

Nutraceutical Interventions for Women's Health: A Clinical Evidence Landscape

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Abstract- Women's health encompasses multiple life stages- adolescence, reproductive years, pregnancy, menopause and aging, each characterized by distinct physiological and nutritional demands. Meeting these needs often requires interventions that go beyond conventional therapies, where nutraceuticals have gained increasing attention as natural, accessible and preventive strategies. Nutraceuticals such as phytoestrogens, isoflavones, omega-3 fatty acids, vitamins, minerals, probiotics and plant-derived bioactives offer diverse health benefits by acting through multiple biological pathways. Unlike single-target pharmacological approaches, these compounds contribute to hormonal balance, preservation of bone mineral density, cardiometabolic regulation, cognitive support, immune modulation and maintenance of urogenital health.

This clinical study map integrates evidence on nutraceutical applications across key domains of women's health, including reproductive and maternal health, menstrual disorders, menopausal transitions, skeletal health, cardiovascular and metabolic conditions, mental well-being and urogenital balance. The analysis underscores their potential to improve quality of life, alleviate symptoms and support preventive care. However, the review also identifies major gaps, including heterogeneous study designs, limited sample sizes, underrepresentation of diverse populations and lack of standardized formulations and dosing protocols. Addressing these limitations requires rigorous, large-scale and personalized research approaches, alongside clearer global regulatory frameworks, to ensure the safety, efficacy and integration of nutraceuticals into evidence-based women's healthcare.

Key words – Women's health, nutraceuticals, phytoestrogens, isoflavones, omega-3 fatty acids, probiotics, vitamins, menopause, cardiometabolic health, cognitive f

Module 1:- Introduction to Women's health and nutraceuticals



Women's health spans unique phases from menstruation to pregnancy, menopause and aging each bringing specific biological and nutritional challenges. Conditions like anemia, osteoporosis and polycystic ovary syndrome (PCOS) remain particularly common, highlighting the need for supportive strategies beyond conventional medicine (Chiu et al., 2022).

Nutraceuticals, broadly defined as food-derived bioactive compounds that provide health benefits beyond basic nutrition, are gaining attention as safe, preventive, and complementary approaches (D Adamo & Sahin., 2020). Unlike drugs, they often work by strengthening natural processes such as hormone balance, bone density and immune defense (Patel & Rauf., 2019).

For example, folate is essential in pregnancy for preventing neural tube defects, while inositols and vitamin D support ovulation in PCOS (Bednarek & Banaszewska., 2021). Calcium and vitamin D remain cornerstones for bone health, and phytoestrogens may ease menopausal symptoms (EFSA Panel., 2023). Similarly, omega-3 fatty acids and B-vitamins contribute to mood regulation and cognitive function, especially relevant given women's higher vulnerability to depression and dementia (Santamarina & Tavares., 2024).

Clinical trials have shown promise- for instance, probiotics reduce recurrent urinary tract infections, and isoflavones alleviate hot flashes (Patel & Rauf., 2019). However, evidence remains uneven, and challenges persist. Nutraceuticals often lack

standardization, regulations vary across countries, and long-term safety data is still evolving (D Adamo & Sahin., 2020).

Looking forward, nutraceuticals may play a central role in personalized women's healthcare, with nutrigenomics guiding targeted interventions. Stronger clinical trials and harmonized regulations will be essential to ensure safety and efficacy (Bednarek & Banaszewska., 2021).

In summary, nutraceuticals represent a growing bridge between nutrition and medicine- empowering women to manage health transitions with practical, evidence-based support. By integrating scientific rigor with holistic care, they can significantly improve quality of life across all stages of womanhood (Chiu et al., 2022, Santamarina & Tavarres., 2024).

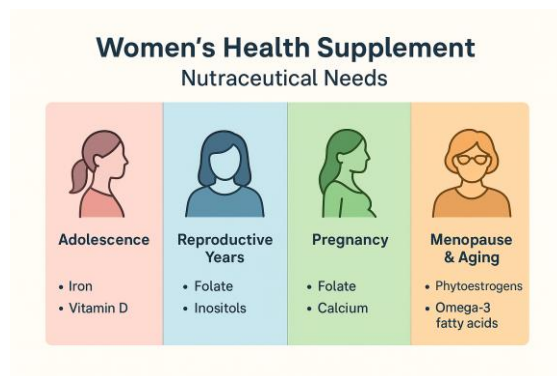


Fig No. – 2:- Women's life stages and corresponding nutraceutical needs.

Module 2 :- Concept of Clinical study mapping

Clinical research in women's health is often complicated by the unique biological, hormonal, and social factors that shape health outcomes across the female lifespan. To make sense of these complexities, researchers increasingly rely on the method of clinical study mapping, which provides a structured way to identify, organize and visualize clinical trial evidence into a coherent landscape. Rather than focusing on a single intervention or outcome, study mapping captures the breadth of available research, enabling scientists, clinicians and policymakers to see not only where evidence is strong but also where significant gaps remain (Ioannidis., 2016). This is particularly valuable in women's health, a field where historical underrepresentation of female participants has often left major questions unanswered (Holdcroft., 2007).

Clinical study mapping is essentially the process of systematically searching databases such as PubMed, ClinicalTrials.gov, and Cochrane to gather relevant studies, extracting key details on interventions, participants and outcomes and then organizing them into thematic categories. These categories may cover areas such as reproductive health, metabolic health, bone and joint disorders, or menopause. The collated information is then presented through tools like evidence maps, heatmaps, or network diagrams, providing a comprehensive overview of the research landscape (Maiké-Lye et al., 2016). Unlike traditional systematic reviews that emphasize depth and quality assessment, study mapping emphasizes breadth and accessibility. Creating a "living knowledge system" that can be updated as new trials emerge.

The importance of this approach in women's health cannot be overstated. Many clinical trials historically excluded women due to hormonal variability, which led to treatment guidelines often relying on male-dominated data (Holdcroft., 2007). By mapping existing trials, researchers can highlight neglected areas such as PCOS, endometriosis, menopause or female cardiovascular risk, while also identifying where nutraceuticals have been studied extensively. For instance, mapping omega-3 fatty acid interventions reveals strong evidence for cardiovascular protection but inconsistent findings for mood disorders, suggesting the need for more rigorous psychiatric studies in women (Freeman et al., 2018). Similarly, mapping studies on probiotics demonstrate moderate support for reducing recurrent urinary tract infections but insufficient long-term safety data, guiding both clinicians and regulators toward future trial priorities (Grinspan & Delgado., 2020).

The benefits of clinical study mapping extend beyond academic research. For clinicians, maps provide an accessible overview of the available evidence, enabling quicker and more informed decision-making in practice. For researchers, maps highlight gaps where new trials are urgently needed, preventing duplication and encouraging efficient use of resources. For policymakers, mapping offers transparency in areas such as nutraceutical regulation, ensuring that recommendation are guided by robust science rather marketing claims (Ioannidis., 2016).

