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ORIGINAL RESEARCH

Big Data Analysis of Traditional Knowledge-based Ayurveda Medicine

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ABSTRACT

Introduction: Modern medicine has embraced data-driven understanding of health, principally through electronic medical records. However, Ayurveda, which is the dominant traditional medicine system in India, much of it is still practiced without digital records.
Methods: In this study, 353,000 patients' data were captured digitally by ~300 Ayurveda doctors over teleconsultation and in-person consultations. The entire dataset was analyzed based on age, sex, region, chronicity, Vikriti, disease morbidity, and comorbitidy and reported effectiveness of the treatment.
Results: Younger patients were found to use more Ayurveda telemedicine, but all age groups were well represented. It was found that 82% patients had disease chronicity greater than 1 year. About 85% of the diseases were related to 6 organ systems, digestive (30.6%), endocrine (14.6%), skeleton (13.5%), skin (11.2%), nervous (7.6%), and respiratory (7.4%). The network analysis of the data revealed difference in sex and age-based patterns. Disease of endocrine and cardiovascular systems become comorbid for patient population at older age-groups as also observed in case of modern medicines.
Conclusion: Within the limitations of using practice data from a single large group of Ayurveda practitioners, this represents the first data-driven view of Ayurveda practice in India. In spite of 82% of all the patients having chronic diseases, Ayurveda treatment offered complete or partial relief in more than 76% of cases, and only 0.9% reported aggravation in symptoms.

Introduction

Understanding of healthcare in an objective data-centric way involves reliable and reproducible generation of analysis of large curated dataset. At present, the global cost of medicines is 1.2 Trillion USD[1] out of which, 60% of market demand is driven by United States, European Union, Japan and Canada. These developed countries demand is primarily modern medicine (branded or generics) and the dataset, that is, electronic medical record for modern medicine's clinical trials, usage exists and act as a platform for analysis of the patient treatment. These electronic medical records and reporting of clinical data have been the basis for international ethical, scientific, and standardized clinical practices.[2]

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Thirty percentage of the global medicine demand is from a combination of China, India, Russia, Brazil, South Africa, Pakistan, Mexico, Indonesia, Egypt, etc. In these countries, medicine usage is predominantly traditional medicines[3] (which is defined as medicines from China, India, Japan (Chinese Medicines, Ayurvedic and Kampo). As per World Health Organization data,[4] in China traditional herbal preparations account for 30–50% of the total medicinal consumption, whereas in Africa, up to 80% of the population uses traditional medicine for primary health care. The population of these countries (Brazil, India, China, Russia, South Africa, Pakistan) accounts for more than 45% of the world population,[5] generating traditional medicine business of around 100 Bn USD.[1] The reason of popularity of traditional medicine in these countries is mainly due to lack of access to modern medicines. In developed countries, mild adoption of traditional medicine is mostly seen in the form of dietary supplements (also referred as Complementary and Alternative Medicine in integrative settings in Europe and North America[6,7]).

In India, 60% of registered physicians are involved in traditional and alternate systems of medicine.[8] There are about 700,000 registered practitioners of traditional medicine (majority in Ayurveda[9–11]) and around 650,000 registered practitioners of modern medicine in India.[8] India has given official recognition to traditional systems of medicine and created AYUSH department.[12] Medical delivery in most of the traditional medicine setup is either oral or

Abbreviations and Acronymns
EOT = effectiveness of treatment

paper based, and it is not reflected in current health databases. Also, lack of information on drug-herbal interactions, limits on what practitioners can cure and absence of digital records acted as an inhibitor in establishing the efficacy of traditional medicine,[13] in spite of being practiced for centuries with documented high outcome.[9] There are not enough well-controlled clinical trials and systematic research reviews of traditional medicines, for example, Ayurveda, in comparison with modern medicine research to prove that the approaches are beneficial[14] although many of the modern medicines are derived from the traditional medicine.[15]

Given the magnitude of traditional medicine and amount of population it is catering, lack of data (ie, electronic health records) to understand its efficacy in the treatment of diseases is a major gap in this field. Telemedicine and associated telehealth technologies[16] supplement the current clinical settings (especially in developing countries) by improving doctor efficiency. Modern computation and communication technologies enable telemedicine and automate the generation of electronic health records. We for the first time used similar digital datasets that captured traditional medicine practice (Ayurveda) and used paper-based records of patients (postdigitization) as a comparator. Here, we provide a descriptive analysis of the spectrum of medical problems and extent of relief based on current dataset for Ayurvedic healthcare services in India. We also used big data analytics techniques to understand the underlying structure of data and any interventions.

Methods

Data background

In this article, we evaluated patient data collected during the Ayurveda consultation at Jiva Ayurveda.[17] Jiva Ayurveda has been providing health care consultations over a phone (telemedicine framework) generating a large amount of contact dataset for several years. The target population of this dataset is primarily Hindi speaking population of north and western regions of India.

Data analysis framework

The telemedicine data were analyzed based on 8 features that is age, sex, region, chronicity, Vikriti, effectiveness of treatment (EOT),

Fig 1. Framework of analysis. The tabulated figure represents the framework for conducting data analysis. Different parameters and their associated classification.

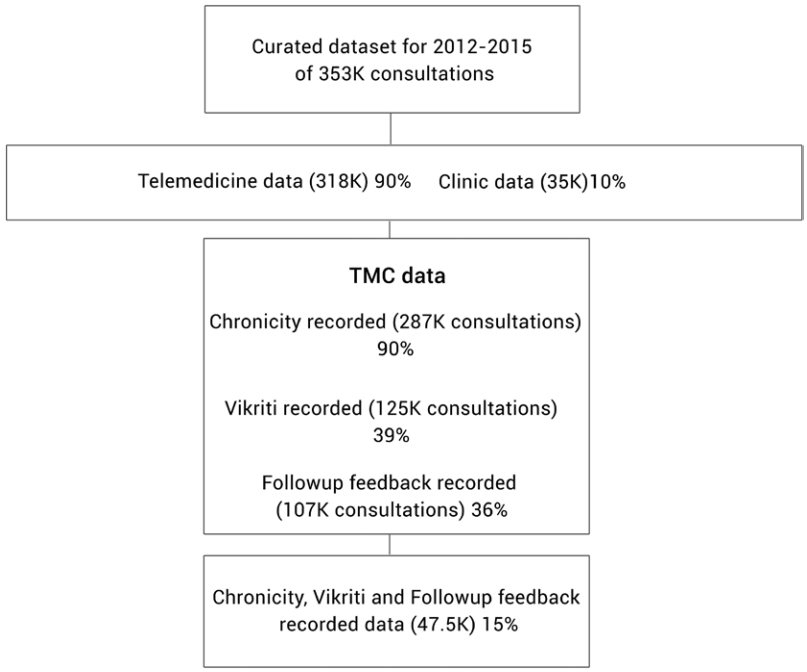


Fig 2. Dataset breakup in terms of patient data count. Dataset breakup in terms of telemedicine and clinic patients. Further breakup in terms of available measured variables that is Vikriti, chronicity, and EOT.

disease, and medicine. These features were further segregated into different categories to generate a framework of data which were used for analysis (Fig 1).

Data collection

The telemedicine process begins with the patient calling the helpline and requesting for a call back from an Ayurveda doctor. Jiva Telemedicine center comprises of 160 BAMS and 12 MD doctors, who call the patients, and capture their demographics, phenotype/disease, current symptom(s) and chief complaints.

Patient's Vikriti assessment[9,10] (**Supplemental Digital Content 1**, ***http://links.lww.com/PP9/A3***) is done by the doctor, based on a series of questions with the patient participation and a profile for the disease is created. Based on the case profile and Vikriti assessment, an Ayurvedic line of treatment and prescription of medicines are generated for the patient. The EOT is periodically captured by the doctor and the quality assurance team.

