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Visualizing Knowledge Evolution and Hotspots of Rural Environment and Health: A Systematic Review and Research Direction

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ABSTRACT With global warming, energy scarcity, water shortages, and air, soil, and water pollution, the situation of environments in countries around the world is getting more and more serious and in some countries, rural environmental issues are more prominent. Health problems in rural areas also cannot be ignored, chronic diseases and infectious diseases have become the greatest threat to human life, while good environment and human health are the foundation of social and economic sustainable development. This paper adopts the bibliometrics method to conduct a visual analysis of 6,971 studies in the field of the rural environment and health published on the Web of Science between 2000 and 2017, including time knowledge map analysis, space knowledge map analysis, knowledge base analysis, and research focus analysis. This paper reveals the development status of research in the field of rural environment and health, analyzes, and discusses the research hotspots and future development trends in this field, and provides important knowledge support for researchers to carry out follow-up research.

INDEX TERMS Rural, health, environment, pollution, bibliometric analysis.

I. INTRODUCTION

With global warming, energy scarcity, water shortages, and air, soil, and water pollution, the situation of environments in countries around the world is getting more and more serious. In some countries, rural environmental issues are more prominent, there is environmental inequality between rural and urban areas, as urban populations receive most of the food and energy from rural areas and then send their waste back to rural areas [1]. In addition, health problems in rural areas cannot be ignored, health problems such as chronic diseases and infectious diseases have become the greatest threat to human life [2]. According to some surveys, in some countries, rural areas are worse than urban areas in terms of health behavior, mortality, morbidity, and maternal and child health [3]. With the advancement of urbanization, rural environment and health issues will pose challenges and threats to the environmental and health development of cities, countries and even the world [4], [5]. Therefore, rural environment and health issues have received widespread attention from governments and scholars around the world.

For this reason, scholars from all over the world have joined in the research in the field of rural environment and health, and many excellent, high-quality papers have been published. Sfez et al. [6] analyzed the potential effect of community digesters on the co-digestion of cow dung and rice straw, on the flow of carbon and nutrients, on human health, and on resource efficiency and climate change by conducting material flow analysis and life cycle assessment. Carausu *et al.* [7] analyzed the health status of the elderly in the rural environment of Lasi County, Romania, and evaluated their incidence of general and oral diseases, and the resolvability of health services in rural areas. Robson *et al.* [8] conducted an analysis of environmental health issues in rural

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communities in the United States. More than half the respondents said environmental problems—such as water pollution, pesticide abuse, and soil erosion, the most important environmental problems rural communities face—may have been the main cause of community health problems. Pong *et al.* [9] proposed that rural health indicators could be used to greatly improve the ability to understand and describe rural health status, and they proposed five health indicators to describe the health status of rural areas in Canada. Hotchkiss et al. [10] explored the effect of access to health infrastructure, personnel, and services on the health and nutrition status of rural children in Nepal. Oliva *et al.* [11] research proved that there was a link between the rural environment and reproductive health. Peres [12] discussed the effect of changes in production paradigms on health and the environment in rural Brazil. Karadžinska-Bislimovska *et al.* [13] conducted a horizontal study to assess the health risks of pollutants emitted by oil refineries to agricultural workers engaged in traffic-related work. Speldewinde *et al.* [14] used the Bayesian space method to examine the effect of environmental degradation (measured by the salinity of dry land) on the mental health of rural Australians, and detected a correlation between drought salinity and depression. Tilt [15] compared and analyzed the effective impact of China's environmental pollution on the health status of elderly people from highly industrialized regions and rural areas. Lopez *et al.* [16] explored the relationship between inhalation exposure and lung function in males in rural Laos. They found that people who experienced prolonged exposure to particulates had a high prevalence of impaired lung function. De Longueville *et al.* [17] took respiratory diseases in northern Benin as an example to explore the initial effect of air quality on health in rural Africa, and to evaluate the real impact of Sahara dust on air quality and the respiratory health of children in West Africa. In a rural area in central Greece, Kelepertzis [18] investigated the possible effects of human activities on the metal loading of surface soils and the possible effect on the chemical quality of tap water in surrounding villages.

At present, most of the literature in the rural environment and health field studies the relationship between the health status of residents and environmental issues in rural areas. The health problems of residents consist mainly of various types of chronic diseases and epidemics, and environmental problems are mainly climate change, air pollution, resource shortages, soil pollution, and water resource shortages and pollution. However, no research has yet integrated the research results in the field of rural environment and health, and then made a visual analysis of the literature published in recent years by bibliometrics. This is a gap in the research, one this paper aims to fill.

Scientific literature is the objective record of human knowledge, the main form of the existence and development of science and technology, as well as the most basic source and material basis for obtaining scientific information. Simply put, bibliometrics is a statistical analysis of published literature: books, journals, newspapers, and so on [19]. The earliest studies on bibliometrics date back to the early 20th century, starting from the literature statistical studies carried out by the bibliographers Cole and Eales in 1917, and have developed about 100 years of history up to now [20]. In 1969, Pritchard [21] first proposed the term *bibliometrics* to replace *statistical bibliography*, because *bibliometrics* has the characteristics of clear meaning and simple science, it has been unanimously recognized by the international library and information science community. This also marked the official birth of bibliometrics. *Bibliometrics* refers to a discipline that studies the distribution structure, quantity relationship, change rule, and quantitative management of literature information by taking the literature system and bibliometrics characteristics as the research object and adopting measurement methods such as mathematics and statistics, and then discussing some structures, characteristics, and laws of science and technology [22]. Time distribution analysis, space distribution analysis, knowledge base analysis, keywords (research focus or hotspot) analysis, and so on are some commonly used bibliometric methods [23]. This paper adopts the bibliometrics method to conduct a visual analysis of 6,971 studies in the field of rural environment and health published on the Web of Science between 2000 and 2017, including time knowledge map analysis, space knowledge map analysis, knowledge base analysis, and research focus analysis. This paper aims to reveal the development status of research in the field of rural environment and health, analyze and discuss the research hotspots and future development trends in this field, and provide important knowledge support for researchers in this field to carry out follow-up research.

