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Ancient Respiratory Healing Traditions in Nepal: Ethnobotanical Practices, Herbal Pharmacology, and Their Relevance for Global Respiratory Health

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ABSTRACT

Respiratory diseases remain a major global health burden, disproportionately affecting low- and middle-income countries. Nepal, home to more than 1,700 medicinal plant species, possesses a deep reservoir of ethnobotanical knowledge used for treating cough, asthma, bronchitis, pneumonia, sinusitis, and other respiratory disorders. Across Ayurvedic, Tibetan (Amchi), and diverse Indigenous healing traditions, respiratory care relies on a pharmacopeia of herbs including Terminalia chebula, Terminalia bellirica,

Phyllanthus emblica, Acorus calamus, Ocimum basilicum, Mentha arvensis, Glycyrrhiza glabra, and Swertia chirayita. Evidence from contemporary studies confirms the strong anti-inflammatory, antimicrobial, antioxidant, bronchodilatory, and immunomodulatory activities of these medicinal plants. These properties have been documented across Nepal's rural districts, including Kaski, Kavrepalanchok, Bardiya, and the Terai Plains. For example, Terminalia bellirica is widely used for cough and cold, and Acorus calamus for respiratory congestion. Several herbs traditionally used for respiratory infections also featured prominently during Nepal's COVID-19 response, including Tulsi, Aloe vera, Cinnamomum zeylanicum, and Mentha species. For Nepal's global diaspora now widespread in the United States, Europe, the Middle East, and Australia, traditional respiratory remedies remain a culturally meaningful and cost-effective adjunct to biomedical care, supporting intergenerational knowledge transfer and community health. Yet rapid biodiversity loss, climate change, commercialization pressures, and declining ethnobotanical transmission threaten these practices. This article uses an integrative review approach to synthesize ancient respiratory healing traditions of Nepal with contemporary pharmacological evidence, identify priority areas for clinical research, and outline pathways for culturally grounded integration of herbal medicine into public health systems.

Keywords: Ayurveda, diaspora health, ethnomedicine, medicinal plants, phytotherapy, respiratory disease, traditional medicine

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INTRODUCTION

Respiratory diseases remain among the leading global causes of morbidity and mortality, accounting for millions of deaths each year and disproportionately affecting low- and middle-income countries (GBD Chronic Respiratory Disease Collaborators, 2020; World Health Organization, 2023). This burden is further exacerbated in regions where access to biomedical care is limited and environmental exposures are high (Boussi Rahmouni et al., 2025). Traditional herbal medicine continues to play an essential role in managing asthma, bronchitis, pneumonia, Chronic Obstructive Pulmonary Disease (COPD), viral respiratory infections, and emerging pathogens, with global evidence demonstrating potent anti-inflammatory, anti-microbial, anti-viral, and bronchodilatory properties across a wide range of medicinal plants (Iqbal & Rahman, 2024; Lakshmi et al., 2024). Nepal presents a rich context for such practices due to its unique altitudinal variation, which supports more than 17,000 medicinal plant species, coupled with deeply rooted

ethnomedical traditions across Indigenous and rural communities (Adhikari et al., 2019; Khakurel et al., 2022). Nepal's environmental and socio-economic conditions create elevated respiratory risks. Extreme altitude differences, heavy reliance on biomass fuels, and high household and ambient air pollution contribute to a disproportionate burden of respiratory illnesses in the Terai, mid-hills, and Himalayan regions.

Studies from these regions consistently document high reliance on herbal remedies for respiratory illnesses, reflecting both cultural continuity and the practical necessity of accessible, low-cost therapeutics (Ambu et al., 2020; Haq et al., 2024). As global respiratory burdens escalate, driven by worsening air pollution, climate change-related exposures, recurrent infectious disease outbreaks, and rapid urbanization, the systematic study of Nepal's respiratory ethnomedicine provides critical scientific and public-health insights (GBD 2020; Romanello et al., 2021; WHO, 2021). Contemporary pharmacological reviews confirm that plants widely used in Nepal, including *Zingiber officinale*, *Ocimum sanctum*, *Artemisia vulgaris*, *Justicia adhatoda*, and the Triphala complex, exhibit significant bioactivity relevant to respiratory health (Khadka et al., 2021; Moshayedi et al., 2021; Ogunwande et al., 2021). During the COVID-19 pandemic, when Nepal faced a critical public-health emergency, and its already-strained healthcare system was overwhelmed, communities turned to familiar plant-based remedies for protection and symptom management. Herbal medicines were widely perceived as accessible antiviral alternatives, grounded in centuries of Indigenous knowledge and cultural practice (Khadka et al., 2021). This period marked an unprecedented resurgence of traditional healing across Nepal, strengthening public trust in these ancient medicinal systems and reaffirming their relevance during times of crisis (Moshayedi et al., 2021). Consequently, the use of traditional respiratory herbs intensified nationwide, with households turning to Ginger, Turmeric, Garlic, Holy basil (Tulsi), and Sichuan pepper (Timur) as frontline preventive and symptomatic remedies (Gahatraj et al., 2020; Jafarzadeh et al., 2021; Rahman et al., 2022), particularly in the context of limited biomedical access and high community transmission (Khadka et al., 2021).

