



# The Pathfinder Network Analysis of Objectification and Standardization of Diagnostics in Traditional Chinese Medicine

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## Abstract

**Objective:** To perform a comparative quantitative and qualitative analysis of Chinese and non-Chinese literature on Objectification and Standardization of Diagnostics of Traditional Chinese Medicine (OSDTCM) by using systematic research and literature analysis, in order to discern research trends in the area and provide baseline data as a reference for relevant decision making and further study.

**Method:** We retrieved literature in PubMed and CNKI during database building to January 1<sup>st</sup>, 2023 by using MeSH terms and keywords related to OSDTCM. According to predefined inclusion and exclusion criteria, we constructed a set of charts by applying annual output and word co-occurrence after conducting output data cleaning by Excel. NetDraw function of UCINET 6.0 software was used to establish the topic structure of Pathfinder Networks algorithms. Based on the strength of external co-occurrence links, the relationship network and strategic indicator coordinate map between Chinese and English topics were made.

**Result:** A total of 1,563 Chinese and 545 English publications were included in CNKI and PubMed respectively. The topic structure map of OSDTCM research has been successfully established. A total of 33 countries/regions participated in the English published study. Chinese published the most publications (N=439, 80.55%), followed by the USA (N=61, 11.19%) and Germany (N=29, 5.32%). Shanghai University of Traditional Chinese Medicine is the institution that publishes most Chinese and English literature. The modern technology and methodology of TCM diagnoses and syndromes drive the progress of OSDTCM research at home and abroad. Chinese research started earlier than English research, and its research topics were more refined and in-depth, in which tongue diagnosis and pulse diagnosis were the main directions. English literature has already formed its own characteristics and made a significant contribution to the unification of terminology. Studies in Chinese or English have shown that the use of evidence-based medicine can better guide the future research of OSDTCM.

**Conclusion:** In the past 40 years, the number of OSDTCM papers published in both Chinese and English has increased significantly, but the research in English is not as rich as that in Chinese and is still in the early stage of development. In order to narrow the knowledge gap at home and abroad and expand the advantages of TCM, we should speed up the construction of an objective evaluation system of TCM clinical diagnosis and the promotion of advanced modern technology, and pay great attention to the application of evidence-based Chinese medicine in the near future.

**Keywords:** Traditional Chinese medicine; Diagnosis; Objectification; Standardization; Cluster analysis

## Instruction

Traditional Chinese Medicine (TCM), with thousands of years of history, played a good protective role in the process of reproduction of the Chinese nation. Many studies have shown the effectiveness of Traditional Chinese Medicine (TCM) in the treatment of various diseases [1,2]. The correct Chinese diagnosis of disease syndrome is the premise of effective TCM prevention and treatment. The basic principles of diagnostics of TCM include overall examination, a combination of diagnostic methods, and a combination of disease and syndrome [3]. In recent years, many scholars have done a lot of work on the objectification and standardization of TCM diagnosis by developing international standardized terminology and using modern techniques and methods,

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trying to improve the problem of non-quantitative description in TCM diagnosis [4,5]. The subjective factors are transformed into objective factors, and the fuzzy characteristics tend to be standardized and mathematized, so as to improve the efficiency of Traditional Chinese Medicine (TCM) accurate syndrome differentiation and promote the development of world medicine.

Based on the current status of Chinese and non-Chinese literature and the visual analysis of PFNET6, the purpose of this paper is to outline the current research situation and trends of the research on objectification and standardization of TCM diagnostics at home and abroad, and to provide baseline data for the gap between domestic and foreign research, and to provide reference for related decision-making and further research.

## Materials and Methods

### Data source and search strategy

Both Chinese (in the CNKI database) and non-Chinese OSDTCM articles and reviews (in the PubMed database) were collected as comparative subjects of research. The Chinese search terms “中医诊断” (/means diagnostics of TCM) AND (“客观化” OR “规范化”) OR “标准化”) (/means objectification or standardization) were used in CNKI. The search terms “diagnosis”, “traditional Chinese medicine”, “standardization”, “normalization” was used for a topic search of PubMed. Both databases were searched from inception to January 1<sup>st</sup>, 2023, and had not imposed restrictions on language and year of publication. We completed all searches and downloaded the results within the same day to avoid the bias caused by daily database updates. A detailed search strategy has been provided in Supplementary Material.