The curated dataset of 353K records spanning over a period of 3 years (2,012–15) was de-identified (Fig 2). These data comprised of 318,618 telemedicine patients data and 34,929 patient data digitally captured from clinics which have been functioning only for last 2–3 years.

From 318K telemedicine patient data, 125K patient data contain documented Vikriti assessment and 107K patient consultations have a measurement of the EOT, that is, the extent of relief. 47.5K patient data represents the complete data with all the parameters (patient demographics, prescribed medicines, EOT, and Vikriti measurement). Patients who are comorbid will have multiple disease entries for a given consultation. This is the reason why 318K patients generated a total of 394K records. It is important to highlight that the analyzed telemedicine dataset in this article comprises data of different patients across all age groups at a given time point.

Data analytics

The flow of data analysis pipeline in terms of the base, derived and advanced analysis (Fig 3)) is presented. Base data analysis was performed on patient data using a single feature namely age, sex, disease, geographical region, Vikriti, chronicity, and effectiveness of the treatment (Fig 1). Derived Analysis involved combining more than one aligned feature to understand their inter-relationship. Based on the derived analysis, it was identified that certain variables and interconnections were important to be explored through advanced analysis for better understanding of data. In advanced analysis, the inter-relationships between age, disease, and sex were looked into. The color coding used in this article to visualize dosha is (1) Vata – blue; (2) Pitta is red; and (3) Kapha is green.

The data for analysis was performed in the form of a curated binary matrix representing the prevalence of a disease feature among the patients. The patients are represented by Patient ID, while the presence or absence of a feature is indicated by 1 or 0, respectively. The curated matrix is prepared for each age group, and the information is aggregated and transformed suitably for the visualization. For visualization of results, Alluvial Charts[18] were generated to see:(a) The disease pattern shift with age and (b) how sex plays a role in diseases across age. The alluvial chart depicts different modules formed by diseases based on their co-occurrence. To classify Ayurveda diseases existing disease elements (318) were grouped into 106 modern medicine subdisease type and eleven organ system (**Supplemental Digital Content 2**, ***http://links.lww.com/PP9/A3***). Equal size samples (17,700) of patient data were randomly selected for each age group across diseases. These samples were used to create network-based interlinking between different diseases. The strength of interconnections was measured using Jaccard's similarity measure[19] between different diseases. This similarity measure was used in construction of a weighted network of diseases stored in a standard network format using Pajek software.[20] The results were visualized through a network-based alluvial[21] generator that is based on a map equation which emphasized the associations between diseases.

Vikriti distribution of analyzed patient data were compared with prakriti distribution of 960 healthy volunteers of an independent study.[22] It was ensured that the location information of the

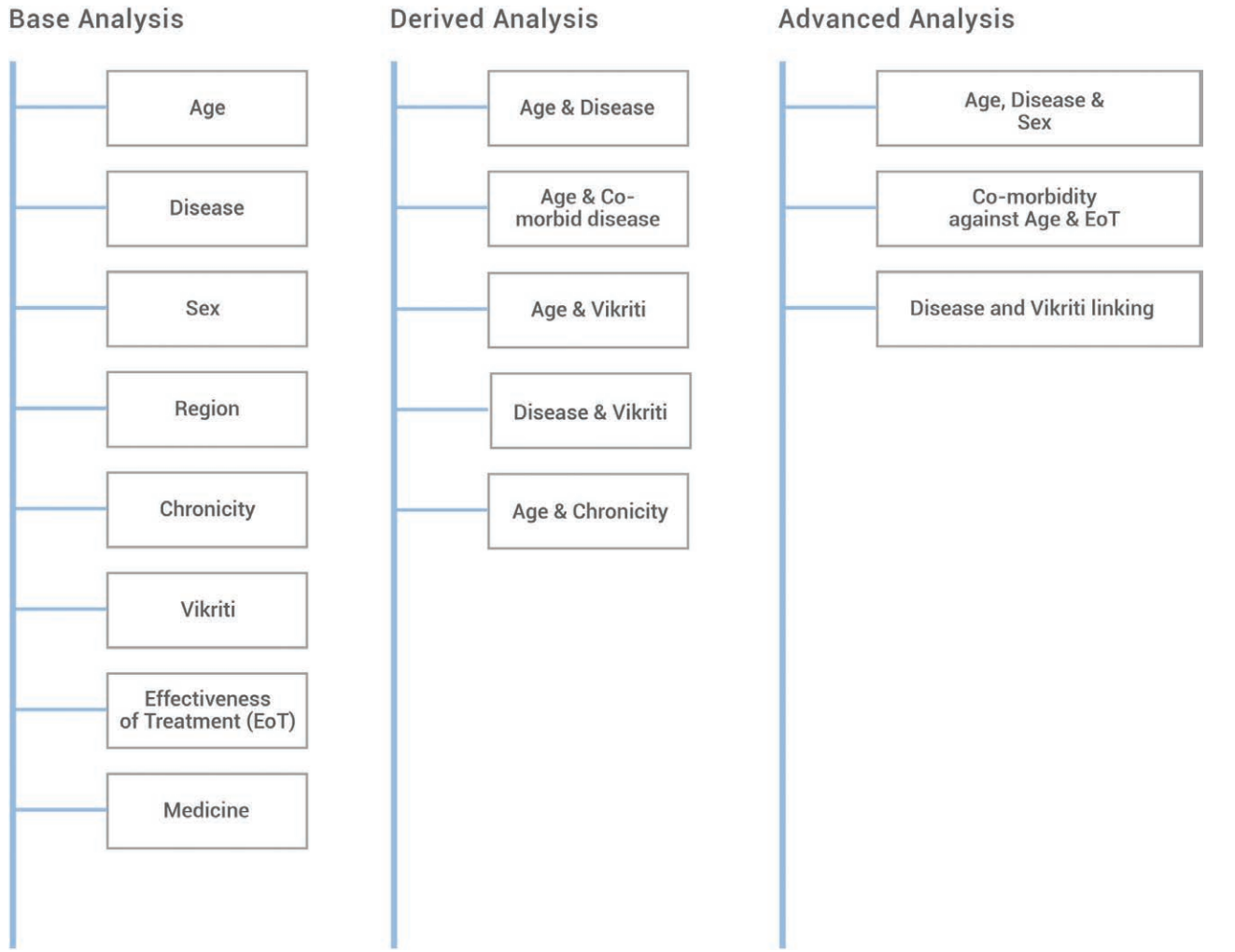


Fig 3. Base, derived and advance analysis of 318K patient records. Base Analysis were performed on 1 parameter at a time that is age, disease, sex, region, chronicity, Vikriti, medicine, and relief data. Derived Analysis were performed on 2 parameters at a time that is age and disease, age and comorbid disease, age and Vikriti, age and chronicity. Advanced analysis were performed on multiple parameters (or derived parameters) at a time, for example age, disease and sex, comorbidity vs. noncomorbidity against age and relief. Alluvial charts were used to represent the derived analysis.

randomly selected 960 patients (repeated 100 times) was similar with the location information of the healthy volunteers.

