

The BRICS HEALTH JOURNAL

SCIENTIFIC PEER-REVIEWED JOURNAL

VOLUME 3 • ISSUE 2 • 2026

SPECIAL ISSUE

INDIA

The word "INDIA" is written in large, white, sans-serif capital letters. The letter "A" is partially replaced by the Indian national flag, which consists of three horizontal stripes of equal width: saffron at the top, white in the middle, and green at the bottom. In the center of the white stripe is the Ashoka Chakra, a navy blue wheel with 24 spokes.

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Biomedicine

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The BRICS HEALTH JOURNAL



Volume 3 | Issue 2 | 2026 | DOI: 10.47093/3034-4700.2026.3.2

ISSN 3034-4700 (Print)
ISSN 3034-4719 (Online)

Goals and objectives: The BRICS Health Journal aims to promote medical research, public health and scientific cooperation among the BRICS countries. The publication is intended for healthcare professionals.

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Founded: the journal has been published since 2024

Frequency: 4 times a year

Distribution: content is distributed under Creative Commons Attribution 4.0 License

Founders: Ministry of Health of the Russian Federation; Sechenov First Moscow State Medical University

Publisher, Editorial Office: Sechenov First Moscow State Medical University

Address: 8/2, Trubetskaya str., Moscow, 119048, Russia

Editorial office phone number: +7 (495) 609-14-00, ext.10-12

Website: <https://www.bricshealthjournal.com>

E-mail: bricshealthjournal@staff.sechenov.ru

DOI Prefix: 10.47093

Published: 29.09.2026

Copyright: © Compilation, design, editing. The BRICS Health Journal, 2026

Price: flexible

Technical Editors: Ekaterina S. Solodnikova

Editor-proofreader: Ekaterina S. Solodnikova

Page layout: Olga A. Yunina

Consulting Designer: Alexander Gladkikh

Printed by: BEAN LLC

Address: 1, Barrikad str., Nizhny Novgorod, 603003, Russia

Format 60×90 1/8. Off set print. Print run 100 copies.

The BRICS HEALTH JOURNAL

journal homepage: <https://www.bricshealthjournal.com>

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It gives me immense pleasure to present this special edition of The BRICS Health Journal, reflecting the shared commitment of BRICS member countries towards strengthening health cooperation and advancing equitable, resilient and people-centred health systems. India's BRICS Chairship in 2026 provided an important platform to translate our shared priorities into concrete outcomes through sustained technical engagement, knowledge exchange and consensus-building among member states.

Under India's Chairship, the BRICS Health Track advanced cooperation across a wide range of priorities, including tuberculosis research, health emergency preparedness, medical products regulation, digital health, healthy lifestyle, mental wellness, Traditional, Complementary and Integrative Medicine (TCIM), diseases driven by social determinants of health, public health institutions, vaccine research and development, and nuclear medicine. These deliberations culminated in the adoption of the 16th BRICS Health Ministers' Declaration, reaffirming our collective resolve to strengthen collaboration and address emerging and persistent health challenges through coordinated action.

Several important deliverables were advanced during India's Chairship, including launch of BRICS Mission for Healthy Lifestyle and its Roadmap for joint initiative (2026–2029), a Sub-Working group on the BRICS

Integrated Early Warning System, proposed establishment of an expert working group on TCIM, exchange of country experiences and innovations on digital health, establishment of a BRICS Training Hub Network and BRICS Network of Centre of Excellence for promotion of mental wellness and operational framework for cooperation among National Public Health Institutes while facilitating the exchange of national best practices through thematic compendiums.

These outcomes demonstrate that effective multilateral cooperation can translate shared aspirations into practical and sustainable initiatives. I am confident that this edition of The BRICS Health Journal will further promote knowledge-sharing, research and innovation, and provide a platform for continued collaboration. The outcomes of India's Chairship provide a strong foundation for advancing the BRICS health agenda and contributing meaningfully to global health cooperation.

Jagat Prakash Nadda

*Minister
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The BRICS HEALTH JOURNAL

2026; 3 (2): 4–4

journal homepage: <https://www.bricshealthjournal.com>
<https://doi.org/10.47093/3034-4700.2026.3.2.4-4>

Editorial



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Punya Salila Srivastava

Secretary
Department of Health & Family Welfare
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It has been our privilege to steer the BRICS Health Track during India's BRICS Chairship 2026, reaffirming our collective commitment to advance health, well-being, and people-centric development. Guided by the theme '*Building for Resilience, Innovation, Cooperation and Sustainability*', India places strong emphasis on equity, innovation, and South-South cooperation.

The BRICS Health Journal aims at promoting medical research, public health and scientific cooperation. We appreciate the Russian Federation for spearheading and taking forward this initiative. The research papers align with the priorities identified by us. I am sure it will provide valuable inputs to all the member countries in our collective efforts to address the challenges and take forward our health initiatives.

As we look ahead, we remain committed to working closely with all BRICS countries in advancing collective action on shared public health priorities across the Global South.



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Informed consent statement: Not required.

Funding: The authors acknowledge funding support from the Council of Scientific and Industrial Research in CSIR-National Institute of Science Communication and Policy Research (NIScPR) under Project Grant No. MLP002635.

Competing interests: The authors declare no conflict of interest.

Ethical approval: Not required.

Data sharing: All data used in this paper are publicly available. Data from the bibliographic analysis are available from the authors upon reasonable request.

Use of artificial intelligence: No artificial intelligence tools were used in the preparation of this manuscript.

India's evolving medical pluralism: the changing relationship between Ayush and biomedicine

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ABSTRACT

The morbidity rates of chronic non-communicable diseases together with medical inflation, have renewed interest in integrative health with the amalgamation of modern science traditional medicine systems. The World Health Organization latest traditional medicine strategy advocates universal access to evidence-based, people-centred traditional, complementary and integrative medicine. In India, Ayurveda, Yoga and Naturopathy, Unani, Siddha, Sowa-Rigpa, Homeopathy (Ayush) and other indigenous medicine systems are deeply rooted in the culture and are currently being mainstreamed through policy and programmatic reforms. This review with bibliographic analysis examines the development, institutionalization and regulation of Ayush in India, together with models of Ayush–biomedicine integration, the available evidence and major barriers. The bibliographic analysis included 256 English-language articles and reviews published between 01.01.2005 and 31.12.2025 in Web of Science and PubMed and identified four major thematic areas, seven co-authorship clusters and increasing publication activity after 2019, reaching 42 publications in 2025. Available studies suggest potential applications of Ayush in chronic diseases, mental health, supportive oncology care, pain management and preventive health. However, many studies remain small, heterogeneous, adjunctive or observational, showing that the evidence base is still uneven. Several integrative practice and India-specific initiatives are discussed,

Acknowledgments: The authors acknowledge Director, Council of Scientific and Industrial Research in National Institute of Science Communication and Policy Research for providing facilities and support for the study.

Manuscript source: Unsolicited manuscript.

Country/territory of origin: India

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Received: 19.06.2026

Accepted: 14.08.2026

Date of publication online: 10.09.2026

Date of publication: 29.09.2026

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ranging from co-location and cross-referral to collaborative and community-based care. Institutional development also involves research, education and regulation, public health integration and digital health. Interdisciplinary research, stronger quality regulation, capacity building and further evaluation of integrative models are needed to support an evidence-based and patient-centred healthcare system. Overall, the findings suggest that India is moving beyond medical pluralism towards a more organized integrative healthcare model.

Key Words: Ayush; evidence-based medicine; TCIM; WHO; traditional medicine; India; health policy; healthcare integration

Citation: Sharma D, Ray S, Lata C. India's evolving medical pluralism: the changing relationship between Ayush and biomedicine. *The BRICS Health Journal*. 2026;3(2):5–20. Epub ahead of print 10.09.2026. <https://doi.org/10.47093/3034-4700.2026.3.2.88>

MeSH terms:

MEDICINE, TRADITIONAL
HEALTH POLICY
INDIA

Introduction

Medical inflation together with the morbidity rates of chronic non-communicable diseases, accounting for around 63% of all deaths in India, have renewed the interest in integrative health, which shows the amalgamation of modern science with traditional medicine systems¹. The World Health Organisation (WHO) latest traditional medicine strategy clearly advocates universal access to evidence-based, people-centred traditional, complementary and integrative medicine (TCIM), with an intention to change medical practices into biomedical forms, where many alternative forms of medical practices still exist in different parts of the world². On a worldwide scale, traditional medicine systems are gaining momentum again. Mainly, traditional and indigenous medicines are practiced in Asia, Africa, and Latin America [1, 2], whereas complementary and alternative medicines do exist in Europe and North America. Many people use TCIM alongside biomedicine for various reasons [3]. According to the WHO survey, 88% of the world's population is optimistic about the development of traditional medicine and is willing to try herbal medicine as their main healthcare drug³. The worldwide herbal/traditional products market is growing rapidly (estimated at approximately USD 148.5 billion in 2022, projected to USD 386 billion by 2032) [4].

Amid this popularity, there are concerns about plural medical systems that combine TCIM and biomedicine. When such systems are practised together, they might produce tensions which could cause adverse healthcare outcomes in patients [5]. In contrast, they may generate tangible healthcare benefits through collaborations between different medical traditions [6]. In India, integration of traditional medicine systems into mental healthcare has been associated with increased community acceptance. These pros and cons may depend on various factors, including the recipient, how TCIM is used together with biomedicine, and the institutional conditions in which TCIM is sanctioned [7]. The

¹ Towards a Fit and Healthy India: Combating Obesity Through Collective Action. Accessed 03.08.2026. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2107179®=48&lang=2>

² WHO Global Traditional Medicine Strategy 2025–2034. Accessed 12.06.2026. <https://www.who.int/publications/i/item/9789240113176>

³ WHO global report on traditional and complementary medicine 2019. Accessed 12.06.2026. <https://www.who.int/publications/i/item/978924151536>

extent to which users are aware of TCIM and want such treatment from primary and other healthcare professionals may also vary across TCIM modalities that are incorporated differently into the biomedical system [8]. Even the treatment outcomes of TCIM seem to be influenced by institutional conditions provided to patients [9] or by the degrees to which TCIM users rely on the expertise of healthcare professionals besides their own knowledge [10]. Overall, the ways in which TCIM is institutionalized in medical systems appear to be consequential for many aspects of healthcare systems.

Healthcare systems worldwide are predominantly based on biomedicine, and it is necessary to inform the global healthcare community on how to incorporating TCIM in such systems [11]. The reasons for incorporating TCIM into biomedical systems in economic, cultural or medical terms. Though at the same time, there are political and theoretical tensions between TCIM and biomedicine that create the incorporation attempts challenging⁴ [5]. Research papers even point to the sustained supremacy of the biomedical system over TCIM so much so that the actual collaborative efforts between these medical traditions are hardly visible [7, 12]. In such situations, members of the medical community should be aware of the different ways in which a knowledgeable use of results of incorporation can be a tool for designing the institutional system that helps to alleviate the tensions between TCIM and biomedicine and in turn, is instrumental in support healthcare provision [5, 10].

There is a growing need to understand the various ways in which TCIM is incorporated into biomedical healthcare systems in different countries. One reason could be biomedical care alone concentrates mostly on treating acute illness and avoids the emphasis on prevention and holistic wellness [13].

This review aims to examine how Ayurveda, Yoga and Naturopathy, Unani, Siddha, Homeopathy (Ayush) is developed, systematized and regulated in India, along with the evidence base and models of integrative care, and the challenges and strategies for strengthening of evidence-based integration with biomedicine.

We performed a bibliographic analysis of publications on Indian Systems of Medicine (ISM) and integrative healthcare using the Web of Science and PubMed databases. The search was carried out independently by the authors in June 2026 and covered English-language articles and reviews published between 01.01.2005 and 31.12.2025. A total of 209 records were identified in Web of Science and 3,237 records in PubMed. After the records were merged and manually screened, and publications on alternative medicine outside the recognised ISM were excluded, 256 articles were included in the final bibliographic dataset. Government press releases, reports, bulletins and policy documents were also used to provide additional narrative and policy context for the review.

This study considers different ways of organizing plural medical systems: the interpenetrative pluralism in India, which is a plural medical system where Ayush and biomedicine mutually and bilaterally incorporate each other at various points of professional practice.

From medical pluralism to institutional integration

India is known for a pluralistic healthcare system in which different healing traditions have coexisted. Ayurveda, Siddha, Sowa-Rigpa, Unani, Yoga and Naturopathy, folk medicine, Homeopathy have continued to provide treatment alongside Western biomedicine, which was

⁴ Integration of traditional, complementary and integrative medicine into health systems: conceptual framework. Accessed 12.06.2026. <https://www.who.int/publications/i/item/9789240110397>

introduced during the colonial period. Ruhil argues that medical pluralism in India didn't develop as a short-lived occurrence but rather as a deeply rooted social reality, which has been shaped by cultural acceptance and diversified healthcare needs [14].

ISM are deeply intertwined with its history and traditions. Over 2000 years ago, the classical texts such as Charaka Samhita and Sushruta Samhita described key principles and practices of Ayurveda, while Siddha, Unani, and others also have long histories. These healthcare systems have always played cultural and societal roles in health and wellbeing [15].

Ayush encompasses several widely practised systems of traditional medicine in India. It includes Ayurveda, Yoga, Naturopathy, Unani, Siddha, Sowa-Rigpa, and Homoeopathy within a system that employs herbal and mineral medicines, dietary therapies, lifestyle interventions, manual therapies, and mind-body practices for health promotion and the management of various health conditions⁵ [16].

Many major policy endeavours have been aimed at bringing indigenous medical systems to the forefront of independence. The setting up of the Department of ISM and Homoeopathy in 1995, its conversion into the Department of Ayush in 2003 and eventually the formation of the Ministry of Ayush in 2014 are significant landmark changes in the institutionalization of traditional medicine. The Central Council for Research in Indian Medicine and Homoeopathy, established in 1969, was dissolved in 1978 to pave the way for separate research councils, including The Central Council for Research in Ayurvedic Sciences, The Central Council for Research in Unani Medicine, The Central Council for Research in Homoeopathy and The Central Council for Research in Yoga and Naturopathy to promote research⁶.

With these measures, India gradually moved towards more active, policy-driven integration of medical systems (Figure 1). The national health policy 2017 acknowledges Ayush and suggests greater use of traditional medicine in primary healthcare, particularly in rural areas. The flagship National Ayush Mission (NAM), launched by the government in 2014, provides financial support for the development of Ayush sector, its education, and community outreach. As a part of NAM, 12,500 Ayushman Arogya Mandirs have been established with an objective to locate Ayush practitioners in Primary Health Centres (PHC) / Community Health Centres (CHC). The Ayush mission also rolled out the "Ayush Health and Wellness Centres" as a part of the larger Ayushman Bharat Program, indicating the official involvement of Ayush at the level of primary care. Insurance support is received for 26 Ayush procedures and many pilot attempts to incorporate some Ayush services under Ayushman Bharat (Pradhan Mantri Jan Arogya Yojana), which mainly covers allopathic hospitalization, while private insurance coverage for Ayush remains limited. Overall, the post-2014 policy changes suggest a gradual shift towards the integration of Ayush into the healthcare system⁷ [15].

Bibliographic trends in Ayurveda, Yoga and Naturopathy, Unani, Siddha, Homeopathy integration research

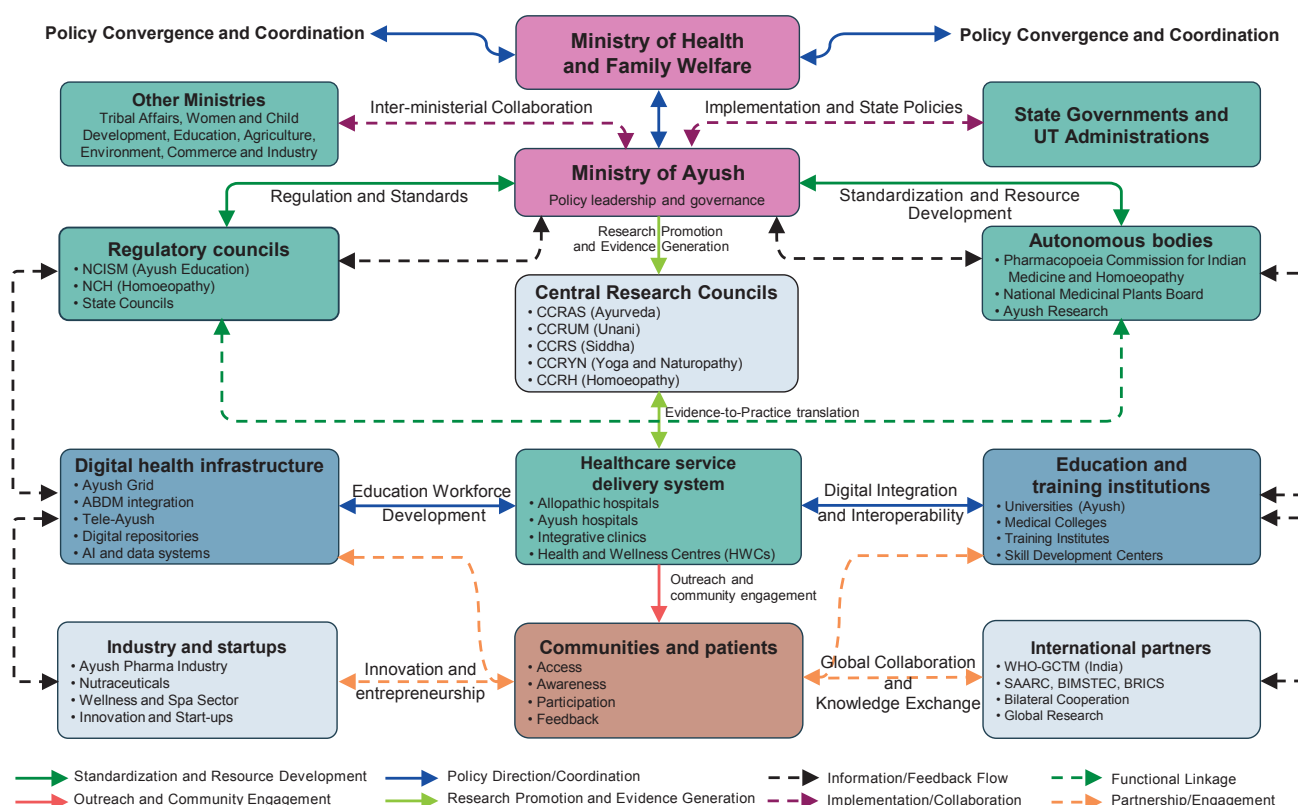
The resulting dataset comprised 256 articles published between 01.01.2005 and 31.12.2025 across reputed journals. The analysis of the keywords reveals the main topics of research and changes in trends in the area. The dendrogram indicates 4 major clusters running through

⁵ Siddha & Sowa Rigpa. Accessed 13.08.2026. <https://ayush.delhi.gov.in/ayush/siddha-sowa-rigpa>

⁶ Ministry of Ayush. Accessed 13.08.2026. <https://ayush.gov.in/>

⁷ Upgrading Ayush dispensaries under NAM. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287052&lang=1®=48>

FIG. 1. India's Integrative Healthcare Ecosystem representing networking of key institutions, policies and stakeholders



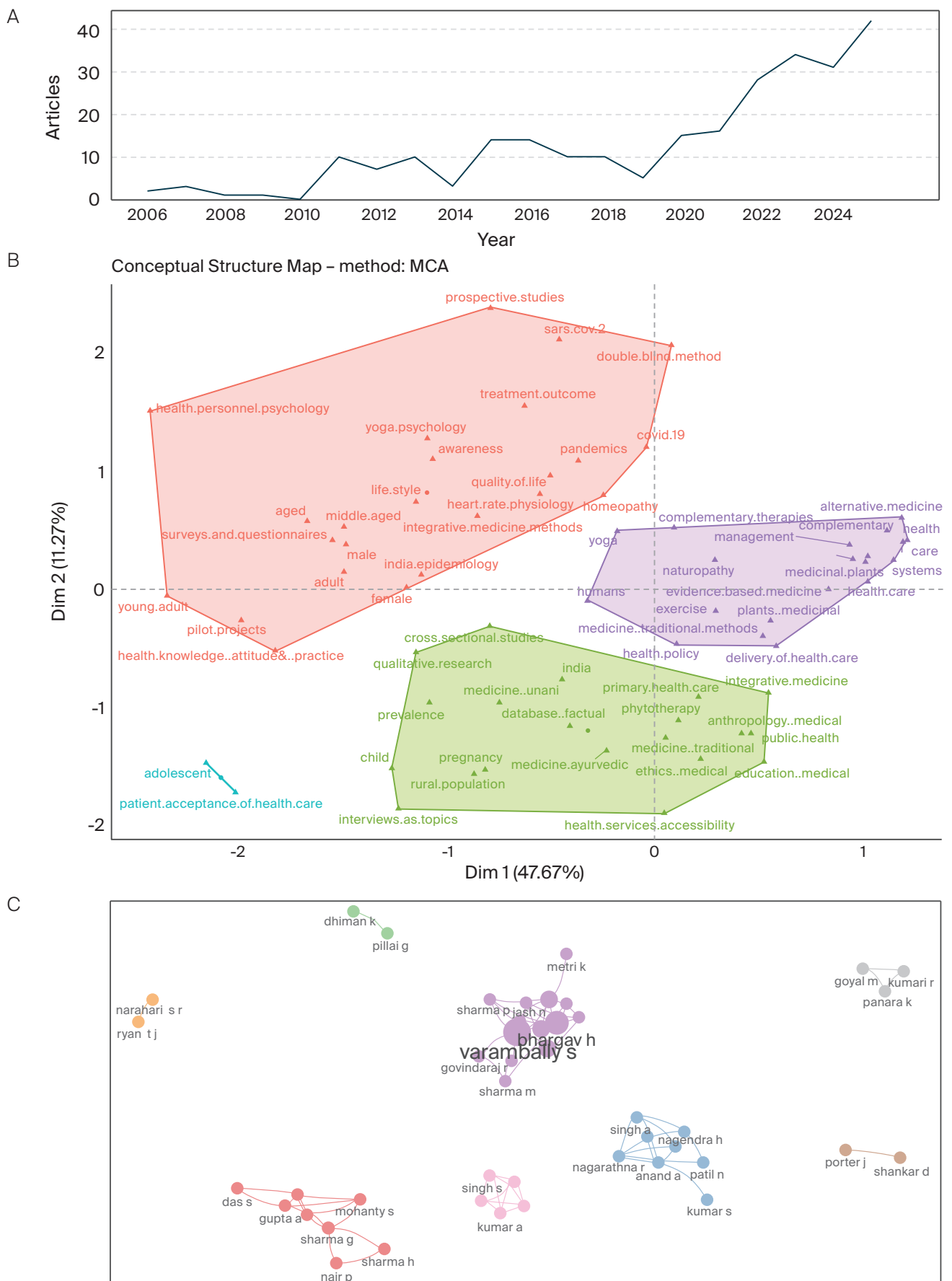
Note: Ayush – Ayurveda, Yoga and Naturopathy, Unani, Siddha, Sowa-Rigpa, and Homeopathy; UT – Union Territories; NCISM – National Commission for Indian System of Medicine; NCH – National Commission for Homoeopathy; CCRAS – Central Council for Research in Ayurvedic Sciences; CCRUM – Central Council for Research in Unani Medicine; CCRS – Central Council for Research in Siddha; CCRYN – Central Council for Research in Yoga and Naturopathy; CCRH – Central Council for Research in Homoeopathy; HWC – Health and Wellness Centre; ABDM – Ayushman Bharat Digital Mission; AI – artificial intelligence; WHO-GTMC – World Health Organization Global Traditional Medicine Centre; SAARC – South Asian Association for Regional Cooperation; BIMSTEC – Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation.

