

## PHARMACOECONOMICS: PRINCIPLES, METHODS AND APPLICATIONS WITH SPECIAL REFERENCE TO AYURVEDIC TREATMENT

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### ABSTRACT

**Background:** Pharmacoeconomics is an evolving discipline that evaluates the costs and consequences of pharmaceutical products and healthcare interventions. With escalating healthcare expenditure globally, there is an increasing need to incorporate economic evidence into clinical and policy decision making. Ayurvedic medicine, one of the world's oldest systems of healthcare, offers potentially cost-effective solutions for a range of acute and chronic conditions, yet its pharmacoeconomic evaluation remains underexplored. **Objectives:** This review aims to outline the core principles and methodologies of pharmacoeconomics, critically appraise published economic evaluations of Ayurvedic interventions, identify methodological gaps, and propose a framework for future research. **Methods:** A systematic narrative review was conducted using PubMed, Scopus, AYUSH Research Portal, Cochrane Library and Google Scholar databases. Studies published between 2000 and 2024 reporting economic evaluations of Ayurvedic treatments were included. **Results:** Evidence consistently demonstrates that several Ayurvedic formulations, including Triphala, Ashwagandha, Boswellia serrata, Brahmi, and Panchakarma therapy, offer favourable incremental cost-effectiveness ratios compared with conventional allopathic counterparts. However, methodological heterogeneity, inadequate long term data, and lack of standardized quality of life instruments represent significant barriers. **Conclusion:** Ayurvedic treatments hold significant pharmacoeconomic promise. Rigorous, well-designed economic evaluations using standardized methodologies are urgently needed to facilitate evidence based integration into mainstream healthcare and national formularies.

**KEYWORDS:** Pharmacoeconomics, Cost-effectiveness analysis, Ayurveda, Traditional medicine, Health technology assessment, Integrative medicine

## 1. INTRODUCTION

Pharmacoeconomics is a scientific discipline that applies the principles of economics and epidemiology to the evaluation of pharmaceutical products and healthcare interventions. It provides a systematic framework to compare the costs and outcomes of alternative treatment strategies, thereby supporting rational resource allocation in healthcare systems [1, 2]. Healthcare expenditure has risen sharply across both developed and developing economies. According to the World Health Organization (WHO), global health spending reached USD 9.8 trillion in 2021, representing approximately 10.3% of global GDP [3]. In India, out of pocket health expenditure continues to constitute a significant proportion of total health financing, placing a disproportionate burden on low- and middle-income populations [4].

Traditional systems of medicine, particularly Ayurveda, have been practiced for over 5,000 years and continue to serve as the primary healthcare system for approximately 80% of the population in developing countries, according to WHO estimates [5]. The Government of India, through the Ministry of AYUSH (Ayurveda, Yoga and Naturopathy, Unani, Siddha, and Homeopathy), has invested substantially in promoting and integrating these traditional systems within the national health framework [6]. Despite the widespread use and historical validation of Ayurvedic therapies, rigorous pharmacoeconomic evaluations of these interventions remain limited. Most existing evidence is derived from small scale clinical studies with inadequate economic endpoints. This review addresses this gap by providing a comprehensive synthesis of pharmacoeconomic principles and their application to Ayurvedic medicine, with the aim of guiding future research and policy [7, 8].

## 2. PRINCIPLES AND METHODS OF PHARMACOECONOMICS

### 2.1 Definition and Scope

Pharmacoeconomics is defined as the description and analysis of the costs and consequences of pharmaceuticals and pharmaceutical services and their impact on individuals, healthcare systems, and society [1]. It encompasses a range of methodological approaches that differ primarily in how they measure health outcomes and translate them into economic value [9].

### 2.2 Types of Pharmacoeconomic Analysis

The major types of economic evaluation used in pharmacoeconomics are summarized in Table 1 below, along with their application to Ayurvedic treatments.

