

Indigenous Knowledge Systems in AYUSH: From Traditional Healing Practices to Translational Healthcare

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ABSTRACT

Indigenous Knowledge Systems (IKS) represent centuries of experience in the health and human-environment relations. The AYUSH systems in India- Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy are based on these traditions. They emphasize preventive, personalized and holistic medicine. Though these systems are now prevalent and increasingly relevant worldwide, their application in modern biomedical systems remains limited. This is primarily due to a lack of standardized scientific validation.

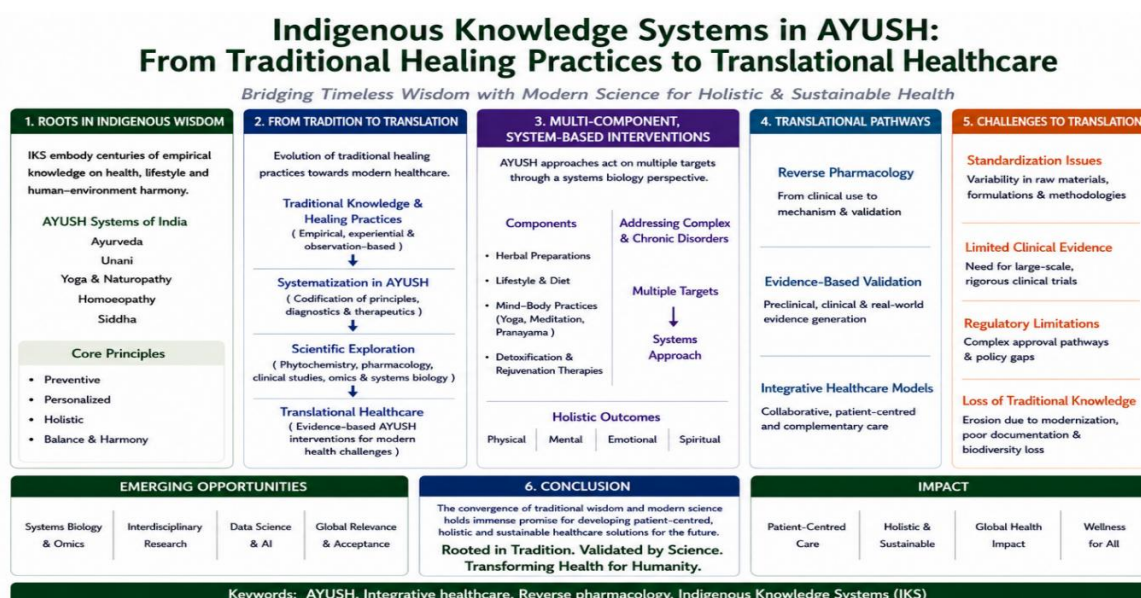
This review critically analyses the principles of IKS underlying AYUSH and the historical development of traditional healing practices into translational healthcare. A detailed literature analysis of major scientific databases was conducted to evaluate philosophical concepts, treatment approaches, and innovative scientific findings. The findings suggest that AYUSH interventions- including herbal preparations, lifestyle and mind- body practices are multi-component and system-based. Such strategies can be promising for treating complex and chronic disorders.

Translational pathways- reverse pharmacology, evidence-based validation, and integrative healthcare models are also discussed in the review. Although systems biology and interdisciplinary research present new opportunities, significant challenges remain. These include issues of standardization, lack of clinical evidence, regulatory limitations and the loss of traditional knowledge.

In conclusion, the combination of traditional knowledge and modern scientific methods has great potential in creating patient-centred, holistic, and sustainable approaches to healthcare.

Keywords: AYUSH, Integrative healthcare, Reverse pharmacology, Indigenous Knowledge Systems (IKS).

Graphical Abstract



INTRODUCTION

The global healthcare system is facing increasing strain. The rise in antimicrobial resistance, chronic diseases, and healthcare costs is becoming a major global concern. Traditional approaches may not be sufficient to treat complex, multifactorial diseases, as they often focus on a single specific target. It has resulted in the shift to more holistic and integrative healthcare models, which include the focus on prevention and long-term health outcomes (World Health Organization, 2019, 2025; Tilburt & Kaptchuk, 2018).

