



**Department of Health Sciences
School of Medicine**

Master's degree in medical biotechnology

**How Gut Microbiota Influence Healthy Aging:
Overview of reviews**

Mentors

Prof. Alice Massini

Dr. Rabia Bibi

Candidate

Tejas Ganesh Todmal

Matricular no.:20054811

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Summary

Rationale of the Study

Aging is most frequently associated with chronic diseases, frailty, inflammation, and cognitive decline, which significantly impact quality of life. Contemporary evidence indicates that gut microbiota plays a crucial role in regulating metabolic, immune, and neurological functions that influence aging processes. Since diet and lifestyle are major modulators of gut microbiota composition, exploring dietary and lifestyle-based interventions may provide valuable insights into promoting healthy aging. The “News of the Week” project aims to translate recent scientific evidence on the role of gut microbiota in healthy aging into simplified, accessible information for public understanding.

Methodology

This overview of reviews was conducted following a predefined inclusion and exclusion criterion. Articles published between 2023 and 2025 were selected, and only English-language, human-based review studies examining the relationship between gut microbiota, diet, lifestyle factors, and aging were included. Non-human studies and articles not directly addressing gut microbiota or healthy aging were excluded.

Results

Total seven review studies met the inclusion criteria and demonstrated a strong association between gut microbiota modulation and healthy aging. Dietary patterns such as the Mediterranean diet, calorie restriction, and plant-based diets were consistently associated with increased gut microbial diversity and higher abundance of beneficial bacteria, including short-chain fatty acid-producing taxa. These microbial changes were linked to reduced inflammation, improved metabolic health, enhanced immune function, and better cognitive outcomes.

Conclusion

Modulation of gut microbiota through dietary and lifestyle interventions represents a promising approach to promote healthy aging and longevity. Strategies such as Mediterranean-style diets, calorie restriction, and microbiota-targeted therapies may help reduce inflammation, improve metabolic balance, and support cognitive and physical health.

1. Introduction

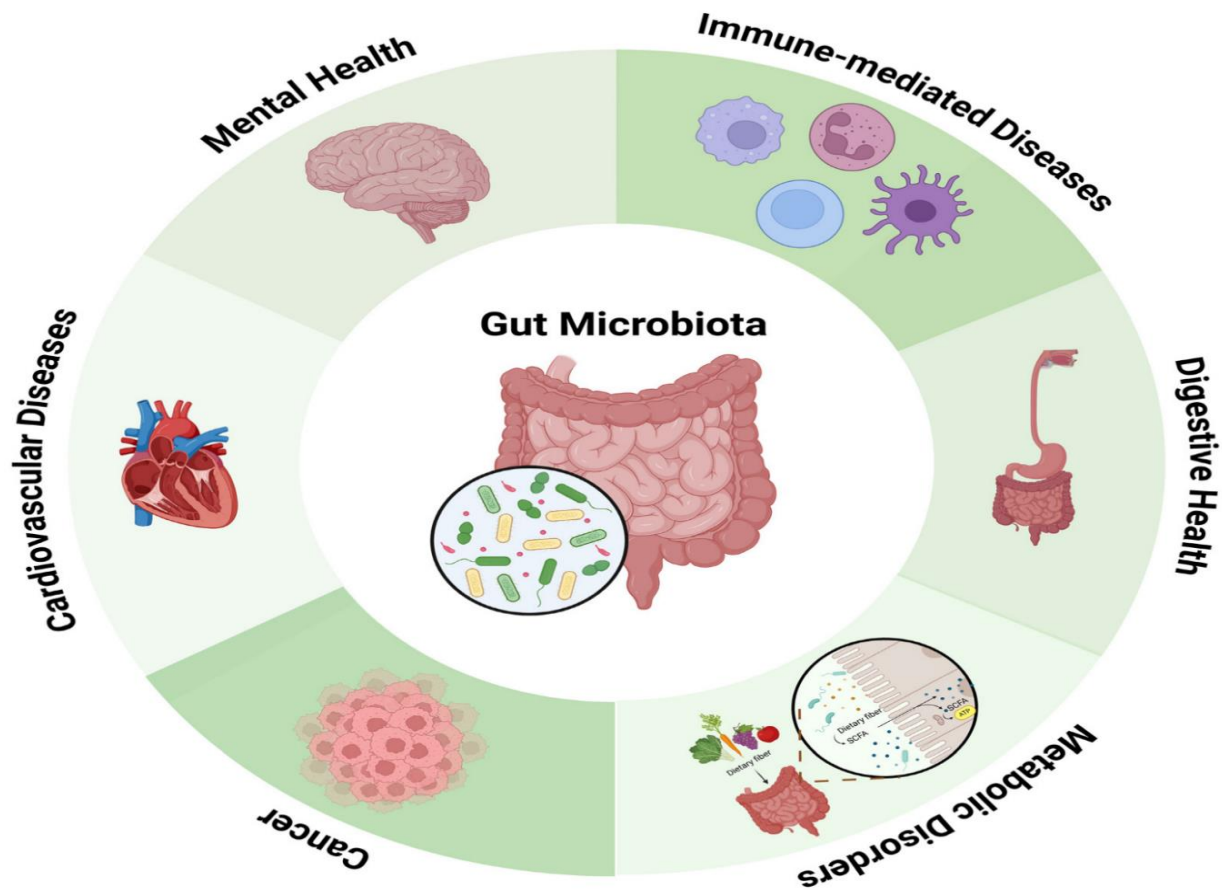
Longevity, active and healthy ageing:

An aging population is increasing throughout the world. According to the World Health Organization, the number of people over 60 and over it will be nearly twice the size, from 12% in 2015 to 22% by 2050 (*Ageing-and-Health*, n.d.). These changes bring challenges and opportunities for health systems, societies, and economies. Moreover, since the last century, life expectancy has also increased, leading to good health and being free from chronic diseases, and functional decline has become one of the main goals of modern healthcare(Shreya et al., 2025).

Healthy ageing, as defined by the WHO, is the process of developing and maintaining the functional ability that enables well-being in older age (Venkatapuram & Amuthavalli Thiyagarajan, 2023) . It comprises physical, mental, and social aspects, which further lead to sustaining autonomy, resilience, and quality of life. Active Ageing is a closely related concept that focuses on optimizing health opportunities, participation, and security to better the quality of life of aging people(Trică et al., 2024). Collectively, these concepts range from disease management to health promotion, prevention, and functional capacity maintenance.

The ability to live advanced age is known as longevity, but it is also viewed in a way of health span, lived in good health without any frailty or disability(Garmany et al., 2021). Recent studies show that lifestyle factors such as nutrition, physical activity, and psychological engagement play an important role in increasing lifespan and health span (Gianfredi et al., 2025). Moreover, along with these factors, emerging evidence has shown that gut microbiota is an important aspect of healthy aging and longevity(Upadhyay et al., 2025).

Figure1: Gut microbiota and disease connections



Source: Yaqub, M.O.; Jain, A.; Joseph, C.E.; Edison, L.K. *Microbiome-Driven Therapeutics: From Gut Health to Precision Medicine. Gastrointest. Disord.* **2025**, *7*, 7. <https://doi.org/10.3390/gidisord7010007>