Despite the richness of Nepal's ethnomedical knowledge, the current literature remains fragmented and methodologically inconsistent, with most studies focusing on isolated districts or cultural groups and offering limited comparative synthesis across ecological zones or medical systems (Ghimire et al., 2004; Kunwar et al., 2022). Research across Nepal's Ayurvedic, Amchi, and Indigenous traditions often documents respiratory plants in localized contexts, yet cross-regional analysis and integration with national biodiversity data remain limited (Singh et al., 2022). In addition, connections between ethnobotanical documentation and contemporary pharmacological evidence remain fragmented constraining the translation of traditional respiratory knowledge into public health, clinical, or integrative medicine frameworks (Chang et al., 2013; Horani et al., 2012; Townsend et al., 2013).

Given Nepal's convergence of exceptional ethnobotanical diversity, deeply rooted cultural knowledge systems, and a growing scientific evidence base validating key respiratory herb, examining these traditional practices offers meaningful insights for global respiratory and integrative health (GBD 2020; Kunwar et al., 2022; Shrestha et al., 2022). These practices, shaped by centuries of lived experience and adapted to Nepal's highly varied ecological landscapes, provide valuable lessons for designing resilient and culturally grounded respiratory-care models, particularly in settings where biomedical

resources remain limited (Ghimire et al., 2004; Uprety et al., 2012). In this context, this review aims to synthesize the breadth of ethnobotanical and ethnomedical knowledge related to respiratory care across Nepal's Ayurvedic, Amchi, and Indigenous healing traditions, evaluate the pharmacological and mechanistic evidence supporting the most widely used herbs within these systems, and explore how such knowledge can inform global respiratory-health initiatives, strengthen primary health-care (PHC) integration, and support culturally responsive public-health strategies (Chang et al., 2013; Townsend et al., 2013; WHO, 2021).

This analysis is framed by Kleinman's explanatory models of illness, the WHO Traditional Medicine Strategy (2014-2023), ecosystem health, and the One Health approach, as well as scholarship on Indigenous knowledge and community resilience. By situating Nepal's respiratory ethnomedicine within these broader theoretical and public-health perspectives, this article provides a robust framework for understanding how traditional respiratory care can contribute to integrative, equitable, and context-responsive health systems.

METHODOLOGY

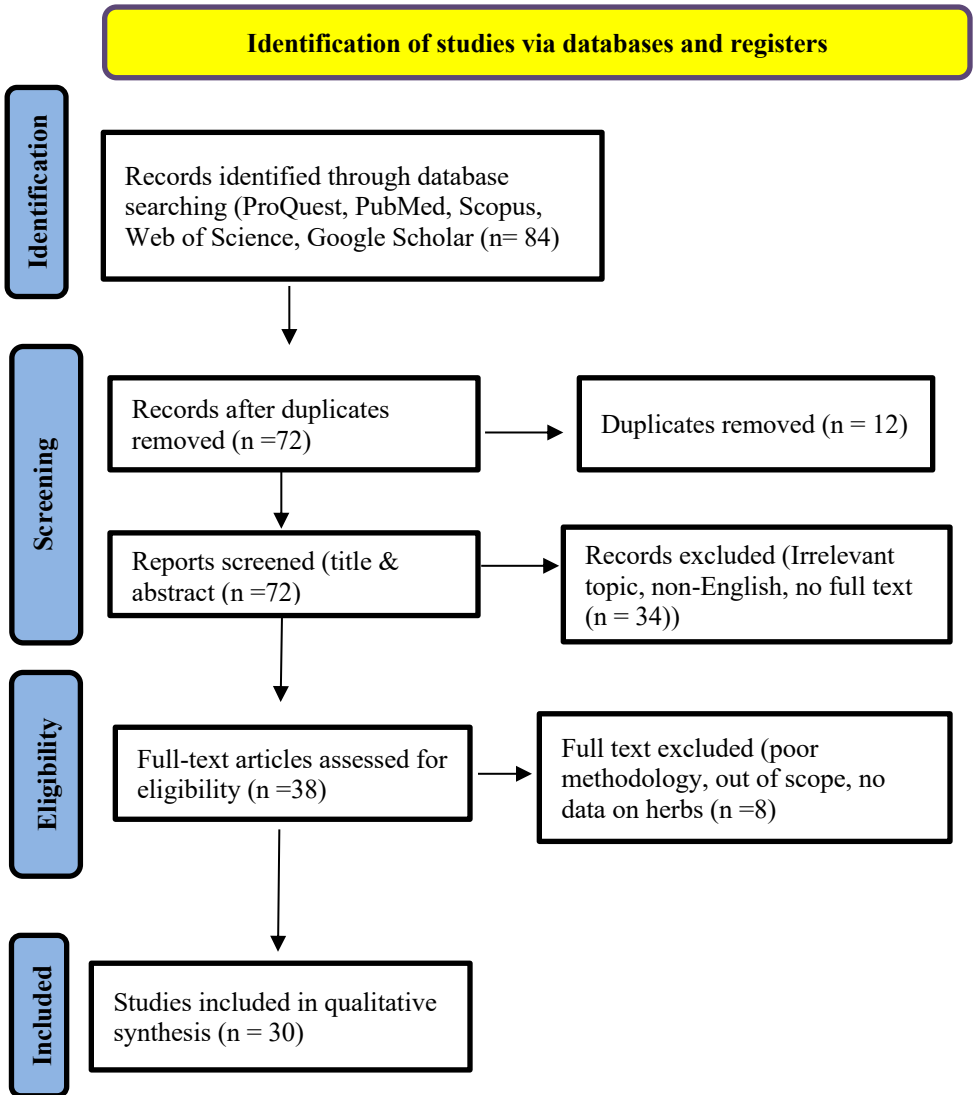
This study employed an integrative review approach to synthesize ethnobotanical, ethnomedical, pharmacological, ecological, and public health literature related to respiratory medicinal plants and healing traditions in Nepal. Integrative reviews are appropriate for bringing together diverse forms of evidence, including ethnographic studies, pharmacological research, policy documents, and broader contextual literature, to generate a comprehensive understanding of a complex health topic.