In this aspect, traditional medicine has returned to the world limelight. The proportion of the world population that continues to rely on traditional systems in primary healthcare is extremely high. These systems provide holistic approaches based on natural products, lifestyle management, and mind-body harmony (WHO, 2025; Atanasov et al., 2021; Kala, 2005). The growing role of traditional medicine in chronic illnesses and lifestyle management is also noted in recent reviews (Koch et al., 2024; Ahmad et al., 2026).

In India, AYUSH systems, Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy is an institutionalized and systematized system of traditional health care. These systems are based on Indigenous Knowledge Systems (IKS) developed by the long-term interactions between communities and the environment. They offer a comprehensive view of health, considering the physical, mental, and environmental aspects (Patwardhan, 2014; Suriyo et al., 2021).

Policy and institutional support for AYUSH have been growing in recent years. National initiatives and international plans have highlighted its role in preventive and primary healthcare. Its relevance in contemporary healthcare systems has also been heightened by the growing popularity of natural and sustainable treatments (WHO, 2025; Samal & Singh, 2026; Thakar et al., 2024).

Despite this advancement, it has not been widely integrated into modern biomedical systems. Much of the existing research is fragmented and often concentrates on individual treatment approaches rather than a unified model. Systematic gaps remain between traditional knowledge, scientific validation, and clinical application (Chandran et al., 2015; Li, 2021; Zhang et al., 2021).

One significant gap is translational understanding. There is no clear definition of how traditional knowledge is translated into clinical applications. Although other approaches, such as reverse pharmacology and network pharmacology, have been proposed, they have not been effective. The unstandardization, disparity in formulations, and lack of high-quality clinical evidence remain the limitations to the further adoption of it (Ahmad et al., 2026; Koch et al., 2024; Philips and Theruvath, 2024).

At the same time, the development of systems biology and integrative medicine leads to new opportunities. The techniques enable multi-target disease and system-level understanding. This is in line with the AYUSH principles and provides a scientific foundation to its validity (Atanasov et al., 2021; Li, 2021). In these aspects, the present review tries to examine the concept of Indigenous Knowledge Systems in AYUSH, its conceptual framework, traditional healing approach, and how it makes progress towards translational healthcare.

Indigenous Knowledge Systems and AYUSH: Conceptual Foundations

Indigenous Knowledge Systems (IKS) are the knowledge that has been created by communities over the years through observation, experience, and engagement with the environment. This is contextual and dynamic knowledge. It is dynamic with regard to realistic consequences and not under controlled laboratory conditions. These features have contributed to the fact that IKS is a very useful tool to study local health practices and resource utilization (World Health Organization, 2023; Pulok et al., 2017). One of the main characteristics of the IKS is the holistic nature. Health is considered to be a balance of body, mind and environment. Social and cultural factors are also considered significant. This combined view enables the conventional systems to take a more holistic approach to complex diseases. Recent research underscores that holistic models are increasingly applicable to treating chronic and lifestyle-related disorders (Heinrich et al., 2020). In India, these Indigenous Knowledge Systems have been institutionalized in the form of AYUSH systems. Traditional practices have, over the years, been structured into systematic medical systems that bear specific principles, techniques of diagnosis and treatment. This has institutionalized them and allowed them to be incorporated into formal healthcare systems without losing their traditional roots (Suriyo et al., 2021; Samal and Singh, 2026). AYUSH has conceptual underpinnings rooted in different philosophical frameworks. Ayurveda describes health in terms of the balance of Tridosha. Unani emphasizes on humoral balance. Siddha stresses the usage of the five factors. Yoga promotes mind-body integration. These systems may vary in terms of terminology but have one thing in common: a focus on balance, harmony, and individualized care (Chandran et al., 2015). All these principles indicate a systems-based concept of health. The human body is considered a network in which various processes interact with one another. Disease is regarded as an imbalance in this balance, rather than a cause. This contrasts with the reductionist nature of modern biomedicine, which tends to focus on particular pathways (Li, 2021; Zhang et al., 2021). Systems thinking has become significant in biomedical research in recent years. Complex diseases are associated with complex biological interactions and biological pathways. Such complexity is being studied using network pharmacology and systems biology methods. The multi-component and holistic

nature of AYUSH systems is consistent with these new scientific models (Atanasov et al., 2021; Chandran et al., 2015). In general, both the IKS and AYUSH conceptual underpinnings point to a transition towards a holistic, systems-based approach to healthcare. Such views provide a strong foundation for the development of translational strategies that would bridge the gap between traditional knowledge and modern science.