### Inclusion and exclusion criteria

Inclusion criteria were as follows: (1)The objective research of TCM diagnostics refers to the research of quantitative collection and analysis of TCM diagnostic methods and syndrome related data combined with modern science and technology in the field of TCM diagnostics such as clinical practice, basic experiment and intelligent medical treatment; (2) The standard research of TCM diagnosis refers to the research on the unification of TCM diagnostic methods, specific repetitive terms, techniques and methods, diagnostic basis,

etc. through the formulation, release and implementation of norms, procedures, and systems in the fields of TCM diagnostics such as clinical practice, basic testing, and intelligent medical treatment. (3) The normalized research of TCM diagnostics refers to the research on refining and optimizing the actual or potential problems in the research topics related to TCM diagnostics, and the research on establishing regulations or lists for common use and repeated use.

Studies were excluded due to the following reasons: (1) Publications that were not articles or reviews (e.g., conferences, newspapers, letters); (2) Duplicates or irrelevant literature; (3) TCM studies mainly about the safety and effectiveness of interventions; (4) Qualitative research on empirical diagnosis from doctors.

### Data extraction and cleaning

The titles and abstracts of the literature identified in the databases online were screened by two reviewers independently with a standardized approach. We resolved any disagreements about research qualifications by discussing or consulting the third reviewer. A flow diagram of the systematic search and study selection process is shown in Figure 1. Then six reviewers were divided into three groups. BICOMB (Bibliographic Items Co-Occurrence Matrix Builder), a basic tool for text mining, was used to export the frequency of years, institutions, and keywords of the literature that met the inclusion criteria from the database online to Excel. Two groups manually cleaned different expressions of authors, institutions, and keywords to ensure data accuracy, such as the author's name, the different writing of the name of the institution, keyword synonyms, synonyms, abbreviations, etc. After reviewing the results of the first two groups for consistency, the third group used data retrospection to ensure authenticity and confirm the final data. We made hierarchical clusters on the co-word matrices of the Chinese and non-Chinese literature, taking cluster distance as the correlation coefficient [6].

### Data analysis

We employed VOSviewer 1.6.14 to identify countries/regions [7]. A related network map was established, in which bubbles represent elements, and the size of the bubbles represents the Number (N) or Frequency (F), the larger bubbles indicate more publications, and the lines between the bubbles represent correlations of elements. The VOSviewer settings were as follows: Counting method (full counting),

