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Education Article

Open science practices in traditional, complementary, and integrative medicine research: A path to enhanced transparency and collaboration

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ABSTRACT

This educational article explores the convergence of open science practices and traditional, complementary, and integrative medicine (TCIM), shedding light on the potential benefits and challenges of open science for the development, dissemination, and implementation of evidence-based TCIM. We emphasize the transformative shift in medical science towards open and collaborative practices, highlighting the limited application of open science in TCIM research despite its growing acceptance among patients. We define open science practices and discuss those that are applicable to TCIM, including: study registration; reporting guidelines; data, code and material sharing; preprinting; publishing open access; and reproducibility/replication studies. We explore the benefits of open science in TCIM, spanning improved research quality, increased public trust, accelerated innovation, and enhanced evidence-based decision-making. We also acknowledge challenges such as data privacy concerns, limited resources, and resistance to cultural change. We propose strategies to overcome these challenges, including ethical guidelines, education programs, funding advocacy, interdisciplinary dialogue, and patient engagement. Looking to the future, we envision the maturation of open science in TCIM, the development of TCIM-specific guidelines for open science practices, advancements in data sharing platforms, the integration of open data and artificial intelligence in TCIM research, and changes in the context of policy and regulation. We foresee a future where open science in TCIM leads to a better evidence base, informed decision-making, interdisciplinary collaboration, and transformative impacts on healthcare and research methodologies, highlighting the promising synergy between open science and TCIM for holistic, evidence-based healthcare solutions.

1. Introduction

In recent years, medical science has witnessed a transformative shift towards open and collaborative practices, collectively referred to as "open science".[1] This paradigm shift is driven by the recognition that increased transparency, accessibility, and collaboration can significantly enhance the quality and impact of research.[2,3] While open science practices have gained widespread acceptance in some disciplines (e.g., psychology[4]), their application in the context of traditional, complementary, and integrative medicine (TCIM) remains largely unknown.[5] In this article, we explore the convergence of open science practices and TCIM, exploring how work at this intersection can benefit both the field of TCIM and the broader medical research community.

1.1. Definition of open science

Open Science represents a philosophy and set of practices aimed at making the entire research process more transparent, accessible, and accountable. It encompasses a range of initiatives, including open access publishing, data sharing, and open-source software development. Open Science fosters a culture of sharing and collaboration, breaking down traditional silos in research and facilitating the free exchange of knowledge.[6,7] The United Nations Educational, Scientific and Cultural

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Organization (UNESCO) defines open science as follows: “Open science is a set of principles and practices that aim to make scientific research from all fields accessible to everyone for the benefits of scientists and society as a whole. Open science is about making sure not only that scientific knowledge is accessible but also that the production of that knowledge itself is inclusive, equitable and sustainable.”[6]

1.2. Definitions of traditional, complementary, and integrative medicine

The World Health Organization defines “traditional medicine” as “the sum total of the knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness”.[8] According to the US National Center for Complementary and Integrative Health (NCCIH), "complementary" health approaches are “non-mainstream” approaches used together with conventional medicine, and “integrative health” refers to bringing complementary approaches and conventional medicine together in a coordinated manner.[9] Complementary and integrative medicine specifically require an association with conventional medicine, potentially limiting the classification of therapies lacking a defined relationship to conventional healthcare.[10] TCIM is a diverse and dynamic field that integrates conventional medical practices with therapies such as acupuncture, herbal medicine, yoga, and mindfulness.[11] The integrative approach to medicine is gaining popularity globally, with patients and practitioners alike recognizing its potential to complement and enhance conventional treatments through treatment of the whole person. While acknoweldging the differences taht exist between these terms, for the purpose of this article, we will refer to this category of therapies as TCIM.

1.3. Significance of open science in traditional, complementary, and integrative medicine

Despite TCIM’s growing acceptance by patients[12] and, in some cases, healthcare practitioners,[13] TCIM research itself faces unique challenges, including the fact that the individualized and multicomponent nature of TCIM therapies can create challenges for researchers in identifying and generalizing core active components, integration with mainstream healthcare, and navigating regulatory frameworks.[14–16] The application of open science practices may be able to address some of these challenges directly, which we will elaborate upon in greater detail in the sections below. By promoting open access to research results, transparency, data sharing, and interdisciplinary collaboration, open science can help TCIM researchers bridge gaps in knowledge, improve research methodologies, engage in citizen science which in turn can make research more relevant to the public, disseminate their research to a wider audience, and build a stronger evidence base.