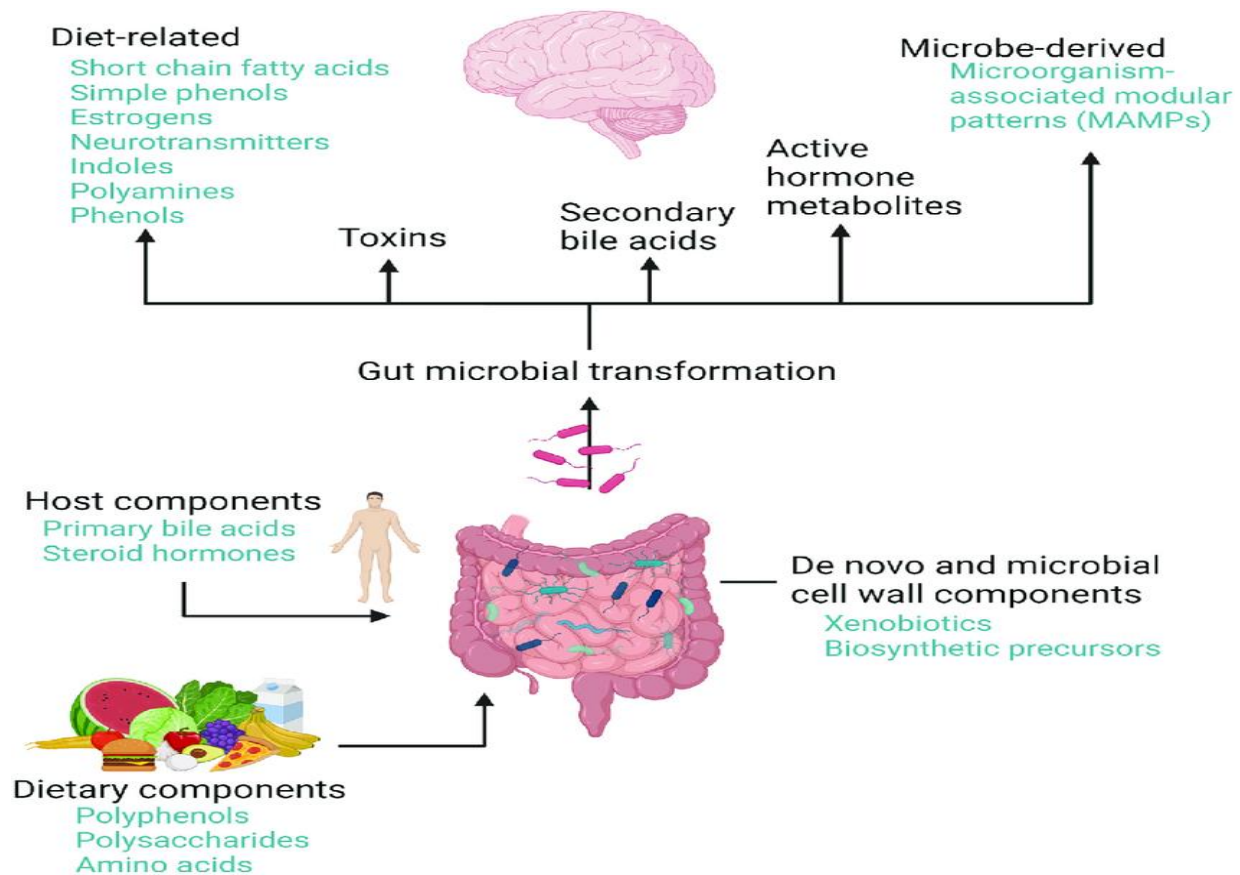
The gut microorganisms have trillions of microorganisms that are found in the gastrointestinal tract, which influence metabolic, immune, and cognitive functions. With an increase in lifespan, the composition of the gut microbiota changes. This age-related dysbiosis causes inflammation, metabolic dysfunction, cognitive decline, and frailty (Salazar et al., 2023). In Contrast, a balanced and diverse gut microbiota leads to improved immunity, metabolic regulation, and neuroprotection, all of which contribute to healthy aging (Beaver et al., 2025) .

For shaping of gut microbiome, dietary patterns play an important role. In which diet-rich foods that include fibers, polyphenols, and plant-based foods, such as the Mediterranean Diet, are essential as they enhance essential microbes such as *Bifidobacterium*, *Faecalibacterium prausnitzii*, and *Akkermansia muciniphila* that produce short-chain Fatty acids, which are

beneficial for intestinal and systemic health (Perrone & D'Angelo, 2025). Opposite of which the western diets include processed food, refined sugars, and saturated fats, which leads to microbial imbalance and chronic low-grade inflammation, which results in the enhancement of the ageing process (Clemente-Suárez et al., 2023).

Therefore, understanding the correlation between diet, gut microbiota, and ageing offers new possibilities for promoting active and healthy longevity. This thesis is based on recent evidence from 2023-2025 on how dietary and lifestyle interventions affect gut microbiota composition and function, and also the effect of microbial changes on healthy aging. By including the insights from these recent studies, this work highlights strategies that are evidence-based based which are capable of extending health span and improving quality of life in older adults.

Figure 2: Brain Gut Microbiome Interaction



Source: Dong, Tien & Mayer, Emeran. (2024). *Advances in Brain-Gut-Microbiome Interactions: A Comprehensive Update on Signaling Mechanisms, Disorders, and Therapeutic Implications*. *Cellular and molecular gastroenterology and hepatology*. 18. 10.1016/j.jcmgh.2024.01.024.

1.1. Lifestyle Medicine

A branch of Medicine that focuses on preventive health care and self-care is called Lifestyle Medicine (LM). Disorders caused by lifestyle factors, preventable causes of death like poor nutrition, lack of exercise, chronic stress, and self-destructive behaviors such as smoking, drug, and alcohol abuse, are prevented, researched, educated, and treated in lifestyle medicine (Frates et al., 2024). The primary focus of lifestyle medicine is to maintain a healthy lifestyle with the help of taking proper nutrition and regular exercise to maintain a healthy body and to cure or treat chronic disease to some extent (Lippman et al., 2024). On the other hand, the conventional approach mostly relies on pharmacological treatment; LM focuses on the major cause of illness by observing the behavioral changes related to nutrition, physical activity, stress management, sleep, hygiene, restricting harmful substances, and indulging in social connectedness(Sadiq, 2023). LM bridges a gap for an individual to follow sustainable, health-promoting behaviors. This patient-focused approach not only aims to reduce disease burden but also improves overall quality of life and longevity(J. A. Matthews et al., 2024).

1.1.1 Pillars of Lifestyle Medicine

Pillars of Lifestyle Medicine: By using the Six Pillars of lifestyle Medicine, i.e., Nutrition, regular physical activity, restorative sleep, stress management, avoidance of risky substances, and positive social connections, LM aims to improve individual health, well-being, and to prevent chronic conditions like cardiovascular disease, diabetes, metabolic syndrome and obesity (Lippman et al., 2024). To give a brief impression of Pillars of LM, they are explained as follows:

Figure 3: Diet and lifestyle impact the development



Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/The-components-of-lifestyle-medicine-Lifestyle-medicine-focuses-on-six-pillars-of-a_fig1_372410795

1.1.1.1 Whole food and Plant Predominated Diet

The main foundation of LM is a whole food, which mainly consists of plant-predominant diet, which plays a main role in preventing and reversing chronic disease. They are rich in dietary fibers, antioxidants, polyphenols, and unsaturated fatty acids, which are beneficial in cardiovascular, metabolic, and gastrointestinal health also help to reduce systemic inflammation (Landry & Ward, 2024). Dietary patterns are a key mechanism that modulates the gut microbiota. Many diverse and beneficial bacteria, such as *Faecalibacterium prausnitzii*, *Bifidobacterium*, and *Akkermansia muciniphila*, are fostered as this plant-based and high fiber diet helps to

maintain the diverse and balanced gut microbiome(Fu et al., 2022). These microbes play an important role in fermenting dietary fibers into short-chain fatty acids(SCFAs) like butyrate, resulting in a strengthened gut barrier, reduced chronic inflammation, and improved metabolic health, which play a key factor in healthy aging and longevity (Morrison & Preston, 2016). Also, following Mediterranean-style diets, which include fruits, vegetables, legumes, and whole grains, has shown improvement in gut microbiota, reduced frailty, and delayed age-related decline in elderly individuals (Ghosh et al., 2020). This represents that dietary intervention supports gut health, as well as playing a major role in promoting healthy aging. Plant predominantly plant-based diet is a stepping stone of Lifestyle Medicine, as it plays an important role in preventing and reversing chronic disease (Landry & Ward, 2024). As it begins rich in dietary fibers, antioxidants, polyphenols, and unsaturated fatty acids, which help in promoting cardiovascular, metabolic, and gastrointestinal health while reducing systemic inflammation, this dietary pattern exerts its benefit by modulating the gut microbiota (Abrignani et al., 2024). From this, we can say that diet interventions not only support gut health but are also powerful tools in promoting healthy aging.

1.1.1.2. Physical Activity

As for good health, it's suggested that there should be 150 minutes of moderate intensity exercise per week, which may include walking, cycling, or swimming, which in turn helps to support heart health, bone strength, and mental health (DHULI et al., 2022). Physical Activity plays a key role in Lifestyle Medicine, which prevents, manages, and even reverse chronic conditions like cardiovascular disease, obesity, type 2 diabetes, and mental health disorders. Specifically, exercise enhances insulin sensitivity, reduces inflammation, improves mitochondrial function, and slows biological aging by activating cellular repair pathways such as AMPK and PGC-1 α (Gibson et al., 2025). Physical activity also impacts gut microbiota by being beneficial for the growth of bacteria like *Faecalibacterium prausnitzii* and *Akkermansia muciniphila*, which support gut homeostasis and reduce inflammation(Varghese et al., 2024). This correlation of exercise and microbiota contributes to better metabolic health and plays a pivotal role in promoting healthy aging. Along with this, there is an enhancement of brain-derived neurotropic factors that support cognitive health by promoting neuroplasticity and protecting against age-related neurodegeneration, also it is also associated with telomere preservation that further extends health span and longevity(Romero Garavito et al., 2025).