Results

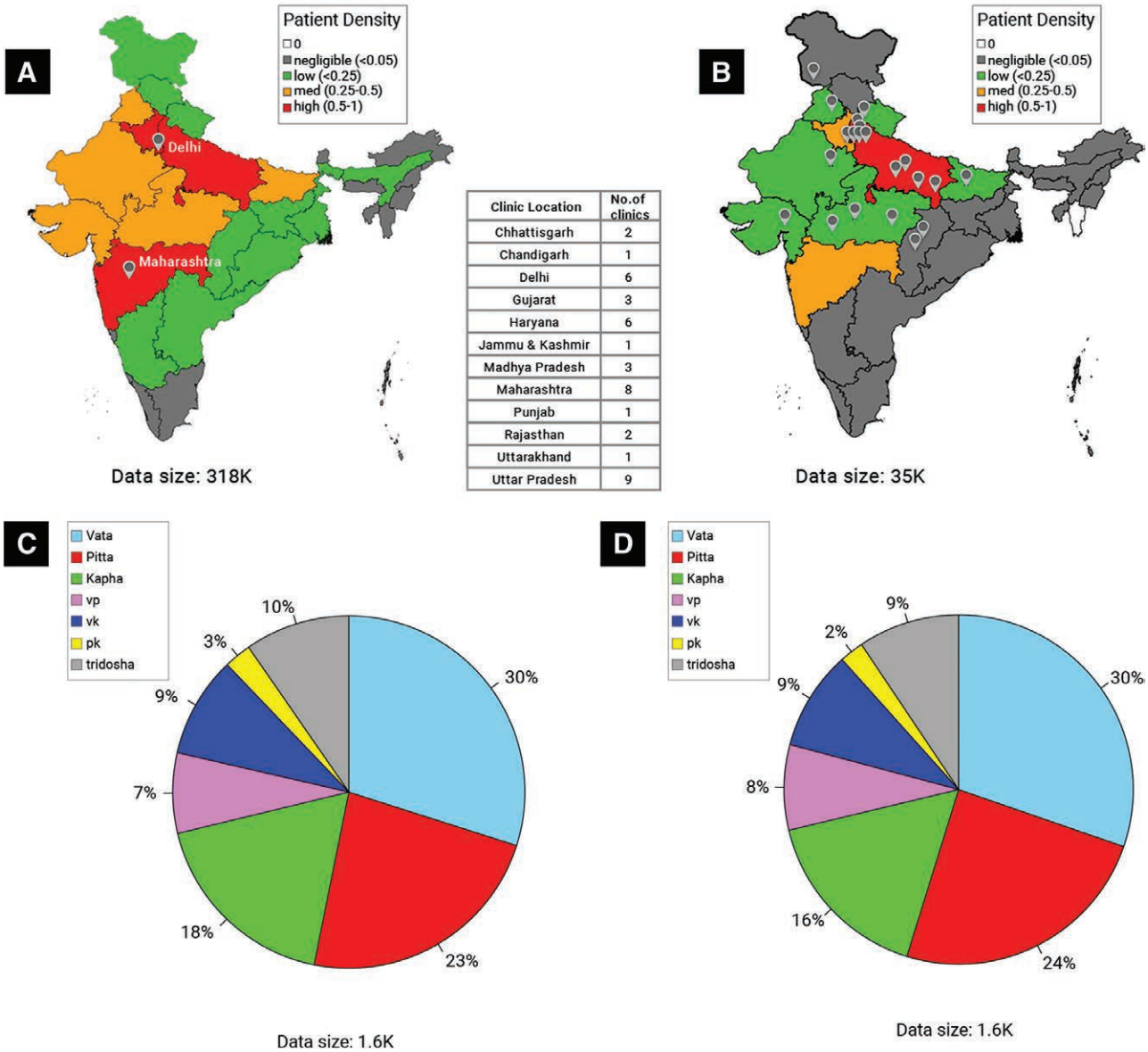
The proportion of patients belonging to different states was normalized by the entire patient population and has been visualized separately for telemedicine and clinic patients (Fig 4A, B). The location information of respective telemedicine centers and clinics has been represented by pins on the map. It is evident from the figures that telemedicine data spans across India whereas, the clinical data belongs to a specific location. Also, the patient count of telemedicine across India is much higher than their distribution across the captured clinic data. To find the Vikriti distribution for telemedicine and clinical data we used equal-sized samples, shown in the respective distribution pie charts (Fig 4C, D) to find whether the telemedicine-based analysis is different in any way from clinic-based analysis. This exercise was deemed necessary to substantiate that there is no difference when patient's Vikriti assessment is done through physical verification at clinics, or as a series of questions over a telephonic conversation. We performed Chi-square and analysis of variance tests on the sampled Vikriti data of telemedicine centers and clinics to evaluate statistical significance (Fig 4).

People of all age groups (Fig 5A) are using Ayurvedic treatment and found that 82.5% of the patient base belongs to the middle age groups (20–60 years). It is generally believed that traditional medicine is used by the older population. However, we found that the age group 20–40 years constitutes 47% of the telemedicine patient data. Although 65% population of India is below 35 years,[23] patient data follows a Gaussian distribution with a peak at age group between 30 and 40 years (**Supplemental Digital Content 3**, ***http://links.lww.com/PP9/A3***). We also analyzed the distribution of patients based on sex. We found that the patient distribution is slightly male dominant [male: 57.8% (184,200); female: 42.2% (134,418)].

Diseases related to the digestive system were found to be most dominant contributing to 30% of the patient population (Fig 5B). The diseases under 6 organ systems (digestive, skin, endocrine, nervous, skeleton and respiratory) comprise 85% of the patient data.

Most of the patient population, represented in telemedicine consultations, were chronic in nature. We found that of the 287K chronic patients, 82% patients had chronicity for 1 year and above (Fig 6A, B). It was observed that 77% of the patients have chronicity up to 5 years.

To better understand how the patient distribution changes with age and disease, we used an alluvial chart (Fig 7A). This revealed that the diseases related to Digestive system are most



Clinic Location	No.of clinics
Chhattisgarh	2
Chandigarh	1
Delhi	6
Gujarat	3
Haryana	6
Jammu & Kashmir	1
Madhya Pradesh	3
Maharashtra	8
Punjab	1
Rajasthan	2
Uttarakhand	1
Uttar Pradesh	9

Fig 4. A, The country heat map represents patient density normalized by Jiva telemedicine population for different states across the country. The heat map is overlaid with locations of telemedicine centers of Jiva. B, The country heat map represents patient density normalized by Jiva clinic population for different states across the country. The heat map is overlaid with locations of Jiva clinics. C, Vikriti distribution of telemedicine population. D, Vikriti distribution of clinics population and Statistical analysis of telemedicine with in-clinic consultations. Pearson's Chi-square test: *P* value is 0.7337 and > 0.05, Ha is not statistically significant and hence H0 is not rejected. ANOVA: *P* value is 0.09 and > 0.05, Ha is not statistically significant and hence H0 is not rejected. Hence, it can be stated that the respective vikriti distributions are similar in proportion, thereby implying that the data samples are inherently from the same patient population. ANOVA, analysis of variance.

frequent across all age groups. Skin was prominent at a very early age group (10–30 years) followed by Endocrine in the age group (30–40 years) and Skeleton system dominated at older ages (> 40 years). Three most prevalent diseases in each of the 6 major organ systems are listed in **Supplemental Digital Content 4 A-F**, ***http://links.lww.com/PP9/A3***.

The dataset was classified based on sex because the prevalence of diseases is different for males and females. It was observed (Fig 7B, C) that Digestive remains most prominent disease for males while for females, Skeletal disease grew dominant after the age group 30–40 years. For the female population, Skin disease was observed to be dominant in the initial years. A bimodal behavior was observed in the Endocrine organ system of females for the age groups 20–30 and 40–50 years respectively. In these age groups, Obesity, Thyroid and Diabetes were found to be the 3 most prominent subdiseases (**Supplemental Digital Content 4F**, ***http://links.lww.com/PP9/A3***).

