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A socio-ecological critique on India's local health traditions amidst rising incidence of global pandemics

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ABSTRACT

Introduction: The COVID-19 crisis has exposed inadequacy to deal with such health emergencies. The state of healthcare facilities in India is shambolic, which is further exacerbated by the exclusivity of modern health systems. The authors argue for vertical and horizontal expansion of the existing system to include traditional medicine systems, in favor of an urgently needed holistic and more inclusive healthcare system.

Methods: Secondary data were collected from free online resources, including preprints, reprints and databases, J-gate Plus, PubMed and Web of Science, using keywords such as, "folk medicine", "folk medicine AND India", "traditional Indian medicines", "indigenous Indian medicines AND India", "Indian ethnomedicines", "Indian AND folk AND medicine", "indigenous Indian medicine".

Results and conclusions: Insufficiently robust public healthcare infrastructure, lack of enough qualified health professionals, and poor use of its traditional medicinal systems, are limiting the access of basic healthcare facilities to a large section of the Indian population. Despite vehement opposition and criticism from modern health system practitioners, indigenous and local healing traditions do offer benefits and share a common global goal of health and healing. The objectives of Universal Health Coverage and Health for All as enshrined in the Sustainable Development Goals (SDGs) cannot be achieved without their involvement, especially in remote and economically disadvantaged regions of the country. Even a sub-optimal utilization of its biological and human resources and related traditional knowledge can not only profoundly change the health, but also the economic landscape of India. Here, we have nuanced the constraints posed by the emerging health challenges, status and prospects of the great and little traditions of the Indian System of Medicines in fulfilling the urgent healthcare needs of the country. The authors based their arguments on the available evidence, rather than emotive ideas or, as a fan of Indian traditional medicines, and suggest for the purposeful inclusion of traditional health systems and practitioners more actively in India's health care delivery systems. The country must not squander the opportunities offered by its traditional medicinal systems.

1. Introduction

Charles Leslie in his seminal work *Asian Medical Systems* highlighted the co-existence of a many "great tradition" and "little tradition" in the South-Asian subcontinent (Leslie, 1976). The book contains an informative account of the rich heritage of different medicinal practices of the region, also termed as - *Medical Pluralism*. This system was essentially hierarchical in nature and largely shaped up by the contemporary political forces of the region (Bode, 2011). There was also a dominant system of formal and codified knowledge and practice that flourished under State patronage and legitimacy and was followed by indigenous

healings systems. Together they are referred to as 'Great Traditions' and "Local Health Traditions" (LHTs) or "Little Traditions". Earlier medical anthropologists, sociologists and naturalists paid much attention to the diversity and complexity of this medical pluralism. The LHTs are informal and non-codified, and were/are hugely popular in masses, especially, with those living at the fringes of society (Lambert, 2018). The extensive works of non-governmental organizations (NGOs), civil societies and people's health movements during the 1980s reinvigorated public and academia's interest in LHTs (Mishra et al., 2018).

Currently the planet, as well as human civilization, is passing through a deep existential crisis. There are many ways in which it could

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happen (Box 1), including the emergence of new and more fatal diseases. The emerging infectious diseases (EIDs) such as Ebola, Influenza, Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), COVID-19, Dengue and Zika have brutally exposed our inadequacy to handle crises. The resulting large-scale human mortality and morbidity, and disruption in trade and travel networks, could potentially lead to serious humanitarian crisis and civil unrest (Pike et al., 2014). During the last quarter of the 20th century, many steps have been taken at national, regional and global levels (institutions, governments and individuals) to ensure basic health for each and every human being, cutting across social-economic and culturo-religious barriers. Goals, such as the United Nations (UN) 2030 Agenda for sustainable development, Universal Health Coverage (UHC) and Health for All (WHO, 2015; NHP, 2017) have been set. However, it has been increasingly realized that very often the nation is failing to realize these goals, hence, in effectively addressing the situations. For governments, these phrases are just effective tools to contain people's discomfort and not provide outcome-based targets, a problem that hurts most during the time of crisis. The COVID-19 pandemic is a glaring example of what happens when a local emergence results into regional outbreaks and a global pandemic; the scale of human loss and sufferings and economic devastations are simply unimaginable (Marco et al., 2020). Furthermore, the overwhelming demands of resources and health facilities to combat the pandemic have halted the other ongoing global immunization programs, thus, putting a huge population under further health risk. Thus, it is urgently needed to develop and strengthen the infrastructure needed against rising health risks (i.e., expansion of medical facilities, personals, rapid communication mechanism, increased funding for global health organizations, dedicated relief funds in case of emergencies, investments in screening, testing, new drug discovery programs and immunization).

In India, during the initial phase of the COVID-19 pandemic and resulting in a great nationwide lockdown, the first quarter GDP growth rate slumped to 1–1.6%, nearly a 4–4.5% reduction in the initial estimate, and reached to negative in the next quarters. However, the impact of COVID-19 and similar pandemics on economies could not be measured only in terms of loss and gain in GDP growth rate. It has exposed the inherent weaknesses of current global economic systems. In modern economic systems, the bulk of production systems, as well as earning opportunities, is centralized in certain pockets of a country, such as megacities, business hubs, special economic zones. In the case they are shut down, it could lead to mass migration of dependent human populations towards villages and small towns, where there are limited or no earning opportunities. The money that funds many government welfare schemes comes from the economic activities taking place in the centralized business hubs. Many state governments felt the shortage of

funds and were overwhelmed by complying with unprecedented demands of the basic necessities (food and medicine) of the population. This critically highlights the need for robust and more diverse, decentralized economic models.

India is an ancient country with its own age-old traditional medicinal systems (Adhikari and Paul, 2018). Traditionally, ethnomedicine is one of the theoretical orientations of medical anthropology and is essentially an interdisciplinary field of study (Waldstein and Adams, 2006). Early research works on ethnomedicine and indigenous healing practices, across the human civilization, have greatly enriched our understanding of the subject. However, these studies paid little attention to the relevance of these practices in public health. They were perused mainly from ethnographic perspectives with emphasis on cross-cultural perspectives of the traditions. These early works dealt profoundly on the shamanic, ritual or magico-religious healing, giving a sense that LHTs are nothing more than ritual healings - primitive, superstitious and nonsense (Sax, 2009). This was/is a gross misunderstanding of the reality as herbal medicines have much more to offer humanity. The emergence of new deadly diseases and associated financial burden to treat many of the chronic illnesses has compelled mankind to reconsider and reanalyze its ignorance to codified (e.g., AYUSH: Ayurveda, Yoga, Unani, Siddha and Homeopathy) and non-codified (e.g., informal LHTs) traditional medicine systems. It is not too late to recognize their contribution, or the entire knowledge base could be lost. Ignoring these rich traditions and related herbal resources of healing is comparable to closing the window on future medicines.

The term 'ethnobotany' that came into use somewhere in the beginning of the 20th century involved two aspects and specialists. Botanists, who are mainly interested in identifying plant species and the way they are used, whereas Anthropologists paid more attention to the cultural role of plants (i.e., how plants fit into people's lives). All in all, ethnobotanists have paid much attention to the listing of herbal plants, their botanical names and uses in treating different kinds of ailments. Undoubtedly, this limited focus on taxonomy and documentation has produced a waste repository of medicinally important plants, which is of immense use in days to come. The New Education Policy (i.e., NEP 2020) of the Government of India emphasizes on harnessing the medicinal knowledge of Indigenous People and Tribal Communities (IPTCs) in collaborations of various stakeholders, such as, the communities, ethnobotanists, phyto-chemists, biotechnologist, public health professionals, policymakers and States, for the greater benefit of mankind.

In India, tribal population accounts for 8.6% of its total population (numerically \approx 105 million). They are distributed in 4639 ethnic communities, of which, 705 are notified Schedule Tribes. A bulk of this population (\approx 95 million) reside in the countryside whereas the rest (\approx 11 million) in urban areas (Census of India Data, 2011). Historically,

Box 1

Driving factors and resulting global challenges.

