

# Pharmacovigilance of Herbal Drugs: Rethinking Safety, Evidence, and Regulation

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**Abstract:** Herbal medicines have gained unprecedented global popularity over the past two decades, with approximately 80% of the world population relying on herbal preparations for primary healthcare. The global market for herbal remedies has expanded from approximately USD 83 billion in 2008 to over USD 100 billion currently. Consequently, pharmacovigilance of herbal medicines has become increasingly critical to ensure patient safety and therapeutic efficacy. This comprehensive review examines the current status of pharmacovigilance systems for herbal medicines, the specific challenges encountered in monitoring their safety, and future perspectives for strengthening these systems. The review synthesizes evidence from multiple sources regarding adverse drug reactions (ADRs) associated with herbal products, discusses the distinctive characteristics of herbal medicines that complicate pharmacovigilance activities, and presents recommendations for improving safety monitoring frameworks globally. Key findings indicate that while significant progress has been made in establishing pharmacovigilance programs in traditional medicine systems, particularly in India, substantial gaps remain in standardization, quality control, and systematic adverse event reporting mechanisms. This review provides a comprehensive framework for understanding the complexities of herbal medicine pharmacovigilance and offers actionable recommendations for regulatory authorities, healthcare professionals, and researchers.

**Keywords:** Pharmacovigilance, Herbal medicines, Adverse drug reactions, Safety monitoring, Quality control, Traditional medicine, Regulatory framework

## I. INTRODUCTION

Herbal medicines represent one of the oldest therapeutic traditions in human healthcare, with documented medicinal plant use dating back over 5,000 years.[1] The practice of using botanical preparations originated simultaneously in China and India, eventually spreading to other civilizations where different cultural systems developed their own approaches to herbal therapeutics.[2] In contemporary healthcare systems, approximately 25% of modern pharmaceutical drugs are derived either directly or indirectly from plants traditionally used in medicine, with notable examples including aspirin, artemisinin, ephedrine, and paclitaxel.[3]

The resurgence of interest in herbal medicines during the past three decades has occurred against a backdrop of growing dissatisfaction with some aspects of conventional pharmaceutical treatment. Factors contributing to this revival include concerns about adverse effects of synthetic drugs, rising costs of conventional medicines, the increasing prevalence of chronic non-communicable diseases that conventional medicine has struggled to address effectively, and a cultural shift toward "natural" or "holistic" approaches to health and wellness.[2,3] This renaissance has translated into substantial economic growth, with the global herbal products market expanding from USD 3.4 billion in 2015 to projected figures approaching USD 100 billion in current estimates.[4]

Despite the extensive historical use of herbal medicines and their growing market share in global healthcare, a critical gap exists regarding systematic safety monitoring of these products. While pharmacovigilance systems have been well-established for synthetic pharmaceutical drugs over several decades, comparable systems for herbal medicines remain underdeveloped or entirely absent in many regions.[5] This asymmetry in safety monitoring capacity creates a



significant public health concern, particularly given the complex composition of herbal preparations and their potential for adverse reactions, drug-herb interactions, and contamination with hazardous substances.

The World Health Organization recognized this critical gap and has actively promoted the integration of herbal medicines into existing pharmacovigilance frameworks.[6] The present review aims to comprehensively examine the current state of pharmacovigilance for herbal medicines, analyse the unique challenges that distinguish herbal product monitoring from conventional drug surveillance, synthesize evidence regarding specific adverse events and safety concerns, and propose future directions for strengthening global pharmacovigilance systems for traditional medicines.

### **Objectives**

#### **Safety Monitoring and Risk Assessment**

Identify herb-drug interactions, particularly with conventional pharmaceuticals.  
Monitor long-term safety profiles and cumulative toxicity risks.

#### **Evidence Generation and Documentation**

Establish robust databases of adverse events related to herbal products.  
Create standardized reporting mechanisms for healthcare providers and consumers.  
Generate real-world evidence on safety and efficacy through post-market surveillance.

#### **Regulatory Framework Enhancement**

Develop appropriate regulatory standards that balance traditional use with modern safety requirements.  
Establish good manufacturing practices (GMP) specific to herbal medicines.  
Create standardization protocols for herbal product composition and quality.