For the male population, Skin and Sexual diseases show greater prominence in age groups of 10–30 and 30–40 years, respectively. Based on chief complaints mentioned by a patient, the cases were further classified into multiple organ systems (comorbid) and single organ system (noncomorbid). Alluvial chart for comorbid patient population (Fig 7D) shows that Digestive, Endocrine, and Skeleton are prominent in comorbid patients. We also observed that the working-age population (20–50 years) suffers from 3 frequent diseases of the Nervous system that is, headache, psychological disorders and spinal disorders (**Supplemental Digital Content 4B**, ***http://links.lww.com/PP9/A3***).

We found that the Vikriti distribution of patients (Fig 8A) was predominantly Vata in nature, followed by Pitta and Kapha. It was also evident (Fig 8B) that Vata was most dominant post 30–40 years and increases with age. Kapha was highest in early (0–10 years) age group, and Pitta enhanced during age group 20–30 years.

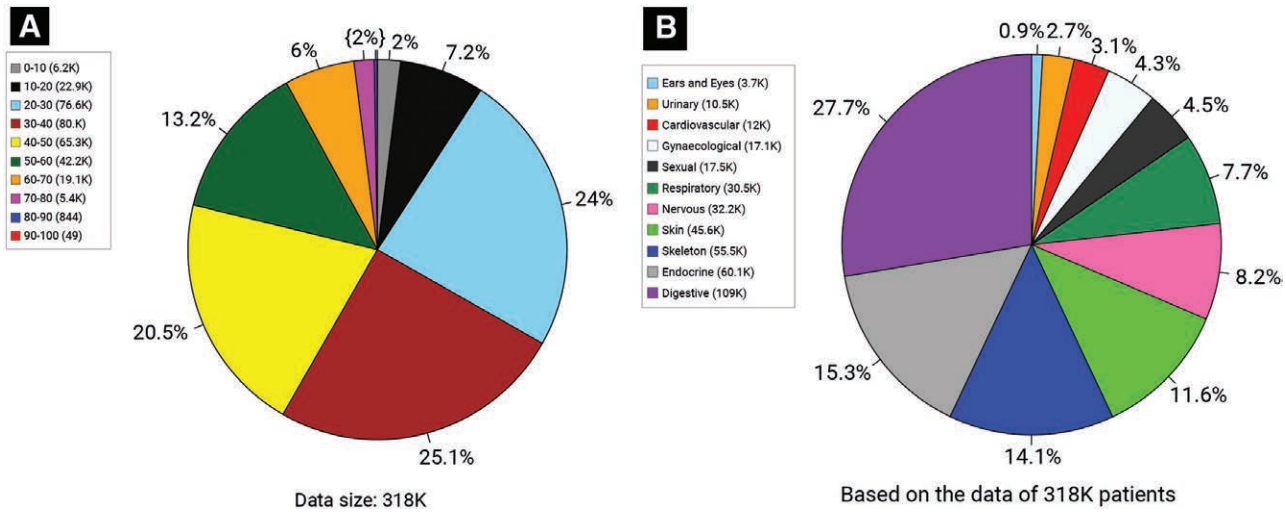


Fig 5. A, Distribution of patients in the order of age group. Pie Chart represents the base analysis with 68% of patient population coming from 20 to 50 years of age group. B, Distribution of patient in the order of diseases. Pie chart shows more than 80% of the patients belongs to 6 diseases that is digestive followed by endocrine, skeleton, skin, nervous and respiratory.

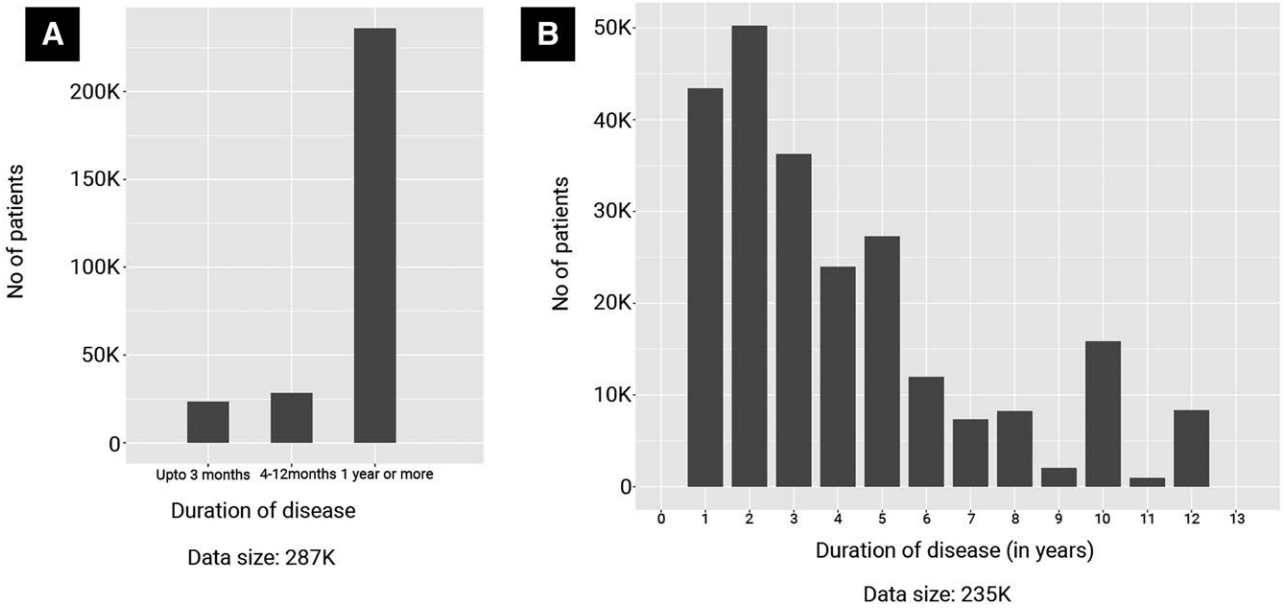


Fig 6. Chronicity distribution of 287K telemedicine patients. Out of 318K telemedicine data, only 287K have reported chronicity. A, Represents the chronicity distribution in patients and it clearly appears that vast majority of the patients have been chronic for at least a year or more. B, Represents distribution for patients with chronicity greater than 1 year. It shows that most of these patients have been chronic for 1–5 years.

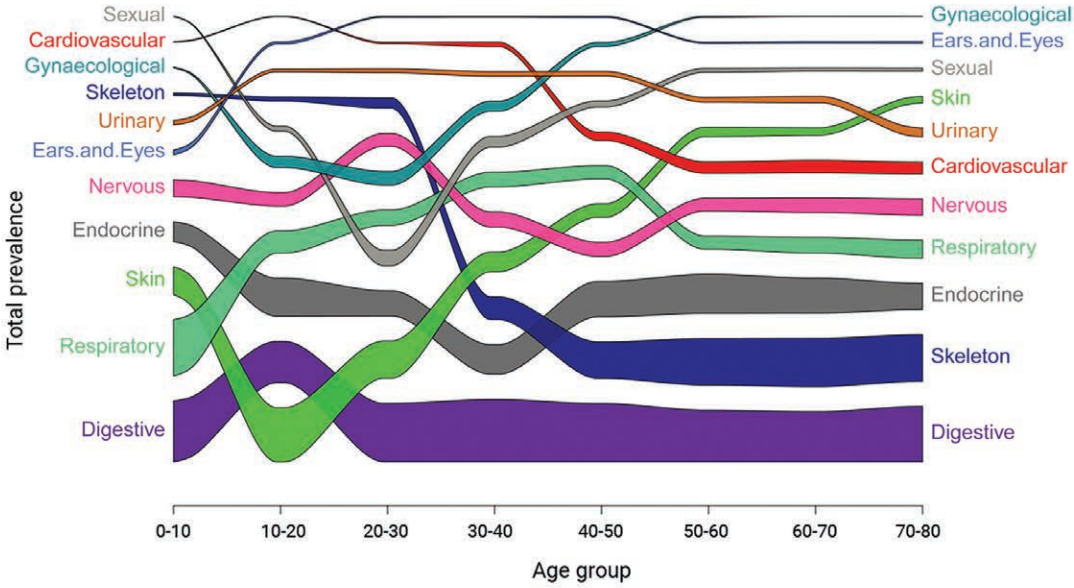
When the Vikriti distribution for each specific disease was observed independently, it was found that the dominant dosha in different disease categories was different. Results indicate that diseases of the organ systems can be broadly classified based on their predominant dosha. It was observed that diseases of Skeleton, Nervous were Vata dominant (Fig 9). Endocrine and Respiratory disease categories were dominant in Kapha, and Skin was Pitta dominant. Vikriti distribution of digestive (Fig 9) showed dominance of Vata and Pitta.[24] We also observed the dissimilarity of vikriti distribution of few disease categories from the organ system to which it belongs to (**Supplemental Digital Content 5**, ***http://links.lww.com/PP9/A3***).