Driving factors

Overpopulation: The current global population is around 7.6 billion (as of April 2018), likely to reach between 8.3 and 10.9 billion by the year 2050
 Climate change
 Emergence of diseases
 Concentration of wealth in few hands
 The changing socio-political and economic landscapes of the world are empowering the people's urge for participation in decision making and sharing of resource benefits

Challenges

Environmental Degradation
 Rising demands for life supporting
 Resources: Global food and water security, energy security and job security.
 Increasing human mortality and morbidity (health security) due to – increase in natural and man-made calamities, war and terrorism and emergence of old and new communicable diseases and life-style related diseases
 Spread of misinformation
 No clear-cut mechanism to control enormously powerful technologies (human cloning, artificial intelligence etc.)

they have been the most vulnerable section of the society, subjugated by poverty, illiteracy, diseases and superstitions. Their access to basic necessities of life, such as health, education and employment, is poor. The ongoing socio-cultural, political and economic changes have influenced their lives and living as never previously. They have rarely been a part of the decision-making process; never as active participants, but mute passive beneficiaries of the policies targeted to them. They have frequently been displaced from their homes by development projects and are incredibly ill equipped to cope with the impact of liberalization and globalization. For some time, tribal communities have been surviving on nature and rely heavily on their time-tested practices, utilizing local flora, fauna and mineral substances for therapeutic and curative purposes (Sharma, 2015). Their traditional medicinal knowledge and practices (known as folk medicine) constitute an important part of the traditional medicinal system of the country.

The importance of LHTs in primary healthcare viz. prevention and treatment of illnesses, health maintenance and health promotion, is now being greatly recognized (Rao, 2015a). In many developing and under-developed countries, the traditional healers outnumber the official medical practitioners (Rao, 2015a) and are the main primary health service providers. However, in India, there is a need to take progressive steps in resolving the long-standing issues confronting and delaying the implementation of LHTs, namely- their socio-legal legitimacy, recognition, revitalization and integration in the policy frameworks and national health systems, by invoking serious discussion and debates amongst regulators, policymakers and states (Albert et al., 2015). Moreover, there are other challenges that local healing practices are facing today. It includes a dwindling number of practitioners due to non-recognition of the traditions by State, the younger generation unwilling to learn them (i.e., unofficialness, social and legal legitimacy); little evidence for efficacy, as no clinical record is maintained by the traditional healers to justify the claims; lack of quality control (i.e., lack of standards and regulators), non-availability of medicinal herbs due to deforestation, climate change and unsustainable use; displacement and migration of the tribal people; ambiguity on indigenous people's right over their knowledge and natural resources; biopiracy; access and benefit-sharing (ABS); lack of respect for their culture and identity.

In India, much work on traditional medicinal systems has been conducted around the Ayurveda system. However, the present article focuses mainly on the current status of India's lesser known traditional medicinal systems practiced by the tribes and other indigenous communities. Nonetheless, it is hard to narrate the story of the Indian system of medicine without Ayurveda; therefore, pertinent information and examples have been used wherever needed. Furthermore, the authors strongly believe that economy is the most important force behind success and usability and of any tradition. Therefore, the various strategies to make LHTs economically viable have been discussed.

2. Methodology

A systematic review of the recent literature was conducted (from 2009 to 2019) focusing exclusively on the use of plants as a part of ethnomedicine in the Indian system of medicines other than Ayurveda. The following bibliographical databases were used to gather relevant information: J-gate Plus (jgateplus.com), PubMed (<https://pubmed.ncbi.nlm.nih.gov/>), and Web of Science (<http://apps.webofknowledge.com/>), using keywords such as, "folk medicine", "folk medicine AND India", "traditional Indian medicines", "indigenous Indian medicines AND India", "Indian ethnomedicines", "Indian AND folk AND medicine", "indigenous Indian medicine". Results are summarized in Table 1, which includes original papers, reviews, policy documents. It was observed that a majority of the publications falsely claimed simple 'botanical studies' as 'ethnobotanical studies', without providing any information on ethnographic elements, cultural and social relevance of the plant(s) to the particular tribal/ethnic community. These elements and a long and sustained history of use of a plant by a community are the

Table 1

Number of ethnomedicinal studies published during 2009–2019, the database searched and keywords used.

Database	Search Term (Title/Abstract)	Number of results (including original papers, reviews, policy documents etc.)
J-gate Plus (jgateplus.com)	Folk medicine	6732
	Folk medicine AND India	543
	Traditional Indian Medicine	316
	Indigenous Medicine AND India	66
	Indian Ethnomedicine	16
	Indian AND Folk AND Medicine	122
Pubmed (pubmed.ncbi.nlm.nih.gov)	Traditional Indian Medicine	96
	Indian Ethnomedicine	5
	Indigenous Indian Medicine	9
	Indian AND Folk AND Medicine	1561
	Traditional Indian Medicine	910
Web of Science (webofknowledge.com)	Indian	56
	Ethnomedicine	
	Indigenous Indian Medicine	91

most important criteria, which distinguish ethnobotanical studies from botanical studies. Moreover, a high number of Indian ethnomedicinal studies are based on classical Sanskrit literature, mainly Ayurveda, and other works based on it (e.g., Astanghridayam), which cannot be treated as ethnomedicine, therefore, such work was removed from the study. Because of a resulting small data set specific bibliometric or statistical tools were used for further analysis.

3. Results and discussion

As Table 1 suggests, not much work has been done on non-Ayurvedic Indian traditional medicine systems. The number of published work decreased sharply when more particular and stringent filters were applied. A bulk of these publications included review articles, book chapters and reports. These studies highlighted the number of gaps in LHTs, needing urgent actions from the governments as well as other stakeholders. Below the key findings are discussed, highlighting the vital health and economic importance of its traditional medicinal knowledge (TMK) to the country. However, to realize these benefits, the country has to work strongly in many gray areas. There is a need for vertical integration of these systems from across the cultures into modern healthcare systems, the designing of a framework for setting research priorities (to avoid being discredited as pseudoscience) and evaluating fidelity and efficacy of potentially valuable therapies and drugs, using data analytic based solutions, to generate new types of traditional medicinal system-inspired medicines (Jansen et al., 2021).

3.1. Curing the incurable and ensuring the supply of life saving drugs

India ranked 145th out of 195 countries on the Healthcare Access and Quality (HAQ) Index, which is lower than neighboring Bangladesh, Sri Lanka, Bhutan and Sub-Saharan countries (GBD-Disease and Injury Incidence and Prevalence Collaborators, 2018). For the finance year 2017–18, the spending on the primary health care (PHC) was roughly 1.28% of the GDP, which was far below the recommended 5–6%. However, if the contribution of the private sector are included, it reaches around 4%, which is still not up to the demand. The key elements of

Indian PHC systems are a shortage of health providers (i.e., doctors, nurses and other health workers) inadequate infrastructure (i.e., hospitals, beds, facilities, Fig. 1), an existing rural-urban divide, gender disparity in the workforce and poor quality of services in public sector. The ratio of center-state share to total health expenditure is 37:63 (for the FY 2017–18), with states showing huge disparity in HAQ index. States like Goa and Kerala have performed comparatively better and are at the top, while Assam and Uttar Pradesh lies at the bottom. The private sector is the main contributor to the overall primary health system of the country (70% in urban and 63% in rural areas). The dependency on public and private health care sectors varies between states. As of 2015, there are approximately 25,308 PHCs, 1,53,655 sub-centers and 5396 community health centers (CHCs) in the country. Only around 10% of this workforce serves in the public health sector. There are nearly one million registered doctors available to serve the 1.3 billion population of the country, with only one government allopathic doctor for every 10, 926 people (recommended ration is 1:1000), one government hospital bed for every 2046 people and one state-run hospital for every 90,343 people. The density of health professionals in urban areas is 4-times that of the rural areas. Though urban India has the access to quality medical care facilities, it is expensive. Even the large Indian middle class living in these centers could barely afford it.

The recent emergence of India as a preferred destination of medical tourism (MT) is a fine example of a health system and corporate collaboration. Mainly thriving in urban centers, it is a growing sector worth \$3 billion USD, that is likely to reach \$9 billion in 2020. The relatively cheap cost (e.g., 1/10th of USA), use of latest technology and ease in communication are some of the reasons for the success. Another reason is growing popularity of Indian Systems of Medicine (ISMs) in the West (Sen Gupta, 2008).