#### **Risk Communication and Public Health Protection**

Educate healthcare professionals about potential risks and benefits of herbal medicines.  
Inform consumers about safe use, contraindications, and interaction risks.  
Dispel myths about herbal medicines being inherently "safe" or "natural".

#### **Integration with Conventional Healthcare Systems**

Bridge the gap between traditional medicine knowledge and modern pharmacovigilance.  
Encourage reporting from both conventional and traditional medicine practitioners.  
Develop interdisciplinary approaches to herbal medicine safety assessment.

### **Defining Pharmacovigilance and Its Scope**

#### **Definition and Core Functions**

The World Health Organization defines pharmacovigilance as the science and activities relating to detection, assessment, understanding, and prevention of adverse effects or any other drug-related problems.[7] Originally developed to monitor synthetic pharmaceutical products, this definition has been progressively expanded to encompass a broader range of medical products including herbal medicines, traditional and complementary therapies, blood products, biologicals, vaccines, and medical devices.[8]

The primary objective of pharmacovigilance is not merely passive adverse event collection but represents a proactive, systematic approach to identifying emerging safety signals, evaluating causality relationships between products and reported adverse events, implementing risk management strategies, and communicating safety information to healthcare professionals and consumers.[8] The specific aims include improving patient care and safety through evidence-based medicine use, enhancing public health outcomes, contributing to benefit-harm assessments, and promoting rational, cost-effective therapeutic practices.



**Herbal Medicines: Definitions and Characteristics**

For the purposes of pharmacovigilance monitoring, the WHO defines herbal medicines as finished labelled medicinal products containing as active ingredients aerial or underground parts of plants or plant material in the crude or processed state, usually as mixtures of multiple constituents. [1,6] This encompasses herbal materials (crude plant preparations), herbal preparations (processed plant material), and finished herbal products (standardized formulations in defined dosage forms).

Herbal medicines present distinct characteristics that fundamentally differentiate them from synthetic pharmaceuticals and complicate standardized pharmacovigilance approaches. These characteristics include: (1) complex chemical composition with often unknown or partially characterized active constituents; (2) natural variability in chemical profiles depending on geographical origin, seasonal variation, soil composition, and harvest timing; (3) multiple active ingredients potentially acting through different pharmacological mechanisms; (4) traditional use-based evidence versus evidence generated through controlled clinical trials; and (5) manufacturing variability and quality control inconsistencies across different producers.[2,9]

**Global Market Growth and Public Health Significance**

**Market Expansion and Consumption Patterns**

The global expansion of herbal medicine markets represents one of the most significant trends in contemporary healthcare. Approximately 80% of the world's population relies on herbal medicines for some aspect of primary healthcare.[3] In the United States, over 158 million Americans spent approximately USD 17 billion on herbal products in 2000, a figure that has

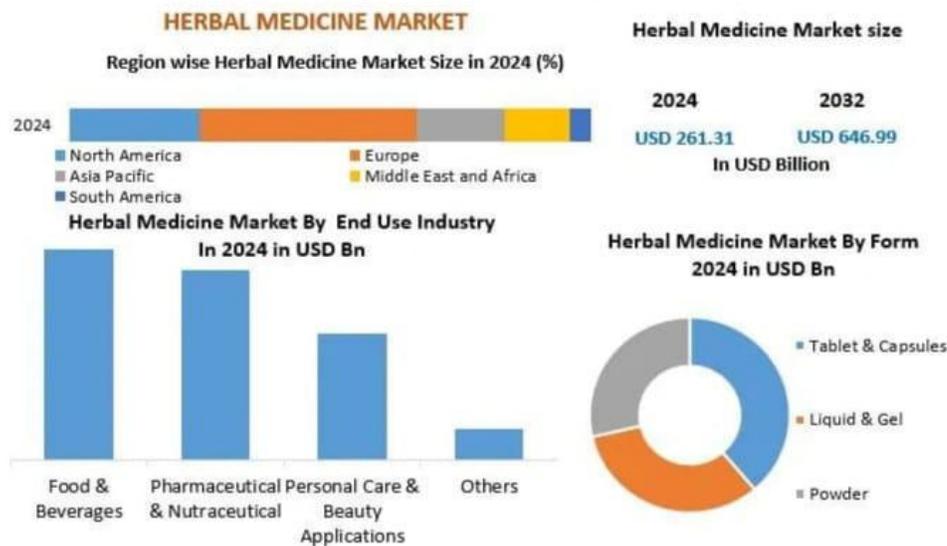


Fig 1. Herbal medicine market growth and expansion.

substantially increased in subsequent years.[10] Germany and other European nations report that 70% of the population uses natural medicines, with herbal products representing the first therapeutic choice for minor illnesses in most cases.[10]

China's traditional medicine industry has demonstrated particularly robust growth, with industry output value of Chinese patent medicines reaching approximately USD 80 billion in 2013, reflecting increasing domestic consumption and international export.[11] Similarly, in India, the Ayurveda industry has experienced exponential expansion driven by both domestic demand and growing international recognition of traditional Indian medicine systems.



