REVIEW ARTICLE

Ayurvedic Therapies to Target the Microbiome: Evidence and Possibilities

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ABSTRACT

Context • The microbiome is a constantly evolving entity, being influenced by diet, lifestyle, age, genetics, medication, and environment; keeping the microbiome in good health is a step toward better health for the body. Ayurveda emphasizes a healthy internal milieu that synchronizes with the circadian and seasonal rhythms, in addition to reacting to other stressors.

Objective • The current review intended to provide an overview of Ayurvedic principles related to health and disease and their management and to briefly discuss the current understanding of the human microbiome and explore Ayurvedic herbs and therapies that have been studied for their effects on the microbiome.

Design • The team included researchers in India and Canada. A Pubmed search was performed using the keywords Ayurveda therapies, Ayurvedic therapies, Gut microbiome, Panchakarma, Therapeutic purgation, Therapeutic emesis, medicated enema.

Results • Research connecting Ayurvedic interventions and the gut microbiome is yet in a nascent stage. Several Ayurvedic herbs have been researched for their potential in altering the gut microbiome. Among the Ayurvedic therapies, virechana (therapeutic purgation) and basti (medicated enema) have been studied for their gut microbiome altering effects. However, the limited number of such studies prevents from drawing categorical conclusions currently, about the effects of Ayurvedic Panchakarma therapy on the human microbiome.

Conclusions • Studying where and how the Ayurvedic herbs and therapies can exert their influence on the human microbiome provides a challenging yet novel opportunity and can help address multiple health and disease conditions. (*Altern Ther Health Med.* 2024;30(2):76-83).

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Introduction

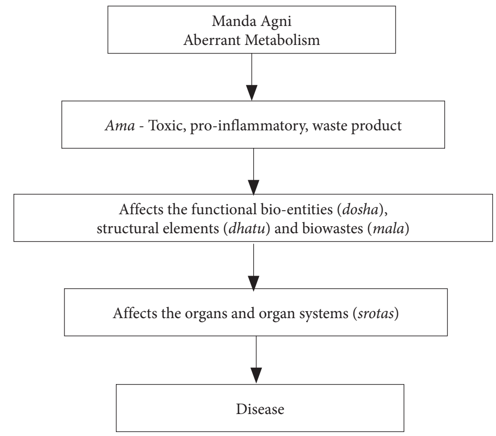
The human microbiota, a group of organisms living and interacting with the human body, is now increasingly being recognized as being responsible for health and well-being. These microbes can be bacteria, archaea, viruses, and eukaryotes and can reside within and outside of the human body, colonizing various body sites. Of these, bacteria are the biggest players.[1]

Trillions of bacteria are distributed within the different organ systems of the human body and have been shown to be intimately connected with its workings. They are responsible for maintaining a stable internal milieu and are connected with the metabolic, immunological, and many other functions.

The last two decades have seen a wealth of information being added to the subject of the human microbiome. Technological advances have paved the way for faster and cost-effective research in the field, and interest has been shifting from identifying different microbial species that colonize the human body to determining how the host-microbe interaction influences health and disease. This has led to an effort to look for opportunities that allow the healing, modulating, and restoring of the microbiome through dietary and lifestyle interventions.

Safe, effective, natural therapeutics are the focus, and new concepts of prebiotics and probiotics have emerged.

Figure 1. Ayurvedic Pathogenesis of Disease



Ayurveda is one healthcare system that can possibly influence changes in the microbiome by virtue of its comprehensive, holistic, and natural approach to living.

Ayurvedic therapies modulate the balance of the internal milieu, such as by altering the pH or through enzyme secretions or functions. Herbs, minerals, diet, lifestyle advice, and specialized therapies are advocated for maintaining that balance.

The different routes of administration of Ayurvedic therapies aid in better drug delivery. The rule of the thumb in Ayurveda is to choose the nearest route to the disease's pathogenesis. In addition, the therapies also focus on the area of maximum symptoms, and in most cases, a combination of therapies is prescribed. The choice of therapies is based on a comprehensive understanding of the patient's strength (rogi bala) and the virulence of the disease (roga bala). Available evidence on the therapies related to biochemical changes can thus be considered to be indirect or surrogate evidence of microbiome modulation.