1.1.3 Restorative Sleep

Disturbed Sleep cycle has been linked with obesity, depression, diabetes, and weakened immunity. This further causes hindrance to a healthy lifespan, leading to chronic disease. To avoid this, proper 7-9 hours of quality sleep are required for rejuvenation. Proper Sleep is associated with optimal physical, mental, and metabolic health(Reis et al., 2018). Restorative sleep helps in hormonal balance, reduces cortisol levels, and supports metabolic homeostasis, which is an important factor in disease prevention and healthy aging(Jiao et al., 2025). Sleep plays an important role in Gut health and microbiota balance, which avoids decreased microbial diversity and increased gut permeability, which further triggers systemic inflammation and metabolic dysfunction (Dos Santos & Galiè, 2024). It's seen that consistent and adequate sleep results in circadian regulation of the gut microbiome, which directly influences digestion, immunity, and good mood regulation(Vučković & Melvan, 2024). Moreover, proper sleep supports detoxification through the glymphatic system, sharpening the memory and increasing emotional regulation, hence securing against the risk of neurodegenerative disorder and promoting healthy cognitive aging(Voumvourakis et al., 2023). Therefore, restorative sleep as an intervention for a therapeutic lifestyle is necessary for healthy aging of the brain and for longevity.

1.1.4.Stress Management

Activities such as meditation, deep breathing, yoga, and mindfulness lower chronic stress, which in turn lowers blood pressure, lifts mood, and enhances the immune system. Systematic stress management is an important pillar of Lifestyle Medicine, as chronic psychological stress is a contributing factor to various health problems like cardiovascular disease, metabolic disorders, depression, and impaired immune function (Keng et al., 2011). Frequently, activation of the hypothalamic pituitary adrenal (HPA) axis causes an increase in cortisol levels, systemic inflammation, and accelerated biological aging (Mbiydzenyuy & Qulu, 2024). Chronic Stress negatively affects gut health, causing dysbiosis, increased intestinal permeability, and altered microbial composition(Warren et al., 2024). As per the correlation of the gut-brain axis, stress negatively affects the homeostasis of the gut microbiota, which, on the other hand, leads to stress-related symptoms like depression and anxiety(Clapp et al., 2017). For stress management, there are several interventions, such as mindfulness, meditation, yoga, and breathing exercises, that

have shown positive results by reducing stress-induced inflammation and by improving gut microbiota diversity. Stress management intervention is multi-beneficial as it also leads to telomere shortening, improved heart rate variability, and also have enhanced emotional resilience, all of which lead to an increase in lifespan and healthy aging (Epel & Prather, 2018). Including an effective stress management strategy is a must not only for mental well-being but also for supporting gut integrity, immunity, and longevity.

1.1.5. Avoidance of Risky Substances

It has been observed that avoiding or limiting the use of risky substances such as tobacco, excessive alcohol, and recreational drugs reduces the risk of cancer, liver disease, addiction, and mental health issues (Atzendorf et al., 2019). Therefore, Avoidance of risk substances is a basic pillar of lifestyle medicine. These risky substances are a major contributing factor to morbidity as well as mortality, by having a strong link with cardiovascular disease, cancer, liver damage, neurodegeneration, and accelerated aging. They systematically cause disruption of physiological homeostasis, promote chronic inflammation, and increase oxidative stress at the cellular level. Tobacco and alcohol are the prominent known disruptors of gut microbial composition. Tobacco smoking supports the growth of pathogenic bacteria and reduces the beneficial microbial diversity, while excessive alcohol intake disrupts the intestinal lining, which leads to an increase in gut permeability, which later changes the microbial homeostasis and then followed by systemic inflammation and liver disease (Capurso & Lahner, 2017). This affects gut-gut-brain axis as well, causing mood disorders and cognitive decline. Avoiding such substances facilitates gut integrity by lowering the risk of chronic disease and slowing biological aging. Studies have presented that quitting smoking and limiting alcohol have reversed some microbiota alterations, causing improvement in metabolic and mental health outcomes (Chen et al., 2022) (Biedermann et al., 2013). Hence, this can be concluded as avoidance of risky substances is not only a protective measure but also a restorative one, leading to healthy aging, which directly contributes to longevity via microbiota and systemic benefits.

1.1.6. Positive Social Connections

Positive social connection is the sixth pillar of lifestyle medicine, which has shown support for physical, mental, and emotional well-being. It's seen that emotional health and even longevity are improved by community support and strong relationships (*Lifestyle Med for Social Connection*, n.d.). In modern times, it's been seen that loneliness and isolation have been a risky

factor for poor physical and mental health(Shankar, 2023). In contrast, social isolation and loneliness have been associated with an increase in inflammation, stress, and mortality, which is the same as compared to smoking and the effect of obesity on health (T. Matthews et al., 2024). Positive social interaction can change the hypothalamic pituitary adrenal axis, which results in lowering stress caused by dysbiosis and inflammation in the gut (Hostinar & Gunnar, 2013). Moreover, positive connections influence gut microbiota composition, which unknowingly supports digestive, metabolic, and cognitive health(Nguyen et al., 2021). Studies on centenarians have shown that having strong social ties and community belonging is a common factor among long-lived individual, as these contribute to healthy aging by promoting resilience, cognitive vitality, and regulating their emotion (Li et al., 2024). So, having healthy relationships is scientifically proven to be less intervention that greatly contributes to longevity and overall well-being of an individual.

1.2 Gut Microbiota

The terms “gut microbiota”, “gut microbiome,” or “gut flora” are the collection of microorganisms, which includes bacteria, archaea, fungi, and viruses that are found in the digestive tracts of animals(*Gut_microbiota*, n.d.). These Microbiota have a critical role in maintaining normal health of the body by providing 70% immunity of the body by training the immune system to fight off harmful germs(Bajić et al., 2025). Mood, memory, and brain functions are also influenced by microbiota due to Gut Gut-Brain Axis(Ullah et al., 2023). Risk of depression, anxiety, and cognitive decline, like dementia, is also lowered by Healthy Gut Microbiota directly or indirectly (Kumar et al., 2023).

1.2.1 Effect of Diet on Gut Microbiota

According to Nutrition, the total food consumed by an individual or other organism is called a diet. Diet also means consuming a specific nutrition for health or weight management reasons(*Nutrition*, n.d.).

A diet that maintains or improves overall health is considered a healthy diet. A healthy diet includes all the essential nutrients required for a healthy body, such as macronutrients (protein, etc.), micronutrients (vitamins, minerals, etc.), fluids, and fiber(*Healthy_diet*, n.d.). Microbiota is directly influenced by the contents of the diet, like fiber-based and fermented diet helps to

increase microbiota and whereas most of the additives and emulsifiers can disrupt the microbiota. Also, the high-fat, high-sugar diet negatively affects Gut Balance(*Healthy-Diet*, n.d.).

Current scientific advancements have marked the gut microbiome as an important mediator of human health. Gut Microbiota is a community of complex microorganisms that are found in the gastrointestinal tract, which plays an important role in nutrient absorption, immune modulation, inflammation regulation, and also brain function through the gut-brain axis(Rastogi & Singh, 2022). Composition and diversity of microbiota are greatly influenced by lifestyle medicine by dietary choices, physical activity, and stress reduction activities(Zhang et al., 2023). The plant-based diet suggested in lifestyle medicine is rich in dietary fibers and polyphenols, which act as a prebiotic that nourishes beneficial bacteria like *Bifidobacteria* and *Lactobacilli* (Tomova et al., 2019). Improved gut barrier integrity and reduced systemic inflammation are backed by increased microbial diversity. Butyrate production, which is a short-chain fatty acid (SCFAs), is enhanced by physical activity, which is known for its anti-inflammatory and gut-protective effects(Yu et al., 2025).

Increased levels of Cortisol due to chronic physiological stress can disrupt the gut microbiome and increase gut permeability(Rusch et al., 2023). Mindfulness and meditation techniques used in stress management that are given in pillars of lifestyle medicine have helped to maintain a balanced gut microbiota and support psychological resilience(Wang et al., 2022).

1.2.2. Effect of Exercise on Gut Microbiota

Physical Activities like exercise and workout contribute to upgrading or maintaining fitness and general health. Exercise is an organized form of physical activity that improves muscular strength, cardiovascular function, and metabolic function(Qiu et al., 2023). Apart from its systemic benefits, recent discoveries have shown regular exercise or physical activity significantly influences the composition and activity of gut microbiota, leading to improved gastrointestinal, immune, and all health(Clauss et al., 2021). Performing aerobic exercise moderately has shown an increase in diversity of gut microbiota, which points towards a healthy microbiome(Cataldi et al., 2022). According to certain studies, it's shown in both animals and humans that exercise can increase beneficial microbial species such as *Faecalibacterium prausnitzii*, *Akkermansia muciniphila*, and *Bifidobacterium*, which are related to anti-inflammatory and metabolic benefits(Zhang et al., 2025). Also, exercise enhances the short-chain fatty acids(SCFAs), producing bacteria that mainly produce butyrate, which are beneficial

in supporting gut barrier integrity, reducing inflammation, and boosting energy metabolism (Nogal et al., 2021). SCFAs also act as a signaling molecule that influences the gut-brain axis and may influence mood and cognitive function (Silva et al., 2020). Exercise type, intensity, duration, and dietary pattern influence the impact of exercise on gut microbiota (Bonomini-Gnutzmann et al., 2022). Regular moderate exercise increases microbial balance, whereas excessive or prolonged exercise without proper nutrition can damage the microbial homeostasis, leading to increased gut permeability known as “leaky gut.” (Peng et al., 2024).

