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Perspective

Perspective: Promoting Healthy Aging through Nutrition: A Research Centers Collaborative Network Workshop Report☆

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A B S T R A C T

Within 20 y, the number of adults in the United States over the age of 65 y is expected to more than double and the number over age 85 y is expected to more than triple. The risk for most chronic diseases and disabilities increases with age, so this demographic shift carries significant implications for the individual, health care providers, and population health. Strategies that delay or prevent the onset of age-related diseases are becoming increasingly important. Although considerable progress has been made in understanding the contribution of nutrition to healthy aging, it has become increasingly apparent that much remains to be learned, especially because the aging process is highly variable. Most federal nutrition programs and nutrition research studies define all adults over age 65 y as "older" and do not account for physiological and metabolic changes that occur throughout older adulthood that influence nutritional needs. Moreover, the older adult population is becoming more racially and ethnically diverse, so cultural preferences and other social determinants of health need to be considered. The Research Centers Collaborative Network sponsored a 1.5-d multidisciplinary workshop that included sessions on dietary patterns in health and disease, timing and targeting interventions, and health disparities and the social context of diet and food choice. The agenda and presentations can be found at https://www.rccn-aging.org/nutrition-2023-rccn-workshop. Here we summarize the workshop's themes and discussions and highlight research gaps that if filled will considerably advance our understanding of the role of nutrition in healthy aging.

Keywords: older adults, diet, dietary intakes, dietary patterns, microbiome, health disparities

Abbreviations: AD, Alzheimer's disease; AI, artificial intelligence; DASH, Dietary Approaches to Stop Hypertension; DII, Dietary Inflammatory Index; DLW, doubly labeled water; MIND, Mediterranean-Dietary Approaches to Stop Hypertension Intervention for Neurodegenerative Delay; PTH, parathyroid hormone; SNAP, Supplemental Nutrition Assistance Program.

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Statement of Significance

Although considerable progress has been made in understanding the contribution of nutrition to healthy aging, it has become increasingly apparent that much remains to be learned, especially because the aging process is highly variable. This article summarizes proceedings from a workshop on nutrition and healthy aging and provides recommendations for future research to fill critical knowledge gaps.

Introduction

Over the past century, human life expectancy has increased by >30 y. Within 40 y, the number of adults aged ≥65 y in the United States is projected to double and exceed 90 million [1]. The risk for most noncommunicable diseases and disabilities increases with age, and most adults aged >75 y are living with >1 chronic health condition [2]. In the context of federal nutrition programs and nutrition research, older adults are typically classified as a homogenous group aged >60 or >65 y. Yet, those aged 65 y and 85 y are not the same [3]. Moreover, there can be considerable heterogeneity among older adults of the same chronological age. Although optimal nutrition is critically important for healthy aging, much remains to be uncovered about the role of nutrition in driving the aging process, which is highly variable [4].

In July 2023, the Research Centers Collaborative Network sponsored a 1.5-d multidisciplinary workshop at the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in Boston, MA, United States, focused on promoting healthy aging through nutrition. The goal of the workshop was to facilitate discussions about a broad range of topics relevant to the role of nutrition in healthy aging. The agenda and recordings are archived at https://www.rccn-aging.org/nutrition-2023-rccn-workshop. Here we describe the workshop's themes and discussions and summarize identified research gaps and opportunities to advance the field (Table 1).

Dietary Patterns in Health and Disease

When considering the role of nutrition in healthy aging one can consider the consumption of individual foods and beverages, micronutrients and macronutrients, and dietary patterns. Dietary patterns are defined as the quantities, proportions, variety, or combination of different foods, drinks, and nutrients in diets, and the frequency with which they are habitually consumed [5]. Dietary patterns are thought to be more relevant to overall health and chronic disease risk than single foods or nutrients [6]. The Mediterranean diet, Dietary Approaches to Stop Hypertension (DASH), Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND), and anti-inflammatory diets are all healthy dietary patterns that share common characteristics, including an emphasis on fruits, vegetables, and whole grains, with limited intake of red and processed meats, saturated fat, added sugars, and sodium. Although some dietary patterns have received more research attention than others have, it is debatable whether one specific healthy dietary pattern is more beneficial to specific diseases of aging than others [7,8]. The Nurses' Health and Health Professionals Follow-up Studies demonstrated higher adherence to any 1 of the 4 examined healthy dietary patterns was associated with a lower risk for cardiovascular disease [9] and early mortality [10]. These findings highlight the multiple ways a healthy diet can be achieved to help mitigate health-related risks in older age. In addition, the effect of dietary pattern changes has been