### **Public Perception and the "Natural Safety" Myth**

A significant factor driving herbal medicine consumption and complicating pharmacovigilance efforts is the widespread public perception that herbal products are inherently safe because of a fundamental misconception that requires systematic correction through evidence-based information dissemination. Historical use, while providing valuable empirical data regarding safety profiles, does not automatically guarantee freedom from adverse effects or preclude the emergence of previously unrecognized toxicity in diverse populations using products differently than traditional contexts.

The phrase "all medicines have their own side effects" appropriately captures the reality that herbal medicines, like all pharmacologically active substances, carry inherent risk profiles alongside their therapeutic potential.[12] The safety of herbal medicines is relative rather than absolute, dependent upon proper dosage, appropriate indication matching, consideration of individual patient factors, manufacturing quality, and recognition of potential interactions with other therapeutic agents.

### **Risk Factors and Adverse Drug Reactions Associated with Herbal Medicines**

#### **Drug-Related Risk Factors**

Adverse reactions associated with herbal medicines arise from multiple categories of causative factors that can be broadly classified as drug-related, patient-related, and system-related contributors.[13] Understanding these distinct etiological pathways is essential for implementing targeted risk mitigation strategies.

Drug-related factors encompassing intrinsic toxicity represent a primary category of concern. Certain herbs contain constituents with inherent toxic potential, such as alkaloids in *Aconitum* species, aristolochic acid in *Aristolochia* species, and various other naturally occurring toxins.[3] The toxicity of these substances varies considerably based on dose, duration of exposure, and individual patient susceptibility factors. For example, comparative research on *Radix Bupleuri Chinensis* demonstrated that the toxic dose (192g per 60kg body weight) substantially exceeds the clinically employed dose (9g per 60kg), indicating a reasonable therapeutic window when medications are appropriately dosed.[12]

External toxicity factors represent a second critical category of drug-related risk. These include contamination of herbal products with toxic metals (lead, mercury, arsenic), bacterial and fungal contamination, pesticide residues, and incorporation of undeclared potent pharmaceutical substances.[13] Multiple documented cases have illustrated the severity of these risks, including instances where herbal formulations were discovered to contain undeclared corticosteroids causing iatrogenic Cushing's syndrome, and cases where misidentification of plant species resulted in aristolochic acid exposure causing severe nephrotoxicity.[2]

#### **Herb-Drug and Herb-Herb Interactions**

The complexity of herbal preparations—typically containing multiple pharmacologically active constituents—creates substantial potential for interactions with conventional medications and with other herbal products. [2,15]

Research examining concomitant use of Chinese herbal medicine formulations with antipsychotic medications found a 36.4% prevalence of combined use, with herbal regimens containing *Radix Bupleuri*, *Fructus Gardenia*, and other constituents associated with nearly 60% increased risk of adverse outcomes when used concurrently with quetiapine, clozapine, or olanzapine.[15]

Documented herb-drug interactions include increased bleeding tendency with concurrent ginger and phenprocoumon use, antagonism of lithium effects through herbal diuretics including *Tribulus terrestris*, and loss of antiepileptic efficacy with concurrent *Shankhpushpi* (*Convolvulus pluricaulis*) use reducing seizure control through complex pharmacokinetic interactions with phenytoin. [15,17]

#### **Misidentification and Adulteration Issues**

Misidentification of medicinal plant species represents a particularly insidious risk factor for adverse events. The extensive biodiversity of medicinal plants, coupled with linguistic complexity surrounding plant nomenclature (synonyms, common names, vernacular variations), creates numerous opportunities for erroneous species substitution.



