Received: 9 November 2024 | Revised: 4 January 2025 | Accepted: 18 March 2025 | Published online: 31 March 2025

Medinformatics
2025, Vol. 00(00) 1–7
DOI: 10.47852/bonviewMEDIN52024764

RESEARCH ARTICLE

TCM2COVID in 2024: Enhanced Data on Traditional Chinese Medicine Formulas and Knowledge Graph for COVID-19

Xianrun Pan[1], **Yang Zhang**[2,*], **Jian Huang**[1] **and Liping Ren**[3,*]

[1]School of Life Science and Technology, University of Electronic Science and Technology of China, China

[2]Innovative Institute of Chinese Medicine and Pharmacy, Chengdu University of Traditional Chinese Medicine, China

[3]School of Healthcare Technology, Chengdu Neusoft University, China

Abstract: Despite the fact that five years have passed since the outbreak of COVID-19, the coronavirus continues to coexist with our lives, making ongoing attention to COVID-19 important for understanding its transmission mechanisms, optimizing prevention and control strategies, and promoting the formulation of public health policies. Meanwhile, traditional Chinese medicine remains actively involved in the prevention and treatment of COVID-19. As a result, our team has continued to collect data on traditional Chinese formulas and natural products for this purpose and has released a new version of TCM2COVID in 2024. This version documents more than 300 traditional Chinese medicine formulas, includes over 320 herbs and more than 90 natural products, and incorporates data on ingredients, ingredient-related targets, diseases, and disease-related targets. On this basis, an online tool has been integrated, featuring a "Formula-Herb-Disease multi-level Knowledge Graph Network" to assist users in conveniently browsing and querying relevant knowledge. In conclusion, TCM2COVID in 2024 offers a more comprehensive and user-friendly resource platform to facilitate continued research on the COVID-19 pandemic. TCM2COVID in 2024 can be accessed for free at https://cellknowledge.com.cn/tcm2covid/.

Keywords: COVID-19, traditional Chinese medicine, herb, natural product, knowledge graph

1. Introduction

Throughout the last 3,000 years of Chinese history, there is a well-documented history of traditional Chinese medicine (TCM) in the treatment of infectious diseases [1]. Modern TCM has played a role in several epidemics, such as the outbreaks of SARS-CoV in 2003 and MERS-CoV in 2012, where TCM interventions showed significant effects [2]. The outbreak of COVID-19 posed a serious threat to global public health [3]. However, China made significant contributions to epidemic prevention and control, with TCM playing an important and indispensable role in combating the pandemic [4, 5]. The "three medicines and three formulas" of TCM played a key role. The "three medicines and three formulas" include Chinese patent medicines such as "Lianhua Qingwen", "Huoxiang Zhengqi", and "Qingfei Paidu Decoction", which have demonstrated significant clinical efficacy, effectively improving patient symptoms, shortening the course of the disease, and reducing the incidence of severe cases [6]. Meanwhile, TCM has relatively mild side effects, making it suitable for patients of various constitutions, emphasizing holistic conditioning, and enhancing the body's immune response. This combination of historical experience and modern research data fully demonstrates the unique value of TCM in epidemic prevention and control.

Clinical research indicates that TCM has a definitive therapeutic effect on COVID-19 [7, 8]. Large-scale clinical trials have demonstrated that patients in the TCM treatment group have significantly shorter symptom relief times compared to the control group, with relief rates for fever and cough symptoms increasing by 40% and 30%, respectively. TCM can reduce the proportion of patients progressing to severe cases by 55% and lower the mortality rate among severe or critically ill patients by 49% [9]. Mechanistic studies have found that TCM regulates immune responses through multiple pathways, inhibits viral replication and inflammatory responses, and enhances the body's resistance to the virus. Additionally, the philosophy of syndrome differentiation and treatment in TCM enables the selection of suitable formulas according to the patients' varying constitutions and conditions, thus facilitating personalized treatment. These mechanistic studies provide scientific evidence for the application of TCM in combating COVID-19, further consolidating its position in the public health system [10].