Therefore, regular moderate physical activity acts as a non-pharmacological attribute for positive modulation of gut health, leading to decreased systemic inflammation, improved metabolic profiles, and increased resilience to age-related disease. Incorporating exercise in daily life promotes physical well-being as well as creates a favorable internal microbial environment that supports healthy aging and longevity (Eckstrom et al., 2020).

1.3. News of the Week

News of the week is a project developed by the Università dell’Piemonte Orientale [(UPO) Italy, Department of Translational Medicine, Division of Public Health], that aims to bridge the gap between scientific research and public understanding. Even by the remarkable progress of scientific research and innovation large number of the general population face challenges in understanding complex scientific and medical concepts. This, in general, leads to the spread of misinformation, low health literacy, and inappropriate public engagement with science-based recommendations. To address this communication void, this project aims to convert complex scientific information into understandable language and make it accessible to non-expert masses. By selecting specific health topics on a weekly basis and doing a systematic review using prominent and genuine scientific databases, the project focuses on the creation of accurate, reader-friendly content. This processed, reader-friendly, genuine information is then passed out through various digital channels like social media platforms and dedicated websites for maximizing outreach and engagement. Moreover, this initiative aims to promote awareness by empowering individuals to make appropriate health decisions, inculcating beneficial health behaviors, and passing the scientific achievement to the general public. Lastly, this helps to get more recognition of a scientifically literate public for their innovations, builds trust in research, and positively demonstrates benefits.

2. Objective

The aim is to review all the existing reviews related to how gut microbiota influences healthy aging, to close the gap between scientific research and public understanding by translating complicated scientific and medical information in an easy-to-understand, trustworthy, and interesting way for the general public. This aim fits in with the bigger goal of our Public Health Laboratory, which is to improve scientific literacy and help people make better choices.

This integrative approach serves two complementary purposes: academically, it provides a systematic and evidence-based analysis of scientific literature, and from a science communication perspective, it demonstrates how complex biotechnological and medical research can be simplified and disseminated to support public awareness and engagement. The ultimate goal is to strengthen the relationship between researchers and the community, which will lead to more people using scientific discoveries to improve their health.

3. Materials and Methods

3.1 Search Strategy

A comprehensive literature search was conducted to identify relevant studies. We use the specific Medical Subject Headings (MeSH) terms and relevant keywords across two major scientific databases: PubMed and Scopus. The search was limited to studies published between 2023 and 2025 for the most recent and updated articles, as this work is correlated with the start of news of the week project, therefore, the timeline is constricted. The articles published in English and with full-text availability were included.

Database	Search String
PubMed	("gut microbiota" OR "gut microbiome" OR "intestinal microbiota") AND ("aging" OR "healthy aging" OR "ageing" OR "older adults") AND ("influence" OR "impact" OR "role" OR "effect")
Scopus	(TITLE-ABS-KEY("gut microbiota" OR "gut microbiome" OR "intestinal microbiota")) AND (TITLE-ABS-KEY("healthy aging" OR "healthy ageing" OR "aging" OR "ageing" OR "older adults")) AND (TITLE-ABS-KEY("influence" OR "impact" OR "role" OR "effect"))

3.2 Eligibility criteria

The present review employed a set of well-defined inclusion and exclusion criteria to ensure that only relevant, high-quality studies were included. The inclusion criteria were designed to capture studies that specifically investigated the gut microbiota in humans and explored the effects of diet and lifestyle modifications on microbial composition and function. The included study design comprised all types of reviews. Only articles published in English were included to maintain consistency in language and interpretation, and the search was limited to studies published between 2023 and 2025 to ensure that the most recent and relevant findings were incorporated into the review, and to incorporate the high-quality studies

Specifically, studies were included if they focused on the human population, analyzed the influence of dietary patterns or lifestyle interventions such as the Mediterranean diet, plant-based

diets, or other lifestyle modifications on gut microbiota, and reported outcomes related to microbial composition, diversity, or functional metabolites. However, when the study had humans as well as animals, we included those studies but focused on human interventions. Conversely, the exclusion criteria were equally stringent to maintain the focus and quality of the review. In particular, the non-human/animal studies were excluded to ensure the applicability of findings is specifically related to human health. Studies in which gut microbiota was not the primary outcome or studies not addressing lifestyle or dietary interventions were omitted. Additionally, articles that are not in English, research lacking original or secondary data, and publications that were not peer-reviewed or published in reputable scientific journals were excluded. These criteria ensured that the research included was immediately relevant, methodologically robust, and amenable to detailed analysis.

We have introduced the PICO framework to help us identify and rate studies methodically:

PICOS Element	Description
Population (P)	Human adults aged ≥ 18 years, all genders, representing diverse adult populations
Intervention (I)	Dietary and lifestyle modifications, including Mediterranean diet, fiber-rich diets, polyphenol-rich diets, and other strategies aimed at improving gut microbiota composition
Comparison (C)	Standard/usual diets, standard care, or alternative dietary patterns (not all studies include a comparison group)
Outcome (O)	Impact on healthy longevity, including changes in gut microbiota diversity and composition, SCFA production, functional metabolites, and effects on physical, cognitive, gut microbial, and overall health
Study design (S)	Review studies and systematic reviews

PRISMA flow diagram is used for a systematic and well-documented literature search and study selection process for ensuring transparency and replicability. Structured Screening, eligibility assessment, and inclusion of studies are done for a rigorous and reproducible review process. For Data Selection, all the important criteria like study design, population characteristics, interventions, comparisons, and reported outcomes were considered. This method helps to ensure a structured and well-organized evidence-based synthesis of current research on how gut microbiota can play a role in healthy aging of the human population.

3.3 Data extraction

We conducted our data extraction systematically, collecting and recording the information from the final included studies. The following data were extracted: author's name, publication year, country, study Design, sample characteristics (such as total participants, sex, and age), Objective of Research, and the characteristics of Diet and microbiota interventions, which include Diet, biota, Gut Microbial Changes, Physical Outcomes, Cognitive Outcomes, and Diet and Longevity. We used the Microsoft Excel spreadsheet to extract the data.