A structured literature search was conducted using PubMed, Google Scholar, Scopus, Web of Science, and ProQuest to identify relevant publications on respiratory ethnomedicine, medicinal plants, and traditional healing practices in Nepal. Search terms included combinations of *Nepal*, *respiratory disease*, *ethnobotany*, *ethnomedicine*, *traditional medicine*, *Ayurveda*, *Amchi*, *medicinal plants*, *respiratory herbs*, *pharmacology*, *public health*, *biodiversity*, and *climate change*. The search initially identified 84 records, which were screened after duplicate removal according to predefined inclusion and exclusion criteria. Studies were included if they:

- (1) examined medicinal plants or traditional healing practices related to respiratory conditions in Nepal,
- (2) provided pharmacological, phytochemical, or clinical evidence relevant to respiratory health; or
- (3) addressed ecological, conservation, or public health dimensions of respiratory ethnomedicine.

Studies were excluded if they were not focused on respiratory conditions, were not specific to Nepal, lacked substantive relevance to ethnomedicine or medicinal plants, or did not provide sufficient data for synthesis. After screening and full-text assessment, 30 studies met the inclusion criteria and were included in the qualitative synthesis. The manuscript cites 53 references overall; however, the remaining references were used to provide theoretical background, global context, methodological support, and policy framing, and were not part of the formal study-selection process summarized in Figure 1. The literature selection process is summarized in Figure 1.

Figure 1: Prisma flow diagram



TRADITIONAL MEDICAL SYSTEMS IN NEPAL

Ayurvedic Respiratory Concepts (Vata Disorders and Pranavaha Srotas)

Ayurveda forms the backbone of Nepal's formal traditional medical system, where respiratory diseases are primarily understood as imbalances in the *Vata dosha and Kapha dosha* and dysfunctions of the *Pranavaha Srotas* (the channels governing respiration) (Sharma & Bhat, 2023). Classical Ayurvedic herbs used for cough, asthma, and bronchial irritation, such as Triphala (*Phyllanthus emblica*, *Terminalia bellirica*, and *Terminalia chebula*), Tulsi (*Ocimum sanctum*), Ginger (*Zingiber officinale*), and Pipla (*Piper longum*), remain widely used and strongly corroborated by modern phytochemical and pharmacological studies (Ghimire et al., 2023; Rahman et al., 2022). Many of these plants exhibit mucolytic, bronchodilatory, anti-oxidant, and immunomodulatory properties consistent with Ayurvedic principles describing the clearing of *ama* (toxic accumulation) and normalization of respiratory flow (Gahatraj et al., 2020; Jafarzadeh et al., 2021; Rahman et al., 2022). Nepal's Ayurvedic practice is also shaped by high-altitude ecological conditions, incorporating plants such as *Rhododendron anthopogon* and *Valeriana jatamansi*.