1.4. Purpose and scope of the article

The primary purpose of this article is to explore the intersection of open science practices and TCIM, shedding light on the potential benefits and challenges of adopting open science practices in this field. We aim to provide researchers, practitioners, and policymakers with a comprehensive overview of the role open science can play in advancing TCIM research and healthcare delivery.

Throughout this article, we will discuss the fundamental tenets of open science and how they can be applied to TCIM. We will examine the benefits of open science, including enhanced research quality, increased public trust, and accelerated innovation, and we will address the unique challenges and barriers that TCIM researchers may encounter in adopting open science practices.

Lastly, we will discuss the future directions of open science in TCIM, including emerging trends, technologies, and the potential role of policy and regulation. As open science continues to evolve, it is crucial for TCIM stakeholders to stay informed and actively participate in shaping the future of this dynamic movement.

Table 1
Where Can I register my study? Examples of common registers for different study designs.

Study design	
Clinical Trials	Primary Registries in the WHO Registry Network https://www.who.int/clinical-trials-registry-platform/network/primary-registries
Systematic Reviews	International Prospective Register of Systematic Reviews (PROSPERO) https://www.crd.york.ac.uk/prospero/
Other Study Types	Open Science Framework (OSF) https://osf.io/

2. Open science practices in the context of traditional, complementary, and integrative medicine

Transparency is a cornerstone of open science[17] and holds particular significance in the context of TCIM as this could enable clearer and more uniform nomenclatures, definitions of TCIM, and therapy protocols.[18] To foster transparency in TCIM research, several key open science practices can be applied, as follows:

2.1. Study Registration

Study registration involves publicly registering a study’s research plan, including hypotheses, methodologies, and outcome measures, before data collection begins.[19–21] This helps prevent selective reporting of results and publication bias, which can be especially pertinent in TCIM, where diverse therapies are being studied.[22] Registering TCIM studies not only enables readers to be aware of key information about the proposed study such as its existence and primary outcomes, which thereby enhances the credibility and reliability of the research, but also fosters confidence in the quality of evidence generated about TCIM healthcare approaches. Table 1 provides examples of where one can register their study.

2.2. Reporting Guidelines

The Enhancing the QUAlity and Transparency Of health Research (EQUATOR) Network defines a “reporting guideline” as “a checklist, flow diagram, or structured text to guide authors in reporting a specific type of research, developed using explicit methodology”.[23] Open science practices encourage TCIM researchers to follow established reporting guidelines,[24] such as for reporting systematic reviews without meta-analysis (SWIM)[25] and with meta-analysis (PRISMA)[26] or reporting randomized controlled trials (CONSORT)[27], in addition to relevant TCIM-specific guidelines and guideline extensions.[28] These guidelines provide standardized frameworks for documenting TCIM research methods and results. Adhering to reporting guidelines in TCIM studies is vital for transparency and the reliable communication of findings. It ensures that researchers, among other readers can understand, evaluate, and replicate the research effectively. Table 2 provides a list of common reporting guidelines by study type.

2.3. Data, Code, and Materials Sharing

Open science encourages researchers to make their data openly available to both the scientific community and the public.[30,31] In the TCIM field, this could involve sharing data on the outcomes of clinical trials, patient-reported outcomes, and even the raw data from studies on TCIM therapies like acupuncture or herbal interventions. Open access to study data, code, and materials not only promotes transparency but also allows for the reanalysis of results, thereby improving the robustness of

Table 2
Common reporting guidelines by study type.[29]

