

Review

Sustainability of the Mediterranean Diet: A Nutritional and Environmental Imperative

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ABSTRACT

Sustainability is increasingly recognized as a key determinant of public health, influencing environmental quality, food security, and long-term well-being. The Mediterranean Diet (MedD) is widely recognized for its health-promoting properties, particularly in the prevention of

cardiovascular and metabolic diseases. In recent years, increasing attention has been given to its role in environmental sustainability. This manuscript explores the MedD through a multidisciplinary lens, integrating nutritional science with ecological and socio-economic considerations. The MedD's low environmental footprint, emphasizing its reduced greenhouse gas emissions, efficient land and water use, promotion of biodiversity, and minimization of food waste. These characteristics position the MedD as a model dietary pattern aligned with the principles of sustainable development.

However, the traditional MedD is facing significant challenges, including the globalized food market, urbanization, climate change, and shifting consumer behaviors, particularly among younger populations. These dynamics threaten both adherence to the diet and the sustainability of its core components. By framing the MedD as both a cultural heritage and a forward-looking strategy, we propose it as a valuable template for achieving global health and sustainability goals. This work calls for renewed commitment to preserving and adapting the Mediterranean Diet in contemporary food systems.

KEYWORD: cardiovascular risk; climate change; pollution; diet; nutrition; mediterranean area

INTRODUCTION

The MedD is widely recognized for its health benefits, particularly in reducing cardiovascular disease (CVD) risk [1]. However, beyond its nutritional advantages, the MedD also serves as a sustainable dietary model that aligns with global environmental and climate goals [1,2]. Given the increasing concerns about food security, climate change, and pollution, adopting and preserving the MedD can play a crucial role in promoting both human and planetary health [3–5]. In 2023, 733 million people experienced undernourishment, while in 2022, 2.83 billion people (35.5%) could not afford a healthy diet [6]. Climate change is worsening food insecurity and undernutrition by decreasing crop yields, limiting labor capacity, and restricting access to water and sanitation. It also disrupts supply chains and threatens marine resources through rising coastal sea surface temperatures, reduced oxygen levels, ocean acidification, and coral reef bleaching [4,6].

While cardiovascular protection remains a well-documented outcome of the MedD, growing evidence highlights its broader health-promoting properties. The MedD has been associated with beneficial modulation of the gut microbiota, which plays a pivotal role in immune regulation and metabolic processes [7]. The MedD is a valuable approach for enhancing gut microbiota, which in turn supports metabolic, cardiovascular, and cognitive health. Its rich content of fiber, healthy fats, and polyphenols fosters beneficial gut bacteria, reduces inflammation, and improves

metabolism [7]. Evidence from clinical and preclinical studies shows that the MedD lowers the risk of chronic diseases such as cardiovascular disease, diabetes, and obesity, while also offering potential in preventing neurodegenerative conditions. These effects highlight the potential of diet-based, personalized interventions [7]. Several studies have indicated that key components of the MedD, such as polyphenols and dietary fiber, possess significant anti-inflammatory and anticancer properties [8–10]. By reducing oxidative stress and inflammation, these compounds help prevent DNA damage, inhibit abnormal cell proliferation and survival, and suppress angiogenesis and metastasis. As a result, the Mediterranean Diet is increasingly recognized as a practical and effective strategy for lowering cancer risk and supporting long-term cellular health [8].

Other health-related outcomes include improved cognitive function, lower incidence of neurodegenerative diseases, and a reduced risk of metabolic syndrome and type 2 diabetes [7]. The MedD has been shown to positively influence gut microbiota in ways that support cognitive health and reduce frailty in older adults [10]. Studies found that adherence to the MedD increased beneficial bacteria and short-chain fatty acid production, which correlated with improved cognitive function and biomarkers linked to Alzheimer's disease, suggesting a potential role of the MD in promoting brain health through microbiome modulation [7,10].

Including these aspects provides a more comprehensive view of the MedD, emphasizing its relevance as a multifaceted dietary pattern with benefits extending well beyond cardiovascular health. This narrative review aims to explore the MedD not only as a nutritional model for cardiovascular and metabolic health, but also as a sustainable dietary pattern with environmental, cultural, and economic implications. By synthesizing recent evidence, the review highlights the multidimensional benefits of the MedD and identifies challenges and opportunities for its promotion in modern society.

HEALTH BENEFITS OF THE MEDITERRANEAN DIET: A CORNERSTONE OF CARDIOVASCULAR AND METABOLIC WELL-BEING

The MedD is widely regarded as one of the healthiest dietary patterns, owing to its nutrient-dense and plant-centered composition [11–13]. This well-balanced combination of nutrient-dense foods provides essential vitamins, minerals, and bioactive compounds that protect against metabolic disorders, CVD, and obesity. The MedD is not merely a set of dietary recommendations but a lifestyle that integrates high-quality nutrition, moderate physical activity, and social engagement, all of which contribute to overall well-being [14].