Despite these advantages, clinical study mapping also encounters certain challenges. Trials often

differ considerably in their design, dosage regimens and outcome measures, which makes direct comparisons difficult. Publication bias further distorts the overall picture, since studies with positive findings are more likely to be published than those with neutral or negative results. In addition, while mapping is highly effective in illustrating the quantity of available research, it does not always reflect the quality- meaning that weaker evidence may appear on par with more rigorous studies unless followed by systematic review (Miake-Lye et al., 2016). Finally, because nutraceutical research is expanding at a rapid pace, evidence maps require ongoing updates to ensure they remain accurate and relevant.

Looking ahead, advances in artificial intelligence and data science may transform clinical study mapping into an even more dynamic tool. Automated literature screening, data extraction, and visualization are already being developed, making it possible to update evidence maps in real time (Marshall et al., 2021). For women's health, this evolution promises continuously refreshed landscapes that capture both clinical trial outcomes

and real-world patient experiences. In nutraceutical research, future mapping may extend beyond biochemical outcomes to include quality-of-life measures, patient preferences, and long-term safety, ensuring that interventions are not only scientifically effective but also meaningful in everyday life.

Clinical study mapping represents a strategic approach to making sense of the fragmented research landscape in women's health. By systematically capturing and organizing evidence, it highlights both opportunities and limitations, shaping the direction of future trials, clinical recommendations and health policy. For nutraceuticals in particular, where evidence is rapidly growing but uneven in quality, mapping provides a valuable tool to bridge scattered findings into cohesive, actionable knowledge. As nutraceuticals continue to gain traction in preventive and complementary care, clinical study mapping will remain essential to ensuring that women's health interventions are guided by scientific rigor and aligned with patient needs (Freeman et al., 2018; Grinspan & Delgado, 2020).

Clinical evidence map:

A graph depicting the number of studies by nutraceutical type and indication:

Nutraceutical	Pregnancy	Menopause	Bone health	Cardiovascular	Mental health
Omega-3 fatty acids.	✓	✓	✓	✓	✓
Isoflavones/ Phytoestrogens.		✓	✓		
Calcium & Vit. D.	✓	✓	✓		
Probiotics.	✓				✓
Herbal extracts.	✓	✓			✓

Fig No. – 3:- Table of nutraceutical type and indication.

Module 3 :- Types of Nutraceuticals in Women's Health

Women's health unfolds across multiple life stages- adolescence, reproductive years, pregnancy, lactation and menopause, each bringing its own nutritional and therapeutic challenges. These needs are influenced not only by hormonal shifts and reproductive cycles but also by a higher vulnerability to conditions such as osteoporosis, anemia, cardiovascular disease, and depression. In this context, nutraceuticals – bioactive compounds derived from foods have gained importance as safe, accessible options that support both prevention and treatment. Unlike conventional drugs, which often act on a single target, nutraceuticals tend to influence several biological pathways at once, promoting

hormone regulation, antioxidant defense, and immune balance (Patel & Rauf., 2019).

To applicate their potential, it is helpful to group nutraceuticals into key categories: vitamins and minerals, phytochemicals, probiotics and prebiotics, omega-3 fatty acids, proteins and amino acids, and herbal or traditional preparations. Each group contributes uniquely to women's health, whether by supporting reproductive function, strengthening bones, balancing metabolism or enhancing psychological well-being.

3.1 - Vitamins and Minerals:-

Micronutrient supplementation is one of the most established and evidence-based forms of nutraceutical support. Among women, folic acid

stands out as a critical nutrient during reproductive years. Adequate folate intake before and during early pregnancy prevents neural tube defects and reduces adverse pregnancy outcomes, making it a cornerstone of prenatal care (De-Regil et al., 2015). Iron is another key nutrient for women, particularly because menstruation and pregnancy increase the risk of iron-deficiency anemia, a condition that can impair cognitive performance, work productivity and overall well-being.

Equally important are calcium and vitamin D, which work synergistically to support bone mineralization. Post menopausal women are especially vulnerable to osteoporosis due to estrogen decline, which accelerates bone resorption. Supplementation with calcium and vitamin D has been consistently shown to reduce fracture risk and improve bone density (ESPA Panel., 2023). Deficiencies in these nutrients are not confined to low-income countries; they remain widespread even in high-income settings, reflecting dietary gaps and lifestyle changes such as reduced sun exposure. Thus, vitamins and minerals form the backbone of nutraceutical interventions for women across life stages.

3.2 - Phytochemicals and plant-derived compounds:-

Phytochemicals, bioactive molecules naturally present in plants, offer therapeutic potential for several women-specific conditions. Isoflavones, found in soy, act as phytoestrogens, meaning they can weakly bind estrogen receptors and mimic some effects of estrogen. This makes them particularly useful in managing menopausal symptoms, such as hot flashes, mood swings, and bone loss (Messina., 2014). Unlike hormone replacement therapy (HRT), which may carry risks for certain cancers, phytoestrogens are generally considered safer, though their effects may vary with genetics and gut microbiota.

3.3 - Flavonoids, abundant in fruits and vegetables, have antioxidant and anti-inflammatory properties. For women with polycystic ovary syndrome (PCOS), flavonoids such as quercetin have been studied for their ability to modulate insulin sensitivity and reduce androgen levels (Nasri et al., 2020). Similarly, curcumin, derived from turmeric, has attracted attention for its role in reducing inflammation and oxidative stress in endometriosis and other gynecological disorders (Gupta et al., 2013). These plant compounds highlight how

dietary components can be harnessed to support both hormonal and metabolic balance in women.

3.4 - Probiotics and Prebiotics :-

The female microbiome, especially in the gut and vaginal tract plays a pivotal role in health. Probiotics, particularly *Lactobacillus* strains, help maintain vaginal pH and inhibit pathogenic bacteria, reducing the recurrence of urinary tract infections (UTIs) and bacterial vaginosis (Grinspan & Delgado., 2020). Vaginal health is often overlooked in broader clinical discussions, yet it directly impacts fertility, comfort and quality of life.

Beyond the reproductive system, probiotics also influence gut health and the gut brain axis. Recent evidence shows that probiotics can alleviate stress, anxiety and depression, conditions that disproportionality affect women, especially during perinatal and menopausal periods (Cryan et al., 2019). Prebiotics, which are dietary fibers that fuel beneficial bacteria, enhance these effects by fostering a healthy microbiome. Together, probiotics and prebiotics (synbiotic) represent an expanding frontier of nutraceutical research in women's health.