Traditional Healing Practices in AYUSH

Ayurveda

One of the oldest traditional medical systems is Ayurveda, which is founded on the holistic concept of health and disease, focusing on the balance of dosha (Vata, Pitta, and Kapha), dushya (body tissues), agni (digestive and metabolic fire), and prakriti (individual constitution) (Patwardhan et al., 2005). Ayurveda uses very personalized therapeutic interventions, which attempt to bring internal balance and prevent the development of disease. The most important treatment modalities are rasayana therapy, aimed at rejuvenation and increased vitality, and panchakarma, a series of detoxification processes aimed at eliminating accumulated toxins (ama) from the body. Moreover, Ayurveda focuses on controlling diet (ahara), lifestyle (vihara), and behavioural changes as elements of disease management and health promotion (Suriyo et al., 2021). Herbal preparations are widely used and are often multi-component, believed to exert synergistic effects at multiple physiological levels (Atanasov et al., 2021).

Yoga and Naturopathy

Yoga and Naturopathy are forms of integrative medicine that focus on the relationship between mind, body and environment. Yoga is a method that involves physical poses (asanas), breathing exercises (pranayama), meditation, and relaxation (to control physiological processes and enhance mental health) (Woodyard, 2011). Such practices are increasingly being noted to moderate stress, neuroendocrine regulation, and boost immune performance (World Health Organization, 2023). Naturopathy is based on the natural capacity of the body to heal itself and involves natural medicines like hydrotherapy, mud therapy, fasting, dietary control, lifestyle rectification (Thakar et al., 2024). Both systems emphasize preventive, health promotion, and control of chronic lifestyle diseases using non-invasive, and drug-free treatment (Samal & Singh, 2026).

Unani

The classical humoral theory underlies Unani medicine, which views health as a balance among four humors: blood (dam), phlegm (balgham), yellow bile (safra), and black bile (sauda) (Ahmad et al., 2026). An imbalance among these humors is said to cause disease, influenced by environmental, dietary, and lifestyle factors. Unani includes ilaj-bil-dawa (pharmacotherapy using herbal, mineral, and animal-derived drugs), ilaj-bil-ghiza (dietotherapy), and ilaj-bil-tadbeer (regimenal therapy), which entails cupping (hijama), massage, and exercise (Kalam et al., 2021). The system focuses on personalised treatment and seeks to re-establish humoral balance through a combination of therapies.

Siddha and Sowa Rigpa

South India practices siddha medicine, which is based on the idea of three humors (Vatham, Pitham, and Kapham) and combines spiritual, alchemical, and herbal methods of health care (Kannan et al., 2019). It employs extensive use of medicinal preparations, such as metals, minerals and herbal compounds, which are processed using special methods. It is diagnosed by pulse reading, an examination of the body constitution, and an assessment of physiological functions. Sowa Rigpa, or Tibetan medicine, is similar to Ayurveda and Unani medicine, but has its own diagnostic and therapeutic systems. It is founded on the harmony of three energies (Lung, Tripa, and Beken) and stresses dietary practices, behavioural therapy, and herbal preparations (Erisa, 2025). Both Siddha and Sowa Rigpa emphasize on regional knowledge systems and plentiful materia medica.

Homeopathy

Homeopathy relies on the law of similia similibus curentur (like cures like) whereby substances that cause symptoms in healthy people are administered in highly diluted amounts to cure similar symptoms in illnesses (Bellavite & Signorini, 2002). The system uses potentized remedies made through serial dilution and succussion, which are thought to activate the body's vital force and facilitate self-healing. One of the main aspects of homeopathy is the personalization of treatment, according to which medications are chosen, not only on the basis of the disease, but also on the basis of the physical, mental, and emotional peculiarities of the patient (Mathie et al., 2014). It is broadly applied in the treatment of chronic diseases and appreciated for its minimal side effects and holistic nature.