A Powerful Shield against Cardiovascular Diseases

The MedD has gained significant attention in recent research related to health outcomes in aging populations, particularly in the context of 'inflammaging,' a term referred the chronic, low-grade inflammation associated with aging that contributes to various age-related diseases [15,16].

Several lines of evidence indirectly indicate that MedD significantly reduces systemic inflammation, counteracting its detrimental effects in elderly people. First, the adherence to the MedD is inversely correlated with inflammatory markers such as C-reactive protein (CRP) and interleukin-6 (IL-6), which are pivotal in the context of inflammation and aging and a systematic review highlighted that dietary pattern rich in fruits, vegetables, and healthy fats, which are staples of the MedD, was associated with lower serum concentrations of these inflammatory markers [17–19]. Second, intervention studies show that not only does adherence to the MedD influence biological biomarkers negatively associated with inflammation, but it may also enhance levels of protective molecules, such as adiponectin, which is known for its anti-inflammatory properties [17,20].

The mechanisms underlying these protective effects of the MedD are far from being clear and are still matter of debate. However, it is generally accepted that the protective effect arises from a combination of antioxidants, dietary fiber, and bioactive compounds present in fruits, vegetables, and whole grains. These components contribute to the reduction of oxidative stress and inflammation, which are both key players in the aging process and the development of chronic conditions associated with inflammaging [21–24].

Notably, it has been proposed that the molecular pathways activated by components of the MedD, such as polyphenols, omega-3 fatty acids, and fiber, may exert beneficial hormetic effects. These mild, adaptive cellular stress responses are thought to enhance physiological resilience and play a key role in mitigating the harmful impact of chronic low-grade inflammation, which underlies many age- and sex-related cardiovascular conditions [21].

Epidemiological investigations further affirm the beneficial relationship between the MedD and the inflammation associated with the aging process. A significant association between high adherence to this diet and reduced mortality rates among older populations has been observed, suggesting a potential protective role against age-related diseases such as CVD and some types of cancers [18]. Additionally, randomized trials like the NU-AGE study aimed at older adults provided direct evidence that adherence to a tailored MedD can effectively counteract inflammaging and improve health markers over time [23,25].

The impact of dietary patterns extends beyond individual health markers. An increasing body of evidence suggests that nutrition interacts with genetic and epigenetic factors influencing inflammaging [26]. The

consumption of plant-based diets, has been shown to modulate gene expression related to inflammatory responses, thereby elucidating another dimension through which diet influences the aging process [26,27]. This synergy between dietary habits and biological aging suggests that dietary modifications may be a feasible strategy for extending healthspan, defined as the period of life spent in good health [28].

Several epidemiological and clinical studies have demonstrated that adherence to the MedD is associated with significantly lower rates of hypertension, type 2 diabetes, and systemic inflammation all of which are key contributors to CVD (Table 1). The MedD helps regulate blood pressure through its abundance of potassium-rich foods, such as leafy greens and legumes, which counteract the harmful effects of excess sodium [29]. Additionally, the high intake of polyphenol-rich foods like olives, nuts, and berries exerts anti-inflammatory and antioxidant effects, reducing oxidative stress and improving endothelial function [30]. Chronic inflammation is effectively mitigated by the diet’s emphasis on plant-based foods, healthy fats, and fiber [31]. Furthermore, the MedD also supports better insulin sensitivity and glucose metabolism, lowering the risk of type 2 diabetes, a condition closely linked to both heart disease and obesity [32–34].

Table 1 provides an overview of the most relevant studies, including randomized trials and cohort analyses conducted in various populations. These studies collectively emphasize how the MedD contributes to improved metabolic profiles, reduced inflammation, and better cardiovascular outcomes. This body of evidence underscores the value of promoting the MedD as a cornerstone of preventive health strategies.

Table 1. Summary of key epidemiological and clinical studies evaluating the effects of adherence to the MedD on cardiovascular and metabolic health outcomes. The table highlights study designs, populations, and the main findings supporting the protective role of the MedD against chronic diseases.

Study	Year	Country/ Region	Type of Study	Key Findings
Dinu M et al. [35]	2018	Italy	Umbrella Review	A greater adherence to the MedD reduced the risk of overall mortality, cardiovascular diseases, coronary heart disease, myocardial infarction, overall cancer incidence, neurodegenerative diseases and diabetes.
Krebs JD et al. [36]	2025	New Zealand	Randomised controlled trial	In participants with increased cardiometabolic risk, the MedD pattern and a behavioural intervention did not improve metabolic risk scores but was associated with reduced weight and improved quality of life.
Estruch R et al. [37]	2018	Spain	Longitudinal multicenter trial (PREDIMED)	In persons at high cardiovascular risk, the incidence of major cardiovascular events was lower among those assigned to a MedD supplemented with extra-virgin olive oil or nuts than among those assigned to a reduced-fat diet.