TABLE 1
Opportunities to address research gaps about the role of nutrition in healthy aging

Topic	Opportunity
The role of dietary patterns in health and disease	• Develop and tailor dietary strategies to the individual needs and health conditions of older adults. • Conduct mechanistic studies to understand how diet affects the molecular pathways underlying the different types of dementia. • Design and conduct rigorous randomized controlled feeding studies to determine the efficacy of different dietary approaches in mitigating age-related diseases and disabilities. • Incorporate mental health assessments as outcomes in dietary intervention studies focused on cognition.
Dietary requirements and intakes of older adults	• Determine how energy requirements and dietary and nutritional needs change across the full range of older adulthood. • Incorporate novel objective measures of dietary exposure, such as photo-based approaches, into diet and nutrition studies in culturally and socioeconomically diverse populations.
Timing and targeting interventions across the lifespan	• Obtain stronger prospective cohort data to better understand how diet and nutrition early in the life course, such as during the perinatal and adolescence periods, influences chronic diseases in older age. • Expand chrononutrition research to clarify the role of meal timing in age-related disease and disability. • Leverage artificial intelligence to deepen our understanding of the microbiome's influence on chronic disease outcomes and to develop microbiome-based interventions that mitigate age-related diseases and geriatric syndromes.
Health disparities and the social context of diet and food choice	• Promote research focused on the inter-relationship of social isolation, diet, and well-being in culturally diverse groups of older adults. • Tailor dietary recommendations and education programs to the cultural, migratory, and dietary experiences among the rapidly growing and diverse aging population. • Monitor the implementation and evaluation of local, state, and national programs that impact dietary behaviors and access to nutrition resources for older adults.

tested in randomized controlled trials [11,12]. Lessons learned from these trials may inform the design and implementation of future dietary interventions.

Mediterranean diet

The Mediterranean diet is one of the most studied dietary patterns and has been consistently associated with a lower risk of many age-related diseases and geriatric syndromes, including cognitive decline, dementia, and frailty [13,14]. The Mediterranean diet was traditionally defined as being low in red and processed meats, high in seasonally fresh vegetables, fruit, nuts, and seeds, high in minimally refined whole grains, with moderate consumption of fish, poultry, red wine (with meals), and olive oil as the primary source of fat [15]. However, as the Mediterranean is not a single region or country, the definition of a Mediterranean diet is somewhat controversial, as there are regional variations [16].

Evidence from nonhuman primates suggests a Mediterranean diet may benefit mental health. Adult female cynomolgus macaque monkeys fed a diet consistent with a Mediterranean dietary pattern ($n = 17$) were more attentive to one another, demonstrated more relaxed behavior, and spent more time in contact with other monkeys than in contact with monkeys fed a diet consistent with a Western dietary pattern ($n = 21$). Monkeys in the Western diet group tended to be more socially isolated and anxious, and these behavioral changes were maintained throughout the duration of the study (~31 mo) [17,18]. The protein sources in the Western diet were mainly animal-based, and the Western diet was higher in saturated fat and sodium and low in monounsaturated fat and omega-3 fatty acids. In the Mediterranean diet, protein and fat were derived mainly from plant sources. It was high in monounsaturated fat and low in sodium and refined sugar [19]. However, it is important to consider that neither the Western diet nor the Mediterranean diet resembled a standard diet typically fed to laboratory monkeys.