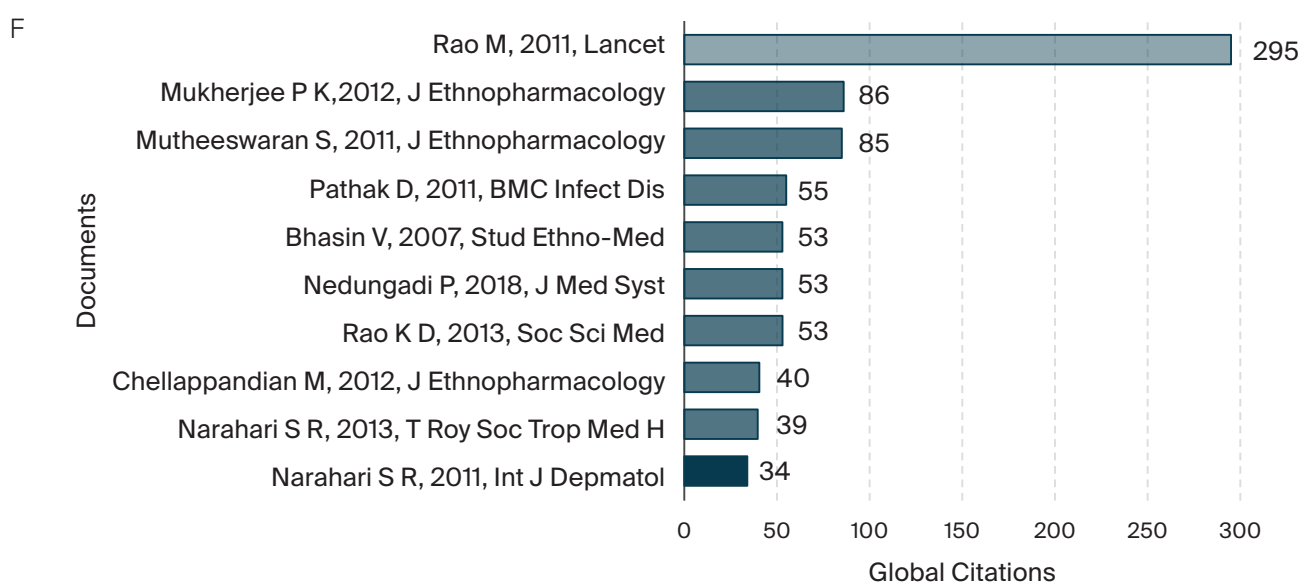
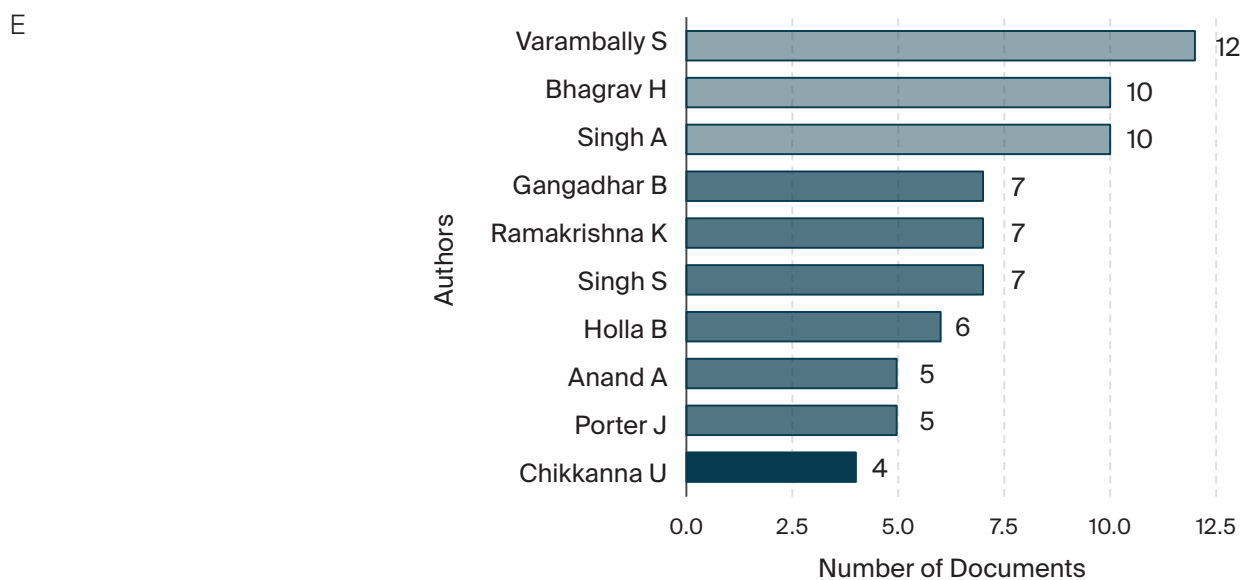
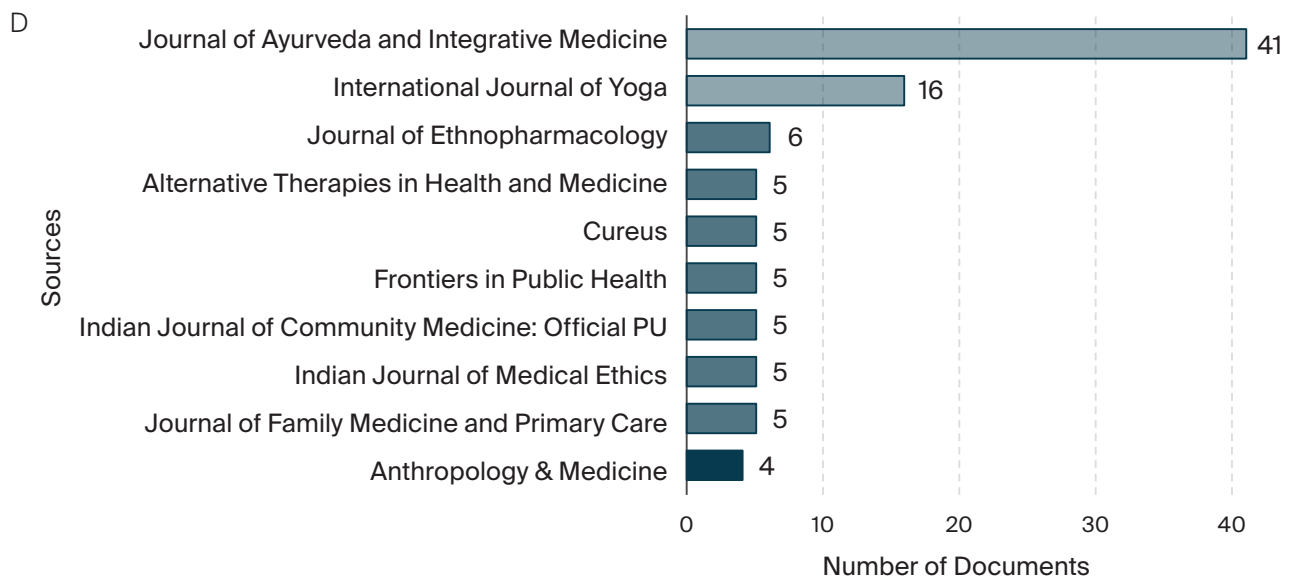
the dataset around the linkage distance of 1.8 (Figure 2B). Such clustering indicates that the topics of the research can be divided into 4 major thematic areas, where the similarity within each cluster is very strong, whereas the similarity between different clusters is relatively weak. Cluster 1 (cyan) signifies Traditional Knowledge, Public Perception and Community Healthcare, Cluster 2 (pink) signifies Clinical Integration and Healthcare Management, Cluster 3 (green) is Public Healthcare and Preventive Care, and Cluster 4 (red) is Research, Evidence and Policy Support.

Our bibliography results also indicate that the research on this subject kept on growing gradually over time, and picked a speed after year 2019 mainly published under reputed journals like Journal of Ayurveda and Integrative Medicine and International Journal of Yoga (Figure 2D). This increase may partly reflect factors such as COVID-19, emerging international acceptance of integrative medicine, and establishment of national Ayush policies and reached the highest number of articles (42) published in the year 2025 (Figure 2A).

Still, most of the time after the government recognised the policy, the integration was only on paper and not in reality. This area has seen the contribution of 1,227 authors who have published papers with the level of productivity and impact of their work. Shivarama Varambally is the most prolific author from the National Institute of Mental Health

FIG. 2. Bibliometric overview of the literature on Ayush and biomedicine in India, 2005–2025





Note: A – annual publication growth within timeline; B – keywords factorial analysis within timeline; C – Author's production and collaboration over time; D – Most relevant journals within timeline; E – Most relevant authors; F – Most global cited documents.

and Neurosciences with 12 papers in total, published almost every year (Figure 2E). Seven collaboration clusters emerged from co-authorship analysis, outlining different research communities where main cluster is led by S. Varambally and H. Bhargav, who have the most connections and act as key collaborative hubs, though medium-sized clusters have strong internal collaborations with minimal external collaboration (Figure 2C). Overall, the network presents a moderately fragmented collaboration structure, which points to lack of interdisciplinary and inter-institutional partnerships to help research on India's changing model of integrative healthcare.

The citation structure is predominantly influenced by studies Rao et al., Mukherjee et al., Mutheeswaran et al., Pathak et al. that validate traditional medicine or report public health issues (Figure 2F) [17–20]. However, there is a significant shortage of well-cited conceptual analyses focused on inter-system collaboration.

Models and levels of integration between Ayurveda, Yoga and Naturopathy, Unani, Siddha, Homoeopathy, and biomedicine

In the literature, a definite shift was observed from traditional medical pluralism, moving towards integrative healthcare models. Shankar suggested that Ayurveda and biomedicine shouldn't be seen as the two competing systems but rather as complementary knowledge traditions that can together provide a new integrative setup [21]. This perspective refers to the idea of the "Ayurvedic Pivot Model", where Ayurveda acts as the main organizing setup while at the same time selectively incorporating biomedical diagnostics and methods of evidence generation.

Comparative international studies showed that integration is not limited to one form only and can have many forms, as explained by Shim [10]. Medical pluralism is practised around the world, with the Chinese medical system described as having a relatively high degree of integration between traditional and modern medicine, influencing each other through multiple channels such as education, clinical practice, and research. Korea, however, kept the 2 systems separate with little interaction, whereas Japan has generally incorporated traditional medicine as a minor part of the biomedical system.

India appears to be moving towards the interpenetrative model by geographically placing Ayush facilities together, jointly making integrated health policies and running collaborative public health programmes. However, this emerging ecosystem of integration in India resulted in a co-location model under which Ayush outpatient and inpatient units are physically located side by side with the conventional (allopathic) treatment⁸. For example, at many district hospitals there are now "Ayush wings" where patients have the option of Ayurveda or Unani or Siddha care alongside conventional treatment [22]. Under NAM, the new PHC and CHC are also provided with on-site Ayush clinics.

Consequently, an emerging ecosystem of integration in India is taking shape, comprising co-located facilities, cross-referral committees and collaboratively held academic forums. For instance, The Central Council for Research in Ayurvedic Sciences commenced Ayurveda integration into PHC for osteoarthritis treatment and antenatal care⁹ [15]. The All India Institute of Ayurveda in Delhi not only provides clinical

⁸ Integration of Ayush Systems with Modern Medicine. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2243056&lang=1®=3>

⁹ Ministry of Ayush has taken multiple initiatives towards integration of Ayush systems of medicine with Allopathic system. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2114965&lang=2®=48>

services but also proffers an interdisciplinary care approach, especially for integrative cancer care, dentistry, and orthopaedics. Even state-level integrative care approach hospitals are also being operated. Two integrated Ayush departments have been established at Safdarjung and Lady Hardinge hospitals through collaboration between The All India Institute of Ayurveda and the Directorate General of Health Services¹⁰. Under NAM co-location approach, Ayush doctors deploy at PHC/CHC (which is a result of the combination of NAM funds and National Health Mission staff commitments), so that the patients get a 'one-stop shop' for multidisciplinary systems¹¹.

Cross-referral systems or collaborative care refer to model where practitioners of different systems work collaboratively in the management of patients. As an example, the integrative medicine department at Safdarjung Hospital, Delhi, is jointly staffed by doctors from both medical systems. There are also a few institutions running integrative clinical services. At AIIMS Jhajjar, Haryana, the All India Institute of Ayurveda provides satellite integrative medical services, including an Integrative Medical Services Unit and a Centre for Integrative Oncology at the National Cancer Institute¹². Here, the cases are discussed with both biomedical and Ayush experts with the aim of developing a single care plan.

Community-based integrative care, especially through the Ayush Health and Wellness Centres under NAM offer preventive Ayush services (yoga classes, herbal medicine) together with maternal and child health outreach support. Besides this, the Ministry of Ayush organizes rural wellness camps where yoga, acupuncture and other herbal workshops and trainings are provided to the Accredited Social Health Activist workers and villagers [15].

Institutional and policy architecture integration of Ayurveda, Yoga and Naturopathy, Unani, Siddha, Homoeopathy

Based on this analysis 6 major interconnected domains were identified: (i) Research and Evidence, (ii) Education and Regulation, (iii) Public Health Integration, (iv) Digital Health, (v) Medicinal Plant Resource Development, (vi) Cross-sectional/Future integration which together may contribute to the transformation of the Indian medical system from the old traditional pluralism to the integrative healthcare model (Supplementary table (supplementary materials on the journal website <https://doi.org/10.47093/3034-4700.2026.3.2.88-annex>)). The pool of initiatives has taken place in conjunction exhibit the gradual institutionalization of Ayush within healthcare governance service delivery, education, research, and digital health systems.

India has built large Ayush infrastructure including more than 750,000 registered practitioners, approximately 700 Ayush medical colleges, and thousands of clinics and hospitals dedicated to these systems. By 2025, India had about 12,500 Ayushman Arogya Mandirs (Ayush Clinics) staffed by qualified Ayush doctors. This network not only reflects the historical prominence of Ayurveda but also the government's present support for the integration of these systems into healthcare [15].

India has rich herbal plant resources, with thousands of plant species used in traditional medical systems, accounting for about 75% of developing countries' herbal species; more than 1,000 factories

¹⁰ MoUs for promotion and research of Ayush. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209004®=48&lang=2>

¹¹ Criteria to establish new units of AIIA. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209290&lang=1®=3>

¹² Integration of Ayush Systems with Modern Medicine. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2243056®=48&lang=2>

produce traditional herbs¹³ [23]. Coupled with Indian medicine's thousands of years of clinical experience in using herbal medicine, this may have contributed to the development of India as a major producer of herbal products [24, 25].

Digital transformation has also become an emerging pathway for Ayush integration. The COVID-19 pandemic situation has further enhanced Ayush teleconsultation. The Ministry of Ayush has started an Ayush telemedicine portal to enable remote consultation. With the introduction of the Unified Health Interface, which is an AI-based initiative, the inclusion of Ayush practitioners is expected. The mobile apps (like mYoga, AyuRythm) are rapidly boosting. One of the areas that is opening up is the AI-based analysis of Ayush data and research on Prakriti-based approaches to personalized healthcare [22].

Preserving and safeguarding traditional knowledge has assumed great significance in recent years, and a variety of initiatives are being made across the globe towards achieving it. Several international bodies and initiatives are particularly relevant to traditional knowledge and are committed to ensuring the promotion of these knowledge systems, such as the International Labour Organization's Convention 169 on Indigenous and Tribal Peoples¹⁴, the United Nations Declaration on the Rights of Indigenous Peoples¹⁵, the United Nations Permanent Forum on Indigenous Issues¹⁶, the World Intellectual Property Organization¹⁷, the United Nations Education, Scientific and Cultural Organization¹⁸ [26].

The WHO supports studying the potential usefulness of traditional medicine including evaluation of practices and assessment of the safety and efficacy of remedies, to upgrade the knowledge of traditional and modern health practitioners, as well as to educate and inform the masses about proven traditional health practices. The WHO traditional medicine strategy and India's traditional medicine-based healthcare reforms provide a favourable policy environment for this change [26].

Current evidence on clinical and public health applications

Along with the institutional integration of Ayush, more attention is now being given to generating clinical evidence and studying its applications in healthcare practice. Research has covered several areas, including chronic diseases, preventive healthcare, mental health, supportive care and public health interventions. However, the available evidence is still different in its strength and quality across these areas [11, 15].

Balkrishna et al. noted that integration is increasingly promoted worldwide as a response to increasing burden of chronic diseases, ageing populations, and higher healthcare costs [11]. Their review highlights the potential relevance of integrative approaches to chronic diseases, preventive healthcare, mental health management, cancer supportive care, and lifestyle disorders.

In the case of type 2 diabetes improvements are observed in glycaemic levels in patients who receive Ayurvedic treatment alongside conventional treatment [27]. A recent article on preventive health discussed the potential role of yoga in supporting the management of chronic diseases such

¹³ World Wildlife Day 2026. Medicinal and Aromatic Plants: Conserving Health, Heritage and Livelihoods. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2234951&lang=1®=1>

¹⁴ C169 Indigenous and Tribal Peoples Convention, 1989. Accessed 13.08.2026. <https://www.ilo.org/media/324306/download>

¹⁵ United Nations Declaration on the Rights of Indigenous People. Accessed 13.08.2026. https://www.un.org/esa/socdev/unpfii/documents/DRIPS_en.pdf

¹⁶ United Nations Permanent Forum on Indigenous Issues (UNPFII). Accessed 13.08.2026. <https://social.desa.un.org/issues/indigenous-peoples/unpfii>

¹⁷ Traditional Knowledge: Publications, Studies and Documents. Accessed 13.08.2026. <https://www.wipo.int/en/web/traditional-knowledge/resources/publications>

¹⁸ Text of the Convention for the Safeguarding of the Intangible Cultural Heritage. Accessed 13.08.2026. <https://ich.unesco.org/en/convention>

as cardiovascular, respiratory, endocrine disorders, obesity, cancer and metabolic syndrome [28]. Nowadays, India has started introducing yoga in some psychiatric and non-communicable diseases clinics, wherein the patient outcomes seem to be encouraging [29]. Another randomized controlled trial demonstrated a reduction in osteoarthritis symptoms after 12 months [30]. So far, the evidence is still limited, but it does suggest that Ayurveda may be an effective partner in managing chronic pain disorders.

Several Ayurvedic, Siddha, and Unani products have been investigated as adjuncts to standard care or, less commonly, as preventive interventions for mild-to-moderate COVID-19. These include formulations containing Haridra (*Curcuma longa*) [31, 32], Ashwagandha (*Withania somnifera*) [33, 34], Guduchi (*Tinospora cordifolia*) [35, 36], and Yashtimadhu (*Glycyrrhiza glabra*) [37]. However, the available studies vary substantially in design, sample size, composition of the interventions, comparators, and outcome measures. In particular, results obtained with multicomponent formulations cannot be attributed to any individual plant component.

Preliminary studies have also assessed Guduchi Ghana Vati, Tiryak Wabai, Nilavembu Kudineer, and Kaba Sura Kudineer in prevention or management settings [35, 36, 38, 39, 40]. Some studies reported improvements in symptoms, time to clinical recovery, hospital stay, viral-load measures, or selected laboratory parameters. These findings should be interpreted cautiously, as several trials were small, some interventions were evaluated in addition to standard treatment, and many reported outcomes were surrogate rather than patient-important clinical endpoints. Further adequately powered, rigorously designed, independently replicated trials would be required before conclusions can be drawn regarding efficacy in preventing infection, reducing disease severity, hospitalization, or mortality.

Evidence cited for homeopathic products, including *Arsenicum album* and *Antimonium tartaricum*, is insufficient to support claims of prophylactic or therapeutic efficacy against COVID-19 [41, 42]. The referenced publications do not provide a sufficient basis for clinical recommendations and should not be presented as evidence that these products prevent or treat COVID-19.

The Ministry of Ayush, Government of India, issued the National Clinical Management Protocol based on Ayurveda and Yoga for Management of COVID-19, which included guidance for prophylactic care, management of asymptomatic and mild cases, and post-COVID care¹⁹. India also published an integrated post-COVID management protocol that included Ayush-related approaches²⁰. Similar traditional medicine guidance was reported in Nepal and Sri Lanka. These documents reflect national policy and service-delivery approaches during the pandemic; their publication or implementation should not be interpreted as proof of clinical effectiveness of the individual interventions.

Barriers to effective integration between Ayurveda, Yoga and Naturopathy, Unani, Siddha, Homoeopathy, and Biomedicine

Some Ayush practitioners may view the standards of biomedicine as a kind of imposition on the traditional systems. It is difficult to reconcile the two approaches, as Ayurveda uses concepts that are tailored to an individual, such as dosha, prakriti, and holistic assessment, which is

¹⁹ Significance of Ayush in Boosting Immunity. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1697469>

²⁰ Health Ministry issues Post COVID Management Protocol for holistic follow up care and well-being of all post-COVID recovering patients. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1653759®=48&lang=2>

in contrast to biomedicine which focuses on disease-specific pathology and employs scientific methods that are reductionist in nature. As a result, traditional interventions can be so complex that conventional randomized controlled trials may fail to capture their intricacies. The epistemological gap has so far been described as a major issue in integration efforts [5, 43, 44].

Although India has taken steps towards integration, its model differs from that of China and continues to face institutional and professional barriers [10]. Limitations in scientific validation, standardized regulation, and clinical trials have also been reported [45]. Despite the presence of regulatory bodies (Ayurvedic Pharmacopoeia Commission, etc.) the implementation of regulatory measures remains a challenge. A national pharmacovigilance system for Ayush drugs is in place; however, heavy-metal toxicity associated with some traditional medicine products remains a documented safety concern. Separate curricula for biomedicine and traditional medicine practitioners eventually lead to mutual scepticism. Professional resistance to cross-system practice has also been reported [46, 47].

These integrative practices also open new ethical dilemmas. Ethical issues are mostly linked to Ayush products that have been promoted as “miracle” cures for diseases without strong evidence. Ensuring patient consent and monitoring unqualified practice are two of the main ongoing issues. Economic challenges also remain, such as the lack of insurance coverage for traditional treatments by private insurers, while government funding for Ayush research remains a very small proportion compared with funding for biomedicine [48].

Balkrishna et al. highlighted that the evidence is still limited, fragmented and diverse because of this, and only a very small number of practitioners can currently adopt the approach [11, 15]. Therefore, although the evidence so far tends to support the role of Ayush in integrative healthcare, powerful clinical evidence and multicentre studies are still indispensable.

Towards an integrative healthcare model: future directions and limitations

According to existing studies, it looks like India is gradually changing from a system where people use different types of medicine in a somewhat disconnected way to a more integrative model of integrative healthcare. This change is being recognized at the policy level through official acknowledgement of the Ayush systems in policy documents, the Ministry of Ayush is taking the lead in bringing these systems into the mainstream institutional set-ups, physical presence of different medical systems together in government health facilities, initiatives to produce more scientific evidence for the Ayush systems, more focus on preventive, holistic health care, and even so, working together in the same place is only a start; more substantive integration may involve collaborative work, joint teaching, common research, and patient-focused care which is still awaited²¹ [49, 50].

Because of this, the move from medical pluralism to integrative healthcare is not only a matter of administration change but may also reflect changing healthcare priorities that call for holistic, preventive and patient-centred care. Institutional recognition and co-location can provide a basis for integration, but they do not automatically create real collaboration between different medical systems. Further progress may depend on how these systems interact in clinical practice, education and research, and how far such interaction can respond to the actual needs of patients [15, 51].

²¹ Integration of Ayush Systems with Modern Medicine. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2243056®=48&lang=1>

Figuring out how to combine modern technological knowledge with a broader perspective on the application of Indian medical principles may help traditional Indian medicine gain wider acceptance. To maintain this traditional medical system as a living tradition, it is necessary to further investigate and demonstrate the scientific basis of Indian medicine [52].

If accompanied by strong evidence production, regulatory enforcement and skill enhancement, India may further develop a model of integrative healthcare that incorporates elements of both traditional medical systems and modern medicine. The Indian experience may therefore become useful for understanding how traditional medical systems can be included in modern healthcare while still keeping their own knowledge traditions.

This review focuses primarily on the institutionalization of Ayush within India's formal healthcare system. It does not address local and informal healing practices, such as folk medicine, spiritual healing, or the medical traditions of ethnic minority communities. The available evidence was heterogeneous. Several studies had small sample sizes, used observational designs, or evaluated Ayush interventions only as adjuncts to conventional treatment. These limitations make it difficult to draw firm conclusions about their clinical effectiveness. In addition, the bibliometric analysis describes publication output and collaboration patterns but cannot, on its own, assess the quality of the underlying evidence or the extent to which integration has been implemented in routine healthcare practice. These limitations should be considered when interpreting the conclusions of this review. The results may provide a basis for future research on the institutionalization of Ayush and its integration with biomedicine, particularly in areas requiring more robust clinical evidence, interdisciplinary collaboration, and systematic evaluation of integrative healthcare models.

Conclusion

India is gradually moving from traditional medical pluralism towards a more organized model of Ayush-biomedicine integration. This process is supported by government policies, development of Ayush institutions, co-location of services, collaborative care initiatives, public health programmes and new digital approaches. At the same time, the literature shows that integration is still developing unevenly, and the available clinical evidence is not equally strong across different areas.

The current models of integration range from simple co-location of Ayush and biomedical services to cross-referral, collaborative care and community-based approaches. These developments suggest that India is moving beyond the simple coexistence of different medical systems, although full integration has not yet been achieved. More high-quality clinical studies, better regulatory and pharmacovigilance mechanisms, interdisciplinary education and stronger collaboration between researchers and healthcare professionals are still needed. Further research should also evaluate which integrative models are most effective, practical and sustainable for routine healthcare.

India may therefore provide an important example for understanding how traditional medicine can be incorporated into a modern healthcare system while maintaining an evidence-based and patient-centered approach to integration.

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The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. All authors approved the final version of the article.

Informed consent statement: Not required.

Funding: The study was not sponsored [own resources].

Competing interests: The authors declare no conflict of interest. The views expressed in this article are those of the authors in their personal capacity and do not represent the official position of the Government of India.

Ethical approval: Not required.

Data sharing: All data used in this paper are publicly available.

Use of artificial intelligence: No artificial intelligence tools were used in the preparation of this manuscript.

Manuscript source: Unsolicited manuscript.

Country/territory of origin: India

Traditional, complementary and integrative medicine in public health system: India's policy experience and strategic insights for BRICS countries

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ABSTRACT

Traditional, complementary and integrative medicine (TCIM) is utilized by billions of people worldwide and is increasingly recognized as an important component of people-centred healthcare and universal health coverage. However, many countries continue to face challenges in incorporating TCIM into mainstream health systems through appropriate governance, regulation, research, education, and service delivery. India has progressively developed an institutional ecosystem for integrating traditional medicine into its public health system through Ministry of Ayush, supported by legislation, regulatory mechanisms, research institutions, educational infrastructure, digital health initiatives, and international partnerships. This review aims to identify policy approaches, implementation strategies, and institutional mechanisms used to facilitate the mainstreaming of Ayush and evaluate their potential relevance for strengthening the incorporation of TCIM into health systems in BRICS countries. Drawing upon peer-reviewed literature, government reports, policy documents, and multilateral declarations, the review traces the evolution of Ayush, the institutional and regulatory architecture including the National Ayush Mission, co-location of Ayush services, Ayushman Arogya Mandirs, national programmes, digital health initiatives, research and education reforms, and international cooperation. The review identifies sustained political commitment, dedicated governance, regulation, investment in research

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Received: 03.07.2026
Accepted: 20.08.2026
Date of publication online: 10.09.2026
Date of publication: 29.09.2026

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and human resource, digital innovation, and international cooperation as potential enablers, while highlighting continuing challenges evidence generation, quality assurance, financing, interoperability, and monitoring and evaluation. Building on these experiences, the review proposes a strategic framework for BRICS cooperation encompassing joint research, regulatory convergence, pharmacovigilance, digital health, academic exchange, and harmonized evidence standards. India's experience may provide a relevant policy case for implementing the World Health Organization Traditional Medicine Strategy 2025–2034 and advancing evidence-informed, people-centred health systems.