Table 1. *Cont.*

Study	Year	Country/ Region	Type of Study	Key Findings
Aznar et al. [38]	2025	Spain	Longitudinal study Nutrition and Cardiovascular Risk in Spain (ENRICA)	Higher adherence to the Planetary Health diet and MedD was similarly associated with lower all-cause mortality and showed comparable low environmental impact.
Davis et al. [39]	2017	Australia	Randomized, controlled dietary intervention trial.	A high adherence to a MedD for 6 months resulted in a significant reduction in F(2)-Isoprostanes and triglycerides among older Australians.
Gardner et al. [40]	2022	USA	Interventional Keto-Med randomized crossover trial.	In adults with prediabetes or type 2 diabetes, both the Well-Formulated Ketogenic Diet (WFKD) and the Mediterranean-Plus (Med-Plus) diet led to significant improvements in HbA1c. Triglycerides improved more with WFKD, while LDL cholesterol improved more with Med-Plus.
Zooravar D et al. [41]	2025		Systematic review and meta-analysis	Adherence to the MedD diet is associated with a reduced risk of diabetic nephropathy and retinopathy.
Salas-Salvado et al. [42]	2011 (corrected in 2018)	Spain	Longitudinal multicenter trial (PREDIMED-Reus)	Lower risk of T2DM only for female participants consuming the MedD
Boughanem H et al. [43]	2025	Spain	Randomized, single-blinded, controlled dietary intervention trial (CORDIOPREV)	The decrease in neutrophil count in Responders who consumed a MedD exhibited a significant increase in Insulin Sensitivity and Disposition Index
Mattioli AV et al. [44]	2013	Italy	Case control study	High MedD Score and high intake of antioxidants had more probability of a spontaneous conversion of atrial fibrillation.
Zhang Q et al. [45]	2024	China	Case control study	The MedD was inversely associated with the risk of Atrial fibrillation in this Northern Chinese population.
Barrio-Lopez MT et al. [46]	2024	Spain	Randomized, controlled, single-blinded trial (PREDIMAR study)	In patients with atrial fibrillation, higher adherence to MedD is associated with a significantly lower amount of Epicardial adipose tissue.
Davis et al. [47]	2017	Australia	Randomized, controlled dietary intervention trial	Australian men and women who consumed a MedD for 6 months had small but significantly lower systolic blood pressure and improved endothelial function.
Rodrigues J et al. [48]	2024	Portugal	Randomized, controlled trial	Increased adherence to the MedD may contribute to a higher potassium intake but seems to have limited effects on the adequacy of sodium levels.
Filippou C et al. [49]	2023	Greece	Randomized, controlled trial	The MedD was superior in office systolic BP-lowering, but the DASH and MedD reduced BP to an extent higher than salt restriction alone.
Rivas-Garcia et al. [50]	2024	Spain	randomized, single-blinded, controlled dietary intervention trial (CORDIOPREV)	Improved diet quality after the dietary intervention was associated with a lower risk of T2DM in patients with CHD.
Jimenez-Torres J et al. [51]	2021	Spain	randomized, single-blinded, controlled dietary intervention trial (CORDIOPREV)	Long-term consumption of a MedD rich in extravirgin olive oil was associated with decreased atherosclerosis progression.

Lipid Profile and Heart Health: Balancing Cholesterol for Longevity

One of the most well-documented cardiovascular benefits of the MedD is its positive effect on cholesterol levels and lipid metabolism [43,52]. Unlike Western diets, which are often high in saturated fats and trans fats from red meat and processed foods, the MedD is primarily centered around monounsaturated fats, particularly from extra virgin olive oil (EVOO). These fats play a crucial role in lowering low-density lipoprotein (LDL) cholesterol, which contributes to plaque buildup in the arteries [53,54]. Simultaneously, the MedD is known to increase high-density lipoprotein (HDL) cholesterol [53,54]. Furthermore, omega-3 fatty acids found in fatty fish such as salmon, sardines, and mackerel have been shown to reduce triglyceride levels, prevent blood clot formation, and improve heart rhythm stability [55,56]. Regular consumption of fish, a key protein source in the MedD, has been linked to lower rates of arrhythmias, sudden cardiac death, and heart failure progression. These combined benefits make the MedD a cornerstone of cardiovascular prevention and management [19,34].