Documented cases include replacement of *Caulis Akebia* with *Caulis Aristolochiaceae Manshuriensis* and substitution of *Stephania tetrandra* with *Aristolochia fang chi*, both resulting in aristolochic acid exposure and subsequent nephropathy.[12]

Plant adulteration represents a parallel concern, with surveys of market samples revealing widespread substitution and adulteration practices. The case of Ashoka (*Saraca Indica*) provides illustration, where manufacturers facing supply constraints due to vulnerable species designation commonly substitute the structurally similar Nakli Ashoka (*Polyalthia longifolia*), which lacks the therapeutic properties and safety profile of authentic Ashoka.[17]

### **Quality Control Challenges in Herbal Medicine Manufacturing**

#### **Raw Material Quality and Variability**

The quality of herbal medicines fundamentally depends upon the quality of raw plant materials employed in formulation. India's extensive biodiversity, while representing a valuable resource for traditional medicine, simultaneously creates complexity regarding plant species identification and geographical sourcing variations.[17] Ayurvedic texts historically recognized geographical variation in therapeutic properties, categorizing plant origins as Sadharan (moderate climate), Anup (water-rich), or Jangal Desha (dry regions), each producing herbs with distinct pharmacological profiles and therapeutic efficacy levels.

Contemporary evidence validates this historical classification. *Withania somnifera* (Ashwagandha) sourced from Nagaur in Rajasthan demonstrates the highest withferine A and withanone content compared to other Indian Ashwagandha varieties, directly corresponding to superior therapeutic efficacy.[18] Environmental factors including soil composition, rainfall patterns, temperature variations, and UV exposure significantly influence bioaccumulation of active compounds and synthetic production of secondary metabolites.

Contamination with pesticides, herbicides, and heavy metals represents a critical quality concern. Heavy metal accumulation in medicinal plants occurs through soil and water contamination, bioaccumulation in plant tissues, and environmental pollution exposure during cultivation and harvesting phases.[19] Regulatory investigations in various countries have documented unacceptable levels of lead, mercury, and arsenic in marketed Ayurvedic products, raising serious concerns regarding contamination control during cultivation and manufacturing processes.

#### **Processing and Standardization Issues**

Traditional processing methods (Sanskara in Ayurvedic terminology) significantly influence therapeutic value, safety profile, and toxicity of herbal medicines. Proper processing techniques can substantially reduce inherent toxicity—heating processing of bitter almonds reduces cyanogenic glycoside toxicity through enzyme inactivation, while thermal processing of *Aconitum* alkaloids converts highly toxic diester-diterpenoid forms to less toxic monoester and aconine variants.[12]

Contemporary manufacturing often employs mechanization and rapid processing protocols that depart substantially from traditional methods, potentially compromising processing quality. This concern is particularly acute for herbomineral formulations containing deliberately incorporated toxic substances (arsenic, mercury, lead) that require precise purification (Shodhana) procedures. When proper purification protocols are not rigorously implemented, potentially harmful effects emerge.

#### **Good Manufacturing Practice Implementation**

The WHO advocates implementation of Good Agricultural and Good Collection Practices (GACP) for medicinal plants, encompassing plant selection, cultivation, harvesting, and storage protocols.[20] These standards should be coupled with Good Manufacturing Practices (GMP) during formulation, processing, and packaging stages. However, implementation of these standards remains inconsistent, particularly among small-scale manufacturers and traditional practitioners who supply substantial portions of herbal products in developing nations.



Schedule T of the Indian Drugs and Cosmetics Act establish comprehensive GMP requirements for Ayurvedic and Siddha medicine manufacturing, yet adherence remains limited.[21] The absence of rigorous quality control at manufacturing stages contributes substantially to product variability and potential safety concerns.