Key Words: Ayush; BRICS; integrative medicine; National Ayush Mission; WHO Traditional Medicine Strategy 2025–2034

Citation: Dutta A, Kumar S, Dash M. Traditional, complementary and integrative medicine in public health system: India's policy experience and strategic insights for BRICS countries. *The BRICS Health Journal*. 2026;3(2):21–37. Epub ahead of print 10.09.2026. <https://doi.org/10.47093/3034-4700.2026.3.2.85>

MeSH terms:
MEDICINE, TRADITIONAL
MEDICINE, AYURVEDIC
INTEGRATIVE MEDICINE
REVIEW

Introduction

The incorporation of traditional, complementary and integrative medicine (TCIM) into public health systems remains an important global health policy challenge. For decades, TCIM and biomedical healthcare have often coexisted with limited structural integration, contested evidence standards, and unresolved regulatory issues. The World Health Organization (WHO) Global Traditional Medicine Strategy 2025–2034¹, adopted by the 78th World Health Assembly in May 2025, identifies the incorporation of safe, effective, and people-centred TCIM into national health systems as important for achieving universal health coverage [1, 2].

Within the expanded BRICS grouping, eleven full members representing approximately 49.5% of the global population, 40% gross domestic product, and 26% trade². TCIM traditions are culturally embedded across BRICS, but their formalisation and integration into health service delivery vary considerably. Through its Ayush (Ayurveda, Yoga and Naturopathy, Unani, Siddha, Sowa-Rigpa, and Homeopathy) framework, India has developed an extensive institutional system spanning government hospitals, primary health centres (Ayushman Arogya Mandirs [AAM]), research councils, academic institutions, regulatory bodies, pharmacopoeia commissions, and a dedicated national ministry with flagship schemes such as National Ayush Mission (NAM) [1]. Ayush services are also co-located at different tiers of healthcare facilities under the National Health Mission of Ministry of Health and Family Welfare³.

Previous studies have described the incorporation of TCIM into national health systems and discussed its possible contribution to universal health coverage [3, 4]. Several publications have also examined India's pluralistic

¹ WHO Global Traditional Medicine Strategy 2025–2034. Accessed 01.07.2026. <https://www.who.int/publications/i/item/9789240113176>

² About Us – BRICS. Accessed 30.06.2026. <https://www.brics2026.gov.in/about-us/>

³ Co-location of Ayush Facilities. Accessed 30.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209323®=48&lang=2>

healthcare system and the development of Ayush services, including institutional reforms, the NAM, primary healthcare integration, digital initiatives, and international cooperation. However, most of these studies focused either on general approaches to incorporating TCIM into health systems or on the Indian experience itself [5].

At the same time, the policy context has changed considerably with the adoption of the WHO Traditional Medicine Strategy 2025–2034⁴ and the expansion of BRICS [6]. Limited literature brings these recent developments together and considers how India's experience may be relevant to cooperation among the expanded BRICS countries. Therefore, this review updates previous work on Ayush integration by examining recent developments in governance, regulation, research, education, service delivery, digital health, and international cooperation.

The aim of this review is to examine India's TCIM incorporation experience in depth and distils its lessons for the BRICS partnership. It focuses on the BRICS health policy context, India's historical and institutional integration trajectory, its achievements and challenges, and potential areas for joint BRICS cooperation.

References were screened manually and identified from the websites of the Ministry of Ayush, Ministry of Health and Family Welfare, WHO, and BRICS, including government reports, legislation, policy documents, and official notifications. Peer-reviewed literature was searched in PubMed, Scopus, and Google Scholar in June–July 2026 using combinations of the terms “traditional medicine”, “complementary medicine”, “Ayush”, “integration”, “public health”, “health system”, “BRICS”, and “WHO Traditional Medicine Strategy 2025–2034”. Sources were included if they addressed TCIM/Ayush integration in public health systems, with a focus on governance, regulation, research and education, service delivery, digital health, and international cooperation. The selected evidence was grouped by these themes and compared across sources where possible.

Traditional, complementary and integrative medicine in BRICS countries

BRICS declarations and policy documents on traditional, complementary and integrative medicine

Traditional medicine has featured in BRICS health cooperation since the grouping's earliest ministerial meetings. BRICS TCIM cooperation has moved from general affirmation toward institutional commitments for more than a decade.

The 2016 Goa Declaration supported intra-BRICS Traditional Medical Knowledge exchange⁵. At the BRICS High-Level Meeting on Traditional Medicine held in Tianjin, China (July 2017), Health Ministers issued the Joint Declaration of BRICS Countries on Strengthening Cooperation in Traditional Medicine, supporting a long-term mechanism for traditional medicine exchange, cooperation, the gradual integration of traditional medicine into national health systems, and supporting research expert communication, seminars, and traditional medicine course promotion⁶. The concurrent Tianjin Communique of BRICS Health Ministers explicitly reaffirmed support for WHO resolutions WHA67.18 on traditional

⁴ WHO Global Traditional Medicine Strategy 2025–2034. Accessed 30.06.2026. <https://www.who.int/publications/i/item/9789240113176>

⁵ Goa Declaration at 8th BRICS Summit – October 16, 2016. Accessed 30.06.2026. <https://www.mea.gov.in/bilateral-documents?dtl/27491/Goa+Declaration+at+8th+BRICS+Summit>

⁶ Joint Declaration of BRICS countries on strengthening cooperation in traditional medicine. Accessed 10.08.2026. https://infobrics.org/files/country/russia/documents/2017/health_/2017_07_06_BRICS_Health_Ministers_Declaration.pdf

medicine and the WHO Traditional Medicine Strategy 2014–2023⁷. The 2017 Xiamen Summit Declaration welcomed the Tianjin outcomes and the establishment of a long-term mechanism for traditional medicine exchange and cooperation⁸ [7].

Subsequent BRICS Health Ministers' Declarations / Joint Communiqués (2019 Geneva; 2021 virtual, hosted by India; 2023 Durban; 2025 Brazil) continued to address cooperation in traditional medicine within the broader BRICS health agenda⁹. In 2021, India played an important role, under its BRICS Chairship, in developing “BRICS Online Declaration in 2021 on Applying Traditional Medicine to Combat COVID-19”¹⁰. The 2024 Moscow Joint Declaration of BRICS Health Ministers, adopted following the 2024 expansion of BRICS, reflected the broader health priorities of the enlarged grouping¹¹. The adoption of the WHO Global Traditional Medicine Strategy 2025–2034 at the 78th World Health Assembly in May 2025¹² provided a new global policy framework for further cooperation.

Overview of traditional, complementary and integrative medicine in BRICS nations

Across BRICS, TCIM constitutes a substantial component of healthcare utilisation. In India, Ayush systems collectively serve hundreds of millions, and overall utilization ranges from 46% (rural) to 53% (urban)¹³. In China, reported Traditional Chinese Medicine service utilisation is substantial, and traditional medicine is integrated into the health system through dedicated hospitals and academic institutions [8–10]. In Brazil, the National Policy on Integrative and Complementary Practices (Política Nacional de Práticas Integrativas e Complementares) formalises 29 complementary practices within the Unified Health System (Sistema Único de Saúde), with homeopathy formally recognised since the 1980s [11, 12]. In Russia, phytopharmacology has state-supported institutional roots, complemented by balneotherapy, hydrotherapy, and manual therapy traditions [13, 14]. In South Africa, an estimated 27 million people¹⁴ use traditional medicines or consult traditional healers, primarily Inyanga herbalists and Sangoma spiritual healers, within a pluralistic health system that formally recognises but inconsistently integrates indigenous healing [15, 16].

Among the newer BRICS members, Iran has integrated Traditional Persian Medicine into academic facilities, national traditional medicine health centres, and traditional pharmacies, with some traditional Persian medicine preparations covered by national insurance [17–19]. Indonesia has a three-tier herbal medicine system under Indonesian Food and Drug Authority (Badan Pengawas Obat dan Makanan), distinguishing Jamu, standardized herbal medicines (Obat Herbal Terstandar), and phytopharmaceuticals (Fitofarmaka) according to increasing requirements for standardization and supporting evidence [20, 21]. Egypt, United Arab Emirates, and Saudi Arabia each have formalised complementary medicine regulatory structures, Saudi Arabia's National Center for Complementary and Alternative Medicine regulation

⁷ Tianjin Communique of BRICS Health Ministers Meeting. Accessed 10.08.2026. <http://brics.br/pt-br/documentos/acervo-de-presidencias-antiores/health-ministerial-declarations/2017-brics-health-ministers-communique.pdf/@download/file>

⁸ [BRICS Summit] Full text of BRICS Leaders Xiamen Declaration [6]. Accessed 10.08.2026. https://www.xinhuanet.com/english/2017-09/04/c_136583399.htm

⁹ Health Ministerial Declarations. Accessed 30.06.2026. <https://brics.br/en/documents/collection-of-previous-presidencies/health-ministerial-declarations>

¹⁰ BRICS Online Declaration in 2021 on Applying Traditional Medicine to Combat COVID-19. Accessed 30.06.2026. https://infobrics.org/files/country/russia/documents/2021/health_/2021_06_30_BRICS_Online_Declaration_in_2021_on_Applying_Traditional_Medicine_to_Combat_COVID-19.pdf

¹¹ MOSCOW Declaration of the XIV BRICS Health Ministers' Meeting. Accessed 10.08.2025. https://infobrics.org/files/country/russia/documents/2024/health_/2024_10_11_Moscow_Declaration_of_the_XIV_BRICS_Health_Ministers_Meeting.pdf

¹² WHO traditional medicine strategy: 2025–2034. Accessed 30.06.2026. https://apps.who.int/gb/ebwha/pdf_files/WHA78/A78_%2814%29-en.pdf

¹³ Results of survey on Ayush (July 2022 to June 2023) Released. Accessed 30.06.2026. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2025076&lang=2®=48>

¹⁴ Bioprospecting Economy. Accessed 30.06.2026. <https://www.dffe.gov.za/bioprospecting-economy>

(2019)¹⁵ [22, 23] licensing acupuncture, cupping, naturopathy, osteopathy, and chiropractic, while Ethiopia hosts one of Africa's richest traditional medicine, which is a fundamental part of society, and culture [24].

Taken together, BRICS countries represent different models of TCIM development, ranging from formal incorporation into public health systems to regulated coexistence with conventional healthcare. This diversity supports shared learning while indicating that approaches to integration need to be adapted to national regulatory, cultural, and health-system contexts¹⁶.

Historical evolution of traditional, complementary and integrative medicine in India

India's contemporary architecture for incorporating TCIM into the health system is the outcome of more than a century of legislative action, and institutional construction.

The colonial period (1858–1947) was characterised by marginalisation of indigenous medicine. The British administration privileged western biomedicine through preferential funding, licensing, and institutional development, while traditional Ayurvedic, Unani, and other practitioners remained largely outside the formal state health system. The nationalist movement renewed interest in indigenous medicine as part of a broader assertion of Indian identity, and by the time of Independence in 1947, a strong political constituency existed for the restoration of traditional systems to public health [25, 26].

The Bhore Committee (1946) outlined India's modern, three-tier public healthcare system (Primary, Secondary, and Tertiary). The Committee on Indigenous Systems of Medicine (Chopra Committee), constituted in 1946 and reporting in 1948, recommended in recognition and gradual integration alongside biomedical systems. The Udupa Committee, constituted in 1958, further advocated specifically to study, standardise, and revitalise traditional medicine. Statutory regulations through the Central Council of Indian Medicine and the Central Council of Homoeopathy in 1970 and 1973 respectively regulated professional education and practice in Ayush systems. The two Acts enacted in 2020 replaced the respective councils with the National Commission for Indian System of Medicine and the National Commission for Homoeopathy [27].

The Government of India set up the Central Council for Research in Indian Medicine and Homoeopathy in 1969. Following its reorganisation, four research councils were created in 1978, for Homeopathy (Central Council for Research in Homoeopathy, CCRH), Ayurveda and Siddha (Central Council for Research in Ayurvedic Sciences, CCRAS), Unani (Central Council for Research in Unani Medicine, CCRUM), and Yoga and Naturopathy (Central Council for Research in Yoga and Naturopathy, CCRYN)¹⁷ [28]. In the year 2010, the Central Council for Research in Siddha (CCRS) was established as a separate entity [28]. The establishment of the Department of Indian Systems of Medicine and Homoeopathy within the Ministry of Health in 1995 was followed by the Department of Ayush in 2003 and its elevation to the Ministry of Ayush, in November 2014 [29].

The National Rural Health Mission launched in 2005, included mainstreaming Ayush within the public health system. The NAM, launched

¹⁵ Regulatory Guidelines. Accessed 30.06.2026. <https://www.edaegypt.gov.eg/en/the-regulatory-reference-of-the-egyptian-drug-authority-eda/regulatory-guidelines/ca-of-pharmaceutical-products>

¹⁶ Integration of traditional, complementary and integrative medicine into health systems: conceptual framework. Accessed 30.06.2026. <https://www.who.int/india/publications/i/item/9789240110397>

¹⁷ Ministry of Ayush. Introduction. Accessed 01.07.2026. <https://ayush.gov.in/assets/pdf/whatsnew/Approved-Ayush-in-India-2024-Single.pdf>

in 2014, provided a centrally sponsored framework to expand Ayush infrastructure, co-locate services in primary and secondary health facilities, and supply essential drugs, in convergence with National Health Mission [1].

The COVID-19 pandemic (2020–2022) expanded the public-health role of Ayush: Ayush interventions were rapidly investigated, Ayush practitioners were deployed in COVID care centres and quarantine facilities for COVID mitigation and management, dedicated Ayush COVID Care Centres were established [30]. The post-pandemic period has been characterised by consolidation and scale-up of Ayush within Ayushman Bharat's primary care architecture, expanding international cooperation, and digital integration.

Institutional architecture of Ayush

The Ministry of Ayush: structure and budget trajectory

The Ministry of Ayush is a central government ministry headed by a Union Minister, with a secretary-level administrative head. Its core mandate encompasses policy development, legislative oversight, research promotion, education, regulation of professional practice and Ayush medicines, public health programmes, international cooperation, and public communication for Ayush systems¹⁸. The Ministry's allocation for 2025–26 stands at INR 39.929 billion, compared with revised estimates of INR 34.9764 billion for 2024–25, reflecting sustained government prioritisation. Within this envelope, the NAM received INR 12.75 billion (2025–26). In addition to this, there are several financial allocations by respective state governments, other central Ministries, Department of Health Research, and so on¹⁹.

National research councils and related activities

The Ayush research councils are the CCRAS, CCRH, CCRUM, CCRYN, and CCRS. They constitute a major part of India's TCIM research infrastructure and maintain networks of research institutes and units covering clinical research, drug standardization, medicinal plants, public health, literary research and documentation²⁰. The councils collectively undertake and support research projects, publish research outputs, collaborate with academic, research and healthcare institutions, and conduct research capacity-building activities. Some councils also run research support schemes for undergraduate and postgraduate scholars [28]. The Ministry of Ayush maintains the Ayush Research Portal, a centralized digital platform cataloguing research across Ayush systems²¹. It currently includes more than 43,000 uploads, with a free access model [31].

The Pharmacopoeia Commission for Indian Medicine and Homoeopathy and pharmacopeial standards

The Pharmacopoeia Commission for Indian Medicine and Homoeopathy is the apex body for Ayush drug quality standards. It publishes the Ayurvedic Pharmacopoeia of India, Unani Pharmacopoeia of India, Siddha Pharmacopoeia of India, and Homoeopathic Pharmacopoeia of India, which provide official standards for medicines and their ingredients. Compliance with the applicable pharmacopeial standards is mandatory under the Drugs and Cosmetics Act, 1940, and the Drugs Rules, 1945²².

¹⁸ Ministry of Ayush. Annual Report 2024–2025. Accessed 01.07.2026. https://ayush.gov.in/assets/pdf/annualReport/Annual-Report24-25_English.pdf

¹⁹ Ministry of Ayush. Demand No. 4. Accessed 01.07.2026. <https://www.indiabudget.gov.in/doc/eb/sbe4.pdf>

²⁰ Ministry of Ayush. Introduction. Accessed 01.07.2026. <https://ayush.gov.in/assets/pdf/whatsnew/Approved-Ayush-in-India-2024-Single.pdf>

²¹ Ayush Research Portal. Accessed 07.06.2026. <https://ayushportal.nic.in/>

²² Standardization and quality control of Ayush products. Accessed 07.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2241692&lang=1®=6>

Good Manufacturing Practice (GMP) compliance for Ayush drug manufacturers is monitored through state licensing authorities under the Drugs and Cosmetics Act, 1940. Around 8,369 Ayush drug manufacturing industries operating in India are subject to these standards, though enforcement variability across states remains a quality assurance challenge^{23, 24}.

The National Medicinal Plants Board

The National Medicinal Plants Board promotes the cultivation, conservation, and sustainable use of medicinal plants. Its activities include research and development, quality control, and standardization of medicinal plant products. It also facilitates the integration of medicinal plants into the healthcare system, encourages agro-based entrepreneurship, and works to enhance the income of farmers engaged in medicinal plant cultivation²⁵.

Education institutes

The Ministry of Ayush supports a network of national educational and research institutions, including the All India Institute of Ayurveda (New Delhi and Goa campus), National Institute of Ayurveda (Jaipur and Panchkula), Rashtriya Ayurveda Vidyapeeth (Delhi), Institute of Teaching and Research in Ayurveda (Jamnagar – Institute of National Importance), National Institute of Homoeopathy (Kolkata and Narela), National Institute of Siddha (Chennai), National Institute of Unani Medicine (Bengaluru and Ghaziabad), North Eastern Institute of Ayurveda and Folk Medicine Research (Pasighat), North Eastern Institute of Ayurveda and Homoeopathy (Shillong), and the Morarji Desai National Institute of Yoga (Delhi), National Institute of Naturopathy (Pune), National Institute of Sowa-Rigpa (Leh)²⁶.

These institutes offer undergraduate, postgraduate, doctoral, and other specialised programmes, depending on the institution, alongside clinical training and research. Apart from these institutions, there are more than 900 state government or private sector owned education institutes²⁷.

Legislative and regulatory framework

The Drugs and Cosmetics Act and Ayush

The Drugs and Cosmetics Act, 1940 and the Drugs and Cosmetics Rules, 1945 constitute the principal legal framework for regulating the manufacture, licensing, quality, sale, and distribution of Ayurvedic, Siddha, Unani, and Homoeopathic medicines, in India²⁸. The Act contains specific provisions for the regulation of Ayurvedic, Siddha, Unani and Homoeopathic drugs, while the Rules prescribe standards and regulatory requirements for these drugs. The licensing requirements vary depending on the category of the medicine. Classical Ayush medicines manufactured in accordance with authoritative texts recognized under the Act are licensed subject to compliance with prescribed standards relating to manufacturing practices, quality control, labeling, and other regulatory requirements. For patent or proprietary Ayurvedic, Siddha, Unani medicines, Rule 158-B specifies

²³ Research in homoeopathy. Accessed 01.07.2026. <https://www.pib.gov.in/newsite/erecontent.aspx?relid=23987®=48&lang=2>

²⁴ Ministry of Ayush. Introduction. Accessed 01.07.2026. <https://ayush.gov.in/assets/pdf/whatsnew/Approved-Ayush-in-India-2024-Single.pdf>

²⁵ National medicinal plants board. Accessed 01.07.2026. <https://nmpb.ayush.gov.in>

²⁶ Ministry of Ayush. Annual Report 2024-2025. Accessed 01.07.2026. https://ayush.gov.in/assets/pdf/annualReport/Annual-Report24-25_English.pdf

²⁷ Ministry of Ayush. Introduction. Accessed 01.07.2026. <https://www.ayush.gov.in/assets/pdf/whatsnew/Approved-Ayush-in-India-2024-Single.pdf>

²⁸ The Drugs and Cosmetics Act and Rules. Accessed 07.06.2026. https://cdsco.gov.in/opencms/export/sites/CDSCO_WEB/Pdf-documents/acts_rules/2016DrugsandCosmeticsAct1940Rules1945.pdf

requirements relating to safety and evidence of effectiveness, depending on the formulation and intended indication²⁹ [32].

The Rules also prescribe GMP, pharmacopeial standards, quality testing, and other quality requirements [33]. State Licensing Authorities, with technical support from pharmacopeial commissions, official formularies, and drug testing laboratories under the Ministry of Ayush, support quality assurance and public health protection.

Schedules E(1) and T of the Drugs Rules, 1945 address poisonous substances in Ayurvedic, Siddha, Unani medicines and GMP requirements, respectively. The Ayush vertical within Central Drugs Standard Control Organisation supports selected central regulatory functions^{30, 31} [32, 33].

New drugs and clinical trials

The regulatory and ethical framework for clinical research involving Ayush interventions in India comprises the Drugs and Cosmetics Act, 1940, the New Drugs and Clinical Trials (NDCT) Rules, 2019, Good Clinical Practice (GCP) for Clinical Trials in Ayurveda, Siddha and Unani Medicine, issued by the Department of Ayush, Ministry of Health and Family Welfare, in 2013, Good Clinical Practice Guidelines for Clinical Trials in Homoeopathy published in 2021, and the Indian Council of Medical Research (ICMR) National Ethical Guidelines 2017 with the 2025 Addendum on Ethical Requirements for Research in Integrative Medicine. While the NDCT Rules apply to clinical trials of new drugs requiring regulatory approval, the Ministry of Ayush GCP guidelines provide system-specific standards for the conduct of clinical trials on Ayush interventions³² [34].

The 2025 ICMR Addendum requires Ethics Committees to invite two subject-matter experts from the relevant Ayush system(s), including at least one expert external to the institution, requiring informed consent to be tailored to the nature of integrative medicine research, and clarifying that codified Ayush medicines used in integrative research generally do not require additional preclinical or safety studies beyond applicable regulatory requirements, while non-codified products remain subject to the full regulatory pathway, and emphasizing compliance with the Drugs and Cosmetics Act, the NDCT Rules, and Ayush-specific GCP guidelines³³.

Education and practitioner regulation policy

Regulation of Ayush education and professional registration underwent reform through two concurrent Acts of Parliament enacted in 2020. As per one of the Acts, the National Commission for Indian System of Medicine prescribes minimum standards for 5.5 years of Bachelor and 3 years Postgraduate degrees in Ayurvedic, Siddha, Unani, and maintains the Central Register for institutions and practitioners. The second Act establishes that the National Commission for Homoeopathy performs equivalent functions for the undergraduate and postgraduate degree for Homeopathy [35].

In line with the National Education Policy 2020, Ayush education has progressively incorporated Indian Knowledge Systems, digital technologies, multidisciplinary learning, competency-based education, and enhanced research opportunities [35]. The Ministry of Ayush has also strengthened the internationalization of Ayush education through

²⁹ The Drugs and Cosmetics Act and Rules. Accessed 07.06.2026. https://cdsco.gov.in/opencms/export/sites/CDSCO_WEB/Pdf-documents/acts_rules/2016DrugsandCosmeticsAct1940Rules1945.pdf

³⁰ Quality assessment and safety audits of Ayush medicines. Accessed 07.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209282&lang=2®=3>

³¹ Single Drug Regulator for Ayush Medicines. Accessed 07.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209322&lang=2®=48>

³² Promoting traditional medicines. Accessed 07.06.2026. <https://sansad.in/getFile/loksabhaquestions/annex/9/AU3288.pdf?source=pqals>

³³ Ethical requirements for research in integrative medicine. Accessed 07.06.2026. https://www.icmr.gov.in/icmrobject/uploads/Guidelines/1740984016_icmraddendumethicalrequirementsforresearchinintegrativemedicine.pdf

scholarship and fellowship programmes implemented in collaboration with the Indian Council for Cultural Relations, enabling students from numerous countries to pursue undergraduate, postgraduate, doctoral, and Yoga-related programmes in Indian Ayush institutions³⁴.

National Medical Commission under Ministry of Health and Family Welfare has embedded Yoga in the foundation course of medical graduates and one-week elective posting in any stream of Ayush during rotatory clinical internship³⁵.

Quality Control, Good Manufacturing Practice, and Pharmacovigilance

The Ministry of Ayush launched the Central Sector Scheme Ayush Oushadhi Gunvatta evam Utpadan Samvardhan Yojana in 2021, under which the Pharmacovigilance Programme for Ayurvedic, Siddha, Unani and Homoeopathic drugs is implemented. The programme operates through a three-tier network comprising one National Pharmacovigilance Centre, five Intermediary Pharmacovigilance Centres, and 97 Peripheral Pharmacovigilance Centres across India. This network monitors and reports misleading or objectionable advertisements related to Ayurvedic, Siddha, Unani and Homoeopathic products to the respective State Licensing Authorities for appropriate action under applicable laws, including the Drugs and Magic Remedies (Objectionable Advertisements) Act, 1954, the Cable Television Networks (Regulation) Act, 1995, and the Consumer Protection Act, 2019³⁶.

GMP compliance is required for licensed manufacturers, while WHO GMP certification may support products intended for international markets. Quality surveillance remains important for identifying substandard, contaminated, or adulterated products [36].

Integration into Public Health System

Ayush Workforce, National Ayush Mission, and Primary Care Integration

India possesses an extensive Ayush network of 751,768 registered practitioners, more than 932 Undergraduate and 254 Postgraduate colleges, 3,885 Ayush Hospitals, 37,804 Dispensaries, and 8,369 drug manufacturing units³⁷.

The Government of India supports expansion of Ayush services, through the NAM. Based on proposals submitted by States and Union Territories, 12,500 Ayush Dispensaries/Sub-Health Centres have been approved for upgradation into AAMs to provide comprehensive primary healthcare services, all of which are reported to be operational and delivering comprehensive Ayush primary healthcare services, including Yoga. NAM also supports integrated Ayush hospitals, co-location of services, and digital health infrastructure. Ayush teleconsultation is also available through eSanjeevani according to state and local service arrangements^{38, 39}.