A majority of Indian people still live in villages, where the bulk of the total public healthcare centers are located. However, the overall quality and access to medical care are extremely limited and poor. The relative

contributions of factors rendering rural healthcare canters ineffective are an undeveloped infrastructure (53%), lack of expert clinical staffs (42%), lack of basic medical facilities (37%), lack of medicine (34%) and lack of doctors (31%). Experienced health care providers are reluctant to serve in the rural and remote areas that are mainly attended by inexperienced trainees. Only 19% of the doctors serving in rural areas have requisite professional qualifications (Anand and Fan, 2016). The self-styled doctors (i.e., Quakers) without formal training provide up to 75% of primary care services in these areas. Alternatively, people in rural and remote areas have to rely heavily on indigenous systems of medicines prevailing in the area (Rural Health Statistics, 2015).

In 1978, the World Health Organization (WHO) acknowledged that the goal of “Health for All” could not be accomplished without herbal medicines (Alma-Ata Declaration 1978). Besides inadequate infrastructure and human resource, accessibility, affordability (due to high cost, a vast section of populace cannot afford it) and availability of quality drugs are major issues associated to the modern medicine system. Moreover, there are growing concerns about the side effects of allopathic/synthetic medicines, increasing drug resistance of pathogens, the emergence of new kinds of communicable and lifestyle-related diseases that warrants the search of new drugs and their sources.

Human dependence on plants dates back to antiquity. They have long been used as naturally occurring substances for medical purposes. Plants, in particular, have played a leading medical role in most cultures. Across the globe, plenty of knowledge about medicinal plants is available from traditional and ethnic societies. Even for allopathic medicine, one in four prescriptions is either synthesized from and/or derived from plant materials. Over 80% of the global population relies upon traditional plant-based systems of medicine as a first line care, especially in rural areas (WHO, 2013, 2019).

In a recent synthesis, Jansen et al. (2021) argued that demonizing traditional medicinal systems as pseudoscience can have negative and dangerous consequences. They evaluated various challenges

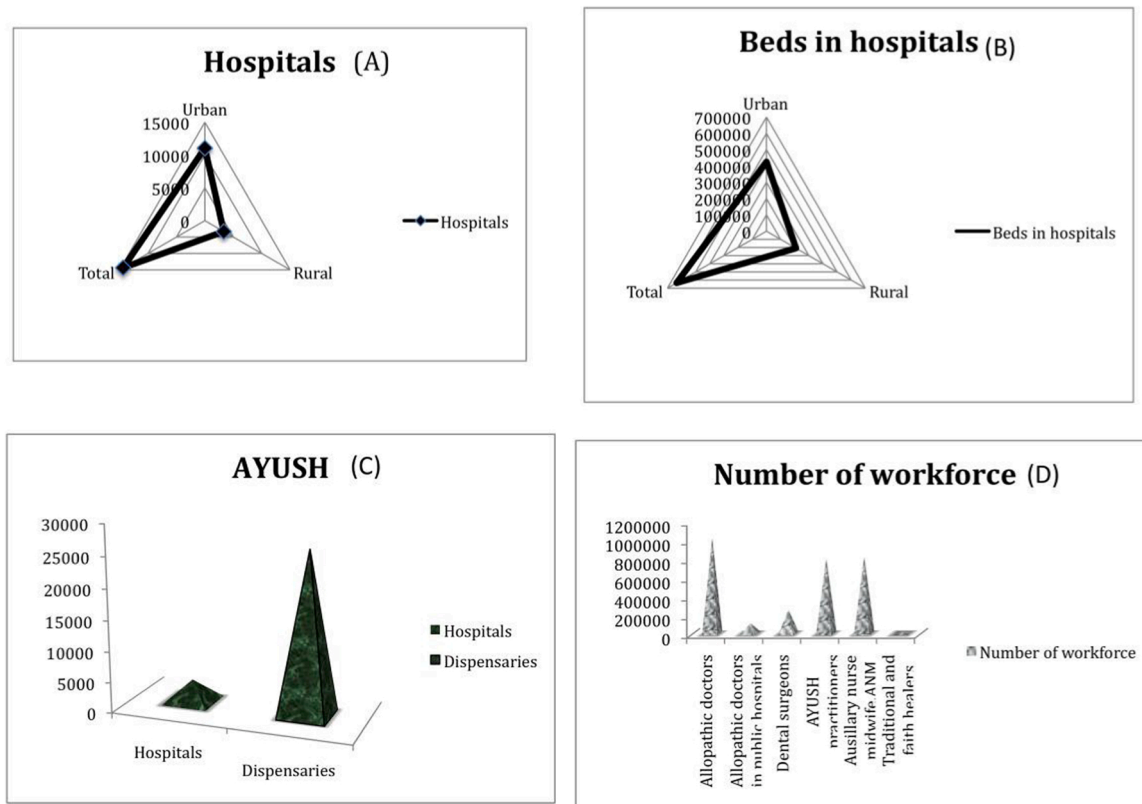


Fig. 1. Available health infrastructure in the country – number of hospitals (A), number of beds (B), number of AYUSH (Ayurveda, Yoga, Unani, Siddha and Homeopathy) hospitals and dispensaries (C) and number of health professionals (D).

confronting traditional medicinal systems, particularly those involving the use of plant-derived medicines, suggesting also certain measures to overcome them, such as de-grouping plant derived medicinal mixtures as an outgroup in complementary and alternative medicines (CAM), by using Bradford-Hill and other alike criteria (e.g. Koch's postulates and statistical evidence from pre-clinical and clinical experiments), overcoming the transformation/abstraction of TM taking place between cultures and from a traditional framework to the Western market, attention to the epistemological contrasts between TM and western scientific medicine and use of viable implementation models and research imperatives to integrate these therapeutic approaches into modern health systems (Jansen et al., 2021).

3.1.1. Importance and role of the traditional medicine systems

All ancient civilizations have evolved their own unique and vibrant indigenous knowledge systems through close interactions of its people with Nature. These systems use native plants to treat basic human needs (for food, clothing, shelter, health etc). Likewise, traditional medicine (TM) and health care traditions include using plant, animal and mineral resources for therapeutic, curative and rehabilitative purposes, by indigenous people and local communities, including tribes.

The First Global Monitoring Report (2015) suggests that nearly 400 million people (one-third of the global population in least economically developed and transition and developing economies) still do not have access to essential modern health care. Global initiatives, such as Universal Health Coverage (UHC), which is a critical component of the Sustainable Development Goals (SDGs) talks of a specific health goal: to ensure healthy lives and promote wellbeing for all at all ages. It is a measure to ensure that all people receive quality essential health services they need and access to safe, effective, quality and affordable essential medicines and vaccines, without being exposed to financial hardship. However, to achieve UHC goals, nearly 18 million health workers will be required in low and low-middle income countries (Anand and Fan, 2016). This becomes more amphibolic if we consider the definition of 'Health' in its fullest sense, which is not merely limited to the cure of a disease or availability of medicines and health services to a population, rather, a state that enables a person to lead a socially and economically productive life. All governments are expected to endeavor to bring in good 'health' within the reach of everyone in their respective countries (i.e., Health for All). It is a herculean task demanding strong political and economic willingness.

In India, about 65% of the population relies primarily on traditional medicines for their health care needs. There are more than 1.5 million traditional medical practitioners in the country who use natural products to prevent disease, maintain health and cure ailments. Also, the plant-based medicines are at the root of the modern health care and are now being increasingly acknowledged for their economic potentials. As an ancient civilization, the present-day India has inherited a rich culture of traditional systems of medicines. The ISM consists of Ayurveda, Yoga, Unani, Siddha, and Homeopathy, acronymed as AYUSH. The individual treatment systems show region-wise variations. For example, the state of Uttar Pradesh has more Unani doctors while Maharashtra with more Ayurvedic doctors. The relative percentage of Ayurvedic and Homeopathic doctors, the two most popular streams, is 56:37.