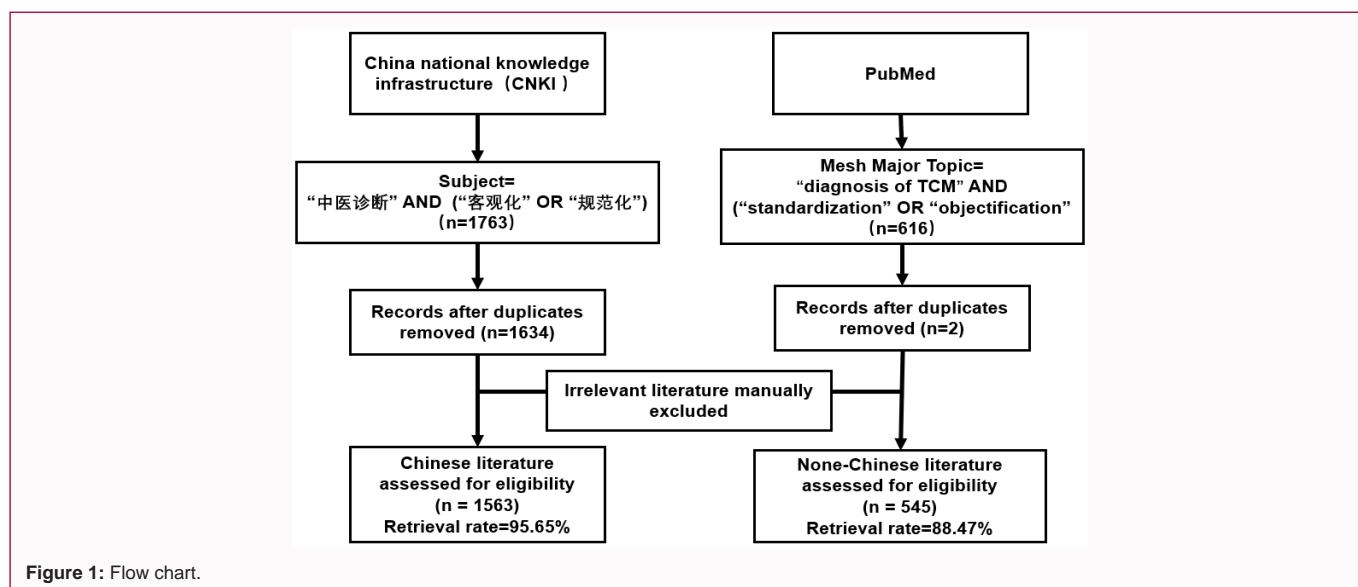


Figure 1: Flow chart.

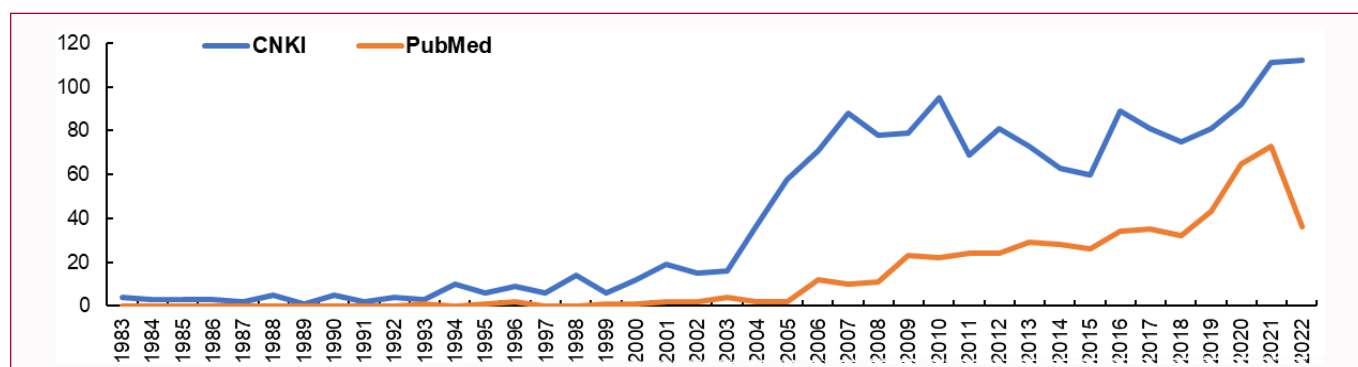


Figure 2: Annual publications quantity of Chinese and non-Chinese article (1983-2022).

Thresholds (T) of elements adopted according to special situations.

The Pathfinder Networks (PFNET) algorithm refers to a method to assess the relationships between concepts. It takes each word as a separate node and co-occurrence frequency between nodes as the weight of link intensity. In order to streamline the network, it decides to retain or delete links according to the result of a triangle inequality test. Usually, a PFNET algorithm determines two parameters (r and q). The letter "r" represents the length of the path, and "q" represents the upper limit of the edge total of the minimum path [8-10]. Using the NetDraw function of UCINET 6.0 software, each class group formed by the topic result network is drawn into the inter-class relationship diagram according to the external link strength between classes, so as to reflect the relationship strength between classes. The thickness of the line represents the strength of the relationship, the thicker the line, the stronger the connection between each other. The formation of the topic indicates that this field is in a relatively important position in the whole discipline of research.

