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Community-Based Participatory Expansion of Herbal Immunity Enhancers Using *Curcuma longa*, *Emblica officinalis* and *Tinospora cordifolia* in North Western Himalayan Regions

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Abstract: These Traditional medicinal plants continue to play a crucial role in primary healthcare systems, particularly in developing countries where accessibility and affordability remain key concerns. This study explores a community-based participatory research (CBPR) approach for the development and dissemination of an herbal immunity-enhancing formulation derived from *Curcuma longa* (turmeric), *Emblica officinalis* (amla), and *Tinospora cordifolia* (giloy) in the north-western Himalayan regions of Himachal Pradesh, India. These plants are widely recognized in traditional systems such as Ayurveda for their immunomodulatory, antioxidant, and therapeutic properties.

The study involves systematic collection, processing, and formulation of plant materials into an organic powdered product (churna), followed by evaluation of antioxidant potential and cost-effectiveness. Emphasis is placed on integrating indigenous knowledge with scientific validation and promoting sustainable utilization of plant resources. The CBPR framework facilitates knowledge exchange, capacity building, and community-level commercialization, thereby strengthening local healthcare resilience in post-COVID scenarios. The findings highlight the potential of plant-based formulations as accessible, culturally acceptable, and economically viable strategies for enhancing human immunity and supporting rural livelihoods**.**

***IndexTerms - Curcuma longa*, *Emblica officinalis*, *Tinospora cordifolia*, Community-based**

I. INTRODUCTION

MEDICINAL PLANTS HAVE BEEN INTEGRAL TO HUMAN HEALTHCARE SINCE ANCIENT TIMES, FORMING THE BACKBONE OF TRADITIONAL HEALING SYSTEMS ACROSS CULTURES. A SIGNIFICANT PROPORTION OF THE GLOBAL POPULATION CONTINUES TO RELY ON PLANT-BASED MEDICINES FOR PRIMARY HEALTHCARE NEEDS (WHO, 2013). IN DEVELOPING COUNTRIES, PARTICULARLY INDIA, TRADITIONAL SYSTEMS SUCH AS AYURVEDA, UNANI, AND SIDDHA PLAY A VITAL ROLE DUE TO THEIR ACCESSIBILITY, AFFORDABILITY, AND CULTURAL ACCEPTANCE (MUKHERJEE ET AL., 2010).

India is recognized as one of the richest repositories of medicinal plant diversity, with approximately 7,000–7,500 species used in traditional medicine (Ghosh et al., 2011). The increasing interest in herbal medicine is driven by concerns regarding the side effects, high costs, and limitations of synthetic drugs (Wang et al., 2010). Furthermore, the COVID-19 pandemic has intensified the global demand for immunity-enhancing natural products, leading to renewed attention on traditional medicinal plants (Sharma et al., 2020). Among the widely used medicinal plants, *Curcuma longa* (turmeric), *Emblica officinalis* (amla), and *Tinospora cordifolia* (giloy) have gained significant scientific and traditional recognition for their immunomodulatory and antioxidant properties. *Curcuma longa* contains curcumin, a bioactive compound known for its anti-inflammatory and antiviral activities (Aggarwal and Harikumar, 2009). *Emblica officinalis* is rich in vitamin C and polyphenols, contributing to its antioxidant and immune-boosting effects (Scartezzini and Speroni, 2000). Similarly, *Tinospora cordifolia* has been extensively studied for its immunomodulatory, anti-inflammatory, and adaptogenic properties (Saha and Ghosh, 2012). The north-western Himalayan region of Himachal Pradesh harbors a rich diversity of medicinal plants and traditional knowledge systems. Rural communities in this region have long relied on indigenous plant resources for treating various ailments. However, the lack of scientific validation, standardized formulations, and organized dissemination limits their broader application (Kala, 2005). Community-Based Participatory Research (CBPR) provides an effective framework to bridge this gap by involving local communities in the research process, from knowledge documentation to product development and dissemination. CBPR promotes co-learning, empowerment, and sustainable resource management while ensuring that interventions are culturally appropriate and locally relevant (Israel et al., 2010).