Such a dynamic appraisal is the hallmark of traditional, complementary, and integrative medicine systems such as Ayurveda. With this approach, treatment is more personalized, and this is the distinguishing feature of Ayurveda when compared with Western biomedicine. Hence, holistic, new-age study designs that better help assess such multimodal, multicomponent interventions need to be developed.

The current study intended to provide an overview of Ayurvedic principles related to health and disease and their management and to briefly discuss the current understanding of the human microbiome and explore Ayurvedic herbs and therapies that have been studied for their effects on the microbiome.

Procedures

The study was conducted by the authors from their respective locations. The research team performed a narrative review by searching for studies using the Pubmed database. The search used the keywords Ayurveda therapies, Ayurvedic therapies, Gut microbiome, Panchakarma, Therapeutic purgation, Therapeutic emesis, Medicated enema. All research articles including review articles, clinical animal and human studies were included.

Setting: The authors conducted the review from their sites.

The review includes articles published in English language. Authors STV and SM compiled, and reviewed articles related to Ayurvedic and microbiome respectively. As it was a narrative review and as the number of research was less, no stringent criterion was applied for selection. All the studies selected were available as full text articles and this was verified by authors SB and SSJ.

RESULTS

Basic Principles of Health and Disease

The Indian system of medicine, Ayurveda, attributes health to a state of balance among various entities: (1) the three functional bio-entities: Dosha or Vata, the subtle energy associated with movement; pitta, the subtle energy associated with transformation; and kapha, the subtle energy associated with binding; (2) the seven structural elements or dhatu: plasma, blood, muscle, fat, bone, bone marrow, and reproductive fluid; (3) mala, the three biowastes; (4) agni, the metabolic activities in the body at the macro and micro levels, (5) manas, the psyche; (6) atma, the spiritual entity; and (7) indriya, the sensory-motor faculties.[2] Discordance among these entities results in disease, and holistic management focuses on healing more than one of the above aspects.

The bio-entities, structural elements, and biowastes are ubiquitously present throughout the body. They are present within every cell and all organs and organ systems (srotas) and execute the functions of these. Another integral factor in the causation of disease is the involvement of agni.[3] Any aberration in metabolic functioning results in the production of ama, which can be understood as a toxic, pro-inflammatory material.[4] The downstream events that follow the introduction of ama include the dysfunction of the functional bio-entities, the structural elements, and the bio-wastes, which affects the organs and organ systems and results in various diseases (Figure 1).[3]

Ayurveda promotes healthy living with comprehensive, prophylactic and therapeutic interventions and diet and lifestyle advice. The science also lays down principles of management of diverse disease entities. The crux of the interventions is to ensure that: (1) metabolic functioning is restored to normalcy, (2) the generation of toxic, pro-inflammatory materials is prevented, and (3) the entities that can be affected downstream are protected and restored. Ayurvedic practitioners give a lot of importance to factors affecting an individual when it comes to correction or restoration of homeostasis.

Therapeutic interventions are elaborated as Panchakarma. The therapies may be external or internal interventions, with topical or systemic effects for pacifying or expelling the aberrant bio-entities, thereby restoring the physiological functioning of the internal milieu. The five main therapies are (1) Vamana, therapeutic emesis; (2) Virechana, purgation; (3) Basti, medicated enema; (4) Nasya, nasal administration and (5) Raktamokshana, bloodletting (Table 1). There are several allied therapies that are also considered a part of Panchakarma and are enumerated briefly below. (Figure 2, Table 2).

External therapies (Bahya) include: (1)Abhyanga, massage with medicated oils; (2) Shirobasti, pooling of oil over the head; (3) Dhara, pouring of decoction or oils; (4) pichu, oil soak (5) Application of heat such as (a) Tapa, dry heat; (b) Upanaha, poultice; (c) Ushma, sauna; (d) Drava, moist heat; (6) Avagaha, immersion in medicated liquids or oils; (7) Pinda sweda, poultice with herbs, powders. Here the herbs or powders are dabbed over the body intermittently. (8) Lepa or upanaha, application of paste; (Lepa is a common term for any application of paste of herbs. It helps with removal of toxins and enhancing the complexion of the skin. Upanaha is the application of the specific hot potency herbs which induce suppuration (Paka) and Sudation (swedana). (9) Udvartana, massage with powders; (10) Agnikarma or Ksharakarma, thermal cautery is a procedure of cauterizing a local area using herbs with cauterizing property or a specific metal instrument (shalaka). (Note: This list of external therapies is not exhaustive).