Strategy coordination charts were made into two-dimensional coordinates. In order to discern the structure of each OSDTCM research area, we divided the topics of the included articles into four quadrants, with the X-axis representing centrality (C) and the Y-axis density (D). Clusters in the first quadrant have high centrality and density. High density means the internal links of the research subjects are intense, indicating that the field is mature. High centrality means research hotspots possess wide links, indicating that research on this subject lies in the center of a research network. Clusters in the second quadrant possess intense links but their internal structure is not so intense, which indicates that research on the topic is popular, but

still at the early stage of development. Clusters in the third quadrant have low density and centrality and loose internal structure, which indicates that research in the area, is immature. Clusters in the fourth quadrant display intense internal links but loose links with other clusters, which indicates that these areas of research are not relevant to research on other topics. Microsoft Excel 2019 was used to manage the data and create tables.

## Result

### Search results

In total, 4,763 articles were retrieved from CNKI and 2,616 from PubMed. After removing literature that did not meet the inclusion criteria, we finally included 1,563 Chinese articles and 545 non-Chinese literatures, which were all in English. The annual output of OSDTCM showed a rising trend from 1983 to 2022 in CNKI, and from 1993 to 2022 in PubMed (Figure 2). The number of published Chinese literature was more than that of English literature each year. The maximum quantity of annual output in CNKI (N=111) and PubMed (N=73) were both in 2021.

### Contributing countries and institutions

A total of 33 countries/regions participated in English published literature. The Chinese published the most publications, accounting for 80.55% (n=439) of the included studies, followed by USA (N=61, 11.19%), Germany (N=29, 5.32%), and Australia (N=23, 4.22%). Collaborations were evident between several countries, the Chinese showed close cooperation with the USA, Germany, Australia Singapore, and the USA showed close cooperation with Canada, Japan, and Australia.

Table 1: The top 10 institutions of the Chinese and non-Chinese article.

Chinese articles (CNKI)			Non-Chinese articles (PubMed)		
Rank	Institution	Count	Rank	Institution	Count
1	Shanghai University of Traditional Chinese Medicine	227	1	Shanghai University of Traditional Chinese Medicine	51
2	Beijing University of Chinese Medicine	124	2	China Academy of Chinese Medical Science	46
3	Tianjing University of Chinese Medicine	89	3	Beijing University of Chinese Medicine	41
4	Guangzhou University of Chinese Medicine	63	4	Guangzhou University of Chinese Medicine	23
5	Tianjin University	55	5	Tianjing University of Chinese Medicine	20
6	Hunan University of Chinese Medicine	55	6	Hong Kong University	19
7	Hainan University of Traditional Chinese Medicine	53	7	Shanghai Jiaotong University	14
8	Shandong Traditional Chinese Medicine University	41	8	Fudan University	12
9	East China University of Science and Technology	40	9	Peking University	11
10	Chengdu university of traditional Chinese medicine	40	10	Hong Kong Polytechnic University	11