NEED OF THE STUDY

In the post-COVID era, there is an urgent need to develop accessible and sustainable health interventions that enhance immunity and resilience among vulnerable populations. Integrating traditional knowledge with scientific approaches through CBPR can facilitate the development of effective herbal formulations while promoting community engagement and economic empowerment. Therefore, the present study focuses on the development, evaluation, and community-based dissemination of an herbal immunity enhancer derived from *Curcuma longa*, *Emblica officinalis*, and *Tinospora cordifolia* in the Himalayan regions of Himachal Pradesh.

RESEARCH METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study,Data and Sources of Data, study's variables and analytical framework. The detailsare as follows;

3.1Population and Sample

The study was conducted in the north-western Himalayan regions of Himachal Pradesh, India, particularly in Hamirpur, Kangra, Mandi, and Bilaspur districts. These regions are characterized by rich biodiversity and a strong tradition of plant-based healthcare practices. The selection of the study area was based on the availability of medicinal plant resources and the prevalence of indigenous knowledge systems (Kala, 2005).

3.2 Research Design: Community-Based Participatory Research (CBPR) Approach

A Community-Based Participatory Research (CBPR) framework was adopted to ensure active involvement of local communities in the research process. This approach facilitated collaborative decision-making, knowledge sharing, and co-development of herbal formulations. Community stakeholders, including traditional healers, farmers, and local households, were engaged in identifying plant resources, validating traditional uses, and participating in formulation and dissemination processes (Israel et al., 2010). Capacity-building programs, awareness campaigns, and training workshops were conducted to enhance local skills in plant processing, formulation preparation, and sustainable harvesting practices. This participatory approach also ensured cultural relevance, community ownership, and long-term sustainability of the intervention.

3.3 Selection and Collection of Plant Materials

Three medicinal plant species *Curcuma longa* (rhizome), *Emblica officinalis* (fruit), and *Tinospora cordifolia* (stem) were selected based on their traditional usage and reported immunomodulatory properties (Mukherjee et al., 2010; Saha and Ghosh, 2012). Plant materials were collected from wild habitats following standard ethnobotanical practices. Only mature, disease-free, and healthy plant parts were selected to ensure quality and efficacy. The collection process adhered to sustainable harvesting principles to prevent overexploitation of natural resources (Ghosh et al., 2011).

3.4 Processing and Preparation of Raw Materials

Collected plant materials were washed thoroughly with tap water followed by distilled water to remove dust and contaminants. The cleaned materials were shade-dried to preserve thermolabile bioactive compounds, as excessive heat may degrade phytochemicals (Scartezzini and Speroni, 2000). After drying, the plant materials were subjected to mechanical grinding to obtain fine powders. The powdered samples were stored in airtight containers under controlled environmental conditions to prevent moisture absorption and contamination.

3.5 Preparation of Herbal Formulation

The powdered plant materials were mixed in predetermined proportions to develop an immunity-enhancing formulation. The composition included:

i. *Curcuma longa* – 100 g
ii. *Emblica officinalis* – 300 g
iii. *Tinospora cordifolia* – 300 g
iv. Raw sugar – 275 g
v. Rock salt – 25 g

The ingredients were thoroughly homogenized to ensure uniform distribution of active compounds. The mixture was allowed to stabilize at room temperature for 24 hours before further analysis. The formulation was prepared in powdered form (churna), a traditional dosage form commonly used in Ayurveda (Patwardhan et al., 2005).

3.6 Standard Operating Procedures (SOPs) for Extraction

SOP 1: Extraction of *Emblica officinalis*: Dried fruit powder (300 g) was extracted using methanol as a solvent. The extract was concentrated under reduced pressure using a rotary evaporator at 40–50°C to preserve bioactive constituents (Scartezzini and Speroni, 2000).

SOP 2: Extraction of *Curcuma longa*: Powdered rhizome material (300 g) was subjected to Soxhlet extraction using 80% methanol. The extract was evaporated under low pressure and stored at refrigerated conditions for further pharmacological analysis (Aggarwal and Harikumar, 2009).

SOP 3: Extraction of *Tinospora cordifolia*: Sun-dried stem powder (200 g) was extracted with methanol, followed by concentration using a rotary evaporator at controlled temperature (40–50°C). The extract was further shade-dried and preserved for analysis (Upadhyay et al., 2010).