3.5 - Omega-3 fatty acids and Lipid-based nutraceuticals:-

Lipids, particularly omega-3 polyunsaturated fatty acids (EPA and DHA), are vital for women's cardiovascular, reproductive and mental health. Omega-3 supplementation during pregnancy supports fetal brain and retinal development and lowers the risk of preterm birth (Greenberg et al., 2008). In postmenopausal women, omega-3 fatty acids contribute to cardiovascular protection, reducing triglyceride levels and improving endothelial function.

Psychological health is another domain where omega-3 fatty acids are impactful. Depression, which affects women nearly twice as often as men, has been linked to low omega-3 levels. Supplementation has shown benefits in reducing depressive symptoms during postpartum and menopause (Freeman et al., 2018). Given their wide-ranging benefits, omega-3 fatty acids are often considered essential nutraceuticals for life long women's health.

3.6 - Protein and amino acid supplements :-

Proteins and amino acids support muscle, bone and reproductive health. For example, arginine has been linked with improved blood flow and reproductive outcomes, while L-carnitine supports energy metabolism and fertility. Collagen peptides are

increasingly popular among women for joint, skin and bone health, with studies showing improved skin elasticity and reduced joint discomfort after supplementation (Borumand & Sibilla., 2015).

Protein supplementation also helps address sarcopenia (loss of muscle mass), which disproportionately affects older women and contributes to frailty and fractures. Thus, protein-based nutraceuticals serve both preventive and restorative roles across women's life stages.

3.7 - Herbal and Traditional nutraceuticals:-

Traditional herbal remedies have been used in women's health and continue to gain scientific backing. Ashwagandha is increasingly studied for its role in reducing stress and balancing cortisol, which indirectly supports reproductive health. Black cohosh and red clover are widely used for menopausal symptom relief, though evidence is mixed. A systematic review reported that black cohosh may help with hot flashes and mood swings, but results are not uniform across studies (Leach & Moore., 2012).

Cultural practitioners around herbal supplements also highlight how women's health intersects with traditional medicine systems. While promising, the lack of standardization in extraction, dosage and clinical testing remains a barrier to fully integrating herbal nutraceuticals into mainstream care.

3.8 - Challenges and future directions:-

Nutraceuticals encompass a diverse spectrum of interventions that address unique health challenges faced by women throughout life. From essential vitamins like folate and iron that safeguard reproductive and hematological health, to innovative probiotics that enhance microbiome balance, these interventions bridge the gap between nutrition and medicine. Emerging compounds such as phytoestrogens, omega-3 fatty acids and collagen peptides expand the toolkit for managing menopause, bone health, cardiovascular disease, and psychological well-being.

However, the variability in product formulations, inconsistent clinical trial designs, and the persistence of publication bias remain challenges. Without standardization, strong evidence may appear equivalent in public perception. To harness the full potential of nutraceuticals in women's health, future research must focus on high-quality clinical trials, standardized dosing and long-term safety evaluations. As evidence grows, nutraceuticals are poised not just supplements, but as integral components of women-centered healthcare, supporting longevity, resilience and overall quality of life.

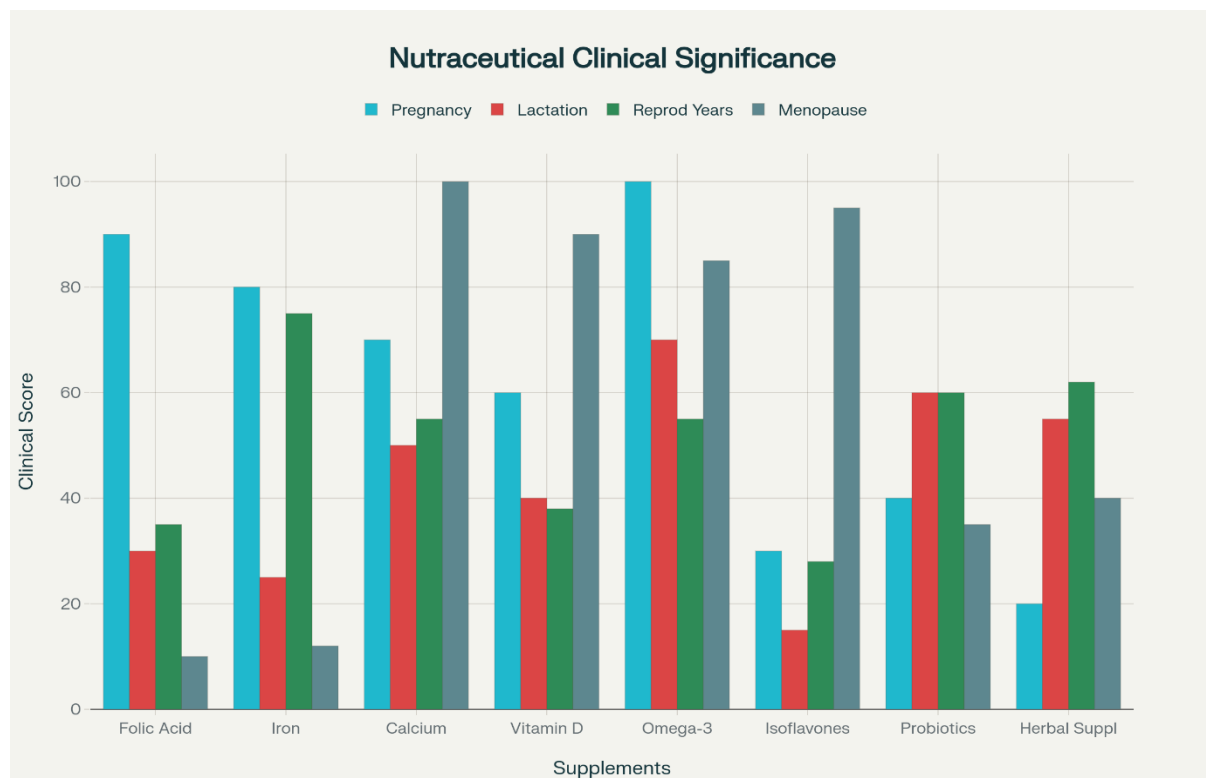


Fig No. – 4:- Nutraceutical clinical relevance by women's life stage.

Module - 4 :- Nutraceuticals in Reproductive Health

Reproductive health is central to women's well-being, influencing fertility, hormonal balance, menstrual cycles, pregnancy and quality of life. Nutraceuticals, which are bioactive compounds derived from foods and natural sources, have emerged as promising tools to support reproductive health in both preventive and therapeutic ways. Unlike synthetic drugs that often act on a single pathway, nutraceuticals can work on multiple mechanisms simultaneously, such as regulating hormones, reducing oxidative stress and improving metabolic health (Patel & Rauf., 2019).