Co-location model: Ayush in Primary Health Centres, Community Health Centres, and District Hospitals

A major model of Ayush integration in India's mainstream public health system is co-location of services: the deployment of Ayush practitioners

³⁴ Scheme-wise Allocation of Scholarship Slots. Academic Year 2024-25. Accessed 07.06.2026. <https://iccr.gov.in/iccr-scholarship-schemes-2024-2025>

³⁵ National medical commission annual report (2023-2024). Accessed 07.06.2026. https://www.nmc.org.in/wp-content/uploads/2024/03/NMC_ANNUAL_2023_24_ENGLISH.pdf

³⁶ Advertisements of Ayush on Mass Media. Accessed 07.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209316&lang=2®=48>

³⁷ From roots to global reach 11 years of transformation in Ayush. Accessed 01.07.2026. <https://ayush.gov.in/assets/pdf/11-Years-Ayush-REPORT-2025.pdf>

³⁸ Ibid.

³⁹ Implementation of Ayush Schemes. Accessed 01.07.2026. <https://www.pib.gov.in/www.pib.gov.in/Pressreleaseshare.aspx?PRID=2209257>

(doctors and pharmacists) and services within existing biomedical primary and secondary health facilities. Ayush services are available at 482 District Hospitals, 3,103 Community Health Centres, 241 block-level health facilities, 6,158 Primary Health Centres, and 3,109 health facilities above the Sub-Centre level⁴⁰.

This model uses existing infrastructure and patient footfall, potentially reducing patient transport barriers, and facilitating referral interactions between Ayush and biomedical practitioners at the point of care. Ayush service components are selectively integrated in over 170,000 AAMs of Ministry of Health and Family Welfare [37].

Ayush hospitals and dispensaries

India's Ayush hospital network, comprising 3,885 hospitals with over 62,000 beds, constitutes a major component of the secondary care backbone of the public Ayush system. These institutions provide inpatient and outpatient Ayush services independently of biomedical facilities. The Ayush dispensary network of more than 37,000 facilities extends this reach to the sub-centre and village level. Standalone Ayush hospitals are the primary sites for secondary care and referral facilities for primary care. Under NAM, 203 Integrated Ayush Hospitals with 10-, 30-, or 50-bed capacities have been sanctioned to strengthen secondary-level services. Indian Public Health Standards have been framed for these facilities to ensure the availability of quality, accessible, and standardized healthcare services across the country⁴¹.

Ayushman Arogya Mandirs: Ayush-Led Health and Wellness Centres

Under NAM, the 12,500 AAM, rechristened from Ayush Health and Wellness Centres, represent India's holistic model: Ayush-led primary care facilities delivering a comprehensive wellness package rather than merely treating illness. AAM provide Yoga sessions, non-communicable disease screening, dietary counselling, health education, and primary-level Ayush therapeutic services, serving as the community-facing node of India's Comprehensive Primary Healthcare strategy. The AAM model operationalises a vision of TCIM as a wellness and prevention focused platform, complementing health primary care's services, that is both epidemiologically relevant (given India's non-communicable disease burden) and cost-effective. The number of AAM beneficiaries reached 115 million in 2024. Indian Public Health Standards have also been framed for these facilities⁴².

Integrative medicine in tertiary settings

A growing number of tertiary biomedical hospitals, including All India Institute of Medical Sciences (AIIMS) – New Delhi, and all new AIIMS institutions, the National Institute of Mental Health and Neuro-Sciences, Bengaluru among others and several state government medical colleges, have established Integrative Ayush outpatient/inpatient services where Ayush practitioners work alongside biomedical specialists. These units are primarily clinical service and research-oriented⁴³.

Ayush in the Central Government Health Scheme and specialised services

Ayush services are embedded in the Central Government Health Scheme, Railways Health Services, and the Employees' State Insurance Corporation, Army and Coal health services, providing Ayush access

⁴⁰ Co-location of Ayush Facilities. Accessed 01.07.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2209323&lang=2®=48>

⁴¹ Ministry of Ayush. Introduction. Accessed 01.07.2026. <https://ayush.gov.in/assets/pdf/whatsnew/Approved-Ayush-in-India-2024-Single.pdf>

⁴² From roots to global reach 11 years of transformation in Ayush. Accessed 01.07.2026. <https://ayush.gov.in/assets/pdf/11-Years-Ayush-REPORT-2025.pdf>

⁴³ Integration of Ayush Systems with Modern Medicine. Accessed 07.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2243056&lang=1®=3>

to millions of central government employees and their dependents. The Ministry has supported Ayush clinical services in selected institutions, including the Supreme Court of India, Central Government apex health institutions such as AIIMS^{44, 45}.

The Government has also established a dedicated Ayush vertical under the Directorate General of Health Services. Essential Medicines Lists have been notified and the availability of Ayush medicines through Jan Aushadhi Kendras is being scaled up. A Sub-Council on Ayush under the Healthcare Sector Skill Council supports workforce upskilling and training [1].

Ayush in non-communicable disease prevention and community outreach

The Ministry of Ayush, through the CCRAS, CCRH, and CCRUM, in collaboration with the Directorate General of Health Services, implemented a pilot integration of Ayush interventions under the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke across selected district hospitals and community health centres [38, 39]. The programme combined Ayush therapies with lifestyle modification and Yoga for prevention and management of non-communicable disease, in line with National Health Policy 2017's "Pluralism" principle [40].

In a retrospective analysis of 1,938 participants with essential hypertension, blood pressure decreased after six months of integrated management, and reductions or discontinuation of conventional antihypertensive medicines were also reported in some participants [38]. A separate multicentre ICMR-CCRAS trial in nearly 4,000 women with moderate iron-deficiency anaemia reported therapeutic equivalence of the studied Ayurvedic interventions to iron-folic acid supplementation in findings presented in 2026⁴⁶. Together, these studies contribute to the evidence base on Ayush interventions within public health programmes⁴⁷.

Research efforts for integration of Ayush systems in the public health system

The Ayush-ICMR Advanced Centre for Integrative Health Research is a collaborative initiative launched on March 4, 2024, by the Ministry of Ayush and ICMR, with CCRAS participating in implementation to advance evidence-based integrative healthcare in India⁴⁸. Established at four selected AIIMS, the centre comprises five specialized research hubs: gastro-intestinal disorders and women and child health; AIIMS Jodhpur focuses on geriatric health; AIIMS Nagpur on cancer care; and AIIMS Rishikesh on geriatric health [1].

The initiative aims to integrate Ayush systems with conventional biomedicine and modern technology to develop holistic healthcare protocols, improve patient outcomes, and generate robust evidence through high-quality clinical trials in priority areas of national importance. The strategic collaboration, formalized through a Memorandum of Understanding signed on May 11, 2023, supports integrative research, capacity building, and development of evidence-informed clinical approaches⁴⁹ [1].

⁴⁴ New Ayush wings in Defence and Railway Hospitals. Accessed 01.07.2026. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1848810®=48&lang=2>

⁴⁵ Dr. Mansukh Mandaviya Chairs 198th Meeting of Employees' State Insurance Corporation (ESIC) at New Delhi. Accessed 01.07.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2279526®=48&lang=2>

⁴⁶ 1st ICMR Annual Clinical Trial Meet 2026 highlights India's emerging leadership in integrative medicine research. Accessed 06.07.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2263574&lang=1®=1>

⁴⁷ Ibid.

⁴⁸ Dr Mansukh Mandaviya launches Ayush-ICMR Advanced Centre for Integrated Health Research in AIIMS. Accessed 01.07.2026. <https://www.pib.gov.in/PressReleaseSelfPage.aspx?PRID=2011170&lang=2®=3>

⁴⁹ Centre for integrated health research. Accessed 01.07.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2039145>

Digital initiatives

The Ministry of Ayush has developed Ayush Grid [41], a digital ecosystem developed in alignment with the Ayushman Bharat Digital Mission to enable interoperability between Ayush and the national digital health infrastructure. Ayush Grid encompasses a suite of digital platforms, including the Ayush Hospital Management Information System (A-HMIS)⁵⁰, the NAMASTE (National Ayush Morbidity and Standardized Terminologies Electronic) Portal⁵¹ for standardized clinical terminology and morbidity reporting and the Showcasing of Ayurvedic Historical Imprints (SAHI) portal⁵² or documenting Ayurveda's historical heritage.

Telemedicine services have also been expanded through eSanjeevani⁵³. Together, these initiatives support digital service delivery, health information exchange, evidence generation, and data-driven governance while integrating Ayush into India's evolving digital health ecosystem.

Internationalisation of Ayush

The international footprint of Ayush has expanded bilateral, regional, and multilateral collaborations. The Ministry of Ayush has signed 27 country-level Memoranda of Understanding on cooperation in traditional medicine and 57 institute-level agreements with foreign universities and research organizations⁵⁴, while establishing 43 Ayush Information Cells in 39 countries⁵⁵.

Collaboration with the WHO has emerged as a cornerstone of this internationalization. India signed the Host Country Agreement for the establishment of the WHO Global Centre for Traditional Medicine, and subsequent agreements have supported technical cooperation on traditional medicine standards, classifications, and evidence generation⁵⁶.

In May 2025, during the World Health Assembly, India's Ministry of Ayush signed a USD 3 million Memorandum of Understanding with WHO to support the inclusion of traditional medicine in the International Classification of Health Interventions, including the classification and standardization of Ayurvedic, Siddha, Unani practices within global health-care data frameworks. India further strengthened its international engagement by co-hosting the Second WHO Traditional Medicine Global Summit in New Delhi in December 2025, which culminated in the Delhi Declaration on Traditional Medicine and the launch of the WHO Traditional Medicine Global Library⁵⁷. Three institutions under the Ministry of Ayush are also designated as WHO Collaborating Centres in relevant areas of traditional medicine.

Beyond WHO, India has actively advanced Ayush through multilateral platforms including BRICS, G20, Shanghai Cooperation Organisation, and Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation. During India's BRICS Presidency in 2026, the BRICS Health Ministers' Declaration included a dedicated section on TCIM and endorsed a BRICS Expert Working Group on TCIM and supported the development of a Framework for BRICS Cooperation in TCIM focusing on research, capacity building, digital knowledge exchange, and integration into health systems. India has also promoted traditional medicine through the G20

⁵⁰ A-HMIS. Accessed 01.07.2026. <https://ahmis.ayush.gov.in>

⁵¹ NAMASTE portal. National Ayush morbidity and standardized terminologies electronic portal. Accessed 01.07.2026. <https://namaste.ayush.gov.in>

⁵² SAHI NIIMH. Accessed 01.07.2026. <https://sahi.niimh.res.in/>

⁵³ eSanjeevani. Accessed 10.08.2026. <https://esanjeevani.mohfw.gov.in/>

⁵⁴ Promotion of Ayush based medical tourism. Accessed 10.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287033®=3&lang=1>

⁵⁵ Global Presence and Partnerships. Accessed 10.08.2026. <https://global.ayush.gov.in/index>

⁵⁶ Ministry of Ayush and World Health Organization signs Host Country Agreement for WHO Global Centre of Traditional Medicine. Accessed 10.08.2026. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1809948&lang=2®=48>

⁵⁷ WHO hosts the second Global Summit to advance evidence, integration and innovation for traditional medicine. Accessed 10.08.2026. <https://www.who.int/news/item/17-12-2025-who-hosts-the-second-global-summit-to-advance-evidence--integration-and-innovation-for-traditional-medicine>

and other multilateral forums, alongside bilateral research, academic, and regulatory cooperation [42].

The Ministry of Ayush, in collaboration with the Indian Council for Cultural Relations, offers scholarships to international students under the Ayush Scholarship Scheme to pursue undergraduate, postgraduate, and doctoral programmes in Ayurveda, Yoga, Unani, Siddha, and Homoeopathy at recognized Indian institutions⁵⁸.

Insights and future directions for BRICS cooperation in traditional, complementary and integrative medicine

Joint research networks

The network should prioritise multinational clinical trials for conditions with a substantial public health importance across multiple BRICS countries: type 2 diabetes, hypertension, musculoskeletal pain, anxiety and depression, dementia, anemia, and metabolic syndrome. Priorities should also reflect existing TCIM use, preliminary evidence, safety, and feasibility of harmonised multicountry protocols [43–45].

Potential traditional medicine interventions, such as Ashwgandha (*Withania somnifera*), black cumin (*Nigella sativa*), turmeric (*Curcuma longa*), acupuncture, and yoga, could provide starting points for collaborative research. A BRICS TCIM trial coordination platform linked to existing WHO-recognised registries could facilitate multicountry study registration and transparency [7, 46, 47].

Regulatory cooperation

Harmonisation of TCIM regulatory standards across BRICS could facilitate product quality assurance, trade, and multinational trial conduct. India's Pharmacopoeia Commission for Indian Medicine and Homoeopathy standards, China's National Medical Products Administration herbal drug guidelines, Indonesia's Food and Drug Authority tiered framework, and Iran Food and Drug Administration standards represent four distinct but potentially convergent reference systems [20, 48]. A regulatory workstream within the BRICS Expert Working Group on TCIM could address pharmacopoeial convergence, harmonised GMP requirements, shared pharmacovigilance approaches, and common principles for traditional medicine product quality classification⁵⁹. Such work should build on existing WHO mechanisms, particularly the International Regulatory Cooperation for Herbal Medicines and the development of the WHO International Herbal Pharmacopoeia, rather than creating parallel standards⁶⁰.

Traditional medicine pharmacovigilance

A BRICS TCIM Pharmacovigilance Network, linking national adverse drug reaction monitoring systems could strengthen pooled post-marketing safety surveillance and cross-national signal detection. China's established Traditional Chinese Medicine adverse drug reaction database, India's Pharmacovigilance Programme of India-Ayush, and Indonesia's Food and Drug Authority pharmacovigilance system could provide

⁵⁸ Ayush Scholarship Scheme 2026-2027. Accessed 01.07.2026. <https://www.indembarg.gov.in/page/ayush-scholarship-scheme-2025-26>

⁵⁹ BRICS elevates traditional medicine with landmark declaration and new expert working group. Accessed 01.07.2026. <https://www.who.int/news/item/27-07-2026-brics-elevates-traditional-medicine-with-landmark-declaration-and-new-expert-working-group>

⁶⁰ WHO advances global harmonization of herbal medicine standards through expert meeting on the development of international herbal pharmacopoeia. Accessed 01.07.2026. <https://www.who.int/vanuatu/news/detail-global/23-06-2026-who-advances-global-harmonization-of-herbal-medicine-standards-through-expert-meeting-on-the-development-of-international-herbal-pharmacopoeia>

the foundational data infrastructure^{61, 62, 63}. A shared TCIM signal detection methodology, aligned with the WHO Programme for International Drug Monitoring, could support harmonised adverse-event reporting and detection of herb–drug interaction signals across countries⁶⁴.

Digital traditional medicine platforms

The development of a BRICS shared digital TCIM platform, integrating TCIM telemedicine, health data collection, International Classification of Diseases, 11th Revision, Traditional Medicine Module implementation, practitioner directory, and evidence resource access, represents a potential cooperation deliverable [49]. India's eSanjeevani, A-HMIS, and NAMASTE platforms provide working prototypes [41, 50]. Such a platform could support harmonised outcome data, links between pharmacovigilance systems, multilingual evidence resources, and professional development, subject to national requirements for privacy, licensing, and data governance. The WHO Traditional Medicine Global Library development is one of the examples of international cooperation in digital space⁶⁵.

Academic exchanges

Systematic academic exchange programmes between BRICS TCIM institutions could strengthen research capacity, mutual understanding, and professional networks. India's Ayush Academic Chairs in foreign universities could be extended within BRICS, for creating a network of institutional linkages that complement governmental Memoranda of Understanding with practitioner and researcher relationships⁶⁶. A BRICS TCIM scholarship programme, enabling graduate students from one member country to pursue postgraduate TCIM training in another, could accelerate mutual learning across the grouping's diverse traditional medicine systems [1].

Common evidence standards

A further priority is the development of shared, BRICS-endorsed standards for TCIM clinical evidence generation. Drawing on WHO guidance on methodologies for research and evaluation of traditional medicine⁶⁷ and the WHO Global Traditional Medicine Strategy 2025–2034⁶⁸, EQUATOR reporting guidelines, and national clinical research guidance, the BRICS Expert Working Group on TCIM could develop minimum methodological and reporting standards for collaborative trials, shared approaches to outcome validation, and principles for evidence appraisal that accommodate relevant features of traditional medicine while maintaining internationally recognised standards of rigour, transparency, and reproducibility. These common standards could support comparability and international interpretability of evidence generated through BRICS TCIM cooperation.

⁶¹ Kolaborasi BPOM-WHO Tingkatkan Farmakovigilans Obat Bahan Alam [BPOM-WHO Collaboration Improves Pharmacovigilance of Natural Medicines] (in Indonesian). Accessed 01.07.2026. <https://www.pom.go.id/berita/kolaborasi-bpom-who-tingkatkan-farmakovigilans-obat-bahan-alam>

⁶² Annual Report for National Adverse Drug Reaction Monitoring [2020]. Accessed 01.07.2026. https://english.nmpa.gov.cn/2021-03/26/c_654833.htm

⁶³ Ayush Suraksha. National portal for pharmacovigilance of Ayurveda, Unani, Siddha, Sowa-Rigpa & Homeopathy. Accessed 01.07.2026. <https://suraksha.ayush.gov.in>

⁶⁴ BRICS elevates traditional medicine with landmark declaration and new expert working group. Accessed 10.08.2026. <https://www.who.int/news/item/27-07-2026-brics-elevates-traditional-medicine-with-landmark-declaration-and-new-expert-working-group>

⁶⁵ TMGL Resources. Accessed 01.07.2026. <https://tmgl.org>

⁶⁶ Ayush Chair in foreign universities to promote and strengthen traditional Indian medicine systems globally. Accessed 01.07.2026. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2118854&lang=2®=48>

⁶⁷ General guidelines for methodologies on research and evaluation of traditional medicine. Accessed 01.07.2026. <https://www.who.int/publications/i/item/9789241506090>

⁶⁸ Global traditional medicine strategy 2025–2034. Accessed 01.07.2026. <https://www.who.int/publications/i/item/9789240113176>

Conclusion

India's experience suggests that the effective incorporation of TCIM may require coordinated governance, regulation, education, research, and service delivery. The development of Ayush illustrates how traditional medicine can be progressively incorporated into public health systems while retaining distinct knowledge and practice frameworks. India's experience also indicates that integration is not a single intervention but a dynamic and iterative process requiring continuous evidence generation, quality assurance, interdisciplinary collaboration, appropriate financing, and rigorous monitoring and evaluation. Important challenges remain in clinical evidence, quality assurance, interoperability, and implementation across states.

For BRICS partnership, India provides a relevant policy case rather than a prescriptive model. Building upon the WHO Global Traditional Medicine Strategy 2025–2034, BRICS countries could strengthen cooperation in joint research, regulatory cooperation, pharmacovigilance, digital health, academic exchange, and evidence generation. Such collaboration could support safe, evidence-informed, and people-centred incorporation of TCIM across diverse health systems.

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Informed consent statement: Not required.

Funding: The study was not sponsored (own resources).

Competing interests: The authors declare no conflict of interest.

Ethical approval: Not required.

Data sharing: The study used de-identified routine programme surveillance data from Nikshay, accessed through authorised programme channels. Individual-level Nikshay data are not publicly available, and access

Beyond boundaries: an operational intelligence framework using geospatial mapping for precision tuberculosis programmatic action in Tamil Nadu, India

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is subject to permission from the relevant programme authority.

Use of artificial intelligence: No artificial intelligence tools were used in the preparation of this manuscript.

Acknowledgments: The authors gratefully acknowledge Mr. Vettrichelvan Venkatasamy, Senior Health Data Analyst, Translational AI for Networked Universal Healthcare (TANUH) and Indian Institute of Science (IISc) Bengaluru, for his technical guidance in geospatial mapping using QGIS for this study. We also extend our sincere appreciation to the State TB Cell, Government of Tamil Nadu, and all State Consultants and District field teams for their continuous programmatic support and facilitation of data access that enabled this operational analysis.

Manuscript source: Unsolicited manuscript.

Country/territory of origin: India

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Received: 27.06.2026

Accepted: 24.08.2026

Date of publication online: 10.09.2026

Date of publication: 29.09.2026

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ABSTRACT

Tuberculosis (TB) programmatic outcomes are heavily influenced by heterogeneous disease distribution and localized variations in loss to follow-up (LFU). While routine electronic surveillance provides robust epidemiological totals, it may mask localized patterns of treatment attrition.

Aim. To develop an operational geospatial intelligence framework using secondary surveillance data to identify and map LFU hotspots and establish a risk-stratified model for targeted programmatic prioritization.

Materials and Methods. This retrospective operational research study analyzed anonymized treatment outcome records from TB patients ($n = 92,824$) in Tamil Nadu, 2022. Treatment outcomes were aggregated across 234 tuberculosis units (TU) in 35 districts and integrated into a Geographic Information System framework. Spatial autocorrelation (Global Moran's I), Getis-Ord G_i^* hotspot analysis, and Kernel Density Estimation were applied to identify LFU clusters. Spatial outputs were integrated with core epidemiological indicators within a risk-stratification framework.

Results. Spatial analysis demonstrated significant positive spatial autocorrelation (Global Moran's I, $p < 0.001$) and marked heterogeneity in LFU across Tamil Nadu. Getis-Ord G_i^* analysis identified statistically significant hotspots (95–99% confidence). District Tuberculosis Centre Vellore showed the highest LFU proportion (12.0%), with additional priority TU identified across Villupuram, Krishnagiri, Coimbatore, Perambalur, and Trichy. Villupuram contributed three hotspot TU. Overall, 8 TU (3.4%) as high-risk programme areas, providing a basis for more focused programme review and prioritisation.

Conclusion. Geospatial analytics directly compliments routine TB surveillance by replacing uniform programmatic strategies with data-driven, geographically targeted actions. This framework offers a scalable, replicable model to improve treatment retention and accelerate TB elimination targets across high-burden settings.

Key Words: geospatial intelligence; hotspot analysis; loss to follow-up; treatment outcomes; routine surveillance; BRICS; National Tuberculosis Elimination Programme; Healthcare in India

Citation: Frederick A, Regy MM, Thiliban N, Achanta Sh, Deka D, Chandra Sh, Rajan Sh. Beyond boundaries: an operational intelligence framework using geospatial mapping for precision tuberculosis programmatic action in Tamil Nadu, India. *The BRICS Health Journal*. 2026;3(2):38–48. Epub ahead of print 10.09.2026. <https://doi.org/10.47093/3034-4700.2026.3.2.89>

MeSH terms:

GEOGRAPHIC INFORMATION SYSTEMS
OPERATIONS RESEARCH
SPATIAL ANALYSIS
TUBERCULOSIS

Introduction

Tuberculosis (TB) poses a substantial public health challenge being one of the common leading contributors towards infectious causes of morbidity and mortality across the globe despite progressive efforts towards case management. In 2024, an estimated 10.7 million people developed TB worldwide and 1.23 million died from the disease; the global incidence rate was 131 per 100,000 population. The burden remained highly concentrated, with 30 high-TB-burden countries accounting for

87% of incident cases and India alone accounting for approximately 25% of the global total. Considering the End TB strategy, a requirement of not only early detection but also the sustenance of care cascade weighs much for a successful outcome¹.

The spatial distribution of cases is a critical factor in understanding the geographical variation in treatment outcomes, with marked geographical differences and clustering reported in several high-burden settings, including border areas, calling for a more structured approach applicable to a defined context. For example, Alene et al. analysed treatment outcomes among 223,244 patients with TB across 722 districts in Ethiopia and found that 9.0% had poor treatment outcomes, including 12,200 patients (5.5%) who were lost to follow-up. The proportion of poor treatment outcomes varied markedly across geographical areas, from 1% to 58%, with significant hotspots identified in districts near international borders in the Afar, Gambelia, and Somali regions [1].

A surveillance model commonly lies on fundamental data, like cohort and cases follow-up, however for further evidence-based monitoring and subsequent program decisions, it is critical to look at comprehensive factors influencing rather than serving solely relying on available epidemiological information for a more holistic and strategic approach to monitoring [2]. In this context, such geographical heterogeneity suggests that state – or district-level aggregate indicators alone may be insufficient to identify programme areas where loss to follow-up (LFU) is disproportionately concentrated, supporting the use of more granular spatial analyses for programme monitoring and prioritization. Comparable subnational heterogeneity in TB burden has been reported elsewhere, including marked county-level differences in China, supporting the use of region-specific approaches to TB control [3].

Previous studies have demonstrated the value of geospatial approaches for characterising heterogeneity in TB burden and treatment outcomes. In Tamil Nadu, Muniyandi et al. used spatial autocorrelation and hotspot analysis to demonstrate district-level variation in TB prevalence and to identify geographical areas that could be prioritised for TB control activities [4]. Evidence from India also indicates that LFU remains an important programme outcome. In a multicentric prospective cohort of 2,006 people with drug-susceptible pulmonary TB from India, 18% experienced an unfavourable outcome during follow-up, including 6.8% who were lost to follow-up [5]. In Chennai, Thomas et al. reported substantial pretreatment LFU among smear-positive patients managed through the public TB programme, with an overall pretreatment loss-to-follow-up rate of 22.1%, highlighting important gaps in continuity of care even before formal treatment registration [6]. In Ethiopia, Alene et al. analysed national routine TB data and identified significant spatial variation and clustering of poor treatment outcomes, including LFU, at district and zone levels [1]. Similarly, Zhang et al. identified spatial clusters of poor TB treatment outcomes using electronic surveillance data from Shanghai, China [7].

Although these studies demonstrate the usefulness of spatial analysis for identifying geographical heterogeneity in TB burden and treatment outcomes, they do not directly address the specific operational application examined in the present study: the integration of routine treatment-outcome surveillance data with spatial analyses at the sub-district tuberculosis unit (TU) level to support LFU-based programme prioritisation in Tamil Nadu. In this study, we extend this line of work by combining spatial analysis with routine programme surveillance data

¹ Global tuberculosis report 2025. Accessed 05.07.2026. <https://www.who.int/teams/global-programme-on-tuberculosis-and-lung-health/tb-reports/global-tuberculosis-report-2025>

to identify priority areas for LFU monitoring and targeted programme action at the TU level in Tamil Nadu.

This study aimed to develop an operational geospatial intelligence framework using secondary surveillance data to identify and map spatial hotspots for programmatic outcomes such as LFU, and to structure a risk-stratified model for targeted programmatic prioritization across TU in Tamil Nadu.