Study type	Reporting Guideline(s)	
Randomized trials	Consolidated Standards of Reporting Trials (CONSORT)	
Observational studies	Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)	
Systematic reviews and meta-analysis	Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)	
Study protocols	Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT)	Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P)
Diagnostic/prognostic studies	Standards for Reporting Diagnostic Accuracy (STARD)	Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD)
Case reports	Case Report (CARE)	
Clinical practice guidelines	Appraisal of Guidelines, Research and Evaluation (AGREE)	Reporting Items for Practice Guidelines in Healthcare (RIGHT)
Qualitative research	Appraisal of Guidelines, Research and Evaluation (SRQR)	Consolidated Criteria for Reporting Qualitative Research (COREQ)
Animal pre-clinical studies	Animal Research: Reporting of In Vivo Experiments (ARRIVE)	
Quality improvement studies	Standards for Quality Improvement Reporting Excellence (SQUIRE)	
Economic evaluations	Consolidated Health Economic Evaluation Reporting Standards (CHEERS)	

findings. The Findability, Accessibility, Interoperability, and Reuse of digital assets (FAIR) guiding principles for scientific data management and stewardship provide guidance on how to structure open data, code, and materials.[32] More specifically "findability" refers to the idea that metadata and data should be easy for both humans and computers to find. "Accessibility" refers to a user being able to know how data can be accessed, possibility including authentication and authorization. "Interoperability" refers to data being integrated with other data, as well as the idea that metadata needs to interoperate with applications or workflows for analysis, storage, and processing. Lastly, "Reuse" refers to the idea that metadata and data should be well-described so that they can be replicated and/or combined in different settings.[32]

2.4. Preprinting

Preprinting, the practice of sharing research findings before formal peer review, allows researchers to disseminate their findings quickly, providing the TCIM community, and patients, with timely access to emerging evidence.[33] This practice is especially valuable as it facilitates the exchange of knowledge and encourages feedback from the scientific community,[34] when addressing health-related questions or exploring novel TCIM therapies. A wide range of preprint servers exist based on disciplinary scope and/or geographic region. While no TCIM-research specific preprint server presently exists, there is no shortage of medicine or all field encompassing preprint servers. A comprehensive list of preprint servers and their key characteristics can be found at the ASAPbio Preprint server directory: https://asapbio.org/preprint-servers.

2.5. Publishing Open Access

Open access publishing is pivotal in TCIM, ensuring that research findings are accessible to both researchers and the public. Open access journals promote transparency and inclusivity by making research freely available, ultimately benefiting patients, healthcare providers, and the broader scientific community.[35,36] In addition to journals, other ways to make research openly accessible include posting manuscripts on preprint servers or in university repositories as long as the authors ensure anything included in the repository meets FAIR criteria.[32] Open access publishing aligns with the patient-centered and holistic approach of TCIM, facilitating the dissemination of evidence-based information. However, it is important to acknowledge the caveats of open access publishing. Open access (notably in the case of predatory journals) can be exploited for the propagation of misinformation, undermining the integrity of research dissemination. Furthermore, some publishers may exploit the open access model for financial gain, charging exorbitant article processing fees that can pose barriers to researchers seeking to publish their work openly.[37]

2.6. Reproducibility/Replication Studies

Reproducibility and replication studies hold great significance in research in general,[38,39] as well as in the field of TCIM research. Reproducibility can be defined as "a minimum standard on a spectrum of activities ("reproducibility spectrum") for assessing the value or accuracy of scientific claims based on the original methods, data, and code".[40] Open science practices also emphasize the conduct of replication studies to validate initial findings, demonstrating the robustness of therapeutic interventions.[41,42] In TCIM, where variability in therapeutic responses is significant, replication studies are essential. They not only verify the generalizability of therapeutic effects but also contribute to the credibility of TCIM research and promote the responsible and ethical conduct of studies. Reproducibility and replication are cornerstones of open science in TCIM, enhancing transparency and the trustworthiness of research outcomes.

By embracing the aforementioned open science practices, TCIM researchers can enhance the quality and credibility of their work, and disseminate their research more widely. These practices not only contribute to a more robust evidence base for TCIM but also promote the responsible and ethical conduct of research in a field that emphasizes patient-centered care and holistic health outcomes. In the next section, we will explore the specific benefits of open science in TCIM research, highlighting the positive impacts these practices can have on both research quality and healthcare outcomes.

3. Benefits of open science in traditional, complementary, and integrative medicine

Open science practices bring a multitude of advantages to the field of TCIM. These benefits span research quality, patient care, and the broader scientific community.

3.1. Enhanced research quality

Better Examination of Methodological Rigour: Open science practices, such as registration and transparent reporting, enable a better examination of rigourous research methodologies.[43] By clearly outlining

their research plans and methods in advance, TCIM researchers reduce the risk of bias, selective reporting, and p-hacking (i.e., inappropriate manipulation of data analysis to suggest a favoured result to be presented as statistically significant), ultimately producing more reliable results.