Comparisons between Prakriti assessment (a healthy balance of dosha (Fig 10A) of western and southern Indian healthy volunteers[22] for age group (20–30 years) and Vikriti data of patient group (Fig 10B) for the same age group from same geographical location in telemedicine dataset was made. The results showed that pure Prakriti distribution was Kapha (41%), Vata (41%), and Pitta (18%). While in Vikriti data of patient group, Pitta (40%) was most dominant followed by Vata (37%) and Kapha (23%). It was found that Vikriti data of patients had higher Pitta compared with healthy normal individuals.

Alluvial chart showing the interconnection between diseases (Fig 11) was generated using the web-based tool MapEquation.[21] The width of the alluvial bands corresponds to the relative strength of a module (which can be a disease, subdisease, a system or a combination). The position of diseases along the *y* axis is anti-correlated to their respective prevalence, thereby implying that lower the position, higher is their prevalence. It was observed that Endocrine and Cardiovascular become comorbid for both males and females at higher age group. As the age increases, the prevalence of Skeleton disease was also higher.

A

Age group	Data size
0-10	5006
10-20	20347
20-30	70333
30-40	74304
40-50	61009
50-60	39490
60-70	17774
70-80	4980



B

Age group	Data size
0-10	1880
10-20	9335
20-30	28898
30-40	32101
40-50	27008
50-60	16312
60-70	6301
70-80	1524

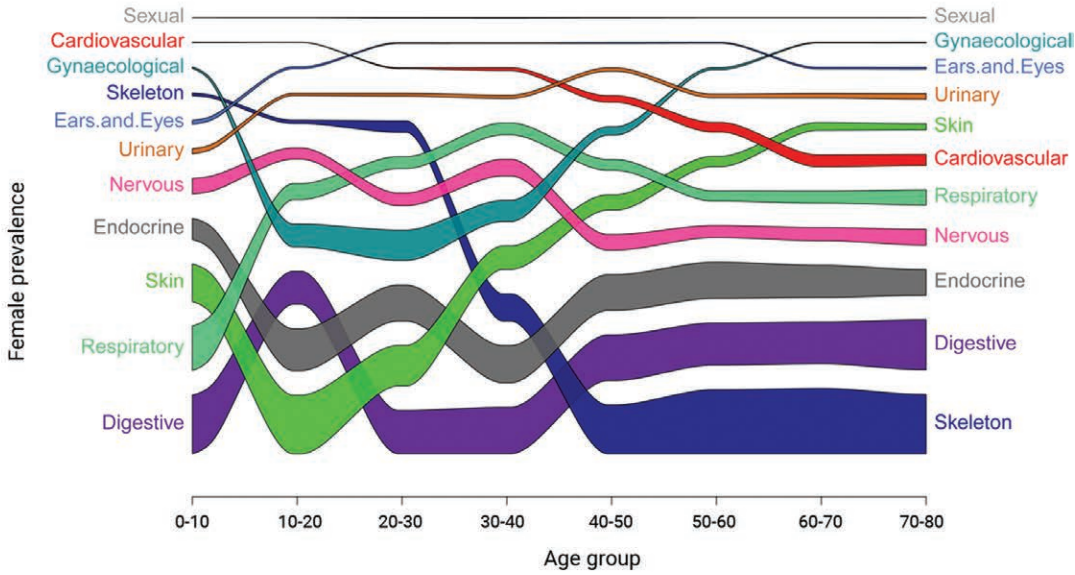


Fig 7. A, Alluvial plot for total patient prevalence by age. Most prevalence disease is at the bottom and thickness of each disease defines the prevalence. Digestive is the most dominant across age group. B, Alluvial plot for female patient prevalence by age. Skin is dominant across initial age group. Although digestive is no longer most prevalent and skeleton disease is prominent post 30–40 (age group). C, Alluvial plot for male patient prevalence by age against diseases. It was observed that digestive remains most prominent disease in male. Endocrine does not show bimodal distribution (compare to female) and is second largest disease post 30–40, age group. D, Alluvial plot for comorbid patient prevalence by age.

To understand sex-based differences on the age of onset of comorbidity, we carried out the same exercise on male and female population. Cardiovascular comorbidity with Endocrine is found to be clearly visible in males much earlier age group (before 30–40 years) compared with female where this phenomenon is seen in later age group past (40–50 years) (**Supplemental Digital Contents 6 and 7**, ***http://links.lww.com/PP9/A3***). Similarly, Gynecology and Skin-related complaints remain a dominant trend in females up to the older age group (50–60 years). While in male Urinary problems are dominant at later age group while Respiratory complaints are among dominant disease until 20–30 years.

Telemedicine consultation database had 261 medicines that consist of tablets (133) and powders/churans (128). A patient is given a personalized prescription by mixing together a unique combination of powders and tablets (Table 1). Table 1 shows the classification of these medicines against the associated Vikriti, which these medicines alleviates.[25,26] Predominantly medicines are alleviating Vata-Kapha and Vata-Pitta combinations.

The EOT of a patient recorded (Fig 12) by doctors in telemedicine patients elucidates that 76% of the patient population have received relief through Ayurveda consultation and only 0.9% have reported aggravation of the condition.

Discussion

Ayurveda is an ancient system of personalized medicine documented and practiced in India since 1500 B.C.[9,10,25] Ayurveda is not only integrated in the Indian healthcare system but also presently recognized in an integrative setting in Europe and North America.[27] Assesment of the disease state (Vikriti) and treatment in Ayurveda system depend on the deviation of an individual from healthy state (Prakriti).[9,10,25] It is also considered Whole Medical