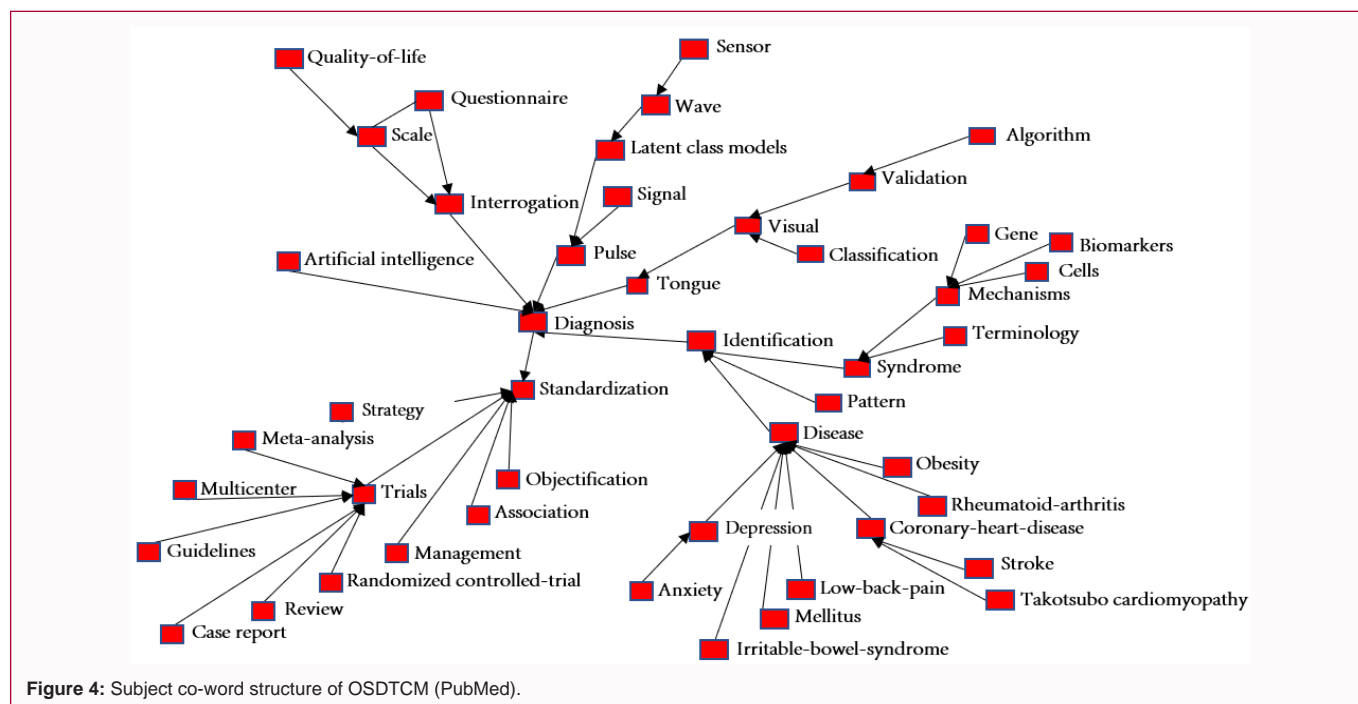


Figure 4: Subject co-word structure of OSDTCM (PubMed).

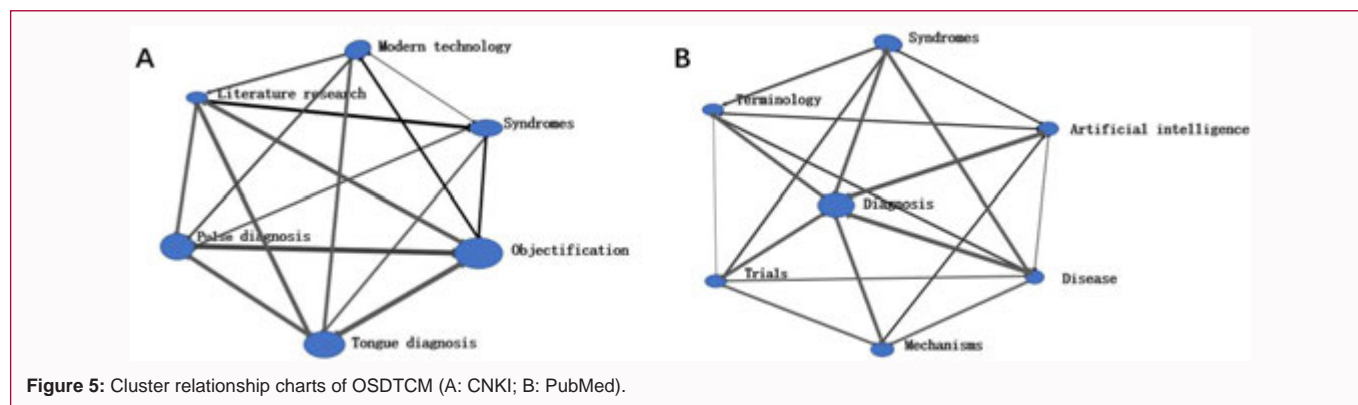


Figure 5: Cluster relationship charts of OSDTCM (A: CNKI; B: PubMed).

topics of Chinese OSDTCM literatures (Figure 5A), "objectification" and "pulse diagnosis" had the closest link (EI=701.0), followed by "tongue detection "(EI=656.1) and" literature research "(EI=475.3). Among the non-Chinese topics (Figure 5B), "diagnosis" and "artificial intelligence" are most closely linked (EI=276.2), followed by "disease" (EI=183.7) and "terminology" (EI=135.9).