II. METHODOLOGY

A. DATA SOURCE

The literature data of this paper is derived from SCI-E, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-E, and IC databases in the core collection of Web of Science, and advanced retrieval is selected. The search strategy we used is as follows: TS = ((''rural'' OR ''countryside ∗'' OR ''village ∗'') AND (''environment ∗'') AND (''health ∗'')). ''∗'' indicates a wildcard, such as ''environment ∗,'' including ''environment,'' ''environmental,'' ''environmentally,'' and so on. The search strategy mainly included three parts: rural, environment, and health. All records retrieved in the core collection of Web of Science using this search strategy were closely related to rural environment and health. Then, the article type was set as the article, and the publication year was set as 2000–2017. Finally, 6,971 retrieval records were obtained.

B. TOOL KITS

This paper mainly uses software such as HistCite, CiteSpace, SATI (Statistical Analysis Tool for Informetrics), Ucinet, Netdraw, and Excel to make a visual analysis of relevant literature in the field of rural environment and health. HistCite is a software package for bibliometric analysis and information visualization [24]. This paper mainly imports the

database exported from Web of Science into HistCite, counts the number of scientific research results and the number of authors invested each year, and then uses Excel software to draw a line chart to realize visualization. Citespace is a bibliometric analysis tool that can capture the knowledge base, development status, and future trends of a discipline or field through visual analysis of the data, and focuses on finding key points in the development of a field, especially turning points and key points of knowledge [25] ,[26]. In this study, CiteSpace is mainly used to analyze the author distribution, institutional distribution, and knowledge base in the field of rural environment and health research. SATI, Ucinet, and Netdraw are mainly used for visual analysis of research hotspots in the field. SATI is a type of powerful statistical analysis software for bibliographic information that can analyze a variety of databases, including Web of Science and CNKI (China National Knowledge Infrastructure) [27]. Both Ucinet and Netdraw are powerful software programs for the analysis of social networks. Ucinet does not contain a network visualization graphics program itself, but it can output data and processing results to software mapping such as Netdraw [28]. In the fifth section of this article, we first use SATI to generate a keyword co-term matrix and then import it into Ucinet for analysis. Finally, the keyword co-occurrence network is drawn by Netdraw to visualize the relationship between various keywords, which is convenient for analyzing the hot issues in the research field.

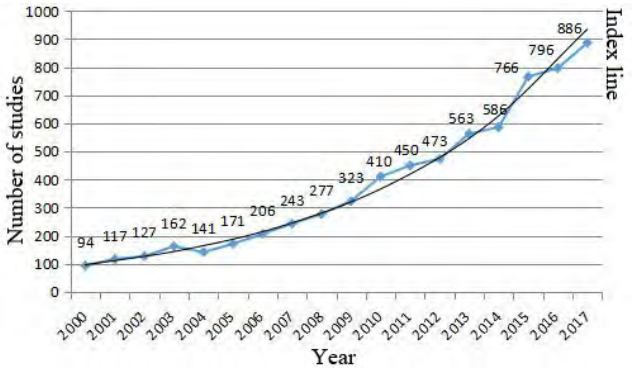

FIGURE 1. Annual number of published articles.

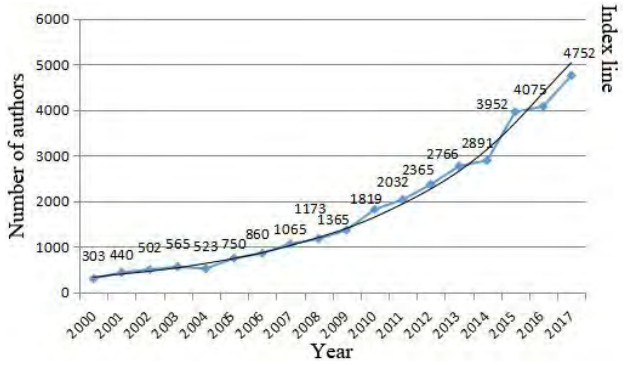

FIGURE 2. Annual number of authors.

III. KNOWLEDGE MAP OF TIME-AND-SPACE ANALYSIS

Time distribution and spatial distribution are the analysis of the development and distribution of knowledge in the field of rural environment and health research from two different dimensions. The time distribution mainly analyzes the annual number of published articles, annual number of authors and average number of co-authors per article from the perspective of time (2000-2017), to explore the development trend of knowledge in this field over time. Correspondingly, the space distribution mainly explores the distribution and cooperation of knowledge in this field from the perspective of space (global), including author collaboration network, institutional collaboration network, journal distribution and so on.

A. TIME DISTRIBUTION MAP

To understand the output of research results in the field of rural environment and health, we conducted a statistical analysis of the scientific literature over the 18 years from 2000 to 2017, and obtained the change trend of annual contents, as shown in Fig. 1. From Fig. 1, we can see that from 2000 to 2017, the annual capacity curve shows an overall growth trend. Before 2009, the growth rate of annual capacity was relatively moderate and the curve showed a gradual upward trend, but after 2009, the field was in a stage of rapid development, showing a gesture of blooming. Growth was most pronounced between 2014 and 2015, with an annual increase of 30.7 percent. Since 2015, the growth rate of content has slowed, but it has not decreased. However, it may be that some published literature has not been included in the core collection of Web of Science. Overall, this curve roughly fits the exponential growth trend. It is obvious that the development of rural environment and health is still in a period of vigorous development, and in the future, research results in this field will still continue to emerge.

