooperation and resource integration.


Figure 2 Collaborative Graph of Research Authors

3.2.2 Analysis of academic influence of issuing institutions

By publishing academic papers and participating in academic seminars, the author delves into specific disciplinary fields. As a result, the research scope and academic achievements of academic institutions are largely reflected in the quantity and quality of their published academic papers. According to the graphical data analysis, the top five institutions in terms of the number of papers issued include the Institute of Developmental Psychology of Beijing Normal University, the School of Psychology of Shandong Normal University, the Institute of Psychology of the Chinese Academy of Sciences, the Department of Education of Beijing Normal University and the School of Psychology of Huazhong Normal University. The CiteSpace software reflects the research hotspots in related fields through node size and centrality. The number of articles published by an institution is intuitively displayed by node size, and the larger the node volume, the more articles published by the institution; Centrality serves as a yardstick for evaluating the importance of nodes, reflecting the core position and influence of institutions in the research field. We analyzed the publishing institutions in the literature using the Institution module of CiteSpace and set a threshold of 3. Figure 3 shows a network structure with 307 nodes and 67 connections, with a density of 0.0014, revealing the degree of interconnectivity between institutions. The scale of nodes directly corresponds to the publication contribution of institutions, and the larger the scale, the richer the research results; Centrality quantifies the key roles and influence of institutions in the overall research network. Based on the visualization analysis of 385 literature, this study identified the main research institutions in the field of academic warning for college students, and visually displayed the cooperation status between institutions through connections between nodes. In terms of the composition of publishing institutions, a representative publishing cluster has been formed with well-known domestic normal universities such as Beijing Normal University, Shandong Normal University, and Central China Normal University as the core. Regional analysis further indicates that China's research in this field presents a research pattern dominated by teacher training universities, supplemented by research institutes and comprehensive universities. The dominant position of universities as the main

force of scientific research, occupying four out of the top five institutions in terms of publication volume, has been fully confirmed. It is worth noting that although there are relatively concentrated cooperation networks, overall, the cooperation networks between institutions are relatively scattered and have not yet formed significant cluster effects. The leading institutions in the research field are mainly concentrated in the education and psychology related fields of a few normal universities. This also means that in future research in this field, strengthening cooperation and communication among institutions, promoting knowledge sharing and resource integration, is of great significance for promoting the in-depth development of research in this field, and there is enormous space and potential for cooperation.
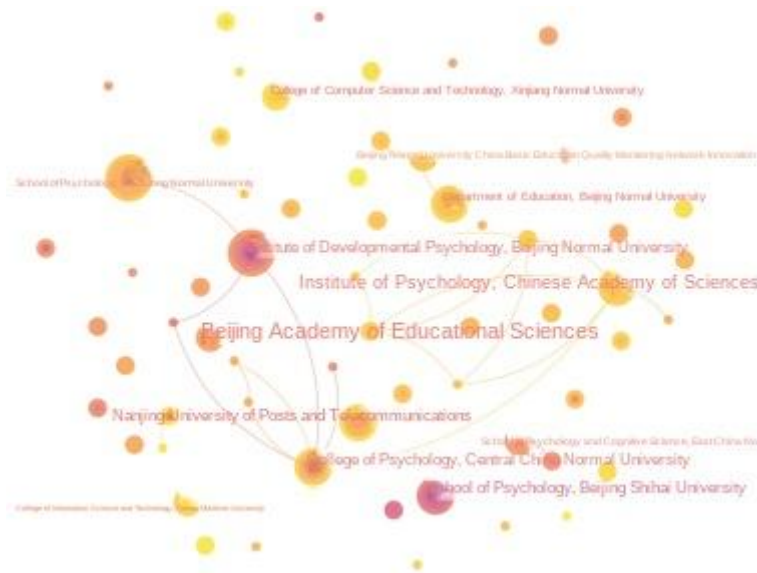
Figure 3 Relationship Map of Collaborative Institutions in the Field of College Student Academic Early Warning