To assist researchers in clarifying the mechanisms of TCM in the fight against COVID and to support efforts against this global pandemic, we previously developed TCM2COVID, a database of anti-COVID-19 TCM resources that provides detailed clinical evidence, treatment mechanism information, an intuitive user interface, and powerful visualization capabilities [11]. On May 5, 2023, the World Health Organization announced that COVID-19

---

[*]**Corresponding authors:** Yang Zhang, Innovative Institute of Chinese Medicine and Pharmacy, Chengdu University of Traditional Chinese Medicine, China. Emails: zhy1001@alu.uestc.edu.cn; yangzhang@cdutcm.edu.cn and Liping Ren, School of Healthcare Technology, Chengdu Neusoft University, China. Email: renliping@nsu.edu.cn

Table 1. Comparative analysis with similar databases

	Formula information	Visual atlas	COVID-19 related contents
TCM2COVID in 2024	Yes	Yes	Yes
HERB	No	No	No
SymMap	No	No Formulas	No
SOFDA	Yes	No Ingredients	No

is no longer considered a public health emergency of international concern. Although the trend of the novel coronavirus pandemic is gradually declining, the risk of new variants still exists, and the virus may still cause localized outbreaks or the emergence of variants; therefore, COVID-19 remains a potential threat to global health [12]. This reminds us that we must learn from the lessons of the COVID-19 pandemic and strengthen our preparedness for future pandemics. In response to researchers' demand for more comprehensive resources and to provide a more convenient and efficient user experience, we have developed an updated version of TCM2COVID—TCM2COVID in 2024, which includes new anti-COVID TCM formulas, natural product (NP), and herb resource data, as well as tools for the "Formula-Herb-Disease multi-level Knowledge Graph Network" TCM2COVID is available for free at https://cellknowledge.com.cn/tcm2covid/.

To better highlight the unique contributions of TCM2COVID in 2024, we compared it with similar databases, such as HERB [13], SymMap [14], and SOFDA [15] as shown in Table 1. While HERB is a well-established TCM database, it lacks information on formulas associated with the herbs, does not include COVID-19 related data, and does not feature visualization graphs. SymMap, although offering useful visualization capabilities, limits flexibility as it does not allow for the simultaneous selection of multiple factors (such as formulas, herbs, and diseases), which is crucial for studying complex diseases like COVID-19. On the other hand, SOFDA, a TCM syndrome ontology database, evaluates the relationships between syndromes, diseases, and formulas, but its visualization results do not include ingredient information, and it does not focus on the dynamic associations between formulas, herbs, and diseases in the context of COVID-19. TCM2COVID in 2024 stands out by integrating these factors into a dynamic, interactive knowledge graph, providing a more comprehensive and flexible tool, especially for COVID-19 research. By combining the relationships between formulas, herbs, and diseases, TCM2COVID in 2024 enables researchers to explore these connections in greater detail. This comparative analysis underscores the uniqueness of TCM2COVID in 2024 in providing a more robust and user-friendly platform for TCM research in the context of the COVID-19 pandemic.

2. Data Expansion

In order to stay updated with the latest progress in the field of COVID-19, we have significantly expanded the data in TCM2COVID in 2024. First, we collected relevant data from the latest literature through manual text mining. Using a series of keywords, we conducted a comprehensive literature search in databases such as CNKI, PubMed, bioRxiv, Web of Science, and Google Scholar. Additionally, we annotated the collected data using information from authoritative reference databases. Data related to "properties", "meridians", "used parts", "indications", and "ingredients" were collected from the HERB database, SymMap database, TCMID 2.0 database [16], and ETCM database [17]. The 2D structural diagrams, molecular formulas, and SMILES of NPs are sourced from the NCBI PubChem database [18]. In summary, the data in TCM2COVID in 2024 have significantly increased compared to TCM2COVID in 2022 (as shown in Table 2):

1) Formula data: A total of 14 records were added, including 11 records of SARS-CoV-2 subtypes, two records of Omicron subtypes, and one record of the SARS-CoV-2 Omicron variant. All 14 of these new data entries are based on experimental evidence from laboratories.
2) Herb data: 12 relevant records have been added.
3) Nature Product data: 12 new records have been added, including 3 records for SARS-CoV subtypes and 9 for SARS-CoV-2 subtypes. Among these newly added Nature Product data, 6 are sourced from computational methods and 6 from laboratory experimental evidence, reflecting a diverse range of data sources.

Finally, and importantly, in order to make the data and functionality more comprehensive, we have added a series of new data by accessing the HERB database:

1) Herb-related data: Includes 14,875 records of herb-related ingredient data and 11,287 records of gene target data for these related ingredients.
2) Disease-related data: A total of 28,212 new disease records and 11,403 disease-related gene target data.