A Preventive Strategy for High-Risk Populations

Given its well-documented health advantages, the promotion of the MedD should be a public health priority, particularly among high-risk populations such as postmenopausal women, individuals with metabolic syndrome, and those with a family history of CVD. Postmenopausal women, in particular, face an increased risk of CVD due to hormonal changes that negatively affect lipid metabolism, vascular function, and body composition [57,58]. Estrogen, which has cardioprotective effects, declines significantly after menopause, leading to higher LDL cholesterol levels, increased blood pressure, and a greater tendency to accumulate visceral fat [59,60]. For women in this stage of life, the MedD offers a natural, non-pharmacological approach to mitigating these risks. The diet high content of fiber, phytoestrogens (found in legumes, nuts, and whole grains), and antioxidants helps regulate lipid levels, support vascular integrity, and prevent metabolic dysfunction. Studies have suggested that postmenopausal women who closely follow the MedD have a significantly lower incidence of stroke, coronary artery disease, and overall mortality [61,62]. Similarly, individuals with metabolic syndrome greatly benefit from adopting the MedD [63].

THE MEDITERRANEAN DIET AND ENVIRONMENTAL SUSTAINABILITY

In addition to its health benefits, the MedD is a sustainable dietary model that reduces the environmental impact of food production [1,2,4,5]. Unlike Westernized diets, which are heavily reliant on industrial meat production and processed foods, the MedD places a strong emphasis on plant-based ingredients, local sourcing, and traditional agricultural

practices [11,12,18]. These characteristics make it a powerful tool in reducing the ecological footprint of food production while simultaneously promoting biodiversity and resource conservation. The MedD has a lower environmental impact than Western diets and showed a carbon footprint between 0.9 and 6.88 kg CO₂/d per capita, a water footprint between 600 and 5280 m³/d per capita, and an ecological footprint between 2.8 and 53.42 m²/d per capita [64]. Environmental sustainability in diets refers to the ability of food systems to provide nutritious food for current and future generations while minimizing environmental impact. This includes reducing greenhouse gas (GHG) emissions, conserving land and water resources, preserving biodiversity, and minimizing food waste. Dietary choices are increasingly recognized as critical to sustainable development.

Conserving Water Resources: Water Footprint

Water scarcity is one of the most pressing environmental challenges of our time, and the food industry plays a substantial role in global water consumption [65]. The MedD, with its emphasis on plant-based foods, substantially reduces water usage compared to diets rich in animal products. The production of plant foods such as grains, legumes, vegetables, and fruits require considerably less water than livestock farming [66]. For instance, producing 1 kg of beef requires approximately 15,400 liters of water, whereas the same quantity of cereals requires only 1600 liters [67]. Similarly, legumes such as lentils and chickpeas, which are staples in the MedD, use significantly less water than dairy or poultry farming. By shifting dietary patterns away from water-intensive foods like red meat and toward a more plant-centered diet, the MedD offers a sustainable approach to mitigate water depletion. The preservation of this dietary pattern is particularly critical in Mediterranean countries, where climate change is exacerbating drought conditions and water shortages, [4,5,67]. Encouraging adherence to the MedD not only benefits individual health but also contributes to the conservation of vital water resources.

Land Use

Land use is another fundamental aspect of environmental sustainability, particularly in light of the growing global population and the increasing scarcity of arable land. The MedD is inherently land-efficient due to its emphasis on plant-based foods [68]. These food groups generally require less land to produce than animal products, particularly red meat, which demands significantly more land per calorie or gram of protein [69,70]. Traditional Mediterranean agriculture also favors crop diversity, rotational planting, and agroecological practices that maintain soil fertility and reduce the need for chemical fertilizers [71]. Such practices contribute not only to efficient land use but also to the health of ecosystems. By supporting polyculture farming and integrating crops with livestock at small scales, the Mediterranean region has historically managed to maintain high productivity without the intensive

monocultures that dominate industrial agriculture. Furthermore, the MedD reliance on local and seasonal produce encourages the use of indigenous crops, well-adapted to Mediterranean climates [72]. These crops generally require fewer inputs and are grown in harmony with the environment, contributing to a lower ecological footprint. Promoting sustainable land management practices rooted in traditional Mediterranean farming techniques can therefore support long-term food security and environmental resilience.

Lower Greenhouse Gas Emissions

Food production is a major driver of GHG emissions, with livestock farming being one of the largest culprits. The MedD emphasis on plant-based foods and its moderate consumption of animal products, particularly red meat, results in significantly lower carbon emissions compared to Western dietary patterns. Dietary data from the National Health and Nutrition Examination Survey (2011–2018) was merged with data on environmental impacts, agricultural resource demand, and food prices from multiple publicly available databases to evaluate the association between adherence to the MedD pattern and various sustainability metrics [73]. The study revealed that greater adherence correlates with lower greenhouse gas emissions, land use, fertilizer, and pesticide use, but a higher water scarcity footprint and diet cost. These findings highlight sustainability trade-offs, primarily driven by reduced intake of animal-sourced and refined carbohydrate foods. The research underscores the need for sustainable dietary guidelines that inform consumer food choices while considering environmental and economic impacts [73]. Studies have shown that diets rich in red meat can produce up to five times more GHG emissions than plant-based diets [74]. The MedD, which relies on legumes, whole grains, nuts, seeds, and sustainable seafood as primary protein sources, helps to reduce these emissions. In contrast, intensive livestock farming not only generates high levels of methane, a potent greenhouse gas, but also leads to deforestation, as large areas of land are cleared for grazing or growing animal feed [75]. By promoting sustainable food choices, the MedD contributes to climate change mitigation. Mediterranean food traditions, which incorporate seasonal and locally sourced ingredients, further minimize the carbon footprint associated with food transportation and storage. Encouraging the consumption of regionally grown produce, along with reducing dependence on highly processed foods, enhances the environmental benefits of this diet [5,76].