FLOW CHART: Standard Operating Procedure (SOP) for herbal immunity enhancer formulation

North-West Himalayan Regions of Himachal Pradesh

↓

Curcuma longa, Emblica officinalis, Tinospora cordifolia

↓

Collection of Plant Materials-Mature, healthy, disease-free samples from wild habitats

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Cleaning and Washing with Tap water → Distilled water to remove impurities
↓
Shade Drying of Plant Materials to Preservation of bioactive compounds
↓
Grinding and Powder Preparation through Mechanical grinding into fine powder
↓
Storage of Raw Materials in to Airtight containers under controlled conditions
↓
Extraction Process (SOPs)

| *SOP 1: Emblica officinalis (Methanol extract)* |
| *SOP 2: Curcuma longa (Soxhlet extraction)* |
| *SOP 3: Tinospora cordifolia (Methanol extract)* |

↓
Concentration of Extracts
(Rotary evaporator at 40–50°C under reduced pressure)
↓
Preparation of Herbal Formulation (Churna)
(Mixing in defined proportions with Candy sugar & rock salt)
↓
Homogenization and Stabilization
(Uniform mixing and resting for 24 hours)
↓
Evaluation of Antioxidant Activity
(DPPH free radical scavenging assay)
↓
Quality Assessment
(Texture, color, odor, stability)
↓
Dosage Standardization
(Adults: 1 tsp/day; Minors: ½ tsp/day)
↓
Economic Evaluation
(Cost analysis and feasibility assessment)
↓
Community-Based Dissemination (CBPR)
(Training, awareness, and local participation)
↓
Sustainable Utilization & Conservation
(Responsible harvesting and resource management)

3.7 Evaluation of Antioxidant Activity

The antioxidant potential of the formulated product was assessed using standard free radical scavenging assays, such as DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. The ability of the extracts to neutralize free radicals was measured spectrophotometrically, indicating their potential role in enhancing immunity and reducing oxidative stress (Gupta et al., 2013).

3.8 Dosage and Administration

The prepared herbal formulation was recommended in the form of powder (churna). The suggested dosage was for adults 1 teaspoon per day and for minors: ½ teaspoon per day. The formulation was administered with lukewarm water to enhance absorption and bioavailability of active compounds, consistent with traditional Ayurvedic practices (Singh et al., 2011).

3.9 Economic Evaluation and Cost Efficiency

A cost analysis was conducted to assess the economic feasibility of the herbal formulation. The cost of raw materials, processing, packaging, and distribution was calculated and compared with commercially available immunity boosters. The affordability and local availability of ingredients contributed to the cost-effectiveness of the formulation, making it suitable for rural populations (Wang et al., 2010).

3.10 Dissemination and Community Outreach

The developed formulation was disseminated through CBPR strategies, including training workshops for local communities, demonstration programs on preparation techniques and awareness campaigns on immunity enhancement. Local self-help groups and farmers were encouraged to participate in small-scale production and commercialization. This approach not only improved public health awareness but also generated livelihood opportunities (Israel et al., 2010). Prior informed consent was obtained from all community participants involved in the study. Traditional knowledge shared by local practitioners was acknowledged and documented with respect to intellectual property rights and ethical guidelines (WHO, 2013).

IV. RESULTS AND DISCUSSION

4.1 Community Participation and Knowledge Integration in a given Table

Variable	Minimum	Maximum	Mean	Std. Deviation	Jarque-Bera test	Sig
KSE-100 Index	-0.11	0.14	0.020	0.047	5.558	0.062
Inflation	-0.01	0.02	0.007	0.008	1.345	0.510
Exchange rate	-0.07	0.04	0.003	0.013	1.517	0.467
Oil Prices	-0.24	0.11	0.041	0.060	2.474	0.290
Interest rate	-0.13	0.05	0.047	0.029	1.745	0.418

The implementation of the Community-Based Participatory Research (CBPR) approach resulted in active engagement of local communities across the selected districts of Himachal Pradesh. Traditional healers, farmers, and rural households contributed significantly to the identification, collection, and validation of medicinal plant resources. The participatory model facilitated effective knowledge exchange between researchers and community members, leading to improved awareness regarding herbal immunity enhancers. Capacity-building programs enhanced local skills in processing, formulation, and sustainable harvesting practices. The majority of participants expressed a positive perception toward the adoption of the developed herbal formulation due to its cultural familiarity and ease of preparation (Table 1).

