Research on the Evaluation Indicator System of Technological Innovation in Traditional Chinese Medicine Universities based on Analytic Hierarchy Process

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Abstract. Objective: To provide theoretical support for improving technological innovation capability of traditional Chinese medicine (TCM) universities and to promote high-quality development of TCM in inheritance and innovation. Methods: Based on the policy documents and related literature research on technological innovation in China, combined with characteristics of TCM universities, analytic hierarchy process model is used to construct the evaluation indicators system of technological innovation in TCM universities from five aspects, namely, policy support and planning deployment, talent cultivation and team building, the transformation of technological fruits and industrial development, the construction of informatization and digitization, and international exchange and cooperation. Results: The weight of the indicators of policy support and planning deployment, talent cultivation and team building, technological fruits transformation and industrial development, the construction of informatization and digitization, and international exchange and cooperation are 0.4708, 0.1863, 0.1795, 0.1122, and 0.0513, and maximum eigenvalue and consistency index are 5.4179 and 0.0933. Conclusion: TCM universities should be guided by national policies, focus on talent cultivation, promote the transformation of technological fruits, accelerate the construction of informatization and digitization, and strengthen international exchange, so as to facilitate TCM development in inheritance and innovation.

Keywords: traditional Chinese medicine universities, technological innovation, evaluation indicators system, analytic hierarchy process

1 Introduction

Since the 18th Communist Party of China (CPC) National Congress, the CPC Central Committee and the State Council have put the work of traditional Chinese medicine (TCM) in a more prominent position, and the 14th Five-Year Plan of the TCM

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Technological Innovation Special Program has clearly stated that technological innovation is the key to promote the development of TCM inheritance and innovation[1].Universities are the front line of technological innovation activities and an important part of national innovation systems[2].As the main technological force of TCM[3],higher education universities of TCM have an important supporting role in realizing the inheritance and innovation of TCM. Accelerating the construction of technological innovation systems in line with characteristics of TCM universities are inevitable requirement to improve the technological innovation capability of TCM universities. Based on the current development situation of TCM universities, this research focuses on the key elements affecting the technological innovation of TCM universities, such as policy support and planning deployment, talent cultivation and team building, the transformation of technological fruits and industrial development, the construction of informatization and digitization, and international exchange and cooperation, in the hope of realizing the high level of self-reliance and self-improvement of TCM universities by enhancing technological innovation capability.

2 Research Methods

Developed by Saaty[4] in 1980, analytic hierarchy process (AHP) is a statistical method that integrates qualitative description and quantitative analysis[5]. At present, this method is widely used in fields such as selection, evaluation, planning, decision-making and prediction[6]. Seven experts were invited to compare the importance of indicators 2 by 2 and assign values according to the 1 ~ 9 scale method (table 1) in this research. Determine the weight of indicators at each level and conduct consistency tests by building judgment matrices When the CR value is less than 0.1, the consistency is considered passed[7]. The square root method is used to calculate the weight values of the judgment matrix[8], mainly due to its concise and intuitive calculation process, which is suitable for small and medium-sized indicators such as this research. The calculation logic of the geometric mean weakens the effect of extreme values which is suitable for extracting consensus weight when there is a slight difference in expert opinion.However, its limitation is that it is sensitive to the consistency of the judgment matrix. If the logical contradiction of expert scores is significant (e.g., CR exceeds the standard), the matrix needs to be repeatedly corrected.And the error may increase for high dimensional matrices, when the number of single level indicators needs to be reduced by hierarchical grouping. The calculation method is shown as follows.

Table 1. Scale and meaning of judgment matrix.

importance scale	meaning
1	Two elements are equally important compared to each other.
3	When comparing two elements, the former is slightly more important than the latter.
5	When comparing two elements, the former is significantly more important than the latter.
7	When comparing two elements, the former is strongly more important

	than the latter.
9	When comparing two elements, the former is extremely more important than the latter.
2,4,6,8	Intermediate values of the above adjacent judgments.
reciprocal	The scale of the former to the latter is the reciprocal of the latter to the former.

2.1 Weight Calculation

$$\overrightarrow{w_i} = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}, (i = 1,2,...,n) \tag{1}$$

In the formula: $\overrightarrow{w_i}$ is the nth root of the product of fractional values of the judgment matrix of each row, and a_{ij} is the element of the judgment matrix.

$$w_i = \frac{\overrightarrow{w_i}}{\sum_{i=1}^{n} \overrightarrow{w_i}}, (i=1,2,...,n) \tag{2}$$

In the formula: w_i is the weight vector obtained by normalizing $\overrightarrow{w_i}$.