Biodiversity Preservation

The MedD is deeply rooted in agricultural biodiversity, supporting a diverse range of crops, livestock, and traditional farming methods that promote ecological balance [71]. Unlike monoculture farming, which depletes soil nutrients and leads to loss of biodiversity, the MedD

encourages the cultivation of a variety of fruits, vegetables, whole grains, and legumes. This approach helps to maintain soil fertility, reduce the need for synthetic fertilizers and pesticides, and support local ecosystems [77]. Furthermore, the MedD's reliance on olive oil as a primary fat source rather than industrial seed oils contributes to sustainable agricultural practices. Olive groves, which are an integral part of Mediterranean agriculture, not only provide food but also help prevent soil erosion and promote carbon sequestration, making them valuable in combating climate change. Another key aspect of biodiversity preservation in the MedD is the promotion of sustainable seafood consumption [73,78,79]. Overfishing has become a critical environmental issue, threatening marine ecosystems and food security worldwide. The MedD emphasizes the consumption of small, sustainably sourced fish such as sardines and anchovies, which have a lower environmental impact compared to larger predatory fish like tuna and swordfish [73,78,79]. By prioritizing responsibly sourced seafood and advocating for sustainable fishing practices, the MedD plays a role in protecting ocean biodiversity.

Food Waste

Food waste is a critical component of environmental sustainability [80]. The MedD, rooted in traditional food cultures, emphasizes full utilization of ingredients. Practices such as home-cooking, use of leftovers, food preservation (e.g., drying, fermenting), and seasonality reduce household-level waste [81]. This dietary model naturally discourages overconsumption and wasteful behaviors, especially when compared with modern, highly processed diets that rely on pre-packaged goods and frequent disposal of unused food [82,83]. Promoting educational initiatives and technological solutions like food-sharing apps can further enhance these traditional low-waste practices. The MedD also contributes to reducing food waste, as demonstrated by Grant et al., who reported significantly lower household food waste among MedD adherents [84]. Gracia et al. added an economic perspective, noting that locally sourced MedD foods bolster rural economies and decrease reliance on food imports [85].

Table 2 summarizes some recent studies that have evaluated the impact of the MedD on various sustainability metrics. Dernini et al. emphasized the MedD's environmental advantages, showing that it reduces carbon footprint and supports biodiversity when compared to typical Western diets [86]. Similarly, Lorca-Camara et al. conducted a systematic review of 35 studies, finding that a majority confirmed the superior sustainability of the MedD in comparison with other dietary patterns [87]. From a health and environmental standpoint, Dinu et al. found that adherence to the MedD improves cardiovascular outcomes while lowering environmental impact, primarily through reduced red meat consumption [88]. Baudry et al. provided a broader view, linking the MedD to better nutritional quality and reduced environmental stress, although they also observed higher

diet-related costs and pesticide exposure due to the increased intake of plant-based foods [89]. Finally, Conrad et al. showed that greater adherence to the MedD is associated with reduced greenhouse gas emissions, land use, fertilizer, and pesticide use [81]. However, they also reported a higher water scarcity footprint and greater overall cost of the diet. Together, these findings confirm the MedD ’s potential as a sustainable dietary model, while also identifying areas, such as cost and resource trade-offs, that warrant further consideration.

Table 2. Summary of Studies on Mediterranean Diet and Sustainability

Study	Year	Sustainability Focus	Key Findings
Grant et al. [84]	2022	Food Waste	Households adhering to MedD generate significantly less food waste.
Gracia et al. [85]	2020	Food Sustainability	Locally sourced MedD foods enhance rural economies and lower dependency on imports.
Dernini et al. [86]	2017	Environmental Impact	MedD reduces carbon footprint and promotes biodiversity compared to Western diets.
Lorca-Camara V et al. [87]	2024	Environmental Impact	The systematic review included 35 studies analyzing the sustainability of the MedD. Of these, 24 compared the MedD's sustainability with other dietary patterns
Dinu et al. [88]	2024	Health & Environment	MedD improves cardiovascular health and lowers environmental burden by reducing red meat consumption.
Baudry J et al. [89]	2023	Nutritional quality, environmental impact, monetary cost, and pesticide exposure	Higher adherence to the MedD was linked to improved nutritional quality and reduced environmental pressures, but also associated with increased monetary costs and higher pesticide exposure due to plant-based food consumption
Conrad, Z et al. [81]	2024	Sustainability	Greater adherence to MedD correlates with lower GHG, land use, fertilizer, and pesticide use, but a higher water scarcity footprint and diet cost.