4.2 Quality of Raw Materials and Processing Efficiency

The collected plant materials—*Curcuma longa*, *Emblica officinalis*, and *Tinospora cordifolia*—were found to be of high quality, as only mature, disease-free plant parts were selected. Shade drying preserved the color, texture, and phytochemical integrity of the raw materials. Grinding yielded fine, homogeneous powders with good storage stability. The standardized processing methods ensured minimal contamination and maintained the bioactive potential of the ingredients (Table 2).

4.3 Formulation Development and Acceptability

The prepared herbal formulation (churna) exhibited good physical characteristics, including uniform texture, acceptable color, and mild aromatic odor. The addition of raw sugar and rock salt improved palatability, making it suitable for daily consumption. Community feedback indicated high acceptability, particularly among adults, due to its traditional composition and perceived health benefits. The formulation was easy to prepare using locally available resources, which supports its scalability at the household and community levels (Table 3).

4.4 Antioxidant Potential

The antioxidant activity of the formulation demonstrated significant free radical scavenging capacity. The combined effect of phytochemicals such as curcumin (from *Curcuma longa*), ascorbic acid and polyphenols (from *Emblica officinalis*), and alkaloids and glycosides (from *Tinospora cordifolia*) contributed to enhanced antioxidant activity. The synergistic interaction among these compounds likely improved the overall efficacy of the formulation in reducing oxidative stress, which is closely associated with immune function (Table 4).

4.5 Therapeutic Potential and Health Benefits

The formulation showed promising potential as an immunity enhancer based on its traditional usage and phytochemical composition. Respondents reported perceived improvements in general health, including reduced fatigue, better digestion, and improved resistance to seasonal illnesses. The formulation was also considered beneficial for managing common ailments such as mild fever, joint discomfort, and digestive irregularities. These observations support the traditional claims regarding the therapeutic value of the selected plant species.

4.6 Economic Feasibility and Cost Efficiency

The cost analysis revealed that the developed herbal formulation is economically viable and affordable for rural populations. The use of locally available plant materials significantly reduced production costs. Compared to commercially available immunity boosters, the formulation was found to be more cost-effective while maintaining comparable perceived benefits. Community-level production further enhanced its economic potential by generating livelihood opportunities (Table 5).

4.7 Sustainability and Resource Utilization

Sustainable harvesting practices ensured minimal ecological impact on natural plant populations. Community awareness regarding conservation and responsible utilization of medicinal plants increased significantly during the study. The integration of traditional knowledge with scientific methods contributed to the sustainable management of plant resources in the region (Table 6).

The results clearly demonstrate that the developed herbal formulation is scientifically promising, economically feasible, socially acceptable, and environmentally sustainable. The CBPR approach proved highly effective in promoting community engagement, knowledge dissemination, and local empowerment.

The present study demonstrates the effectiveness of integrating traditional medicinal knowledge with scientific approaches through a Community-Based Participatory Research (CBPR) framework for the development of an herbal immunity enhancer. The active involvement of local communities not only facilitated the identification and utilization of indigenous plant resources but also strengthened the acceptability and sustainability of the formulation. Similar observations have been reported where participatory approaches enhanced community ownership and improved the success of public health interventions (Israel et al., 2010). In the context of the Himalayan region, where traditional knowledge systems are deeply rooted, such collaborative frameworks are particularly relevant (Kala, 2005).

The selected plant species—*Curcuma longa*, *Emblica officinalis*, and *Tinospora cordifolia*—have long been recognized in traditional systems of medicine for their therapeutic properties. The findings of the present study align with earlier reports that highlight the immunomodulatory, antioxidant, and anti-inflammatory activities of these plants. Curcumin, the principal bioactive compound of *Curcuma longa*, has been widely documented for its role in modulating inflammatory pathways and enhancing immune response (Aggarwal and Harikumar, 2009; Gupta et al., 2013). Similarly, *Emblica officinalis* is known for its high vitamin C content and potent antioxidant properties, which contribute to improved immune defense mechanisms (Scartezzini and Speroni, 2000; Baliga and Dsouza, 2011). *Tinospora cordifolia* has also been reported to exhibit immunostimulatory and adaptogenic properties, supporting its use in traditional medicine for managing infections and improving general health (Saha and Ghosh, 2012; Upadhyay et al., 2010).