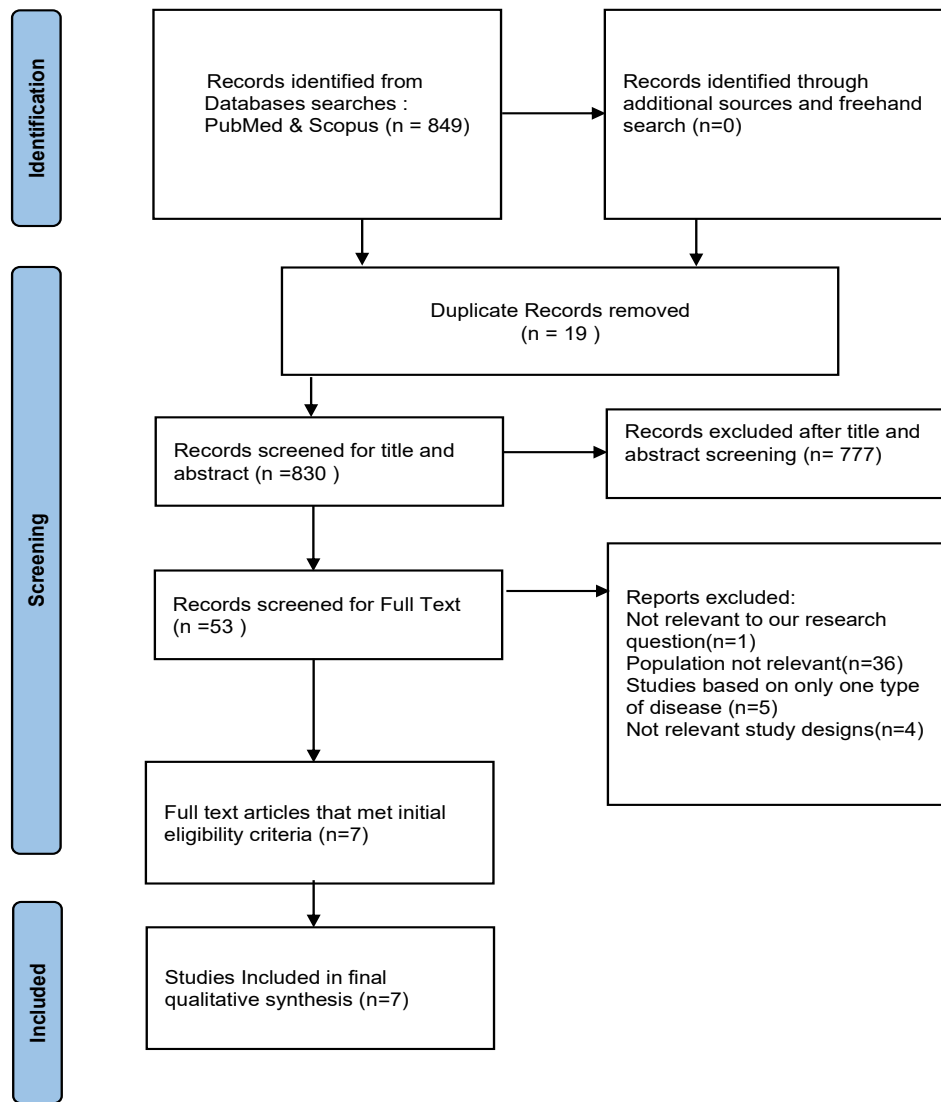
4. Result

4.1 Identification of studies

We identified 849 records from the databases, while no relevant record was identified from the external sources. After removing 19 duplicates, 830 articles underwent title and abstract screening, leading to the exclusion of 777 studies due to irrelevance, inadequate data, or lack of focus on gut microbiota and lifestyle factors.

Subsequently, 72 full-text articles were reviewed for eligibility, and 11 were excluded for reasons such as insufficient data or unsuitable design. Ultimately, seven studies met all inclusion criteria and were incorporated into the qualitative synthesis, providing key insights into the relationship between gut microbiota, diet, and lifestyle in healthy aging. Finally, we included 7 articles that were included for our qualitative synthesis. The entire process is summarized in Figure 3 following the PRISMA framework.

Figure 4: PRISMA flow chart of the included studies



Reference : Page M J, McKenzie J E, Bossuyt P M, Boutron I, Hoffmann T C, Mulrow C D et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews *BMJ* 2021; 372 :n71 doi:10.1136/bmj.n71

4.2 General Characteristics of Included Studies

The included studies, published between 2023 and 2025, originated from a diverse set of countries, including one from Greece, 3 from China, one from the USA, Venezuela, and Japan. From these seven studies and six are narrative reviews, and one is a mini review. Sample characteristics varied substantially in terms of population, gender, and age ranges, while most reviews did not report participant demographics. Gyriki et al. (2025) included data from 2841 adults to centenarians of mixed sex, and Xu X et al. (2024) focused on 110 middle- and older-aged women. However, across all reviews, the main theme was the exploration of how gut microbiota composition shifts with aging and how such changes influence longevity, immune function, metabolic health, and age-related diseases. Many studies shared overlapping objectives: for example, Gyriki et al. (2025), Li et al. (2023), Upadhyay (2025), and Salazar et al. (2023) all examined the association between gut microbiota, aging, and chronic disease development, while Xu X et al. (2024) and Luo et al. (2024) similarly focused on the role of microbiota-derived metabolites and gut ecosystem markers as indicators of aging.

All the included studies also investigated comparable intervention strategies to improve microbiota composition and promote healthy aging. Reviews by Xu X et al. (2024), Upadhyay (2025), and Salazar et al. (2023) all discussed the use of probiotics, prebiotics, dietary modulation, and fecal microbiota transplantation (FMT) as potential therapeutic approaches. Likewise, Gyriki et al. (2025) and Li et al. (2023) reviewed microbiota-targeted interventions positioned as tools to enhance lifespan and reduce age-related disease risk. A unique yet related perspective was provided by Shintani et al. (2023), who examined calorie restriction mimetic (CRM) drugs and their influence on gut microbiota as an alternative pathway to mimic the anti-aging effects of calorie restriction. Overall, all the studies collectively emphasize the global scientific interest in understanding aging-related microbiota changes and identifying promising interventions to support healthy aging and increased longevity.

The main characteristics of the included studies, including author details, year of publication, country, study design, sample characteristics, and research aims, are summarized in Table 1 below.

Table 1: General characteristics of included studies

Author's Name	Publication year	Country	Study Design	Sample Characteristics Sex and age	Aim and Objective of Research
Gyriki et al.	2025	Greece	Narrative Review	Total Participants 2841, all adults to centenarians of mixed sex	To review and examine the relationship between gut microbiota and aging. Explore links with age-related diseases. Assess potential microbiota-targeting interventions to extend lifespan and improve health outcomes.
Xu et al.	2024	China	Mini-Review	110 middle-aged and elderly women	To review the role of gut microbiota as a biomarker of aging. To explore microbiota-targeted interventions (FMT, probiotics, diet) to promote healthy aging and longevity.
Luo et al.	2024	China	Narrative review	Not Specified	The study aimed to explore the mechanisms by which gut microbiota influences healthy longevity and to summarize how microbiota-derived metabolites (e.g., short-chain fatty acids, tryptophan metabolites, bile acids) enhance intestinal barrier integrity, reduce inflammaging, optimize

Author's Name	Publication year	Country	Study Design	Sample Characteristics Sex and age	Aim and Objective of Research
					mitochondrial function, regulate nutrient-sensing pathways, and protect against age-related diseases.
Li et al.	2023	China	Narrative Review	Not specified	Summarizing how gut microbiota composition changes with age. Highlighting links between gut microbes and host immunity, nutrition, and signaling pathways. Examining how microbiota dysbiosis contributes to age-related diseases. Discussing the potential of gut microbiota in promoting healthy aging and longevity.
Upadhyay et al.	2025	USA	Narrative Review	Not specified	To critically assess how gut microbiota changes with aging and its relationship with age-related diseases. Evaluate dietary strategies (fiber, probiotics, prebiotics, polyphenols, Mediterranean diet, fasting) that modulate the gut microbiota. Explain mechanisms linking microbiota, inflammation, and chronic diseases. Highlight challenges in translating microbiota–aging research into clinical practice.
Salazar et al.	2023	Venezuela	Narrative Review	Not specified	Explore how the gut microbiota changes with age. Examine its role in age-related diseases (metabolic,

Author's Name	Publication year	Country	Study Design	Sample Characteristics Sex and age	Aim and Objective of Research
					inflammatory, musculoskeletal, and neurological). Highlight potential therapeutic strategies (e.g., probiotics, prebiotics, symbiotics, diet, physical activity) to modulate gut microbiota for healthy ageing and increased longevity
Shintani et al.	2023	Japan		Not specified	To review evidence on calorie restriction mimetic (CRM) drugs and their effects on gut microbiota. To explore whether CRMs can mimic calorie restriction benefits and thus influence gut microbiota to extend lifespan and improve healthy aging.

Unless indicated otherwise, the participants are presented as total number, age as ranges, and gender as a category (M/F) presented in total number

4.3 Relationship Between Diet, Gut Microbiota, and Healthy Aging

4.3.1. Gut Microbiota Outcomes

Across all seven included studies Gyriki et al. (2025), Xu et al. (2024), Luo et al. (2024), Li et al. (2023), Upadhyay et al. (2025), Salazar et al. (2023), and Shintani et al. (2023) show that dietary interventions consistently demonstrated a strong modulatory effect on the gut microbiota. Mediterranean diet patterns, calorie restriction, vegetarian/vegan diets, and balanced diets were repeatedly shown to increase beneficial short-chain fatty acid (SCFA)-producing bacteria, including *Faecalibacterium*, *Roseburia*, *Bifidobacterium*, *Lactobacillus*, and *Akkermansia muciniphila*. At the same time, these dietary strategies reduced harmful or pro-inflammatory taxa such as *Prevotella*, *Collinsella*, *Ruminococcus torques*, *Escherichia-Shigella*, *Bilophila*, and *Oscillibacter*.

Similarly, microbiota-directed interventions, including probiotics, prebiotics, symbiotics, FMT, and microbial metabolites, produced parallel outcomes. All studies reported an enrichment of beneficial bacterial species, improved microbial diversity, and enhanced SCFA production. Notably, Xu et al. (2024) and Luo et al. (2024) demonstrated that combining diet with FMT and probiotics produced the most significant microbiota restoration, while Upadhyay et al. (2025) highlighted how whole-diet approaches such as the Mediterranean diet and intermittent fasting supported long-term microbial balance. Shintani et al. (2023) further showed that calorie-restriction mimetic drugs mimic the microbiota benefits of fasting and the Mediterranean diet.

Overall, the collective evidence shows that both dietary patterns and microbiota-based interventions synergistically restore eubiosis, enhance SCFA production, and reduce dysbiosis, establishing a strong mechanistic link to healthy aging.