Himalayan Amchi (Tibetan/(Sowa-Rigpa)) Medical Frameworks

In Nepal's Himalayan belt, Amchi (Sowa-Rigpa) medicine uses a distinct diagnostic system emphasizing disturbances of wind (*rlung*), bile (*mkhris pa*), and phlegm (*bad kan*). According to the Four Tantras (Gyushi), respiratory disorders are conceptualized as accumulations of cold or dampness in the lungs, which are treated with warming medicinal herbs such as *Artemisia*, *Rhododendron*, and *Nardostachys jatamansi*. Ethnobotanical mapping shows that many high-altitude plants used in Amchi respiratory practices are documented in Kaski, Rasuwa, and the high mountains. These studies also demonstrate potent anti-microbial and anti-viral properties validated in modern laboratory research (Haq et al., 2024; Manandhar et al., 2019; Shrestha et al., 2020). Amchi traditions, therefore, represent an ecologically grounded healing medical system that has evolved in direct response to cold, high altitude respiratory burdens and is reinforced by a rich pharmacologically active alpine flora.

Folk Healing Traditions (Dhami/Jhakri, Herbalists, and Household Practices)

Folk healing remains integral to respiratory health management across rural Nepal. Dhami/Jhakri (shamanic practitioners) combine ritualized healing, spiritual diagnostics, and herbal pharmacotherapy, often using plants identified through intergenerational community knowledge. These practices are deeply embedded in Indigenous belief systems that view illness as both biological and spiritual in origin. Ethnobotanical surveys from the Terai Plains, Kavrepalanchok, and Machhapuchchhre document extensive use of smoke inhalation, poultices, decoctions, steam therapy, and compound herbal formulations for cough, cold, fever, bronchitis, and pneumonia (Adhikari et al., 2019; Ambu et al., 2020; Thorn et al., 2020). These traditions emphasize

household-level prevention and early intervention, supported by plants such as Asuro (*Justicia adhatoda*), Titepati (*Artemisia* spp.), Ginger, Turmeric, Garlic, and Timur, many of which demonstrate strong scientific evidence for anti-inflammatory, anti-bacterial, anti-viral, and bronchodilatory activities in recent pharmacological reviews (Garg et al., 2024; Iqbal & Rahman, 2024). This practice affirms the biomedical relevance of long-lasting household practices. As demonstrated across all 30 articles, these parallel healing systems, Ayurvedic, Amchi, and folk, form a complementary ecosystem of respiratory care that is botanically rich, culturally embedded, scientifically validated, and vital to Nepal's public health landscape.

MAJOR RESPIRATORY HERBS IN NEPAL: EVIDENCE -BASED REVIEW

Nepal's respiratory ethnomedicine relies on a rich pharmacopeia of medicinal herbs validated across indigenous knowledge systems and increasingly supported by modern pharmacological research. Ethnobotanical surveys from the Kavrepalanchok district document extensive use of *Justicia adhatoda* (Asuro), *Zingiber officinale* (Ginger), *Curcuma longa* (Turmeric), *Acorus calamus* (Sweet flag), *Artemisia vulgaris* (Mugwort), and *Allium sativum* (Garlic) for asthma, cough, fever, and bronchitis, with local healers preparing juices, decoctions, and pastes for rapid symptomatic relief (Adhikari et al., 2019; Ambu et al., 2020). These findings are consistent with broader national reviews indicating that 119 medicinal plant species across 54 botanical families are used for respiratory diseases among 15 ethnic groups in Nepal (Kandel et al., 2021). Scientific validation aligns with these traditional applications, and the pharmacodynamic properties of these herbs help clarify the mechanisms underlying their therapeutic effects.

Bronchodilators and Smooth-Muscle Relaxants

Justicia adhatoda - one of Nepal's most widely used respiratory herbs acts as a potent bronchodilator due to its key alkaloids vasicine and vasicinone, which relax airway smooth muscle, enhance mucociliary clearance, and reduce bronchospasm. These effects are supported by both traditional Ayurvedic use and modern pharmacological studies demonstrating its relevance for managing asthma, wheezing, and obstructive airway diseases (Ghimire et al., 2023; Rahman et al., 2022).

Expectorants and Anti-Inflammatory Agents

Zingiber officinale is among Nepal's most widely employed respiratory herbs. Its bioactive constituents - gingerols, shogaols, and zingerone exhibit potent anti-inflammatory, anti-oxidant, and smooth-muscle-relaxing effects. Recent meta-analyses have shown its ability to modulate airway inflammation and improve mucociliary clearance (Paudel et al., 2025). High-altitude Himalayan communities traditionally utilize *Thymus linearis*, whose essential oils function as expectorants, anti-microbials, and warming agents (Haq et al., 2024).

Anti-viral and Anti-microbial Herbs

Species of *Artemisia*, particularly *A. vulgaris* and *A. dubia*, are widely used in the Himalayan and mid-hill regions for fever, cough, and viral respiratory syndromes. In-vitro studies carried out in Nepal have demonstrated that *Artemisia* extracts inhibit a range of respiratory pathogens, including influenza-like viruses and upper-respiratory-tract bacteria (Manandhar et al., 2019; Shrestha et al., 2020). These findings parallel global anti-viral research on *Artemisia* species and highlight their relevance in both traditional and contemporary respiratory therapeutics.