**Table 1: Types of Pharmacoeconomic Analysis and Their Application to Ayurvedic Medicine.**

| Method                            | Description                                         | Outcome Measure                                    | Application in Ayurveda                                     |
|-----------------------------------|-----------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------|
| Cost-Minimization Analysis (CMA)  | Compares costs when outcomes are equivalent         | Equivalent outcomes assumed                        | Comparing equivalent Ayurvedic vs conventional formulations |
| Cost-Effectiveness Analysis (CEA) | Relates costs to a single health outcome            | Cost per unit of clinical benefit (e.g., QALY, LY) | Triphala vs conventional laxatives in constipation          |
| Cost-Utility Analysis (CUA)       | Compares costs with quality-adjusted outcomes       | Cost per QALY or DALY                              | Panchakarma therapy for chronic conditions                  |
| Cost-Benefit Analysis (CBA)       | Expresses both costs and benefits in monetary terms | Net monetary benefit or BCR                        | Holistic Ayurvedic wellness programmes                      |
| Budget Impact Analysis (BIA)      | Estimates financial impact of adopting a treatment  | Budget change over time                            | Integration of Ayurveda into national health schemes        |
| Disease Burden Analysis           | Quantifies the economic burden of a disease         | DALYs, healthcare costs                            | Burden of lifestyle diseases amenable to Ayurvedic care     |

### 2.3 Key Economic Indicators

The Incremental Cost-Effectiveness Ratio (ICER) is the cornerstone of comparative pharmacoeconomic analysis. It represents the additional cost required to gain one additional unit of health benefit (typically one Quality Adjusted Life Year, or QALY) compared with an alternative intervention. An intervention is generally considered cost-effective if its ICER falls below a predefined willingness to pay (WTP) threshold, which varies by country [10]. In high income countries such as the United Kingdom, the National Institute for Health and Care Excellence (NICE) uses a WTP threshold of GBP 20,000–30,000 per QALY [11]. For India, various studies have proposed thresholds ranging from one to three times the per capita GDP, which approximates USD 2,000–6,000 per QALY, consistent with WHO recommendations [12]. Other important indicators include: Net Monetary Benefit (NMB) = (QALY gain x WTP threshold) - Incremental cost; Budget Impact (BI), which estimates the financial implications of adopting a new intervention at the population level; and the Disability-Adjusted Life Year (DALY), which is frequently used in burden-of-disease analyses in low-income settings [13].

## 3. OVERVIEW OF THE AYURVEDIC SYSTEM OF MEDICINE

Ayurveda, literally meaning 'the science of life,' is an indigenous Indian system of medicine codified in ancient texts such as the Charaka Samhita, Sushruta Samhita, and Ashtanga Hridayam. It is based on the tridosha theory (Vata, Pitta, and Kapha) and emphasizes individualized treatment, preventive care, and the use of natural substances including herbs, minerals, and animal products [14]. The Ayurvedic pharmaceutical industry in India is valued at approximately USD 9.5 billion and growing at a compound annual growth rate (CAGR) of over 16%, reflecting both domestic and global demand

[15]. Key therapeutic categories include digestive disorders, metabolic diseases, neurology, dermatology, and musculoskeletal conditions. Key Ayurvedic formulations of pharmacoeconomic significance, their indications, and comparators are presented in Table 2.

**Table 2: Key Ayurvedic Formulations of Pharmacoeconomic Relevance.**

| Formulation                      | Indication                          | Comparator                    | Cost Advantage                                    | Evidence Level            |
|----------------------------------|-------------------------------------|-------------------------------|---------------------------------------------------|---------------------------|
| Triphala churna                  | Constipation, bowel disorders       | Osmotic laxatives (lactulose) | 60–70% lower monthly cost                         | Level II (RCT)            |
| Ashwagandha (Withania somnifera) | Anxiety, stress, fatigue            | Anxiolytics (benzodiazepines) | Significantly lower; fewer ADRs                   | Level I (Meta-analysis)   |
| Boswellia serrata                | Osteoarthritis, IBD                 | NSAIDs (diclofenac)           | Lower long term cost; renal safety benefit        | Level II (RCT)            |
| Brahmi (Bacopa monnieri)         | Cognitive decline, dementia         | Cholinesterase inhibitors     | Lower cost; minimal hepatotoxicity                | Level II (RCT)            |
| Guduchi (Tinospora cordifolia)   | Immune modulation, COVID-19 adjunct | Standard immunomodulators     | Cost-effective; widely available                  | Level III (Pilot studies) |
| Panchakarma (detox therapy)      | Chronic lifestyle diseases          | Conventional rehabilitation   | Long-term savings; QALY benefit reported          | Level III (Observational) |
| Ayurvedic Rasayana               | Geriatric care, cancer adjunct      | Nutritional supplements       | Comparable or lower cost; quality of life benefit | Level II (Clinical trial) |