4.3.2. Physical Outcomes

All included studies reported improvements in physical health associated with diet and microbiota modulation. The Mediterranean diet, calorie restriction, and probiotics/prebiotics were consistently linked to reduced frailty, enhanced immune function, improved metabolic balance, healthier skin, cardiovascular protection, and better bone and muscle health.

Gyriki et al. (2025), Xu et al. (2024), and Luo et al. (2024) found that diets rich in fiber, polyphenols, and plant-based foods reduced systemic inflammation and improved overall metabolic resilience. Li et al. (2023) and Salazar et al. (2023) showed improved skin health, increased muscle function, and reduced inflammatory markers following prebiotic–probiotic supplementation.

Across seven studies, increases in SCFA producers were directly associated with enhanced gut barrier integrity, improved metabolic homeostasis, and reduced inflammatory load, which together promoted healthier physical aging. Even pharmacological mimetics such as those evaluated by Shintani et al. (2023) produced similar benefits, decreasing inflammation and improving cardiometabolic function.

Collectively, these findings show that diet and microbiota-targeted interventions generate consistent and significant physical health improvements, primarily through anti-inflammatory pathways and improved metabolic function.

4.3.3. Cognitive Outcomes

Cognitive outcomes showed strong convergence across the studies. Mediterranean diets, calorie restriction, prebiotics, probiotics, and symbiotics were frequently associated with reduced risk of Alzheimer’s disease, Parkinson’s disease, and slower cognitive decline. Studies such as Gyriki et al. (2025) and Luo et al. (2024) emphasized that increases in SCFA-producing bacteria reduced neuroinflammation and supported neuroprotection. Xu et al. (2024) provided evidence that diet combined with probiotics or FMT could even partially reverse aging-related dementia, likely by restoring healthy hippocampal function. Similarly, Upadhyay et al. (2025) highlighted that plant-based diets and fasting enhanced microbial metabolites that support cognitive resilience, while Salazar et al. (2023) found that blueberry intake and symbiotic improved memory and learning through modulation of Sirt1 and FOXO signaling pathways.

Together, these studies indicate that diet and microbiota interventions exert consistent cognitive benefits by lowering inflammation, improving metabolic brain pathways, and maintaining gut–brain axis integrity.

4.3.4. Relationship of Diet and Gut Microbiota with Longevity

Across all studies, a clear and consistent relationship emerged between dietary patterns, microbiota modulation, and longevity. The Mediterranean diet was the most frequently associated with increased lifespan, primarily due to its ability to sustain beneficial gut bacteria, reduce inflammation, and maintain metabolic health. Calorie restriction and fasting strategies enhanced longevity by improving microbial diversity and reducing inflammaging. Studies such as Gyriki et al. (2025), Luo et al. (2024), and Salazar et al. (2023) concluded that combining diet with microbiota interventions (probiotics, prebiotics, symbiotics) had the strongest positive effects on healthy aging and lifespan extension. Shintani et al. (2023) demonstrated that even mimicking dietary restriction through pharmacological compounds yielded similar longevity benefits by inducing favorable microbiota shifts.

In summary, the collective evidence indicates that diet microbiota synergy is a central determinant of longevity, with interventions that increase SCFA producers and reduce pro-inflammatory taxa consistently promoting healthier and longer life trajectories.

The characteristics of dietary patterns and gut microbiota targeted interventions, along with their effects on gut microbiota composition, physical and cognitive outcomes, and longevity, are summarized in Table 2 below.

Table 2 Characteristics of Diet and Microbiota Interventions

Author & Year	Diet type	Biota type	Gut Microbiota outcomes	Physical Outcomes	Cognitive Outcomes	Main findings on Longevity
Gyriki et al. (2025)	Mediterranean Diet, Calorie Restrictions	Prebiotics, Synbiotics	Increase in SCFA-producers (<i>Faecalibacterium</i> , <i>Roseburia</i> , <i>Bacteroides</i>), increase <i>Bifidobacteria</i> , decrease harmful taxa	Reduced frailty, stronger immunity, better metabolic health	Lowering the risk of Alzheimer's disease, Parkinson's disease, and cognitive decline	Mediterranean diet = healthy aging, dysbiosis↓, and longevity ↑.
Xu et al. (2024)	Mediterranean Diet, Calorie Restrictions, Prebiotics	Probiotics, Fecal Microbiota Transplantation	Increase in <i>Lactobacillus</i> , <i>Bifidobacterium</i> , <i>Akkermansia muciniphila</i> , SCFA-producers; decrease in	Reduced frailty, healthier skin, stronger bones, better immunity	Could reverse aging-related dementia and cognitive decline to some extent via hippocampal restoration	Diet + Healthy biota = longevity, ↑inflammaging ↓

Author & Year	Diet type	Biota type	Gut Microbiota outcomes	Physical Outcomes	Cognitive Outcomes	Main findings on Longevity
			<i>Collinsella, R. torques</i>			
Luo et al. (2024)	Mediterranean Diet, Calorie Restrictions, Metformin/Rapamycin	Probiotics, Fecal Microbiota Transplantation	Increase in <i>Lactobacillus</i> , <i>Bifidobacterium</i> , <i>Akkermansia</i> , SCFA-producers; decrease in harmful/pro-inflammatory taxa	Reduced frailty, healthier skin, enhanced immunity, cardiovascular and bone health	Reduces the risk of Alzheimer's disease & Parkinson's disease	Mediterranean Diet+Biota=longevity ↑ and anti-aging ↑ benefits.
Li et al. (2023)	Balanced Diet, Prebiotics	Probiotics, Fecal Microbiota Transplantation, Microbial Metabolites	Increase in <i>Bifidobacterium</i> , <i>Lactobacillus</i> , <i>Akkermansia</i> , SCFA-producers; decrease in pathogenic/pro-inflammatory taxa	Improved immunity, healthier skin, metabolic balance	Reduced frailty, neuroprotection	Balanced Diet + Biota = inflammaging ↓, longevity ↑ and metabolic stability ↑

Author & Year	Diet type	Biota type	Gut Microbiota outcomes	Physical Outcomes	Cognitive Outcomes	Main findings on Longevity
Upadhyay . et al. (2025)	Mediterranean Diet, Intermittent Fasting, Vegetarian/Vegan Diets.	Probiotics	<i>Bifidobacterium</i> , <i>Lactobacillus</i> , <i>Faecalibacterium</i> , <i>Roseburia</i> , and <i>Akkermansia muciniphila</i>	Protects against cardiovascular disease, diabetes, and Age-Related Macular Degeneration (AMD)	Protection against neurodegeneration and age-related cognitive decline.	Microbiota-focused dietary strategies = dysbiosis↓, mitigate age-related functional decline, and healthy aging and longevity ↑.
Salazar et al. (2023)	Mediterranean diet, prebiotics, symbiotics, healthy diet, blueberry intake	Probiotics	Increase in Beneficial strains (Akkermansia, Lactobacillus, Bifidobacterium); ↑ SCFAs; Decrease in Pro-inflammatory bacteria (Prevotella)	Improved Muscle function, enhanced Bone health (in some studies), decrease in Inflammation	Increases Memory & Learning (via reduced Sirt1, FOXO1/3)	Mediterranean Diet + Probiotics/Prebiotics = Longevity↑ inflammaging ↓

Author & Year	Diet type	Biota type	Gut Microbiota outcomes	Physical Outcomes	Cognitive Outcomes	Main findings on Longevity
Shintani et al. (2023)	Calorie Restriction Mimetic Drugs & Compounds		Increase in beneficial taxa (<i>Akkermansia</i> , <i>Bifidobacterium</i> , <i>Lactobacillus</i> , <i>Faecalibacterium</i>) ; decrease in harmful bacteria (<i>Escherichia-Shigella</i> , <i>Bilophila</i> , <i>Oscillibacter</i>)	Improved metabolism, reduced inflammation	Decreases the risk of Alzheimer's disease, Parkinson's disease	Calorie Restriction +Mimetic Drugs = Lifespan ↑ and healthy aging ↑.