At the beginning and end of the diet intervention, the monkeys underwent brain MRI. In the Mediterranean diet group, brain volumes (total, gray matter, white matter, and cerebrospinal fluid) did not change substantially. However, in the Western diet group, gray matter volume increased and white matter and cerebrospinal fluid volumes both decreased. The increase in gray matter occurred mainly in a region related to Alzheimer's disease (AD). And, although an increase in gray matter might be considered positive, it could also reflect an increase in inflammatory processes that can precede neurodegeneration [18]. The expression of 7 genes in the temporal cortex differed between the 2 diet groups at the end of the study, and 4 of these genes were involved in inflammatory pathways. Moreover, correlations between inflammatory gene expression and changes in gray matter, white matter, and cerebrospinal fluid brain volumes were noted in AD-associated brain regions [20], supporting the hypothesis that a Western-type diet can promote increased gray matter volume via neuroinflammatory mechanisms.

DASH diet

The DASH diet was initially constructed around nutrients, namely, potassium, magnesium, and saturated fat, which informed the selection of foods included in the diet. Randomization to the DASH diet, which was higher in potassium- and magnesium-rich fruits and vegetables, carbohydrate and protein, and low in saturated fat, resulted in lower blood pressure, compared with randomization to a potassium- and magnesium-rich fruit and vegetable diet or a typical American (control) diet [11,12]. The fruit and vegetable diet was also successful in lowering blood pressure, albeit to a lesser extent than the DASH diet [11,12]. This suggests altering intakes of a few food groups may represent a reasonable approach of changing dietary patterns is too challenging. It should be noted that the conduct of rigorous feeding studies is complex, which may explain why they are relatively few in number. For example, all in-study meals were provided to DASH study participants, and they were followed daily for 11 wk, which required immense dedication on the part of the study participants and intervention teams. The per-participant cost of the DASH trial (which was completed in 1996) was ~\$17,000 and diet interventions completed more recently have cost ≤\$64,000 per participant [21]. However, these and other rigorous and well-conducted feeding studies have provided essential foundational data for health care policy and dietary guidance [5,22,23].

MIND diet

The MIND diet, a hybrid of the Mediterranean and DASH dietary patterns, encourages higher intakes of berries, nuts, fish, green leafy vegetables, and olive oil, and lower intakes of saturated fat and added sugar [24]. In observational studies, higher adherence to a MIND dietary pattern (as reflected by the MIND diet score) was associated with less cognitive decline and a lower risk for dementia [7,24]. However, a recently completed randomized controlled 3-y dietary intervention trial in older adults with a suboptimal diet and BMI ≥25 kg/m^2 at baseline, and a family history of dementia, did not find a beneficial effect of the MIND diet with respect to cognitive performance or white matter, gray matter, or total brain volumes [25]. By design, both the intervention diet and control diets were mildly calorically restricted and participants in both groups received dietary counseling throughout the study. In the intervention group, dietary counseling was specific to the MIND diet, whereas in the control group, it focused on portion control and behavioral weight loss strategies. Despite this difference, however, dietary changes made in the control group may have confounded the results.

Anti-inflammatory diets

The Dietary Inflammatory Index (DII) is an a priori-defined diet score that reflects the inflammatory potential of the diet based on 45 foods and nutrients that have either proinflammatory or anti-inflammatory properties [26]. The DII ranges from −5.5 (more anti-inflammatory) to +5.5 (more proinflammatory), although most individuals' diets fall in the middle of the range. A recent analysis of the Framingham Offspring found a positive association between the DII and the development of frailty and depression [27]. Given that depression, anxiety, and psychological stress are also associated with cognitive decline [28,29], these findings suggest that anti-inflammatory diets may benefit mental and physical health in older age, but this needs to be confirmed by intervention trials.

Taken together, these studies indicate that unanswered questions regarding the potential of diet or dietary constituents to protect against cognitive decline and dementia remain.