Data Validation and Reproducibility: Open access to data and methodologies enables other researchers to validate and replicate studies.[44] This thus bolsters the credibility of TCIM research findings, providing a higher level of confidence in the evidence associated with these therapies.

Reduction of Publication Bias: Open science practices, including registration, reduce publication bias by ensuring that both positive and negative results are accessible.[45] Research has found that inadequate use and regulation of interventions against publication bias decreases their effectiveness; these challenges may be further exacerbated by the fact that a lack of resources to publish open access, as an example, exists in developing countries where the article processing fees imposed by publishers prove to be unaffordable.[46]

3.2. Increased public trust

Community Engagement: Open science encourages active involvement from both the public and patients.[47] TCIM often places a strong emphasis on patient-centered care and shared decision-making. Open access to research allows patients to engage with the evidence and participate more actively in their healthcare choices.[48]

Citizen Science: Projects that actively involve the general public in scientific endeavours with the aim of democratizing science are referred to as citizen science. This may occur at any stage of the research process, where citizen scientists can participate as leaders of projects, collaborators, or contributors.[49] Open science facilitates citizen science by promoting accessibility, transparency, and collaboration,[50] with the field of TCIM being no exception. Through open practices like transparent reporting and data sharing, research is freely accessible to the general public, fostering understanding and engagement. Shared data and findings encourage the public's participation in interpreting results, validating findings, and shaping the holistic healthcare landscape. Open science platforms provide dedicated spaces for collaboration, facilitating communication between researchers and the general public, ultimately cultivating a participatory and inclusive scientific community in research.[50]

3.3. Accelerated innovation

Building on Existing Knowledge: Open science practices, such as open access to research findings and data, enable researchers to build upon existing knowledge more effectively.[1] In turn, this can allow TCIM researchers to build an evidence base for TCIM therapies more efficiently and effectively. For example, finding indications for new emerging infectious disease using existing herbal medicines.[15]

3.4. Improved clinical practice

Evidence-Based Decision-Making: Open science promotes open access to research evidence.[51] While clinicians often have access to evidence through point-of-care systems (e.g., Dynamed, UpToDate), the sheer volume of research findings necessitates efficient evaluation and summarization. Those who create content for such point-of-care systems may fail to include relevant research if it is not openly available. Thus, open access to article types such as systematic reviews and clinical practice guidelines (including their supporting data), indirectly contributes to informed clinical practices ensuring that clinicians can stay abreast of the latest evidence, facilitating quicker assimilation of research into their decision-making processes.[36]

Enhanced Safety and Efficacy: TCIM interventions can vary widely in safety and efficacy. Open science practices, such as replication studies and transparent reporting, help identify which therapies are safe and effective for specific conditions.[52] Open access to clinical trial data[53] for transparency and reproducibility in addition to replication of clinical studies[54] are both crucial, offering a more comprehensive understanding of adverse events associated with TCIM interventions. The sample size of most randomized trials on TCIM is too small to detect less frequent side effects. With the opening of data, the safety information from different trials can then be pooled, which increases the sample size, and thus better allows for such detection. Thus, in the long run, open science practices can allow healthcare providers to make better informed recommendations and tailor treatments to individual patient needs.

In summary, open science practices offer substantial benefits to TCIM research, patient care, and the scientific community as a whole. By promoting research quality, transparency, collaboration, and evidence-based decision-making, open science not only enhances the credibility of TCIM but also contributes to the advancement of integrative healthcare, ultimately benefiting patients seeking holistic and personalized approaches to wellness. In the next section, we will explore the challenges and barriers that TCIM researchers may encounter when adopting open science practices and discuss strategies to overcome them.

4. Open science practices in the context of traditional, complementary, and integrative medicine: challenges and barriers

While the adoption of open science practices in TCIM holds great promise, it is not without its challenges and barriers. Recognizing and addressing these obstacles is crucial for TCIM researchers and practitioners aiming to embrace open science practices effectively and ethically.

4.1. Data privacy and ethical concerns

Patient Privacy: Protecting patient privacy while sharing data in the context of open science poses a significant challenge,[55,56] with researchers grappling with the complexities around obtaining informed consent and ensuring robust data anonymization processes. While not necessarily unique to TCIM, where individualized treatment approaches are common and may involve sensitive patient information, the delicate balance between open science principles and safeguarding patient privacy requires careful consideration to maintain the integrity of research while respecting the confidentiality of personal health information.