5. Discussion

5.1. Gut Wellbeing as a Foundation for Longevity

This review is based on the findings that promote gut wellbeing, which further help to enhance longevity. There are several interventions, like the Mediterranean diet, calorie restriction, prebiotic and probiotic supplementation, that foster healthy aging via gut microbiota modulation. In contrast to other dietary paradigms, such as Western, ketogenic, or high-protein diets, the Mediterranean diet exhibits a greater capacity to augment microbial diversity, elevate the abundance of short-chain fatty acid (SCFA)-producing bacteria, and diminish pro-inflammatory taxa. These observations align closely with prior studies indicating that Mediterranean and plant-based dietary patterns cultivate a gut environment characterized by an abundance of *Faecalibacterium prausnitzii*, *Roseburia*, and *Akkermansia muciniphila*, all of which are associated with reduced inflammation, enhanced metabolic health, and a postponement of age-related deterioration (Ghosh et al., 2020) (Claesson et al., 2012)

5.2. Western Diet and Calorie Restriction: Contrasting Impacts on Aging

Conversely, diets prevalent in Western societies, which are distinguished by elevated saturated fat levels, refined sugars, and reduced fiber consumption, have been implicated in the promotion of dysbiosis and systemic inflammation, thereby accelerating the aging process. Comparative data, consequently, highlight that the quality of the diet, specifically its fiber and polyphenol content, directly influences microbial composition and metabolic output. The calorie restriction and its mimetics, such as metformin and rapamycin, are beneficial supplements that provide metabolic and microbiota benefits linked to conventional Mediterranean diets (Luo et al., 2024; Shintani et al., 2023). Although we have found that metformin or any pharmaceutical interventions have been beneficial, there is limited data; therefore, future research should be more focused on such interventions.

5.3. Synergistic Benefits of Probiotics, Prebiotics, and Mediterranean Diet

Probiotics and prebiotics supplementation, along with the Mediterranean diet, have shown an enhanced benefit. In fact, our findings found uniform cognitive improvements, diminished frailty, and more favorable metabolic profiles when dietary modifications were implemented alongside microbiota-targeted therapies (Xu et al., 2024; Li et al., 2023). Normally, diet strategies prioritize caloric intake or macronutrient distributions, but the Mediterranean approach and microbiota-focused diet comprise a more comprehensive and enduring strategy to promote healthy aging. Various studies state that interventions like plant-based, polyphenol-rich rich and fiber-dense diets favor and support gut microbiota, which further impact lifespan and health span.

5.4. Regional Bias in Diet, Microbiota, and Aging Research

It's important to know that much of the literature is regionally concentrated. Most of the studies or interventions that examine the link between diet, microbiota, and aging are based on Mediterranean or Western populations. However, another aspect is based on diets around the world. Research from other parts of the world, such as South Asia, Latin America, Japan, China, and Korea, remains limited. Culturally, dietary models from these regions include different combinations of fermented foods, seaweed, legumes, and spices, which may have a positive impact on gut microbiota, but they are not fully studied. For example, the traditional Japanese diet (“washoku”) is associated with improved cognition and reduced frailty, but it has been observed that Latin American and South Asian populations remain poorly characterized in microbiome studies (Magne et al., 2016; Saji et al., 2022). According to current findings, most of the data is concentrated on the Mediterranean model, without any clue about other global diet and their benefits.

5.5. No Universal Microbiome: Need for Personalized Nutritional Strategies

A specific ideal microbiome profile is unattainable because different factors, like genetic predispositions, environmental exposures, dietary habits, and pharmaceutical interventions, affect microbial composition. Nevertheless, certain convergent characteristics, such as elevated microbial diversity, a predominance of short-chain fatty acid (SCFA) producers, and a reduced presence of pro-inflammatory taxa, consistently characterize healthy aging across diverse populations. As a solution, a personalized nutritional strategy will be useful for customized interventions, by this collective solution will provide both gut and overall health.

5.6. Limited Focus on Cognitive Outcomes in Diet–Microbiome Research

While most of the literature is limited mainly to diet microbiome interactions that focus on metabolic or inflammatory markers, neglecting cognitive health and neurodegenerative outcomes such as cognitive decline, dementia, and memory loss, are main components of aging that remain unexplored in the context. Current research has suggested promising links between gut microbial composition and cognitive outcomes, including mild cognitive impairment and Alzheimer's disease (Tana et al., 2025)

This lack of evidence is concerning. Cognitive decline affects quality of life, but it also affects independence, emotional well-being, and long-term care needs. Now, researchers are in the early stages of linking microbiomes to brain health. As we have discussed, some studies are now showing that certain gut bacteria may be linked with cognitive impairment and even Alzheimer's disease. For example, Tana et al. (2025) studied emerging connections between gut microbial patterns and cognitive outcomes. Their study has shown SCFAs, which are produced by gut microbes, show neuroprotective effects by maintaining blood-brain barrier integrity, changing microglial activation, and regulating oxidative stress and neuronal metabolism.

5.7. Emerging Links Between Gut Microbes and Neurodegeneration

Nevertheless, the current research does not provide an in-depth analysis. still need to identify specific dietary patterns that consistently support the gut-brain axis, especially in older adults, who are already vulnerable. Therefore, without more data, it's not easy to create practical nutritional plans, preventive programs, or caregiving guidelines that can help to protect and support the cognitive function in elderly people. The scarcity of evidence shows a void. Filling this void is mandatory for future studies, especially as the global population is inclined towards an aging population and increasing risks of dementia.

5.8. Gaps in Implementing Microbiota-Focused Diets in Elderly Care Settings

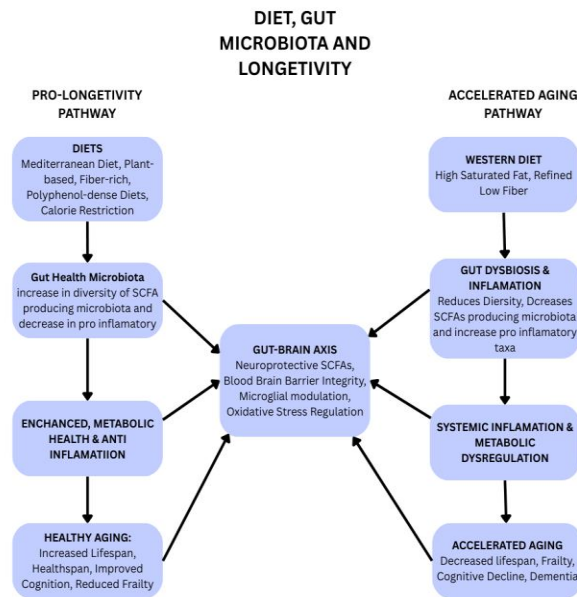
Including these endpoints in future studies will help to clarify how changes in diet can influence gut microbiota that not only support physical but also cognitive longevity. In practical terms, as European nursing homes and elder care centers mostly follow general nutritional guidelines for older adults (ESPEN, 2019; WHO, 2020), however, they do not typically enforce Mediterranean-

style or microbiota-specific diets. Strict dietary implementations are often limited due to factors such as cost, cultural preferences, and malnutrition risk.

5.9. Translating Microbiome Research into Public Health Policies

Finally, converting these studies into practical usage in the world remains a major public health challenge. Even though European countries and WHO initiatives promote Mediterranean or Nordic dietary models, few policies exclusively include microbiome-related outcomes. Most nutrition plans encourage emphasizing general dietary quality, encouraging higher fruit, vegetable, and whole grain intake without direct microbiome monitoring. As the studies establish the causal link between microbiota composition and aging, future public health strategies can benefit from integrating microbiome parameters into dietary recommendations, healthcare guidelines, and institutional meal planning (WHO Europe, 2022). To achieve this, there is a need for more studies that test interventions, analyses that weigh costs and benefits, and practical policy plans.

Figure 5: Flow diagram for the relationship between Diet, Gut microbiota and longevity



The figure shows how diet influences gut microbiota to promote healthy aging or accelerate aging.

5.10. Strengths & Limitations

The data extracted for this review is procured from recent years, proving its time-oriented study (2023-2025). Within this time frame, no other overview of reviews was published, which proves the novelty of the review. The studies included are human based based therefore, their investigation was primarily based on the effect of diet and lifestyle on gut microbiota to support healthy aging. In fact, we observed common themes among the included studies such as increase in SCFA producing bacteria, decrease in pro inflammatory taxa, along with improved metabolic, immune, and cognitive outcomes with the diverse interventions such as MD, calorie restriction, probiotics, prebiotics, symbiotics, FMT and calorie restriction mimetics which gives us strong concision based common result and also the potential future research including systematic review and metanalysis to produce a high level of evidence. Moreover, in addition, the study is systematically performed by following PRISMA guidelines, which gives transparency and shows methodological proof.

We have also noticed that, due to time constraints, many influential and important studies were not incorporated in the review, which might have caused the exclusion of crucial and valuable insights. Similarly, a language barrier is another limitation, as we could not include more studies regarding similar topics. All of the studies that are included are narrative reviews, from which most do not present general characteristics such as age, gender, etc, which makes it hard to apply the concepts for different individuals. Furthermore, as part of diet interventions, the Mediterranean diet stands out as an extensively researched one, leaving other diet contributions in vain, which shows that there is a still scarcity of information on other diets on the human gut influencing longevity.