2.2 Consistency Test

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} w_j}{w_i} \tag{3}$$

In the formula: λ_{max} is the maximum eigenvalue of the judgment matrix.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{4}$$

In the formula: CI denotes consistency index and n is the order of the judgment matrix.

$$CR = \frac{CI}{RI} \tag{5}$$

In the formula: CR is the test coefficient and RI(table 2) is the mean random consistency index.

Table 2. Mean random consistency index(n=9).

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

3 Construction of Evaluation Indicator System for Technological Innovation in TCM Universities

In constructing the technological innovation evaluation indicator system of TCM universities, this research adopts a two-track screening method of policy orientation and literature analysis. For the policy part, the policy documents of the State Council involving the support direction of TCM technological innovation, the key development areas and the relevant evaluation orientation are carefully sorted out, from which the macroscopic guiding principles and key elements related to the construction of evaluation indexes are extracted. For the literature part, the literature related to the evaluation of TCM technological innovation and the construction method of the indicator system are screened out through the subject words search for intensive study, from which the relevant indicators and evaluation dimensions which are of great significance to the construction of this indicator system are mined out. On this basis, the screened key information is integrated and analyzed by combining the own characteristics of TCM universities and the actual needs of technological innovation. Using the Delphi combined with AHP to sort the weight of indicators, a technological innovation evaluation indicator system for TCM universities containing 5 level 1 indicators and 20 level 2 indicators is finally constructed.

Level 1 indicators include five aspects: policy support and planning deployment, talent cultivation and team building, the transformation of technological fruits and industrial development, the construction of informatization and digitization, and international exchange and cooperation. Among them, policy support and planning deployment include four level 2 indicators on the construction of TCM inheritance and innovation, the construction of TCM governance system, the construction of TCM service system, and the allocation of TCM resources. Talent cultivation and team building include four level 2 indicators: platform and environment construction of TCM talent cultivation, planning formulation of TCM talent cultivation, resource inputs in school, and talent team-building at various levels in TCM and its related important fields. The transformation of technological fruits and industrial development includes four level 2 indicators: the research and development of TCM products, hospital-school co-construction, school-enterprise cooperation, and school-local cooperation. The construction of informatization and digitization includes four level 2 indicators: digital equipment of TCM, data standard formulation of TCM, digital service system development of TCM health, and composite talents of artificial intelligence in TCM. International exchange and cooperation includes four level 2 indicators: international education cooperation of TCM, research project cooperation of TCM, international symposium of TCM, and international market promotion and brand building of TCM products. The weight of indicators of policy support and planning deployment, talent cultivation and team building, the transformation of technological fruits and industrial development, the construction of informatization and digitization, and international exchange and cooperation are 0.4708,0.1863,0.1795,0.1122 and 0.0513. Its maximum eigenvalue and consistency index are 5.4179 and 0.0933, which meets the consistency test, and the specific information is shown in table 3. The CR value of this research is 0.0933, which is slightly lower than the critical threshold of 0.1, but still strictly satisfies the AHP

consistency test (CR<0.1), indicating that the logical conflicts of the expert judgment matrices are within the controllable range.The phenomenon of its approaching critical value may stem from the complexity of multidisciplinary cross-evaluation in the field of TCM, but the logical relationship of the indicators has been stabilized through the correction of the Delphi method and the validation of the weight allocation.This result reflects the limited volatility of expert opinions in real research scenarios, which is in line with the inclusiveness of "acceptable deviation"in soft science evaluation, and we will try to introduce new methods to further optimize the sensitivity indicators in the subsequent research.

Table 3. Evaluation indicator system of technological innovation in TCM universities.

Level 1 indicators	Weight of Indicators	Level 2 indicators	Weight of Indicators
A policy support and planning deployment	0.4708	A1 the construction of TCM inheritance and innovation	0.4472
		A2 the construction of TCM governance system	0.1841
		A3 the construction of TCM service system	0.1563
		A4 the allocation of TCM resources	0.2124
B talent cultivation and team building	0.1863	B1 platform and environment construction of TCM talent cultivation	0.3880
		B2 planning formulation of TCM talent cultivation	0.1993
		B3 resource inputs in school	0.2814
		B4 talent team-building at various levels in TCM and its related important fields	0.1313
C the transformation of technological fruits and industrial development	0.1795	C1 the research and development of TCM products	0.4669
		C2 hospital-school co-construction	0.2534
		C3 school-enterprise cooperation	0.1886
		C4 school-local cooperation	0.0912
D the construction of informatization and digitization	0.1122	D1 digital equipment of TCM	0.4615
		D2 data standard formulation of TCM,	0.2099
		D3 digital service system development of TCM health	0.1888
		D4 composite talents of artificial intelligence in TCM	0.1397
E international exchange and cooperation	0.0513	E1 international education cooperation of TCM	0.2599
		E2 research project cooperation of TCM	0.4531
		E3 international symposium of TCM	0.1378
		E4 international market promotion and brand building of TCM products	0.1492

4 Discussion

TCM is the treasure of Chinese civilization, and the construction and development of TCM universities have an important impact on the enhancement of China's healthcare. Because of unique and distinctive characteristics, TCM universities need a set of evaluation indicator system that can reflect both the common characteristics of general universities and the individual characteristics of TCM universities.This research has formed the technological innovation evaluation indicator system of TCM universities suitable for TCM development by constructing AHP model, which has a certain reference effect on the improvement of technological innovation capability of TCM universities.