Next, we studied the input of scientific researchers in the field of rural environment and health. We conducted a statistical analysis on the number of scientific researchers over the years from 2000 to 2017, and obtained the change trend of annual author input, as shown in Fig. 2. Comparing Fig. 1 and Fig. 2, we can clearly find that the variation trend of the annual number of authors' curve is roughly the same as that of the annual number of published articles. This is also easy to understand: the more the annual amount of documentation, the more researchers in this field will surely be invested, and there is a positive correlation between them. The annual authors' input and the annual number of published articles mutually reinforce and influence each other. As the authors' input in this field increases, the output of research achievements in this field will also increase. On the contrary, the more research results produced in a field, indicating that it is a larger research hotspot, the more it is bound to attract more researchers to join this field.

Finally, we studied the input-output ratio of researchers in the field of rural environment and health. We conducted a statistical analysis of the number of participants in a single article in the 18 years from 2000 to 2017, and obtained the

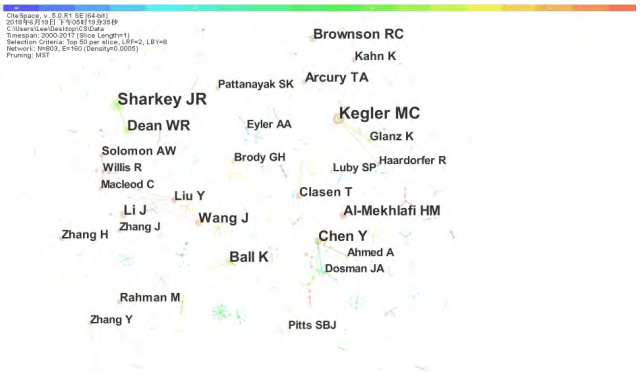

FIGURE 3. Author collaboration network.

ratio of participants to a single article. In the 18 years from 2000 to 2017, the average ratio of participants in a single article reached 4.74. In general, the number of co-authors of a single article is relatively high in the field of rural environment and health. And to some extent, the quality of the article can be guaranteed and can also reflect the researchers' emphasis on the rural environment and health.

B. SPACE DISTRIBUTION MAP

1) AUTHOR DISTRIBUTION

To study the author cooperation distribution in rural environment and health research, we use CiteSpace to form an author collaboration network, as shown in Fig. 3. In Fig. 3, the size of the nodes is proportional to the number of articles published by the author, the thickness of links between nodes is proportional to the number of cooperative papers among authors, and different colors represent the year of cooperative papers among different authors. The largest node in Fig. 3 is Kegler, who has published the largest number of articles—as many as 23, he mainly studies a series of problems related to obesity in rural environments [29], [30]. In this figure, the number of network nodes is 803, the number of connections between nodes is 160, and the density of network is 0.0005, indicating that although there are many high-yield authors in the field of rural environment and health, they are not closely related to each other. The close cooperation between different researchers will produce new sparks, which will foster in-depth innovation in research and make it better.

Table 1 specifically lists the relevant information of the top 10 authors, who have published no fewer than 13 papers in the field of rural environment and health. In the HistCite software system, citation frequency is divided into LCS and GCS, where LCS (local citation score) refers to the citation frequency of a reference in the current database, and GCS (global citation score) refers to the citation frequency of a reference in the Web of Science database [31]. It should be noted that the LCS is definitely not greater than the GCS. If the GCS value of an article is very high, the article is important to researchers in various fields around the world. If the GCS value of an article is high but the LCS value is low, it means that people who pay attention to it generally come from other

TABLE 1. The top 10 authors and their number of published articles.

Author	Number of published articles	LCS	GCS
Kegler MC	23	52	332
Sharkey JR	22	138	710
Chen Y	18	20	458
Wang J	16	9	279
Brownson RC	15	200	1100
Li J	15	3	132
Liu Y	14	1	197
Zhang Y	14	1	137
Arcury TA	13	9	193
Dosman JA	13	10	107

fields that are different from the authors'. As can be seen from Table 1, although Kegler published the most papers, the citation frequency of his work was not the highest. Among the top 10 productive authors, Parks *et al.* [32] published only 15 research results in this field, but the citation frequency of his paper reached more than 1,000. It can be seen that his published research results have been unanimously recognized by his peers, and the published papers are of high quality and of great reference value.

According to Price law [33], we can calculate the number of core authors in the field of rural environment and health. The calculation formula is as follows:

$$N_a = 0.749\sqrt{N_{\max}}$$

where $N_{\max}$ represents the number of articles published by the author who published the most articles during the statistical time period, which is 23 in this paper; and N_a represents the number of articles that the core author needs to publish at least during the statistical time period.

Finally, N_a is calculated to be approximately equal to 4, and only 572 authors have published four or more articles in the statistical period—only a tiny fraction of the total number of authors' input. The results indicate that there is no stable core author group in the field of rural environment and health.