Internal therapies (Abhyantara) have systemic effects and include: (1) Snehapana, ingestion of fats (a modality of Snehana) (2) Vamana, therapeutic emesis; (3) Virechana, purgation; (4) Basti, medicated enema; (5) Nasya, nasal administration; and (6) Kavala or Gandusha, gargling with medicated oil or decoction.

Furthermore, Ayurvedic therapies whether external or internal, may require following a specific diet and lifestyle, which is called Pathya, and are a means to enhance health. Typically, these diet and lifestyle changes are advised before, during and after most of the therapies that we have discussed above.

Multiple ways exist in which these different interventions can bring about a change in the human body, modulating the microbiome being one of them. The interventions are also associated with explicit diet and lifestyle guidelines that positively ensure alterations in the microbial compositions.

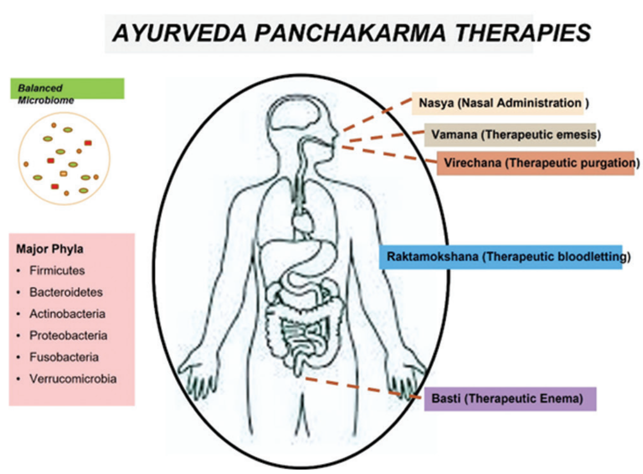
Table 1. Main Ayurvedic Therapies

Panchakarma Therapies	Route of Drug Administration	Route of Exit	Prime Target Area
Vamana (therapeutic emesis)	Oral	Oral	Chest and upper abdomen
Virechana (therapeutic purgation)	Oral	Anal	Lower abdomen and pelvis
Nasya (nasal administration)	Nasal	Nasal, oral	Head and neck
Basti (therapeutic enema)	Anal	Anal	Full body
Raktamokshana (therapeutic bloodletting)	Skin	Skin	Topical

Table 2. Allied Ayurvedic Therapies

Ayurvedic therapies
External Therapies (Bahya)
○ Application of oil (Abhyanga)
○ Pooling of oil over head (Shirobasti)
○ Pouring of decoction or oils (Dhara)
○ Oil soak (pichu)
○ Application of heat (swedana) such as Tapa, dry heat; (b) Upanaha, poultice; (c) Ushma, sauna; (d) Drava, moist heat
○ Immersion in medicated liquids or oils (Avagaha)
○ Poultice with herbs, powders (Pinda sweda)
○ Application of paste (lepa, upanaha)
○ Massage with powders (Udvartana)
○ Thermal cautery (Agnikarma, Ksharakarma)
Internal Therapies (Abhyantara)
○ Internal fats (Snehapana)
○ Gargling with medicated oils or liquids (Kavala, gandusha)

Figure 2. Ayurvedic Panchakarma Therapies



Microbiome and Health and Disease

Human microbiota. Stable interaction and symbiosis between the microbiome and the human body begins at childbirth. During stabilization, the microorganisms actively adjust to a specific habitat and reside in their respective niches within the human body. After stabilization, they identify as a part of the body and are responsible for changes from conception until death.[5]

The largest concentration of the human microbiome is found in the gut; other sites include the skin, oral cavity, respiratory tract, urinary tract, and reproductive tract.[6,7] Approximately 90% of total human cells are associated with microbiota, and only 10% are free from the microbiome.[8] The microbial community varies among anatomical sites in its complexity and function, and it correlates with the individual's health status, genotype, diet, and hygiene practices.[9]

Bacterial phyla. The predominant bacterial phyla comprising hundreds of bacterial genera and species in the human body are the Bacteroidetes, Firmicutes, Actinobacteria, and Proteobacteria, and in lesser abundance, the Fusobacteria, Spriochaetes, and Verrucomicrobia.[10,11] The microbial composition is considered to be highly dynamic and constantly changing during the first three years of life, and after that, it becomes relatively stable. However, environmental changes occur constantly throughout childhood, adolescence, middle age, and old age and can influence the microbiome's composition throughout the lifespan.[12]