6. Future Direction

While current evidence strongly supports the Dietary and Lifestyle modulation shows a strong support in changing gut microbiota into a healthy gut microbiota that promotes healthy aging, but there are also various gaps and opportunities that still remain. For establishing causal links between specific microbial taxa and aging outcomes, future efforts must focus on large-scale, longitudinal clinical trials. This study is mostly extracted from reviews that are observational or short-term interventional trials, which limit the ability to generalize findings across different populations. Microbiota composition. The studies should include diverse ethnic groups, age ranges, and geographical contexts. It is important to know the global and population-specific aspects of diet microbiota interactions. The interconnected relationship between gut health and a healthy human is not researched deeply; their relationship is still scarcely explored.

However, precision nutrition shows a reliable option. Collaboration of microbiome sequencing with metabolic and genomic profiling can help in suggesting dietary recommendations to individual microbial signatures. The synergistic impact of combining dietary intervention with other lifestyle factors, such as physical activity, stress management, and sleep optimization, should be examined in future research, as each of these characteristics independently influences gut microbial composition. Researching the role of next-generation probiotics, symbiotics, and postbiotics can also open new therapeutic aspects for the targeted modulation of gut microbiota.

As the studies included were from 2023 and 2025, it is important to keep in update the systematic reviews and meta-analyses to include new findings. This future direction will help us to understand how gut microbiota modulates healthy aging, as well as inform the development of evidence-based, personalized interventions that can expand human health span and, along with that, help in improving quality of life.

Apart from scientific understanding and research, future direction should also include active research into integrating it into actionable public health policies and clinical guidelines. As the relation between dietary patterns, gut microbiota, and healthy aging is being explored but there is limited focus on integrating this study in the general population. Public health structure still is mainly focused on macro/micronutrient balance and calorie intake, with the least emphasis on microbiomes as a key determinant of long-term health. To bridge this gap, there should be collaboration between researchers, policymakers, healthcare providers, and global health

organizations to incorporate the emerging microbiome findings into practical, evidence-based interventions.

An interesting initiative of this translational approach at the academic level is the LifestyleMedicine.it project, which was developed with the help of the University of Eastern Piedmont (UPO) and is backed by the Public Health laboratory. The main objective of this platform is to increase public understanding by converting scientific subjects, such as microbiome research, into a language that is both understandable and accessible. Students play an important role in this endeavor; they investigate recent findings, simplify scientific concepts, and transform them into comprehensible and captivating content made for the general public. LifestyleMedicine.it, through its aim and work, fosters scientific understanding along with simultaneously addressing the disconnect between research findings and public awareness. Such innovations set up an example of how the universities can serve as facilitators of public health education, therefore ensuring the belief that scientific advancements are confined to academia, thus enabling individuals to make better choices regarding their nutrition, daily habits, and general health.

National and regional health agencies might consider integrating microbiota-related findings into dietary recommendations, specifically highlighting foods abundant in fiber, plant-based components, and polyphenols, which foster microbial diversity. Existing Mediterranean dietary models, as promoted by the World Health Organization (WHO) and the European Food Safety Authority (EFSA), could, for instance, provide a foundation for more expansive, culturally sensitive nutritional programs. Future policy endeavors should not only address dietary choices but also elucidate the underlying biological processes through which diet impacts gut microbes, inflammation, and aging-related outcomes.

Additionally, the implementation of science will be a pivotal point for knowing how these policies work outside a controlled research environment. The laboratory findings and clinical trials provide valuable insight, but the real-world settings, like schools, hospitals, and elderly care facilities, face practical limitations on the application of dietary interventions. Therefore, further public health research must explore whether microbiome-supportive diets are truly feasible in everyday institutions or not. This will not only involve changes in the menu but also consider factors such as cost, cultural preferences, kitchen capacity, staff training, and the willingness of individuals to try new foods.

For instance, introducing fiber-rich vegetables, whole grains, and fermented foods into school lunches or hospital meals might be straightforward from a scientific perspective, but institutions may struggle with budget limitations or procurement challenges. Likewise, elderly care homes will need to balance microbiome-friendly meals along with their dietary restrictions and also with the chewing or swallowing difficulties common in older adults. All of these practical thoughts need to be studied, documented, and addressed by carefully designing integration programs.

Cooperation between universities, public health agencies, and national health ministries can help to bridge this gap. Academic researchers can express their expertise in microbiome analysis, along with this, health authorities offer their expertise in policy, logistics, and large-scale implementation. Collaboratively, they can develop small projects that consist of microbiome supportive menus into selected institutions and track participants for several months. Recording the changes in gut microbiota composition, inflammatory markers, nutritional status, and overall well-being would support for understanding to researchers in analyzing what works, what needs adjustment, and which approaches are economic.

Real-world data would provide a practical definition of a "microbiome-friendly" institutional diet. These measurable standards could then be used to develop national dietary guidelines, hospital nutrition policies, and elder-care programs. As a result, this approach would ensure that new scientific findings about gut microbiota are translated into useful public health actions that benefit a wide range of people.

Food and biotechnology sector stakeholders will also be crucial. Policymakers should encourage innovation and regulation in developing new probiotics, symbiotic, and functional foods, ensuring they are safe, accessible, and effective. In addition, creating microbiome literacy campaigns can help the public make informed dietary choices based on scientific evidence, rather than just marketing claims.

The subsequent imperative for global health organizations involves transitioning from research dissemination to the practical application of policy. By integrating microbiome science into existing nutritional and aging frameworks, governments can develop more holistic and sustainable approaches to promote healthy aging. Collaborative efforts among scientists, clinicians, public health experts, and other important stakeholders are essential. However, the potential benefits, such as improved quality of life and reduced disease in older populations, are considerable.

Figure 6: Future Directions in Diet–Gut Microbiota Research and Healthy Aging

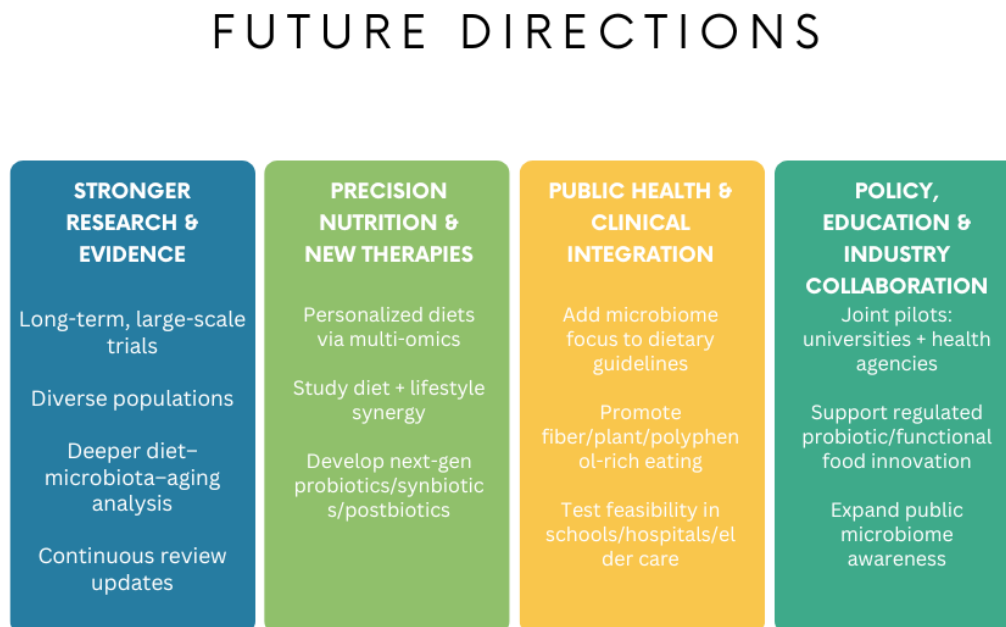


Diagram illustrating the primary future directions in microbiota-focused healthy aging research. These include expanding robust long-term evidence, developing personalized and therapeutic nutrition approaches, incorporating microbiome insights into clinical and public health settings, and fostering multi-sector collaboration for effective implementation.

7. Conclusion

The study suggests that gut microbiota acts as a major connection linking lifestyle and diet to general health and longevity. The intervention of prebiotics, probiotics, and symbiotics positively increases the health benefits of nutrition by ensuring microbial diversity and promoting short-chain fatty acid synthesis. Along with these, calorie restriction and calorie restriction drugs like metformin and rapamycin show dietary and pharmacological interventions collaboratively leading to healthy aging. The microbial alterations are consistently related to enhanced metabolic balance, immunological resilience, lower inflammation, and better cognitive and physical outcomes, hence supporting healthy aging and longer lifespan. The main aim of this review was to focus on gut microbiota through diet and lifestyle modification for an increased health span and delay age-related decline. For better understanding causative mechanism to translate these findings to clinical and public health applications, further research must be focused on longitudinal human studies, precision nutrition, and microbiota-based personal intervention.

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