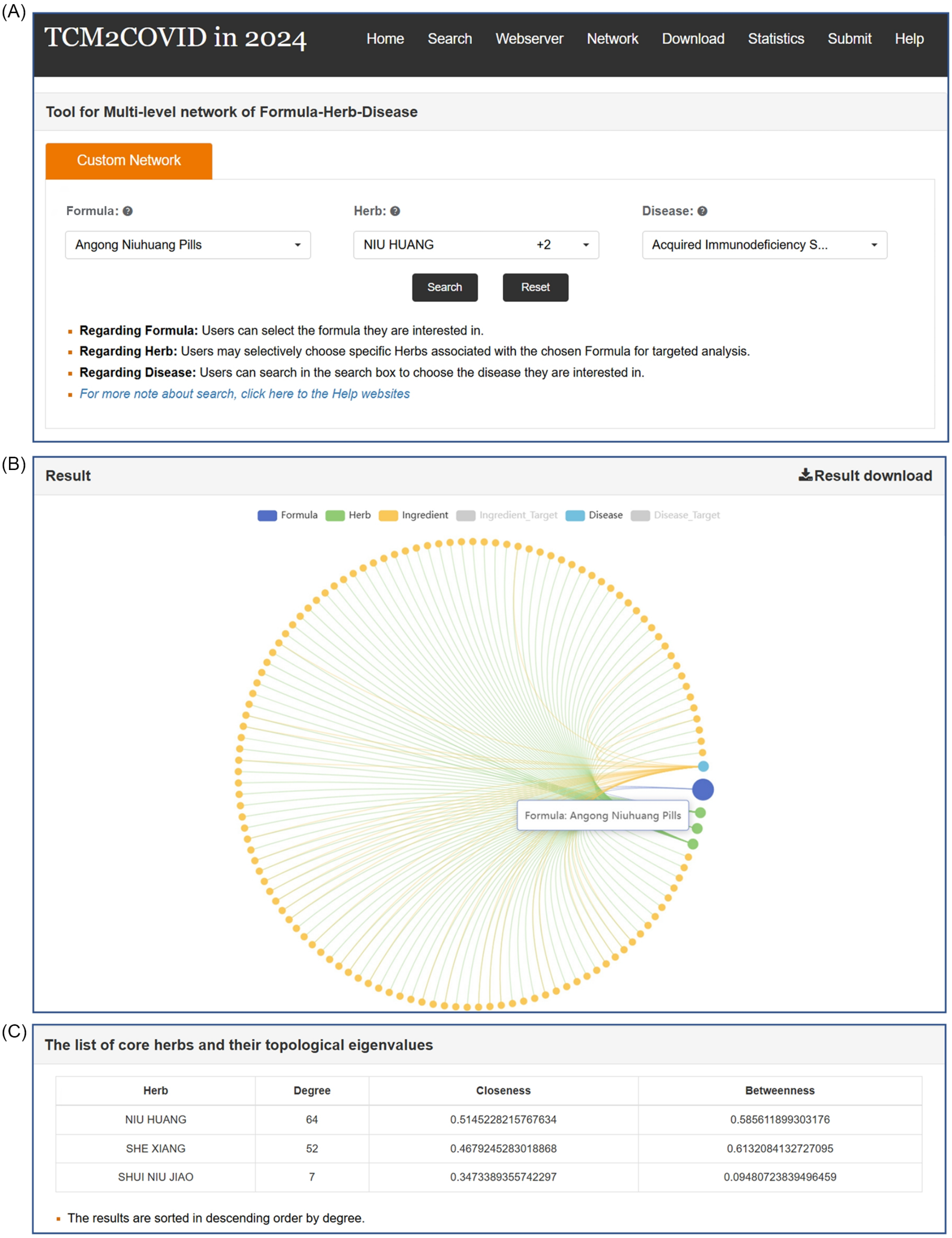
Table 2. Detailed comparison of data entries between TCM2COVID and TCM2COVID in 2024

Data	Classification		2022	2024	Increase
Formula	Formula Distribution	SARS-CoV	1	1	–
		SARS-CoV-2	280	291	11
		SARS-CoV;SARS-CoV-2	6	6	–
		Omicron	0	2	2
		SARS-CoV-2 Omicron variant	0	1	1
	Formula Classification	By in silico method	21	21	–
		By wet-lab experiment	266	280	14
	Total of Formula		287	301	14
Herb	Total of Herb		313	325	12
Nature Product	Nature Product Distribution	SARS-CoV	30	33	3
		SARS-CoV-2	51	60	9
		MERS-CoV	3	3	–
	Nature Product Classification	By in silico method	14	20	6
		By wet-lab experiment	70	76	6
	Total of Nature Product		84	96	12

3. Knowledge Graph Visualization

Due to the complexity of medicinal ingredients, numerous targets, and the complexity of TCM terminology, in-depth research in TCM faces numerous challenges. Therefore, further elucidating the relationships between various TCM terms, including formulas and herbs, as well as deriving new discoveries based on TCM principles to promote precision medicine, are pressing issues that need to be addressed [19]. To tackle this, we have added a new knowledge graph visualization tool on the TCM2COVID in 2024 website: the "Formula-Herb-Disease multi-level Knowledge Graph Network". This tool enables users to efficiently and conveniently conduct multi-layer association analysis of the "Formula-Herb-Disease" knowledge graph network.