2) INSTITUTIONAL DISTRIBUTION

The preprocessed data is imported into CiteSpace to analyze the institutions of scientific literature and generate the institutional collaboration network diagram, as shown in Fig. 4. In Fig. 4, the size of the nodes is directly proportional to the number of articles issued by institutions, the thickness of connections between nodes is directly proportional to the number of cooperative papers among institutions, and different colors represent the year of cooperative papers among different institutions. The number of network nodes is 375, the number of connections between nodes is 585, and the density of network is 0.0083. Compared with the author collaboration network, the institutional collaboration network is much more intensive, but there is still plenty of room

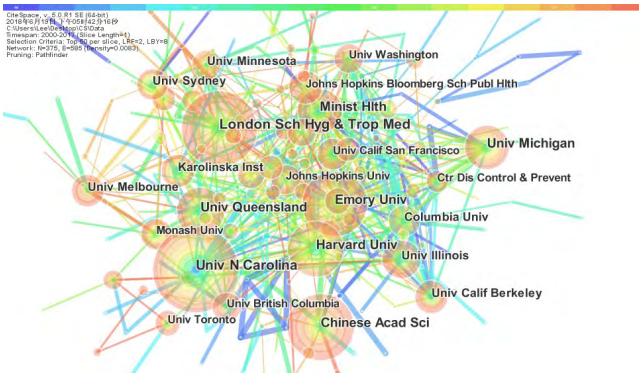

FIGURE 4. Institutional collaboration network.

TABLE 2. The top 10 institutions in number of published articles.

Institution	Number of published articles	LCS	GCS
University of North Carolina	119	177	3449
London School of Hygiene and Tropical Medicine	106	36	1801
Chinese Academy of Sciences	92	39	1747
Emory University	92	111	1541
Harvard University	82	66	3182
University of Queensland	76	32	1360
University of Michigan	71	39	1107
University of Illinois	66	47	1507
University of California at Berkeley	63	45	1484
University of Minnesota	61	74	982

for improvement. The strengthening of cooperation between different institutions is conducive to the full use of resources, the sharing of knowledge and common progress [34].

Table 2 shows the related information of the top 10 institutions with number of published articles. The largest node in the network is the University of North Carolina, which has published 119 articles in the field of rural environment and health and has the highest citation frequency of all institutions, nearly 3,500. The top 100 institutions have published at least 23 articles each, indicating that this research field has received extensive attention from various authoritative academic institutions around the world, presenting a posture of 100 schools of thought and 100 flowers in bloom. Among the top 10 institutions in the number of published articles, most are world-famous universities, indicating that universities are the backbone of the research in this field. American universities account for more than half of them, which shows that the United States is in the forefront of research in this field and has far-reaching effects.

3) JOURNAL DISTRIBUTION

Finally, we analyzed the journals of the papers in the field of rural environment and health. Table 3 lists the top 10 journals with literature quantity, GCS, and average times cited.

TABLE 3. The top 10 journals with literature quantity.

Name of Journal	Literature quantity	GCS	Average times cited
BMC Public Health	148	1910	12.91
PLOS ONE	129	1322	10.25
Rural and Remote Health	101	579	5.73
International Journal of Environmental Research and Public Health	94	703	7.48
Social Science and Medicine	92	2609	28.36
Science of the Total Environment	84	2435	28.99
Journal of Rural Health	76	1112	14.63
Environmental Research	52	889	17.10
Atmospheric Environment	49	1543	31.49
Annals of Agricultural and Environmental Medicine	44	429	9.75

The journal with the largest collection of literature in this field is *BMC Public Health*. It pays special attention to the social determinants of health, health and disease environment, the correlation between behavior and occupation, and the effect of health policies, practices, and interventions on communities. Although *BMC Public Health* has the largest collection of papers, the average number of times cited is relatively low, only 12.91.

Among the top 10 journals listed in Table 3, articles in *Atmospheric Environment* had the highest average number of citations, reaching 31.49. The scientific literature published by *Atmospheric Environment* is primarily concerned with the emission and deposition of gases and particulate compounds. Although the number of articles published by *Rural and Remote Health* reached 101, ranking third among all journals, the average rate at which its articles were cited was only 5.73, indicating that the quality of the literature it published in the field was generally not high. Therefore, this study can reflect the quality of journals to some extent. In Table 3, only the subject of the journal *PLOS ONE* does not match rural environment and health. *PLOS ONE* is a journal that accepts multidisciplinary research literature and publishes thousands of articles every year.

Similarly, according to Price law [33], the number of documents that a core journal should publish at least can be calculated, and the calculation result is approximately equal to nine. Therefore, journals with a total of nine or more publications can be considered the core journals in the field of rural environment and health, and their published articles represent the overall research grade and academic level of the literature in this field.

IV. KNOWLEDGE BASE ANALYSIS

The continuous development and progress of science is based on original science; therefore, the birth of almost all new research cites existing research results [35]. In the entire

TABLE 4. List of the top 10 co-citation articles with the corresponding frequencies and other information.

	Frequency	Author	Year	Name of Journal	Theme of literature
1	57	Liese AD	2007	*Journal of the American Dietetic Association*	food health
2	56	Lim SS	2012	*The Lancet*	disease risk and health
3	49	Sharkey JR	2008	*Journal of Nutrition*	food environment
4	39	Larson NI	2008	*American Journal of Preventive Medicine*	food intake
5	33	Jackson JE	2005	*Journal of Rural Health*	obesity
6	32	Befort CA	2012	*Journal of Rural Health*	obesity
7	31	Patterson PD	2004	*Journal of Rural Health*	obesity
8	28	Lutfiyya MN	2007	*Obesity*	obesity
9	25	Brownson RC	2009	*American Journal of Preventive Medicine*	sport and health
10	25	Glanz K	2007	*American Journal of Preventive Medicine*	nutrition environment

scientific literature system, the scholarship is related, and the achievements of later generations usually refer to and cite the scientific literature published by predecessors, which is the relationship between citing and cited in scientific literature [36]. The term *co-citation network* refers to a knowledge network formed when two pieces of scientific literature are simultaneously cited by a third or other, different piece of scientific literature. Co-citation is when two scientific documents are cited by other literature at the same time. The higher the frequency of citations at the same time, the closer the relationship between the two documents and the more similar the subject background and research theme [37]. When articles or journals are repeatedly cited by their peers, those co-cited studies would gradually be recognized by the scientific community and then evolve into a scientific paradigm [38]. In accordance with Kuhn's historicist scientific development model, the paradigm refers to a set of beliefs, traditions, or theories that are collectively recognized by the scientific community during a certain historical period [39]. Therefore, co-citation network could represent the knowledge base of a research field [40]. The visualization of the knowledge domain can help researchers understand the structure and discipline development of a particular knowledge domain, and will play a guiding role in the future evolution and development of the discipline.