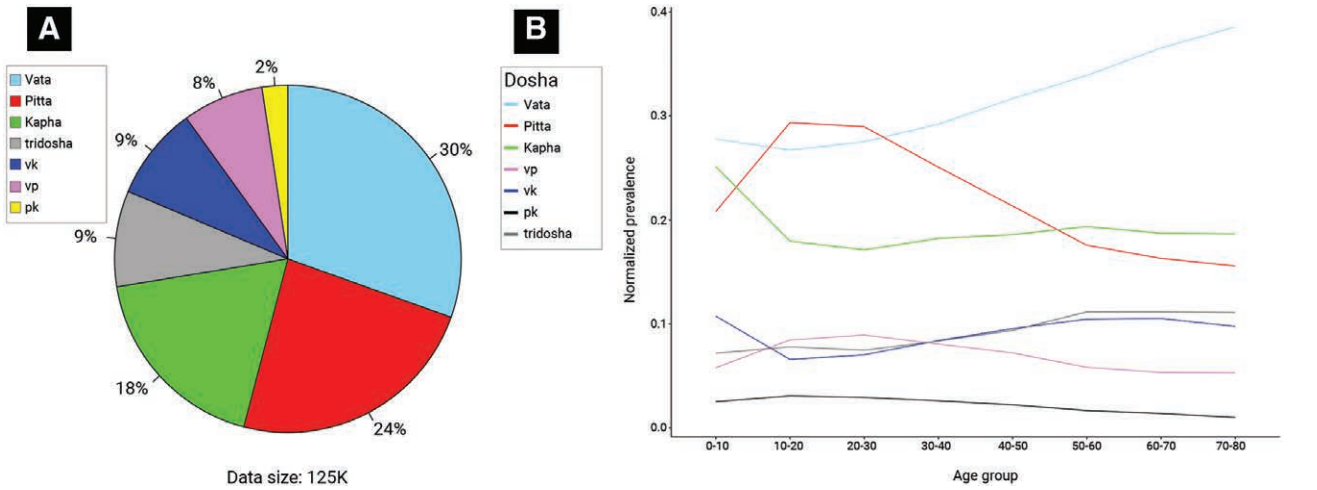


Fig 8. A, Vikriti distribution of telemedicine patients with vata, pitta, kapha and their combinations. Vikriti data are available for 125K patients. Pie chart shows vata dosha is most prevalent followed by pitta and kapha dosha. B, Line plot of normalized vikriti prevalence across age. Figure represents line plot of vikriti prevalence normalized by the corresponding age group population. All 7 dosha are represented in the plot, and among them vata dosha clearly shows a rise as age progresses and is dominant across almost all age groups (post 30–40).

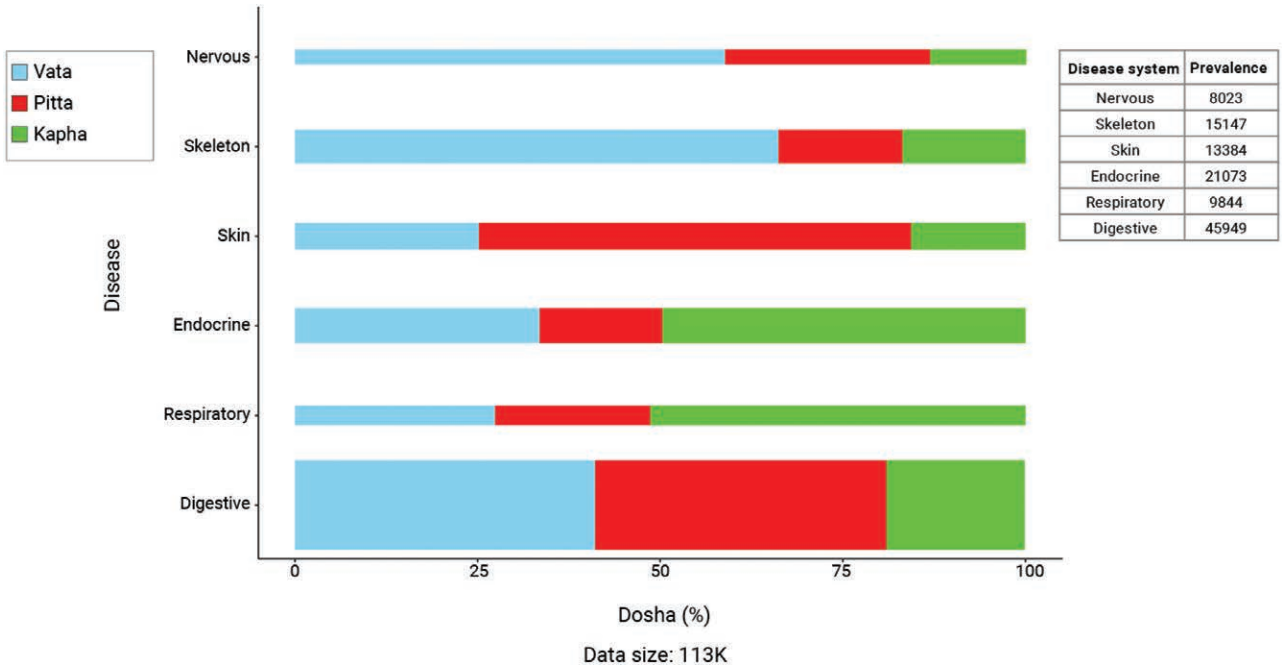


Fig 9. Vikriti distribution of diseases showing Vata, Pita, Kapha dominant diseases: Vata dominant (Nervous, Skeleton); Pitta dominant (Skin); Kapha dominant (Endocrine, Respiratory); Patients with digestive disease do not exhibit dominant dosha.

System[28,29] and provides a biological basis of human individuality through the interplay of Prakriti and Vikriti.

Analysis of large dataset of telemedicine patients treated by traditional knowledge-based medicine as prescribed in Ayurveda presented here provides several new insights on chronic noncommunicable diseases. Across the world, new efforts are undertaken in modern medicine, to combat chronic noncommunicable diseases, based on integrated care and system medicine as a part of P4 (Predictive, Preventive, Personalized, and Participatory) medicine.[30–32] These new initiatives are shown to have a convergence of both eastern and western principles of health care.[33]

Various ongoing studies have tried to establish a molecular correlation of modern medicine with prakriti based endo-phenotypic analysis in Ayurveda.[34–39] These attempts have integrated the concepts of P4 system medicine and aiming to establish relationships between the phenotypic classification of Ayurveda (ie, Vata, Pitta, and Kapha) and modern genomic analysis leading to the emergence of a new field of Ayurgenomics.[40]

The current data provided proof of efficacy of specialized Ayurveda treatment over telemedicine via experienced doctors. EOT obtained in the data shows that traditional medicine is a good option for noncommunicable chronic diseases. Among the diseases associated with Endocrine system **Supplemental Digital Content 4F**, ***http://links.lww.com/PP9/A3***), there is a high prevalence of obesity between 20 and 40 years, while in 40–60 years the patient population showed a high prevalence of Diabetes. Similarly, in Skeletal system **Supplemental Digital Content 4E**, ***http://links.lww.com/PP9/A3***) 20–40 years age group shows a domi-

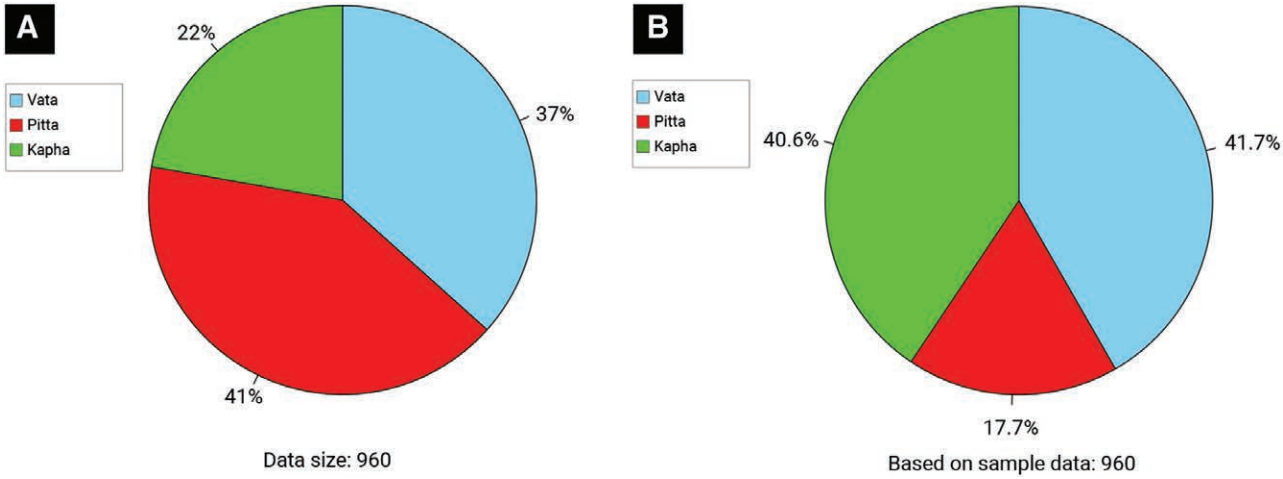


Fig 10. A, Vikriti distribution for telemedicine patients in the age group of 20–30 years. Pitta dominates the age group vikriti distribution, followed by Vata. The major dosha form almost three-fourths of the total prevalence. The distribution is similar to the overall vikriti distribution. B, Prakriti distribution of healthy individual based on Human Constitution Types of Indian Traditional Medicine15. Kapha dominates the age group Prakriti distribution, followed by Vata. The population for Prakriti distribution is mostly from southern and western part of India.