Dysbiosis. Dysbiosis or disturbance in the balance of the microbiota can be brought on by certain diets, infectious illnesses, prolonged use of antibiotics or other bacteria-destroying medications, and even lack of exercise. Since the microbiome is a dynamic entity, any alteration to the composition and function of the microbiota observed in diseased individuals is dysbiosis.[13]

Because the largest concentration of the microbiota is present in the gut, the gut microbiome has received significant attention thus far, and the term dysbiosis is mostly used in the context of the gut. Dysbiosis in other sites, such as the respiratory tract in respiratory illnesses[14] and the skin in skin diseases[15] can also occur.

Dysbiosis in the gut is mainly associated with a relative abundance of Firmicutes in relation to Bacteroidetes, the F:B ratio, with both being among the most abundant phyla. In addition, Shin et al have also hypothesized an abnormal Proteobacteria abundance.[16] Overall, the definition of dysbiosis ranges from a reduction in the number of beneficial microbes to an abundance of potentially harmful microbes to a loss of microbial diversity.[17]

Effects of diet. A diet that is varied and complex is associated with a more diversified microbiome. All types of diets and food components have a significant impact on the composition and diversity of the gut microbiome. Dietary fibers provide beneficial nutrients to the gut microbiota, and therefore, richness in diversity is increased. The Western diet, which is high in fats and low in fiber content, is linked to a decrease in bacterial diversity and reduced beneficial microbiota.[18,19]

In the Indian population, Prevotella is dominant, implicating it as a signature genus in this ethnicity. Species under the genus Prevotella are known to degrade complex, plant-derived polysaccharides, which concur with consumption of a predominantly plant-rich, high-fiber diet among Indians.[20]

Low et al found that personalized dietary interventions based on individuals' ethnicities can help nurture the highly malleable gut microbiome to alter the aging trajectory.[21] The Indian thali, which includes multiple food groups such as cereals, legumes, vegetables, curd, and spices, is based on Ayurvedic concepts and provides both fiber and different phytochemicals. Shondelmyer et al have proposed this diet to restore diversity in the gut bacteria and potentially to prevent or reverse chronic disease.[22]

Effects of medications. Medications are known to alter the microbial composition.[23] Antibiotics are known to have negative effects on the gut microbiota, including reduced species diversity, altered metabolic activity, and loss of colonization resistance, leading to colonization by pathogens.[24,25] Palleja et al found that restoration of the microbiome after antibiotic exposure requires 1.5 months, with several common species remaining undetectable for up to 180 days.[26]

Proton-pump inhibitors can contribute to dysbiosis by their acidic antisecretory mechanisms. The hypochlorhydria caused by these medications creates a pro-inflammatory environment because it favors the survival and migration of oral bacteria into the lower gut.[27] Antidiabetics on the other hand, decrease the F:B ratio and increase the efficiency of carbohydrate fermentation, indicating a possible reversal of dysbiosis.[28]

Effects of exercise. Recent research has highlighted the capacity of exercise to modify the diversity, composition, and functionality of the gut's microbial populations. Quiroga, et al found that a 12-week, strength-and-endurance exercise intervention could modify the composition and functionality of the gut microbiota, modestly affecting systemic metabolites and body composition.[29]

Physical activity, regardless of its specific characteristics, can significantly contribute to the composition of the gut microbiome and associated metabolites and helps in determining an individual's health status.[30] Exercise reportedly influences the composition of the gut microbiota by stimulating the development of bacteria able to determine adaptive changes in the host's metabolism.[31]

Ayurveda and Microbiome Research

Research connecting Ayurveda and the microbiome is a growing area of interest among researchers. Ayurvedic Prakriti phenotyping can function as a potential method of stratification of the gut microbiome in a given population. Ayurveda practitioners categorize the individuals into different phenotype based on the physical, physiological and psychological parameters specific to each prakriti. Thus, individuals may be categorized into 7 phenotypes. Based on dominance of a single dosha individuals could be Vata prakriti individual, Pitta prakriti individual and Kapha prakriti individual; based on dominance of 2 dosha, individuals could be Vata-pitta prakriti dominant, Pitta-kapha dominant prakriti and Vata-kapha prakriti dominant; and, based on equal dominance of all 3 dosha, Vata-pitta-kapha prakriti individual. Several validated questionnaires like TNMC questionnaire for prakriti are available for eliciting these phenotypes. (Bhalerao et al., 2012). The first 3 of these phenotypes are considered extreme and susceptible to diseases. There is sufficient scientific literature that has correlated the Ayurvedic phenotypic Prakriti classification with areas of the human body including anthropometry, biochemical characteristics, genome and gene expression, amongst others. However, this is beyond the purview of discussion for this paper.