Ayurvedic preparations are regulated in India under the Drugs and Cosmetics Act (1940) and the Drugs and Magic Remedies Act (1954). The Pharmacopoeia of India and Ayurvedic Pharmacopoeia of India (API) provide quality specifications for classical formulations [16]. Internationally, the WHO has published monographs on selected medicinal plants used in Ayurvedic practice [17].

#### 4. PHARMACOECONOMIC EVIDENCE FOR AYURVEDIC TREATMENTS

##### 4.1 Summary of Key Studies

A growing body of literature has examined the economic implications of Ayurvedic interventions. Table 3 presents a summary of key pharmacoeconomic studies evaluating Ayurvedic treatments published between 2010 and 2023.

**Table 3: Summary of Key Pharmacoeconomic Studies on Ayurvedic Treatments. (2010–2023)**

| Author (Year)           | Country      | Intervention                                 | Study Type | Key Finding                                                                            | References |
|-------------------------|--------------|----------------------------------------------|------------|----------------------------------------------------------------------------------------|------------|
| Chopra et al. (2010)    | India        | Ayurvedic vs allopathic rheumatoid arthritis | CEA (RCT)  | Ayurvedic treatment showed 40% lower cost per responder with comparable efficacy       | [18]       |
| Dhakar et al. (2023)    | India        | Panchakarma for type 2 diabetes              | CUA        | QALY gains of 0.35 at 30% lower cost than standard care over 1 year                    | [19]       |
| Peterson et al. (2017)  | India        | Triphala vs lactulose for constipation       | CMA        | Triphala costs INR 180/month vs INR 540/month for lactulose                            | [20]       |
| Gupta et al. (2025)     | India/Global | Integrative medicine for metabolic syndrome  | CBA        | Benefit-cost ratio of 3.2:1 for Ayurvedic lifestyle intervention                       | [21]       |
| Mikulska et al. (2020)  | India        | Ashwagandha for anxiety disorders            | CEA        | Cost per responder 52% lower than conventional anxiolytic therapy                      | [22]       |
| Mishra et al. (2021)    | India        | Ayurvedic adjunct therapy in COVID-19        | BIA        | Potential national savings of INR 4,200 crore with integration into treatment protocol | [23]       |
| Roy et al. (2019)       | India        | Boswellia for osteoarthritis                 | CEA        | ICER of USD 120/QALY vs USD 890/QALY for NSAIDs; superior economic profile             | [24]       |
| Chaudhari et al. (2017) | India        | Brahmi for mild cognitive impairment         | CUA        | Cost per QALY of USD 210 vs USD 1,250 for cholinesterase inhibitors                    | [25]       |

#### 4.2 Cost-Effectiveness of Specific Interventions

- **Musculoskeletal Disorders:** *Boswellia serrata* extract has been extensively studied in osteoarthritis and inflammatory bowel disease. A landmark randomized controlled trial demonstrated non inferior clinical efficacy to NSAIDs, with significantly fewer gastrointestinal and renal adverse events, and a markedly favourable ICER [26]. The avoidance of NSAID related gastropathy alone which contributes substantially to morbidity and costs makes Boswellia economically attractive.
- **Neuropsychiatric Conditions:** *Bacopa monnieri* (Brahmi) has demonstrated benefit in mild cognitive impairment and age associated memory decline. Economic modelling studies indicate a cost-per-QALY of USD 210 for Brahmi based therapy compared with USD 1,250 for donepezil, a widely used cholinesterase inhibitor [27]. Given the projected surge in dementia prevalence, these findings have profound pharmacoeconomic implications.
- **Metabolic Diseases:** Panchakarma, a comprehensive Ayurvedic detoxification and rejuvenation therapy, has been evaluated in type 2 diabetes mellitus. Findings suggest that a structured Panchakarma programme yields significant improvements in glycaemic control, lipid profiles, and quality of life, with per-QALY costs well within Indian WTP thresholds [28-29].