PCOS is one of the most studied conditions in this field. Affecting nearly 10% of reproductive age women, PCOS is marked by irregular ovulation, insulin resistance and hormonal imbalance. Among nutraceuticals, inositols (myo-inositol and D-chiro-inositol) have been widely studied, showing improvements in insulin sensitivity, ovulation and pregnancy rates. A meta-analysis confirmed that myo-inositol can restore ovulation and improve metabolic health in PCOS patients with fewer side effects than standard drugs (Unfer et al., 2017).

Other nutraceuticals also support fertility. Omega-3 fatty acids improve egg quality and pregnancy outcomes, particularly in women undergoing assisted reproduction (Chiu et al., 2018). Micronutrients like folic acid, iron and vitamin D are fundamental in preconception and pregnancy. Folic acid prevents neural tube defects and is recommended globally for women planning pregnancy (De-Regil et al., 2010), while vitamin D deficiency is linked with lower fertility success rates (Farzadi et al., 2015).

Probiotics are another promising group, as they help restore vaginal microbiota, reducing infections like bacterial vaginosis that can impair fertility (Petricevic & Witt, 2008). Additionally, herbal nutraceuticals such as *Vitex agnus-cactus* (Chasteberry) and *Lepidium meyenii* (maca root) have shown potential in regulating menstrual cycles and improving sexual urge, though larger studies are needed.

In summary, nutraceuticals play a valuable role in reproductive health by complementing conventional care. From inositols for PCOS to folic acid in pregnancy, omega-3s for fertility, and probiotics for microbiome balance, they provide safe, natural and accessible options that support women across

reproductive stages. More standardized research will help strengthen their integration into clinical practice.

Module-5 :- Nutraceuticals in Pregnancy and Lactation

Pregnancy and lactation are among the most critical stages in a women's life, marked by heightened nutritional demands to support both maternal health and the growth and development of the child. Adequate nutrition during these stages not only ensures safe pregnancy outcomes but also sets the foundation for lifelong health in the offspring. In this context, nutraceuticals, bioactive compounds from food and natural sources offer preventive and therapeutic benefits that complement conventional nutritional care. They contribute to fetal growth, maternal well-being, lactation quality and even long-term disease prevention (Patel & Rauf., 2019). One of the most important nutraceuticals in pregnancy is folic acid, which plays a key role in DNA synthesis and neural tube formation. Periconceptional folic acid supplementation has been shown to reduce the risk of neural tube defects by up to 70%, making it a cornerstone recommendation for women planning pregnancy (De-Regil et al., 2010). Similarly, iron is essential to prevent maternal anemia, a condition that affects nearly 40% of pregnant women world wide and is linked with preterm birth and low birth weight (WHO., 2021).

Calcium and vitamin D are critical for skeletal development and maternal hypertension and preeclampsia, while ensuring proper fetal bone mineralization (Hofmeyr et al., 2014). Omega-3 fatty acids particularly DHA, have gained attention for supporting fetal brain and retinal development. Maternal DHA supplementation has been associated with improved cognitive outcomes in infants and reduced risk of preterm birth (Greenberg et al., 2008).

During lactation, nutraceuticals influence both the quality and composition of breast milk. Omega-3 fatty acids consumed by the mother enrich breast milk DHA, supporting neonatal neurodevelopment (Koletzko et al., 2008). Probiotics taken during late pregnancy and lactation may reduce the risk of infant eczema and allergies by modulating maternal and neonatal microbiota (Dotterud et al., 2010). Additionally, galactagogues, natural nutraceuticals like fenugreek and moringa are traditionally used to

enhance breast milk production, with emerging scientific evidence supporting their role in improving lactation performance (Kapoor et al., 2021).

Herbal nutraceuticals also play a complementary role. For example, ginger is widely used to alleviate nausea and vomiting in pregnancy, with multiple trials confirming its safety and efficacy when used appropriately (Viljoen et al., 2014). However, unlike vitamins and minerals, herbal supplements require careful evaluation, as dosage, safety and potential interactions are not always well established.

In summary, nutraceuticals in pregnancy and lactation extend beyond basic nutrition to play active roles in maternal and child health. From folic acid for neural development, iron for anemia prevention, omega-3 fatty acids for brain development, to probiotics for microbiota balance, these interventions offer safe, natural and evidence-based ways to support women during these vulnerable stages. While their potential is promising, continuous research and clinical validation are essential to ensure optional recommendations tailored to maternal and infant needs.

Module – 6 :- Nutraceuticals in Menstrual disorders and PMS

Menstrual health is an essential component of women's overall well-being, yet many face monthly challenges such as irregular cycles, dysmenorrhea (painful menstruation) and premenstrual syndrome (PMS). These conditions, though not life-threatening, can significantly affect quality of life by influencing energy levels, mood and daily productivity. Conventional treatments such as painkillers, hormonal contraceptives or antidepressants are effective for some, but they often come with side effects or may not fully address women's preferences for natural, holistic care. This has led to increasing interest in nutraceuticals – food derived bioactive compounds and herbal extracts – that provide gentle but effective support for menstrual disorders and PMS.

PMS is one of the most common menstrual disorders, affects up to 80% of women to varying degrees, with symptoms ranging from mood swings and irritability to bloating and fatigue. Research highlights the role of vitamin B6, which helps regulate neurotransmitters like serotonin, reducing mood-related symptoms of PMS (Wyatt et al., 1999). Calcium and vitamin-D have also been linked

to improved mood and reduced PMS severity, likely due to their role in neuromuscular function and hormone regulation (Thys-Jacobs et al., 1998).

For dysmenorrhea, nutraceuticals like omega-3 fatty acids have shown promising effects by reducing prostaglandin production, thereby decreasing uterine inflammation and pain (Harel et al., 1996). Similarly, magnesium supplementation has been reported to ease cramps and headaches by relaxing smooth muscles and regulating serotonin pathways (Facchinetti et al., 1991).

Herbal nutraceuticals also play a valuable role. Vitex agnus-castus (Chasteberry) is one of the most widely studied herbs for PMS. It has been shown to reduce breast tenderness, irritability and mood swings by modulating prolactin levels (Schellenberg., 2001). Ginger, traditionally used for menstrual pain, has demonstrated efficacy comparable to nonsteroidal anti-inflammatory drugs (NSAIDs) in reducing dysmenorrhea, but with fewer side effects (Ozgoli et al., 2009).

In summary, nutraceuticals provide women with natural, accessible and generally safer approaches to managing menstrual disorders and PMS. When used thoughtfully, combinations of vitamins, minerals, omega-3 fatty acids and herbal extracts can help ease physical discomfort while supporting emotional balance, thereby improving overall quality of life. Nevertheless, individualized recommendations and further large-scale clinical research are essential to define their most effective and evidence-based use.