Tribal groups are one of the important stakeholders of traditional medicinal knowledge (Sreedevi et al., 2013), and are of paramount importance in the healthcare of tribal and ethnic communities. Their medicinal knowledge is non-codified and passed verbally from one generation to another in a teacher-pupil tradition. This makes its documentation and record keeping a herculean task. It is estimated that tribal and ethnic societies use approximately 8000 plants species with 25,000 effective plant-based formulations for healthcare (Sen and Chakroborty, 2015). Tribes living in different parts of the country have their own healing systems. For example, in Jharkhand state, the Hodopathy system of healing is widely practiced, and relies on vegetation growing in jungles and wild bushes. The Hodopathy Ethnomedicine

Doctors Association (HEDAN), with headquarters at Ranchi, has made several presentations to governments for the recognition and integration of the tradition into the primary healthcare system. It would be a great mistake to ignore the contribution of local traditions and healers, who are backbone of the primary health care in communities lacking basic health set-ups.

The major objection against the inclusion of non-codified traditions, and up to certain levels against AYUSH, is the scientific sanctity of the drugs, practices and educational and medical qualification of the practitioners. Both parameters can neither be taken lightly, nor over-emphasized. In a highly professional trait like medicine, the requirement for a particular level of training and qualification is indispensable and non-negotiable; however, it does not mean that all doctors should mandatorily have a bachelor's degree in medicine (i.e., Bachelor of Medicine and Bachelor of Surgery, MBBS) or equivalent degree. In many countries those having three-year medical diplomas are part of the healthcare system. Ironically, in India, amongst total allopathic doctors, nearly 32% have education only up to secondary school level; approximately 58% did not have a medical qualification. This situation is more precarious in rural areas (Anand and Fan, 2016) and there is no effective mechanism (rules are there but due to practical reasons and quid pro quo business) to weed out such practitioners from the system. Therefore, a rather practical approach would be to provide basic training to those who have at least secondary level of formal education, along with a necessary certification. Thus, trained personals shall impart only the firsthand treatment and subsequent high-end treatment shall only be from qualified doctors. This continuous and converging (through lateral entry mode) addition to the medical education will not only strengthen our already weakened/inadequate healthcare workforce demand but also facilitate the retention of practically trained workforce.

Furthermore, an important lesson that developed and developing nations may learn from the experience of the African nations from their fight against communicable and viral diseases is the need for a strong and well-connected network of community health facilities and workers in the geographically remote areas. In the wake of deadly disease outbreaks, often, it is not possible for centralized and unified health systems to respond effectively. For this, we need to train the local population as community health workers. The government of Prime Minister Narendra Modi has taken a right step in this direction by starting skill development programs for local people. The Healthcare Sector Skill Council (HSSC) has initiated a large number of skill programs designed for particular job roles. An effective skill program not only includes imparting a new skill to the learner but also re-skilling and up-skilling to meet the changing service demands and technology. To supplicate this growing demand, the young generation of folk healers may be appropriately trained as community health workers armed with added knowledge of basic healthcare services, along with their own health traditions. Surveillance programs in partnership with trained indigenous people and local communities, is a much-needed step to ensure the betterment of individuals, as well as the rural economy.

The scientific validation of indigenous medicines and crude drugs is an ongoing process. Historically, plants (followed by microbes in the antibiotic era and now marine invertebrates) have played an important role in providing drugs or templates for drugs. Plenty of this information is available in the form of traditional knowledge (TK), which is an outcome of decision making of the concerned society, resulting from its long traditions. Three cornerstones of acquiring traditional knowledge are "respect, protect and connect". Furthermore, TK should be given the same weight as scientific knowledge, where appropriate, since both are two different frameworks and cannot be arbitrarily inserted into any other framework. Development of a new drug is a complex, time consuming (12 years on average) and expensive processes (approx. 1 billion USD per drug). The Integrated Drug-Discovery programs seek synergy between traditional medicinal wisdom and drug discovery approaches. It starts with the identification of the right candidate applying traditional wisdom, followed by the isolation of molecules from natural

products/identified plants through biological activity guided fractionation or chemical synthesis (Box 2). This saves cost and time, as well as enhances the success rate of drug discovery. Since the selection of candidate species was based on long-term use by humans (ethnomedicine), it is also likely to be safer than those derived from plant species with no history of human use. Furthermore, a semi-synthetic molecule could be developed from a natural resource in order to overcome any inherent limitations of original molecule (e.g., podophyllin derived from *Podophyllum hexandrum* showed dose-limiting toxicities that could be overcome by semi-synthesis of etoposide, used in cancer therapy; Camptothecin-derived topotecan and irinotecan anticancer molecules) (Beutler, 2009). Besides, a great majority of crude natural products show immune-boosting and other rehabilitative properties and thereby, may be of immense help in immune-compromising diseases (e.g., AIDS, COVID-19 and other viral infections) (Fig. 2). The common understanding about the use of crude herbs or herbal products suggests that they could provide real health benefits when used long-term.

It has been a norm for mainstream health professionals to belittle and sideline the valuable contribution of these resources and knowledge systems on the pretext of scientific approval. The father of modern ethnobotany Richard Evans Schultes (1915–2001) once said “*The ethnobotanical researcher must realize that far from being a superior individual, he - the civilized man - is in many respects far inferior.*”. Similar sentiment was echoed by ethnobotanist and plant explorer Mark J Plotkin in an interview with South American Explorer magazine in the year 1998, where he argued “*No medical system has all the answers - no shaman that I’ve worked with has the equivalent of a polio vaccine and no dermatologist that I’ve been to could cure a fungal infection as effectively (and inexpensively) as some of my Amazonian mentors. It shouldn’t be the doctor versus the witch doctor. It should be the best aspects of all medical systems (ayurvedic, herbalism, homeopathic, and so on) combined in a way which makes health care more effective and more affordable for all.*”.

Since the beginning, the evolution of local and indigenous health traditions and native flora are explicitly linked to each other. In addition to health security, medicinal plants and their parts provide a secondary source of income to Indigenous People and Local Communities (IPLCs) (Fig. 3). In the National Five-Year Plan of the country, the medicinal plant sector has been included as an integral part of the Indian Systems of Medicine and Homeopathy.

3.2. Floristic diversity in India: the current scenario

India is blessed with a rich repository of plant-based natural resources, which are adored traditionally and considered as God given. The geographical positioning, topographic, altitudinal and climatic variations have allowed greater diversification of ecological habitats within the territorial boundaries of India that possess roughly 2.4% of the global land area. The country is represented by 12 biogeographic regions, five basic biomes and three bioregion domains (Cox et al., 1993). It is home to 7–8% of globally recorded species, including over 47,000 plants (11.4% of global flora; 28% endemic) and 91,000 animal species (Table 2). Due to conceptual and methodological limitations it

will be unrealistic to assign numbers (even approximation) to the total microbial taxa (Sharma and Rai, 2011). Nevertheless, the authors confine their present discussion to vascular and flowering plants only.

There are roughly 19,384 known vascular plants (flowering plants, gymnosperms, and pteridophytes) and 2523 bryophytes in the country (Singh and Dash, 2014). Of this, Indian angiospermic flora consists of 17,527 species, 296 subspecies, 2215 varieties, 33 subvarieties and 70 forma (altogether 20,141 taxa under 2991 genera and 251 families), representing approximately 7% of the described species in the world (Karthikeyan, 2009). It is characterized by a rich element of endemism (second only to Australia) and monotypic genera (total 236 with 176 dicot, 60 monocot and 84 endemics, belonging to 33 families), which are represented by only one species in a given territorial boundary (e.g., India) (Rana and Ranade, 2009). It is estimated that about 4045 taxa belonging to 975 genera in 155 families are considered as strictly endemic to Indian (nearly 6.5% of the total), this includes, 2984 taxa (74%) under 720 genera in 128 families of dicotyledones and 1061 taxa (26%) belonging to 255 genera under 27 families of monocotyledones (Arisdason and Lakshminarasimhan, 2017; Botanical Survey of India, 2019).