- Infectious and Immune Disorders: The use of Guduchi (*Tinospora cordifolia*) as an immunomodulatory agent received renewed attention during the COVID-19 pandemic. Preliminary budget impact analyses suggested substantial national savings if Guduchi based protocols were incorporated as adjunctive therapy, though evidence quality remains low and further confirmatory studies are warranted [30].

## 5. CHALLENGES IN PHARMACOECONOMIC EVALUATION OF AYURVEDA

Despite encouraging preliminary evidence, the pharmacoeconomic evaluation of Ayurvedic treatments faces several methodological and structural challenges. These are outlined in Table 4.

**Table 4: Challenges in Pharmacoeconomic Evaluation of Ayurvedic Treatments and Recommended Solutions.**

| Challenge                                 | Impact on Pharmacoeconomic Analysis                    | Recommended Solution                                                                    |
|-------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Lack of standardized preparations         | Variability in cost and efficacy data                  | Establish Good Manufacturing Practice (GMP) standards and pharmacopoeial specifications |
| Limited high-quality RCT data             | Weak evidence base for CEA/CUA models                  | Fund large-scale pragmatic RCTs; use adaptive trial designs                             |
| Short follow-up in clinical studies       | Underestimates long-term benefits                      | Conduct long-term cohort studies (5–10 years)                                           |
| Absence of QoL measurement tools          | Cannot perform CUA without validated HRQOL instruments | Develop and validate Ayurveda-specific HRQOL questionnaires                             |
| Individualized treatment variability      | Difficult to generalize cost models                    | Use decision-analytic modelling with probabilistic sensitivity analysis                 |
| Regulatory heterogeneity across countries | Limits global pharmacoeconomic comparisons             | Advocate for international regulatory harmonization for traditional medicines           |
| Intellectual property and access issues   | Commercialization reduces affordability advantage      | Protect traditional knowledge via sui generis IPR frameworks                            |

### 5.1 Methodological Limitations

The heterogeneity of Ayurvedic practice where treatment is tailored to the individual's prakriti (constitutional type) and vikrti (current imbalance) makes the standardization required for rigorous pharmacoeconomic analysis inherently challenging. This individualized approach, while therapeutically valid, complicates the construction of homogeneous study populations necessary for conventional trial designs [31]. Furthermore, the natural history of many conditions treated by Ayurveda often spans years or decades, whereas most clinical and economic studies capture outcomes over short follow up periods of three to twelve months. This systematically underestimates the long term preventive benefits and cost savings associated with Ayurvedic care, which often acts through modification of underlying constitutional risk factors [32].

## 5.2 Data Availability and Quality

The majority of pharmacoeconomic studies in Ayurveda originate from India and are frequently characterized by small sample sizes, single centre designs, inadequate blinding, and short follow up periods. There is also a marked absence of head-to-head trials comparing Ayurvedic interventions against active comparators using validated quality of life instruments such as the EQ-5D or SF-36, which are essential for conducting CUA [33].

## 6. GLOBAL INTEGRATION OF AYURVEDA: PHARMACOECONOMIC PERSPECTIVES

The integration of Ayurveda into mainstream healthcare systems offers significant potential for improving population health outcomes at reduced cost. Table 5 summarizes pharmacoeconomic outcomes observed in various global integration models.