Module – 7 :- Nutraceuticals in Polycystic ovary syndrome (PCOS)

Polycystic ovary syndrome (PCOS) is one of the most common endocrine disorders in women of reproductive age, affecting fertility, metabolism and long-term health. It is marked by irregular menstrual cycles, excess androgen levels, insulin resistance, and symptoms such as acne, weight gain and hirsutism. While conventional management often relies on lifestyle changes, insulin sensitizers and hormonal therapies, nutraceuticals are emerging as valuable adjuncts that can address multiple aspects of the syndrome in a natural and holistic manner.

7.1 – Insulin sensitivity and metabolic health-
Insulin resistance plays a central role in PCOS pathophysiology. Inositols (myo-inositol and D-chiro-inositol) are among the most studied nutraceuticals for PCOS. They improve insulin sensitivity, promote ovulation and restore menstrual

regularity by supporting proper ovarian function (Unfer et al., 2017). Supplementation with inositols has also been linked to improved oocyte quality, making them particularly important for women seeking fertility support.

7.2 - Hormonal regulation and symptom relief-

Nutraceuticals also help balance hormones and reduce androgen-related symptoms. Omega-3 fatty acids improve lipid profiles, reduce inflammation and may lower testosterone levels, contributing to improved menstrual cyclicity and reduced acne (Cussons et al., 2009). Vitamin D, frequently deficient in women with PCOS, plays a role in glucose regulation, follicular development and mood stabilization. Correcting vitamin D deficiency has been associated with improved menstrual function and metabolic outcomes (Krul-Poel et al., 2015).

7.3 - Antioxidant and anti-inflammatory support-

Oxidative stress is increasingly recognized as a contributor to PCOS. N-acetylcysteine (NAC), an antioxidant and glutathione precursor, has shown benefits in improving insulin sensitivity, restoring ovulation and reducing androgen excess (Rafraf et al., 2016). Herbal nutraceuticals such as cinnamon have also demonstrated potential in improving insulin resistance and menstrual regularity.

7.4 - Integrative approach to management-

The strength of nutraceuticals lies in their multi-targeted actions, addressing insulin resistance, hormonal imbalance, inflammation and oxidative stress simultaneously. When combined with lifestyle strategies such as balanced nutrition and regular physical activity, they provide a holistic approach to managing both reproductive and metabolic aspects of PCOS.

Module – 8 :- Nutraceuticals in Bone and Joint health

8.1 - Introduction -

Bone and joint health is a vital aspect of women's wellbeing, especially as risks for osteoporosis, osteopenia and arthritis increase with age, hormonal changes and menopause. Declining estrogen levels after menopause accelerate bone loss, making women particularly vulnerable to fractures and joint-related disabilities. While conventional therapies like hormone replacement and bisphosphonates are effective, many women prefer natural and preventive strategies. Nutraceuticals offer promising support by strengthening bone structure,

maintaining joint flexibility and reducing inflammation.

8.2 - Calcium and Vitamin D –

Calcium and vitamin D remain the cornerstones of bone health. Calcium provides the structural building block for bones, while vitamin D enhances calcium absorption and regulates bone metabolism. Studies have shown that adequate supplementation reduces fracture risk and slows bone mineral density loss in postmenopausal women (Tang et al., 2007).

8.3 - Collagen and protein supplements -

Collagen peptides are increasingly recognized for improving bone density and joint comfort. Supplementation has been linked to enhanced bone mineralization and reduced joint pain, likely due to stimulation of osteoblast activity and support for cartilage integrity (Konig et al., 2018). Adequate protein intake, whether from diet or supplements, is equally important for preserving muscle mass that protects bone health.

8.4 - Omega-3 fatty acids and antioxidants -

Chronic low-grade inflammation accelerates bone resorption and joint degeneration. Omega-3 fatty acids from fish oil not only improve bone density but also help reduce stiffness and pain in conditions like rheumatoid arthritis (Gioxari et al., 2018). Antioxidant nutraceuticals such as vitamin C, vitamin E and polyphenols protect bone cells from oxidative stress and promote collagen synthesis, thereby contributing to both bone and joint health.

8.5 - Herbal nutraceuticals –

Traditional herbal compounds also provide support. Soy isoflavones, phytoestrogens derived from soy, mimic estrogenic activity and have been shown to improve bone mineral density in postmenopausal women (Ma et al., 2008). Similarly, curcumin from turmeric has anti-inflammatory effects that may alleviate joint discomfort and protect cartilage.

In summary, nutraceuticals do not replace medical therapies but serve as valuable allies in maintaining strong bones and healthy joints across a woman's lifespan. By combining foundational nutrients like calcium and vitamin D with emerging options such as collagen, omega-3 fatty acids and phytoestrogens, women can adopt a holistic, natural approach to reducing their long-term risk of fractures and joint degeneration.

Module – 9 :- Nutraceuticals in Menopause and Health Aging

9.1 - Introduction -

Menopause is a natural phase in a woman's life, yet it is often accompanied by challenges such as hot flashes, night sweats, mood swings, sleep disturbances and increased susceptibility to osteoporosis and cardiovascular disease. These changes are primarily driven by the decline in estrogen, which impacts multiple systems throughout the body. Although hormone replacement therapy (HRT) remains an effective option, many women prefer nutraceuticals as gentler, safer and more holistic approaches to ease symptoms and support long-term health.

9.2 - Phytoestrogens and Isoflavones:

Phytoestrogens are naturally occurring plant compounds that resemble the structure of estrogen and can weakly bind to estrogen receptors in the body. During menopause, when estrogen levels decline, these compounds provide a gentle alternative that helps bridge the hormonal gap without the risks associated with synthetic hormone therapy. Among the different classes of phytoestrogens, soy isoflavones are the most extensively studied. It has shown significant benefits in reducing vasomotor symptoms like hot flashes and night sweats. They also support bone mineral density by exerting mild estrogen-like effects on bone tissue (Chen et al., 2015). Flaxseed lignans, another source of phytoestrogens, contribute both estrogenic activity and cardiovascular protection.

9.3 - Omega-3 fatty acids:

Menopause is often associated with metabolic changes, including altered lipid profiles and increased risk of heart disease. Omega-3 fatty acids from fish oil offer anti-inflammatory benefits, improve cholesterol balance and reduce cardiovascular risk (Gioxari et al., 2018). They also support cognitive function and emotional well-being, making them particularly valuable for women experiencing mood swings, anxiety or sleep difficulties during this transition.

9.4 - Holistic benefits for healthy aging:

When used together, phytoestrogens, isoflavones and omega-3 fatty acids create a complementary strategy for supporting women during menopause and healthy aging. This combination not only eases vasomotor symptoms such as hot flashes and night sweats but also strengthens bone health. Safeguards cardiovascular function and nurtures cognitive resilience. Unlike conventional single-target therapies, these nutraceuticals act across multiple

physiological pathways, making them well-suited to address the diverse and interconnected challenges women face in this life stage.