4.2. Resistance to cultural change

Traditional Medicine Research Paradigms: The TCIM field has historically operated within its own research paradigms, which may differ from those in conventional medicine. Some TCIM researchers and practitioners may be resistant to adopting open science practices, viewing them as incompatible with their existing approaches.[57,58] For example, in traditional herbal medicine practices within certain indigenous communities, healers often rely on ancestral knowledge passed down through generations to formulate herbal remedies, raising questions about ownership and control over this intellectual property.[59] The research paradigm in this context may involve closely guarded traditional knowledge, specific rituals, and oral traditions for transmitting information about medicinal plants and their uses.[60] When considering open science practices, such as transparent reporting and open access to data, some traditional herbal medicine practitioners may express resistance. They may perceive the open dissemination of their traditional knowledge as conflicting with their cultural protocols, raising concerns about potential misappropriation or misuse of sacred healing practices.[61,62] This example illustrates the challenge of aligning open science principles with the entrenched research paradigms in certain TCIM traditions, where protecting cultural heritage and indigenous intellectual property are paramount. Integrating open science principles while respecting intellectual property rights requires careful consideration of legal frame-

works and ethical guidelines to ensure that indigenous communities retain sovereignty over their traditional knowledge.[63] In addressing these concerns, the CARE Principles for Indigenous Data Governance offer valuable guidance. These principles emphasize Collective benefit, Authority to control, Responsibility, and Ethics, providing a framework for respecting and safeguarding indigenous knowledge within the context of open science initiatives. By integrating the CARE Principles, TCIM researchers can navigate the tension between open science practices and the preservation of traditional knowledge, ensuring that indigenous communities retain control over their data and cultural heritage.[64]

4.3. Limited resources and funding

Resource Constraints: Open science practices can be resource-intensive. It is well-acknowledged that the field of TCIM research is severely underfunded and faces severe resource limitations.[14] In many countries, there are no specific funding schemes dedicated to TCIM and in countries with TCIM specific funding scheme, for example the United States, less than 1% of the National Institutes of Health (NIH) budget is allocated to NCCIH funding.[65] Instead, student tuition provides the majority of funding for TCIM educational institutions, and historically, this has also been the source from which their research programs have had to be developed.[66] In other countries, investigator-initiated trials are often philanthropically funded, and therefore often lack extensive resources. Thus, challenges lie ahead with respect to allocating the necessary time and funding to implement these practices effectively. Preparing data and metadata for data-sharing in accordance with FAIR principles is especially time-consuming. In addition, data sharing platforms, research support, training programs, and open access publishing will require additional resources.

Funding Models: Typical funding models may not prioritize open science initiatives. TCIM researchers may encounter challenges in securing funding for projects that prioritize study registration, reporting guidelines, data, code, and material sharing, preprinting, publishing open access, and/or reproducibility/replication studies.

4.4. Integration with traditional medicine

The successful integration of open science practices within the field of TCIM requires a nuanced understanding of the intricate relationship between these two approaches. It involves acknowledging the diversity of traditional practices, often deeply rooted in cultural and historical contexts, while simultaneously embracing the principles of open science. Recognition is not merely an acknowledgment of coexistence; it is a commitment to understanding and valuing the knowledge systems embedded in TCIM. This involves fostering a collaborative environment where traditional wisdom and contemporary scientific methodologies coalesce synergistically. Striking a balance is crucial to ensuring that the incorporation of open science does not undermine the authenticity and efficacy of traditional practices. The approach must be one of harmonious integration, where open science amplifies the strengths of TCIM, contributes to evidence-based advancements, and respects the diversity of healing traditions that characterize this field.[67]

To address these challenges and barriers in TCIM research, we suggest several strategies that can be employed in the following sections.

Ethical Guidelines: Develop and adhere to ethical guidelines that prioritize patient privacy, informed consent, and the responsible use of TCIM therapies. These guidelines should align with open science practices and ensure the ethical conduct of research.

Education and Training: Provide education and training programs for TCIM researchers and practitioners to familiarize them with open science practices. These programs should address the benefits, ethical considerations, and practical implementation of open science in TCIM. Furthermore, training for preparing data for open science repositories should be available to TCIM researchers.