**Strategy coordination chart**

As shown in strategic coordinate diagram (Figure 6A), "tongue diagnosis" (C=16.69, D=18.00) and "pulse diagnosis" (C=19.16, D=17.56) were in the first quadrant, indicating that these two topics were the core forces to promote the development of objectification and standardization of TCM diagnostics; "modern technology" (C=6.39, D= -9.20) was in the second quadrant, "syndrome" (C= -12.23, D=3.42) was in the third quadrant, and "literature research" (C= -2.08, D= -17.28) was in the fourth quadrant. As shown in Figure 5B, "syndrome" (C=5.08, D=4.89) and "diagnosis" (C=11.08, D=8.89) were the main driving forces of OSDTCM non-Chinese studies; "mechanism research" (C=9.08, D= -4.11), "disease" (C=3.08, D= -10.11) and "artificial intelligence" (C=9.07, D= -11.11) were in the second quadrant, "terminology" (C= -6.92, D=1.89) was in the third quadrant, and "trials" (C= -2.53, D= -3.12) was in the fourth quadrant.

**Discussion**

**General information**

After de-duplicated and screening the searches results of the CNKI database and PubMed database through the pre-established strategy, a total of 35 countries/regions participated in the publication of articles in the field of OSDTCM, including 1,563 Chinese literature and 545 English literatures. Both the number of Chinese and English studies showed a significant upward trend. China was with the most published literature in this field, followed by the United States and Germany. It showed that most continents in the world are actively exploring the diagnosis of TCM. Shanghai University of Traditional Chinese Medicine was the leader in this field and the institution with the largest number of published articles. Although the topics were different, the main topics involved in both Chinese and English were: Diagnosis, syndromes, modern technology, and literature research. It showed that the overall research direction at home and abroad was basically the same. Through the visualization research based on PFNET analysis, it is confirmed that the original driving force of OSDTCM research at home and abroad revolves around the four diagnoses of TCM, which promotes the development of the standardization of diagnostic technology, terminology expression,

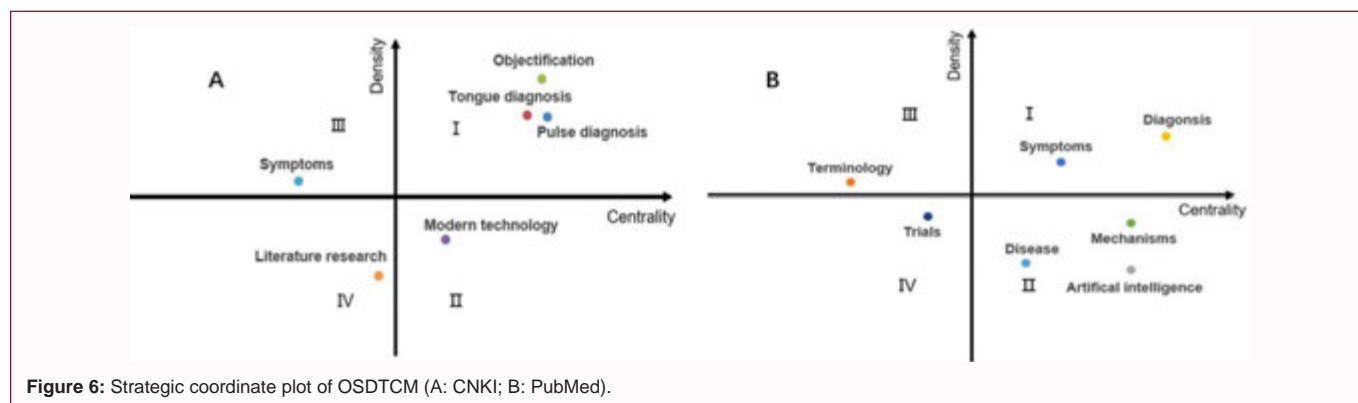


Figure 6: Strategic coordinate plot of OSDTCM (A: CNKI; B: PubMed).

and clinical research methodology.