3.2.3 Research hotspot analysis

The CiteSpace tool was used for in-depth analysis and processing of keywords. After merging semantically similar words, a keyword co-occurrence knowledge graph was constructed, as shown in Figure 4. In this graph, the term 'academic warning' shows the highest frequency, with the most significant node size, and runs through the entire research period. However, given that this study has clearly adopted the core retrieval strategy of "college students+academic warning" in the topic keyword retrieval stage, the keyword "academic warning" will no longer be the focus of discussion in this analysis framework. In addition, considering that "college students" are the subject of analysis and naturally situated in the learning environment of "universities", the term "universities" is also excluded in subsequent discussions. After excluding the keywords "college students", "academic warning", and "universities", this study sorted and screened the remaining keywords based on two key indicators: frequency and centrality. Finally, the keywords ranked in the top five in terms of frequency and centrality were selected and sorted according to these two indicators. The results are shown in Table 1 (based on frequency sorting) and Table 2 (based on centrality sorting) for further in-depth analysis of the importance and influence of these keywords in the research field.

Table 1 High Frequency Keywords for Academic Warning of Chinese College Students

Hot words	frequency	Center coefficient
Academic difficulties	34	0.2
Academic assistance	26	0.05
data mining	21	0.15
credit system	20	0.37
Academic crisis	17	0.21

Table 2 Key Words of Academic Warning Center Degree for Chinese College Students

| Hot words	frequency	Center coefficient
Warning mechanism	17	0.55
school tradition construction	10	0.41
credit system	20	0.37
Academic crisis	17	0.21
Academic difficulties	34	0.2

Through in-depth analysis of Tables 1 and 2, it can be seen that high-frequency keywords include "academic difficulties," "academic assistance," "data mining," "credit system," and "academic crisis. However, not all high-frequency keywords have high centrality, and relying on high-frequency keywords cannot accurately determine research hotspots. In the CiteSpace software framework, the centrality of keywords is a key indicator for measuring

their importance in the knowledge graph. When the centrality threshold is set to ≥ 0.1, such keywords are considered a turning point in the network structure and often accurately reflect current research hotspots in the field. From the perspective of centrality analysis, the "early warning mechanism" and "academic atmosphere construction" demonstrate extremely high network support, with the "early warning mechanism" having a centrality of 0.55, significantly enhancing the overall architecture stability of the network and becoming the core support point; The centrality of "academic atmosphere construction" is 0.41, which also has a significant impact on the network structure. Both not only lay a solid foundation for the entire knowledge network, but also clearly point to the main research hotspots at present. Therefore, "warning mechanism" and "academic atmosphere construction" are the main research hotspots, followed by "credit system", "academic crisis" and "academic difficulties".

Figure 4 shows a graph of keyword co-occurrence and centrality analysis, which intuitively reflects the frequency of keyword co-occurrence through the size of nodes, while the thickness of the connections between nodes quantifies the centrality of keywords in the network. Centrality, as an indicator of a node's ability to serve as a medium for information transmission or connection in a network, the larger its value, the more critical its position in the overall network structure [8]. It is generally believed that nodes with centrality exceeding 0.1 are considered important nodes in network analysis, playing a more central role in information transmission and relationship building. According to the statistical results of the software used, the keywords with centrality exceeding 0.1 are: academic warning (207), warning mechanism (17), academic atmosphere construction (10), credit system (20), academic crisis (17), academic difficulties (34), student academic performance (2), college students (45), data mining (21), students with learning difficulties (16), influencing factors (6), assistance (12), universities (31), and talent cultivation (4). The specific data can be found in Table 3. Among them, "academic warning" as the largest node in the graph indicates that it occupies the highest media centrality position in the network structure of the entire academic warning research field, and is the core connecting other keywords and research fields. Next are keywords such as "warning mechanism", "academic atmosphere construction", "credit system", "academic crisis", and "academic difficulties". These keywords are represented by larger nodes and thicker connections in the graph, indicating that they play a significant role in connecting and mediating in the relationship network, and together constitute the current hotspots and focuses of academic warning research.