Folk and Tribal Healing Traditions

Although not recognized as part of AYUSH, folk and tribal healing practices are a vital part of Indigenous Knowledge Systems and have played a fundamental role in the evolution of traditional medicine in India (Heinrich et al., 2020). These

traditions can be defined as localised versions of indigenous knowledge, intertwined with cultural traditions and ecological contexts. They depend on the knowledge of traditional healers, who use locally available medicinal plants, animal products, and natural resources to treat illnesses (Kala, 2005). These practices are commonly integrated with spiritual and ritualistic practices, as well as empirical knowledge passed down through generations. Tribal medicine is a vital element of primary healthcare, especially in remote and underserved areas. Nevertheless, the cultural shift, the absence of systematic records, and the loss of biodiversity are becoming threats to these knowledge systems, highlighting the necessity to preserve and scientifically validate them (Kunwar et al., 2010).

Scientific Basis and Emerging Evidence

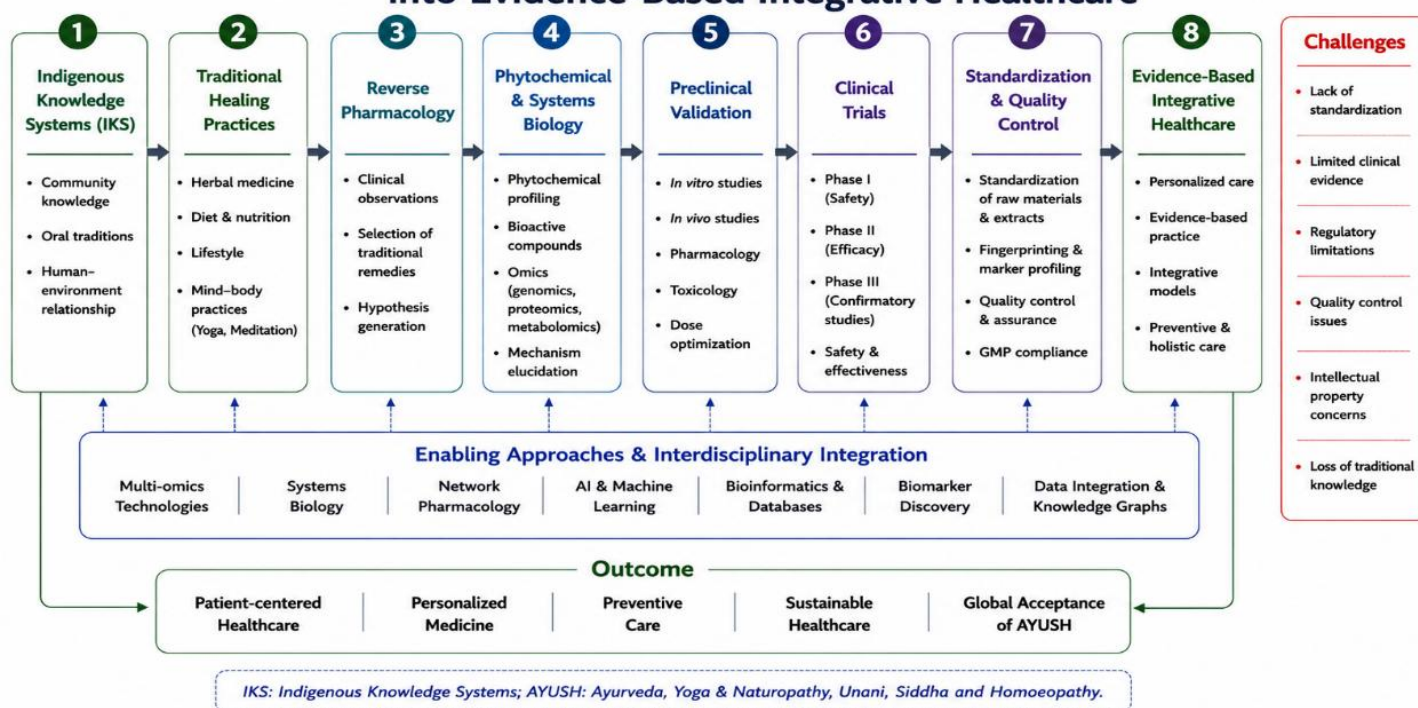
In recent years, AYUSH's scientific knowledge has improved significantly. Current studies focus on the discovery of bioactive compounds, the elucidation of mechanisms of action, and the validation of traditional therapies using contemporary scientific instruments. This change is contributing to the bridging of the traditional knowledge and modern biomedical science (Pulok et al., 2017). AYUSH preparations are rich in bioactive substances: alkaloids, flavonoids, phenolics, and terpenoids. These compounds have various pharmacological effects, including anti-inflammatory, antioxidant, antimicrobial, and immunomodulatory effects. These properties make them useful for managing complex and chronic illnesses (Atanasov et al., 2021; Heinrich et al., 2020). These findings are further supported by recent experimental and clinical research, but variability in composition and dosage is a problem (Ahmad et al., 2026). A characteristic of a traditional formulation is multi-target, synergistic action. Compared with traditional medications, which typically act on a single pathway, polyherbal preparations have a multi-pathway effect. Compound-compound interactions can be synergistic to improve treatment outcomes and minimize adverse effects. The method is particularly applicable to diseases characterised by complex biological networks, including cancer, diabetes, and neurodegenerative diseases (Li, 2021; Zhang et al., 2021; Atanasov et al., 2021). These properties are similar to those of systems biology. Research in modern biomedicine is increasingly recognising that diseases are caused by disruptions in complex biological systems, not by single molecular defects. Such complexity is being studied using network pharmacology and systems-based approaches. The multi-component nature of AYUSH formulations is well-suited in this frame and has new prospects of integrative drug discovery (Chandran et al., 2015; Li, 2021). The latest developments of the computational tools have only intensified this relationship. Network analysis, omics technologies, and bioinformatics are among the techniques used to elucidate the mechanisms underlying traditional formulations. Such methods assist in identifying active compounds, predicting interactions, and confirming therapeutic pathways (Zhang et al., 2021; Li, 2021). Despite these developments, there are several limitations. The evidence is not always of high quality. Numerous studies are not standardized with regard to formulation, dosage and methodology. Clinical trials are not extensive and are occasionally not rigorously designed. Herb-drug interactions and safety issues, such as toxicity, should also be carefully considered (Philips and Theruvath, 2024; Ahmad et al., 2026). The other major issue is the lack of connection between the experimental and clinical practice. Although laboratory research has been promising, there is little application of the research to clinical practice. This underscores the importance of properly designed clinical trials, standard procedures, and stronger regulatory frameworks (Ahmad et al., 2026). In general, emerging scientific evidence supports the therapeutic potential of AYUSH systems. Nevertheless, more validation, enhanced standardization and combination with more current research approaches are needed. The solution to these issues will play a significant role in the further development of AYUSH into evidence-based and translational healthcare.