In summary, nutraceuticals such as phytoestrogens, soy isoflavones and omega-3 fatty acids provide women with safe, accessible and evidence-based options to ease menopausal symptoms and promote healthy aging. While they cannot fully replace medical therapies, they empower women to take a natural approach that enhances quality of life well into later years.

Module – 10 :- Nutraceuticals in Urogenital health

Urogenital health is a vital component of women's overall well-being, yet it is frequently affected by conditions such as recurrent urinary tract infections (UTIs), bacterial vaginosis (BV), vulvovaginal atrophy, and bladder dysfunction, particularly during menopause and aging. Although antibiotics and hormonal therapies remain the standard of care, nutraceuticals are increasingly recognized as safe, supportive and preventive options for sustaining urogenital balance.

Among the most extensively studied interventions is cranberry extract, rich in proanthocyanidins that prevent bacteria from adhering to the urinary tract lining, thereby lowering the risk of recurrent UTIs (Gupta et al., 2007). Probiotics, especially *Lactobacillus* strains, also play a central role by restoring healthy vaginal microbiota. They help reduce the risk of BV and yeast infections by lowering vaginal pH, producing antimicrobial compounds and strengthening mucosal immunity (Reid, 2016).

For women facing urogenital symptoms linked to menopause, nutraceuticals such as soy isoflavones and black cohosh have demonstrated estrogen-like effects that improve vaginal lubrication, alleviate dryness and enhance comfort during intercourse (Chen et al., 2015). In addition, omega-3 fatty acids and vitamin D contribute to urogenital health through their anti-inflammatory actions and immune-supporting roles, which indirectly benefit both bladder and vaginal function.

What makes nutraceuticals particularly valuable is their preventive and holistic approach. Instead of focusing solely on symptom relief, they enhance host defenses, strengthen microbiota resilience, and correct underlying nutritional gaps. Still, while the evidence is encouraging further large-scale clinical

trials are necessary to establish optimal dosages, formulations and long-term safety.

In summary, nutraceuticals such as cranberry extract, probiotics, phytoestrogens and essential fatty acids offer women natural and accessible strategies to maintain urogenital health. When combined with conventional treatments, they provide a more comprehensive and sustainable approach to managing these sensitive aspects of women's health.

Nutraceuticals and their primary benefits:

- Cranberry extract:- Prevents recurrent urinary tract infections.
- Probiotics (*Lactobacillus spp.*) :- Restores vaginal microbiota, prevents BV and yeast infection.
- Soy isoflavones :- Reduces vaginal dryness and discomfort during menopause.
- Black cohosh :- Relieves menopausal urogenital symptoms.
- Omega-3 fatty acids:- Supports bladder function, reduces inflammation.
- Vitamin D :- Enhances immune defense and mucosal health.
- Flaxseed lignans:- Contributes to vaginal health and cardiovascular protection.

Module – 11:- Nutraceuticals in Mental health and Cognition

Women's mental health and cognitive performance are deeply influenced by hormonal transitions, stress and aging, often leading to challenges such as depression, anxiety and memory decline. Nutraceuticals are increasingly being recognized as natural, supportive strategies that complement conventional therapies by promoting emotional balance and brain vitality.

Among the most valuable are omega-3 fatty acids, well known for their role in improving mood, reducing depressive symptoms and protecting against cognitive decline. They achieve this by supporting neuronal membrane function, regulating neurotransmitter activity and reducing neuroinflammation, all of which are essential for mental resilience.

B Vitamins, including folate, vitamin B6 and vitamin B12 also play a central role in brain health. These vitamins are critical for neurotransmitter production and homocysteine regulation, and low levels have been strongly linked with mood

disorders and cognitive impairment. Supplementation, on the other hand, has been shown to improve mood stability and slow the progression of age-related memory loss.

Vitamin D, often described as a neurosteroid. Beyond its role in bone health, it supports serotonin synthesis and helps regulate inflammation in the brain. Deficiency in vitamin D has been associated with a greater risk of depression and cognitive decline, especially in postmenopausal women.

Herbal nutraceuticals provide additional support. St. John's Wort is widely studied for its ability to ease mild to moderate depression by modulating serotonin, dopamine and norepinephrine activity. Similarly, Ginkgo biloba enhances memory, concentration and overall cognitive performance through antioxidant protection and by improving blood flow to the brain.

What makes these nutraceuticals particularly important is their multi-targeted action. Unlike single-pathway drugs, omega-3 fatty acids, vitamin D, B vitamins and selected herbal extracts act across multiple systems- supporting neurotransmitters, reducing oxidative stress, improving vascular health and strengthening immunity. This broad approach makes them well suited to the interconnected challenges women face in mental and cognitive health across life stages.

In summary, nutraceuticals such as omega-3 fatty acids, B vitamins, vitamin D and herbal supplements like St. John's Wort and Ginkgo biloba offer women safe, natural and holistic ways to protect mental health and support cognition. While further research is still needed to refine dosing and confirm long-term effects, current evidence highlights their potential as powerful allies in promoting emotional balance and cognitive vitality throughout a woman's life.

Module – 12 :- Nutraceuticals in Cardiovascular and metabolic health

Cardiovascular and metabolic disorders, including hypertension, obesity, dyslipidemia and metabolic syndrome, are major health challenges for women, particularly with aging and hormonal transitions. While lifestyle modifications and medications remain central to treatment, nutraceuticals have emerged as complementary and natural strategies that target multiple biological pathways at once.

Omega-3 fatty acids, found in fish oil and flaxseed, play a central role in cardiovascular health. They

lower triglyceride levels, improve vascular elasticity, and reduce inflammation, thereby lowering the risk of hypertension and atherosclerosis (Mozaffarin & Wu., 2011). Similarly, plant sterols and stanols compete with cholesterol absorption in the gut, leading to significant reductions in LDL cholesterol.

Soluble fibers such as beta-glucan from oats and psyllium also improve lipid profiles while supporting satiety and weight management, making them particularly valuable in obesity and metabolic syndrome. Additionally, polyphenols from green tea, cocoa and berries act as antioxidant and anti-inflammatory agents, supporting vascular health while enhancing insulin sensitivity.

Micronutrients such as B vitamins (B6, B12, folate) contribute by lowering homocysteine levels, a risk factor for cardiovascular disease, while coenzyme Q10 enhances mitochondrial energy production and has shown benefits in managing hypertension and statin-induced muscle weakness (Flowers et al., 2022). In addition, vitamin D, which is often deficient in women, supports vascular function and metabolic regulation.