CHALLENGES AND BARRIERS TO MEDITERRANEAN DIET ADOPTION

Despite the well-documented health and sustainability benefits of the MedD, adherence to this traditional dietary pattern has been declining in recent years [90]. Several socio-economic, cultural, and environmental factors have contributed to this shift, making it increasingly difficult for individuals, especially those in urbanized, lower-income, and climate-affected regions, to maintain the MedD [91,92]. Understanding these challenges is crucial to developing targeted strategies that promote and preserve this valuable diet.

Urbanization and Westernization: The Shift toward Processed Foods

One of the most significant barriers to MedD adoption is the rapid urbanization and Westernization of dietary habits. The traditional MedD, which is rich in fresh, minimally processed foods, is increasingly being replaced by diets high in ultra-processed foods, refined sugars, unhealthy fats, and fast food [93]. Globalization has led to the widespread availability of cheap, calorie-dense convenience foods that appeal to busy lifestyles but lack the essential nutrients found in the MedD [58]. Fast-food chains, sugary beverages, and ready-to-eat meals have become staples in many

urban households, particularly among younger generations. These foods are often engineered to be highly palatable and addictive, making them more appealing than whole, unprocessed foods like legumes, whole grains, and vegetables [94]. Additionally, the rise of sedentary lifestyles and digital entertainment has further decreased traditional home-cooked meals, which were once the foundation of the MedD. This shift in eating behaviors is particularly evident in Mediterranean countries, where younger populations are moving away from their cultural dietary heritage in favor of Westernized eating patterns. Studies show that adolescents and young adults in countries like Italy, Greece, and Spain are consuming more processed meats, sugary drinks, and fast food while reducing their intake of vegetables, fish, and legumes [95,96]. As a result, the prevalence of obesity and metabolic diseases is rising, even in regions where the MedD was once the norm [97].

Socioeconomic Inequalities: Accessibility and Affordability Issues

Another major challenge in maintaining the MedD is socioeconomic disparity. Access to fresh, high-quality ingredients, the foundation of the MedD, can be limited for lower-income populations. Fruits, vegetables, olive oil, nuts, and fresh seafood, which are essential components of the diet, are often more expensive than processed foods, making them less accessible to economically disadvantaged communities [98–100]. For many low-income families, budget constraints force them to prioritize quantity over quality, leading to higher consumption of cheap, processed, and calorie-dense foods. In many urban areas, food deserts, regions with limited access to fresh and nutritious foods, further exacerbate this issue [97,98]. Supermarkets and farmers' markets offering fresh produce are often located far from low-income neighborhoods, making them difficult to access without reliable transportation [100]. Additionally, food assistance programs and subsidies often do not prioritize fresh produce, leading to an over-reliance on packaged and processed foods among economically vulnerable populations. In contrast, highly processed foods tend to be heavily marketed and subsidized, making them both affordable and convenient, despite their negative health effects [100]. The rising cost of olive oil, a cornerstone of the MedD, further limits its accessibility for many families. The French NutriNet-Santé study evaluates the MedD's sustainability by examining its associations with nutritional quality, environmental impact, monetary cost, and pesticide exposure among 29,210 French adults. Higher adherence to the Mediterranean diet correlated with improved nutritional quality and reduced environmental impact, but also resulted in increased monetary costs and higher pesticide exposure, highlighting the need for strategies promoting safe and sustainable diets [89]. Socioeconomic status also influences dietary education and awareness [101]. Individuals from lower-income backgrounds often have less exposure to nutritional education, making it harder for them to understand the long-term benefits of the MedD.

Without proper knowledge of how to prepare and incorporate traditional Mediterranean foods into their daily meals, many individuals opt for quick, easy, and less nutritious alternatives.