The literature co-citation network is shown in Fig. 5. Each node in the figure represents the cited literature, the size of the node is proportional to the number of citation frequencies, the connection between nodes represents the co-citation relationship, the thickness of the connection indicates the strength of co-citation, and different colors indicate the year of co-citation. In the figure, the number of network nodes is 678, the number of connections between nodes is 626, and the density of network is 0.0027. The text beside the node indicates the name of the first author and the year when the literature was published. Among them, the most cited was an article published by Liese in 2007 titled ''Food Store Types, Availability, and Cost of Foods in a Rural Environment.'' At this point, this paper has been cited 197 times in the Web of Science database, and 57 times in the co-citation network

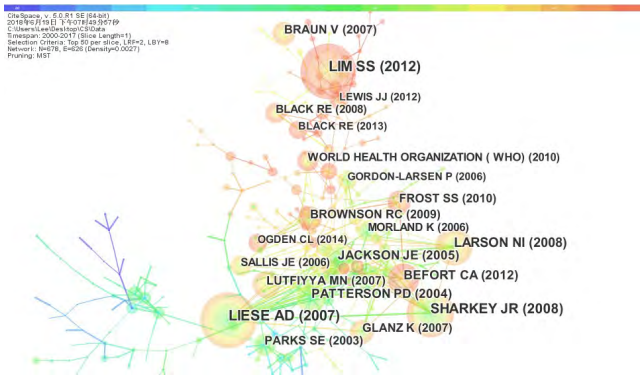

FIGURE 5. Articles in the co-citation network.

of this paper. Liese *et al.* [41] found that buying healthful, cheap food in rural areas was somewhat challenging. Liese mainly analyzed the current situation of rural food environments; food environment safety is also one aspect of rural environment and health research. Some nodes in the figure are connected with Liese, indicating that there is a strong co-citation relationship between Liese and these nodes, and their themes are strongly correlated. On the whole, the distribution of co-citation network in the field of rural environment and health research is relatively scattered, and a complete and mature co-citation network system has not been formed.

Table 4 lists the top 10 co-citation articles with their frequency, first author, theme, and so on. It can be seen from Table 4 that the co-citation frequency of these 10 documents has reached at least 25 times, and the years of publication of the literature are mainly concentrated between 2004 and 2012. Among the journals that include these highly cited articles, *Journal of Rural Health* and *American Journal of Preventive Medicine* are particularly eye-catching, each occupying three seats in the table. These highly cited articles can be broadly divided into two categories: the first is about rural obesity, and the second is about rural food environment and nutrition. This shows that in the field of rural environment and health, obesity and food issues have received widespread attention from researchers. Jackson *et al.* [42] and

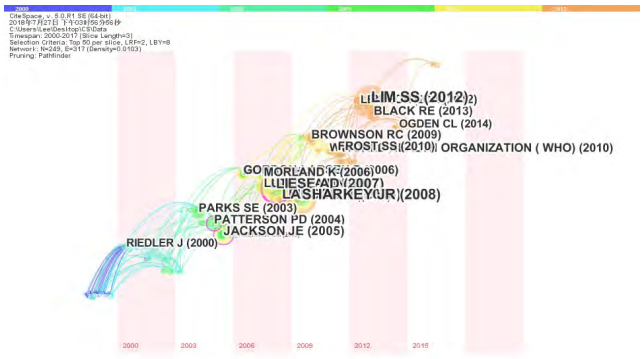

FIGURE 6. Co-citation time chart.

Patterson *et al.* [43] have laid the foundation for rural obesity research, and Liese *et al.* [41] and Sharkey and Horel [44] have laid the foundation for rural food health research.

A co-citation time chart is shown in Fig. 6, showing the important scientific literature in the betweenness centrality. Betweenness centrality was first proposed by Freeman [45], it is a network index used to measure individual status in social networks, and in the literature co-citation network, it can be used as a scientific measurement index for bibliometric analysis. In the figure, we can clearly see the distribution of important scientific literature in different time periods, and the innovation path of this field is made up of these pieces of scientific literature.

We can also see from the figure that important scientific literature is mainly concentrated between 2004 and 2012. Most of the articles with high frequency of co-citation were distributed in this period, which is consistent with the information conveyed in Table 4. This indicates that during that period, many high-level articles were published in the field of rural environment and health (or related fields), roughly laying its knowledge foundation. The betweenness centrality sequencing of the co-cited network is the same as the cited frequency and other indicators, satisfying the Zipf-Pareto distribution [46]. Generally speaking, the value of betweenness centrality of a published study is relatively high, and correspondingly, its cited frequency is also relatively high. In terms of betweenness centrality, the betweenness centrality value of five studies reached above 0.18, and Liese *et al.* [41] still ranked the first, which was enough to show the status of this literature in the field of rural environment and health. In addition, the betweenness centrality of Jackson *et al.* [42], Patterson *et al.* [43], and other literature was also relatively high. Through the unrelenting efforts of researchers in the field of rural environment and health research and their excellent research results, the knowledge base of this field has been formed and developed, providing important knowledge support for follow-up research.