Through the navigation bar, users can easily link to the Network tool page. First, users can select the formula of interest and corresponding herbs in the search box (e.g., Figure 1: Formula: Angong Niuhuang Pills; Herbs: NIU HUANG; SHUI NIU JIAO;



Tool for Multi-level network of Formula-Herb-Disease

Formula: Angong Niuhuang Pills

Herb: NIU HUANG +2

Disease: Acquired Immunodeficiency S...

- **Regarding Formula:** Users can select the formula they are interested in.
- **Regarding Herb:** Users may selectively choose specific Herbs associated with the chosen Formula for targeted analysis.
- **Regarding Disease:** Users can search in the search box to choose the disease they are interested in.
- *For more note about search, click here to the Help websites*

Result

The list of core herbs and their topological eigenvalues

Herb	Degree	Closeness	Betweenness
NIU HUANG	64	0.5145228215767634	0.585611899303176
SHE XIANG	52	0.4679245283018868	0.6132084132727095
SHUI NIU JIAO	7	0.3473389355742297	0.09480723839496459

- The results are sorted in descending order by degree.

Figure 1. New features page in TCM2COVID in 2024. (A) Search section. (B) Result 1: Network interaction graph. (C) Result 2: Herb nodes and their indicator data

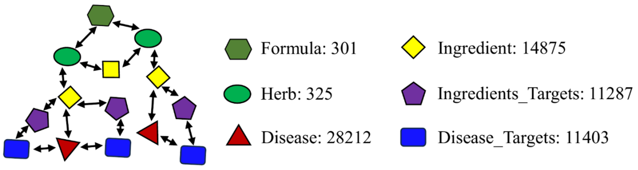


Figure 2. Data relationship diagram

SHE XIANG). If users want to explore whether the formula and herbs are associated with certain diseases (e.g., Figure 2: Disease: Acquired Immunodeficiency Syndrome), they can search for and select the disease in the disease-specific search box.

After making these selections, clicking "Search" will generate a knowledge graph for "Formula-Herb-Disease". By clicking "Result download", users can download the JSON data file corresponding to the graph. It is important to note that users can select the data to be plotted from the legend above the graph for a clearer view of the data of interest and can highlight the interaction relationships by hovering the cursor over the graph.

Next, I will provide a brief introduction to the interaction relationships in the network graph:

1) Formula-Herb

The database includes 301 formulas, involving 325 herbs. Users can view the corresponding relationship between formulas and herbs through detailed pages. To make it more convenient, we developed the "Formula-Herb-Disease" interaction network analysis function, where users can select the formulas and herbs of interest in the search box for an intuitive understanding of their relationships.

2) Herb-Ingredient

To ensure the integrity of the interaction network, we obtained herb-related ingredient information by accessing the HERB database. After selecting the herb of interest, users can directly view the ingredients associated with the herb in the network graph.

3) Ingredient-Ingredient_Target

By accessing the HERB database, we obtained the active ingredients of the herbs and their targets, referred to as Ingredient_Target. Users can click on the annotations in the graph to explore these targets' relationships with others.

4) Disease-Disease_Target

By accessing the HERB database, we obtained information on diseases and their related targets. By considering disease-related genes, we can intuitively connect formulas with diseases, revealing drug-gene-disease module associations [20].

5) Disease-Ingredient

Finally, by analyzing the obtained Ingredient_Target and Disease_Target, we determine the association between diseases and ingredients. If there is an overlap between the Ingredient_Target and Disease_Target, they are considered linked; otherwise, they are not.

Below the network interaction graph, users can view a table with the selected herbs, along with their degree, closeness, and betweenness data in the interaction relationships. It is important to note that the table is sorted in descending order based on degree (e.g., Figure 1: NIU HUANG; SHUI NIU JIAO; SHE XIANG).