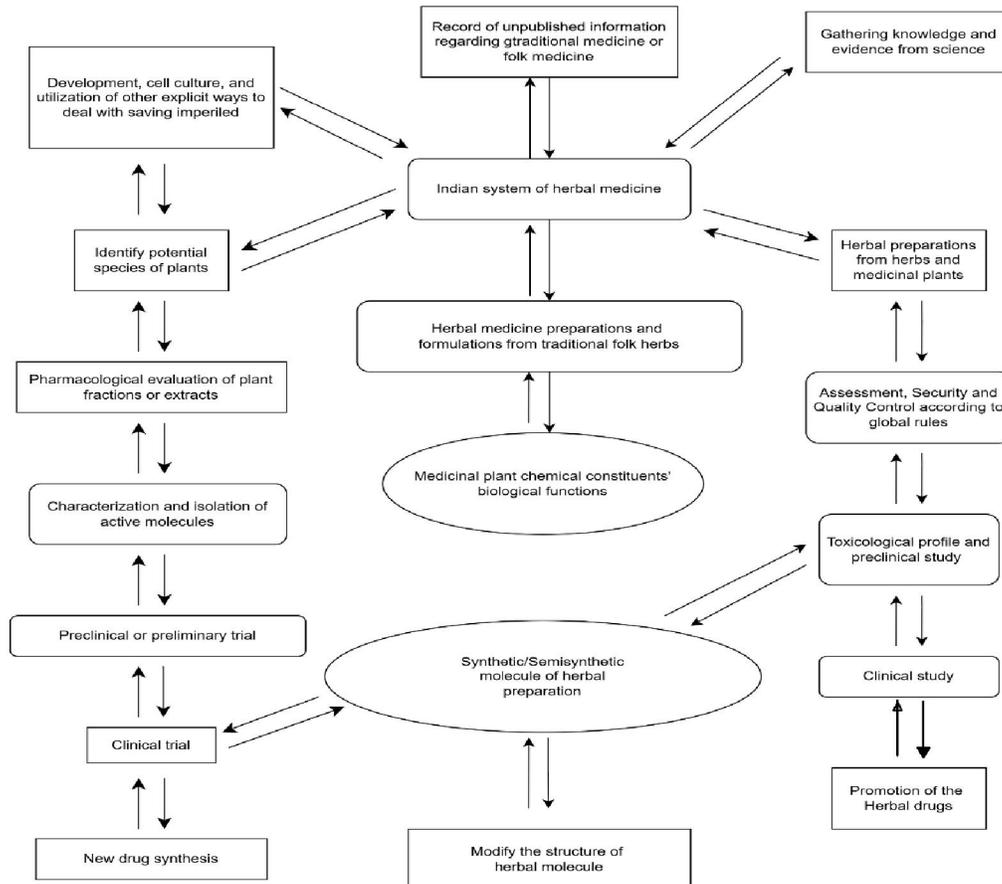


Fig 2. Herbal medicine formulation and standardization process.

### Current Pharmacovigilance Systems for Herbal Medicines

#### National Initiatives: The Indian Model

India has established the most comprehensive pharmacovigilance framework specifically designed for traditional medicine systems including Ayurveda, Siddha, and Unani medicines. Following successful international workshops on pharmacovigilance of Ayurvedic medicines in 2006-2007, the Ministry of AYUSH implemented a structured program with three-tier organizational hierarchy.[18]

The National Pharmacovigilance Centre for ASU&H Drugs (National PvCC) is coordinated by the All India Institute of Ayurveda in New Delhi, serving as the primary coordinating center. Five designated National Institutes of AYUSH function as Intermediary Pharmacovigilance Centres (IPvCC) facilitating regional coordination and specialized analysis. Forty-two institutions with Ayurveda-related clinical facilities serve as Peripheral Pharmacovigilance Centres (PPvCC) responsible for frontline adverse event detection, documentation, and preliminary assessment.[4]

This framework specifically addresses the unique characteristics of Ayurvedic pharmacovigilance through incorporation of traditional concepts (Dosha, Prakriti, Rasa, Guna) into safety assessment protocols. The program



emphasizes documentation of adverse effects and systematic surveillance of misleading advertisements in both print and electronic media, recognizing that inappropriate promotion contributes to inappropriate use and subsequent adverse events.

### **Global WHO Initiatives and Guidelines**

The WHO has developed comprehensive guidelines on safety monitoring of herbal medicines within existing pharmacovigilance systems, promoting inclusion of herbal medicines in national pharmacovigilance programs rather than parallel, separate systems.[6] These guidelines recognize that monitoring herbal medicines presents unique technical challenges while emphasizing that core pharmacovigilance principles apply uniformly across medicine types. The Uppsala Monitoring Centre (UMC) has expanded the global WHO database to incorporate herbal medicine adverse event reports and developed the Herbal Anatomic-Therapeutic-Chemical (HATC) classification system structurally equivalent to the standard ATC classification used for chemical medicines.[10] These technical innovations facilitate international harmonization and comparative analysis of herbal adverse events across jurisdictions.