Dementia is an umbrella term for several diseases, including AD, Lewy body dementia, vascular dementia, and others [30] that have different pathologies and underlying mechanisms. It is unlikely that the same dietary approach will similarly affect the molecular mechanisms underlying every type of dementia. Cognitive decline occurs over several years or decades, and the optimal timing for dietary interventions to delay cognitive decline is also uncertain. Furthermore, because individuals' response to diet is highly variable [31], nutritional approaches that are adapted to individual needs and conditions may be needed to understand the influence of diet and dietary behaviors on cognitive decline and dementia in more detail [32,33]. Future dietary intervention studies focused on cognitive function should consider incorporating some evaluation of mental health as well. There is also a need for research to understand how diet and psychosocial stress interact to impact cognitive function and dementia and elucidate the underlying molecular mechanisms.

Dietary Requirements and Intakes of Older Adults

Despite consistent evidence that a healthy diet is essential for healthy aging, less is known about the dietary and nutritional needs in advanced age. Federal definitions of older adults were created when the average lifespan was <70 y and do not acknowledge the large biological variability in this age group. Instead, for the purpose of dietary guidance and food assistance programs, individuals in their 60s are combined with centenarians. Metabolic and physiological changes that occur throughout older adulthood influence dietary requirements. For example, total energy expenditure remains relatively stable in adulthood ≤60 y of age, then declines throughout older adulthood [34–36]. These findings are based on experiments conducted using doubly labeled water (DLW), which is the "gold standard" method for assessing energy requirements in free-living adults. However, most of the DLW data are derived from convenience samples of individuals participating in studies not focused on energy requirements and few studies have evaluated energy requirements of adults aged ≥80 y using DLW. Therefore, the current estimations for this age group may not be accurate, which is a notable research gap. Furthermore, it is unclear if there needs to be ranges in energy requirements that better reflect the large diversity of the older adult population.

Related to the lack of knowledge on the range of nutrition requirements in this age group, is the paucity of knowledge about dietary intake across older adulthood. Among the challenges in understanding what older adults consume is the reliance on traditional dietary assessment methods. Questionnaire-based dietary assessment tools rely on recall ability, which may be particularly problematic for older adults who may have memory or visual challenges. This and other limitations of diet questionnaires can be overcome by using objective approaches, which are becoming more feasible with advancing technology. Spectrometry-based devices, such as the Veggie Meter (Longevity Link Corporation, Salt Lake City, Utah), can enable brief, inexpensive, and noninvasive assessment of dermal carotenoid concentrations, which reflect fruit and vegetable intake, from the fat pad of a finger [37,38] and has been validated in racially and ethnically diverse groups [38]. Photo-based approaches have gained popularity and can improve the accuracy of conventional dietary assessment tools [39]. Integrating these novel dietary assessment tools into clinical practice can improve patient–clinician communication about patient dietary behaviors and prevention of diet-related chronic diseases [40]. These dietary assessment tools need to be tested further in culturally and socioeconomically diverse older populations, as well as with relevant caregivers and/or their families. In addition, strategies to integrate these data with healthcare systems merit attention. Existing federally funded resources may be leveraged to begin to address this gap [41].

Timing and targeting interventions across the lifespan

Although a considerable amount of research has focused on identifying dietary constituents or patterns to lower risk for age-related disease and disability, less attention has been given to the appropriate timing and targeting of dietary or nutritional interventions. Timing nutritional interventions during specific periods earlier in the life course can have important health consequences in older age. For example, in rodent models, perinatal choline deficiency impaired hippocampal development and cognitive performance later in life [42,43]. However, the translation to humans remains uncertain. This is in large part due to methodological challenges of linking perinatal nutritional exposure with age-related diseases that tend to manifest in humans many decades later. There is evidence that perinatal choline exposure affects cognitive performance up to 7 y later [44,45], but it is not known if this apparent benefit extends into adulthood. Stronger prospective cohort data with information about choline intake during the life course (including pregnancy) and more robust indicators of choline status are needed.