V. ANALYSIS OF RESEARCH FOCUS

Research focus refers to the focus and intensity of subject research in a certain period, which is reflected in a large number of publications on a subject, the centralized emergence of academic thoughts, and the emergence of a large number of related researchers [47]. Kuhn emphasizes that the development of science is the alternation between conventional science and the scientific revolution, which indicates that the scientific revolution is changing and there is incommensurability between the old and new paradigms [48]. It is precisely because of incommensurability that the vocabulary system between the old and new paradigms will change accordingly, so whether the scientific revolution has occurred can be judged from whether the vocabulary has changed at that time. Statistics of the number of occurrences of a pair of keywords in the scientific literature can reflect the degree of relevance between keywords and the hot issues in specific fields during this period. Therefore, keyword co-occurrence analysis can reveal the research structure and research focus in specific fields [40]. Callon *et al.* [49] first proposed the method of co-term analysis, which has been widely used in the field of information science since then. The idea of co-term analysis comes from the concept of citation coupling and co-citation in bibliometrics. That is to say, when two professional terms (mainly inscriptions or keywords) that can express the research topic or direction of a subject area simultaneously appear in a published document, it indicates that these two words have a certain connection between them. The more they appear at the same time, the more it indicates that they are closely related and close to each other [50]. Therefore, compared with co-citation analysis and co-authorship analysis, co-term analysis is one of the content analysis methods commonly used in bibliometrics.

In this paper, we use the three-step method of co-term analysis proposed by Zhang *et al.* [51]. Since the co-word analysis method is based on the word frequency analysis method, the first step is to extract high-frequency keywords that can represent the research subject or direction of the field from the database; the second step is to count the number of simultaneous occurrences of these high-frequency keywords in the same document and construct a co-word matrix; and the last step is to analyze the co-word matrix [51].

A. KEYWORD EXTRACTION AND FREQUENCY COUNTING

Keywords are highly concise and generalized to an article, capturing its core and essence. Keywords that appear at a high frequency are often used to identify hot issues in a research field. By analyzing keywords, we can intuitively grasp a paper's main research content and even a field's overall research situation [52]. To build a more reasonable keyword co-occurrence network, this paper uses SATI software to calculate keyword frequency. Among all keywords, high-frequency keywords are better able to reflect research hotspots and research trends in specific fields. We take the top 100 high-frequency keywords as the research sample of this paper.

The top 30 keywords are listed in Table 5. They are all at least 25 in frequency. In Table 5, the keywords that appeared most frequently are *rural*, *health*, and *environment*, echoing

TABLE 5. List of the top 30 keywords with the corresponding frequency.

	Keyword	Frequency		Keyword	Frequency
1	rural	166	16	India	37
2	health	126	17	mental health	37
3	environment	89	18	community	34
4	physical activity	72	19	sanitation	34
5	children	63	20	urbanization	34
6	obesity	62	21	agriculture	30
7	epidemiology	59	22	climate change	30
8	prevalence	54	23	risk	30
9	China	52	24	policy	30
10	public health	49	25	arsenic	29
11	rural health	49	26	built environment	28
12	nutrition	45	27	environmental	27
13	environmental health	41	28	education	26
14	air pollution	41	29	adolescents	26
15	urban	40	30	HIV	26

TABLE 6. Selected keywords co-term matrix.

	rural	health	environment	physical activity	children	obesity	epidemiology	...
rural	166	17	9	17	7	9	6	...
health	17	126	12	8	3	2	5	...
environment	9	12	89	8	0	6	0	...
physical activity	17	8	8	72	1	11	1	...
children	7	3	0	1	63	5	2	...
obesity	9	2	6	11	5	62	2	...
epidemiology	6	5	0	1	2	2	59	...
...	...	...	...	...	...	...	...	...

the search strategy at the beginning of this study. The search strategy of this paper is mainly composed of "AND" connected with three parts: *rural*, *environment*, and *health*. This shows that most of the documents we searched are related to rural environment and health. These high-frequency keywords can be roughly divided into four categories:

(1) Related to the research area: *rural, China, India, urban, community, urbanization, agriculture,* and so on. This list includes two countries—China and India—indicating that in the field of rural environment and health, many scientific research survey areas are in rural China or India. China and India are both developing countries and have the largest populations in the world, and the corresponding rural populations are among the largest in the world.

(2) Related to health: *health, physical activity, obesity, epidemiology, prevalence, public health, rural health, nutrition, environmental health, mental health, HIV,* and so on. In this category of high-frequency keywords about health, both obesity and HIV are chronic diseases, and governments and researchers around the world are increasingly interested in their prevention and treatment.

(3) Related to the environment: *environment, air pollution, sanitation, climate change, arsenic, built environment, environmental,* and so on. Among these keywords, *arsenic* appears at a higher frequency. It is a kind of metal element, its compound arsenic trioxide is a kind of inorganic drug often used in agricultural pest control insecticides, and it has a certain harmful effect on human health and the ecological environment.

(4) Related to the research object: *children, adolescents, women, elder,* and so on. These are all terms for vulnerable people living in the countryside. In addition, according to the ranking of word frequency, human physical activity, children, obesity, and epidemiology have become the research foci in the field of rural environment and health.

B. NETWORK CONSTRUCTION AND THE ANALYSIS OF RESEARCH FOCUS

Keywords are extracted by SATI 3.2 software to generate a keyword co-word matrix of 100 × 100, as shown in Table 6. In Table 6, diagonal data refers to the frequency of occurrence of keywords in the row (or column), and non-diagonal data refers to the frequency of occurrence of keywords in the row and the column. For example, the data 59 on the diagonal indicates the frequency with which the keyword *epidemiology* appears, and the data 12 on the non-diagonal line indicates the frequency with which the keywords *environment* and *health* appear together.