Chauhan et al found that Pitta individuals had enriched Bacteroides and Parabacteroides while Aata individuals had enriched Desulfovibrio, Slackia, and Succinivibrio, and Kapha individuals didn't show any differentially abundant taxa.[32] Shalini, et al's recent study on the gut microbiome and prakriti found that potentially pathogenic organisms were highest in Kapha prakriti and lowest in Pitta prakriti compared to individuals fitting into other bio-entities.[33] These researchers also found a preferential presence for Paraprevotella and Christensenellaceae in Vata individuals. All of these findings correlate to the Ayurvedic descriptions of fast and slow metabolizers and their disease susceptibility. These leads may pave the way for the conceptual framework of personalized medicine in Ayurveda.

Correction of dysbiosis or intestinal microflora manipulation is considered a powerful preventive and therapeutic intervention against inflammation.[34] It is also responsible for the interpersonal variations observed in the action of drugs or therapy administered, especially within the gut.[35]

Some Ayurvedic herbs that are used as culinary spices, such as *Curcuma longa* (*Haridra*), *Zingiber officinale Roscoe* (*Shunti*), *Piper longum* (*Pippali*), *Cinnamomum tamala Buch.-Ham* (*Twak*), and *Piper nigrum Linn* (*Maricha*), have shown prebiotic potential. These spices possess fiber and phytochemicals that encourage the growth of beneficial microbes and inhibit the microbes that have the potential of inducing inflammation.[36] The spices interact with the gut microbiota and produce gastrointestinal and systemic effects. Lu, et al found in a preclinical study on isolates from intestinal microbiota that Sunthi can enhance the growth of beneficial Bifidobacterium and Lactobacillus species and control the growth of several Ruminococcus species.[37]

Peterson performed a number of studies with various other researchers on the effects of herbs on the human microbiome. In a 2018 study, Peterson et al found that supplementation with *Glycerrhiza glabra* (*Yashtimadhu*); *Triphala* [a combination of *Terminalia belerica* (*Vibhitaki*), *Terminalia chebula* (*Haritaki*), and *Phyllanthus emblica* (*Amalaki*)]; and Ulmus rubra on anaerobic human fecal cultures significantly increased health promoting Bifidobacterium, Lactobacillus, and Bacteroides species and reduced the relative abundance potential pathogens, such as Citrobacter freundii and Klebsiella pneumoniae.[38] A second study in 2018 found that *Curcuma longa Linn.* (*Haridra*) and one of its biologically active constituents, curcumin, enhanced healthy gut microflora in healthy human participants.[39]

In 2019, Peterson et al examined the effects of supplementation with certain herbs on fecal cultures, including: (1) *Bacopa monnieri* (*Brahmi*), (2) *Evolvulus alsinoides* (*Shankhapushpi*), (3) *Centella asiatica* (*Mandukaparni*), (4) *Nardostachys jatamamsi* (*Jatamansi*), (5) *Boswellia serrata* (*Shallaki*), (6) *Eclipta alba* (*Bringaraja*), (7) *Mucuna pruriens* (*Kapikacchu*), (8) *Withania somnifera* (*Ashwagandha*), (9) *Asparagus racemosus* (*Shatavari*), or (10) *Tinospora cordifolia* (*Guduchi*).[40] Those researchers found that each herb influenced and promoted specific healthy bacterial species, emphasizing the strong and unique selective properties of the herbal substrates.