**Current research frontiers of OSDTCM**

Whether in Chinese or English, the four methods of diagnosis-observation of TCM were in the core position in the strategic coordinate axis. Among them, tongue diagnosis and pulse diagnosis are the key research directions. As Huangdi Neijing said, the tongue is the seedling of the heart, and the fur is the emblem of the stomach [12]. Tongue diagnosis is not only an important part of TCM inspection but also in the core position in the strategic coordinate axis. Through the observation of tongue quality and tongue coating, we could understand the location of the lesion and treat it according to syndrome differentiation. With the further development of clinical modernization of Traditional Chinese Medicine, new requirements for objective and quantitative diagnosis of tongue image are put forward. It has become the inevitable direction of tongue diagnosis research to study the principle of tongue diagnosis and improve its clinical application value by means of modern science and technology [13]. Through the study of physiological anatomy, microcirculation, cytochemistry, and gene molecules of tongue coating, this field had clarified the mechanism and mechanism of the formation of normal and partial pathological tongue images on the basis of Traditional Chinese Medicine. In addition, due to the diagnostic criteria of traditional methods of tongue diagnosis, it is often affected by doctors' clinical experience and environmental factors such as light source, brightness, and so on. The use of computer technology can avoid the subjective interference caused by lack of experience and errors, contribute to the objectivity and repeatability of TCM diagnosis and treatment, and better ensure the accuracy of diagnosis [14]. The key technologies involved in the research of computer automatic recognition of tongue diagnosis in TCM include the standardization of tongue image acquisition environment and method, the segmentation of tongue body, the index of tongue image (color and shape of the tongue body and color and texture of tongue coating, etc.), and the establishment of tongue image database [15].

Pulse diagnosis of TCM is a special diagnostic method for doctors to understand the changes of qi and blood ups and downs and to judge the influence of pathogens on viscera through brain analysis and synthesis of effective information by finger cutting according to the superficial pulse of the radial artery of the patient. Therefore, the study of pulse diagnosis in TCM should focus on two questions: (1) what is the pulse that doctors perceive, and how to reproduce it objectively? [16]; (2) what is the information of pulse diagnosis obtained by comprehensive analysis of the brain, and how to quantify that? [17]. After the modern research of pulse diagnosis in TCM, a

variety of pulse instruments have been developed to record the pulse fluctuation, which can effectively and objectively reproduce the law of the pulse graph. On the other hand, through the pulse diagnosis information provided by the pulse map, the quantitative index can be quickly obtained by using various signal analysis techniques, such as wavelet analysis [18] and Hilbert-Huang transform [19]. In order to understand the formation mechanism of a pulse and what kind of physiological and pathological information the effective pulse diagnosis information represents; the principles and methods of hemodynamics had also been deeply analyzed and discussed in many works of literature.

Although the interrogation diagnosis of TCM has not been obviously put forward in the results, it is also very important in the objective research of traditional Chinese medicine diagnosis [20]. There were many related words in high-frequency keywords, such as scale, questionnaire, and so on. With the transformation from the biomedical model to the bio-psychological-social medical model, the theory of quality of life is put forward. The quality-of-life assessment scale has been recognized by the World Health Organization (WHO) as an effective way to quantify, objectify and standardize clinical data [21]. The existing clinical consultation scale is based on natural observation, makes a qualitative and quantitative estimation of the evaluation content, and uses digital language instead of text description, which is helpful for statistical processing, so it is analyzable. Because the measurement meter is easy to operate, does not need special equipment and conditions, and has the advantages of economy and convenience, the research on the objectification of TCM consultation can be expanded and deepened in the future. In addition, "Wen diagnosis" (闻诊) includes acoustic diagnosis and olfactory diagnosis [22]. Although there is not much research, it has made some progress with the help of modern scientific instruments, such as sonograms, infrared spectroscopy and so on.

Medical Law (医门法律) has mentioned that the four diagnoses of Traditional Chinese Medicine cannot be without one [23]. As the disease is a complex process, its clinical manifestations can be reflected in many aspects, and it is necessary to combine the four diagnoses in order to obtain the data needed for diagnosis in a more comprehensive and detailed manner. The process of syndrome differentiation and treatment of TCM has gradually changed from the subjective mode of traditional four diagnoses to the new mode of data and physical and chemical indexes [24].