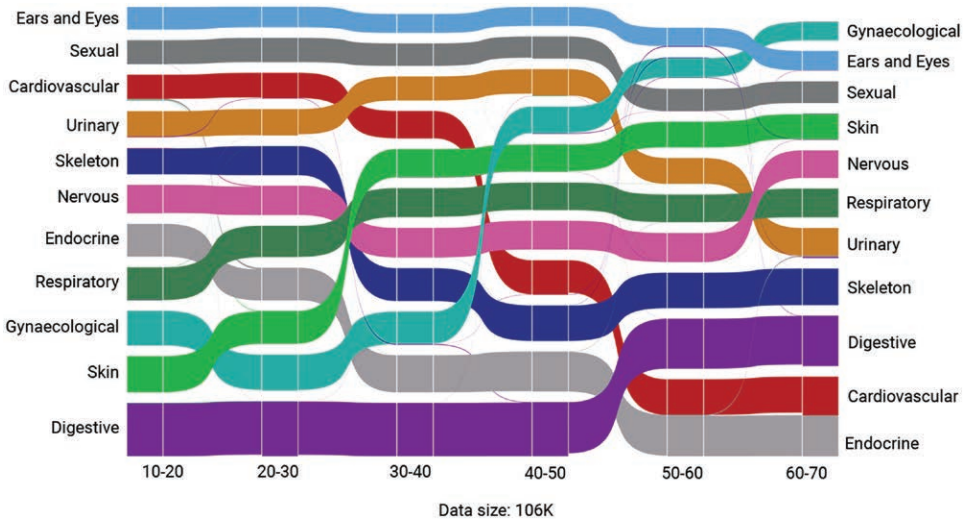


Fig 11. Network-based alluvial plot for disease association across age groups.

TABLE 1.

Medicines with Single Constituents and Compound Herbs

Medicine Type	Ingredient Type	Count	V	P	K	PK	VK	VP	VPK
Mixture	Multiple	66	0	7	0	7	32	13	7
	Single	62	2	9	0	18	20	3	10
Tablet	Multiple	123	0	2	1	9	59	46	6
	Single	10	0	0	0	4	3	2	1

K, Kapha; P, Pitta; PK, Pitta Kapha; V, Vata; VK, Vata Kapha; VP, Vata Pitta; VPK, Vata Pitta Kapha Majority of these medicines are targeting the alleviation of single dosha (V, P, K), or combination dosha (PK, VK, VP, VPK).

nance of Arthritis while above 40 age group shows a high prevalence of Osteoarthritis. These results suggest the need for longitudinal trials on a controlled population to see if these diseases manifestation can be controlled through Ayurveda. It is important to mention that the prevalence of diseases reviewed as part of current telemedicine dataset is different from World Health Organization data on noncommunicable disease data of India[41] wherein cardiovascular diseases, cancer, chronic respiratory diseases and diabetes make the largest contribution to high disablement and mortality in India. But this difference of disease set might be due to the availability of published modern medicine data for India in contrast to the lack of traditional medicine practice data for these diseases. Our analysis shows that Ayurvedic treatment becomes

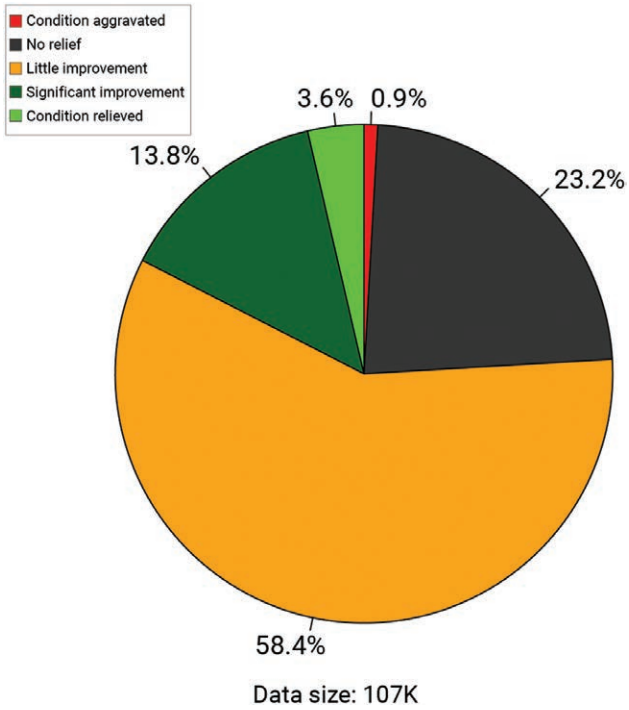


Fig 12. Distribution of follow-up relief—Overall. Pie chart represents the population with their percentage of outcome relief marked in terms of little improvement, significant improvement, condition relieved and no relief. In total, 0.9% has aggravated or have side effect, more than 75% have got relief.

a preferred choice in India when the diseases are chronic and non–life-threatening.

Another study in modern medicine which focused on the Indian population analyzed a dataset of 204,912 patients[42] visiting primary health care practitioner on a single day. These were not specialized physicians and they primarily dealt with nonchronic diseases. Analyzed data shows fever (35.5%) was the most common presenting symptom. Diseases under Respiratory organ system were the most common across age groups. Other 3 prominent organ system diseases were Digestive (28%), Circulatory (14%) and Skin (11%). Thus, similar analytics gave different diseases and interrelationships based on chronic versus nonchronic and specialized versus nonspecialized patient needs. However, it is evident from the data presented here that chronic noncommunicable disease patients are a major beneficiary of the traditional ayurvedic knowledge-based system.

Conclusions

It was observed that more than 80% of the patients coming for Ayurveda treatments were suffering from chronic diseases for more than 1 year. Even though our dataset contained patients diagnosed in clinics and over telemedicine, the statistical distribution of measured parameters from both were similar. Disease profile across sex showed that male and female have different disease prevalence across age groups. Digestive was highest as a single disease category and its co-occurrence with other diseases was also highest among other disease categories. Even with mostly chronic diseases, the EOT was obtained in more than 75% of the cases. Most remarkably it was seen that condition aggravated cases obtained in telemedicine data were only 0.9% of overall data. Percentage of EOT might get further improved if people would approach Ayurveda before the disease gets more chronic. Ayurveda treatment before chronic stage has the potential to reduce burden of ever-increasing healthcare cost.