There are four biodiversity hotspots in the country, namely the Himalayas, Western Ghats, North-Eastern (NE) part of India and Andaman and Nicobar islands. The highest number of endemic taxa has been reported from the NE region, followed by the Southern peninsula and the North-West Himalayas. The Himalayan flora included elements from the adjacent regions. The active speciation owing to its geographic positioning has added many Neo-endemics to the richness and diversity of the Himalayan flora (Rao, 2015a for details). The country harbors approximately half of the world’s aquatic flowering plants (a total of 107 species). Another unique feature is the presence of a large number (131 species) of primitive flowering plants in India, particularly in the NE region.

3.2.1. Medicinal and aromatic plants (MAPs) in India

Globally, the use of plants for therapeutic and curative purposes is as old as human civilization itself. The ancient Hindu texts notably - *Rigveda*, *Ayurveda*, *Charaka Samhita*, *Susruta Samhita* and *Astanga Hridayam* - contain references of nearly 4000 plants with medicinal use. Ethnic tribes homing in forested parts of the country also hold vast amounts of traditional medicinal knowledge, including information about aromatic plants, as essential oils also have medicinal value. Traditional healers in India have been using more than 10,000 different plant species, of which, approximately 7500 are also used by its tribal healers (Tiware et al., 2004). Moreover, studies suggest that due to micro-climatic and edaphic variations many subtypes or local populations (infra-species diversity, ecotypes, chemotypes) exist for many of these species, especially in species distributed far away. In this context, evaluation of the biodiversity, including the infra-specific diversity, is very much needed (Cornwell et al., 2019) before they become extinct, due to anthropogenic pressure, particularly those of ‘elite types’ for commercial cultivations. The discovery of new taxa each year univocally suggests that the work of documentation is far from complete. Factors such as severe

Box 2

Plants can provide drug products through the following ways -

1. Bioactive compounds for direct use as drug e.g., digoxin.
2. Bioactive compounds with structures which themselves may act as lead compounds for more potent compounds e.g., paclitaxel from *Taxus* species.
3. The novel chemophore that may be converted into druggable compounds with/without chemical analoging
4. Pure phytochemicals for the use as marker compounds for standardization of crude plant materials or extracts
5. Pure phytochemicals that can be used as pharmacological tools
6. Herbal extracts as botanical drugs e.g., green tea extract.

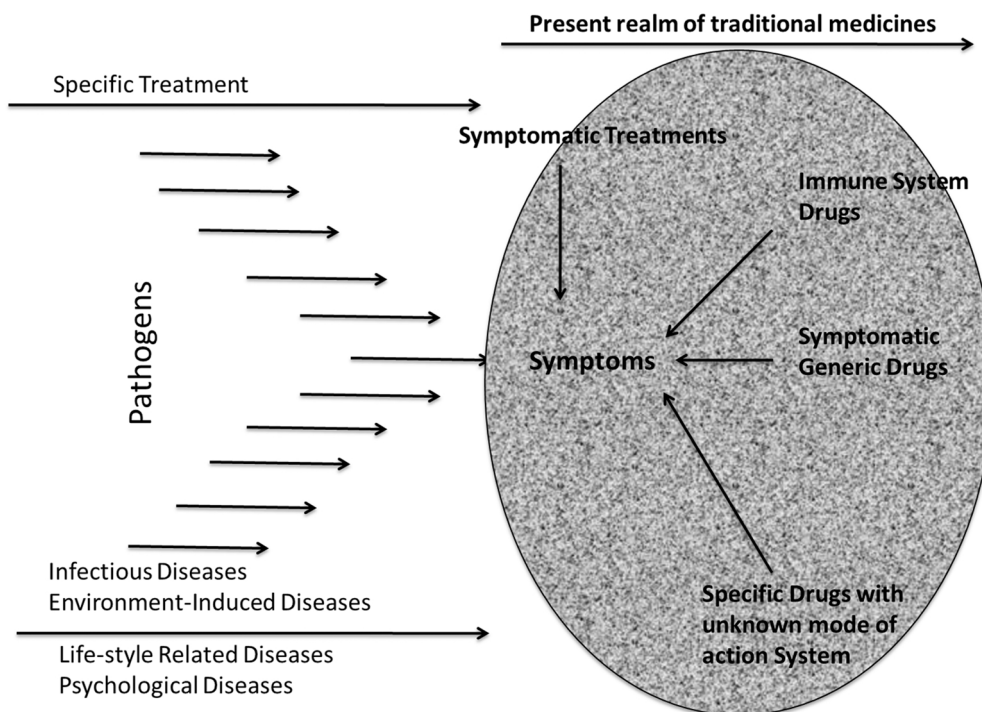


Fig. 2. Majority of drugs in Indian System of Medicines (ISMs) and Local Health Traditions (LHTs) are symptomatic in nature (not disease specific). They are better suited to act as rehabilitative and cover a broad range of therapeutic drugs, unlike allopathic drugs, which are target specific. So, even in case of pathogenic infection they facilitate healing via an immune-boosting response of the patient.



Fig. 3. Photographs showing (A) a traditional Indian healer at Amarkantak town; (B) Rastriya Guni Mission, Udaipur (courtesy of their Facebook mission page); (C) Children of Jana village in Jharkhand with medicinal plants (courtesy of Dibyendu Chaudhary, Parijat Gosh, Temba Oraon, Vivek Sinha – downtoearth.org.in) (D) Amarkantak Arka Eye Drop extracted from the flowers of Gulbakawali *Hedychium coronarium*, to treat cataracts.

shortage of trained manpower, aversion among the current generation of students to take up these highly demanding fields of work, lack of adequate funds and fewer job opportunities for taxonomists and field botanists, are major hurdles in moving things forward (Rao, 2015b). Efforts of surveying and inventorization of flora must be continued,

especially in areas that are still unexplored, using more robust technologies.

The conventional survey-documentation approach used to characterize and manage biodiversity has limitations. In recent times, the use of more accurate, fine resolution, remote sensing technology for quick

Table 2

Total number of plant species (including virus, bacteria, algae, fungi and lichens) and their status in the World and India (adopted from BSI website; [Chapman, 2009](#); [Singh and Dash, 2014](#)).

Sl. No.	Type	Number of known Species		Percentage of Occurrence in India (%)	Number of Endemic Species	Number of Threatened Species
		World	India			
I	Flowering Plants					
1.	Gymnosperms	1021	74	7.35	8	7
2.	Angiosperms	268,600	18,043	6.72	(ca. 4036)	1700
III	Non-flowering Plants					
1.	Bryophytes	16,236	2523	15.54	629	ca. 80
2.	Pteridophytes	12,000	1267	10.57	47	414
III	Others					
1.	Virus	11,813	986	8.77	Not Known	Not known
2.	Bacteria	40,000	7284	18.21	1924	Not known
3.	Algae	98,998	14,883	15.09	ca. 4100	ca. 580
4.	Fungi & Lichens	17,000	2401	14.12	ca. 520	Not known
Total		465,668	47,513	–	11,273	2781

assessment of resources has increased significantly. They are cost-effective and of repetitive nature with synoptic coverage technology ([Chandrashekhar et al., 2003](#)). The geospatial techniques have been used for modeling of medicinal and aromatic plants, their habitats and other factors relevant to understand their impact on human lives. The Geographic Information System (GIS) maps provide information about distributional pattern of species in a given area (presence, absence, as well as density of the species), growth patterns and habitat of plants (i.e., ecological parameters) and quantum availability of the raw materials. This could enable professionals to make better decisions while harvesting endangered medicinal plants from the wild (i.e., promote sustainable collection) thereby avoiding overexploitation of commercialized species, and streamlining the conservation measures (e.g., germplasm collection) and implementation of suitable regeneration methods. GIS maps could also be used to define new reserve zones for endangered plants, in conservation and management of plant resources, and to restore ecological zones and determine the effect of global warming on ecosystems and their biodiversity. The Indian Institute of Remote Sensing (IIRS), Dehradun, has inventorized the medicinal flora of India and have listed 1879 medicinally important plant species ([Roy et al., 2012](#)).