During childhood and adolescence, adequate calcium and vitamin D intakes are critical to achieving peak bone mass [46]. Higher peak bone mass can protect against osteoporosis and fracture later in life. Weight-bearing physical activity during adolescence and early adulthood can also help optimize peak bone mass. An interesting aspect of timing with respect to calcium and bone health involves timing calcium intake around exercise because acute bouts of moderate-to-vigorous exercise can lower serum-ionized calcium and increase serum parathyroid hormone (PTH) [47]. If this occurs repeatedly, it can promote bone resorption and bone loss. A study in trained cyclists found calcium infused intravenously during vigorous cycling exercise attenuated a rise in serum PTH and serum carboxy-terminal collagen crosslinks (a biomarker of bone resorption) [48]. Similar findings were reported in a study of older adults during brisk walking exercise [49]. However, the magnitude of change in serum-ionized calcium and PTH was smaller than reported in younger cyclists [47,48]. It is uncertain whether the discrepancy is related to the participants' age or the exercise mode or intensity. Because the majority of studies investigating exercise-induced calcium disruption focused on endurance exercise, it is not known if or how resistance or interval training affects calcium homeostasis. It is also unclear how exercise influences calcium requirements in children. Because bone remodeling is a coupled process, it is possible that acute periods of bone resorption may be followed by enhanced bone formation, but this knowledge gap also remains to be addressed.

Chrononutrition, which refers to the alignment of the timing and frequency of food and beverage intake with the body's circadian rhythm, is getting increasing attention due to its associations with health and susceptibility to age-related disease [50,51]. Findings from a recent cross-sectional study indicated that chrononutrition behaviors including time of first and last intake, eating window (time between first and last intakes), and daily eating frequency correlate with muscle function in older adults [52]. For example, longer eating windows and later last food/beverage intake were associated with more muscle mass and/or power, whereas an earlier timing of the first food/beverage intake was associated with higher grip strength. This highlights the potential importance of meal timing in promoting muscle health in older adults. However, these findings are distinct from the interest in time-restricted feeding, which has shown benefits to life span in animal models [53]. It will be important to resolve this apparent conflict. Future research focused on chrononutrition in age-related disease and disability is needed to guide not just what we eat but also when to eat for optimal health in older age.

Gut health

Interventions targeting the intestinal microbiome to delay or prevent the onset of age-related diseases have attracted considerable attention. The human microbiome contains 2–20 million microbial genes. Yet, until recently, the contribution of the microbial genome to lifespan and health span has been largely ignored. This is unfortunate because microbial genes are modifiable, including by host diet [54]. Predictive models for many phenotypes related to healthy aging can be derived from the intestinal microbiome composition. For example, a person's obesity status can be classified with 90% accuracy from their microbial DNA but only with 57% accuracy from their human DNA [55]. To advance the field, additional research is needed to determine the ability of microbial DNA to predict predisposition to diseases of aging.

Although the most dramatic changes in the intestinal microbiome occur before age 3 y, subtle age-dependent microbiomial changes occur later in life. These changes have been discovered using artificial intelligence (AI). Applying AI to publicly available microbiota data from the United States, United Kingdom, China, and Tanzania [56] led to the discovery that the skin microbiome can predict chronological age within 4 years, while the oral and intestinal microbiomes can predict chronological age within 5 and 12 y, respectively [57]. This study has opened new research opportunities to develop noninvasive microbiome-based tests that detect signs of accelerated or decelerated aging and develop microbiome-based AI models to predict clinical conditions or geriatric syndromes. Currently, it is not known if or how changes in oral, skin, and intestinal microbiomes correlate with one another, which is an additional knowledge gap.