The strength of nutraceuticals lies in their ability to address interconnected risk factors such as blood pressure, cholesterol, glucose balance and weight—rather than focusing on a single outcome. By

working synergistically with diet and lifestyle changes, they provide women with safer, preventive and long-term tools to support cardiovascular and metabolic health. Still, More large-scale clinical trials are needed to establish the most effective combinations and dosing strategies for individualized care.

Summary of nutraceuticals and their benefits in cardiovascular and metabolic health:-

- Omega-3 fatty acids – Reduce triglycerides, improve vascular elasticity, lower inflammation.
- Plant sterols/ stanols – Block cholesterol absorption in the gut.
- Soluble fibers (β -glucan, psyllium) – Improves lipid profile, enhances satiety, helps weight management.
- Polyphenols (Green tea, cocoa, berries) – Antioxidant & anti-inflammatory effects, improves insulin sensitivity.
- B vitamins (B6, B12, folate) – Lowers homocysteine levels.
- Coenzyme Q10 – Supports mitochondrial function, lowers BP, reduces statin side effects,
- Vitamin D – Enhances vascular function & metabolic regulation.

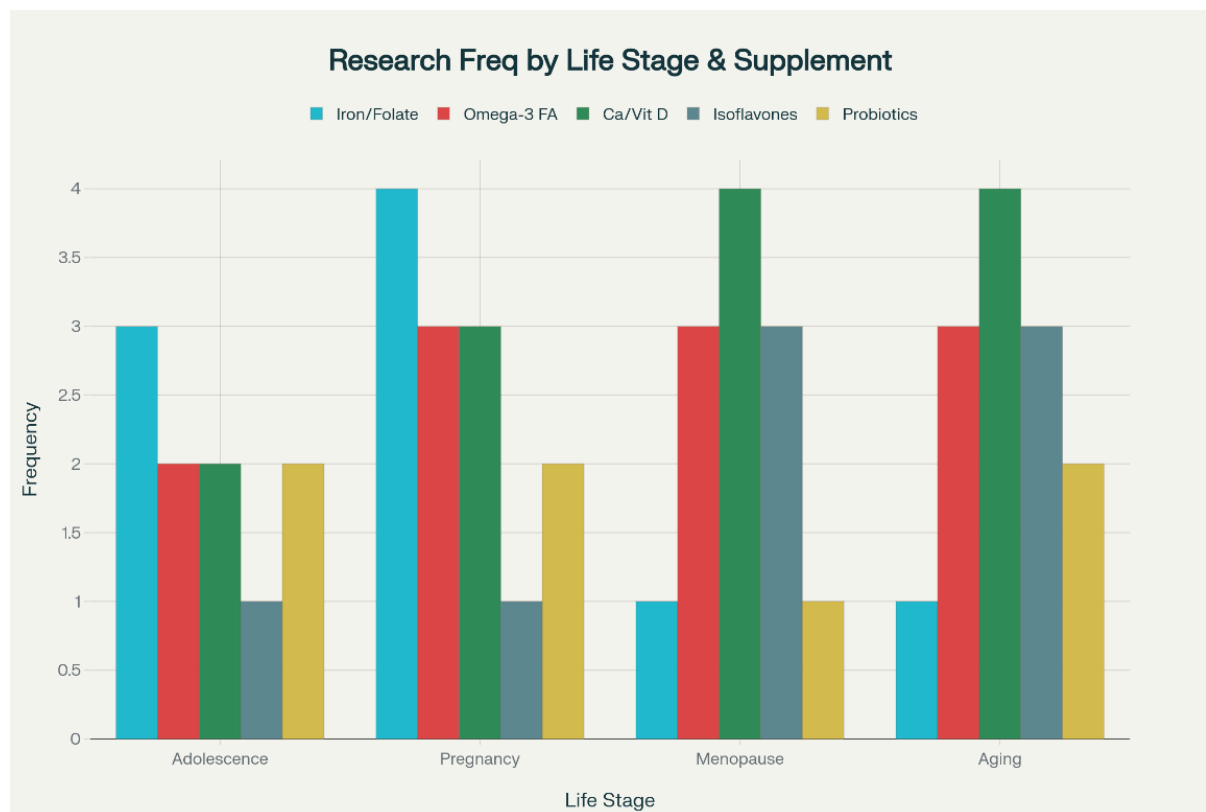


Fig No. – 5:- Clinical research frequency graph by supplement and life stages.

This graph highlights how research focus on specific supplements shifts according to women's health stages, with Iron/Folate most studied during pregnancy, Calcium/Vitamin D during menopause and aging, and Omega-3 fatty acids maintaining high relevance across all life stages.

Module – 13 :- Safety, Regulation and quality of nutraceuticals

The increasing use of nutraceuticals in women's health brings attention to the importance of evaluating their clinical safety, global regulations and quality assurance. Although often perceived as "natural and safe", nutraceuticals can pose risks when used inappropriately, taken in excessive doses or combined with prescription medications. For example, high intakes of fat-soluble vitamins (A, D, E, K) may cause toxicity, while herbal products such as St. John's Wort can interfere with drug metabolism and reduce the efficacy of contraceptives or antidepressants (Posadzki et al., 2013). Therefore, clinical safety must be carefully considered, particularly in sensitive stages like pregnancy, lactation and menopause.

Regulation of nutraceuticals varies worldwide. In the United States, they are classified as dietary supplements under the Dietary Supplement Health and Education Act (DSHEA), meaning they do not require pre-market clinical trial evidence but must be safe and properly labeled. In the European Union, they fall under food law, with strict oversight of labeling and health claims. India regulates them under the Food Safety and Standards, Authority of India (FSSAI), while Japan includes them as Foods for Specified Health Uses (FOSHU). This diversity in global frameworks can create uncertainty for both consumers and healthcare providers, reinforcing the need for international harmonization and stronger evidence-based guidelines (Ariens et al., 2019).

Ensuring quality assurance is another critical challenge. Issues such as adulteration, mislabeling, contamination and variability in bioactive content are well-documented. Adopting Good Manufacturing Practices (GMP), third-party testing, and standardization of formulations are vital steps to improve safety and consumer trust. Advanced techniques like DNA barcoding and chromatography are also being applied to verify the authenticity of herbal products and prevent adulteration (Ichim & de Boer., 2021).

In summary, nutraceuticals have great potential to support women's health, but their safe and effective use depends on clinical safety evaluations, harmonized regulatory standards, and strict quality control. Building stronger global frameworks and encouraging transparent labeling will not only protect consumers but also strengthen trust in women's health supplements.