Translational Pathways in Integrative Healthcare

Translational pathways in AYUSH aim to transform traditional knowledge into clinically viable, scientifically proven healthcare solutions. This requires a transition of empirical practices into evidence-based applications by engaging in systematized documentation, experimental validation and clinical assessment. Recent international and national systems have stressed the importance of reinforcing such translational models in the traditional medicine systems (World Health Organisation, 2023; Ahmad et al., 2026; Samal and Singh, 2026). One of the key ideas of this transition is reverse pharmacology. Reverse pharmacology, in contrast to more traditional drug discovery, which initiates with target identification and laboratory screening, is based upon documented clinical use and traditional knowledge. Active compounds and mechanisms are explored using therapies that have demonstrated long-term safety and efficacy. This method is specifically applicable to AYUSH systems and has been discussed more recently in the context of integrative drug discovery (Chandran et al., 2015; Atanasov et al., 2021; Heinrich et al., 2020). The translation of AYUSH into mainstream healthcare requires evidence-based validation. The evaluation of traditional therapies is being conducted using modern research methods, such as randomized controlled trials, pharmacological studies, and systems biology-based analyses. Recent systematic reviews and meta-analyses have shown promising results regarding several AYUSH interventions. Unstable study design, small sample sizes, and the absence of standardization are, however, significant drawbacks (Thakar et al., 2024; Ahmad et al., 2026; Philips and Theruvath, 2024). Another potential translational pathway is integration with contemporary healthcare systems. Integrative medicine models focus on integrating the power of conventional biomedicine with the traditional ones. In India, AYUSH has been integrated into the national health policies