### **Regional Variations and Limitations**

Despite these initiatives, substantial regional variations persist in pharmacovigilance implementation. Approximately 90 countries regulate herbal medicines according to WHO surveys, representing less than half of WHO Member States, and an even smaller proportion has systematic qualification and regulation of herbal medicine providers.[10] Regulatory categories vary substantially—herbal products may be classified as medicines, dietary supplements, functional foods, or nutritional products, creating differential regulatory requirements and safety monitoring approaches.

Nepal exemplifies the challenges faced by developing nations with extensive traditional medicine use but limited pharmacovigilance infrastructure. While the Department of Drug Administration has been nominated as the national pharmacovigilance center, no systematic adverse event reporting mechanisms specifically for herbal products exist, resulting in zero reported adverse events despite widespread herbal medicine use through self-medication and concurrent use with allopathic drugs.[22]

### **Specific Adverse Effects and Case Examples**

#### **Documented Adverse Events and Toxicity Cases**

Multiple well-documented cases illustrate the serious adverse events that can emerge from herbal medicine use. The Aristo lochia nephropathy epidemic affecting Belgium, France, and other nations demonstrated how misidentification of plant species combined with individual susceptibility could produce severe organ-specific toxicity affecting multiple patients before causality recognition and public health response.[15]

Ephedra-related cardiovascular events including myocardial infarctions, strokes, and fatal arrhythmias resulted when traditionally used Ephedra species were incorporated into weight-reduction supplements in the United States at dosages substantially exceeding traditional use recommendations.[12]

Similarly, cases of interstitial pneumonia (sometimes fatal) emerged from traditional herbal medicine combinations when used concurrently with interferon therapy, representing previously unrecognized herb-drug interactions.

Hepatotoxicity represents the most frequently reported adverse event class associated with herbal medicines, likely reflecting liver's role in metabolic processing of numerous botanical constituents.[2] Documented cases include drug-induced liver injury from prolonged consumption of Kanchnar Gugglu and Punarnava Mandoor, traditional Ayurvedic formulations, demonstrating that even classical traditional preparations can produce delayed hepatotoxic effects with prolonged use patterns not previously encountered historically.

### **Quality-Related Adverse Events**

Multiple investigations by health authorities including Health Canada have documented herbal products containing pharmaceutical contaminants. Analysis of unapproved Ayurvedic products marketed in Canada revealed dangerous



levels of lead, mercury, and arsenic in numerous formulations including Karela, Maha Sudarshan Churna, Yograj Guggul, and various Shilajit preparations.[23]

These quality-related adverse events raise critical questions regarding manufacturing oversight, intentional incorporation of mineral substances without appropriate purification, and regulatory gaps in quality assurance. Such contamination represents preventable harm directly attributable to manufacturing deficiencies rather than inherent therapeutic limitations of traditional medicine systems.

### **Unique Challenges in Herbal Medicine Pharmacovigilance**

#### **Complexity of Formulation and Standardization**

Traditional herbal formulations typically incorporate multiple plant species, animal-derived components, and mineral substances in carefully balanced combinations reflecting accumulated clinical experience. This complexity, while potentially conferring therapeutic advantages through synergistic interactions and reduced side effects, simultaneously complicates pharmacovigilance activities through obscuration of causality relationships and difficulty isolating contributory substances in adverse events.

When adverse events occur with polyherbal formulations, attribution to specific ingredients becomes technically challenging and often impossible without sophisticated analytical capability. This multingredient complexity differs fundamentally from typical pharmaceutical adverse event investigations involving single-entity drugs with known chemical structures and well-characterized pharmacokinetics and pharmacodynamics.

#### **Standardization and Variability Issues**

Unlike synthetic pharmaceuticals characterized by precise chemical formulation and consistent batch-to-batch composition, herbal products exhibit substantial variability related to botanical source variability, extraction method variations, and formulation differences. This heterogeneity creates challenges for signal detection when adverse events from the same marketed product may actually reflect different underlying formulations due to ingredient sourcing differences or processing variations.