Module – 14:- Gaps and Limitations in current clinical evidence

14.1 - Identified gaps-

Despite the growing interest in nutraceuticals for women's health, the current clinical evidence is limited by several critical gaps and challenges. A major issue lies in trial design flaws including small sample sizes, short durations and lack of standardized protocols. Many studies focus on biochemical markers rather than clinically meaningful outcomes such as reduced fracture risk, improved fertility, or enhanced quality of life, which limits their real-world applicability (Ioannidis, 2016).

Another significant challenge is the underrepresentation of diverse populations in research. Women from different ethnic, socioeconomic and age groups- particularly pregnant, lactating and postmenopausal women, are often excluded or poorly represented. This makes it difficult to generalize findings across the full spectrum of women's health needs.

Inconsistent outcomes are another limitation. Trials of the same nutraceutical, such as soy isoflavones or probiotics, often report conflicting results due to differences in dosage, formulations and study populations (Lopez-Martinez et al., 2021). This lack of standardization creates confusion for both clinicians and consumers, making it hard to establish evidence-based recommendations.

Equally important is the lack of long-term safety data. While nutraceuticals are generally considered safe, chronic use, high doses or interactions with prescription drugs are poorly studied. For instance, fat-soluble vitamins can accumulate and cause toxicity, and herbal nutraceuticals may interfere with drug metabolism (Kaur et al., 2022).

The regulatory environment contributes to these limitations. Since nutraceuticals are often classified as supplements or foods rather than

pharmaceuticals, rigorous clinical trials are not always required for market approval. This regulatory gap leads to widespread consumer use of products without sufficient clinical validation.

In summary, the clinical evidence base for nutraceuticals in women's health is promising but incomplete. Addressing these gaps, through larger, longer and safety assessments, is essential to move the field from preliminary promise to evidence-based practice.

14.2 - Filled gaps-

Gaps identified in the clinical study map on women's health nutraceuticals can be filled by implementing more rigorous, inclusive and innovative research approaches as well as improving regulatory and clinical practices.

Strategies to fill research gaps:

- Expand Large-scale clinical trials-

Future studies should recruit more participants and extend follow-up durations to obtain generalizable results across all major life stages for women.

- Standardize study designs and interventions-
Adopt uniform protocols for product formulations, dosages and outcome measures to reduce inconsistencies and enable meta-analyses, which will help validate the real-world effectiveness of nutraceuticals.
- Incorporate diverse populations-
Make diversity a recruitment in research enrollment. Ensure participation by women from different socioeconomic, ethnic and age groups so findings apply to broader populations.
- Emphasize real-world outcomes-
Shift focus from only biochemical markers to clinically meaningful results such as improved quality of life, symptom relief and disease prevention.
- Strengthen long-term safety monitoring-
Require extended follow-up and post-market surveillance to document the long-term safety and side effects to chronic nutraceutical use. Ensure clinicians and consumers have access to safety profiles.
- Adopt personalized nutrition approaches-
Use genomics, metabolomics and microbiome analysis to develop precision nutraceutical recommendations tailored to individual women's genetic, metabolic and lifestyle factors.

- Leverage innovative study designs and digital tools-

Employ adaptive trials, patient reported outcomes and continuous, real-time study mapping using digital health technology for practical data collection and updated evidence landscapes.

Research roadmap for future progress:-

- Integrate personalized genomic and microbiome data-
Utilize advanced data analytics to personalize supplement recommendations based on each women's genetic profile and gut microbiome, enhancing effectiveness while reducing adverse reactions.
- Promote cross- sector collaboration-
Encourage researchers, healthcare providers and policymakers to share data and strategies for integrating nutraceuticals into standardized healthcare pathways.
- Refine quality assurance protocols-
Advance quality verification with modern analytical tools, ensuring women receive safe, authentic and clinically validated supplements.

By taking these steps, the evidence landscape and practical value of nutraceuticals for women's health will advance, from supporting supplements to comprehensive, trusted solutions for wellbeing across the lifespan.

Module – 15:- Future directions in nutraceutical research for women's health

The future of nutraceutical research in women's health requires moving beyond current limitations by focusing on personalized strategies, modern research approaches and stronger policy support. Although many studies highlight the promise of nutraceuticals in managing menopause, urogenital conditions and cardiovascular health, the next step is to generate more consistent and clinically relevant evidence.

One major direction is the advancement of personalized nutrition. Women's nutritional requirements shift across different life stages and are influenced by factors such as genetics, hormones, microbiome composition and lifestyle. Incorporating tools like genomics, metabolomics and microbiome analysis could help design interventions that are tailored to individual needs. Such approaches may clarify which women benefit most from specific nutraceuticals, such as omega-3

fatty acids, phytoestrogens or probiotics, reducing inconsistent outcomes often seen in current studies (Ordovas et al., 2018).

Another critical step involves adopting innovative study models. Conventional randomized controlled trials, while important, may not fully capture the complexity of women's health. Approaches such as adaptive trials, real-world evidence studies, and the use of digital health tools can provide deeper insights into both safety and effectiveness. The integration of wearable devices and patient-reported outcomes will also allow for more patient-centered and practical evaluations (Sherman et al., 2019).

Equally important is strengthening global regulation and evidence-based policies. At present, there are wide differences in how nutraceuticals are regulated across regions, leading to issues with quality, labeling and health claims. Establishing harmonized international standards, guided by high-quality clinical evidence, would improve safety, ensure consistency and support the responsible integration of nutraceuticals into healthcare. Greater collaboration among researchers, clinicians, industry and policymakers will be key in achieving this (Dwyer et al., 2018).

In summary, the future of nutraceuticals in women's health will depend on precision-driven research, innovative trial designs, and stronger policy frameworks. By embracing these directions, nutraceuticals can progress from being supportive tools to becoming trusted, evidence-based strategies for promoting women's health across all stages of life.

CONCLUSION

Nutraceuticals represent a rapidly expanding field in women's health, offering natural, accessible and often safer alternatives to conventional therapies. Across this study map, evidence demonstrates their role in alleviating menstrual discomfort, supporting reproductive and urogenital health, managing cardiometabolic risk, enhancing cognition, preserving bone density and easing menopausal transitions. Their multisystem effects reflect the holistic nature of women's health needs, making them attractive for long-term wellness strategies.

However, significant gaps remain. Much of the current research is constrained by small sample sizes, inconsistent study designs and lack of standardized formulations, which limits clinical

translation. In addition, women from diverse populations and life stages are still underrepresented in clinical trials, raising concerns about equity and generalizability. Moving forward, progress in this field will depend on the adoption of personalized nutrition approaches, the use of innovative study frameworks, and the development of harmonized international policies to ensure quality, safety and efficacy.

In essence, nutraceuticals hold the potential to become trusted, evidence-based interventions that empower women across all stages of life. With rigorous science and regulatory support, they can transition from supportive supplements into comprehensive strategies for achieving sustainable health and well-being.

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