Immunomodulators

The Triphala complex (*Terminalia chebula*, *Terminalia bellirica*, and *Phyllanthus emblica*). It's widely used for chronic cough, recurrent respiratory infections, and general immune strengthening. Phytochemical analyses have documented its high tannin, flavonoid, and polyphenol content, supporting its anti-oxidant, anti-inflammatory, and immunomodulatory activity (Gahatraj et al., 2020; Ghimire et al., 2023). These properties make Triphala a major component of long-term respiratory wellness in both Ayurvedic and household healing systems.

High-Altitude Respiratory Herbs

Himalayan communities employ warming, aromatic, and anti-microbial herbs such as *Rhododendron anthopogon*, *Valeriana jatamansi*, and *Thymus linearis* to alleviate cold-induced respiratory irritation, altitude-related dyspnea, and winter coughs. These species contain essential oils, phenolics, and terpenoids with expectorant, anxiolytic, and anti-microbial functions, offering ecological adaptations particularly suited to high-altitude respiratory burdens (Haq et al., 2024).

Critical Interpretation and Research Gaps

Despite a strong ethnomedical foundation, scientific evidence supporting Nepal's respiratory herbs remains limited. Most available studies are based on in vitro experiments or animal models, with few well-designed clinical trials assessing efficacy, safety, optimal dosing, or long-term outcomes. Variability in plant chemotypes across altitude and harvesting practices also limits reproducibility and standardization. These gaps highlight the need for rigorous pharmacological studies, quality-control systems, and clinical evaluations aligned with the WHO Traditional Medicine Strategy to enable safe integration of these herbs into mainstream respiratory care.

Risks and Safety Considerations

While generally safe at traditional doses, several herbs may pose toxicity risks if misused. *Acorus calamus* varieties containing β -asarone have potential genotoxic and mutagenic effects (Mukherjee et al., 2008); *Artemisia* species contain the compound

thujone, which is responsible for inducing neurotoxicity risks at high doses (Sharifi-Rad et al., 2022), and potent expectorants such as Asuro have documented bronchodilatory and expectorant effects, suggesting a theoretical potential for additive action when used alongside pharmaceutical bronchodilators (Khan et al., 2018). Current reviews underscore the importance of dosage standardization, accurate plant identification, and awareness of contraindications, particularly when herbal therapy is combined with modern pharmacological treatments.

MODES OF ADMINISTRATION AND THERAPEUTIC PRACTICES

Traditional respiratory care in Nepal encompasses a range of therapeutic preparation and delivery methods that optimize bioavailability and align with local cultural norms. Ethnobotanical studies from Kavrepalanchok and the Terai show widespread use of decoctions (Kadha/Jhol) combining Ginger, Turmeric, Pepper, Tulsi, and Cinnamon, which are traditionally administered for colds, fever, and chest congestion. Steam inhalation using Titepati (*Artemisia*) or Tulsi leaves to relieve nasal blockage and sinus infections, with practices reported consistently across Indigenous groups in Nepal's mid-hill and mountain regions. These practices align with evidence demonstrating the high volatile oil content and anti-microbial activity of these plants (Ambu et al., 2020; Manandhar et al., 2019).

In high-mountain communities, fumigation and herbal smoking mixtures prepared from *Rhododendron spp.*, *Juniperus indica*, or *Artemisia* species have been historically used for ritual purification and to clear "cold-wind" respiratory disorders, aligning with Amchi frameworks describing wind imbalance in the lungs (Haq et al., 2024; Thorn et al., 2020). Additionally, rural households commonly use warm poultices of Ginger, Turmeric, and Mustard oil applied to the chest as counter-irritants to improve circulation and ease bronchoconstriction (Adhikari et al., 2019; Ambu et al., 2020).

Dietary and preventive practices are central to the management of respiratory illnesses. Triphala infusions, hot ginger-lemon drinks, turmeric milk, and spiced soups (jhol) remain common for strengthening immunity and reducing phlegm accumulation, a theme echoed in COVID-19-era studies where communities turned to these same preparations for prevention and symptom control (Gahatraj et al., 2020; Ghimire et al., 2023; Jafarzadeh et al., 2021; Khadka et al., 2021; Moshayedi et al., 2021). Ritual and spiritual elements such as Dhama/Jhakri healing sessions, the burning of Juniper or *Artemisia* for purification, and chanting during illness reinforce psychosocial well-being and community support structures documented across Nepal's ethnographic landscapes (Thorn, J. P. R., Thornton, T. F., Helfgott, A., & Willis, K. J., 2020). Collectively, these administration practices of steam, decoctions, poultices, smokes, dietary regimens, and ritualized healing represent a holistic respiratory care system validated both by indigenous knowledge and modern phytochemical and pharmacological research.