Funding Advocacy: Advocate for funding to support open science initiatives within TCIM research. Highlight the value of transparency, collaboration, and data sharing in advancing integrative healthcare.

Interdisciplinary Dialogue: Foster open dialogue and collaboration between TCIM researchers, traditional medical practitioners, and regulatory bodies to navigate the integration of TCIM research within open science. Open, transparent conversations should be encouraged to bridge the gap between diverse perspectives and methodologies. Traditional medical practitioners bring invaluable insights from generations of practice, while TCIM researchers contribute scientific rigour and evidence-based methodologies. Regulatory bodies play a crucial role in ensuring compliance and safeguarding public health. Establishing a collaborative space allows for the exchange of knowledge, experiences, and concerns.

Patient Engagement and Citizen Science: Involve patients and the public in discussions about open science in TCIM. Ensure that their perspectives and needs are considered in the development of open science practices within TCIM research.

In conclusion, while open science practices offer numerous benefits to both research in TCIM, but also other medical fields, they are not without challenges. Specific to the TCIM field, addressing issues related to data privacy, traditional medicine research paradigms, resource/funding constraints, and the integration with this category of therapies is essential for researchers and practitioners to effectively embrace open science and unlock its potential to advance evidence-based integrative healthcare.

5. Future directions

The future of TCIM holds exciting possibilities as it intersects with the evolving landscape of open science. Embracing open science practices in TCIM research can pave the way for innovative and transformative developments in both healthcare and research methodologies. Here, we explore some potential future directions and trends resulting from the evolution of open science within the field of TCIM.

5.1. The evolution of open science in TCIM

Maturation of Open Science Practices: As open science practices become more deeply ingrained in TCIM research, they are likely to evolve and mature. Researchers may increasingly adopt standardized protocols for data sharing, registration, and transparent reporting, enhancing the reliability and reproducibility of TCIM studies.

Development of TCIM-Specific Open Science Guidelines: Recognizing the unique aspects of TCIM, there may be a growing need for specialized open science guidelines tailored to the field's diverse therapies and approaches. These guidelines would provide researchers with clear frameworks for conducting TCIM research within open science practices.

5.2. Promising trends and emerging technologies

Advancements in Data Sharing Platforms: Innovative data sharing platforms and repositories will likely emerge, specifically designed to accommodate the unique data types generated in TCIM research. As an example, a platform could integrate traditional healthcare databases with modern scientific repositories, accommodating the diverse and nuanced data types inherent in TCIM. It might include sections for traditional healing practices, herbal remedy formulations, and patient outcomes, alongside conventional biomedical data. The platform could employ advanced data categorization algorithms to ensure efficient retrieval and analysis, catering to the distinctive features of TCIM research. These platforms may enhance data accessibility and usability for both researchers and clinicians.

Artificial Intelligence and Big Data Analytics: The integration of artificial intelligence and advanced analytics in TCIM research may be-

come more prevalent. Machine learning algorithms can analyze vast datasets, uncover patterns, and provide insights into the effectiveness and safety of TCIM therapies. One example of this could include a system that utilizes machine learning algorithms to analyze extensive datasets comprising patient profiles, treatment outcomes, and various TCIM interventions. By processing this vast quantity of information, the system could identify patterns and correlations that might be challenging for human researchers to discern. For example, it could analyze the effectiveness of herbal remedies in specific populations or unveil potential safety concerns associated with certain TCIM therapies not previously considered. In the same vein, similar algorithms may be used to also recommend suitable TCIM treatments for patients.

Blockchain for Data Security: The use of blockchain technology may enhance data security and privacy in research.[68–70] As an example, a decentralized, blockchain-based system could be established to manage and secure patient information, treatment outcomes, and research data, data analyses plans and statistical analyses. Each entry into the blockchain would be time-stamped, encrypted, and linked to the previous block, creating an unalterable and transparent record. This approach has the potential to ensure the integrity of TCIM research data, mitigating concerns about data tampering or unauthorized access. Through smart contracts, only authorized parties, such as researchers and healthcare providers, with explicit patient consent, could access specific portions of the data.