Table 3 Keywords with Center>=0.1

| Count	Centrality	Year	Keyword	Count	Centrality	Year	Keyword
207	0.98	2007	Academic warning	45	0.17	2009	college student
17	0.55	2007	Warning mechanism	21	0.15	2009	data mining
10	0.41	2011	school tradition construction	16	0.14	2007	Students with learning difficulties
20	0.37	2007	credit system	6	0.14	2014	influence factor
17	0.21	2010	Academic crisis	14	0.12	2013	help
34	0.20	2009	Academic difficulties	31	0.11	2011	colleges and universities
2	0.18	2007	Student academic performance	4	0.10	2017	talent training
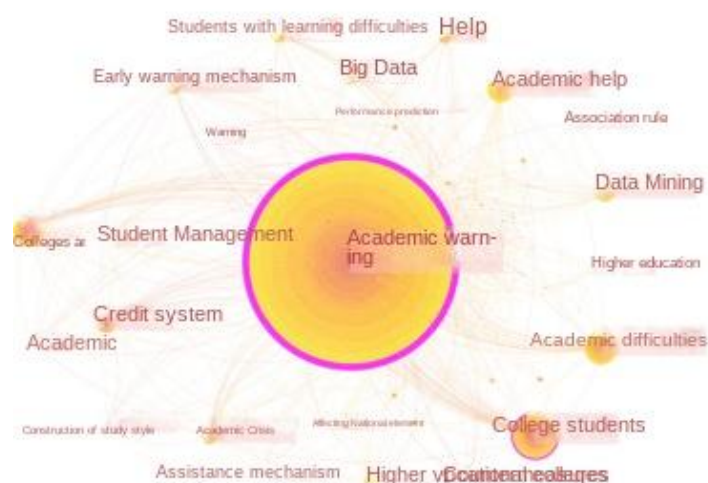
Figure 4 Keyword Co-occurrence Map

3.2.4 Cluster analysis

This study used a clustering analysis method based on the Log Likelihood Ratio (LLR) algorithm to systematically classify and organize keywords related to academic warning applications, aiming to deeply analyze the research topic categories in this field. Through the clustering function of CiteSpace software, eleven highly cohesive clustering groups were formed, with a modularity index of 0.8154 and an average silhouette coefficient of 0.9805. Both indicators significantly indicate excellent clustering performance, verifying the rationality and accuracy of the classification. These eleven results are: # 0 academic warning, # 1 credit system, # 2 warning mechanism, # 3 college students, # 4 assistance mechanism, # 5 data mining, # 6 student management, # 7 countermeasures, # 8 students with learning difficulties, # 9 universities, and # 10 delayed graduation. Among them, # 0 academic warning includes keywords such as academic difficulties, college students, data mining, and warning mechanisms; #The credit system includes keywords such as counselors, academic issues, local industry universities, and information inquiry; #The warning mechanism includes keywords such as academic studies, academic guidance, assistance, and talent cultivation; #3 keywords for college students, including academic difficulties, causes, suggestions, and academic warnings; #The four assistance mechanisms include keywords such as academic crisis, academic atmosphere construction, comprehensive education, and humanistic management; #Data mining includes keywords such as academic performance, grade prediction, incremental learning, and precise coaching; #6. Student management includes key words such as indicator system, assistance, student status warning, and leadership mechanism; #The 7 strategies include keywords such as academic assistance, big data, problems, and ethnic colleges; #Keywords for 8 students with learning difficulties include secondary departments, student assistance, compassionate aid, and "Double First Class" universities; #9 universities include keywords such as academic warning, academic atmosphere, student status processing, and learning quality; #10 keywords for delayed graduation include warning and assistance, influencing factors, graduate education, and graduate student diversion, see Figure 5.
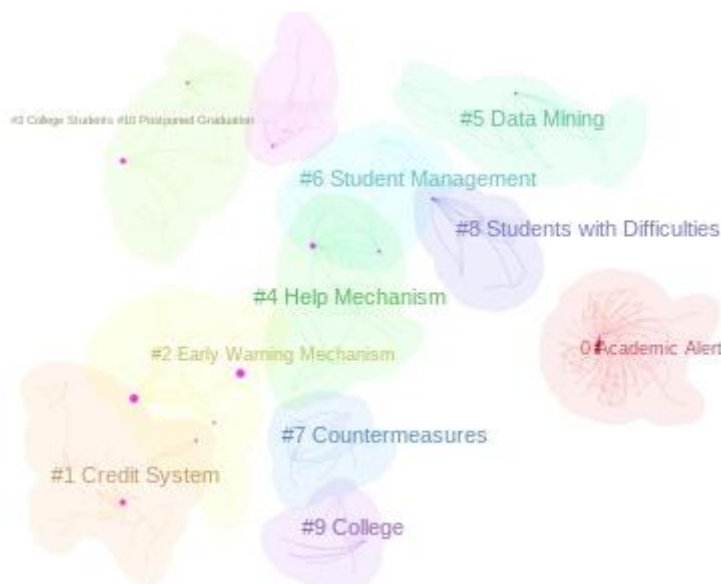