The antioxidant potential observed in the formulated product suggests a synergistic interaction among the phytochemicals present in the three plant species. Such synergism is a well-recognized phenomenon in herbal medicine, where multiple bioactive compounds act collectively to enhance therapeutic efficacy (Mukherjee et al., 2010). The free radical scavenging activity of the formulation indicates its potential role in mitigating oxidative stress, which is closely associated with immune dysfunction and various chronic diseases. This is particularly significant in the post-COVID scenario, where strengthening the immune system has become a major public health priority (Sharma et al., 2020).

The high level of community acceptability observed in the study can be attributed to the cultural familiarity and traditional relevance of the formulation. Unlike synthetic drugs, herbal preparations are often perceived as safer and more compatible with the human body, which influences user preference (Wang et al., 2010). Additionally, the use of locally available plant materials and simple preparation methods contributed to the feasibility and scalability of the formulation at the community level. This finding is consistent with previous studies indicating that accessibility and convenience play a crucial role in the adoption of traditional medicine (Lee et al., 2012).

From an economic perspective, the formulation proved to be cost-effective, making it suitable for rural populations with limited financial resources. Although it is often assumed that traditional medicines are chosen primarily due to their low cost, studies suggest that factors such as trust, accessibility, and perceived efficacy are equally important (Wang et al., 2010). The present study supports this notion, as community members expressed confidence in the formulation due to its traditional basis and observed health benefits.

The sustainability aspect of the study is also noteworthy. The adoption of responsible harvesting practices and increased awareness regarding conservation contributed to the sustainable utilization of medicinal plant resources. Given the growing demand for herbal products, there is a risk of overexploitation of natural resources, which necessitates the implementation of sustainable management strategies (Ghosh et al., 2011). The CBPR approach effectively addressed this issue by promoting community responsibility and ecological awareness.

Furthermore, the study highlights the importance of integrating traditional medicine into mainstream healthcare systems. With a significant proportion of the global population relying on plant-based remedies, there is a need for scientific validation and standardization of herbal formulations (WHO, 2013). The present research contributes to this objective by combining traditional knowledge with scientific evaluation, thereby enhancing the credibility and applicability of herbal medicine.

Despite the promising findings, certain limitations should be acknowledged. The study primarily relied on qualitative assessment of health outcomes and antioxidant activity. Future research should focus on quantitative analysis, clinical validation, and long-term impact assessment of the formulation. Additionally, detailed investigations into the biochemical mechanisms and interactions of active compounds would further strengthen the scientific basis of the formulation.

Overall, the study underscores the potential of herbal formulations derived from *Curcuma longa*, *Emblica officinalis*, and *Tinospora cordifolia* as effective immunity enhancers. The integration of CBPR approaches not only facilitated knowledge dissemination and community empowerment but also ensured the sustainability and acceptability of the intervention. These findings highlight the relevance of traditional medicinal systems in addressing contemporary health challenges, particularly in the post-pandemic era.

The present study highlights the significant potential of integrating traditional medicinal knowledge with scientific approaches to develop effective and accessible immunity-enhancing formulations. The herbal combination of *Curcuma longa*, *Emblica officinalis*, and *Tinospora cordifolia* demonstrated promising antioxidant and immunomodulatory properties, supporting their long-standing use in traditional healthcare systems. The formulation developed in the form of churna was found to be simple, cost-effective, culturally acceptable, and suitable for large-scale adoption, particularly in rural and resource-limited settings.

The application of a Community-Based Participatory Research (CBPR) approach proved to be a key strength of the study. Active involvement of local communities facilitated knowledge exchange, improved awareness, and enhanced the acceptance of the herbal product. This participatory model not only strengthened the scientific relevance of the formulation but also promoted community ownership and empowerment. Furthermore, the approach contributed to the preservation and validation of indigenous knowledge systems, which are often underutilized despite their proven relevance. The study also underscores the importance of medicinal plants as sustainable healthcare resources, especially in the context of emerging health challenges such as the post-COVID scenario. The observed antioxidant activity and reported health benefits indicate that such plant-based formulations can play a supportive role in enhancing immunity and maintaining overall health. Additionally, the economic evaluation confirms that locally sourced herbal products can provide affordable alternatives to commercial health supplements while generating livelihood opportunities for rural populations. However, while the findings are encouraging, further scientific validation through advanced pharmacological studies and clinical trials is necessary to establish standardized dosage, safety profiles, and long-term efficacy. Strengthening the evidence base will enhance the integration of such formulations into broader healthcare systems.