According to the results above, syndrome research was one of the main topics of TCM academic research [25]. Based on the present situation of TCM diagnosis and its important position in the academic

field of Traditional Chinese Medicine, more and more studies are combined with modern multidisciplinary theory and technology, from the point of view of literature, clinic, and experiment. The essence and standardization of the syndrome were studied from different macro and micro levels [26]. The modern research direction of the syndrome could be divided into two categories: (1) Collecting and analyzing the descriptive data of machine pulse syndrome of TCM syndrome in a specific time through the methods of clinical epidemiology and statistical analysis and exploring the distribution and evolution of syndrome. Establish the diagnostic criteria of the syndrome [27]. (2) Through the experimental study of establishing an animal model, the pathological and physiological basis of the syndrome was explored from the levels of the whole, organ, cell, and molecule [28]. From the point of view of modern science, this study revealed the scientific connotation and essence of TCM syndrome. With the increasing acceptance of Traditional Chinese Medicine, many international organizations and institutions have participated in the objective research of TCM diagnosis, such as TC249 and TC215, the two main technical committees of the International Organization for Standardization (ISO), have participated in the formulation of TCM standards, and have successively issued 10 international standards and projects for TCM diagnosis, such as TCM Diagnostic terms (4). According to the strategic coordinate map, compared with English research, the terminology standardization research of Chinese research is not outstanding, which might be because English is a more popular international lingua franca. With the increasingly close academic exchanges and cooperation among countries, it is believed that there is still much room for the development of this research topic in the future.

Based on the analysis of OSDTCM, it was illustrated that the previous research work of the information collection, analysis and fusion method of the diagnoses of Traditional Chinese Medicine extracted and analyzed the diagnoses information of chronic diseases such as coronary heart disease [29,30] and diabetes [31,32]. A large number of TCM disease syndrome models have been established and analyzed. Objective detection of TCM diagnosis is expected to provide evaluation indicators for early warning of different diseases, health assessment, clinical efficacy, and clinical trials of new drug evaluation of Traditional Chinese Medicine.

Among the high-frequency keywords extracted from literature, such as "meta-analysis", "multicenter" and "randomized controlled trial", which could be found that the application of evidence-based medicine in TCM literature research to accelerate the promotion of TCM modernization has been the main development of OSDTCM [33]. This would be an inevitable trend in the future. The core idea of evidence-based medicine is to seek and apply evidence. Search the evidence according to the specific problem, and make the best decision to solve the problem according to the individual situation of the patient. Therefore, the clinical symptoms and signs of patients are quantified under the guidance of evidence-based medicine [34]. At the same time, we should pay attention to collecting multicenter studies with good correlation, use statistical methods to find out the best diagnostic criteria, do a better job in standardized TCM diagnosis research, and improve accuracy, consistency and repeatability.

## Strengths and limitations

Our study has several strengths. First, it is the first PENET analysis in comparing study in Chinese and non-Chinese of OSDTCM, and thus provides a comprehensive reference for researchers. Second,

established Scientometric software tools (VOSviewer, and Unicet) were employed to analyze related countries/regions, organizations and co-occurrence of keywords, which clearly show the current status and frontiers of OSDTCM research. Third, we searched the OSDTCM-related literature based on common terms to conduct a topic search to ensure the comprehensiveness and accuracy of the included data.

This study also has some limitations. First, we only searched CNKI and PubMed databases and did not search other medical databases, which inevitably led to sample bias. Second, our inferences and demonstrations in this paper were based on the frequency of MeSH/keywords, which usually do not completely cover the main content of publications. Thus, there may have been some bias in terms of topic classification. Besides, low-frequency keywords were not reflected in this analysis.

## Conclusion

This study described the current research directions and trends of OSDTCM and provided a historical insight into the development trend. In the past 40 years, the number of papers published in both Chinese and English had increased significantly, but the international development of this field is still in its early stage. In order to narrow the knowledge gap at home and abroad, it is necessary to speed up the construction of objective evaluation system of TCM clinical diagnosis, promote advanced modern medical technology and evidence-based methodology.

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