Climate Change and Food Supply: Threats to Mediterranean Agriculture

The Mediterranean region is facing increasing climate-related challenges, which directly impact the availability and affordability of key ingredients in MedD [5,99]. Droughts, soil degradation, extreme weather events, and rising temperatures are undermining agricultural productivity, making it more difficult to cultivate the fresh, high-quality foods that define the MedD. One of the most affected components of the MedD is olive oil, a staple fat source known for its heart-protective properties. Olive groves are highly sensitive to climate variability, and prolonged droughts and extreme heat have led to reduced olive yields in major producing countries such as Spain, Italy, and Greece [102]. As a result, olive oil prices have surged, making it less accessible to consumers. This price increase forces many individuals to switch to cheaper, less healthy alternatives like refined vegetable oils, which lack the nutritional benefits of EVOO. Similarly, the production of fresh vegetables, legumes, and whole grains, core staples of the MedD, is being disrupted by climate change-induced soil degradation and water scarcity [5]. Rising temperatures and erratic weather patterns reduce crop yields and increase farming costs, leading to higher market prices for fresh produce [71,72,102]. In some Mediterranean regions, farmers are shifting toward drought-resistant but less nutritious crops, further altering traditional dietary patterns [103]. Moreover, the Mediterranean fishing industry is also facing challenges due to overfishing and rising ocean temperatures, both of which threaten the availability of sustainably sourced seafood. The MedD emphasizes the consumption of small, oily fish like sardines and anchovies, which are not only nutrient-dense, but also environmentally sustainable. However, disruptions in marine ecosystems have led to declining fish populations and increased reliance on farmed seafood, which often lacks the same nutritional quality as wild-caught fish.

Intensive Farming and the Spread of Pathogens

The recent resurgence and global spread of the H5N1 avian influenza virus present new public health challenges that intersect with food system sustainability and CVD prevention [104,105]. Intensive poultry farming—often characterized by high-density animal populations and poor biosecurity—has been identified as a major driver of zoonotic transmission, including H5N1 [106,107]. This practice not only facilitates viral mutation and interspecies transmission but also exacerbates environmental degradation, undermining sustainable food systems. In contrast, the MedD emphasizes lower consumption of industrially produced animal products and favors plant-based foods, legumes,

sustainable seafood, and traditional agricultural practices [107]. By promoting reduced reliance on poultry and red meat, the MedD aligns with a more resilient food model that minimizes the ecological and epidemiological risks associated with zoonotic outbreaks. From a cardiovascular perspective, the MedD's emphasis on unsaturated fats, fiber-rich vegetables, and anti-inflammatory nutrients contributes to reduced systemic inflammation, improved lipid profiles, and lower incidence of hypertension and type 2 diabetes—all of which are risk factors for CVD [108]. Moreover, exposure to zoonotic pathogens like H5N1 can indirectly exacerbate CVD risk through systemic inflammation, cytokine storms (as already seen during SARS-CoV2 pandemic), and endothelial dysfunction, particularly in vulnerable populations [109,110]. Thus, dietary patterns that lower the likelihood of zoonotic emergence while simultaneously supporting cardiovascular health are of increasing relevance. Promoting the MedD may therefore serve a dual role: fostering pandemic resilience through sustainable agriculture and protecting cardiovascular health through nutritionally optimized food choices [111]. Public health policies that integrate infection control with sustainable dietary strategies could mitigate both acute infectious threats and the chronic disease burden [112].

OVERCOMING THE CHALLENGES: STRATEGIES TO PRESERVE AND PROMOTE THE MEDITERRANEAN DIET

Ensuring the continued adoption of the MedD requires a multifaceted approach that addresses the various social, economic, and environmental barriers to its accessibility. To counteract the declining adherence to this diet, a combination of education, policy interventions, urban planning, sustainable agriculture, and digital engagement must be implemented (Table 3). One of the most crucial steps in preserving the MedD is the implementation of nutrition education and awareness campaigns. Schools, community centers, and healthcare providers play a pivotal role in shaping dietary habits, particularly among younger generations and underserved populations [113]. By integrating MedD-focused nutritional education into school curriculums and community programs, individuals can develop an understanding of the diet's benefits while also learning practical cooking skills and budget-friendly meal preparation techniques. Additionally, healthcare professionals should be encouraged to discuss the MedD as a preventive tool for cardiovascular disease, obesity, and diabetes, further reinforcing its importance in daily life. Alongside education, economic and policy interventions are necessary to make the MedD more accessible to all socioeconomic groups. Governments should offer subsidies and financial incentives to promote the affordability of key MedD components, such as fresh produce, olive oil, whole grains, and legumes. At the same time, policy measures should reduce subsidies for ultra-processed foods, which often contribute to poor health outcomes and environmental degradation. Urban planning also plays a vital role in

improving food accessibility, particularly in low-income and urban areas where access to fresh, healthy foods can be limited. Expanding farmers' markets, supporting local food cooperatives, and developing urban agriculture initiatives can help make fresh, locally grown produce available to a wider population. Initiatives such as community gardens and rooftop farms can be especially beneficial in urban centers, allowing residents to grow their own fruits, vegetables, and herbs, reinforcing a direct connection with the food they consume. Beyond accessibility, ensuring the long-term sustainability of the MedD requires investing in climate-resilient farming techniques and biodiversity-friendly agriculture practices. Climate change is already affecting crop yields and food production, threatening staple MedD ingredients like olive oil, fresh vegetables, and grains. Encouraging regenerative agriculture, soil conservation techniques, and water-efficient farming methods can help mitigate these challenges and ensure that the MedD remains a viable dietary model for future generations. Additionally, policies that promote sustainable fishing practices can help preserve marine biodiversity, ensuring that the diet's reliance on seafood remains environmentally responsible.