The systematic documentation of plant uses by native people started well before the 20th century in various parts of the world, known as Aboriginal Botany. Cross-cultural ethnobotanical studies could help in short-listing many species and elite types for further bioprospection. Many Indian texts and traditions (even different ethnic groups) refer to the use of different unrelated medicinal plants in the treatment of a particular ailment. Such cross-cultural comparison should be applied to short-listed potential target plants usable in a particular diseases. Although urgently needed, these types of studies, especially from developing countries, are negligible ([Rao, 2015b](#)). Ethnic communities and tribes are the custodian of the germplasm of several native plant species, potential targets for future drug discovery programs. The development of potential drugs from these plants subject to critical scientific evaluation and pharmacological trials could certainly boost the regional economy ([Rao, 1994](#)). However, a closer and effective interaction between biodiversity know-how and biotechnologists is key to the success of any bioprospection initiative.

3.2.2. Threat to biodiversity

Climate change, along with factors such as alteration in natural habitats (land use and land cover changes), overexploitation of natural resources, genetic drift, proliferation of invasive species and heavy livestock grazing, have been a serious threat to biological diversity, especially of the plants showing narrow range of distribution, due high habitat specificity ([Kala et al., 2006](#)). To contain these losses, the adoption of appropriate conservation strategies with a plethora of remedial measures ([Table 3](#)) is needed. Conservation is not just a

concept, but is for economic, social and ethical reasons. [Mehta et al. \(2020\)](#) stated that assessing the impact of threats and identification, prioritization and predicting conservation pockets are vital inputs for conservation and management of threatened species. Over a period of time, different conservation strategies have been developed and applied in various places, each having their own limitations ([Singh, 2002](#)). To overcome these challenges, we need to design coordinated programs for identifying the existing gaps; avoid duplication of efforts, embark upon training programs to develop expertise, analyze infra-specific diversity of selected groups; develop distribution maps, strengthen biodiversity collection centers, develop national biodiversity databases with strong networking for sharing of information among regional centers. There are contradictory reports on the role of indigenous communities in the protection of biodiversity or conservation of bioresources (bioresource is a sub-set of biodiversity). [Nzau et al. \(2020\)](#) reported that a successful Participatory Forest Management depends on inter-ethnic relations and the history of the local people living in the ecosystem.

As a pilot project in the India states of Arunachal Pradesh, Chhattisgarh and Uttarakhand, the United Nation Development Programme (UNDP), along with other agencies, have developed practices for the conservation and sustainable use of medicinal plants. They used rapid threat assessment to prioritize a sustainable management action program; landscape based approaches of establishing Medicinal Plant Development Areas (MPDA) of 1500 ha, a Medicinal Plant Conservation Area (MPCA) of 200-hectare size for sustainable collection and *ex-situ* conservation approach in the form of home herbal gardens to meet family demands. Success of the project at a relatively large-scale will certainly help in releasing the pressure resulting from the over-collection of important MPs ([UNDP, 2013](#)).

3.3. Traditional medicinal knowledge and bioprospection

In recent times, the demand for herbal medicines has rapidly increased. The high diversity and richness of Indian medicinal flora offers an enormous opportunity for bioprospection, which is the process of discovery and commercialization of novel products from biological resources. It has three facets, namely: chemical prospecting, gene prospecting and bionic prospecting ([Pushpangadan and Nair, 2005](#)). The entire process of finding a potential source to the final release of a product/drug in the market is a cumbersome job ([Beutler, 2009](#)). Traditional knowledge about medicinal plants could serve as a ready-made platform for efforts to develop new products/drugs, saving both time and money. The incomplete listing of medicinal flora and lack of an authentic and comprehensive ethnomedicinal database acts as an initial hurdle to bioprospection efforts. [Drescher and Edwards \(2018\)](#) have provided a set of guidelines on how to report expert knowledge in an authentic and transparent manner. Furthermore, as a measure to overcome the continued biasness in favor of recorded knowledge and

Table 3

Anthropogenic factors responsible for biodiversity loss and remedial measures to be adopted (after Rao, 2015a; NBSAP, 2018).

Sl No.	Threat Factor	Remedial measures
1	Increasing population	<ul style="list-style-type: none"> • Rehabilitation and restoration of degraded ecosystems
2	Fragmentation of natural habitats	
3	Demand for road connectivity to human settlements located in remote natural settings	<ul style="list-style-type: none"> • Priority action for conservation at diversity levels; develop methodology for biodiversity managements (e.g., see Mehta et al., 2020; Carrasco et al., 2020)
4	Urbanization/extension of township	
5	Growing focus on Tourism Economy	<ul style="list-style-type: none"> • Inventorization of the biodiversity; develop local, national and regional biodiversity databases
6	Proliferation of invasive species	
7	Free access and unregulated exploitation of bioresources in many parts of the world, especially in developing and under-developed countries	<ul style="list-style-type: none"> • Training of field botanists and taxonomists • Identification of area-specific threat factors to biodiversity • Monitoring of alien species
8	Selective removal of specific groups of plants	<ul style="list-style-type: none"> • Identification, recovery and rehabilitation of RET taxa in their natural and near natural habitats and preparation of their distributional maps. Use of tissue culture and micropropagation techniques
9	Forest degradation and unhealthy agricultural practices, such as slash and burn by locals in an area	
10	Changing lifestyle and values of local/indigenous people	<ul style="list-style-type: none"> • Establishment of effective and representative networks of protected areas (PAs) (Visconti et al., 2019); and establishment of biological corridors to link the PAs • Identify over-exploited species, promotion of cultivation of commercially important plants • Emphasis on research and establishment of international cooperation on protection, conservation and management of bioresources • Species-oriented conservation sites • Accessing and ensuring local people's participation in all stages of conservation and management of bioresources (Nzau et al., 2020); strengthen Access and Benefit sharing, their intellectual property rights and ensure proper execution of Forest Right Acts • Establishing botanical gardens, arboreta, gene/seed banks of all wild plants • Incorporate biodiversity concern in environmental protection assessment and in other working plans • In addition to governments, scientists need to maintain proper communication with public (Fischhoff and Scheufele, 2019, and references therein)

established scientific practices, we have to put traditional knowledge in modern scientific terms, similar to any other established scientific undertaking. Based on their work in the Doodhganga forest range, Mir et al. (2021) suggested that to authenticate the indigenous knowledge plant species with high value use (HVV) and fidelity level value (FL) should be further investigated for phytochemical and pharmacological properties.

The role of ethnobotanists/field botanists in the correct identification and collection of plant materials based on the field and cross-cultural knowledge of the species and their uses would be highly rewarding (Rao, 2015b). For instance, scrutiny of herbaria of different parts of the world could provide valuable information about ethnobotanical uses of medicinal plants by different ethnic and tribal groups. The information may suggest the medicinal use of plants of particular

locality or tribe, wide use of a specific plant species by many different tribes and total number of species worldwide used to cure a particular disease (Nesbitt, 2014 and references therein). A number of plant-derived drugs have been developed taking clue from prevailing traditional knowledge (Cox and Balick, 1994; Kayne, 2009). A plant species either from the same region or elsewhere, but previously not evaluated, could provide a high amount of a particular drug. For example, *Nothopodytes foetida*, a tree species from Western Ghat contains a much higher amount of Camptothecine (0.1%), an anti-cancerous, drug compared to that of the Chinese plant *Camptotheca acuminata* (0.005%) (Rao, 2015a).

Bioprospection need not necessarily be limited to the discovery and development of novel molecules. Alternatively, a rationally designed and carefully standardized synergistic traditional herbal formulation and botanical drug product, with robust scientific evidence, is an equally valuable contribution. Strategies, such as use of the reverse pharmacology approach to develop new drugs and synergistic botanical formulations, inspired by traditional medicines and indigenous systems, could also be useful (Patwardhan and Mashelkar, 2009). In other words, combining natural products, indigenous wisdom and biotechnology is very much a demand of the time. Almost 80% of drug molecules are of natural origin and about 50% of drugs approved since 1994 are based on natural products (Kala et al., 2006).