Figure 5 Keyword Clustering Diagram

3.2.5 Development trend analysis

In order to visually display the evolution process and development trend of keywords in different time periods, this study used Time zone visualization technology to process and analyze keywords, aiming to deeply analyze the research characteristics and mainstream research directions of academic warning for college students from 2005 to 2024, and reveal the dynamic evolution rules of this field. Figure 6 shows the overall Time zone view of research on academic warning for college students, where the horizontal axis represents the time axis. Along this dimension, the evolution path of keywords is clearly depicted, intuitively revealing the changing trends in research on academic warning for college students. In the figure, the significant increase in the number of literature during a specific time period reflects the focused attention and in-depth exploration of the field by researchers during that period. The node connections between time periods symbolize the inheritance and continuation of research, and the density of connections intuitively reflects the degree of close connection between research in different time periods. Analysis shows that from 2007 to 2010, research mainly focused on themes such as academic warning, academic difficulties, and academic crises, dedicated to exploring the fundamental causes of academic crises, marking the exploratory stage of research on the causes of academic warning for college students. Subsequently, from 2011 to 2016, research on academic warning and other theories further deepened, with a dense distribution of keywords and a wide range of themes, showing a trend of diversified development. Especially in 2014, the emergence of emerging hotspots such as academic assistance greatly promoted the deepening and development of academic warning research. The increase in high-frequency keyword nodes further proves the depth of research and the wide coverage of topics. Since 2017, the number of nodes in the Time zone graph has increased but the scale has been relatively small. At the same time, the number of literature

publications during this period has decreased compared to previous years, reflecting the trend of research towards dispersion and diversification, which is consistent with the characteristics of a stable and deepening stage of research. During this period, researchers conducted more in-depth discussions on a large number of new research topics that emerged earlier. At the same time, the emergence of new research hotspots such as big data and artificial intelligence algorithms indicates that academic warning research is gradually integrating information technology, opening a new chapter in the combination of traditional academic warning research and modern information technology.
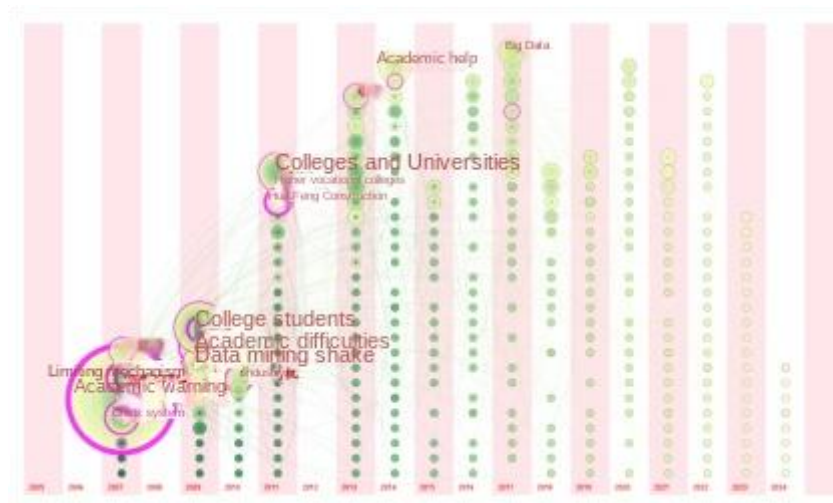
Figure 6 Keyword Time Zone Analysis

Based on a detailed analysis of the research content on academic warning for college students in various time periods, it can be reasonably inferred that by 2024, the exploration and application of artificial intelligence algorithms and big data technology in the field of academic warning research will move towards a deeper level. This trend is mainly reflected in two dimensions: firstly, to continuously deepen exploration, consolidate and expand relevant theoretical foundations within the existing basic research framework; Secondly, it actively utilizes artificial intelligence algorithms to comprehensively collect, efficiently process, and deeply analyze academic performance data of college students, aiming to improve the accuracy and interpretability of academic warning and prediction, and provide solid data support and decision-making basis for universities to formulate and implement personalized and precise student academic guidance strategies. This not only helps to identify and intervene in academic risks in a timely manner, but also effectively promotes students' comprehensive development and academic achievement.