**Table 5: Global Integration Models for Ayurvedic Medicine and Associated Pharmacoeconomic Outcomes.**

| Country/Region          | Integration Model                                              | Health System Impact                                  | Pharmacoeconomic Outcome                                                         |
|-------------------------|----------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------|
| India (AYUSH Ministry)  | Parallel system with government funding                        | Expanded access; reduced OOP expenditure              | Estimated 15–25% reduction in per-capita treatment cost for chronic diseases     |
| Germany                 | Complementary medicine reimbursement under statutory insurance | Increased patient choice; reduced antibiotic usage    | Net savings of EUR 200 million annually in select indications                    |
| USA                     | Integrative oncology centres (e.g., MSKCC)                     | Improved QoL in cancer patients; fewer adverse events | ICER within acceptable willingness-to-pay threshold of USD 50,000/QALY           |
| China (TCM integration) | Full integration into national health system                   | Significant cost reduction in primary care            | TCM responsible for 30% of treatments at < 15% of total healthcare expenditure   |
| Sri Lanka/Nepal         | State-sponsored Ayurveda hospitals                             | Reduced burden on allopathic sector                   | 60% of rural primary care delivered at 40% lower cost than biomedical equivalent |

The experience of China, which has achieved full integration of Traditional Chinese Medicine (TCM) a system with significant parallels to Ayurveda into its national health system, provides an instructive model. TCM accounts for approximately 30% of all healthcare treatments in China while consuming less than 15% of total healthcare expenditure, a pharmacoeconomic achievement that has been attributed to lower drug acquisition costs, reduced hospitalization rates, and favourable safety profiles [34]. In India, the National AYUSH Mission has facilitated the establishment of over 25,000 AYUSH health and wellness centres, which provide primary care at significantly lower per visit costs than allopathic facilities. A prospective study by the All India Institute of Medical Sciences (AIIMS) estimated that integration of Ayurvedic care in primary health centres could reduce per capita primary care expenditure by 18–24% [35].



## 7. A PROPOSED FRAMEWORK FOR PHARMACOECONOMIC RESEARCH IN AYURVEDA

Based on this review, the following stepwise framework is proposed for conducting rigorous pharmacoeconomic evaluations of Ayurvedic interventions:

- Step 1 – Standardization: Establish GMP compliant, pharmacopoeially defined preparations with specified active constituent profiles, to enable reproducibility and comparative analysis.
- Step 2 – Clinical Evidence Generation: Conduct adequately powered, blinded RCTs or pragmatic trials with a minimum follow-up of two years, incorporating both clinical and quality of life endpoints (EQ-5D, SF-36, or validated Ayurveda specific instruments).
- Step 3 – Economic Modelling: Construct decision-analytic models (Markov models, decision trees) using both trial data and real world evidence to extrapolate long-term costs and outcomes. Apply probabilistic sensitivity analysis to capture parameter uncertainty.
- Step 4 – Perspective and Time Horizon: Adopt a societal perspective including direct medical costs, indirect costs (productivity losses), and patient time costs, with a time horizon commensurate with the natural history of the disease.
- Step 5 – Policy Translation: Engage with health technology assessment (HTA) bodies, the Ministry of AYUSH, and insurance regulators to translate economic evidence into coverage decisions and reimbursement policies.

## 8. CONCLUSION

Pharmacoeconomics provides an essential evidence framework for evaluating the true value of healthcare interventions in resource constrained systems. The existing body of evidence, while limited in methodological rigour, consistently suggests that several Ayurvedic treatments offer favourable cost-effectiveness profiles compared with conventional therapeutic counterparts, particularly for chronic conditions such as osteoarthritis, cognitive decline, metabolic syndrome, and anxiety disorders. The growing burden of non-communicable diseases, rising pharmaceutical costs, and an aging global population create an urgent imperative to rigorously evaluate low-cost, evidence based alternatives. Ayurveda, with its vast pharmacopoeia, preventive philosophy, and established safety track record, is well positioned to contribute meaningfully to sustainable healthcare delivery. Future research must prioritize methodological standardization, long-term outcome measurement, and the development of validated instruments for quality of life assessment within the Ayurvedic paradigm. Collaborative, multi-centre, internationally co-ordinated trials are essential to generate the robust pharmacoeconomic evidence required for integration into national and international health technology assessment frameworks.

## DECLARATIONS

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