The research finds that the level 1 indicators of policy support and planning deployment accounted for a weight of 0.4708, which accounts for a larger weight of the overall evaluation indicators, and is the primary factor affecting the technological innovation capability of TCM universities. In recent years, in order to promote the development of TCM inheritance and innovation, China has issued a number of policy documents, such as TCM Inheritance and Innovation "One Hundred Million" Talent Project (Qihuang Project)--National Support Program for Leading Talents in TCM[9], Opinions on Promoting the Development of TCM Inheritance and Innovation[10], the Implementation Plan of Major Projects for the Revitalization and Development of TCM[11], etc. A series of supportive policies issued by the state for TCM development have provided guidelines for TCM universities to promote the construction of technological innovation systems and pointed out the way forward for the future work of TCM universities.

The weight of talent cultivation and team building is in the second place with 0.1863. With the passage of time, the development of TCM requires not only the perseverance of the older generation but also the inheritance and innovation of the younger generation. TCM universities, as the mainstay of talent cultivation, need to formulate a rational plan for the cultivation of TCM talents. Strengthen the building of talents at all levels in TCM and its related important fields, deepen the organic combination of institutional education and apprenticeship education[12], focus on inheriting the essence, and keep the right and innovation. It is also more important for TCM universities to rationally allocate the limited TCM resources on campus and innovate the construction of talent cultivation platforms[13]. Make good use of the existing advantages of TCM resources and the scientific research platform of leading talents, and stimulate innovative ideas of students, with a view to enhance the technological innovation capability of TCM universities.

The weight of transformation of technological fruits and industrial development is 0.1795, which is in the third place. The State supports universities in conducting scientific research and technical innovation in TCM, and encourages the building of technological innovation highland in order to accelerate the modernization and industrialization of TCM. TCM universities should focus on problem orientation and practical application value in the process of scientific research, accelerate the development of TCM products, and promote the effective docking of scientific research results with market demand. Industry-university-research collaborative development mode is an important path for the innovative development of TCM universities[14]. TCM universities, based

on this mode, should further strengthen hospital-school co-construction, and deepen the strategic cooperation school-local and school-enterprise. It will facilitate the transformation of TCM technological fruits and the upgrading of TCM industries.

The weight of construction of informatization and digitization is 0.1122, which is in the fourth place. The State Administration of TCM, together with the National Data Bureau, issued Several Opinions on Promoting the Development of Digital TCM[15], which proposes to promote the gradual integration of big data, artificial intelligence and other emerging digital technologies into all aspects of the whole chain of inheritance, innovation and development of TCM. TCM universities should take the initiative with digital technology to explore and practice the development of TCM. Introduce actively digital equipment, develop TCM health digital service systems, cultivate TCM artificial intelligence composite talents, and promote the development of TCM data standards, so as to accelerate the wide application of information and digital technologies in TCM field.

International exchange and cooperation has a weight of 0.0513, which is in the fifth place. In recent years, TCM exchange and cooperation with foreign countries has been deepening continuously. It is essential for TCM universities to comprehensively promote the high-quality integration of TCM into the Belt and Road Initiative[16]. They should create an outward-oriented talent cultivation model, strengthen cooperation in international education and scientific research programs in TCM, actively participate in international academic exchange meetings in TCM to improve the internationalization level of TCM education. In addition, international marketing and branding of TCM products should also be strengthened to facilitate the overseas development and promotion of TCM and to further internationalize not only the dissemination but also the development of TCM.

5 Conclusion

By analyzing various policy documents and literature on technological innovation in TCM universities and combining experts' opinions, this research constructs a framework of evaluation indicators for technological innovation in TCM universities from five aspects: policy support and planning deployment, talent cultivation and team building, the transformation of technological fruits and industrial development, the construction of informatization and digitization, and international exchange and cooperation. AHP is used to assign weight and consistency test to the evaluation framework, and finally the evaluation indicator system of technological innovation in TCM universities is established. Today, with the increasingly rapid development of society, TCM universities should be guided by the national policies, rely on their own advantages, focus on talent cultivation, integrate technological innovation into industrial innovation, and promote the transformation of technological fruits. It's necessary for TCM universities to accelerate the construction of informatization and digitization, strengthen international exchange and cooperation, realize creative transformation and innovative development of TCM culture, and promote TCM high-quality development.

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