CROSS-CULTURAL COMPARISONS

Cross-cultural comparison offers an important analytic lens for understanding Nepal's respiratory ethnomedicine. Many global healing systems, despite vast cultural

differences, have developed strikingly similar remedies for respiratory diseases due to convergent therapeutic evolution, shared ecological constraints, and common human exposures to respiratory pathogens. Comparative analysis, therefore, highlights deeper structural logics within traditional medicine: how different cultures interpret respiratory pathogenesis, how ecological availability shapes local pharmacopoeias, and how trade, migration, and knowledge exchange have historically linked medicinal systems across Asia and beyond (Kleinman, 1980; Singh et al., 2022).

Nepal and Classical Indian Ayurveda

Nepal's respiratory ethnomedicine is distinctly shaped by its Himalayan ecology and indigenous cultural practices. Classical Ayurveda emphasizes imbalances of doshas and dysfunction of the *Pranavaha Srotas* in respiratory illnesses, using formulations such as Triphala, Pippali, Tulsi, and Vasaka, all of which are widely used in Nepal and supported by robust phytochemical and pharmacological evidence (Gahatraj et al., 2020; Rahman et al., 2022). However, Nepal's high-altitude regions introduce herbs absent or rare in classical Indian Ayurveda, such as *Rhododendron anthopogon*, *Nardostachys jatamansi*, and *Thymus linearis*, documented in the Machhapuchchhre and Rasuwa studies (Adhikari et al., 2019; Haq et al., 2024). These high altitude species reflect the ecological determinism where cold climate and hypoxic environments shape distinct therapeutic adaptations. Thus, Nepal's respiratory herbology represents a hybrid Ayurvedic–Himalayan system adapted to cold climates and high-altitude disease patterns.

Nepal and Traditional Chinese Medicine (TCM)

Traditional Chinese Medicine conceptualizes respiratory disease through Qi deficiency, Cold-Wind invasion, and Phlegm stagnation, prescribing warming herbs (e.g., ginger, cinnamon), expectorants, and volatile oil-rich aromatic decongestants. Many functional parallels exist between TCM and Nepalese practice, most notably in the use of *Zingiber officinale* and *Artemisia* species (Manandhar et al., 2019; Singh et al., 2022). Global pharmacology reviews show that these herbs possess widely recognized anti-inflammatory, bronchodilatory, and anti-viral effects consistent across both systems. While TCM relies on complex multi-herb formulations, Nepalese practice typically employs simpler, household-based preparations, reflecting differences in accessibility, ecological, and community health structures.

Nepal and Indigenous U.S. Respiratory Herbal Traditions

Indigenous North American healing traditions also use warming, aromatic, and anti-microbial herbs for respiratory ailments such as *Echinacea*, Sagebrush (*Artemisia tridentata*), *Yerba Santa*, and *Lobelia*. Strikingly, many of these share genera or functional analogues with Nepali herbs. For example, the use of *Artemisia* species for colds, bronchitis, and purification rituals is common to both the Himalayas and Indigenous U.S. communities (Thorn et al., 2020). Global systematic reviews confirm that medicinal plants across cultures converge on similar immunomodulatory and anti-

viral pathways, suggesting independent yet parallel therapeutic evolution (Rahman et al., 2022; Singh et al., 2022). These parallels reinforce that similar ecological niches, respiratory exposure, and cultural needs can produce convergent therapeutic strategies across continents.

PUBLIC HEALTH SIGNIFICANCE

Accessibility and Low Cost

Across Nepal, medicinal plants serve as first-line respiratory care options, particularly in rural and mountainous regions where healthcare access is limited. Studies from Kavrepalanchok, Kaski, and the Terai Plains have documented widespread household dependence on herbal remedies for cough, asthma, pneumonia, and fever due to their cost-effectiveness, cultural familiarity, and immediate local availability (Adhikari et al., 2019; Ambu et al., 2020; Thorn et al., 2020). Given that forty percent of Nepalese face limited access to primary care and over half of healthcare expenditure being paid out of pocket, herbal medicine remains an essential safety net (WHO, 2023).

Relevance for the LMIC Respiratory Burden

Respiratory infections are a leading cause of morbidity and mortality across LMICs. Nepal's respiratory disease burden is among the highest in South Asia, driven in part by the continued reliance on traditional biomass fuels, with 51% of households still using fuelwood for cooking as of 2021 (Wang et al., 2024). Recent data indicate that COPD affects approximately 11.7% of Nepalese adults (Karki et al., 2021), while acute respiratory infections still afflict about 2.1% of children under five in any given two-week period (Dharel, Shrestha, & Basel, 2023). The global pharmacological literature, including systematic reviews, emphasizes that affordable herbal medicines with anti-inflammatory, anti-viral, and bronchodilatory properties offer critical options for resource-limited populations. Studies also highlight that widely used Nepalese herbs—*Justicia adhatoda*, *Zingiber officinale*, *Curcuma longa*, *Artemisia* spp., and Triphala exhibit anti-inflammatory, anti-viral, and bronchodilatory properties well-suited to LMIC contexts where pharmaceutical access is limited (Rahman et al., 2022; Singh et al., 2022).