5.3. The role of policy and regulation

Policy Integration: Policymakers and regulatory bodies have the potential to play an increasingly pivotal role in aligning TCIM research with open science practices. The adoption and/or development of policies and regulations that encourage data sharing, transparency, and ethical practices (e.g., the application of the CARE Principles for Indigenous Data Governance[63]) in TCIM research may gain momentum. For example, the US National Library of Medicine's Strategic Plan 2017–2027 advocates for and prioritizes the advancement of open science by democratizing access to the products and processes of scientific research by making them widely accessible.[71]

Global Standardization: International collaboration and standardization efforts may promote consistency in open science practices across borders. TCIM research may benefit from globally recognized standards that facilitate data sharing and interoperability.

Ethical Frameworks: The establishment of ethical frameworks specific to TCIM may guide researchers in navigating the ethical complexities associated with open science. These frameworks may address issues such as patient consent, cultural sensitivity, and the responsible use of TCIM therapies.

5.4. Enhanced patient-centered care

Personalized Integrative Medicine: Open science in TCIM may enable the development of personalized integrative medicine approaches. Patient data, combined with open-access research findings, may empower healthcare providers to tailor treatment plans that align with individual patient needs and preferences.

Informed Decision-Making: Patients may have greater access to open-access TCIM research, empowering them to make informed decisions about their healthcare. Open science may bridge the gap between patients and scientific evidence, supporting shared decision-making in TCIM.

5.5. Interdisciplinary synergy

Cross-Disciplinary Innovation: Interdisciplinary collaboration may thrive, leading to novel research projects and integrative healthcare solutions. TCIM researchers, along with experts from various disciplines, may work together to uncover synergies between TCIM therapies and conventional medicine.

Education and Training: Academic institutions and training programs may integrate open science practices into TCIM curricula. Future TCIM professionals may be well-versed in open science practices, promoting a culture of transparency and collaboration from the outset of their careers.

6. Conclusion

Open science, with its emphasis on transparency, accessibility and collaboration, aligns with the core principles of TCIM, where individualized wellness, interdisciplinary collaboration, and comprehensive care are paramount and research visibility is increased. Open science in TCIM offers a pathway to advance the field, enhancing research quality, building public trust, and accelerating innovation. By embracing open science practices, TCIM researchers can cultivate increased methodological rigour, providing a foundation of reliable results for these therapies. It also allows TCIM researchers to save limited funding and resources by being aware of other researchers' prior and ongoing projects (and associated data). These practices reduce publication bias, ensuring that both positive and negative outcomes are accessible, ultimately leading to more informed healthcare decisions. Furthermore, open science empowers patients, supporting informed decision-making and shared care with healthcare providers. It strengthens interdisciplinary collaboration, fostering innovative approaches that bridge the gap between conventional and TCIM therapies. In this way, open science may enhance TCIM's role in evidence-based healthcare. However, the integration of open science in TCIM is not without its challenges. Ensuring data privacy and ethical conduct while sharing sensitive patient information and respect for indigenous data sovereignty is imperative. Resistance to cultural change, limitations in resources and funding for open science, and the integration of TCIM with conventional medicine need to be thoughtfully addressed. Despite these challenges, the future of open science in TCIM holds promise. As open science practices mature in the field, we can anticipate that specialized reporting guidelines may emerge, tailored to the diverse therapies within TCIM. Advancements in data sharing platforms, artificial intelligence, and blockchain technology may play a role in facilitating secure and transparent research. Policy and regulatory support can encourage standardization, ethical conduct, and data sharing. The establishment of ethical frameworks specific to TCIM may be required to guide researchers in navigating the ethical complexities associated with open science. Patients may have greater access to TCIM research published open access, fostering personalized integrative medicine and informed decision-making. As the field of TCIM research and open science continue to evolve together, they offer a promising future, where evidence-based, holistic healthcare solutions are at the forefront, benefiting patients, practitioners and researchers, among others.

CRediT authorship contribution statement

Jeremy Y. Ng: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **L. Susan Wieland:** Writing – review & editing. **Myeong Soo Lee:** Writing – review & editing. **Jian-ping Liu:** Writing – review & editing. **Claudia M. Witt:** Writing – review & editing. **David Moher:** Methodology, Writing – review & editing. **Holger Cramer:** Writing – review & editing.

Declaration of competing interests

The authors declare that they have no competing interests.

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Ethical statement

This is an educational article; it did not require ethics approval or consent to participate.

Data availability

All relevant data are included in this manuscript.

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