4. Discussion and Conclusion

Since the outbreak of COVID-19, TCM has been widely used in the treatment of COVID-19 with significant results [21]. However, there are still controversies regarding the safety and effectiveness of TCM within the global medical community [22–25]. Before effective vaccines were developed, Chinese doctors achieved good therapeutic outcomes by integrating Eastern and Western medicine [26, 27]. As a result, many studies have called for breaking down the barriers between Eastern and Western medicine and using TCM and Conventional Western Medicine together in treatment [28–30]. Some studies have begun systematically analyzing Chinese herbal formulas for treating COVID-19, exploring the integration mechanisms of TCM, and developing knowledge graph networks related to formulas [31].

TCM2COVID is committed to addressing the controversies surrounding the effectiveness and mechanisms of TCM. The previous website recorded detailed information on more than 280 Chinese formulas (including over 300 herbs), covering clinical evidence and therapeutic mechanisms, and documented more than 80 NPs with potential therapeutic mechanisms. To supplement the information on emerging viral variants, we updated the website data by consulting literature and public databases. We have also developed a new "Formula-Herb-Disease multi-level Knowledge Graph Network" tool. This tool allows users to quickly analyze the multi-layered associations in the "Formula-Herb-Disease" knowledge graph, helping to predict the efficacy of formulas and explore the relationships between formulas and diseases.

To improve data accessibility, we have integrated API interfaces within TCM2COVID in 2024, allowing users to conveniently access and retrieve data programmatically. Users can access data from the search and network pages through the following API endpoints: https://cellknowledge.com.cn/tcm2covid/php_mysql/API_search_formula.php, https://cellknowledge.com.cn/tcm2covid/php_mysql/API_search_ingredient.php, https://cellknowledge.com.cn/tcm2covid/php_mysql/API_search_herb.php and https://cellknowledge.com.cn/tcm2covid/php_mysql/API_network.php. We believe this improvement will significantly enhance the usability of the database and the convenience of data access, providing users with a more flexible way to interact with the data.

However, TCM2COVID in 2024 still has some limitations. First, the "Formula-Herb-Disease multi-level Knowledge Graph Network" tool does not directly associate diseases with formulas or herbs but connects diseases to ingredients via gene targets. While this network pharmacology-based approach has shown significant advantages in identifying potential therapeutic targets and related pathways, it reveals correlations rather than direct causal relationships. Additionally, some gene-target associations have not been fully validated experimentally, which may result in incomplete or inaccurate links within the network. Despite these challenges, network pharmacology remains a key tool in TCM research, and with the integration of artificial intelligence, it holds promise for enhancing the precision and reliability of TCM treatments. Looking ahead, we plan to address these limitations by incorporating experimental validation and multi-omics data in future studies, aiming to refine and strengthen the connections within the knowledge graph.

Moreover, because each herb option involves multiple ingredients and gene targets, the large amount of data may cause delays in system processing when handling numerous queries. Therefore, it is not recommended for users to select too many herbs at once. To address the delays in handling large-scale queries, we plan to implement key optimization strategies. First, we will enhance data processing by introducing more specific and precise filtering conditions. By filtering out irrelevant or redundant data during each query, we can significantly reduce the data volume that needs to be processed, improving the system's overall efficiency, especially when handling complex relationships in large datasets. Moreover, we will add new scoring methods to assess the relationships between formulas, herbs, ingredients, and diseases, refining the strength of these connections to help users select the most relevant data. Additionally, we recognize the role of hardware limitations in contributing to system delays, particularly when processing large amounts of data. To overcome this, we plan to upgrade our hardware infrastructure, which may include server upgrades, expanding storage capacity, and enhancing computational power. We believe that by implementing these improvements, system delays will be significantly reduced, and the overall performance of the knowledge graph tool will be enhanced.

Another limitation of the dataset is its primary focus on TCM, which may introduce certain geographic or cultural biases. While TCM has gained increasing global recognition for its therapeutic effects, particularly in addressing public health challenges like COVID-19, we acknowledge that expanding the scope of the dataset to include other traditional medicines from different regions could offer valuable insights. For instance, traditional systems such as Ayurvedic medicine [32] or Western herbal medicine [33], though not included in our current database, have demonstrated significant therapeutic potential in various studies. A comparison of their effects alongside TCM could provide a more comprehensive understanding of global traditional medicine practices and their collective efficacy in treating diseases. In future updates, we plan to consider incorporating data from these other traditional medical systems to broaden the scope of our dataset and reduce potential geographic and cultural biases.