Materials and methods

Study design and setting

A retrospective operational research study with a geographical and programmatic approach was conducted using anonymised secondary surveillance data routinely collected under the national surveillance web-based portal for the National Tuberculosis Elimination Program (Nikshay). The study used outcome records of TB cases notified in Tamil Nadu, India, in 2022. The study therefore pertained to the 2022 notification cohort, with treatment outcomes assessed after completion of the available two-year outcome-ascertainment period. Data were extracted from Nikshay on 03 April 2025.

As a state, Tamil Nadu is located in southern India, sharing boundaries with Kerala, Karnataka, Andhra Pradesh, and the Union Territory of Puducherry also posing the possibility of geographically adjacent distribution resulting in frequent scope of migration, varying healthcare access, and systemic vulnerabilities that may contribute to increased LFU.

The study used retrospective, anonymized secondary surveillance data from the National Tuberculosis Elimination Programme. The study involved no direct participant contact, intervention, or collection of additional identifiable information. Therefore, institutional ethics committee approval and individual informed consent were not required. Patient confidentiality and privacy were maintained through the use of de-identified data.

TU is a sub-district administrative unit under the National Tuberculosis Elimination Programme responsible for programme implementation and patient management, typically covering a population of approximately 250,000 to 300,000 individuals, with dedicated staff for TB surveillance, diagnosis, treatment and follow-up.

LFU is one of the unfavorable outcomes and defined as cases lost to treatment out of the total notified cases (based on current cohort) with transfers excluded to ensure LFU was accurately represented as treatment dropouts within addressed state. In accordance with the National Tuberculosis Elimination Programme, a patient was classified as lost to follow-up when anti-tuberculosis treatment was interrupted for one consecutive month or more. For the present analysis, the TU-level LFU proportion was calculated as the number of patients with LFU as the final recorded treatment outcome divided by the corresponding current treatment outcome cohort, of that TU, expressed as a percentage.

Study population

A total of 94,536 TB cases notified in Tamil Nadu during 2022 constituted the initial source cohort retrieved from Nikshay. Following data validation and treatment-outcome ascertainment, 92,824 patient records constituted the final eligible analytical cohort, corresponding to the exclusion of 1,712 records (1.81%) that did not fulfil the analytical criteria. Exclusions criteria were duplicate records, incomplete/invalid records, transferred-out cases and records for which the required final treatment outcome information was not available. Transferred records

and records without an ascertainable final treatment outcome were excluded from the outcome analysis to restrict the analysis to outcomes attributable to the reporting geography.

Within the statewide cohort, 2,653 patients were recorded as LFU. Patient-level treatment-outcome information was subsequently aggregated at the TU level to derive TU-specific LFU proportions for the epidemiological and geospatial analyses. Thus, the patient-level cohort and the TU-level spatial analytical units represent sequential levels of the same analytical pathway rather than separate study populations.

An initial exploratory geographical assessment was additionally undertaken using 16 of the 35 districts in Tamil Nadu, comprising eight border districts and eight population-comparable non-border districts. This exploratory subset was used to examine geographical variation in LFU and informed the subsequent extension of the analysis to TU-level spatial assessment. Importantly, cases outside this exploratory geographical subset were not excluded from the statewide analytical cohort.

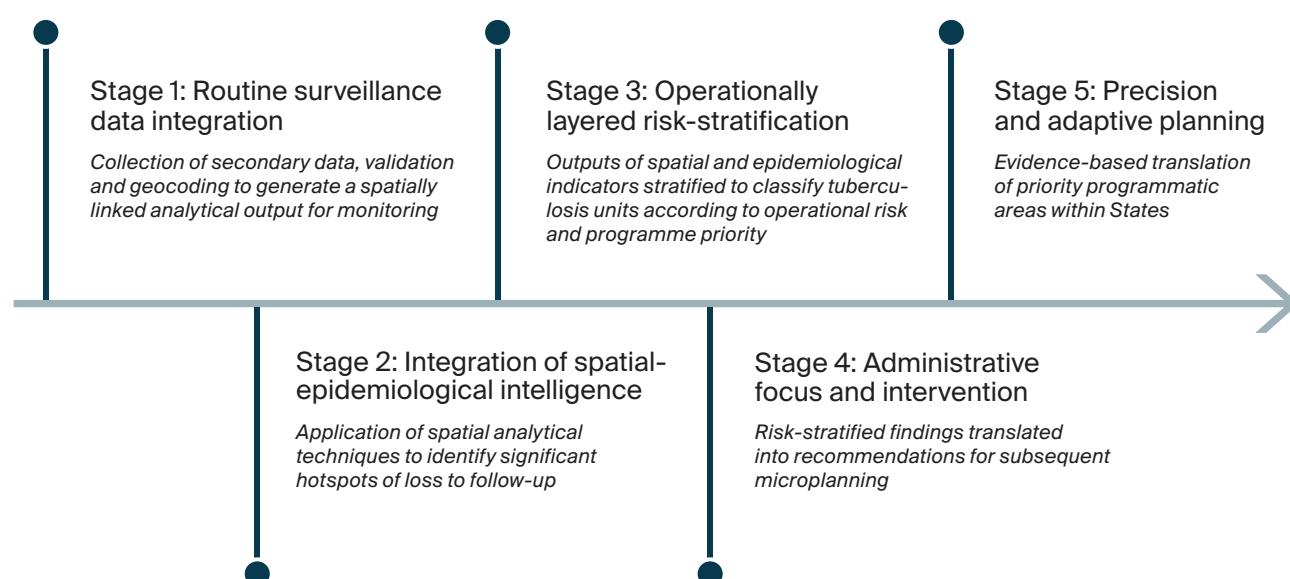
The Operational Intelligence Framework

The analytical structure of the integrated approach was guided by the Timeline-based Operational Intelligence Framework, developed to systematically translate routine surveillance data into evidence-informed program action. The framework was intended to operate as a continuous surveillance-based-action cycle, enabling periodic reassessment and follow-up based on updated surveillance data. The framework comprised five sequential stages which are presented in Figure 1.

Data management and geocoding

The surveillance dataset was systematically validated for quality assurance prior to spatial analysis. Cases and outcomes were subsequently aggregated at the TU level and TU-level LFU proportions constituted the spatial analytical variable. TU-level latitude and longitude coordinates were obtained from the Nikshay State coordinates dataset and linked to the corresponding LFU proportions. The geospatial base layers were

FIG. 1. Sequential stages of the Operational Intelligence Framework



obtained from the India-WRIS geospatial data repository. These spatial datasets were integrated and linked with corresponding administrative boundary shapefiles using the geographic information system – QGIS v3.40.3 (open-source GIS software) to generate a spatially referenced analytical database appropriate for epidemiological and geospatial analysis.

Spatial analysis

Spatial epidemiological analyses were undertaken to characterise the geographical distribution of LFU across Tamil Nadu, while descriptive epidemiological analyses were performed to estimate LFU proportions across each TU. Spatial analyses were conducted at the aggregated TU level rather than at the individual-patient level. This was followed by assessment of Global spatial autocorrelation using Global Moran's I [8] to determine whether the significant spatial distribution of LFU patterns was by-chance or weighed real.

Local clustering of high-risk areas was identified using Getis-Ord Gi* hotspot analysis [9], enabling detection of statistically significant hotspots at 95% and 99% confidence level. Kernel Density Estimation (KDE) [10] was additionally employed to visualise the spatial intensity of LFU and identify areas with higher concentrations of LFU. KDE was used primarily as a spatial visualisation tool rather than as an independent measure of statistical significance. The geographical inputs represented TU-level coordinates rather than individual patient residential locations; therefore, the resulting KDE map was interpreted as programme-level spatial intensity rather than patient-level disease density. Integration of these complementary spatial analytical techniques enabled the identification of priority geographical areas requiring focused programme attention was enabled.

Operational risk stratification

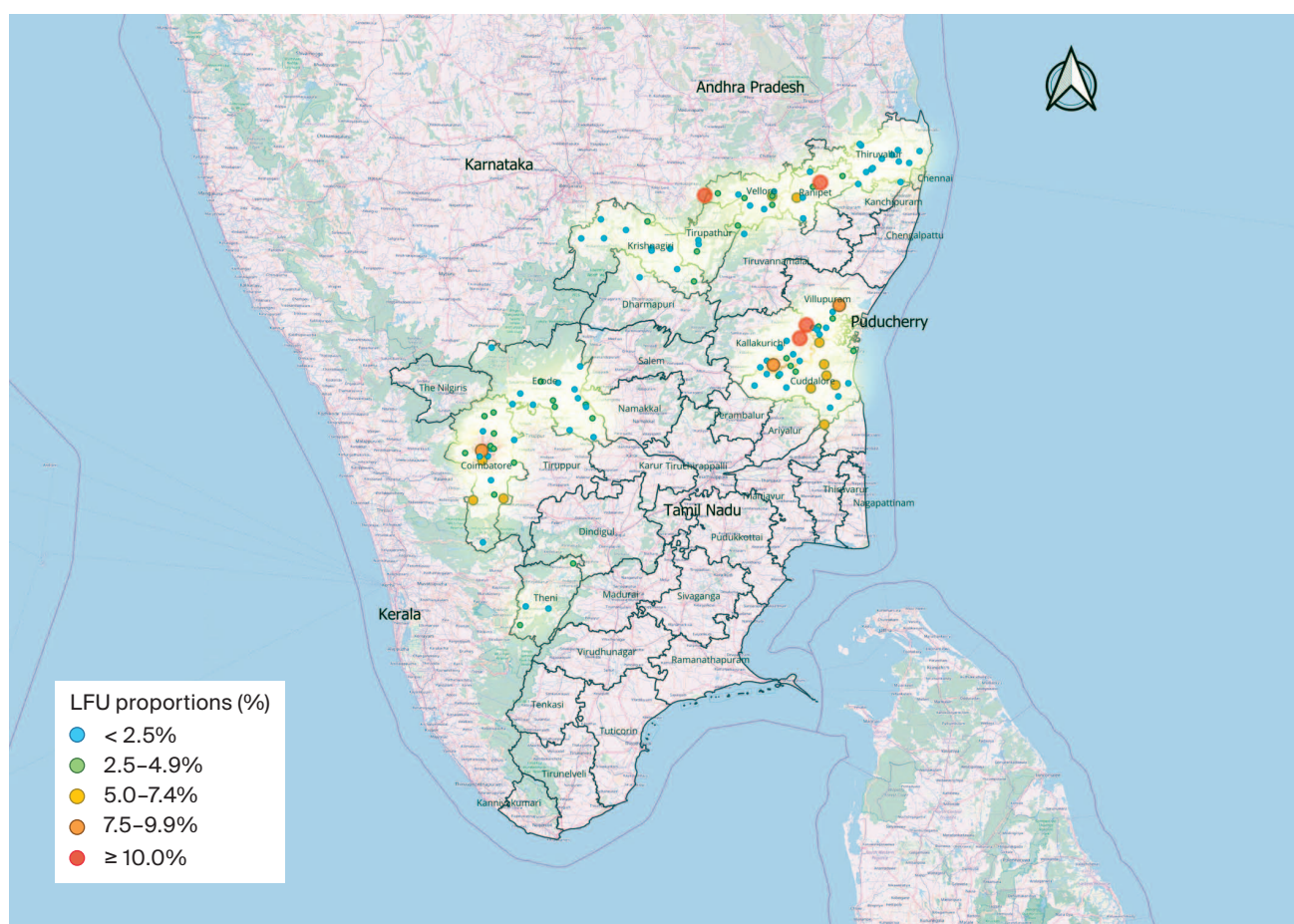
Spatial outputs generated through Global Moran's I, Getis-Ord Gi* hotspot analysis and KDE [10] were integrated with routine epidemiological indicators to develop an operational risk-stratification framework. TU within districts were categorised according to spatial clustering, hotspot significance and LFU burden to identify programme areas requiring differentiated levels of administrative attention. For descriptive programme prioritisation, TU with LFU $\geq 10\%$ were classified as high-LFU hotspots, while TU with comparatively elevated LFU proportions located around the identified hotspot areas were categorised as peripheral hotspots. Areas demonstrating convergence of elevated LFU burden and spatial clustering were considered high-priority programme areas within the Operational Intelligence Framework. High-risk TU were prioritised for targeted programme interventions, and this approach was intended to translate descriptive spatial findings into operationalizing evidence-based programme decision-making.

Results

A total of 92,824 individuals with TB notified under the programme in Tamil Nadu (2022 cohort) were included in the analysis and the final dataset represented 35 districts and 234 TU across Tamil Nadu.

The spatial distribution of LFU outcomes demonstrated geographical heterogeneity across the state, more towards the borders visually (Figure 2). Global Moran's I analysis showed statistically significant positive spatial autocorrelation ($p < 0.001$), indicating that the observed distribution of LFU was spatially clustered rather than randomly dispersed. Getis-Ord

FIG. 2. Spatial distribution of tuberculosis loss to follow-up proportions across Tuberculosis Units in Tamil Nadu, 2022



Note: LFU – loss to follow-up.

GI* hotspot analysis identified one statistically significant hotspot at District Tuberculosis Centre Vellore, which reported the highest LFU proportion (11.97%). In addition, other hotspot TU were identified across Villupuram, Krishnagiri, Coimbatore, Perambalur and Trichy districts (Table 1). Villupuram district contributed three of the identified hotspot TU, suggesting concentrated sub-district clustering within the district. The KDE further demonstrated areas of increased LFU intensity corresponding to the identified hotspot regions, showing localized areas of higher LFU

Table 1. Loss to follow-up hotspots identified from spatial mapping

District	TU	Current treatment-outcome cohort, n	LFU, n	LFU proportion, %	Operational classification
Vellore	DTC Vellore	259	31	11.97	Hotspot
Villupuram	Sathiyamangalam	238	28	11.76	Hotspot
Villupuram	Murukkeri	213	25	11.74	Hotspot
Krishnagiri	Barur	148	14	9.46	Peripheral hotspot
Villupuram	Kiliyanur	242	22	9.09	Peripheral hotspot
Coimbatore	Singanallur	191	17	8.90	Peripheral hotspot
Perambalur	Thirumanur	153	13	8.50	Peripheral hotspot
Tiruchirappalli	Ariyamangalam	283	23	8.13	Peripheral hotspot

Note: TU – tuberculosis unit; LFU – loss to follow-up; DTC – District Tuberculosis Centre.

concentration. Spatial analysis identified few high-risk TU with clustered LFU burden, predominantly along border districts, supporting risk-based need for targeted interventions.

As a three-step approach, from descriptives to Geo-Spatial analysis followed by Risk-stratified framework modelling, the structure of the Operational Intelligence Framework (Table 2) provided a layered approach for evidence-based programme follow-up on a timeline basis, respectively.

Discussion

Routine disease surveillance provides epidemiological insights with the ongoing monitoring data. However, programme indicators frequently overlook important geographical variations in disease burden and treatment outcomes. In this study, geospatial analyses demonstrated significant clustering of LFU across Tamil Nadu along with identifying few high-priority TU that accounted for a heterogenous burden of LFU. Building upon these findings, we developed the Operational Intelligence Framework that integrates spatial epidemiology with programme decision-making to facilitate risk-based prioritization and targeted programme action.

The concentration of higher LFU in a relatively small number of TU is important from a programme perspective because state- or district-level averages may not reflect variation at the sub-district level. Identifying these local differences may help programme teams recognise areas that need closer review and follow-up.

The observed spatial clustering of LFU though remained consistent with studies demonstrating that burden and treatment outcomes, not being uniformly distributed, may vary according to local epidemiological, demographic and health system factors. Geospatial analytical techniques, including Global Moran's I, Getis-Ord Gi* hotspot analysis and KDE [10], have been increasingly applied to identify geographical clusters of TB and support targeted public health interventions [8–10]. Similarly, spatial heterogeneity reported from studies done across other high-burden settings such as China, Ethiopia and South Africa, where spatial and hotspot analyses facilitated the identification of priority areas for intensified programme management [11–13].

Geographical variation in TB burden has been reported within Tamil Nadu. Muniyandi et al. demonstrated substantial district-level variation in self-reported TB prevalence using spatial autocorrelation and hotspot analysis; the adjusted prevalence decreased from 356 per 100,000 population in 2014–2015 to 184 per 100,000 in 2019–2021, while persistent

Table 2. The Operational Intelligence Framework with integrated epidemiological and spatial approach

Stage	Timeline	Key Activity	Output	Implication
Routine surveillance data integration	Weeks 1–2	Data collection, validation, and geocoding	Spatially linked surveillance database	Preliminary analysis for channelling direction
Integration of Spatial-Epidemiological intelligence	Weeks 2–3	Descriptive epidemiology, Global Moran's I, Getis-Ord Gi*, KDE, GIS mapping	Hotspot maps and spatial clusters	Identification of high-risk areas
Operationally layered risk-stratification	Weeks 3–4	Integrate epidemiological and spatial indicators; classify TU based on risk	Risk-prioritised TU and districts	Evidence-based resource prioritisation
Administrative focus and intervention + Precision and adaptive planning	Week 4	Review hotspot findings, and microplan for more focussed interventions	Targeted action plan	Optimised programme management and way forward

Note: GIS – geographic information system; KDE – Kernel Density Estimation; TU – tuberculosis unit.

geographical differences remained between districts. The authors suggested that spatial identification of high-prevalence areas could support programme managers in focusing control activities [4].

The use of routine programme data for local spatial analysis has also been explored in other parts of India. Poojar et al. mapped 507 drug-resistant TB patients notified from three districts of Karnataka between 2015 and 2018 and observed an increase in both the geographical area of aggregation and the number of spatial grids containing more than the expected number of drug-resistant TB cases. Their findings showed that routinely collected TB data can provide useful spatial information for programme planning. However, their analysis focused on the distribution of drug-resistant TB, whereas the present study uses treatment outcome data to identify areas with higher LFU [14].

A closer comparison can be made with the study by Alene et al. in Ethiopia, previously discussed in the Introduction, which similarly demonstrated substantial geographical variation and spatial clustering of poor TB treatment outcomes, including LFU, with several clusters located near international borders [1].

In Shanghai, Zhang et al. analyzed 53,475 pulmonary TB patients and reported an overall treatment success rate of 91.6%, but identified 12 spatial clusters of poor treatment outcomes during the study period. This is relevant to the present findings because it shows that favourable aggregate programme indicators do not necessarily exclude local areas with poorer outcomes. Such local variation may therefore be missed when programme performance is assessed only at a higher administrative level [7].

The observed geographical heterogeneity should also be considered alongside known patient-level determinants of unfavorable treatment outcomes in India. In a multicentric prospective cohort of 2,006 persons with drug-susceptible pulmonary TB, Prakash Babu et al. reported unfavorable outcomes in 18% of participants, including LFU in 6.8%. Older age, male sex, lower educational attainment, underweight status, and alcohol use were associated with poorer outcomes. These findings suggest that spatial concentrations of LFU may reflect a combination of patient characteristics, socioeconomic conditions, mobility, and health-system factors rather than geography alone. Such determinants were not examined in the present analysis and therefore cannot be inferred from the observed spatial clusters [5].

Considering most of these studies have their preliminary focus towards describing spatial patterns or disease clustering, our study emphasized utilizing this lead to help plan more targeted interventions as a way forward template, thereby integrating geo-spatial epidemiology with the Operational Intelligence Framework that systematically links surveillance data, spatial risk stratification and helps sustain the evidence-based monitoring approach in the defined geography.

The use of the TU as the unit of analysis allows the spatial findings to be linked more directly with the administrative level at which programme follow-up is organised. In this framework, hotspot identification is not considered an endpoint, but rather a way to identify areas where closer review and additional programme attention may be required. The framework therefore provides a practical approach for combining routinely available epidemiological indicators with spatial information. However, the present study did not evaluate whether such prioritisation results in more efficient resource allocation or improved treatment outcomes.

The proposed framework may have implications for programme management, specifically within resource-constrained settings where

uniform implementation may not adequately address local epidemiological variation. Risk-based prioritization may help higher administrations to allocate supervisory and innovative support, health-system strengthening and utilization of novel community-based interventions based on local needs.

Although developed using routine monitoring data from Tamil Nadu, the proposed framework model may be adaptable across other Indian states and high-burden countries with existing digital monitoring platforms. Its application in other settings, however, would require consideration of local surveillance structures and programme contexts.

One practical advantage of this approach is that it is based mainly on data already collected through routine TB surveillance. Where treatment-outcome data and geographical identifiers are sufficiently complete, similar analyses could potentially be included in periodic programme reviews without establishing a separate surveillance system. Importantly, identification of a hotspot should be considered a signal for further local assessment rather than an indication of a specific intervention. Programme teams would still need to determine whether higher LFU is related to patient mobility, access to services, treatment support, data quality, or other local factors before deciding on an appropriate response.

Additionally, the incorporated analytical principles may be extended to other public health programs requiring geographically targeted implementation strategies, including malaria, leprosy, acquired immunodeficiency syndrome and other neglected tropical diseases. The same general approach may be relevant to these programmes, although the indicators, geographical units, and criteria for prioritisation would need to be adapted to the specific disease and programme context.

These findings should be interpreted in light of several limitations. The framework was developed using routine surveillance data from a single calendar year as part of a pilot geospatial analysis at the state level. Therefore, the findings reflect the spatial distribution observed for the 2022 cohort and require validation across additional time periods and diverse epidemiological and programmatic settings. The analysis relied on available secondary surveillance data, which may be subject to variations in data completeness and reporting quality. Although data validation was performed before the integrated analysis, the study remained dependent on the completeness and accuracy of information recorded in the surveillance system.

The analysis did not incorporate individual-level socioeconomic variables (such as income, education, occupational mobility) or detailed migration histories. As a result, the study could not fully explore the complex relationship between social determinants, patient migration, and LFU among TB patients. Spatial patterns may depend on the geographical unit used for aggregation. The present findings reflect TU-level patterns in Tamil Nadu and may differ if the same data are analysed at the district, facility, or individual-location level.

Conclusion

This study showed that LFU was not uniformly distributed across TU in Tamil Nadu and that a limited number of areas had a higher LFU burden. Combining routine surveillance data with geospatial analysis helped identify these local differences and provided a practical basis for more focused programme monitoring and prioritisation. The identified clusters should be considered areas for further programme review rather than direct evidence of specific causes of LFU.

The proposed approach may also be useful in other high-burden settings where routine digital TB surveillance data are available. This may be particularly relevant for BRICS countries, which include several settings with a substantial TB burden and growing use of data-driven approaches in public health programmes. However, the framework would need to be adapted to local programme structures and evaluated across different time periods and settings before its broader use can be recommended. Future studies should assess whether this approach can contribute to better programme decision-making, more focused use of resources, and improved treatment retention.

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Transforming cancer care in emerging economies: India's AI innovation

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Informed consent statement: Not required.

Funding: The development of iOncology.ai software was supported by grants from the Ministry of Electronics and Information Technology (MeitY), Government of India.

Competing interests: Several authors are affiliated with the All India Institute of Medical Sciences, New Delhi, and the Centre for Development of Advanced Computing, Pune, the institutions involved in the development of iOncology.ai. The iOncology.ai project received financial support from the Ministry of Electronics and Information Technology, Government of India. These institutional affiliations and project funding are disclosed for transparency. The authors declare no personal financial or commercial conflicts of interest related to the work described in this manuscript.

Ethical approval: Not required.

Data sharing: All data used in this paper are publicly available.

Use of artificial intelligence: No artificial intelligence tools were used in the preparation of this manuscript.

Acknowledgments: The authors express gratitude to Mr. Shobhit Gupta, Under Secretary to the Govt of India, Ministry of Health and Family Welfare, for extending guidance in finding information.

Manuscript source: Unsolicited manuscript.

Country/territory of origin: India

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ABSTRACT

Cancer remains a major public health challenge across BRICS member countries. Together, these countries represent more than 40% of the global population and account for approximately 9.0 million new cancer cases and 4.66 million cancer deaths. This review aims to summarize cancer epidemiology across the 11 BRICS member countries, with emphasis on breast and ovarian cancers, describe India's cancer-control and digital-health architecture, and assess the evidence and translational potential of iOncology.ai. Cancer patterns and access to screening, early diagnosis, and specialist oncology care vary across member countries. Breast cancer is among the leading malignancies affecting women and is the leading female cancer in most BRICS countries. Ovarian cancer is less common but is frequently diagnosed at advanced stages and is associated with poor outcomes. In India, cancer-control activities are delivered through the National Health Mission, the National Programme for Prevention and Control of Non-Communicable Diseases, and complementary surveillance, population-based screening, tertiary-care, and financial-protection mechanisms. The Viksit Bharat 2047 vision and Digital India programme provide a policy context for digital health development, including the Ayushman Bharat Digital Mission. Within this ecosystem, iOncology.ai is a national artificial-intelligence platform undergoing pilot-stage clinical validation and implementation evaluation. The review also identifies priorities for collaborative digital oncology in the context of India's BRICS Chairship in 2026.