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Disclosure

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References

[1] The Global Use of Medicines: Outlook Through 2016, IMS Institutes for Healthcare Informatics. Available at http://apps.who.int/medicinedocs/documents/s20306en/s20306en.pdf. Accessed April 23, 2018.
[2] Kasaw A, Dagnachew M, Molla A. Processing medical data: a systematic review. Arch Public Health. 2013;71:1–6. DOI:10.1186/0778-7367-71-27.
[3] Global medicines use in 2020, IMS Institutes for Healthcare Informatics. Available at https://s3.amazonaws.com/assets.fiercemarkets.net/public/005-LifeSciences/imsglobalreport.pdf. Accessed April 23, 2018.
[4] WHO fact sheet: traditional medicine. Available at http://www.who.int/mediacentre/factsheets/2003/fs134/en/. Accessed June 15, 2010.
[5] BRICS population. Available at https://en.wikipedia.org/wiki/BRICS. Accessed June 15, 2010.
[6] National Center for Complementary and Alternative Medicine (NCCAM). The use of complementary and alternative medicine in the United States. Bethesda, Md.: National Institutes of Health. 2008. Available at http://nccam.nih.gov/news/camstats/2007/camsurvey_fs1.htm. Accessed June 15, 2010.
[7] Institut für Demoskopie Allensbach, Naturheilmittel. Ergebnisse einer bevölkerungsrepräsentativen Befragung. 2011. Available at http://www.pandalis.de/en. Accessed April 23, 2018.
[8] Roy V. Time to sensitize medical graduates to the Indian systems of medicine and homeopathy. Indian J Pharmacol. 2015;47:1–3. PMC. Web. 22 Aug. 2016.
[9] Sharma P. Charaka Samhita: Text with English Translation. Varanasi, India: Chaukambha Orientalia Publisher; 1981. pp. 240.
[10] Sharma P. Susruta-Samhita: with English Translation of Text and Dalhana's Commentary Along with Critical Notes. Varanasi, India: Chaukamba Vishwa Bharati; 1999.
[11] Indian National Health Portal. Available at http://www.nhp.gov.in/ayush_ms. Accessed 23 April 2018.
[12] Planning Commission, Government of India. Indian systems of medicine and homeopathy. Available at http://www.planningcommission.gov.in/plans/mta/mta-9702/mta-ch19. Accessed 23 April 2018.
[13] Fokunang CN, Ndikum V, Tabi OY, et al. Traditional medicine: past, present and future research and development prospects and integration in the National Health System of Cameroon. Afr J Tradit Complement Altern Med. 2011;8:284–295.
[14] National center for complimentary and integrative health, Ayurvedic Medicine in depth. Available at https://nccih.nih.gov/health/ayurveda/introduction.htm. Accessed 23 April 2018.
[15] Tu Y. Acceptance remarks by Tu Youyou". Lasker~DeBakey Clinical Medical Research Award. New York, NY: Lasker Foundation. "Equipped with a sound knowledge in both traditional Chinese medicine and modern pharmaceutical sciences, my team inherited and developed the essence of traditional Chinese medicine using modern science and technology and eventually, we successfully accomplished the discovery and development of qinghaosu from qinghao (Artemisia annua L)."

[16] Stanberry B. Telemedicine: barriers and opportunities in the 21st century. J Intern Med. 2000;247:615–628.
[17] Jiva Ayurveda. Available at https://www.jiva.com/about-us and https://www.facebook.com/jivaayurveda. Accessed 23 April 2018.
[18] Rosvall M, Bergstrom CT. Maps of random walks on complex networks reveal community structure. Proc Natl Acad Sci U S A. 2008;105:1118–1123.
[19] Teknomo K. Similarity Measurement. 2015. Available at http:\\people.revoledu.com/kardi/tutorial/Similarity. Accessed 23 April 2018.
[20] Batagelj B, Mrvar A. Pajek - Program for Large Network Analysis. Connections. 1998;21:47–57.
[21] Edler D, Rosvall M. The MapEquation software package. 2017. Available at http://www.mapequation.org. Accessed 23 April 2018.
[22] Rotti H, Raval R, Anchan S, et al."Determinants of Prakriti, the human constitution types of Indian traditional medicine and its correlation with contemporary science." J Ayurveda Integr Med. 2014;5:167–175.
[23] Demographics of India. Available at https://en.wikipedia.org/wiki/Demographics_of_India. Accessed 23 April 2018.
[24] Vivek A, Mukesh D, Naresh "Concept of Ama with special reference to clinical evaluation and therapeutic view of Amavata (Rheumatoid Arthritis)". Int J Res Ayur Pharm. 2013;4:23–26.
[25] Narayana Sristaya S. The Caraka Samhita, Part- I, 1992 Chaukhambha. Varanasi, India: Bharati Academy.
[26] Tripathi B. Astanga Hrdayam of Srimadvagbhata. 2017. Delhi, India: Chaukhambha Sanskrit Pratishthan.
[27] Kessler C, Wischnewsky M, Michalsen A, et al. "Ayurveda: between religion, spirituality and medicine." Evid Based Complement Alternat Med. 2013. Article Id 952432.
[28] Kessler C, Michalsen A. "The role of whole medical systems in global medicine." Forsch Komplementmed. 2012;19:65–66.
[29] Witt CM, Michalsen A, Roll S, et al. "Comparative effectiveness of a complex Ayurvedic treatment and conventional standard care in osteoarthritis of the knee—study protocol for a randomized controlled trial." Trials. 2013;14, no. 1, article 149.
[30] Bousquet J, Anto JM, Sterk PJ, et al. Systems medicine and integrated care to combat chronic noncommunicable diseases. Genome Medicine. 2011;3:43.
[31] Auffray C, Charron D, Hood L. Predictive, preventive, personalized and participatory medicine: back to the future. Genome Med. 2010;2:57.
[32] Hood L, Auffray C. Participatory medicine: a driving force for revolutionizing healthcare. *Genome Med.* 2013;5:110.
[33] Sagner M, McNeil A, Puska P, et al. "The P4 health spectrum—a predictive, preventive, personalized and participatory continuum for promoting healthspan." Prog Cardiovasc Dis. 2016. pii: S0033-0620(16)30078-0. doi: 10.1016/j.pcad.2016.08.002.
[34] Prasher B, Negi S, Aggarwal S, et al.; Indian Genome Variation Consortium. Whole genome expression and biochemical correlates of extreme constitutional types defined in Ayurveda. *J Transl Med.* 2008;6:48.
[35] Mitali M, Bhavana P. "Ayurgenomics: a new approach in personalized and preventive medicine Science and Culture." 2011;77:1–2, pages 10–17.
[36] Govindaraj P, Nizamuddin S, Sharath A, et al. Genome-wide analysis correlates Ayurveda Prakriti. Sci Rep. 2015;5:15786.
[37] Shilpi A, Gheware A, Anurag A, et al. "Combined genetic effects of EGLN1 and VWF modulate thrombotic outcome in hypoxia revealed by Ayurgenomics approach." J Transl Med. 2015;13:184, DOI: 10.1186/s12967-015-0542-9.
[38] Bhavana P, Greg G, Mitali M. "Genomic insights into ayurvedic and western approaches to personalized medicine." J Genet. 2016;95:209–228
[39] Rotti H, Mallya S, Kabekkodu SP, et al. DNA methylation analysis of phenotype specific stratified Indian population. J Transl Med. 2015;13:151.
[40] Sethi TP, Prasher B, Mukerji M. Ayurgenomics: a new way of threading molecular variability for stratified medicine. ACS Chem Biol. 2011;6:875–880.
[41] Burden of NCDs and their risk factors in India, (Excerpted from Global Status Report on NCDs -2014). Available at http://www.searo.who.int/india/topics/noncommunicable_diseases/ncd_situation_global_report_ncds_2014.pdf Accessed 23 April 2018.
[42] Salvi S, Apte K, Madas S, et al. Symptoms and medical conditions in 204 912 patients visiting primary health-care practitioners in India: a 1-day point prevalence study (the POSEIDON study). *Lancet Glob Health.* 2015;3:e776–e784.