The rapid growth of molecular biology and a plethora of biotechnological tools and techniques have made it easy to screen novel genes from different bioresources and the transfer of useful genes from donor to biotechnologically friendly microorganisms, for greater and efficient production of target molecules. However, a clear inverse relationship between the two components of bioprospections viz., biodiversity (resource; upstream) and biotechnology (use process; downstream components of a production system) has been observed. Quite clearly, the biodiversity rich countries (poor economies) have poor access to biotechnological tools and techniques (developed economies). Consequently, many biotechnologically rich but biodiversity poor countries are involved in biopiracy via illegally patenting of the traditional knowledge of economically weak societies and countries. All bioprospection-based attempts to convert biological wealth to money should be given due consideration to the conservation of biodiversity and protection of intellectual property rights (IPR) of the TK holder and to access and benefit sharing mechanism (see Pushpangadan and Nair, 2005 for detail). To date, this country has no reliable and long-term effective models of ABS between traditional knowledge providers and users (refer to failure of Pushpangadan Kani model and PepsiCo model).

3.3.1. Socio-economic wellbeing of indigenous people and tribal communities

The enormity of the health market has attracted big and multinational companies (MNCs) to invest heavily in the herbal drug sector. Intensive marketing strategies flaunted with “back to nature” adverts have resulted in exorbitant pricing of these medicinal/neutraceutical products. On the other hand, the legitimate owners of the knowledge remain incognito, rarely benefiting from the commercialization of their time-tested and trusted knowledge. This has necessitated that all bioprospection programs based on traditionally used medicinal plants must run in a legally secured environment, so as to ensure the sovereign right of TK-holders and countries whose biodiversity is used. It should be made mandatory to engage indigenous and tribal people in documentation and validation of TK, which will provide jobs to the people, thereby ensuring their economic wellbeing. The engagement especially of youth in scientific research will boost their confidence in the knowledge and will help them in reclaiming their rights.

Reyes-García et al. (2019) emphasized that IPLCs should be a given greater importance in any post-2020 Convention of Biological Diversity agenda. Since they directly rely on their immediate environment for meeting basic livelihood needs, they are more affected by global environmental change. As it is critical for their well-being, IPLCs (their

traditions and customary institutions) actively participate in protecting and restoring ecosystem resilience, maintaining traditional practices and restoring land degraded by outsiders. Success of restoration projects increases with co-designing and seeking early-stage association of IPLCs. This resulted in both short-term direct benefits to the IPLCs and long-term maintenance of the restored areas. They have also given a mechanism about how indigenous and local knowledge can be incorporated in the planning, execution and monitoring of restoration activities (Reyes-Garcia et al., 2019). A similar approach in the case of traditional medicinal knowledge and practices shall be greatly appreciated. Despite the ever-increasing global demand for plant-based products, India is unable to exploit the situation. This is because of non-availability of raw materials, the quality of finished products, a shortage of skilled man power and producer friendly marketing strategies.

3.3.1.1. Cultivation of MAPs. The majority of commercially important medicinal plants are still gathered and collected from the wild, only a few are cultivated in farmland. Because of over-exploitation and selective removal to meet the increasing demand for natural products, many species have already become, or are, on the verge of becoming endangered. There are two possible ways to reverse this trend: (1) to find the alternative sources; and (2) take the necessary steps to popularize commercial cultivation of select species. The first step is time and money consuming while, the latter one offers huge economic potential for people living in remote and rural areas of the country. Suitable cultivation practices should be developed in order to meet the demands of the industries. Besides putting a check on over-exploitation, it will create job opportunities and promote economic wellbeing of the people. A shift from collection to cultivation of medicinally important plants will also ensure purity, authenticity and sustainable supply of raw drugs (Malti and Geetha, 2007). The majority of farmers in the country have small land holdings, whereas, a critical level of cultivable land is needed to ensure profitability and consistent supply of the material. Other aspects, such as the identification and promotion of cultivation of highly traded MPs, non-availability of quality planting materials, lack of agro-climatic data, appropriate training modules, investments in new technologies and integration of various government programs/schemes to support livelihood generation, should be considered, addressed and duly implemented.

3.3.1.2. Value addition to the MAPs. One of the major hurdles in the way of commercial exploitation of medicinal plants is the quality concern of the products (plant materials, crude drugs, extracts and pure compounds), arising out of improper harvesting, adulteration, substitution of drugs and manipulations in quality control parameters. The Government of India has issued detailed guidelines on Good Manufacturing Practices (GMPs), including good agricultural practices to ensure and enhance the quality of Ayurvedic, Siddha and Unani (ASU) medicines, at every steps of the production process (i.e., farm to factory). Value addition is an essential for the commercial success of the plant-based natural products. For example, the concentration of metabolites varies with season and growth phases of the plants, affecting the efficacy and potency of the resulting products. Thus, it is very much needed to collect/harvest the plant materials in the appropriate season. Similarly, variation in physicochemical parameters could also have unwanted effect on the concentration of the active constituents. Such faulty materials fail in pharmacopoeial standards and industrial requirements, hence, are either rejected or accepted at very low prices. This results in economic loss to the cultivators/collectors, as well as raising doubts about the efficacy and potency of the products. Value addition in medicinal plants could be achieved through both direct (improving the quality of the cultivated/collected material) and indirect (quality assurance of the finished product or semi-processing of the material to a value-added product) ways (Kumar et al., 2014). Table 4 enlists

Table 4

Direct and indirect ways to instill value addition in the medicinal and aromatic plants (after Kumar et al., 2014).

Sl. No.	Direct approach	Indirect approach (Physico-chemical standards)
1	Collection in the proper season	Minimal moisture content
2	Grading and sorting (remove infested, immature and unacceptable materials)	Remove foreign materials (FOMs)
3	Cleaning (remove soil and other organic and inorganic matters)	Low ash content
4	Packaging for shipment or storage	Extractives (number of soluble constituents)
5	Storage (under specified condition to avoid contamination and deterioration)	Remove pesticide residues & microorganisms
6	Macroscopic and microscopic examinations (for purity and quality)	Certification of the quality
7		Semi-processing of the raw materials as powder, tablets/capsules, extracts etc.

parameters related to the direct and indirect ways of value addition. There is also a need to adopt modern mechanized ways of packaging the products, as conventional methods suffer many limitations (durability of the products including contamination).

3.3.1.3. Marketing of MAPs and the products. India is one of the world's largest suppliers of plants and their products. The quantity of exported Ayurvedic products from India has tripled between the years 2001–2003. The current domestic trade of the AYUSH industry is around 80–90 billion INR, whereas, our export potential lies in the range of 10 billion INR, which is comparatively low for when a global share is concerned. It is suggested that the plant-based medicines market is doubling in size every 4–5 years. For example, in the year 2004, the demand for medicinal plants was approximately 14 billion USD per year, which is likely to increase more than 5 trillion in 2050 USD. The foreign exchange earning potential in India for medicinal plants is estimated to be over 3000 million USD per annum (Kala et al., 2006; Malti and Geetha, 2007). However, to receive this benefit, India has to document its traditional knowledge, strengthen drug development related research activities and safeguard the economic interests of TK holders (Pushpangadan and Nair, 2005; Pushpangadan, 2008). Currently, about 960 species of medicinal plants are in trade, of which, 178 species have annual consumption levels in excess of 100 metric tonnes (Kala et al., 2006).

The lack of inclusivity has been an enduring feature of current global economic order. Few large companies, executives and middlemen are managing a huge chunk of the pie, while those lying at the bottom of the pyramids are surviving on a kind of sustenance allowance. This uneven distribution of benefits (e.g., money, wealth) has been the root cause of socio-economic unrests severely undermining the stability of many nation-states. Also, in the case of the huge and highly lucrative natural product market, the unjust distribution of accrued dividends amongst producers, TK holders (e.g., tribal healers and farmers) is a prime concern.

In marketing propositions, marketing is placing the right product/service (demand) in the right place (accessibility), at the right price (justified and affordable), at the right time (timing) (source Anonymous, open internet information). There are different models to analyze the chance of success of a product in the market, based on parametric choices one makes during a product/service to market, known as Marketing Mix. McCarthy's (1960) 4P model consists of Product, Place, Price and Promotion, which are interrelated but may differ in order, as key elements of marketing. Their careful analysis is vital in planning for a new venture, evaluating an existing offer, or, optimizing the impact of the target market. Over the years, several modified and extended models

have emerged, some differing in perspective, for example, Lauterborn's 4Cs model views marketing from buyer's perspective.