To further explore the relationship between high-frequency keywords, the co-word matrix was imported into Ucinet 6.0 for format conversion, and the converted file was imported into Netdraw. The co-occurrence matrix of 100×100

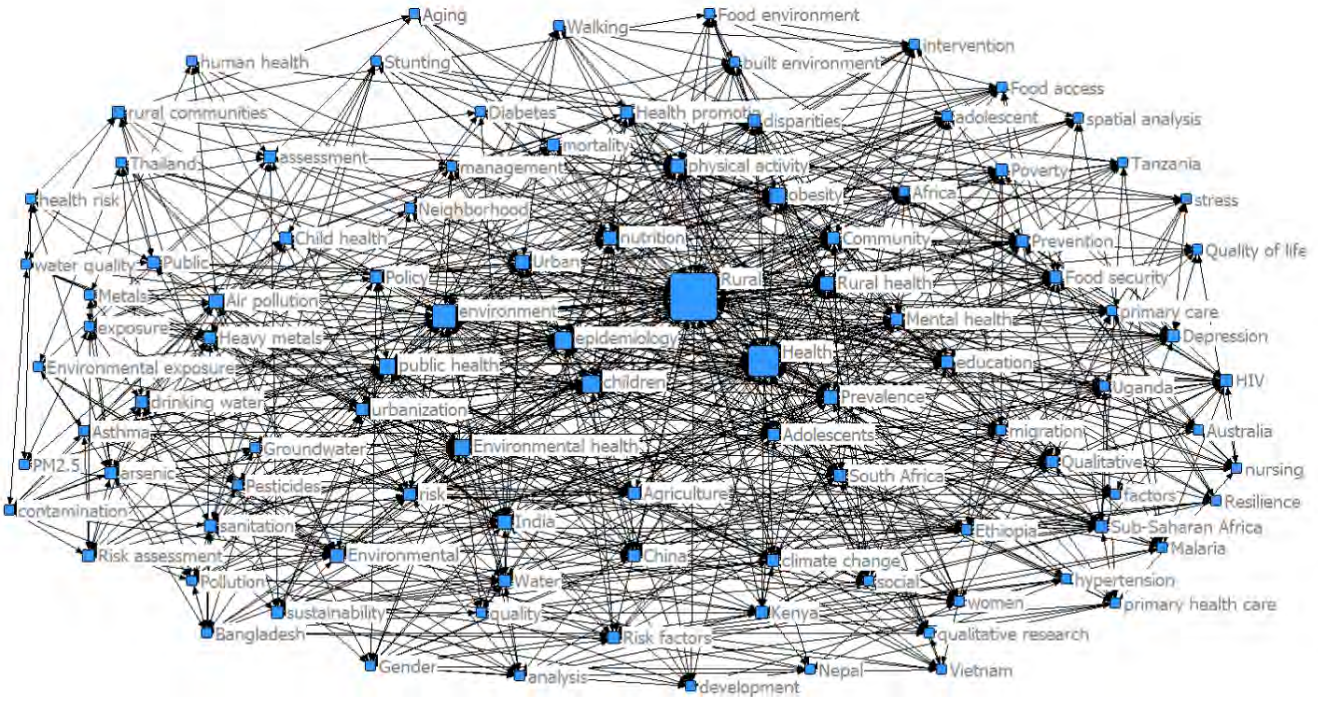

FIGURE 7. Keyword co-occurrence network.

keywords was used by Netdraw visualization software to generate the co-occurrence network diagram of keywords, as shown in Fig. 7. In the figure, each node represents different keywords, and the size of the node is displayed with different betweenness centrality. The larger the node, the greater mediating centrality of the keyword. The higher the central position of the node in the network, the more likely the keyword is to be a hot topic in the current research on rural environment and health. The connection between nodes indicates the number of simultaneous occurrences between different keywords. The thicker the connection, the higher the number of co-occurrences and the closer the relationship between keywords. In Fig. 7, we can clearly see a few large nodes, such as *rural, health, environment, epidemiology, children, prevalence, obesity,* and so on. These keywords in Table 4 word-frequency statistics are also in the top few, meaning that not only are they high-frequency keywords, but their betweenness centrality is higher also, which explains that they have a pivotal position in the rural environment and health sector.

In the keyword co-occurrence network, in addition to the three keywords *rural, environment,* and *health*, there are some keywords that are outstanding, and the current research status and development trend in this field can be found through them. Some examples are *nutrition, epidemiology, children, adolescent, education, climate change, air pollution,* and *drinking water.*

(1) Nutrition problems of rural children, including malnutrition, overnutrition, and growth retardation, have generated wide concern from scholars all over the world. Zhang *et al.* [53] explored the underlying mechanism of malnutrition and overnutrition among children in rural China.

(2) The level of medical services in rural areas is relatively backward, and people's awareness of health is relatively weak. Mckinney [54] reviewed AIDS monitoring data and rural health literature, and summarized the prevalence of AIDS in rural areas, the characteristics of the rural environment that affect HIV service delivery, and the measures being taken in rural areas.

(3) Children's education is also a major problem in rural areas. The quality of rural teachers is not high enough, and parents pay insufficient attention to children's education. It is crucial to carry out health education in rural areas, but the existing training methods for rural residents are generally not effective enough. Based on field reports from the Ghana Population Communication Project, Gokah [55] has proposed a new approach to address rural population training and education.

(4) In recent years, climate change has reduced agricultural crop and grain production in rural areas, air pollution is harming people's health, and drinking unsanitary water is a serious threat to human health. Martin *et al.* [56] explored the potential threat to human health of drinking water in rural areas of Nunavik and proposed five strategies for adapting to climate change. Padhi and Padhy [57] investigated the link between household use of biomass fuel for cooking and respiratory symptoms and disease prevalence in rural areas of India. All of these are some of the hot research questions getting the attention of scholars in the field of rural environment and health.

