Reinventing Ayurveda for the 21st Century

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Context

Human life span has been continuously increasing over the past 100 years with the innovations in modern medicine and better availability of health care services. The disease burden has been shifting slowly from infectious diseases to non-communicable diseases. In spite of the increased life span, the disease-free life, quantified using *Years Lived with Disability (YLDs),* has been reducing over the years. Non-communicable diseases such as diabetes, cancer, cardiovascular diseases have high YLD scores thus causing significant health care burden. While modern medicine has seen success in treating the diseases, it has largely been a "one size fits all" approach and reactive care. A paradigm shift is occurring from a reactive healthcare model to *Predictive, Preventive, Personalized, and Participatory (P4)* medicine for a holistic and proactive management of health across the entire lifespan in the 21st Century. In this future medicine, health and diseases are seen as a continuous spectrum rather than two distinct points.

Potential of Ayurveda in Future Integrative Medicine

Ayurveda science, an ancient Indian approach of holistic medicine, has evolved over the last two thousand years, that is still contemporary and encompasses all aspects of P4 medicine, has great potential for promoting a healthy lifestyle and curing of diseases with reduced side effects [1,2]. Highly personalized nature of treatment is inbuilt into Ayurveda where the baseline homeostatic state of the patient, "Prakriti", is understood first before diagnosis of the disease and subsequent therapeutic recommendations. Prakriti also determines the genetic predisposition of a patient to various diseases and hence Ayurveda based preventive diet, lifestyle, medicines, panchakarma can be followed to maintain a healthy lifestyle. There have been several peer reviewed studies which clearly show the biochemical [3], genomic [4], metagenomic [5,6] basis of Ayurveda in the last 10 years and its potential in stratified medicine. Interestingly, the highly personalized nature of Ayurveda treatment is also evident from the multiple subtypes described for each modern disease. For example, diabetes in broadly classified as "Type 1" and "Type 2" diabetes in the modern medicine while Ayurveda describes >15 sub-types of diabetes depending on the expression of clinical symptoms and the treatment is tailored as per the patient's prakriti and the disease sub-type. Further, the pharmacopeia of traditional Ayurveda medicines is vast and has significant potential to compliment the modern medicine to achieve "Integrative and personalized medicine" which also gives multiple treatment options to the patients especially suffering from various chronic metabolic, autoimmune and gastric disorders.

Path forward for Mainstreaming and Globalizing Ayurveda

Ayurveda has great potential to realize the next generation of *P5 medicine: Personalized, Preventive, Predictive, Participatory and Promotive. However,* for Ayurveda to transform from an alternative medicine to mainstream medicine, rigorous evidence-based approach in both diagnostics and therapeutics is the need of the hour. To start objectivizing and quantifying the beneficial aspects of Ayurveda for its integration with mainstream medicine, one needs to start collecting, structuring, and organizing Ayurveda knowledge both from the classical texts and clinical studies over the past century, without compromising the key aspects of personalization and heterogeneity in disease management. Recently, there has been a big data analytics study analysing >350,000 subjects data undergoing Ayurveda treatment which provide key insights into the target population, diseases for which it could be a preferred choice and treatment efficacy [7]. Ontological frameworks routinely used in modern medicine also need to be developed both for structuring Ayurveda clinical knowledge as well as understanding the molecular pathways and scientific basis of multi-drug Ayurveda medicine.

Ayurveda diagnostics can greatly benefit from data driven "Phenomics" approaches where in the personalized "Prakriti" is quantified using a combination of computer vision, IoT sensors and machine learning for capturing key anatomic, physical, physiological and psychological parameters (see fig. 1). Further, "Vikriti" or disease including its sub-type can be diagnosed using a conversational AI based differential diagnosis combined with "digital pulse diagnosis". In addition, explainable AI will play a key role in providing trusted assist to Ayurveda doctors and clinicians. Companies such as Babylon, DemDx, have built AI driven differential diagnosis engines for modern medicine which have the potential to reduce the health care costs, unnecessary hospital visits and remote teleconsultations at the comfort of the home. Similar initiatives in Ayurveda and other traditional systems are the need of the hour.

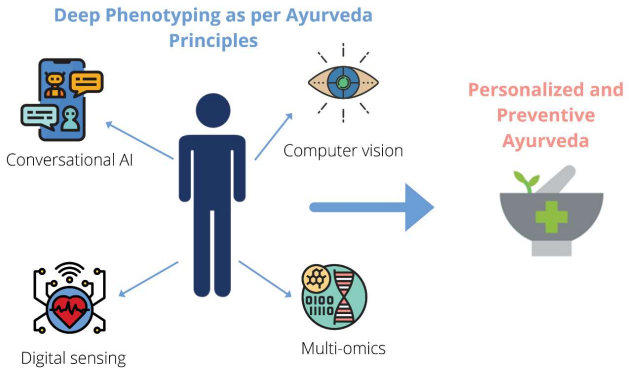

Fig. 1: Deep phenotyping of individuals as per the Ayurveda principles leveraging computer vision, digital sensing and biochemical, multi-omics markers to deliver highly personalized and preventive Ayurveda

Currently, the Ayurveda industry is valued at more than 10 billion USD, growing at a Compound Annual Growth Rate (CAGR) of >16%. For the industry to grow exponentially and reach a >100 billion market value in the next 20 years, more rigorous evidence-based approaches in Ayurveda therapeutics are needed. Due to the highly personalized nature of Ayurveda, compared to randomized control trials, patient specific longitudinal tracking of clinical, biochemical and multi-omics parameters would be more suitable to evaluate the drug efficacy. In addition, standards for Ayurveda drug efficacy evaluation and potential toxicity, side effects need to be clearly established. Another area that is ripe for innovation is discovery of bio-actives in Ayurveda drugs and repurposing of Ayurveda drugs to the emerging infectious and non-communicable diseases. Recently, a landmark study has been published, which employed transcriptomics and connectome analysis for deeper understanding of the genetic and molecular pathways of *Cissampelos pareira,* a herbal drug used for the treatment of female hormone disorders and fever [6]. This approach revealed a novel pathway which could be a potential target in dengue viral infection. More such rigorous multi-omic studies are needed to understand the multiple disease curing potential of Ayurveda drugs.

IIT Jodhpur with its excellent track record of designing multi-disciplinary and transdisciplinary programs, has recently initiated the formation of a Transdisciplinary Centre of Excellence in Integrative Precision Health. As a part of this, an AyurTech Centre of Excellence in collaboration with the Dr. Sarvepalli Radhakrishnan Rajasthan Ayurved University, Jodhpur, is planned with the goal of "Establishment of AI driven integrative framework for population and individual risk stratification and early actionable precision health interventions with a special focus on arid regions". This scientific and data driven approach to Ayurveda diagnostics and therapeutics can achieve evidence based Ayurveda, which will greatly help in globalizing Ayurveda similar to traditional Chinese medicine which has seen higher acceptance and adoption internationally.

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