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Received: 20.06.2026

Accepted: 19.08.2026

Date of publication online: 10.09.2026

Date of publication: 29.09.2026

© Sharma A., Behera A., Qazi S., Gupta S., Dhamija E., Pandey R., Haresh K.P., Panat L., Swapna Y., Kataria B., Sharma J., Jayraj A.S., Kamboj K., Ray M.D., Khurana S., Batra A., Mishra A., Siraj F., Kumar A., Sharma J.B., Chauhan S.S., Rath G.K., 2026

Key Words: BRICS; Ayushman Bharat Digital Mission; National Health Mission; Viksit Bharat 2047; artificial intelligence

Citation: Sharma A, Behera A, Qazi S, Gupta S, Dhamija E, Pandey R, Haresh KP, Panat L, Swapna Y, Kataria B, Sharma J, Jayraj AS, Kamboj K, Ray MD, Khurana S, Batra A, Mishra A, Siraj F, Kumar A, Sharma JB, Chauhan SS, Rath GK. Transforming cancer care in emerging economies: India's AI innovation. *The BRICS Health Journal*. 2026;3(2):49–69. Epub ahead of print 10.09.2026. <https://doi.org/10.47093/3034-4700.2026.3.2.103>

MeSH terms:

NEOPLASMS

ONCOLOGY SERVICE, HOSPITAL – ORGANIZATION & ADMINISTRATION

MEDICAL INFORMATICS – METHODS

PUBLIC HEALTH SURVEILLANCE

Introduction

Cancer is a generic term for a large group of diseases characterized by abnormal cells that grow beyond their usual boundaries, invade adjoining tissues, and may spread to distant organs; metastasis is a major cause of cancer-related mortality. The Indian Council of Medical Research defines cancer as the uncontrolled and uncoordinated growth of body cells that invade surrounding normal tissues and can spread to distant organs if not checked in time^{1,2}. Despite substantial advances in prevention, screening, diagnosis, molecular characterization, and treatment, cancer remains one of the leading causes of mortality worldwide [1]. International Agency for Research on Cancer estimated 20.64 million new cancer cases and 9.76 million cancer-related deaths globally in 2024, with age-standardized incidence and mortality rates of 194.9 and 87.8 per 100,000 population, respectively³. Lung cancer was the most commonly diagnosed cancer globally (approximately 2.64 million cases; 12.8%), followed by breast cancer (2.43 million; 11.8%) and colorectal cancer (2.04 million; 9.9%)[2]. The global cancer burden is projected to rise to approximately 34.4 million new cases annually by 2050, driven largely by population ageing and growth, together with urbanization, environmental exposures, and changing lifestyle-related risk factors⁴ [2]. The author-generated visualization based on publicly available International Agency for Research on Cancer “Cancer Tomorrow / GLOBOCAN 2024” data illustrate the projected increase in incidence and mortality between 2024 and 2050 for both sexes (Figure 1)⁵.

Low- and middle-income countries (LMIC), including several BRICS member countries, are expected to bear a disproportionate share of this increase due to persistent disparities in cancer prevention, organized screening, early diagnosis, and access to quality oncology services [2, 3]. Although improvements in cancer prevention, screening, and treatment have contributed to better outcomes in many settings, the overall disease burden continues to increase across LMIC because of demographic transition, population ageing,

¹ Cancer. Accessed 04.08.2026. <https://www.who.int/news-room/fact-sheets/detail/cancer>

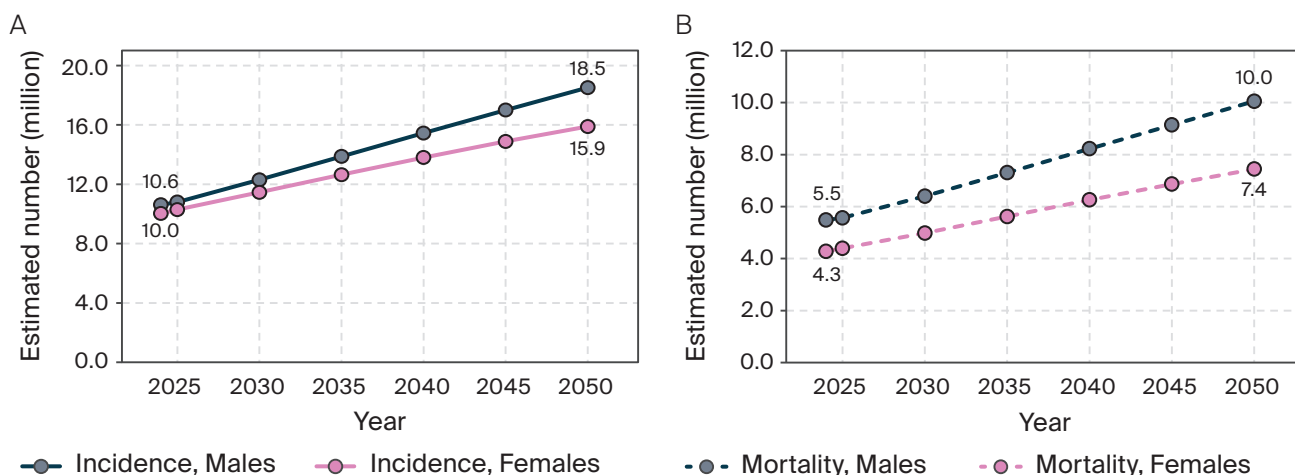
² ICMR – National Institute of Cancer Prevention and Research. Ministry of Health and Family Welfare, Government of India. FAQs. Accessed 13.08.2026. <https://cancerindia.org.in/faqs/>

³ Cancer today. Globocan 2024. Accessed 06.08.2026. <https://gco.iarc.who.int/media/globocan/factsheets/populations/900-world-fact-sheet.pdf>

⁴ Estimated number of new cases from 2024 to 2050, Both sexes, age [0-85+]. All cancers. World. Accessed 04.08.2026. <https://gco.iarc.who.int/tomorrow/en/dataviz/isotype>

⁵ Predictions of the future cancer incidence and mortality burden worldwide up to 2050. Accessed 13.08.2026. <https://gco.iarc.who.int/tomorrow>

FIG. 1. Projected global cancer burden, 2024–2050



Note: A – Incidence; B – Mortality. Author-generated visualization based on publicly available data from the International Agency for Research on Cancer, Global Cancer Observatory, Cancer Tomorrow, GLOBOCAN 2024.

urbanization, and changing lifestyle patterns [2, 4]. Healthcare systems in these countries continue to face multiple constraints, including limited access to organized screening programmes, delayed diagnosis, inadequate pathology and molecular diagnostic infrastructure, shortages of trained oncology specialists, restricted availability of advanced cancer therapies, and insufficient survivorship and palliative care services [2]. LMIC face a double burden of disease, with non-communicable diseases, including cancer, rising rapidly alongside continued morbidity and mortality from infectious diseases. The absolute number of patients diagnosed with cancer annually in LMIC is growing rapidly. By 2030, approximately three-quarters of all cancer deaths will occur in LMIC, with one in eight people experiencing a cancer diagnosis in their lifetime [5]. Most of the increase in the global cancer burden over the next 50 years will come from LMIC (400% in low-income countries, 168% in middle-income countries, 85% in HIC and 53% in very HIC) due to population growth, increasing life expectancy, growing urbanization, and lifestyle changes [2–4, 6].

Recent GLOBOCAN 2024 country profiles demonstrate substantial heterogeneity in cancer burden across the 11 BRICS member countries [2, 7], while BRICS-focused comparative studies have also examined economic burden and trends in cancer incidence, mortality, and disability-adjusted life years [7, 8]. However, to our knowledge, no review identified in the present search has integrated the current 11-member BRICS cancer burden based on GLOBOCAN 2024 with India's cancer-control architecture, digital-health ecosystem, and the emerging iOncology.ai platform. This review's novelty lies in bringing these epidemiological, health-system, digital-health, and national artificial intelligence (AI) components together within a single BRICS-focused framework. Accordingly, this review aims to summarize cancer epidemiology across the 11 BRICS member countries, with particular emphasis on breast and ovarian cancers, describe India's cancer-control and digital-health architecture, assess the evidence and translational potential of iOncology.ai and identify priorities for collaborative digital oncology across BRICS.

A targeted narrative literature search was conducted and updated through 22 August 2026. PubMed/MEDLINE and Google Scholar were

searched using combinations of the terms “cancer,” “breast cancer,” “ovarian cancer,” “BRICS,” “India,” “GLOBOCAN,” “NP-NCD,” “ABDM,” “digital health,” “artificial intelligence,” and “iOncology.ai.” We considered peer-reviewed original studies, reviews, and relevant implementation literature. Authoritative epidemiological and programme-related information was additionally obtained from International Agency for Research on Cancer/Global Cancer Observatory, the World Health Organization, the Ministry of Health and Family Welfare, Indian Council of Medical Research – National Centre for Disease Informatics and Research, National Health Authority, the Ministry of Electronics and Information Technology / Digital India, Press Information Bureau, Parliament of India, and relevant government portals. No lower publication-date restriction was applied; priority was given to recent authoritative sources, while older foundational references were retained where relevant. Sources were selected for relevance, authority, and retrievability.

Cancer epidemiology and digital health opportunities across BRICS nations

The BRICS countries collectively represent more than 48.5% of the world’s population and account for a substantial proportion of the worldwide cancer burden. Population ageing, urbanization, industrialization, environmental exposures, and lifestyle transitions have accelerated the epidemiological shift toward non-communicable diseases, making cancer a major public health and socioeconomic challenge across the region. Owing to their large populations, China and India contribute the highest absolute numbers of cancer cases and cancer-related deaths within the BRICS bloc⁶ [9]. The GLOBOCAN 2024 estimates demonstrate considerable heterogeneity in cancer incidence and mortality among BRICS countries, reflecting differences in demographic structure, risk-factor profiles, health-system capacity, screening practices, and access to diagnosis and treatment. Breast cancer is the leading cancer among women in Brazil, Russia, India, and South Africa, while lung cancer is the leading cancer among women in China. Among men, prostate cancer is the leading cancer in Brazil and South Africa, lung cancer in Russia and China, and lip and oral cavity cancer in India⁷.

Based on the GLOBOCAN 2024 country fact sheets, the cancer burden across the 11 BRICS member countries varies substantially in both magnitude and epidemiological profile. According to GLOBOCAN 2024 data, the 11 BRICS nations collectively represent a major portion of the global cancer burden, both in terms of new diagnoses and mortality. China contributes the largest absolute burden, with approximately 5.15 million new cases and 2.58 million deaths⁸, followed by India with 1.56 million cases and 0.90 million deaths⁹. However, absolute burden does not correspond directly to age-standardized rates. Russia has the highest age-standardized incidence rate among the 11 countries (243.4 per 100,000)¹⁰, followed by Brazil (211.1)¹¹ and China (207.7)¹², whereas India has

⁶ Incidence and Mortality, Both sexes, in 2024. All cancers. Accessed 06.08.2026. https://gco.iarc.who.int/today/en/dataviz/tables?types=0_1&mode=population&key=total&sort_by=value1&populations=156_356_643_710_76

⁷ Population Factsheets. Accessed 06.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations>

⁸ Cancer Today. China. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/156/china>

⁹ Cancer Today. India. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/356/india>

¹⁰ Cancer Today. Russian Federation. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/643/russian-federation>

¹¹ Cancer Today. Brazil. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/76/brazil>

¹² Cancer Today. China. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/156/china>

a substantially lower one (104.1)¹³ despite its much larger absolute burden. Age-standardized mortality similarly varies considerably, ranging from 106.7 per 100,000 in Russia and 92.2 in Iran to 60.4 in India, 59.4 in Ethiopia, and 44.7 in Saudi Arabia¹⁴. These differences illustrate the considerable heterogeneity in cancer risk, demographic structure, disease profile, detection, and survival across the BRICS group. The following charts show substantial variation by country and sex in age-standardized incidence rate in 2024 across BRICS member countries (Figure 2).

Cancer also imposes a substantial economic burden across the BRICS countries through premature mortality and associated productivity losses. Pearce et al. estimated that premature cancer mortality resulted in approximately USD 46.3 billion in productivity losses across Brazil, the Russian Federation, India, China and South Africa in 2012, equivalent to 0.33% of their combined gross domestic product [8]. China accounted for the largest absolute productivity loss (USD 28 billion), while South Africa had the highest productivity loss per cancer death (USD 101,000) [8]. A more recent comparative analysis by Nath et al. compared cancer incidence, mortality, and disability-adjusted life years across the five original BRICS countries and projected future increases in cancer cases and deaths, with the largest percentage increases anticipated in South Africa and India [7]. These findings underscore the importance of strengthening cancer prevention, early detection, and timely access to effective treatment.

The site-specific cancer profiles further demonstrate this heterogeneity. Breast cancer is the leading cancer among women in the overwhelming majority of the BRICS countries, including Brazil, Russia, India, Egypt, Ethiopia, Iran, Saudi Arabia, the United Arab Emirates, Indonesia and South Africa¹⁵. In India, breast cancer accounts for 237,231 new cases (30.4% of female cancers), while in China, lung cancer ranks first among women, followed by thyroid and breast cancer. In several African and Middle Eastern members, infection-related and regionally prevalent cancers remain prominent: cervical cancer is the second most common cancer among women in South Africa and Ethiopia, while liver cancer is the leading cancer overall in Egypt and among Egyptian men. Conversely, China has a particularly prominent burden of lung cancer, which is the leading cancer overall and the leading cancer among both men and women. Indonesia shows a mixed profile, with breast cancer leading among women and lung cancer leading among men, with lung cancer ranking after breast cancer overall. The findings therefore indicate that BRICS does not represent a homogeneous cancer epidemiological setting; rather, it encompasses diverse cancer profiles across member countries. This diversity supports the rationale for country-adapted prevention and screening strategies, while creating opportunities for BRICS-wide collaboration in cancer surveillance, digital health, AI-enabled early detection, data interoperability, and precision oncology.

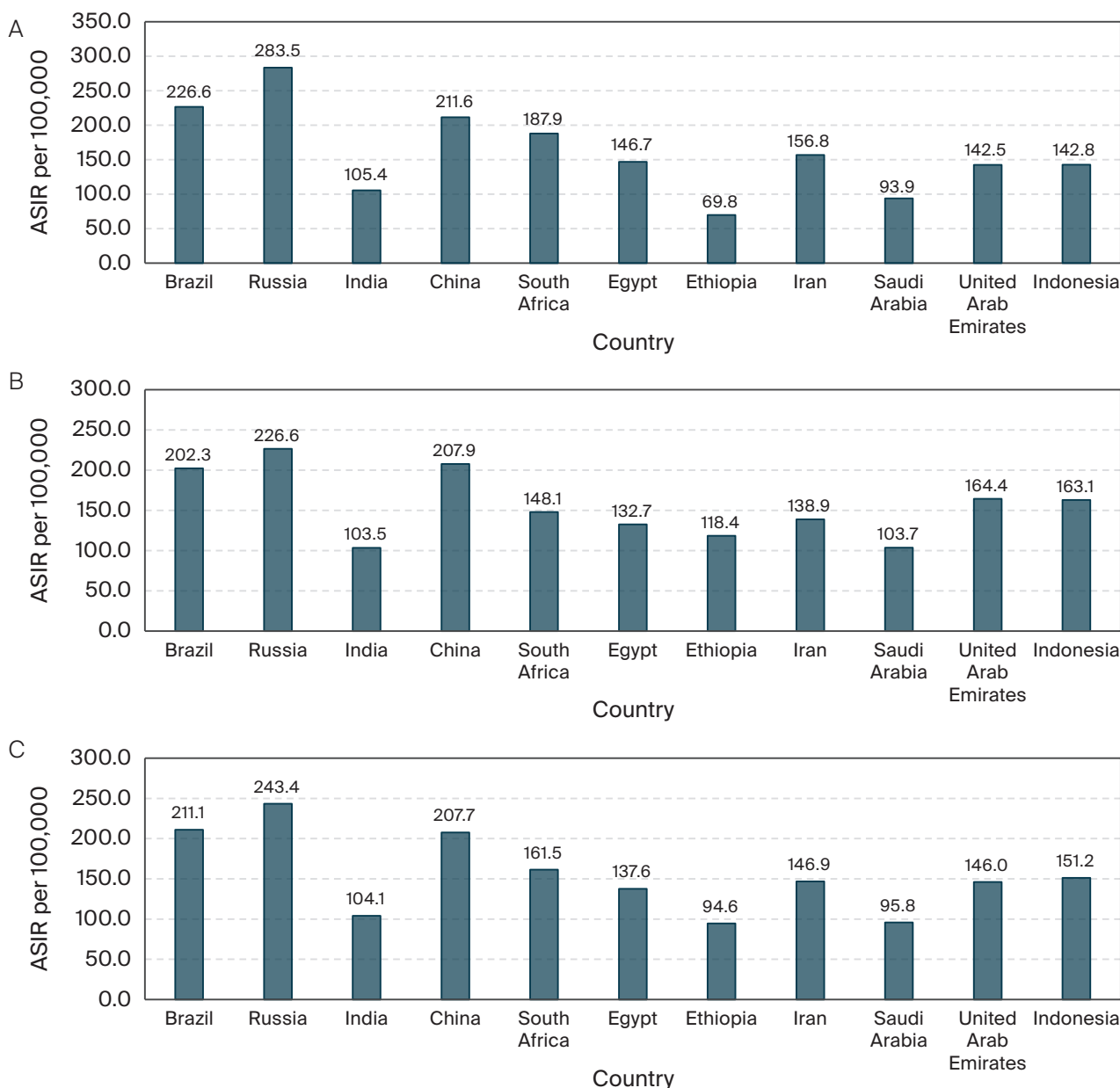
India is experiencing a sustained cancer burden in the context of demographic transition, increasing life expectancy, urbanization, and the growing burden of non-communicable diseases. The GLOBOCAN 2024 estimates indicate that India recorded 1,562,581 new cancer cases and 901,828 cancer-related deaths in 2024. The cumulative risk of developing cancer before the age of 75 years was estimated at 11.2%. Among Indian women, breast cancer was the leading malignancy, accounting for 237,231 new cases (30.4% of all female cancers), while

¹³ Cancer Today. India. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/356/india>

¹⁴ Population Factsheets. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations>

¹⁵ Incidence, Females, in 2024. Accessed 06.08.2026. https://gco.iarc.who.int/today/en/dataviz/tables?types=0&mode=cancer&key=total&sort_by=value1&populations=156_231_356_360_364_643_682_710_76_784_818&group_populations=1&multiple_populations=1&sexes=2

FIG. 2. Age-standardized cancer incidence rates across 11 BRICS member countries



Note: A – Cancer incidence ASIR in BRICS countries – males; B – Cancer incidence ASIR in BRICS countries – females; C – Cancer incidence ASIR in BRICS countries – both sexes. ASIR – Age-standardized incidence rates.

ovarian cancer accounted for 45,566 new cases (5.8%)¹⁶. Based on GLOBOCAN 2024 estimates, India ranked third globally in the absolute number of new cancer cases, after China and the United States¹⁷. GLOBOCAN projections estimate that the annual number of incident cancer cases in India will increase to approximately 2.33 million by 2040, a nearly 49% increase from 2024 estimates^{18,19}. These projections

¹⁶ Cancer Today. India. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/356/india>

¹⁷ Age-Standardized Rate (World) per 100 000, Incidence, Both sexes, in 2024. All cancers. Continents. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/dataviz/bars?mode=population>

¹⁸ Cancer Today. India. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/356/india>

¹⁹ Estimated number of new cases from 2024 to 2040, Both sexes, age [0-85+]. All cancers. World. Accessed 06.08.2026. https://gco.iarc.who.int/tomorrow/en/dataviz/isotype?group_cancers=1&multiple_cancers=1&populations=900&single_unit=1000000&years=2040

indicate the need for scalable approaches that can improve cancer prevention, facilitate earlier diagnosis, and support precision oncology. These epidemiological trends emphasize the importance of strengthening population-based screening programmes and highlight the need for innovative approaches to strengthen cancer prevention, diagnosis, treatment planning, and the continuum of cancer care.

The epidemiological profile of breast and ovarian cancers varies considerably across BRICS member countries, reflecting differences in population size, demographic characteristics, risk-factor distribution, healthcare infrastructure, and access to cancer screening, diagnosis, and treatment. China and India account for the largest absolute numbers of breast and ovarian cancer cases, mostly because of their large populations^{20,21}; however, age-standardized incidence and mortality rates vary substantially across the 11 member countries. For example, the highest absolute burden does not necessarily correspond to the highest age-standardized rates, highlighting important differences in population structure and cancer risk across the region. Table 1 presents a comparative overview of female breast and ovarian cancer incidence, mortality, age-standardized incidence rate, and age-standardized mortality rate across BRICS member countries, providing the epidemiological context for the subsequent analysis.

In India, rapid demographic transition, increasing life expectancy, urbanization, changing reproductive patterns, and lifestyle-associated risk factors have contributed to the increasing burden of breast cancer and other cancers²² [6]. National initiatives, including the National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD) and Ayushman Bharat, have expanded programme capacity for cancer screening, referral and treatment-related financial protection [10]. At the same time, the National Cancer Registry Programme contributes surveillance data for cancer-control

Table 1. Comparative burden of female breast and ovarian cancer in BRICS member countries (GLOBOCAN 2024 Estimates)

Country	New female breast cancer cases	Female breast cancer deaths	Breast cancer ASIR (per 100k)	Breast cancer ASMR (per 100k)	New ovarian cancer cases	Ovarian cancer deaths	Ovarian cancer ASIR (per 100k)	Ovarian cancer ASMR (per 100k)
Brazil	90,307	23,152	58.6	14.2	8,999	5,037	5.8	3.1
Russia	75,047	20,491	53.8	12.3	15,275	8,014	11.8	5.1
India	237,231	96,100	31.2	12.7	45,566	28,782	6.0	3.8
China	375,808	73,030	34.0	5.7	61,947	32,516	5.6	2.5
South Africa	13,338	5,377	37.5	14.7	1,361	1,039	3.8	2.9
Egypt	26,052	9,717	48.3	18.3	2,981	1,914	5.6	3.7
Ethiopia	18,840	8,812	40.8	20.0	1,544	1,085	3.7	2.7
Iran	21,304	9,400	38.1	17.0	2,763	1,915	5.1	3.5
Saudi Arabia	3,865	1,022	35.7	10.1	293	176	2.8	1.8
United Arab Emirates	1,774	482	59.2	17.5	141	86	4.8	3.2
Indonesia	93,236	38,012	55.8	22.7	17,492	11,681	10.6	7.0

Note: ASIR – age-standardized incidence rate; ASMR – age-standardized mortality rate.

²⁰ Cancer Today. China. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/156/china>

²¹ Cancer Today. India. Accessed 13.08.2026. <https://gco.iarc.who.int/today/en/fact-sheets-populations/356/india>

²² Ibid.

planning [10]. However, substantial disparities remain between urban and rural populations in access to cancer detection and care. These disparities, together with other socioeconomic and health-system barriers, contribute to delayed diagnosis, and a considerable proportion of patients continue to present with advanced-stage disease, which is associated with poorer survival, increased treatment costs, and greater socioeconomic burden [3, 6, 11]. Continued improvements in early diagnosis, referral pathways, integrated cancer care, and digital health infrastructure are therefore required to improve patient outcomes within the national healthcare system.

AI is increasingly being explored in oncology for image interpretation, digital pathology, risk stratification, clinical decision support, tele-oncology, and personalized cancer management [12–21]. These applications may support diagnostic workflows, specialist decision-making, and access to oncology expertise, particularly in resource-constrained settings [12–21]. Within the broader BRICS context, such digital-health developments may create opportunities for collaboration in cancer surveillance, digital pathology, health-data interoperability, multicentre research, and capacity building. iOncology.ai, developed through collaboration between the All India Institute of Medical Sciences (AIIMS), New Delhi, and the Centre for Development of Advanced Computing, Pune, with support from the Ministry of Electronics and Information Technology, Government of India, represents one such emerging national research and technology-development initiative [22].

National Health Programme architecture for cancer control in India

India has developed an integrated national framework for cancer prevention, early detection, diagnosis, treatment, rehabilitation, and palliative care through the National Health Mission [23]. The programme follows a continuum-of-care approach that is designed to link population-based screening, strengthened healthcare infrastructure, financial protection mechanisms, affordable access to medicines, digital health systems, and community-based awareness initiatives [23]. The NP-NCD serves as the principal platform for delivering cancer prevention, screening, referral, and management services across different levels of healthcare²³. Complementary initiatives, including Ayushman Bharat–Pradhan Mantri Jan Arogya Yojana (AB-PMJAY)²⁴, the Strengthening of Tertiary Cancer Care Facilities Scheme, the Pradhan Mantri Bhartiya Janaushadhi Pariyojana, Affordable Medicines and Reliable Implants for Treatment (AMRIT) Pharmacies, and the National Non-Communicable Diseases Data (NCD) Portal, collectively expand access to cancer screening, diagnosis, treatment, and follow-up care nationwide^{25,26}.

Cancer surveillance and data systems

Reliable surveillance is central to cancer control. The National Cancer Registry Programme, coordinated by the Indian Council of Medical Research with support from the National Centre for Disease Informatics and Research, draws on Population-Based Cancer Registries and Hospital-Based Cancer Registries to estimate cancer incidence, monitor trends, and describe clinical and treatment patterns [24]. Cancer

²³ NCD – National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD). Accessed 05.08.2026. <https://nhmmizoram.org/page/348>

²⁴ Towards Universal Healthcare. Accessed 05.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2185049®=3&lang=2>

²⁵ Update on Availability of Cancer Care Centres. Accessed 05.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2286948&lang=1®=48>

²⁶ Affordable and Accessible Healthcare for All. Accessed 05.08.2026. <https://www.pib.gov.in/PressNoteDetails.aspx?ModuleId=3&NotelId=154668&lang=1®=1>

mortality information is complemented by the Medical Certification of Cause of Death scheme under the Civil Registration System²⁷, while programme-level screening and treatment activities are monitored through the National NCD Portal^{28,29}. Together, these systems provide complementary evidence for cancer-control planning and evaluation. Integration with the Ayushman Bharat Digital Mission (ABDM) may further improve health-data interoperability and information exchange across the healthcare system [25] (Table 2).

Population-based prevention and early detection

Population-based screening for breast, oral, and cervical cancers is implemented across all districts through Comprehensive Primary Health Care delivered by Ayushman Arogya Mandirs under the National Health Mission, Government of India [10, 26]. Individuals aged 30 years and above are targeted for population-based screening for common non-communicable diseases, including selected cancers³⁰. Trained Accredited Social Health Activists and Auxiliary Nurse Midwives facilitate screening, referral, follow-up, and treatment adherence, strengthening continuity of care at the community level³¹ [26]. As of March 2026, more than 184,000 Ayushman Arogya Mandirs were operational across the country, providing preventive, promotive, and screening services³². The expansion of the NP-NCD infrastructure across district and community health centre levels is summarised in Table 3³³.