VI. CONCLUDING REMARKS AND FUTURE TRENDS

A. CONCLUDING REMARKS

In this study we completed a bibliometric analysis of the rural environment and health. The main work and results are as follows: Through the analysis of the time distribution, we found the trend of research output, author input and the number of literature co-authors in the rural environment and health field; We understood the distribution of research results in the world from author cooperation, institutional cooperation and journal publishing using a space distribution map analysis; We found the core authors, core literature and innovative paths in the field of rural environment and health by a knowledge base analysis; Through the analysis of keywords, we found the development status and future development trend of rural environment and health, and provided research profiles and hotspots for scholars in this field.

In general, we explored the knowledge base, innovation path and critical issues in the field of rural environment and health research, aiming to provide an important knowledge support for researchers to carry out follow-up research. (1) In terms of time distribution, the research output and author input in this field has increased year by year and the number of literature co-authors has reached 4.74; (2) In the aspect of space distribution, the collaborations among authors are numerous but that the cooperation network is dispersed and lacks a stable cooperative relationship. Cooperation between institutions has initially formed a network, but it still needs to be further consolidated. The strengthening of cooperation between different authors and institutions is conducive to the full use of resources, the sharing of knowledge and common progress. Therefore, we strongly recommend that authors from different countries or institutions strengthen their cooperation. Finally, the analysis of the distribution of journals can reflect the influence of some journals in this field to some extent; (3) In terms of knowledge base analysis, our research lists leading researchers and core scientific literature in rural environment and health research fields, and they have made tremendous contributions to the construction of knowledge bases in this field; (4) In the aspect of research focus analysis, keywords can be roughly divided into four categories, the focus of research in the rural environment and health is diversified. Some keywords not only are the high-frequency keywords, but their betweenness centrality was high. These keywords roughly reflect the major social concerns of global rural environment and health research.

B. FUTURE TRENDS

Current and future trends for rural environment and health research and development include:

(1) In recent research results, the frequency of the keyword *physical activity* is second only to *rural, health,* and *environment*, which is also shown in Table 4. It can be said that physical activity has become a hot research topic in the field of rural environment and health. In recent years, especially, many researchers have devoted themselves to this hot research subject. Wakely *et al.* [58] directed their study to rural children with disabilities and investigated their parents' views on opportunities for physical activity. Daly *et al.* [59] studied the effects of diet, physical activity, and access to fruits and vegetables on the weight status of children living in low-income rural areas. Thomson *et al.* [60] used a randomized controlled trial to test the effects of intensive family visiting programs on postpartum physical activity in rural African American mothers in the South. The research objects of these three studies are all rural children or rural women, and keywords such as *children, adolescent, women,* and *elder* also frequently appear in the literature. However, these groups are the focus of research in the field of rural environment and health.

(2) At present, global environmental problems are becoming more and more serious. In terms of rural environmental problems, air pollution, water shortages, and water pollution have become hot research topics in the field of rural environment and health. In modern agricultural production, more and more chemicals such as pesticides, fertilizers, and plastic films are used. On the one hand, the use of these chemicals has greatly increased agricultural production and economic benefits, but on the other hand, it has also brought a series of environmental problems. For example, the destruction of the ecological balance and pollution of the rural environment has also reduced the quality of agricultural products to some extent. Fertilizer pollution results in eutrophication of water in rural areas. In addition, the heavy metals and inorganic salts in fertilizers affect the quality of crops. Pesticides can pollute the atmosphere, soil, water, agriculture, livestock, and aquatic products and harm human health through the food chain. Water is the source of human life, but in some rural areas, it is difficult to find healthful, safe water, which poses a great threat to human health. Although safe water and adequate sanitation are recognized as human rights, about 30 percent of people around the world do not have access to safe drinking water [61]. The white pollution left in the soil makes soil permeability worse and reduces crop yields. In addition, the smoke from crop burning in rural areas can cause serious air pollution, increasing the amount of sulfur dioxide and dust. Household garbage is also one of the causes of environmental pollution in rural areas. In general, rural residents have a weak awareness of environmental protection and do not pay enough attention to the issue of environmental pollution. As a result, they dump their household garbage everywhere, rural cooking uses a lot of biomass fuel, which can also cause environmental pollution and even harm human health. Joon and Chandra [62] analyzed household air pollution from the use of biomass fuels in cooking by women and children in rural households in developing countries, as well as the effect of household air pollution on their health. Streets *et al.* [63] pointed out that around a quarter of global black carbon emissions come from China, mainly because of rural China's high utilization rate of coal and biofuels, which are often needed for cooking and heating. In addition, incomplete combustion of biomass fuels can cause greenhouse gas

emissions, and excessive greenhouse gas emissions can cause serious environmental problems.

(3) The health problems of rural residents cannot be ignored. Their health status is related to the development of the national economy and the progress of the whole society. From that perspective, chronic diseases and epidemic diseases have become a hot topic. Chronic diseases have a long course, complicated causes and are difficult to be completely cured [64]. Sedibe *et al.* [65] investigated differences and similarities in dietary habits among young and older, rural and urban South African adolescents in specific environments (families, communities, and schools), as well as their association with overweight and obesity. Quinn *et al.* [66] qualitatively studied the intersection of aging and AIDS in rural America. AIDS is a contagious disease and is particularly harmful, and at present, there is no way in the world that can completely cure it [67]. Therefore, the most important thing is to take preventive measures. In addition, scholars around the world have paid more attention to population aging and corresponding health issues in rural places.

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