Despite some current limitations, TCM2COVID has played a crucial role in promoting the global recognition and application of TCM, especially in the context of pandemic prevention and control. By integrating and organizing a large amount of data related to TCM, it has become a valuable resource for global researchers and medical experts studying TCM for COVID-19. The platform offers a convenient way for researchers worldwide to share and analyze TCM data, enhancing global understanding of the therapeutic potential of TCM and providing vital support for more scientific and effective use of TCM in combating the pandemic. In response to global public health crises like the COVID-19 pandemic, TCM2COVID has played a key role in facilitating the rapid application of TCM treatments. Furthermore, TCM2COVID supports the integration of TCM with global healthcare systems. By offering a scientifically rigorous and accessible database, the platform demonstrates how TCM can complement modern medicine, especially in public health emergencies. This integration plays a crucial role in enhancing global healthcare responses and addressing the diverse needs of different medical traditions worldwide. Looking ahead, in the future, users will be able to leverage our knowledge graph to connect formulas, herbs, ingredients, and diseases via gene targets, enabling researchers to quickly identify potential therapeutic targets and pathways. This will not only accelerate research progress but also provide scientific evidence for the application of TCM in pandemic control, fostering the integration of TCM with global public health strategies. TCM2COVID in 2024 will continue to play a central role in promoting the global recognition and application of TCM, contributing not only to the in-depth understanding of TCM mechanisms but also supporting the development of global public health policies that incorporate traditional medicine.

In conclusion, TCM2COVID in 2024 records more than 300 Chinese formulas (including over 320 herbs), offers detailed clinical evidence and therapeutic mechanisms, and documents over 90 NPs with potential therapeutic mechanisms. Additionally, over 14,000 ingredient data, 28,000 disease data, and over 11,000 gene target data have been added, along with the newly developed "Formula-Herb-Disease multi-level Knowledge Graph Network" tool. This platform provides user-friendly and practical resources for recording, querying, and browsing TCM treatments for COVID-19, which will help develop and clarify the mechanisms of new TCM treatments for COVID-19 and support research efforts against the pandemic.

Funding Support

This work was supported by the National Natural Science Foundation of China (62471071, 62202069) and the Natural Science Foundation of Sichuan Province (2023NSFSC0678).

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

Jian Huang is an Associate Editor for *Medinformatics*, and was not involved in the editorial review or the decision to publish this article. The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

TCM2COVID in 2024 is publicly accessible and available free of charge at the following URL: https://cellknowledge.com.cn/tcm2covid/.

Author Contribution Statement

Xianrun Pan: Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Yang Zhang:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Jian Huang:** Resources, Supervision, Project administration, Funding acquisition. **Liping Ren:** Conceptualization, Software, Visualization, Supervision, Project administration, Funding acquisition.

References

[1] Huang, K., Zhang, P., Zhang, Z., Youn, J. Y., Wang, C., Zhang, H., & Cai, H. (2021). Traditional Chinese medicine (TCM) in the treatment of COVID-19 and other viral infections: Efficacies and mechanisms. *Pharmacology & Therapeutics*, *225*, 107843. https://doi.org/10.1016/j.pharmthera.2021.107843

[2] Li, H., Yang, L., Liu, F. F., Ma, X. N., He, P. L., Tang, W., . . . , & Zuo, J. P. (2020). Overview of therapeutic drug research for COVID-19 in China. *Acta Pharmacologica Sinica*, *41*(9), 1133–1140. https://doi.org/10.1038/s41401-020-0438-y

[3] Tang, R., Wang, L., Zhang, J., Fei, W., Zhang, R., Liu, J., . . . , & Zhang, H. (2024). Boosting the immunogenicity of the CoronaVac SARS-CoV-2 inactivated vaccine with Huoxiang Suling Shuanghua Decoction: A randomized, double-blind,

placebo-controlled study. *Frontiers in Immunology*, *15*, 1298471. https://doi.org/10.3389/fimmu.2024.1298471

[4] Kang, X., Jin, D., Jiang, L., Zhang, Y., Zhang, Y., An, X., . . . , & Lian, F. (2022). Efficacy and mechanisms of traditional Chinese medicine for COVID-19: A systematic review. *Chinese Medicine*, *17*(1), 30. https://doi.org/10.1186/s13020-022-00587-7

[5] Wang, W. Y., Xie, Y., Zhou, H., & Liu, L. (2021). Contribution of traditional Chinese medicine to the treatment of COVID-19. *Phytomedicine: International Journal of Phytotherapy and Phytopharmacology*, *85*, 153279. https://doi.org/10.1016/j.phymed.2020.153279