In today's digital era, leveraging social media and digital platforms is a powerful way to reconnect younger generations with the MedD. With the growing influence of food trends and online content, engaging videos, interactive recipes, and social media campaigns can help shift public perception and encourage people to return to traditional eating patterns. Digital platforms also provide an opportunity for nutritionists, chefs, and health professionals to share practical advice on how to incorporate the MedD into modern lifestyles, making it more relatable and accessible.

By integrating these strategies, education, economic support, improved food accessibility, sustainable agriculture, and digital outreach, we can ensure that the MedD remains not only a nutritional gold standard but also a sustainable and culturally relevant dietary pattern for generations to come.

By addressing these socio-economic and environmental barriers, we can preserve the Mediterranean Diet as both a cultural heritage and a scientifically proven model for health and sustainability. Ensuring that this dietary pattern remains accessible and practical for future generations will require collaborative efforts between policymakers, public health advocates, and the agricultural sector. To ensure that the MedD remains both a health-promoting and sustainable way of eating, a collective effort is needed across various levels of society. Education and awareness play a crucial role in this mission. Public health campaigns should highlight the benefits of the MedD, integrating its principles into school curriculums and community programs to encourage healthier eating habits from an early age. Equally important are sustainable agriculture policies. Governments must invest in local food production, implement strategies to reduce food waste, and promote environmentally

friendly farming methods that protect natural resources while maintaining food security. Affordability is another key factor. Fresh, nutritious foods should be accessible to everyone, regardless of income level. Policies that lower costs and improve availability in underserved communities can help ensure that the MedD remains an attainable option for all.

Table 3. Sustainability Indicators of the Mediterranean Diet.

Sustainability Indicator	Mediterranean Diet Characteristics	Environmental Impact	Suggestions for Improvement
GHG Emissions	Low red meat, high plant-based intake	Lower emissions vs. Western diet	Promote legumes over imported meat substitutes
Land Use	Reliance on cereals, vegetables, and legumes	More efficient land use	Support crop rotation and organic farming
Water Footprint	High fruit/vegetable consumption; some water-intensive crops	Moderate footprint	Encourage seasonal/local produce and rain-fed crops
Biodiversity	Rich traditional varieties and polyculture	Promotes ecosystem diversity	Protect local seed banks; resist monoculture trends
Food Waste	Cultural habits around full use of food	Lower household waste	Modernize storage and food redistribution systems

CONCLUSIONS

The MedD stands out as a comprehensive and sustainable dietary model with well-documented benefits for cardiovascular, metabolic, and cognitive health. Its rich composition of plant-based foods, healthy fats, and bioactive compounds contributes not only to disease prevention but also to environmental sustainability (Figure 1). The growing body of evidence supports its integration into national dietary guidelines and public health strategies. To maximize its impact, future policies should promote education and accessibility to MedD friendly foods, especially in younger populations and lower socioeconomic groups. Clinical practice should incorporate dietary counseling rooted in MedD principles, tailored to individual risk profiles.

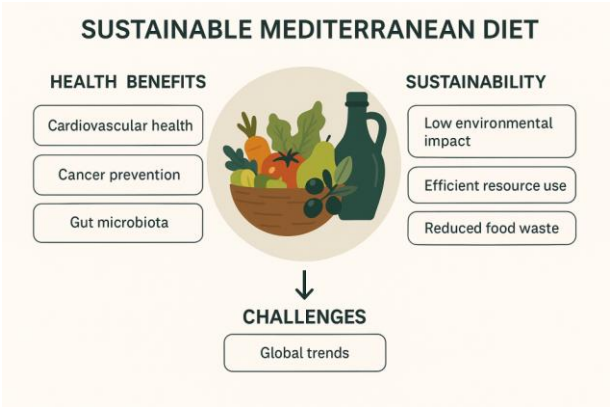


Figure 1. Summary of the Mediterranean Diet’s dual role in promoting human health and environmental sustainability. The diet supports cardiovascular health, cancer prevention, and gut microbiota balance, while also reducing environmental impact through efficient resource use and lower food waste. However, global trends pose challenges to its continued adoption.

Future research should focus on long-term adherence strategies, the role of the MedD in diverse populations, and its effects in conjunction with other lifestyle factors such as physical activity. Further investigation into cost-effectiveness, accessibility, and the environmental trade-offs of increased plant-based consumption is also warranted.

AUTHORS CONTRIBUTION

Conceptualization: MP, AVM; Methodology; Writing—Original draft preparation. GM, CC, GS, FC, GZ, FM, MN, AVM Software; GM, CC, MP. Validation.: AVM, SG, SS, GD, CB. Writing—Reviewing and Editing; all authors. Supervision: GD, MP, CB, AVM.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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