Cancer screening and management through the National Non-Communicable Diseases Portal

The National NCD Portal supports programme-level recording and monitoring of screening, diagnosis, treatment, and follow-up for major non-communicable diseases, including oral, breast, and cervical cancers [27]. By consolidating routine service data across different levels of the public health system, the Portal supports monitoring of programme coverage, referral coordination, continuity of care, and programme

Table 2. Major cancer surveillance and data systems in India

Surveillance system	Nodal agency	Primary purpose
National Cancer Registry Program	ICMR-NCDIR	National cancer incidence, prevalence, survival and trend analysis
Population-Based Cancer Registries	ICMR-NCDIR	Population-level estimates of cancer burden and trends
Hospital-Based Cancer Registries	ICMR-NCDIR	Clinical characteristics, treatment patterns and patient outcomes
Medical Certification of Cause of Death	Office of Registrar General of India	Cancer mortality statistics and cause-specific mortality
National NCD Portal	MoHFW	Digital monitoring of cancer screening, diagnosis, treatment and follow-up
Ayushman Bharat Digital Mission	MoHFW / National Health Authority	Interoperable digital health records and integration of cancer data systems

Note: ICMR-NCDIR – Indian Council of Medical Research – National Centre for Disease Informatics and Research; MoHFW – The Ministry of Health and Family Welfare; NCD – non-communicable disease.

²⁷ Medical Certification of Cause of Death Report 2024. Accessed 07.08.2026. <https://censusindia.gov.in/nada/index.php/catalog/47157>

²⁸ NCD – National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD). Accessed 06.08.2026. <https://nhmmizoram.org/page/348>

²⁹ Steps taken to use AI in Cancer Screening. Accessed 07.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2244526®=48&lang=2>

³⁰ Ministry of Health and Family Welfare. Annual report 2025-26. Accessed 07.08.2026. <https://www.mohfw-dohfw.gov.in/static/uploads/2026/06/cb5989724e38171c770da36265e9161a.pdf>

³¹ Ibid.

³² India's Transformation into a Global Health Powerhouse. Accessed 07.08.2026. <https://www.pib.gov.in/PressNoteDetails.aspx?ModuleId=3&NotId=157599®=3&lang=2>

³³ NCD – National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD). Accessed 06.08.2026. <https://nhmmizoram.org/page/348>

Table 3. The National Programme for Prevention and Control of Non-Communicable Diseases Healthcare Infrastructure in India

Type of healthcare facility	Number reported	Status
District NCD Clinics	770	Set up at district level
Community Health Centre NCD Clinics	6,410	Set up at Community Health Centre level
Cardiac Care Units	233	Set up
District Day Care Cancer Centres – cumulative total	372	Set up
Functional District Day Care Cancer Centres	364	Reported as functional
Additional District Day Care Cancer Centres approved for FY 2025–26	297	Approved under National Health Mission

Note: The figures reflect different reporting categories and periods. The 372 District Day Care Cancer Centres (DCCCs) represent the cumulative number reported as established, whereas the Ministry of Health and Family Welfare Annual Report 2025–26 separately reports 364 functional DCCCs and 297 additional DCCCs approved during FY 2025–26. These figures are not additive. FY – financial year; NCD – non-communicable disease.

review^{34, 35}. More than 500 million beneficiaries have been recorded on the National NCD Portal under the NP-NCD, and disease-wise screening, diagnosis, and treatment data illustrate the scale of service delivery (Table 4)³⁶.

The Strengthening of Tertiary Cancer Care Facilities Scheme

To address the increasing cancer burden, the Government of India has implemented the Strengthening of Tertiary Care Cancer Facilities Scheme to expand specialized oncology services across the country. The scheme supports State Cancer Institutes and Tertiary Cancer Care Centres through one-time central assistance of up to INR 1.2 billion and INR 450 million, respectively, generally under a 60:40 Centre–State cost-sharing arrangement, modified to 90:10 for North-Eastern and Himalayan states³⁷. Nineteen State Cancer Institutes and 20 Tertiary Cancer Care Centres have been approved, of which 15 State Cancer Institutes and 18 Tertiary Cancer Care Centres were reported as functional and providing patient-care services in the Ministry of Health and Family Welfare Annual Report 2025–26, thereby contributing to regional tertiary cancer-care capacity³⁸. This tertiary-care network is complemented by Tata Memorial Centre institutions, the AIIMS network, the National Cancer Institute, Jhajjar, Chittaranjan National Cancer Institute, Kolkata,

Table 4. Population-based screening and management under National Non-Communicable Diseases Portal

Clinical condition	Total screened	Diagnosed	Registered and put on treatment
Hypertension	389,574,840	51,347,549	47,489,354
Diabetes	387,715,539	34,562,655	28,374,805
Oral Cancer	328,067,132	187,939	176,866
Breast Cancer	172,113,785	41,386	61,742*
Cervical Cancer	102,093,675	90,291	97,085*

Note: * – figures are reproduced as reported by the Ministry of Health and Family Welfare from the National Non-Communicable Diseases Portal and represent aggregate programme indicators. For breast and cervical cancers, some cases diagnosed at tertiary centres were not entered in the Portal at diagnosis; patient-level linkage between diagnosis and treatment categories is not reported.

³⁴ NCD – National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD). Accessed 06.08.2026. <https://nhmmizoram.org/page/348>

³⁵ Steps taken to use AI in Cancer Screening. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2244526®=48&lang=2>

³⁶ Update on progress achieved under NPCDCS. Accessed 13.08.2026. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=2152535&lang=2®=48>.

³⁷ Update on Availability of Cancer Care Centres. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2286948®=48&lang=2>

³⁸ Ministry of Health and Family Welfare. Annual report 2025-26. Accessed 07.08.2026. <https://www.mohfw-dohfw.gov.in/static/uploads/2026/06/cb5989724e38171c770da36265e9161a.pdf>

and other public-sector cancer centres³⁹. During 2025–26, approval of 297 additional District Day Care Cancer Centres further reflected efforts to decentralize cancer-treatment services and improve access closer to patients' residences⁴⁰.

Financial protection and affordable cancer care

To reduce the financial burden on patients, the Ministry of Health and Family Welfare has developed a comprehensive pathway for financial protection, generic drug distribution, and the expansion of tertiary care infrastructure. These complementary mechanisms operate at different levels of the cancer-care pathway, combining insurance-based financial protection, targeted financial assistance, access to affordable medicines, and strengthened public-sector treatment capacity.

Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana

The AB-PMJAY, a cashless publicly funded health assurance scheme started in 2018, is covering up to INR 500 thousand per family per year for secondary and tertiary hospitalization through empanelled public and private hospitals, targeting the bottom 40% of the population and already helping over 120 million vulnerable families and more than 8.6 million senior citizens⁴¹. AB-PMJAY covers comprehensive oncology services, including diagnostics, surgical oncology, chemotherapy, and radiotherapy, thereby providing financial protection against eligible hospitalization costs⁴².

The Pradhan Mantri Bhartiya Janaushadhi Pariyojana

The scheme aims to improve access to quality generic medicines, surgical items, and consumables at substantially lower prices through Jan Aushadhi Kendras. The availability of several oncology and supportive care medicines through this network can help reduce out-of-pocket medication costs, particularly for patients requiring prolonged or repeated cancer treatment⁴³.

AMRIT pharmacies

AMRIT pharmacies provide medicines, implants, and selected medical consumables at discounted prices, particularly through government healthcare institutions. Availability of anticancer medicines and supportive therapies at is intended to improve treatment affordability for patients undergoing prolonged oncology care. As of November 2025, more than 255 AMRIT pharmacies were operational, and programme data reported that more than 68.5 million patients had been served, with cumulative estimated savings of approximately INR 84 billion⁴⁴.

National pharmaceutical pricing authority

This agency regulates the ceiling prices of essential oncology drugs under the Drugs (Prices Control) Order. Through price control of medicines, including several essential medicines used in cancer treatment, and by

³⁹ Update on Availability of Cancer Care Centres. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2286948®=48&lang=2>

⁴⁰ Ministry of Health and Family Welfare. Annual report 2025-26. Accessed 07.08.2026. <https://www.mohfw-dohfw.gov.in/static/uploads/2026/06/cb5989724e38171c770da36265e9161a.pdf>

⁴¹ Towards Universal Healthcare. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2185049®=3&lang=2>

⁴² Ibid.

⁴³ Pradhan Mantri Bhartiya Janaushadhi Pariyojana' (PMBJP). Accessed 13.08.2026. <https://pharma-dept.gov.in/sites/default/files/Website%20updatation%202022%20PMBJP-1.pdf>

⁴⁴ Union Health Minister Shri J P Nadda Inaugurates Amrit Pharmacy's 10th Anniversary, Announces Nationwide Expansion. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2190300&lang=2®=3>

monitoring compliance, The National Pharmaceutical Pricing Authority seeks to improve medicine affordability while monitoring availability and compliance with statutory price controls. It fixes ceiling prices for scheduled formulations, monitors drug shortages, and enforces price controls; as of 18 December 2025, ceiling prices were effective for 131 anticancer formulations, generating estimated annual savings of about INR 2.9434 billion for patients⁴⁵.

The Health Minister's Cancer Patient Fund

The Health Minister's Cancer Patient Fund is a component of the umbrella Rashtriya Arogya Nidhi scheme. It provides one-time financial assistance of up to INR 1.5 million to poor cancer patients living below the poverty line for specialized treatment at designated government hospitals and Regional Cancer Centers, covering chemotherapy, radiation therapy, malignant tumor surgeries, and bone marrow transplants. The Rashtriya Arogya Nidhi and its specialized components provide an additional layer of financial protection for patients facing high treatment costs, complementing health insurance and other affordable-medicine initiatives^{46,47,48}.

The Pradhan Mantri Swasthya Suraksha Yojana

The Pradhan Mantri Swasthya Suraksha Yojana aims to reduce regional disparities in access to affordable tertiary healthcare by establishing new AIIMS and upgrading existing Government Medical Colleges and Institutions. As of August 2025, 22 new AIIMS had been approved, with undergraduate courses started in 19 of them. In addition, 75 medical college upgradation projects had been approved under Pradhan Mantri Swasthya Suraksha Yojana, of which 71 Super Specialty Block projects had been completed. These institutions are equipped with advanced oncology, radiotherapy, and surgical facilities, expanding access to evidence-based care in the public sector⁴⁹.

The National Cancer Institute, Jhajjar

The National Cancer Institute at the AIIMS Jhajjar campus represents a major expansion of public-sector tertiary oncology capacity in India. The 710-bed institute provides multidisciplinary services encompassing surgical, medical, and radiation oncology, nuclear medicine, anaesthesia, and palliative care, together with molecular diagnostics and translational research facilities. Beyond specialized cancer treatment, the National Cancer Institute contributes to oncology research, training, human-resource development, and referral care within the national cancer-control system. As a publicly funded tertiary cancer centre, it also supports access to cancer care through subsidized services, thereby complementing broader national efforts to improve the affordability and accessibility of specialized oncology care⁵⁰.

⁴⁵ Department of Pharmaceuticals, Ministry of Chemicals and Fertilizers, Government of India. Annual Report 2025–26. Accessed 13.08.2026. <https://pharma-dept.gov.in/sites/default/files/Annual%20Report%202025-26.pdf>

⁴⁶ Ministry of Health and Family Welfare. Annual report 2025–26. Accessed 07.08.2026. <https://www.mohfw-dohfw.gov.in/static/uploads/2026/06/cb5989724e38171c770da36265e9161a.pdf>

⁴⁷ Steps taken to assist cancer patients under Rashtriya Arogya Nidhi (RAN). Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2154159®=48&lang=2>

⁴⁸ Rashtriya Arogya Nidhi. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1524808®=48&lang=2>

⁴⁹ Ministry of Health and Family Welfare. Annual report 2025–26. Accessed 07.08.2026. <https://www.mohfw-dohfw.gov.in/static/uploads/2026/06/cb5989724e38171c770da36265e9161a.pdf>

⁵⁰ National Cancer Institute at Jhajjar dedicated to the nation as part of AIIMS, New Delhi. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1566423®=48&lang=2>

State-level cancer care initiatives

Since health is primarily a State subject, State Governments and Union Territories complement national programmes such as the NP-NCD and the AB-PMJAY by adapting financial protection, referral pathways, and cancer treatment services to State-specific needs. The combined Central-State framework is important for supporting geographical access, reducing out-of-pocket expenditure, strengthening financial protection, expanding cancer treatment infrastructure, improving early detection, and ensuring access to a comprehensive continuum of cancer care, particularly for vulnerable and underserved populations (Table 5)⁵¹ [28–35].

Prevention, awareness, and continuum of care

Primary prevention remains an integral component of India's national cancer control strategy. Human papillomavirus vaccination is being implemented through designated public health facilities for eligible 14-year-old girls as part of India's cervical cancer prevention strategy⁵². The National Programme for Palliative Care complements curative oncology services by integrating pain management, symptom control, psychosocial support, and end-of-life care into district and tertiary healthcare facilities⁵³. Public awareness is promoted through National Cancer Awareness Day (November 7), community outreach programmes, and health-promotion activities⁵⁴. Broader lifestyle interventions are supported through national

Table 5. State-level schemes providing financial protection for cancer care

State	Scheme	Financial assistance / cancer-care component
Kerala	Karunya Arogya Suraksha Padhathi	Provides cashless tertiary treatment up to INR 500 thousand per family per financial year through empanelled public and private hospitals, fully covering clinical oncology. Kerala also has the Karunya Benevolent Fund, which provides additional financial assistance to eligible beneficiaries
Tamil Nadu	Chief Minister's Comprehensive Health Insurance Scheme	Provides cashless financial protection of up to INR 500 thousand per family, annually, for eligible families for specified secondary and tertiary healthcare procedures. Cancer treatment is among the tertiary-care services covered under the scheme
West Bengal	Swasthya Sathi	Provides state-funded, cashless health assurance coverage of up to INR 500 thousand per family per annum for secondary and tertiary hospitalization. The scheme also provides financial protection for cancer treatment, although out-of-pocket expenditure may persist
Odisha	Gopabandhu Jan Arogya Yojana (Formerly Biju Swasthya Kalyan Yojana)	Operates as an integrated health-assurance model merged with Ayushman Bharat Pradhan Mantri Jan Arogya Yojana. It offers cashless tertiary healthcare packages up to INR 500 thousand for male and up to INR 1 million for female beneficiaries, including specialized oncology procedures
Andhra Pradesh	Dr. NTR Vaidya Seva / Aarogyasri Health Scheme	Provides universal, end-to-end cashless healthcare coverage up to INR 2.5 million per family annually for major diseases and surgical interventions. This includes extensive coverage for staging diagnostics, chemotherapy, and tumor resections.
Telangana	Rajiv Aarogyasri	Provides cashless financial assistance for major illnesses, including cancer treatment, to eligible economically disadvantaged families through empanelled hospitals
Karnataka	Ayushman Bharat-Arogya Karnataka	Employs an integrated state-central co-referral framework providing up to INR 500 thousand for tertiary healthcare. It features structured oncology packages accessible across public institutions and empanelled private super-specialty hospitals
Gujarat	Mukhyamantri Amrutam / Pradhan Mantri Jan Arogya Yojana – Mukhyamantri Amrutam	Provides cashless financial coverage of up to INR 500 thousand per family per year for secondary and tertiary healthcare, including specified oncology services and cancer treatment packages, to eligible families
Rajasthan	Mukhyamantri Ayushman Arogya Yojana	Provides cashless health coverage/financial protection up to INR 2.5 million for eligible beneficiaries for hospitalization and a broad range of specialized healthcare services

Note: NTR - Nandamuri Taraka Rama Rao.

⁵¹ Odisha becomes the 34th state to implement Ayushman Bharat Pradhan Mantri Jan Arogya Yojana scheme. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2092541®=48&lang=2>

⁵² Update on HPV Vaccination Programme and Cervical Cancer Prevention. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2286947&lang=1®=3>

⁵³ Ibid.

⁵⁴ National Cancer Awareness Day 2025. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2187212&lang=2®=48>

initiatives such as the Eat Right India Movement, Safe and Nutritious Food Initiative, Aaj Se Thoda Kam Campaign, and the Fit India Movement, which encourage healthy dietary practices, regular physical activity, obesity prevention, and reduction of modifiable risk factors associated with cancer and other non-communicable diseases [36].

Emerging need for artificial intelligence in cancer care

Although national programmes have substantially expanded cancer prevention, screening, treatment, and financial protection, the increasing burden and growing complexity of oncology care require technologies that improve efficiency across the cancer care pathway. AI has emerged as an important tool for supporting image interpretation, standardized pathology reporting, clinical decision support, risk stratification, and integration of longitudinal patient records. In India, the India AI Mission provides a national framework for the responsible development and deployment of AI through investments in computing infrastructure, foundational models, innovation, and workforce development. The programme seeks to improve accessibility of advanced digital technologies across the healthcare system, including district-level facilities, while promoting ethical, safe, and evidence-based implementation. An allocation of INR 103.72 billion⁵⁵ has been approved to strengthen domestic AI infrastructure and accelerate application development across multiple sectors, including healthcare. These developments may create an enabling ecosystem for developing and evaluating AI-enabled platforms into cancer prevention, diagnosis, treatment planning, and health system [12–19, 37, 38].

The Viksit Bharat 2047 and digital health transformation: a vision for technology-driven healthcare

Within the Viksit Bharat 2047 vision India as a developed nation by the centenary of its independence, with universal health coverage, technological innovation, and digital transformation have emerged as important priorities for healthcare development. The vision emphasizes creating a resilient and equitable health system by expanding digital health infrastructure, improving access to quality healthcare services, and responsibly adopting AI and data-driven technologies. Particular emphasis is placed on preventive healthcare, early diagnosis, management of non-communicable diseases, and integrating digital solutions into routine clinical practice to improve healthcare delivery, patient outcomes, and health-system performance [25, 38, 39].

The Digital India programme has provided the technological foundation for this transformation by expanding digital infrastructure, strengthening e-governance, improving nationwide connectivity, and promoting technology-enabled public services. In healthcare, these initiatives have accelerated the adoption of telemedicine, electronic health records, cloud computing, big data analytics, the Internet of Medical Things, and AI across clinical and public health settings. Wider availability of these technologies has supported expanded access to healthcare services, facilitated information exchange, and reduced barriers to specialist consultation, particularly in rural and underserved regions where shortages of trained healthcare professionals and diagnostic facilities continue to affect timely diagnosis and treatment [25, 37, 38, 40, 41].

⁵⁵ Cabinet Approves Ambitious India AI Mission to Strengthen the AI Innovation Ecosystem. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2012355®=48&lang=2>

The digital infrastructure established through the Digital India programme has also enabled the implementation of national digital health initiatives, most notably the ABDM. The ABDM provides a secure, standards-based, and interoperable framework for digital health by facilitating unique health identities, longitudinal electronic health records, consent-based health information exchange, and standardized communication among healthcare providers, diagnostic laboratories, pharmacies, insurers, and public health agencies. This framework supports continuity of care by enabling secure data sharing, reducing duplication of diagnostic investigations, and providing individuals with greater control over their health information. The interoperable architecture of ABDM also creates an enabling environment for supporting the integration of advanced digital technologies, including AI-assisted diagnostics, digital pathology, telemedicine, clinical decision-support systems, and population health analytics, thereby supporting evidence-informed clinical practice and health-system planning [25, 38, 40].

AI is increasingly influencing multiple components of healthcare, including disease surveillance, population-level risk assessment, healthcare resource planning, and evidence-based public health decision-making. Integration of clinical, imaging, molecular, and population-level data enables predictive modelling, improves diagnostic workflows, and supports more individualized patient management. In oncology, advances in digital pathology, telepathology, tele-oncology, AI-assisted image analysis, molecular diagnostics, and predictive analytics are expanding the capabilities of cancer screening, diagnosis, treatment planning, and longitudinal follow-up. These technologies are particularly relevant in resource-constrained settings, where digital platforms can extend specialist expertise beyond tertiary cancer centres and support improved access to multidisciplinary oncology services [13–21, 37, 38].

iOncology.ai: aligning with the Viksit Bharat 2047 and the Digital India

iOncology.ai is an emerging national, AI / machine learning enabled oncology platform intended to support cancer-related data integration, research, and clinical decision-support functions within India's evolving digital-health environment (Figure 3)⁵⁶ [22]. Its development is consistent with the broader policy direction of the Viksit Bharat 2047, the Digital India, and the ABDM, which emphasize digital transformation, interoperability, and responsible use of emerging technologies in healthcare [25, 38, 39]. The platform is developed through a collaboration between the AIIMS, New Delhi, and the Centre for Development of Advanced Computing, Pune, with support from the Ministry of Electronics and Information Technology [22]. Its design emphasizes interoperability with electronic-health-record workflows and potential compatibility with ABDM-aligned health-information exchange; these should be regarded as implementation objectives rather than evidence of routine clinical integration [25].

iOncology.ai uses curated Indian clinical, radiological, histopathological datasets and is intended to support the integration of additional patient-level information, including genetic data and is currently being evaluated in research mode [22]. The platform's intended applications include early cancer detection, risk stratification, treatment support, multidisciplinary review, and longitudinal data management. Comparable AI / machine

⁵⁶ Ministry of Electronics and Information Technology, Government of India. Annual report 2024–25. Accessed 13.08.2026. <https://www.meity.gov.in/static/uploads/2024/12/10fca4ec462c330211502fed3d24ea83.pdf>

FIG. 3. Web Interface: iOncology.ai



learning approaches have demonstrated potential in medical imaging and computational pathology [14, 20, 21], but translation into routine clinical care requires prospective validation, workflow evaluation, assessment of generalizability, and continued performance monitoring [15, 17, 18]. The currently identified sources describe the platform and its development [22]; however, peer-reviewed evidence establishing the diagnostic accuracy, clinical utility, or effectiveness of iOncology.ai has not yet been identified, and this is still in progress.

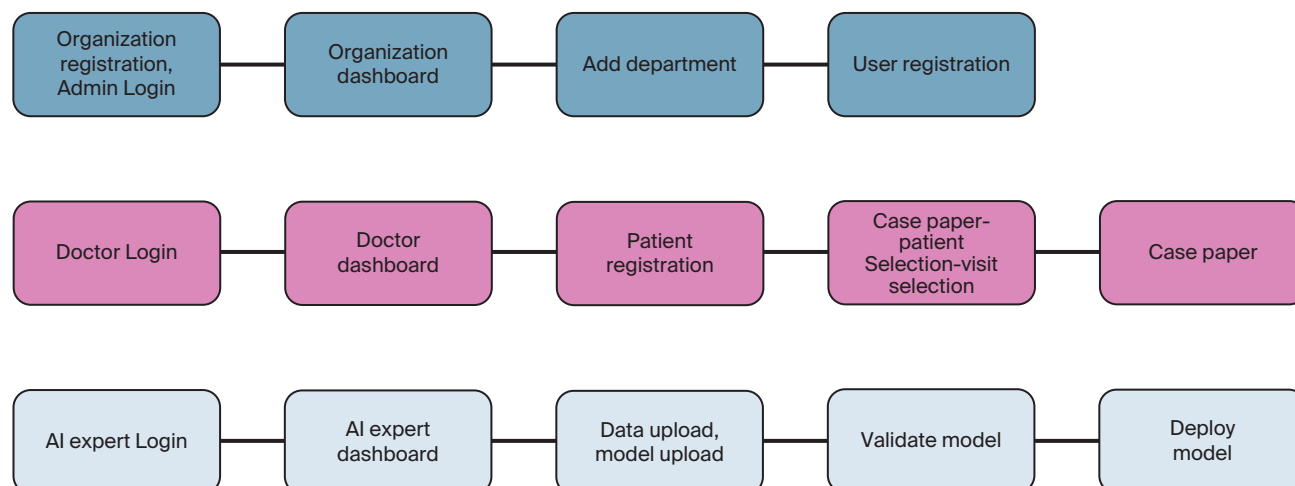
Accordingly, iOncology.ai should currently be regarded as a research and technology-development platform with potential for future clinical translation, rather than as a clinically validated AI system (Figure 4) [22]. Its potential contribution to precision oncology, cancer surveillance, and collaborative research remains to be established through rigorous prospective multicentre validation and implementation studies evaluating clinical utility, safety, interoperability, and generalizability before wider clinical deployment [15, 17, 18, 22].

In the context of India's BRICS Chairship (2026), experience gained through national digital-health platforms such as iOncology.ai may inform future collaboration in cancer surveillance, digital pathology, interoperable digital oncology, multicentre research, harmonization of health-data standards, and capacity building [22]. Such collaboration could also support the development and evaluation of AI applications using locally representative clinical datasets. Any cross-country application would require appropriate governance, privacy protection, interoperability standards, and context-specific clinical validation [42, 43].

Limitations and future research directions

This review integrates epidemiological, programme-related, digital-health, and AI-related evidence rather than applying a systematic-review or meta-analytic design. It draws on heterogeneous sources, including GLOBOCAN estimates, cancer-registry data, government reports, programme statistics, and peer-reviewed literature, which differ

FIG. 4. Workflow of iOncology.ai



Note: Illustrating the user interface for patient registration, clinical data management, AI-assisted image analysis, and decision-support functions. AI – artificial intelligence.

in reporting periods, definitions, and methods. The review gives greater attention to India and to breast and ovarian cancers than to other cancer sites and BRICS health systems, which may limit broader generalizability. In addition, no formal risk-of-bias assessment was undertaken. Evidence specifically concerning iOncology.ai currently derives mainly from project and institutional descriptions, and the present review did not identify peer-reviewed evidence establishing its clinical effectiveness [22].

Future research should include prospective multicentre studies evaluating iOncology.ai for diagnostic performance, calibration, safety, subgroup performance, generalizability, workflow impact, and clinical utility before routine clinical deployment. Health-economic and implementation studies should assess cost-effectiveness, usability, interoperability with ABDM-compatible systems, and performance in resource-constrained settings. At the BRICS level, future research could examine harmonized oncology-data standards, governance frameworks, and collaborative or federated approaches using locally representative datasets. Comparative studies and future reviews may also extend the present analysis to additional cancer sites and emerging national digital-oncology initiatives.