[6] Jia, K., Li, Y., Liu, T., Gu, X., & Li, X. (2023). New insights for infection mechanism and potential targets of COVID-19: Three Chinese patent medicines and three Chinese medicine formulas as promising therapeutic approaches. *Chinese Herbal Medicines*, *15*(2), 157–168. https://doi.org/10.1016/j.chmed.2022.06.014

[7] Capodice, J. L., & Chubak, B. M. (2021). Traditional Chinese herbal medicine-potential therapeutic application for the treatment of COVID-19. *Chinese Medicine*, *16*(1), 24. https://doi.org/10.1186/s13020-020-00419-6

[8] Ren, J. L., Zhang, A. H., & Wang, X. J. (2020). Traditional Chinese medicine for COVID-19 treatment. *Pharmacological Research*, *155*, 104743. https://doi.org/10.1016/j.phrs.2020.104743

[9] Zhao, Z., Li, Y., Zhou, L., Zhou, X., Xie, B., Zhang, W., & Sun, J. (2021). Prevention and treatment of COVID-19 using traditional Chinese medicine: A review. *Phytomedicine: International Journal of Phytotherapy and Phytopharmacology*, *85*, 153308. https://doi.org/10.1016/j.phymed.2020.153308

[10] Zou, Q., Chen, Y., Qin, H., Tang, R., Han, T., Guo, Z., . . . , & Xu, D. (2023). The role and mechanism of TCM in the prevention and treatment of infectious diseases. *Frontiers in Microbiology*, *14*, 1286364. https://doi.org/10.3389/fmicb.2023.1286364

[11] Ren, L., Xu, Y., Ning, L., Pan, X., Li, Y., Zhao, Q., . . . , & Zhang, Y. (2022). TCM2COVID: A resource of anti-COVID-19 traditional Chinese medicine with effects and mechanisms. *iMeta*, *1*(4), e42. https://doi.org/10.1002/imt2.42

[12] Lenharo, M. (2023). WHO declares end to COVID-19's emergency phase. *Nature*. Advance online publication. https://doi.org/10.1038/d41586-023-01559-z

[13] Fang, S., Dong, L., Liu, L., Guo, J., Zhao, L., Zhang, J., . . . , & Zhao, Y. (2021). HERB: A high-throughput experiment- and reference-guided database of traditional Chinese medicine. *Nucleic Acids Research*, *49*(D1), D1197–D1206. https://doi.org/10.1093/nar/gkaa1063

[14] Wu, Y., Zhang, F., Yang, K., Fang, S., Bu, D., Li, H., . . . , & Chen, J. (2019). SymMap: An integrative database of traditional Chinese medicine enhanced by symptom mapping. *Nucleic Acids Research*, *47*(D1), D1110–D1117. https://doi.org/10.1093/nar/gky1021

[15] Zhang, Y., Wang, N., Du, X., Chen, T., Yu, Z., Qin, Y., . . . , & Xu, H. (2022). SoFDA: An integrated web platform from syndrome ontology to network-based evaluation of disease-syndrome-formula associations for precision medicine. *Science Bulletin*, *67*(11), 1097–1101. https://doi.org/10.1016/j.scib.2022.03.013

[16] Huang, L., Xie, D., Yu, Y., Liu, H., Shi, Y., Shi, T., & Wen, C. (2018). TCMID 2.0: A comprehensive resource for TCM. *Nucleic Acids Research*, *46*(D1), D1117–D1120. https://doi.org/10.1093/nar/gkx1028

[17] Xu, H. Y., Zhang, Y. Q., Liu, Z. M., Chen, T., Lv, C. Y., Tang, S. H., . . . , & Huang, L. Q. (2019). ETCM: An encyclopaedia of traditional Chinese medicine. *Nucleic Acids Research*, *47*(D1), D976–D982. https://doi.org/10.1093/nar/gky987

[18] Kim, S., Chen, J., Cheng, T., Gindulyte, A., He, J., He, S., . . . , & Bolton, E. E. (2023). PubChem 2023 update. *Nucleic Acids Research*, *51*(D1), D1373–D1380. https://doi.org/10.1093/nar/gkac956

[19] Zhang, P., Zhang, D., Zhou, W., Wang, L., Wang, B., Zhang, T., & Li, S. (2024). Network pharmacology: Towards the artificial intelligence-based precision traditional Chinese medicine. *Briefings in Bioinformatics*, *25*(1), bbad518. https://doi.org/10.1093/bib/bbad518

[20] Li, S., & Zhang, B. (2013). Traditional Chinese medicine network pharmacology: Theory, methodology and application. *Chinese Journal of Natural Medicines*, *11*(2), 110–120. https://doi.org/10.1016/S1875-5364(13)60037-0