4 SUMMARY AND PROSPECT

Through analyzing the annual publication volume, author institution cooperation, hotspots, frontiers, and development trends of academic warning research literature on college students in the CNKI database from 2005 to 2024, it was found that: firstly, from the perspective of literature publication, 2005-2014 was the initial exploratory stage of academic warning research; The number of studies from 2015 to 2020 continues to increase, and the research fields continue to expand. The peak of research was reached in 2020, which is the explosive period of academic warning research. There is a downward trend from 2021 to 2024, but it still maintains a high level. The stable and deepening period of academic warning research is when the number tends to stabilize. Secondly, from the perspective of collaboration between authors and institutions, the distribution of research institutions on academic warning for college students is relatively scattered, and there is a lack of collaborative research between institutions. Except for a few research teams within each institution, the collaborative relationships between researchers are also relatively loose, and most research institutions and researchers lack sustainability in their research on this topic; Thirdly, from the distribution, clustering, and time zone graph of keyword co-occurrence, research on academic warning focuses on multiple research hotspots such as warning mechanisms, assistance mechanisms, data mining, and big data applications, with a wide range of topics, demonstrating the academic interest of researchers in the field of academic warning.

Therefore, in future academic warning research, expanding the distribution of disciplines and strengthening the connections between disciplines can better explore and discover academic warnings; Strengthen cooperation and communication between authors and institutions to make academic warning research more detailed and sustainable; On the basis of existing research hotspots, explore other hotspots and expand their research topics to further deepen and diversify academic warning research. For example, the deep utilization of information technology such as big data and machine learning intelligent algorithms to deeply explore the rich information contained in the data itself also provides a new paradigm and path for credit based universities to develop talent training programs. Identifying students at risk of academic crisis through data information, improving warning and assistance mechanisms, and developing relevant strategies to support and assist them in a timely manner, further improving the quality of student learning and enabling them to successfully complete academic tasks, will be a key focus of attention for major universities and researchers in the future.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

FUNDING

This paper is supported by the Basic Research Funds for the Central Universities Project (Project No. 3122025015).

REFERENCES

[1] Bai Xuejun, Yuan Sheng, Du Xu, et al. Preliminary exploration of warning factors for academic failure among college students. Journal of Tianjin Normal University (Social Sciences Edition), 2022, (01): 70-76.
[2] Wang Li, Wang Hongzhen. Analysis of the Misunderstandings in the System Transplantation of Academic Early Warning System in Chinese Universities with Academic Classification System. Exploration of Higher Education, 2019, (12): 56-60.
[3] He Wei. On the Function of Ideological and Political Education in the Academic Warning Mechanism for College Students. School Party Building and Ideological Education, 2020, (24): 78-80.
[4] Shu Yueyu, Li Huifang, Wang Liling. Current Status and Development Trends of Chinese Psychobiography Research: Knowledge Graph Analysis Based on CiteSpace. Journal of Central China Normal University: Humanities and Social Sciences Edition, 2019, 58(4): 8.
[5] Wu Yue, Li Chaoxu. The Current Status and Development Trends of Spatial Metaphor Research in China: Knowledge Graph Analysis Based on CiteSpace. Psychological Exploration, 2020, 40(4): 8.
[6] Hou Jianhua, Hu Zhigang. Review and Prospect of CiteSpace Software Application Research. Modern Intelligence, 2013, 33(4): 5.
[7] Hu Fu, Ma Jianrong, Qin Boqiang. Analysis of the Scientific Knowledge Graph of Global Water Bloom Research. Scientific Bulletin, 2023, 68(24): 3196-3210.
[8] Zhuang Yuliang, Wang Yuqing. The Current Status and Trends of Digital Supply Chain Research in China: A Bibliometric Analysis Based on CiteSpace. Logistics Technology, 2023, 42(2): 103-109.