In another study in 2019, Peterson et al found that *C. longa, Z officinale, P. longum* (*Pippali*), and *P. nigrum* could modulate the microbial community in human fecal cultures, which contributed to health-enhancing effects on digestive efficiency and health.[41] In 2020, Peterson et al supplemented the diets of healthy individuals with the herbs Triphala and *Rubia cordifolia* (*Manjishta*) for 4 weeks and found no signature microbes in the gut, but the intervention altered the microbial picture with a trend toward a reduced F:B ratio.[42]

In a study in 2021, Peterson et al studied the prebiotic potential of 11 herbs—*Terminalia arjuna* (*Arjuna*), *Crataegus laevigata* (*Hawthorn berry*), *Andrographis paniculata* (*Kalamegha*), *Picrorhiza kurroa* (*Katuki*), *Rubia cordifolia* (*Manjishta*), *Cyperus rotundus* (*Musta*), *Boerhavia diffusa* (*Punarnava*), *Embelia ribes* (*Vidanga*), and *Ipomoea digitate* (*Vidarikanda*)]—and two formulations—*Kanchanara guggulu* and *Triphala guggulu*.[43] Each herb altered the composition of fecal microbial communities to varying extents relative to control cultures and formed three clusters: (1) Cluster 1 were communities supplemented with hawthorn berry, *Andrographis paniculata*, *Picrorhiza kurroa*, *Cyperus rotundus*, *Picrorhiza kurroa*, *Boerhavia diffuea*, and *Ipomoea digitate*, which had a relatively balanced structure comprised of multiple bacterial families; (2) Cluster 2 were communities supplemented with *Triphala Guggulu* and *Kanchanara Guggulu* and showed a strong expansion of Bacteroidaceae, driven by members of the genus Bacteroides; and (3) Cluster 3 were communities supplemented with *Terminalia arjuna*, *Rubia cordyfolia*, and *Embelia ribes*, which drove a strong expansion of Enterobacteriaceae. The authors concluded that the therapeutic efficacy of Ayurvedic herbs is mediated through the intermediary of the gut microbiome.

Impact of Panchakarma on Microbiome

Together with the use of varied herbs, Panchakarma procedures are an equally important part of holistic management of health and disease, making it interesting to review and collate information regarding the different Panchakarma modalities and their observed or postulated effects on the human microbiome, chiefly the gut microbiome. For example, in the case of neurological diseases, a combination of nasal therapies, medicated enemas, purgation and topical treatments, such as massage, are used. The discussion that follows draws parallels from conventional treatment procedures that may have similar benefits.

Oleation: Massage with or ingestion of fats. Use of fats in therapeutic doses, both internally and externally, is advised in Ayurveda for maintaining good health and in the management of diseases. The most-used fats are ghee (ghrita) and oil (taila), and less commonly used are animal fat (vasa) and marrow (majja). These fats are most often processed with herbs, thereby acquiring the medicinal qualities of the herbs.

Among these fats, ghee or clarified butter is regarded as most suitable for internal consumption. Poudyal et al found that an ovo-lacto, vegetarian-style dietary regimen, in which 45% of the dishes used ghee that contained up to 30% butyric acid, significantly improved the clinical picture in a small group of Parkinson's disease (PD) patients, as assessed by the motor part of the Unified Parkinson's Disease Rating Scale (UPDRS).[44] Other research has shown that the impact of different types of lipids on the body is dependent on the degree of saturation.[45] Fava et al found that the medium- and short-chain fatty acids, as present in ghee, can have beneficial effects on the gut microbiome's profile.[46]

Oils are the most preferred fats for external application, with sesame oil, castor oil, and coconut oil being the most common base oil, used either alone or steeped in herbs. The oils are rhythmically massaged and are expected to be absorbed via the dermal surface. Similar effects are observed with conventional massage therapy.[47]

Periodic, full-body oil massages are advised in Ayurveda, and the specific areas include the head, ears, and feet.[2] A 12-week application of a topical coconut oil in dandruffaffected individuals enhanced the core fungal and bacterial species that are associated with a healthy scalp's microflora.[48] An increased biotin metabolism pathway, which is integral to skin and hair health, was also observed in that study. Similar studies on topical products such as emollients have shown an increase in the skin microbiome's diversity.[49,50]

Therapeutic emesis. Therapeutic emesis is a specialized procedure that induces vomiting with the use of herbs. It's performed under medical supervision and is usually advised for conditions associated with an increase in Kapha Dosha, such as from respiratory illnesses or skin diseases.[51] The Kapha increase may be due to a seasonal influence in healthy individuals and can be observed at the end of winter and beginning of spring; a seasonal cleanse is advised in Ayurveda.