Integration with Primary Health Care (PHC)

WHO recommends integrating validated traditional practices into Primary Health Care (PHC) systems, particularly when they are safe, accessible, effective, and culturally accepted (World Health Organization, 2014; WHO, 2023). Evidence from Nepal's ethnobotanical and pharmacological studies shows that many respiratory herbs used in rural settings meet these criteria, supporting their potential for PHC integration (Adhikari et al., 2019; Ambu et al., 2020; Ghimire et al., 2023). These herbs are already used informally by community health workers and volunteers during early respiratory care, and for Nepalese households, herbal medicines remain the first line of treatment.

Most Nepalese do not seek biomedical care for common respiratory illnesses like cough and flu in their early stages; instead, management typically begins in the kitchen with familiar herbal remedies- a practice now reinforced by growing scientific evidence strongly supporting the immunomodulatory, bronchodilatory and anti-microbial properties of widely used herbs such as *Justicia adhatoda*, Ginger, Turmeric, and Tulsi (Rahman et al., 2022; Singh et al., 2022). This method of treatment supports PHC integration. Ayurvedic experts have also emphasized the suitability of these herbs for PHC-linked protocols. COVID-era studies documented a nationwide increase in herbal use, underscoring their role in public education, immune support, and early symptom management during periods of health-system strain (Khadka et al., 2021; Moshayedi et al., 2021).

CLIMATE CHANGES AND BIODIVERSITY THREATS

Loss of Medicinal Plants in Nepal

Climate-driven shifts in temperature, precipitation, and habitat quality threaten the distribution of key medicinal species. Ensemble species distribution models for 20-30 high-value species in Nepal and the eastern Himalaya predict consistent upslope shifts in suitable habitat and 13-16% projected habitat loss by mid to late century, with particularly sharpest contraction in mid-elevation medicinal plants 'hotspots' where many respiratory herbs are concentrated (Manish, 2022; Shrestha et al., 2022;). As identified in biodiversity and forest-resource studies from the high Himalayan region, Nepal's richest medicinal plant zones are experiencing rapid biodiversity loss. National reviews warn that these areas are increasingly threatened by overexploitation and land-use change.

For high-altitude species such as *Nardostachys jatamansi*, *Rhododendron anthopogon*, and *Valeriana jatamansi*, these shifts create a 'mountain-top trap,' and these species are already experiencing range contraction and overharvesting (Ghimire et al., 2019). Field studies further document phenological disruptions such as earlier flowering and altered growth phases, undermining long-established harvesting calendars and lowering regenerative capacity (Acharya, 2022; Bhattarai et al., 2021). These climatic pressures compound long-standing overharvesting for trade. *N. jatamansi* is listed as Critically Endangered in the IUCN Red List and included in CITES Appendix II due to unsustainable root extraction and habitat degradation (CITES, 2022; IUCN, 2020). Recent rapid vulnerability assessments in the Annapurna region similarly classify several respiratory medicinal plants as high-risk when climate projections are combined with harvest intensity (Khakurel et al., 2024).

These trends unfold within a broader global conservation and governance framework. As a signatory to the Convention on Biological Diversity (CBD) and Nagoya Protocol, Nepal is obligated to conserve biodiversity, ensure sustainable use, and establish fair and equitable benefit-sharing for genetic resources and associated traditional knowledge (Beato et al., 2023; CBD, 2011). IUCN assessment and CITES non-detriment findings now shape Nepal's species-specific management plans and export controls (CITES, 2022; IUCN, 2020). Within Nepal, Indigenous and community forestry institutions, including more than 22,000 Community Forest User Groups, serve as primary stewards of medicinal plant landscapes, regulating harvest timing, altitudinal

access, and protection of sacred groves (Ghimire P. & Lamichhane U., 2020). Amchi and Ayurvedic practitioners whose livelihoods depend on sustainable wild harvest are increasingly recognized as conservation partners whose ecological knowledge can guide climate-responsive in-situ management and cultivation strategies (Kunwar et al., 2014).

PUBLIC HEALTH IMPLICATIONS

For many rural Nepalese communities, particularly in mid-hill and mountain regions, herbal remedies represent primary respiratory care, not complementary medicine. Ethnobotanical surveys from the Terai to the high Himalaya consistently show strong reliance on locally gathered plants for cough, asthma, bronchitis, and cold-related illnesses, largely due to geographical barriers, limited biomedical services, and cultural familiarity with traditional remedies (Kunwar et al., 2022; Singh et al., 2012). Climate-driven range shifts, phenological instability, and market-driven scarcity of key respiratory herbs, therefore, directly constrain access to home-based treatments, pushing households toward more expensive pharmaceuticals or, in some cases, toward delayed or avoided care (Manish et al., 2022). As high-altitude species migrate beyond customary harvesting zones, travel time and collection difficulty increases, deepening inequities for remote and marginalized populations (Shrestha et al., 2022). Loss of medicinal plant diversity directly affects community respiratory health, especially in areas where herbal remedies serve as primary care. Reduced availability increases dependence on expensive pharmaceuticals, widens inequities, and accelerates the erosion of indigenous medical knowledge. Several studies emphasize that younger generations are losing exposure to wild medicinal plants, threatening the long-term sustainability of respiratory ethnomedicine.