and primary health care delivery. Complementary and integrative medicine is becoming accepted around the world as an adjunct method in managing diseases and promoting health (World Health Organization, 2023; Samal and Singh, 2026). AYUSH systems demonstrate a high potential in the treatment of chronic and complex illnesses. Such disorders as diabetes, cardiovascular diseases, cancer, and neurodegenerative diseases have a multitiered biological pathway and a long-term development. Traditional treatments tend to be symptom management-oriented, whereas AYUSH treatment methods involve restoring systemic balance by using multi-component treatment, lifestyle changes, and mind-body therapies. This renders them especially applicable to long-term and preventive healthcare (Atanasov et al., 2021 Koch et al., 2024; Heinrich et al., 2020). Recent developments in computational biology and network pharmacology have further enhanced translational research in AYUSH. Network analysis, molecular docking, and omics technologies are tools used to investigate multi-target interactions and predict therapeutic outcomes. These strategies give a science-based paradigm of incorporating the old formulations into the contemporary drug discovery pathways (Li, 2021; Zhang et al., 2021; Chandran et al., 2015; Srivastava et al., 2024). Irrespective of these developments, there are a number of challenges. There is a lack of standardization in formulations, dosage, and quality control. The narrow clinical evidence remains insufficient in many respects, and regulatory frameworks are not well adapted to the complexity of traditional systems. It is also necessary to consider safety issues, such as herb-drug interactions and toxicity (Philips & Theruvath, 2024; Ahmad et al., 2026). The other important gap is the lack of translation of research findings into clinical practice. There are numerous positive outcomes that do not reach the level of healthcare but are only investigated in studies. This underscores the importance of more interdisciplinary teamwork among traditional practitioners, biomedical researchers, and clinicians. Bridging this gap will require policy support and structured research frameworks (Samal & Singh, 2026; World Health Organization, 2023). All in all, translational pathways can offer a key connection between Indigenous Knowledge Systems and contemporary medicine. Through the combination of traditional knowledge, scientific validation, and clinical use, AYUSH can potentially become a part of holistic, patient-centred, and sustainable healthcare (Atanasov et al., 2021).

Translational Pathway of Indigenous Knowledge Systems (IKS) into Evidence-Based Integrative Healthcare



Challenges and Future Directions

However, despite growing interest and evidence, a number of obstacles inhibit the broader acceptance and integration of AYUSH systems into mainstream healthcare. These problems need to be resolved in order to promote translational and integrative medicine. Absence of standardization and quality control is one of the biggest challenges. The composition of AYUSH formulations varies depending on the raw materials, geographical origin, and mode of preparation. This variability influences reproducibility, safety and clinical outcomes. To maintain a good quality, it is necessary to have uniform procedures, raw materials verification, and sophisticated testing methods. The other significant concern is the gap in clinical validation. Despite the long histories of use of traditional practices, there is limited high-quality clinical evidence. Most of the studies are small in size, do not have appropriate controls or use non-standardized formulations. This complicates drawing conclusions about efficacy and safety. It is crucial to strengthen clinical research by designing randomized controlled trials and multicenter studies (Koch et al., 2024; Ahmad et al., 2026). Policy and regulatory