Current lack of standardized manufacturing procedures for many traditional formulations exacerbates this challenge. Small-scale manufacturers and individual practitioners producing traditional preparations may employ markedly different processing techniques, ingredient ratios, and storage methods, resulting in products distributed under identical names but with substantially different chemical compositions and therapeutic profiles.[24]

#### **Underreporting of Adverse Events**

Systematic underreporting of adverse events represents a critical limitation affecting pharmacovigilance effectiveness globally, but this challenge is particularly acute for herbal medicines. Multiple factors contribute to underreporting including: (1) public perception of herbal products as inherently safe, reducing patient and provider suspicion of causality; (2) limited integration of herbal medicine reporting into conventional pharmacovigilance systems; (3) lack of awareness among traditional medicine practitioners and consumers regarding reporting mechanisms; (4) fear of professional liability among practitioners; (5) reluctance to report if concerns about herbal product safety might threaten traditional medicine system credibility; and (6) absence of mandatory reporting requirements for herbal adverse events in many jurisdictions.[8,23]

Studies in Nepal and other developing nations demonstrate that zero reported herbal medicine adverse events do not reflect absolute safety but rather reflects inadequate reporting infrastructure and limited surveillance capacity.[22] In developed nations including Canada and the United States, heightened reporting systems have revealed adverse events previously unrecognized, indicating that enhanced surveillance uncovers problems that existed but were previously invisible.

#### **Regulatory Complexity and Heterogeneity**

The regulatory status of herbal products varies substantially across jurisdictions, with products classified alternately as medicines, dietary supplements, functional foods, or nutraceuticals depending on jurisdiction and specific formulation characteristics. This regulatory heterogeneity creates practical complications for pharmacovigilance coordination, as the



same product may be subject to different regulatory requirements and reporting mechanisms in different nations, impeding international signal detection and harmonized risk management responses.

### **Integration of Traditional Knowledge with Modern Pharmacovigilance**

#### **Ayurvedic Concepts Relevant to Adverse Event Prevention**

Ayurvedic classical texts contain extensive documentation regarding causes and prevention of drug-induced adverse effects, organized systematically according to traditional concepts that parallel modern pharmacological principles.[25] These include recognition of drug interactions (Viruddha Dravya Prayoga), overdose effects (Atimatra Dravya Prayoga), iatrogenic complications (Vaidhya Kruti), and inappropriate drug indication matching (Avastanu Sara Dravya Prayoga).

Traditional emphasis on patient constitution (Prakriti) assessment, while not identical to contemporary pharmacogenomics, reflects fundamental recognition that drug responses vary among individuals based on innate constitutional characteristics. Recent research demonstrating associations between Prakriti classification and specific drug-metabolizing enzyme polymorphisms suggests that ancient constitutional classifications contained practical validity for predicting differential drug metabolism and response patterns.[25]

Ayurvedic guidelines regarding drug administration timing (Aushadha Sevana Kaala), use of appropriate drug adjuvants or vehicles (Anupaana), and necessary diet restrictions (Pathya-Apathya Sevana) represent practical safety measures ensuring optimal therapeutic action while minimizing adverse effects. These recommendations, though described in traditional language, address the same pharmacokinetic and pharmacodynamic principles now recognized through modern pharmacology.

#### **Standardization of Traditional Knowledge**

Integration of traditional knowledge into contemporary pharmacovigilance frameworks requires systematic compilation and standardization of safety-related information historically scattered throughout classical texts and traditional practice. This represents an opportunity to leverage centuries of accumulated clinical experience regarding adverse effect patterns, risk factors, and prevention strategies while maintaining analytical rigor of modern scientific evaluation.[18]

The challenge lies in translating traditional concepts into terminology compatible with contemporary regulatory and scientific frameworks, facilitating systematic data collection and international signal detection while preserving the conceptual validity and practical applicability of traditional systems.

### **Education and Awareness Requirements**

#### **Healthcare Professional Training Deficiencies**

Studies documenting knowledge and practices of pharmacovigilance among healthcare professionals reveal substantial educational gaps in both developed and developing nations.[26] In many pharmacy and medical curricula, pharmacovigilance receives minimal coverage, and content specifically addressing herbal medicine safety is particularly sparse. This creates situations where healthcare professionals, despite possessing general pharmacovigilance knowledge, lack specific training regarding:

- Unique characteristics complicating herbal medicine safety assessment
- Common herb-drug interactions and their clinical manifestations
- Quality and contamination concerns affecting herbal products
- Communication strategies for discussing herbal medicine risks with patients
- Proper adverse event reporting procedures specific to herbal medicines



### **Public Education and Misconception Correction**

The widespread public perception that herbal medicines are universally safe requires systematic, evidence-based correction through multiple communication channels. This necessitates coordinated education efforts by regulatory authorities, healthcare professionals, and scientific organizations emphasizing that natural origin does not confer automatic safety, that historical use while informative does not preclude adverse effects, and that appropriate medical supervision remains essential for herbal medicine use.