Some research has also shown that despite the gut's microbial stability among individuals, a consistent and significant shift occurs in microbiome composition across seasons.[52] This concept of shift in the composition of the gut microbiome that can lead to pathological variations in the body is consistent with the Ayurvedic theory of seasonal fluctuation of the Dosha.

A Kapha increase is also associated with certain disease conditions, such as allergic rhinitis or bronchial asthma, and emesis can help to reduce those conditions.[51] While the effects of emesis have been studied, although sparsely, to the best of the current research team's knowledge, no studies on its possible influence on the gut microbiome have occurred.

Gupta, et al tried to characterize the intestinal flora—Bacteroides and *Eschericia coli*—before and after emesis in healthy individuals but found no significant changes.[53] They did, however, find that the procedure was safe and also found positive influences on several physiological and biochemical parameters that may have been influenced by the gut microbiome's modulation. They also found that bowel movements were regularized for all of the study's participants. Some studies have shown that an improvement the stools' consistency is associated with a shift in the fecal microbiota's composition at the level of community structure and diversity.[54,55] From that finding, researchers can safely speculate a corrective action for the emesis procedure on gut dysbiosis.

Therapeutic purgation. Therapeutic purgation involves the prescription of herbs that are categorized as purgatives and laxatives. This therapy is recommended as a seasonal cleanse prior to the Fall season and for conditions associated with an increase in Pitta Dosha, such as migraines (*ardhavabhedaka*), skin diseases (*kushta*), or diabetes (*prameha*).[51]

In 2019, Chaturvedi, et al found that therapeutic purgation could reduce the colonization of aerobic bacteria—Escherichia coli—in obese individuals.[56] In 2016, Chaturvedi et al had found that therapeutic purgation in Albino rats could decrease fat content in the feces; lower fasting blood sugar and serum triglycerides; reduce fatty changes in the liver, heart, and kidney; and increase insulin sensitivity in the insulin receptors present in skeletal muscles.[57]

Pooja and Bhatted found that gentle purgation, in conjunction with other therapies and diet as part of the Self-Directed Biological Transformation Initiative (SBTI), could significantly alter metabolomic profiles largely related to signaling and lipid digestion, mobilization, transport, and biosynthesis in healthy individuals.[58] Further, one study showed that purgation enhanced the benefits of a dyslipidemia-like medicated enema.[59] The administration of purgation has also shown benefits in treatment of migraines[60] and Parkinson's disease (PD).[61] Considering that the pathways for lipid metabolism in dyslipidemia and the gut-brain axis in migraines and Parkinson's disease seem to be closely dependent on the health of the microbiome, researchers can hypothesize that purgation has the potential to alter gut dysbiosis.

Nasal administration. Nasal administration involves administering herbs as a fine powder or fresh juice or in the form of oils or ghee, into the nasal cavity. It's preferred for increased Kapha Dosha and prophylactically for health, including for types of headaches; nasal problems, such as rhinitis; neurological disorders; and many more conditions.[51] The nasal route is being investigated extensively as a better route of drug delivery, especially for central-nervous-system agents. One study found that nasal administration, as part of a treatment protocol, showed outcomes similar to conventional management for stroke patients.[64]

Ayurvedic formulations for nasal administration are mostly lipid based and by virtue of their nanoparticle drug delivery system may be helpful in delivering active botanical ingredients across specific barriers, such as the blood brain barrier.[72] Kajaria, et al found that nasal administration with a compound of *Albizia lebbeck* (*Shirisha*), *Cyperus rotundus* (*Musta*), and *Solanum xanthocarpum* (*Kanthakari*), given through nebulizer in aerosol form, improved pulmonary functions in acute and chronic, uncomplicated bronchial asthma.[73]

The nose as an effective route of administration is now being explored for different conditions. Interestingly, oxytocin spray in combination with or without probiotic Lactobacillus reuteri is currently being studied for possible effects in autism spectrum disorder.[74] One study found that microbial diversity did change after intranasal administration of steroid mometasone furoate or mupirocin in chronic noninfectious rhinitis.[75] Researchers don't yet have sufficient information on the pathways by which nasal administration can influence local microbiome and distant changes, definitely indicating the need for more research into this area.

Medicated enema. Administration of medications, either in the form of herbal decoctions or medicated ghee or oils, through the rectal route is called basti. The herbal-decoction basti is a homogenous mixture of fats, such as sesame oil; castor oil; medicated ghee; bone broth; lard; liquids such as decoctions of herbs and milk or buttermilk; or pastes of herbs or herbal powders. The choice of the ingredients is based on the condition for which the basti is being prescribed.