At the same time, biodiversity loss accelerates the erosion of indigenous medical knowledge. Ethnoecological studies show stark generational gaps: elders maintain a detailed understanding of respiratory plants, while younger generations shaped by migration, wage labor, and formal education have reduced forest interaction and limited involvement in ethnomedicinal practices (Ghimire et al., 2004; Kunwar et al., 2014). This weakens intergenerational transmission, essential for both cultural identity and community health resilience. Strengthening community forestry, formally recognizing Amchi and Ayurvedic practitioners as biodiversity stewards, and advancing CBD/Nagoya-compliant benefit-sharing schemes that reinvest in local health and conservation institutions are, therefore, not only environmental actions but public health strategies. By stabilizing medicinal-plant populations and supporting the knowledge systems that sustain them, these measures help safeguard culturally grounded respiratory-care options for communities most vulnerable to climate change and limited healthcare access.

RECOMMENDATIONS FOR RESEARCH AND POLICY

Need for Clinical Trials and Validation

Although many herbs have strong laboratory and ethnopharmacological support, clinical trials remain limited. Future research should be targeted toward clinical and translational studies on these specific medicinal herbs. Systematic reviews call for controlled trials on *Justicia adhatoda*, Ginger, *Artemisia*, and Triphala, especially for asthma, bronchitis, viral infections, and COPD (Heinrich et al., 2018; Pandey et al., 2020; Weckerle et al., 2018). Although there is strong evidence supporting these herbs as bronchodilators, mucolytics, immunomodulators, and anti-virals, the existing gaps should be filled with rigorous clinical trials. Priority next steps include:

- Pragmatic RCTs evaluating Asuro- and Ginger-based formulations for asthma, chronic bronchitis, and productive cough;
- Trials assessing *Artemisia*-based preparations for influenza-like illness and mild COVID-19
- Pilot studies of Triphala for COPD or chronic bronchitis.

Research should emphasize policy-relevant outcomes (lung function, exacerbations, safety, herb-drug interactions). Supporting this requires community-embedded research infrastructure, including ethnopharmacology field stations in high-use districts and a national Respiratory Ethnopharmacology Network linking universities, Ayurvedic hospitals, Amchi clinics, and the Department of Plant Resources to standardize plant identification, dosage, and outcome measures.

Preservation of Ethnomedicinal Knowledge

Climate pressures and social change are accelerating the loss of intergenerational medicinal plant knowledge. Ethnobotanical studies across Nepal warn that cultural knowledge transfer is weakening as modernization accelerates. Elders retain a detailed understanding of plant identification, preparation, and use, while younger generations shaped by migration, wage labor, and reduced forest interaction have limited exposure to ethnomedicinal practices. Policies should support documentation, community-based knowledge banks, Amchi training programs, and school-level botanical education to preserve respiratory healing traditions. Preservation efforts must be grounded in CBD/Nagoya-aligned access and benefit-sharing principles, ensuring community control, free prior and informed consent (FPIC), and respect for data sovereignty, especially for sacred or sensitive knowledge.

Integration Pathways

Evidence supports integration through:

- Pharmacopoeial monographs and preparation protocols for core herbs

- Standardized herbal protocols for mild respiratory infections and chronic respiratory symptoms as adjuncts to biomedical care
- Training on safe indications, contraindications, drug reactions, and referral criteria
- Establishing sustainable harvesting and cultivation programs, and
- Linking Amchi and Ayurvedic practitioners with local PHC centers.

These pathways align with WHO traditional-medicine integration guidelines and are reinforced by consistent findings across Nepal's ethnobotanical literature.

CONCLUSION

Across Nepal's diverse ecological zones and cultural traditions, medicinal plants remain foundational to respiratory health, accessible, affordable, culturally meaningful, and increasingly validated by modern science. Ethnobotanical surveys, pharmacological studies, and global reviews of respiratory herbs all demonstrate that Nepal's respiratory pharmacopeia possesses significant anti-microbial, anti-viral, anti-inflammatory, and bronchodilatory potential. Yet climate change, overharvesting, and cultural transitions threaten this knowledge system and the biodiversity that sustains it. Strengthening research, conservation, policy integration, and intergenerational transmission will ensure that Nepal's ancient respiratory healing traditions continue to inform global health, contribute to primary care, and expand the evidence base for integrative medicine.

DECLARATIONS

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