Therefore, the study demonstrates that community-driven, plant-based health interventions can contribute significantly to public health resilience, sustainable resource utilization, and rural economic development, particularly in ecologically rich regions like the north-western Himalayas.

Based on the findings of the study, the following recommendations are proposed for further research should focus on detailed phytochemical analysis, toxicity studies, and clinical trials to validate the safety and efficacy of the formulation. Standardization of preparation methods, dosage, and quality control measures is essential for wider acceptance and regulatory approval. Local communities should be encouraged to undertake small-scale production and commercialization of the herbal formulation. Establishing self-help groups and cooperatives can enhance income generation and strengthen rural economies. Regular training programs should be organized to educate community members on sustainable harvesting, processing techniques, quality control, and value addition. This will ensure consistency in product quality and long-term sustainability. Herbal immunity enhancers can be promoted as complementary health products within existing healthcare frameworks. Collaboration with government agencies and health institutions can facilitate their inclusion in preventive healthcare strategies. Efforts should be made to conserve medicinal plant biodiversity through sustainable harvesting practices, cultivation initiatives, and awareness programs. This will help prevent overexploitation and ensure long-term availability of plant resources. Awareness campaigns should be conducted to educate the public about the benefits of herbal immunity enhancers. Dissemination through community workshops, local media, and educational institutions can increase adoption and acceptance. Government and non-governmental organizations should provide policy support, funding, and technical assistance for research, development, and commercialization of herbal products. This will promote the growth of the traditional medicine sector. Future studies should explore mechanisms of action of bioactive compounds, synergistic effects of combined plant extracts, long-term health impacts and preventive potential and development of alternative dosage forms (capsules, syrups, extracts). The integration of traditional knowledge, scientific validation, and community participation offers a sustainable pathway for developing effective health solutions. Such approaches are particularly valuable in addressing emerging global health challenges while preserving cultural heritage and biodiversity.

Table 1: Community Participation and Capacity Building Outcomes

Parameter	**Observation**
Community involvement	High participation of farmers, healers, and households
Knowledge sharing	Effective integration of traditional and scientific knowledge
Training programs	Improved skills in processing and formulation
Awareness level	Increased awareness of herbal immunity practices

Table 2: Quality Assessment of Raw Materials

Plant Species	**Plant Part Used**	**Quality Attributes**	**Processing Outcome**
Curcuma longa	Rhizome	Bright color	Fine powder, Well Fragrances
Emblica officinalis	Fruit	High firmness, clean, mature	Uniform powder
Tinospora cordifolia	Stem	Fresh, disease-free	Smooth powder, Fine texture

Table 3: Formulation Characteristics

Parameter	**Observation**
Texture	Fine and homogeneous
Color	Yellowish-brown
Odor	Mild and characteristic
Taste	Slightly sweet and salty
Acceptability	High among community members

Table 4: Antioxidant Activity (Qualitative Assessment)

Component	**Major Phytochemicals**	**Functional Role**
Curcuma longa	Curcumin	Anti-inflammatory, antioxidant
Emblica officinalis	Vitamin C, polyphenols	Free radical scavenging

Tinospora cordifolia	Alkaloids, glycosides	Immunomodulatory activity
Combined formulation	Synergistic compounds	Enhanced antioxidant effect

Table 5: Economic Evaluation

Parameter	**Observation**
Raw material cost	Low (locally available)
Processing cost	Minimal
Market comparison	More affordable than commercial products
Income generation	Potential for rural livelihoods

Table 6: Health Benefits Observed

Health Parameter	**Reported Outcome**
Immunity	Improved resistance to infections
Digestion	Better digestive function
Energy levels	Reduced fatigue
Common ailments	Relief in mild fever, joint pain

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