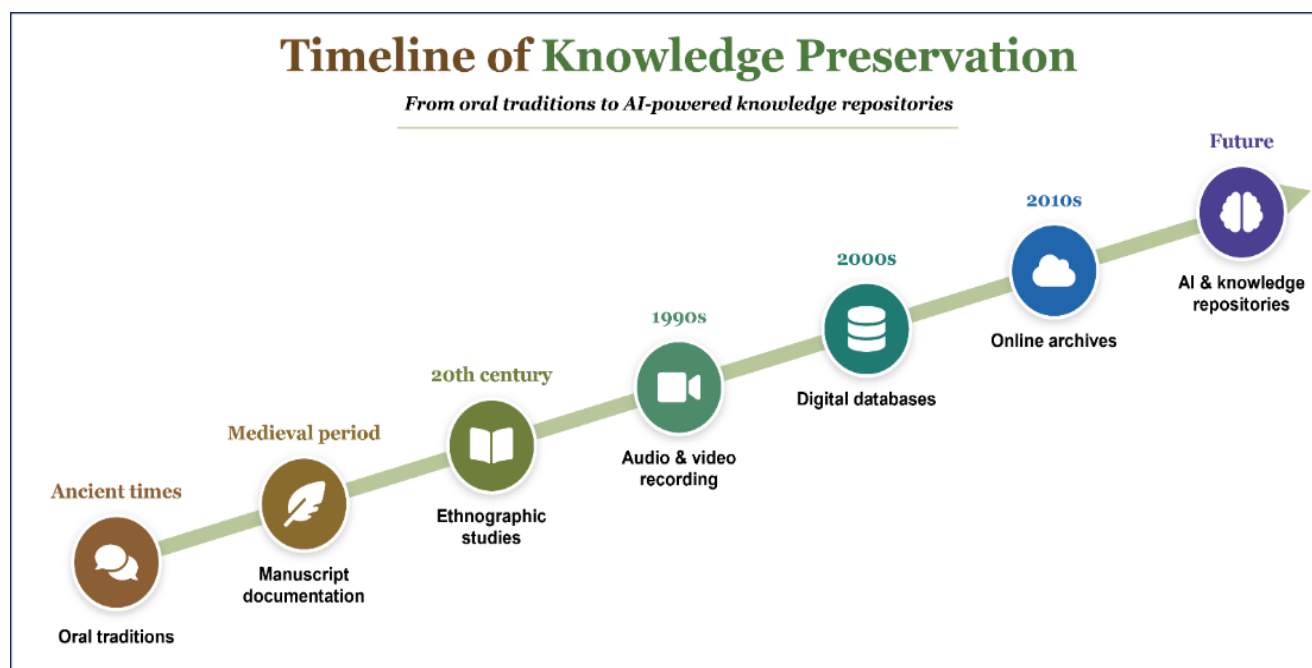
obstacles also impede integration. Conventional medicine systems can hardly be easily accommodated within conventional regulatory frameworks, which are oriented towards single-compound drugs. Variations in standards between nations also make it harder to gain global acceptance. To be more widely adopted, more flexible but strict regulatory models, which take into account the complexity of the AYUSH formulations, are needed (World Health Organization, 2023; Samal and Singh, 2026). The other emerging issue is knowledge erosion. The Indigenous Knowledge Systems on which AYUSH is based are mostly passed down orally or by traditional means. This knowledge base is threatened by rapid modernization, degradation of biodiversity, and deterioration of interest in younger generations. To protect this heritage, its systematic documentation, digital archiving, and community-based preservation are required (Pulok et al., 2017). Meanwhile, the future of AYUSH is bright. The development of systems biology, artificial intelligence, and network pharmacology has offered novel techniques to comprehend multi-component therapies that are complex in nature. These strategies can be used to discover mechanisms, optimize formulations, and facilitate evidence-based validation (Li, 2021; Chandran et al., 2015). Personalized and integrative medicine is one of the major future directions. Individualized treatment, depending on constitution, lifestyle, and environment is already a focus of AYUSH systems. Integration with current-day diagnostics and precision medicine has the potential to result in more effective and patient-centered healthcare models. This integration could enhance outcomes for chronic and lifestyle-related diseases (Atanasov et al., 2021). All in all, the current challenges will be overcome only through concerted research, policy, and education efforts. Enhancing evidence, quality assurance, and traditional knowledge will be necessary. Having proper scientific validation and integration, AYUSH can contribute greatly to the global healthcare systems of the future.