Conclusion

Cancer remains a growing public health challenge across BRICS member countries, with breast and ovarian cancers contributing substantially to the cancer burden among women. India's national cancer control architecture encompasses surveillance, population-based screening, financial protection, and service delivery under the National Health Mission and the NP-NCD, alongside an evolving digital-health infrastructure under the ABDM. Within the broader context of the Viksit Bharat 2047 and India's digital-health transformation, iOncology.ai represents an emerging national research and technology-development initiative that may support future evaluation of AI-assisted oncology workflows, particularly in resource-constrained settings. Its diagnostic performance, clinical utility, and effectiveness remain to be established through rigorous prospective multicentre validation.

In the arena of BRICS collaboration, iOncology.ai and similar national platforms may offer a framework for exploring interoperable digital oncology, collaborative multicentre research, harmonized health-data standards, and the development and evaluation of AI approaches using locally representative datasets. Such experience may also be relevant to other resource-constrained and low- and middle-income settings. Realizing the full potential of these platforms will depend on evidence of diagnostic performance, clinical utility, safety, cost-effectiveness, interoperability, appropriate governance, and context-specific clinical validation. India's BRICS Chairship in 2026 provides an opportunity to encourage collaborative research and responsible digital-health innovation while maintaining an evidence-based approach to clinical translation across the Global South.

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The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. All authors approved the final version of the article.

Informed consent statement: Not required.

Funding: The study was not sponsored (own resources).

Competing interests: The authors declare no conflict of interest.

Ethical approval: Not required.

Data sharing: All data used in this paper are publicly available.

Use of artificial intelligence: No artificial intelligence tools were used in the preparation of this manuscript.

Manuscript source: Unsolicited manuscript.

Country/territory of origin: India

Strengthening the public health systems in the BRICS countries through networking of national public health institutes: an operational framework

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ABSTRACT

The BRICS nations are demographically and geographically diverse but face shared public health challenges that require stronger and more coordinated public health cooperation. The National Public Health Institutes (NPHI) participating in The BRICS Network of National Public Health Institutes (BNN) are science-based national centres of excellence that support public health leadership, capacity building, disease prevention and control, surveillance, emergency preparedness, research, and evidence-informed policy. Building on established international experience with collaborative NPHI and public health networks, the BNN represents a BRICS-specific approach to institutional cooperation. The aim of this article is to examine the 2026 Operational Framework for the BNN in the context of current evidence and international experience, with particular attention to its strategic priorities, governance arrangements, and implementation challenges.

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Received: 01.07.2026

Accepted: 25.08.2026

Date of publication online: 10.09.2026

Date of publication: 29.09.2026

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The BNN focuses on NPHI capacity mapping, workforce and faculty exchange, knowledge sharing, public health workforce development, strengthening surveillance and response systems, and collaborative research and innovation across BRICS countries. The 2026 Operational Framework outlines a three-tiered governance model intended to support strategic alignment, coordination, and technical implementation, guided by the principles of collective leadership, country ownership, continuity across Chairships, and result-oriented collaboration. It also proposes mechanisms for strengthening other Public Health Institutes within member countries. The 2026 Operational Framework provides a structured basis for institutional collaboration across BRICS; however, its implementation, sustainability, and effects on public health system performance and population health remain to be evaluated over time.

Key Words: BRICS Network; public health institutes; BRICS; public health challenges; health security; institutional collaboration

Citation: Jayapal P, Kumar A, Shewale A, Yadav A, Nanda S. Strengthening the public health systems in the BRICS countries through networking of national public health institutes: an operational framework. *The BRICS Health Journal*. 2026;3(2):70–79. Epub ahead of print 10.09.2026. <https://doi.org/10.47093/3034-4700.2026.3.2.102>

MeSH terms:

PUBLIC HEALTH PRACTICE

INTERNATIONAL COOPERATION

LEADERSHIP

HEALTH WORKFORCE – ORGANIZATION & ADMINISTRATION

CAPACITY BUILDING – METHODS

Introduction

The COVID-19 pandemic exposed gaps in public health preparedness, early warning, coordination, laboratory and workforce capacity, risk communication, and access to medical countermeasures^{1,2} [1]. The World Health Organization pulse surveys also documented disruption of essential health services, highlighting the need for strengthened public health systems capable of maintaining routine services during emergencies^{3,4}. Together, these findings underscored the importance of sustained institutional capacity for both emergency response and health-system resilience.

The National Public Health Institutes (NPHI) are science-based national centers whose functions include surveillance and health intelligence, reference laboratory services, outbreak investigation and management, emergency preparedness and response, workforce development, risk communication, applied research, and translating evidence into national health policy [2–5]. Although their mandates and organizational structures vary across countries, they can provide an interface between national

¹ Main Report & accompanying work. Accessed 17.08.2026. <https://theindependentpanel.org/mainreport/>

² Independent review of WHO's response to COVID-19 in the Eastern Mediterranean Region: Report – February 2023. Accessed 13.08.2026. <https://www.who.int/publications/m/item/independent-review-of-who-s-response-to-covid-19-in-the-eastern-mediterranean-region>

³ Pulse survey on continuity of essential health services during the COVID-19 pandemic: interim report, 27 August 2020. Accessed 17.07.2026. https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS_continuity-survey-2020.1

⁴ Second round of the national pulse survey on continuity of essential health services during the COVID-19 pandemic. Accessed 17.08.2026. https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS_continuity-survey-2021.1

and subnational authorities, laboratories, universities, health services, and international partners [2–7].

The pandemic further demonstrated that capable national institutions are necessary but not sufficient [3]. Cross-border threats require trusted relationships, agreed communication routes, shared technical approaches, and joint work before emergencies. A network of NPHI can turn multilateral contacts into an institutional platform for peer consultation, joint risk assessment, workforce exchange, collaborative research, and coordinated preparedness and response without displacing national authority or obligations under the International Health Regulations (2005)⁵ [8–11].

The International Association of NPHI supports countries in strengthening NPHI through institutional assessment, peer assistance, leadership development, and shared technical expertise [8]. Experience following the West African Ebola epidemic similarly emphasized strong national institutes and regional cooperation for outbreak detection, laboratory support, operational research, and workforce development [9–11].

BRICS countries have substantial but diverse public health capacities in surveillance, epidemiology, vaccine and pharmaceutical development and production, laboratory science, genomics, digital health, workforce training, environmental health, and large-scale programme implementation [12–14]. The group represents nearly half of the global population and spans marked demographic, epidemiological, ecological, and institutional diversity [15]. This provides an opportunity for reciprocal collaboration among NPHI: pooling complementary strengths and sharing technical knowledge while respecting national priorities and sovereignty.

Collaborative networks of NPHI and regional public health institutions can strengthen operational capacity, workforce development, surveillance, emergency preparedness, and institutional resilience [11, 16, 17]. Their effectiveness may depend also on governance, sustainable financing, institutionalized leadership, and continuity [17]. Recent literature has described BRICS health cooperation and the 2025 Conference of BRICS NPHI; the strategic and governance arrangements of the 2026 Operational Framework have received limited examination [18].

The First BRICS Experts' Meeting on Public Health hosted by Russia in September 2024 initiated discussions on institutionalized public health cooperation, and the subsequent XIV BRICS Health Ministers' Meeting established the BRICS Public Health Institutes Network as a standing expert platform⁶. During the 2025 Brazilian Chairship, the Conference of the BRICS NPHI further advanced cooperation and mutual support among BRICS countries in public health [18]. Following these developments, under the 2026 Indian Chairship, the BRICS Health Ministers endorsed the 2026 Operational Framework for the BRICS Network of National Public Health Institutes (BNN)⁷.

The aim of this article is to examine the 2026 Operational Framework for the BRICS Network of NPHI in the context of current evidence and international experience, with particular attention to its strategic priorities, governance arrangements, and implementation challenges.

A focused search of PubMed and Google Scholar was conducted through August 2026 using the keywords “NPHI”, “public health networks”,

⁵ International health regulations (2005) as amended in 2014, 2022 and 2024. Accessed 12.06.2026. https://apps.who.int/gb/bd/pdf_files/IHR_2014-2022-2024-en.pdf

⁶ MOSCOW Declaration of the XIV BRICS Health Ministers' Meeting 11 October 2024. Accessed 13.08.2026. <https://brics.br/pt-br/documentos/acervo-de-presidencias-antiores/health-ministerial-declarations/2024-brics-health-ministers-declaration.pdf/@download/file>

⁷ 16th BRICS Health Ministers' Meeting Concludes Successfully under India's BRICS Chairship 2026. Accessed 16.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2288267&lang=1®=3>

“governance”, “sustainability”, and “BRICS”. Relevant peer-reviewed studies and reviews were selected, prioritizing recent evidence and key seminal publications. Official institutional and government sources were also reviewed. The 2026 Operational Framework for BNN was analyzed as the primary document for its strategic priorities, governance, and proposed operational mechanisms. Sources outside NPHI or public health network organization and governance were excluded.

The BRICS Network of National Public Health Institutes: vision, objectives and strategic pillars

The 2026 Operational Framework envisions BNN to support collaboration on the prevention and control of priority diseases and contribute to health security. Participating NPHI would serve as national hubs linking relevant public health institutions within a coordinated structure. The BNN aims to address shared public health challenges through institutional strengthening, knowledge exchange, coordinated applied research and agreed governance^{8,9}. Its objectives focus on institutional capacity mapping and building, workforce and faculty exchange, strengthening other public health institutions within member countries, and multi-country applied research and innovation. The full objectives and proposed operational arrangements are provided in the Supplementary File (supplementary materials on the journal website <https://doi.org/10.47093/3034-4700.2026.3.2.102-annex>).

The BNN is proposed as a collaborative technical platform operating within the mandates of participating NPHI and priorities agreed upon by BRICS member states. Its activities would be guided by country ownership and respect for national laws, equality and inclusivity, evidence-based decision-making, knowledge exchange, complementarity with existing global and regional public health initiatives, and sustainability of governance and financing arrangements.

The 2026 Operational Framework is structured on seven Strategic Pillars and Policy and Advisory Support. These pillars define broad areas for collaboration while allowing member countries to accommodate their respective national priorities (Figure).

These priorities are broadly consistent with established approaches to NPHI development and international public health collaboration, which emphasize institutional capacity, core public health functions, workforce development, surveillance and response, applied research, peer learning, and sustained institutional cooperation¹⁰ [8, 11, 16]. The BNN extends these principles by combining cross-country collaboration among designated NPHI with a national coordination role while participating institutes are expected to strengthen other public health institutions within their countries. This dual network-and-national-institutional model may link shared BRICS priorities with country-specific public health needs.

Strategic areas of collaboration within the BRICS Network of National Public Health Institutes

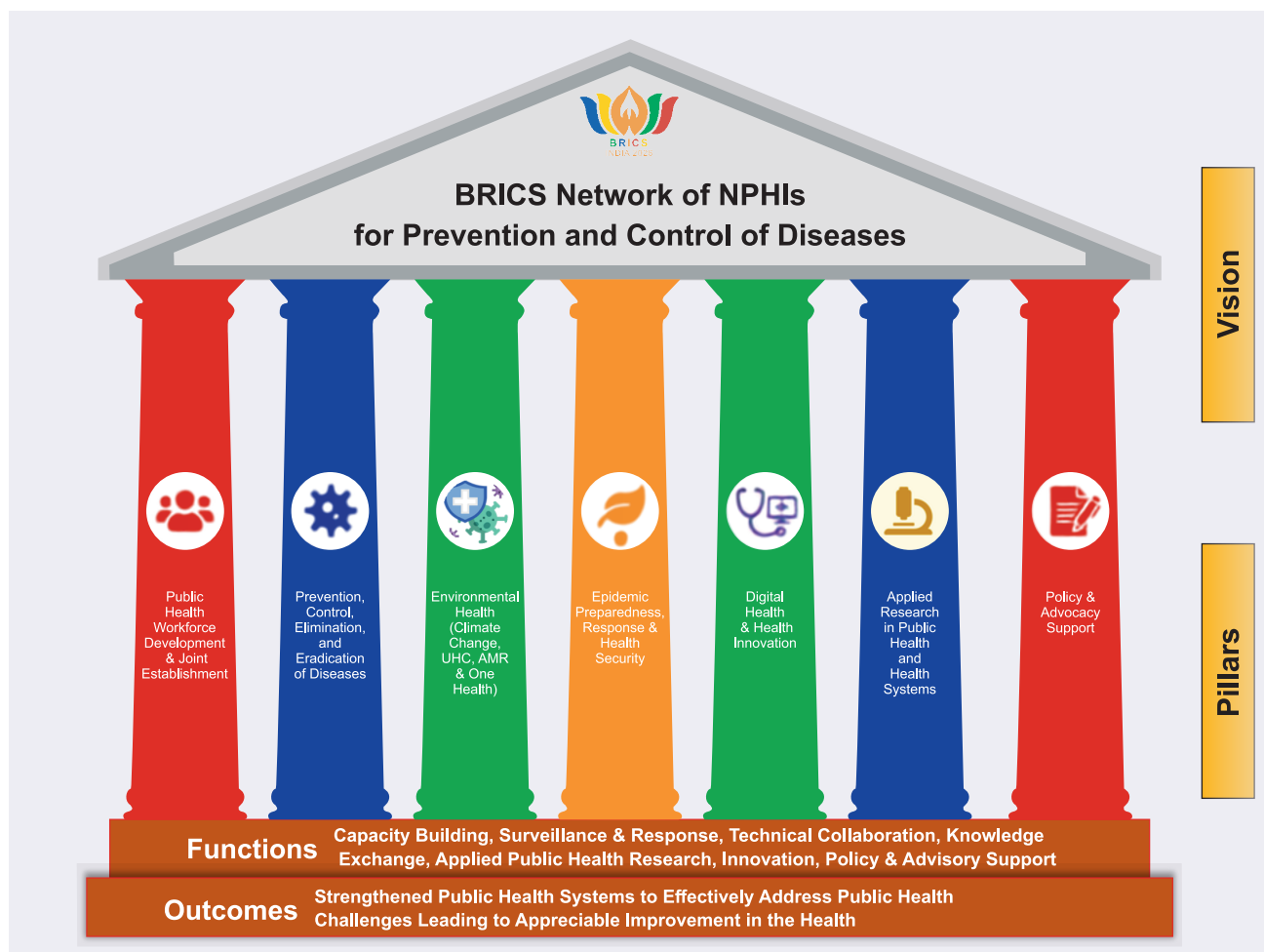
Aligned with the vision and objectives of the BNN, the 2026 Operational Framework proposes the following strategic areas of collaboration for the BNN and NPHI.

⁸ 16th BRICS Health Ministers' Meeting Concludes Successfully under India's BRICS Chairship 2026. Accessed 16.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2288267&lang=1®=3>

⁹ Senior Officials' Meeting Held in Chandigarh as Part of Ongoing BRICS Health Ministerial Meetings Under India's Chairship. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287898®=48&lang=2>

¹⁰ IANPHI Framework for the Creation and Development of National Public Health Institutes [2026]. Accessed 13.08.2026. <https://ianphi.org/tools-resources/nphi-framework.html>

FIG. Schematic structure of the BRICS Network of National Public Health Institutes



Note: UHC – Universal Health Coverage; NPHIs – National Public Health Institutes. Full description of the 2026 Operational Framework is provided in Supplementary File.

Each BRICS member country would identify and designate a NPHI to serve as the focal institution for participation in the BNN and to coordinate public health institutions and activities within the country^{11,12}. The BNN would map the expertise and capacities of participating NPHI to identify complementary strengths, capacity gaps, and opportunities for targeted capacity building and technical collaboration. Member NPHI would also jointly identify shared public health priorities, including pandemic and epidemic response and antimicrobial resistance. Such capacity mapping and identification of priority needs are consistent with established approaches to NPHI development, which emphasize assessment of institutional capacities, identification of gaps, and strengthening of core public health functions according to the national context¹³ [6].

The BNN would support the development of public health workforce through thematic training programmes and collaborative learning initiatives. Technical collaboration, knowledge exchange, and sharing

¹¹ 16th BRICS Health Ministers' Meeting Concludes Successfully under India's BRICS Chairship 2026. Accessed 16.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2288267&lang=1®=3>

¹² Senior Officials' Meeting Held in Chandigarh as Part of Ongoing BRICS Health Ministerial Meetings Under India's Chairship. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287898®=48&lang=2>

¹³ IANPHI Framework for the Creation and Development of National Public Health Institutes (2026). Accessed 13.08.2026. <https://ianphi.org/tools-resources/nphi-framework.html>

of best practices could include institutional and faculty exchanges, joint training, and exchange of experience across surveillance, laboratory systems, epidemic preparedness and other agreed public health priorities (Supplementary File). Similar collaborative approaches have been used within NPHI and regional public health networks to support workforce development, technical exchange, and operational public health capacity [11, 16]. The BNN would encourage joint research initiatives and multi-country studies addressing priority public health challenges through mechanisms for institutional cooperation.

The BNN would further support national health programmes by providing technical expertise, facilitating cross-country learning, and strengthening monitoring and evaluation, operational research, and implementation of priority interventions. It would also provide technical advice to relevant health authorities and working groups. Thematic Working Groups (TWG) would serve as the main technical platform for focused dialogue, knowledge sharing, and joint action on agreed priority areas (Supplementary File). Experience from other public health networks suggests that regular communication, clear priorities and deliverables, institutional leadership, and continuity are important for effective collaboration [17]. These considerations may be particularly relevant for the BNN because of differences in institutional mandates, capacities, and public health priorities across BRICS countries.

Governance, operational mechanisms and sustainability

The 2026 Operational Framework defines a set of collaboration, implementation, and governance mechanisms intended to support coordination across BRICS member countries. The BRICS Health Ministers' Annual Meeting would provide the strategic direction and priorities for the BNN, while the BNN Secretariat under the BRICS Chair would provide technical and secretarial support and facilitate continuity across successive BRICS Chairship. The Chair country would provide leadership and host the annual Conference. Collaboration would be facilitated through designated NPHI as national focal institutions, TWG for joint technical work, and periodic consultations and expert meetings^{14,15}. The detailed collaboration and operational mechanisms are presented in Supplementary File.

Member NPHI would implement agreed activities at the national level, supported by TWG with defined deliverables. The NPHI would also support capacity building and institutional strengthening of other public health institutions within their respective countries. The annual Conference, hosted by the BRICS Chairship country, would serve as a convening and coordination forum for policy dialogue, knowledge exchange, joint planning, and cooperation among member countries. The BNN would also engage with international organizations and national academic and research partners for technical cooperation, training, and institutional strengthening, while National Steering Committees would coordinate implementation within member countries.

The 2026 Operational Framework proposes a three-tiered governance structure to support strategic alignment, coordination, and technical implementation across BRICS countries. This structure reflects collective leadership, country ownership, continuity across Chairships,

¹⁴ 16th BRICS Health Ministers' Meeting Concludes Successfully under India's BRICS Chairship 2026. Accessed 16.06.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2288267&lang=1®=3>

¹⁵ Senior Officials' Meeting Held in Chandigarh as Part of Ongoing BRICS Health Ministerial Meetings Under India's Chairship. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287898®=48&lang=2>

and results-oriented collaboration. The three tiers define the proposed governance architecture, while the annual Conference and TWG provide complementary convening and technical mechanisms for Network activities (Table).

Experience from other public health networks suggests that institutionalized leadership, regular communication, strategic planning, and continuity are important for network sustainability [17]. These considerations are particularly relevant to the BNN because the Secretariat and leadership rotate with the annual BRICS Chairship. The proposed governance arrangements provide mechanisms for continuity; however, their effectiveness will depend on consistent handover of ongoing activities and institutional knowledge, sustained participation of member NPHI, and implementation of agreed work plans across successive Chairships.

Network sustainability would depend on adequate financing. The 2026 Operational Framework identifies potential financing through BRICS cooperation mechanisms, including the Science, Technology and Innovation Framework, national sources, and other multilateral or multi-country mechanisms (Supplementary File). Evidence from NPHI and public health networks also identifies sustainable financing as an important factor for institutional continuity and network development [17, 19]. These financing mechanisms represent potential sources of support, and the extent to which they can provide adequate and predictable financing for BNN activities remains to be established.

International experience for the BRICS Network of National Public Health Institutes

A systematic review of African NPHI reported improvements in outbreak detection, surveillance, workforce capacity, inter-institutional cooperation, health equity, and evidence-informed policy, while noting persistent gaps in governance, communication, outbreak preparedness, and system resilience [20]. More recent African evidence similarly highlights sustainable financing, workforce development, sound governance, and integration into regional networks as for NPHI maturation and resilience [19]. These findings indicate that strengthening individual NPHI and linking them through regional cooperation may be complementary approaches to public health capacity development.

Complementary lessons come from academic and institutional public health networks. The Global Network for Academic Public Health illustrates the role of supporting education, competency development,

Table. Three-tier governance structure of the BRICS Network of National Public Health Institutes

Tier	Activities	Mandate
Tier 1 BRICS Health Ministers	Ministers' meeting (annual)	Policy direction, political mandate, strategic endorsement and resource mobilization for the BNN
Tier 2 BNN Secretariat under BRICS Chair	Assembly session (annual)	Guidance, operational coordination, and documentation for the BNN
Tier 3 National Steering Committee located at NPHI	Assembly/ Meeting (twice yearly)	Strategic support, coordination, implementation, and oversight of agreed activities within the respective member country

Note: BNN – BRICS Network of National Public Health Institutes; NPHI – National Public Health Institute. Full description of the 2026 Operational Framework is provided in Supplementary File.

academic exchange, collaborative research, and links between evidence and policy^{16,17,18,19} [21].

The International Association of NPHI and other collaborative models show that NPHI with different legal and organizational structures can cooperate around shared public health functions without adopting a uniform institutional model. Such cooperation is supported by peer learning, institutional partnerships, capacity mapping, and technical exchange²⁰ [8, 11].

Regional public health networks provide further lessons for BNN design and sustainability. The Eastern Mediterranean Public Health Network combines workforce development, surveillance, emergency preparedness, research, and knowledge exchange across countries [16]. Evidence from networks in the Eastern Mediterranean and Arab region suggests that institutionalized leadership, regular communication, strategic planning, and diversified financing support sustainability, whereas fragmented governance and unstable financing undermine it [17]. These experiences are relevant to the BNN, which depends on continuity across rotating BRICS Chairships, sustained institutional participation, and adequate financing.

The BNN adds a BRICS-specific dimension by linking cross-country collaboration with national institutional coordination. Designated NPHI and national coordination mechanisms would connect surveillance, laboratory systems, workforce development, applied research, and other public health institutions within each country. This model is broadly consistent with international experience, but its sustainability will depend on implementation of the proposed governance, financing, and continuity mechanisms.

Strengths, implementation challenges and evidence gaps

The 2026 Operational Framework has broad scope, linking workforce development, disease prevention and control, epidemic preparedness and health security, the One Health and antimicrobial resistance, digital health, applied research, and policy support within a common governance structure. By combining cross-country coordination through the BNN with national implementation through designated NPHI and National Steering Committees, it may help align shared BRICS priorities with country-specific public health needs²¹.

Implementation may nevertheless be affected by institutional, governance, and financial differences among BRICS countries, including variations in NPHI mandates and capacities, public health structures, and administrative systems [17, 19]. Continuity across successive BRICS Chairships and sustainable financing will therefore be important. Differences in institutional capacity may also affect participation in joint activities and translation of agreed BNN priorities into national implementation. To our knowledge, published evaluative evidence on BNN implementation and effectiveness is not yet available. Future evaluation should consider participation, collaborative activities,

¹⁶ Global Network For Academic Public Health. Accessed 13.08.2026. <https://globalnetworkpublichealth.org/>

¹⁷ ASPHER course: Ethics, Law and Governance for Climate and Environmental Action in Public Health. Accessed 13.08.2026. <https://www.aspher.org/>

¹⁸ Vision and Mission. Accessed 13.08.2026. <https://www.apacph.org/wp/about/vision-and-mission/>

¹⁹ Arab Network for Academic Public Health (ANAPH) Officially Launched. Accessed 13.08.2026. <https://globalnetworkpublichealth.org/arab-network-for-academic-public-health-anaph-officially-launched/>

²⁰ IANPHI Framework for the Creation and Development of National Public Health Institutes [2026]. Accessed 13.08.2026. <https://ianphi.org/tools-resources/nphi-framework.html>

²¹ Senior Officials' Meeting Held in Chandigarh as Part of Ongoing BRICS Health Ministerial Meetings Under India's Chairship. Accessed 13.08.2026. <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287898®=48&lang=2>

workforce development, joint research, surveillance and response capacity, governance continuity, and financial sustainability, while distinguishing between implementation and process indicators, intermediate public health system outcomes, and longer-term population health effects [19]. Whether these mechanisms lead to stronger public health systems or population health benefits remains to be established.

Several limitations should be considered. Experience from established NPHI and regional networks may not be directly transferable to BRICS because of differences in institutional mandates, health-system organization, governance, resources, and national priorities. Evidence on recent BRICS public health cooperation also relies substantially on official and institutional sources rather than peer-reviewed evaluations. In addition, the 2026 Operational Framework was formally endorsed only in July 2026 and is provided in full as the Supplementary File. Evidence on its implementation and outcomes is not yet available, and the present analysis is limited to the proposed design of the BNN and its comparison with international experience.

Conclusion

The BNN concept rests on a simple progression: strong public health systems require capable national institutions, and capable national institutions can benefit from reliable mechanisms for international collaboration when public health threats, such as COVID-19, cross the borders. COVID-19 exposed the cost of fragmentation, while experience from the International Association of NPHI and regional NPHI networks suggests that institute-to-institute cooperation can support national and regional public health capacities.

Building on these lessons, the BNN through a reciprocal platform among public health institutions with diverse and complementary capabilities across BRICS nations is intended to strengthen national public health systems and collective capacity to effectively address existing and emerging public health challenges. Its proposed strategic priorities and governance mechanisms provide a BRICS-specific approach for institutional collaboration; however, the extent to which implementation of the 2026 Operational Framework translates into improved public health system performance will depend on its implementation by the BRICS countries and the future evaluation.

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