The National Medicinal Plant Boards (NMPB, New Delhi), along with its State wings, have created a network for the procurement and selling of natural products from local collectors and producers. States, such as Madhya Pradesh, Chhattisgarh, Jharkhand, have opened a number of procurement points (within the state) and selling outlets within and outside their administrative realms. However, these state-run procurement processes supported by different government agencies and pro-seller policies have failed miserably. Apparently, all good policies are at the helm, however, the entire process of purchasing medicinal products from locals/tribes has been taken over by a vast network of middlemen.

Alternatively, in each state there are open-local markets (known as rural Hats), free from middlemen. These markets operate on weekly basis but collectors/farmers have to sell their produce on minimal price (i.e., lack of pricing mechanism). This is partly because many of sellers are village simpleton unable to understand the intricacies of market. In longer periods of time, this kind of trading acts as a deterrent/discouragement to local collectors/farmers who gradually leave the business. It is a high time to create more transparent and seller friendly market linkages. The emergence of digital financial initiatives and social communication platforms has enormous potential to establishing this kind of linkages. Use of WhatsApp groups in the local languages, use of countrywide network of Krishi Vigyan Kendra (KVKs), dedicated mobile apps, and training imparted through incubation clusters may provide needed help (Box 3). Further to this, rather than a fit for all strategy, area and community specific marketing strategies shall be more fruitful. Prabhakar and Banerjee (2021) have reviewed problems and challenges (i.e., technical, regulatory and market-related) involved in bringing a herbal drug into mainstream of modern medicinal practices.

3.4. Traditional medicines in the government policies

In recent times, preservation and promotion of traditional medicinal knowledge systems and conservation of biodiversity has occupied a prominent place in the development agenda of many countries. India, with the help of institutions like foundation for revitalization of local health traditions (FRLHT) and the folk medicine department in AYUSH, has taken serious efforts to document, set standards, preserve, promote and integrate indigenous and non-codified traditions of healing with

mainstream healthcare system (Unnikrishnan and Suneetha, 2012). The government has recognized seven such traditions under AYUSH and created a separate ministry at federal level to look after their promotion and policy issues. There are some pre-conditions such as extensive field studies, empirical evidence and proof of contemporary relevance that need to be taken care of prior to the integration and mainstreaming of these traditions in primary healthcare systems.

From policy and research perspectives despite growing interests, the indigenous healing practices are still the less-studied component. The condition of LHTs is much worse. They are disappearing fast, due to loss of knowledge, unaccounted number of practitioners, non-recognition by the State, demand of evidence for efficacy, inclusion and integration in public health system, non-availability of materials, biopiracy and non-reprisal of intellectual property right related issues, from policy makers and the State. They have shown reluctance to acknowledge the importance of traditional medicine in public health structure of the country. The WHO recommends that governments should establish a system of education, qualification, accreditation, licensing of traditional and complementary medicines, practices and practitioners based on needs and risk assessments. The subsequent National Health Policies of India (NHP) and National Rural Health Mission (NRHM) accepted the need for revitalizing the LHTs in Indian Systems of Medicines, through the instrument of validation, identification, reinforcement and propagation (NHP, 2002, 2017; NRHM, 2005). Priya (2010) has reported high household use of AYUSH (60–98%) and LHTs (80–100%) in different states of India. To strengthen the data-taking mechanism, citizen science may be used, which involves non-scientific volunteers in research related activities.

However, many good practices, such as the formulation of policies on medicinal plants, preservation of TK through People's Biodiversity Registers (PBRs), Bio-Cultural Community Protocols (BCPs) that activate the ABS mechanism of the Nogyo protocols ensuring community rights over local bioresources and knowledge and sustainable harvest protocol, are still restricted to a particular locality as a project activity only (UNDP, 2013). There is a need to implement these steps from project level to fully integrated activity.

4. Concluding remarks

The COVID-19 pandemic has exposed the extensive interlink of economies and public health. A daily loss of millions of jobs and an

Box 3

Initiatives needed to promote cultivation and marketing of medicinal plants.

Initiative

Creation of dedicated mobile app

Local WhatsApp groups, mobile apps of farmers and buyers

Use Krishi Vigyan Kendras (KVK) as nodal agencies Skill Development Schemes

Use of innovation clusters to train farmers and collectors

Use of local languages for dissemination of information

Equitably sharing of the benefits amongst farmers/collectors and TK-holder

Improvement in post collection handling, value addition and product presentation

In-depth analysis global demand and supply of the products

Activity/information

Containing information on agro-climatic, nearby market, price etc.

Facilitated through non-governmental organizations and government agencies

For cultivation and marketing information

Programs run by Agriculture Skill Council of India (ASCI)

Rural skill development program; universities innovation clusters

In line with agriculture departments of governments

Government initiatives to reduce the number of intermediaries involved in the distribution and marketing chain and increase the negotiating power of the farmers/collectors;

Through proper training: participatory training, knowledge management and capacity building

Through in-depth market research

existential crisis looming over businesses were/are undeniable truths. Only time will tell how far mankind is going to recover from this global crisis that has opened wide the inefficiency of our current health system to cope up with this kind of disaster. One of the serious drawbacks associated with the modern health systems is its exclusivity. Hippocrates exclaimed “Foolish the doctor who despises the knowledge acquired by the ancients” (cf. Kayne, 2009). Therefore, we need to put an intensive, quick and target-based inclusive health system in the future. The nature/status of many of the traditional medicines and practices are hotly contested and are yet to be scientifically approved. Nonetheless, the undeniable truth is that they have played a vital role in promoting health. There are several challenges to traditional medicine systems, to name a few: clinical trials related to efficacy and safety evaluation; faulty collection and preparation; incorrect formulation processes; quality control-related issues (i.e., standardization, adulteration, poor quality control procedure and lack of good manufacturing practices); pharmacovigilance studies; and adverse drug reactions, herb-drug interaction studies of herbal drugs, intellectual property rights and biopiracy related issues, creation of standard monographs and marker-based reference standards, export opportunity and, above all, the protection of TK. However, due to space limitation the authors have not discussed the above-stated issues in detail.

Health is just not all about curing of diseases and curative potentials of proven drugs. It also includes therapeutic and rehabilitative roles of un-proven natural products and healing potential of indigenous medicinal traditions and small, but crucial, social practices, such as cleanliness and personal hygiene, which are vital in the prevention of diseases. The basic dictum of medicine argues that prevention is always better than cure, therefore, it is our inherent tendency to discard things in favor of apparently better and smart options, until and unless reminded otherwise. Thus, conserving our good traditions (i.e., preserving the cultural diversity) is equally important, as they offer alternative options during a crisis. Marthe van der Bles et al. (2020) showed that openly communicating uncertainty around facts and numbers on important topics (e.g., climate change and immigration statistics) have a minor impact on peoples trust in the facts. They reported that people’s prior beliefs influenced their trust in the facts, but do not influence people’s response to the uncertainty being communicated, suggesting that academics and science communicators should be more transparent while communicating about the limits of human knowledge.

However, the most serious onus on ensuring people’s acceptance to traditional medicines and systems rests on practitioners themselves, they must refrain from exaggerated and unsubstantiated claims of panacea for all seen and unseen ills in the long run, it is a counter-productive for traditional medicine systems. Governments must try to discuss, debate and, if proven, integrate these small traditions in their public health structures, without any prejudice and bias. Certainly, there is no need to be caught up in stories but a need to carefully analyze the reason behind them. We must believe in science, but science also needs to be more inclusive and non-elite, responsive to the ideas of people. Empirical science is just one form of science, yet, a great many believe in observational science (i.e., results observed in field and society). Even thoughtful explanation of indigenous healing practices or indigenous health knowledge is satisfactory. Moreover, the sustained availability of biological resources along with sufficient access to good quality health care to all is a necessity.

CRediT authorship contribution statement

PKS and NKS conceptualized while AS collected the data. All the authors contributed in drafting the article.

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Conflict of interest statement

There is no conflict of interest amongst the authors.

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