It is indicated prophylactically before the monsoon season and for Vata-Dosha dominant conditions such as most neurological and musculoskeletal disorders (*Vata vyadhi*).[51] It has the advantage of bypassing the gastric and liver metabolism, which would otherwise change the properties and actions of the herbs introduced; the herbs have been proven to reach the ileocecal junction.[62]

Hegelmaier et al found clinical improvement in PD patients from administration for 14 days of an enema with oil, which was mixed with a suspension of electrolytes and paired with a dietary intervention.[44] The outcome measure used was the Movement Disorder Society - Unified Parkinson's Disease Rating Scale III (MDS-UPDRS III); the researchers found a reduction in the abundance of Clostridiaceae.

Some studies have found that medicated enema given with other Ayurvedic interventions can decrease cardiac autonomic dysfunction[63] and improve functional outcomes in stroke patients.[64] Pathak-Gandhi and Vaidya found that 15 patients with idiopathic PD who received a treatment based on an oil enema for 16 days, showed encouraging responses, as assessed by the MDS-UPDRS.[65] With the recent discovery of the microbiota-gut-brain axis, researchers have a strong reason to believe that medicated enema might be a highly successful treatment for prevention and management of neuropsychiatric conditions.

Thatte et al found that a therapeutic course of medicated enema could reduce weight and modulate immune responses by regulating pro-inflammatory cytokines, immunoglobulins, and functional properties of T-cells in a group of obese individuals.[66] The interaction between the microbial community and the host immune factors is well characterized. Hence, it may be hypothesized that basti influenced changes in the microbial community and subsequent cascading effect on host immune factors.[67,68]

Metabolites derived from the gut microbiota have been shown to help maintain cardiovascular function, and dysregulation can potentially be causally linked to cardiovascular disease.[69] In that context, medicated enema may also help reverse heart failure by enhancing maximum aerobic capacity and ejection fraction.[70] Mane et al found that a 15-day course of enema given with buttermilk that had been processed in herbs showed a decrease in obese patients in the abundance of Firmicutes, Proteobacteriae, and Deinococcus-thermus at the sixteenth day after the enema.[71] The changes, however, reverted to baseline at 45 days after therapy.

From the studies above, it's evident that medicated enema has the potential to positively modulate the gut microbiome and impact several chronic conditions via multiple pathways.

Post procedural therapeutic diet guidelines (Samsarjana krama). This process involves modulation of diet by progressing from liquids to semisolids to a solid diet involving vegetarian and nonvegetarian components, typically prescribed before, during, and after a Panchakarma for a stipulated time. Such an incremental progression helps the system to rest and reset after the elaborate procedures. This is in tune with the understanding of amending the amount of vegetable-based or animal-based food within the diet and of carbohydrate and fat intake that can prompt changes in the make-up of the intestinal microbiome,[76,77] and thereby, improve digestion, absorption, cognition, physical and mental well-being.[78]

DISCUSSION

Although at present information regarding the effects of Ayurvedic Panchakarma therapies on the human microbiome is limited, the outcomes look positive. Ayurveda has highlighted the role of the gut in the maintenance of health and the pathogenesis of various diseases, and it's interesting to note that 3 of the 5 main Panchakarma therapies are focused on the gut.

Dysbiosis is still an evolving concept and its mechanistic underpinnings as the cause or effect of diseases is still being evaluated.[79] Ayurvedic therapies are complex and involve a preparatory phase, a procedural phase and a postprocedural dietary and behavioral regimen. The microbiome too is a dynamic entity and stressors such as diet and lifestyle can impede or facilitate the changes that these therapies can possibly have on the microbiome.

CONCLUSIONS

Methodological challenges exist in the study of the effects of Ayurvedic therapies on the microbiome and in the drawing of conclusions about the effects of Panchakarma therapy. Studying where and how the Ayurvedic therapies can exert their influence on the human microbiome provides a challenging yet novel opportunity and can help address multiple health and disease conditions.

AUTHORS' DISCLOSURE STATEMENT

There is no conflict of interest.

ACKNOWLEDGMENTS

STV and SSJ would like to thank Dr. GG Gangadharan, Director, Ramaiah Indic Specialty Ayurveda, Bangalore, India for his support and encouragement.

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