Consumer-directed educational materials should specifically address risks of self-medication, importance of healthcare provider notification regarding herbal product use, potential herb-drug and herb-herb interactions, quality considerations, and appropriate reporting of suspected adverse events.

### **Future Directions and Recommendations**

#### **Standardization and Quality Control Enhancement**

Strengthening pharmacovigilance systems for herbal medicines requires parallel investment in manufacturing quality control, raw material standardization, and finished product characterization. Recommendations include:

Mandatory implementation of GMP and GACP standards with rigorous inspectional oversight for all commercial herbal medicine manufacturers

Development and enforcement of national monographs establishing quality specifications, authenticity criteria, and safety parameters for widely used medicinal plants

Establishment of regional analytical laboratories with capability for botanical identification, chemical constituent analysis, and contamination detection

Harmonization of quality standards across major pharmaceutical markets to reduce incentives for distribution of substandard products in regions with weaker regulatory oversight

#### **Integration of Technology and Modern Tools**

Future pharmacovigilance systems for herbal medicines should incorporate emerging technologies to enhance surveillance efficiency:

Development of mobile applications and web-based platforms facilitating adverse event reporting from diverse stakeholders including healthcare providers, patients, and traditional practitioners

Implementation of machine learning and natural language processing technologies for signal detection from unstructured adverse event descriptions in diverse languages and terminologies

Utilization of electronic health records for real-world evidence collection and identification of herb-associated adverse events

Establishment of social media monitoring protocols to identify emerging safety signals discussed by consumers

#### **Regulatory Framework Development**

Jurisdictions lacking specific regulatory frameworks for herbal medicine pharmacovigilance should prioritize development of clear, science-based guidelines addressing:

Herbal product classification and regulatory categorization

Pre-market safety requirements and clinical trial expectations

Post-market surveillance obligations and adverse event reporting mandates

Manufacturing oversight and quality control inspection protocols

Mechanism for responsive regulatory action when safety signals emerge

#### **International Harmonization and Data Sharing**

The WHO should facilitate greater international harmonization and data sharing regarding herbal medicine adverse events through:



Establishment of standardized botanical nomenclature requirements in adverse event reporting to enable cross-database signal detection  
Development of training programs for national pharmacovigilance centers regarding herbal medicine-specific assessment methodologies  
Creation of international collaborative research networks investigating common safety concerns and emerging herb-drug interactions  
Facilitation of regular international conferences enabling exchange of pharmacovigilance expertise and emerging safety findings

## II. CONCLUSION

Herbal medicines occupy an increasingly important role in global healthcare, with utilization patterns continuing to expand. While traditional medicines have accumulated extensive historical safety data through centuries of use, this historical evidence requires integration with contemporary pharmacovigilance approaches to ensure systematic identification and management of emerging safety concerns in modern medical contexts. Current pharmacovigilance systems for herbal medicines remain substantially underdeveloped in most regions despite growing recognition of their necessity. The unique characteristics of herbal products—including complex polyherbal formulations, manufacturing variability, contamination risks, and potential for herb-drug interactions—present distinctive challenges requiring pharmacovigilance approaches tailored specifically to herbal medicine characteristics rather than simple application of pharmaceutical drug monitoring protocols. The Indian pharmacovigilance framework for traditional medicines represents a valuable international model incorporating classical traditional concepts into contemporary safety monitoring structures. However, expansion and strengthening of pharmacovigilance systems globally requires coordinated action by regulatory authorities, healthcare professionals, manufacturers, and research organizations directed toward enhanced standardization, strengthened quality control, mandatory adverse event reporting, public and professional education, and international harmonization. The fundamental principle guiding future pharmacovigilance advancement should recognize that safety and efficacy validation need not compromise traditional medicine integrity or accessibility. Rather, rigorous safety monitoring demonstrates commitment to patient welfare and establishes traditional medicine systems on the strongest possible evidence foundation for sustainable global integration within contemporary healthcare frameworks.

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