[21] Yang, F., Zhang, Q., Ji, X., Zhang, Y., Li, W., Peng, S., & Xue, F. (2022). Machine learning applications in drug repurposing. *Interdisciplinary Sciences: Computational Life Sciences*, *14*(1), 15–21. https://doi.org/10.1007/s12539-021-00487-8

[22] Wang, Y., Zeng, X., Zhao, Y., Chen, W., & Chen, Y. Z. (2020). The pros and cons of traditional Chinese medicines in the treatment of COVID-19. *Pharmacological Research*, *157*, 104873. https://doi.org/10.1016/j.phrs.2020.104873

[23] Gray, P. E., & Belessis, Y. (2020). The use of traditional Chinese medicines to treat SARS-CoV-2 may cause more harm than good. *Pharmacological Research*, *156*, 104776. https://doi.org/10.1016/j.phrs.2020.104776

[24] Yang Y. (2020). Use of herbal drugs to treat COVID-19 should be with caution. *The Lancet*, *395*(10238), 1689–1690. https://doi.org/10.1016/S0140-6736(20)31143-0

[25] Xiong, Y., Gao, M., van Duijn, B., Choi, H., van Horssen, F., & Wang, M. (2021). International policies and challenges on the legalization of traditional medicine/herbal medicines in the fight against COVID-19. *Pharmacological Research*, *166*, 105472. https://doi.org/10.1016/j.phrs.2021.105472

[26] Liu, T., Qiao, H., Wang, Z., Yang, X., Pan, X., Yang, Y., . . . , & Zhang, Y. (2024). CodLncScape provides a self-enriching framework for the systematic collection and exploration of coding LncRNAs. *Advanced Science*, *11*(22), 2400009. https://doi.org/10.1002/advs.202400009

[27] Luo, E., Zhang, D., Luo, H., Liu, B., Zhao, K., Zhao, Y., . . . , & Wang, Y. (2020). Treatment efficacy analysis of traditional Chinese medicine for novel coronavirus pneumonia (COVID-19): An empirical study from Wuhan, Hubei Province, China. *Chinese Medicine*, *15*, 34. https://doi.org/10.1186/s13020-020-00317-x

[28] Jiang, F., Xu, N., Zhou, Y., Song, J., Liu, J., Zhu, H., . . . , & Li, R. (2021). Contribution of traditional Chinese medicine combined with conventional western medicine treatment for the novel coronavirus disease (COVID-19), current evidence with systematic review and meta-analysis. *Phytotherapy Research*, *35*(11), 5992–6009. https://doi.org/10.1002/ptr.7209

[29] Yin, B., Bi, Y. M., Sun, L., Huang, J. Z., Zhao, J., Yao, J., . . . , & Fan, G. J. (2021). Efficacy of integrated traditional Chinese and

Western medicine for treating COVID-19: A systematic review and meta-analysis of RCTs. *Frontiers in Public Health*, *9*, 622707. https://doi.org/10.3389/fpubh.2021.622707

[30] Tiwari, S., Sapkota, N., Tiwari, S., & Sapkota, B. (2022). When Eastern meets Western medicine to manage SARS-CoV-2/COVID-19 patient: A case report. *SN Comprehensive Clinical Medicine*, *4*(1), 58. https://doi.org/10.1007/s42399-022-01142-z

[31] Qiao, L., Huang, W., Zhang, X., Guo, H., Wang, D., Feng, Q., . . . , & Cheng, J. (2021). Evaluation of the immunomodulatory effects of anti-COVID-19 TCM formulae by multiple virus-related pathways. *Signal Transduction and Targeted Therapy*, *6*(1), 50. https://doi.org/10.1038/s41392-021-00475-w

[32] Lopus, M. (2023). Nano-ayurvedic medicine and its potential in cancer treatment. *Journal of Integrative Medicine*, *21*(2), 117–119. https://doi.org/10.1016/j.joim.2022.12.001

[33] Stephens, L., Whitehouse, J., & Polley, M. (2013). Western herbal medicine, epigenetics, and endometriosis. *Journal of Alternative and Complementary Medicine*, *19*(11), 853–859. https://doi.org/10.1089/acm.2012.0623

How to Cite: Pan, X., Zhang, Y., Huang, J., & Ren, L. (2025). TCM2COVID in 2024: Enhanced Data on Traditional Chinese Medicine Formulas and Knowledge Graph for COVID-19. *Medinformatics*. https://doi.org/10.47852/bonviewMEDIN52024764