7. Conclusion The recent research findings provide evidence to support the claim that Indigenous Knowledge Systems and AYUSH practices represent a rich source of holistic therapeutic strategies. A brief overview of ethnopharmacological, clinical, and integrative methodologies shows that they can be used not only in traditional medicine but also as complementary methods in modern medicine. By focusing on translational research, standardization and clinical validation, AYUSH can be re-positioned as a plausible, integrative system able to bridge the gap between traditional wisdom and the modern healthcare requirements, and thus, facilitate personalized, accessible and sustainable wellness solutions.

Table 1. Selected Medicinal Herbs Used in AYUSH: Traditional Uses and Evidence from Scientific Studies

S. No.	Medicinal Herb (Scientific Name)	Traditional Use	Scientific Evidence	Key Reference
1	<i>Withania somnifera</i> (Ashwagandha)	Stress, anxiety, rejuvenation	Reduced stress, cortisol levels, and improved sleep quality.	Chandrasekhar et al. (2012)
2	<i>Tinospora cordifolia</i> (Guduchi)	Immunomodulation, fever	Immunomodulatory and anti-inflammatory effects.	Singh & Chaudhuri (2017)
3	<i>Ocimum tenuiflorum</i> (Tulsi)	Respiratory disorders, stress	Adaptogenic and anti-inflammatory effects with potential respiratory benefits.	Jamshidi & Cohen (2017)
4	<i>Terminalia arjuna</i> (Arjuna)	Cardiovascular disorders	Improved cardiovascular function and exercise tolerance.	Dwivedi (2007)
5	<i>Glycyrrhiza glabra</i> (Yashtimadhu)	Respiratory and liver disorders	Anti-inflammatory and hepatoprotective effects reported in clinical studies.	Pastorino et al. (2018)
6	<i>Bacopa monnieri</i> (Brahmi)	Memory enhancement	Improved memory, attention, and cognitive performance.	Kongkeaw et al. (2014)
7	<i>Asparagus racemosus</i> (Shatavari)	Women's reproductive health	Potential benefits in female reproductive and menopausal health.	Alok et al. (2013)
8	<i>Phyllanthus emblica</i> (Amla)	Antioxidant, metabolic disorders	Improved antioxidant status and metabolic health markers.	Variya et al. (2016)
9	<i>Curcuma longa</i> (Turmeric)	Inflammation, arthritis	Reduced pain and inflammatory biomarkers in osteoarthritis.	Daily et al. (2016)
10	<i>Azadirachta indica</i> (Neem)	Skin and oral diseases	Antimicrobial activity with benefits in periodontal health.	Alzohairy (2016)
11	<i>Commiphora wightii</i> (Guggulu)	Hyperlipidemia	Improvement in lipid profile.	Ulbricht et al. (2005)

12	<i>Boswellia serrata</i> (Shallaki)	Arthritis	Reduced joint pain and improved physical function.	Yu et al. (2020)
13	<i>Moringa oleifera</i> (Moringa)	Nutrition, metabolic disorders	Potential benefits for metabolic health and antioxidant status.	Vergara-Jimenez et al. (2017)
14	<i>Andrographis paniculata</i> (Kalmegh)	Fever, respiratory infections	Reduced severity and duration of upper respiratory tract infections.	Hu et al. (2017)
15	<i>Allium sativum</i> (Garlic)	Cardiovascular disorders	Reduced blood pressure and serum cholesterol levels.	Ried (2016)
16	<i>Trigonella foenum-graecum</i> (Fenugreek)	Diabetes	Improved glycemic control in patients with type 2 diabetes.	Neelakantan et al. (2014)
17	<i>Zingiber officinale</i> (Ginger)	Nausea, inflammation	Reduced nausea and improved inflammatory symptoms.	Morvaridzadeh et al. (2020)
18	<i>Piper nigrum</i> (Black Pepper)	Digestive disorders	Enhanced bioavailability of co-administered phytochemicals.	Srinivasan (2007)
19	<i>Crocus sativus</i> (Saffron)	Depression	Improved symptoms of mild-to-moderate depression.	Hausenblas et al. (2013)
20	<i>Aloe vera</i>	Wound healing, gastrointestinal disorders	Improved wound healing and glycemic control.	Hekmatpou et al. (2019)



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