Zeevi et al. [31] used AI to integrate clinical, anthropometric, physical activity, and lifestyle characteristics along with readouts from the intestinal microbiome and found intestinal bacteria taxa and functional pathways to be key contributors to the interindividual variability in glucose response to the same meal. Interestingly, some individuals had a more favorable blood glucose response after eating ice cream than after eating white rice, and this was related to their gut microbiome [31]. This raises an intriguing question regarding how modifying one's intestinal microbes influences the blood glucose response to certain foods. The intestinal microbiome's contribution to the individual's response to certain foods or diets is likely important for other health outcomes. To help facilitate the discovery of novel microbiome-targeted interventions to delay the onset of cognitive decline and dementia, the Alzheimer's Gut Microbiome Project [58] is investigating the influence of the MIND diet [59], a low carbohydrate ketogenic diet [60], and a healthy lifestyle intervention [61] on the gut microbiome, the metabolome, and cognitive function. These studies could pave the way for future research into microbiome-based interventions to help mitigate other geriatric syndromes [62]. In humans, changes in the intestinal microbiome can take months to years and a habitual or long-term diet is more likely to have a meaningful impact. Therefore, developing dietary interventions targeting the microbiome could require testing over longer time periods than has been done typically [54,63], which is a limitation of most of the currently available studies.

Health Disparities and the Social Context of Diet and Food Choice

The aging population in the United States is becoming more racially and ethnically diverse [1], and the risk for and prevalence of age-related morbidity disproportionately impacts minoritized racial and ethnic populations. For example, a retrospective analysis of nearly 2 million adults aged ≥55 y who received care at a Veterans Health Administration medical center found that Hispanic and Black adults had the highest age-adjusted cumulative incidence of dementia [64]. Similar racial and ethnic disparities are reported for other diseases and geriatric syndromes [65–67]. The risk for many age-related chronic diseases and disability also increases with lower income and socioeconomic status [68–70] and with food insecurity [71–73]. Over 5 million older adults are food-insecure [74] and those who experience food insecurity are more likely to have a poorer diet [75], which is related to poorer health [76]. Screening for food insecurity in clinical settings is an important step in integrating nutrition and clinical medicine and connecting food-insecure older adults with available resources [77]. The Hunger Vital Sign, a 2-item screener, and the United States Household Food Security Survey 6-item Short Form are available screening tools for food insecurity that can be implemented in clinical settings [78]. Economic and food insecurity are among the social determinants of health objectives for the Department of Health and Human Services Healthy People 2030 initiative [79]. The NIH Common Fund has also launched the Community Partnerships to Advance Science for Society Program to advance research-focused community-led health equity structural interventions that address social determinants of health [80]. The Community Partnerships to Advance Science for Society Program offers the opportunity to explore and expand nutrition efforts toward multisector and multilevel interventions in real-world settings.

Several federal programs are available to help reduce food insecurity in the United States [81], the largest of which is the Supplemental Nutrition Assistance Program (SNAP). Nearly 5 million older adults receive SNAP benefits, but this is only ~40%

of those who are eligible to participate [82]. This has been attributed, in part, to a lack of awareness about SNAP benefits and eligibility, challenges in the application process such as language barriers, and/or avoidance because of immigration status and fear of being deemed a public charge [83,84]. SNAP is designed to meet the nutritional needs of an average person consuming a healthy, affordable diet. The benefit amounts are determined by the Thrifty Food Plan [85], which is calculated to be the lowest amount of money needed to purchase a nutritious diet. The Thrifty Food Plan can present a tight cost constraint, resulting in a trade-off between diet quality and food costs and raising questions as to whether a diet can be healthy and affordable for low-income individuals, including older adults. SNAP is intended to provide means to consume a healthy diet, but SNAP benefits can be used to purchase unhealthy foods (e.g., sugar-sweetened beverages), which is controversial [86]. Although updates such as this have been proposed or implemented to SNAP programs at the state and local levels, their effectiveness in increasing nutritious diets is under-researched, and a more holistic evaluation of broader public health benefits, beyond diet quality, is warranted. As discussed earlier, these federal plans assume that all older adults have similar nutritional needs, regardless of age, an assumption that has yet to be established through evidence-based research.

Social isolation

Approximately 25% of adults aged ≥65 y are socially isolated [87]. Social isolation is associated with poorer nutrition [88] and is reported to be as detrimental to health [89] and mortality risk as other known risk factors [90,91]. As discussed earlier, studies in nonhuman primates demonstrate the detrimental effects of a poor dietary pattern on social isolation [17,18]. In 2023, the United States Surgeon General issued a report calling attention to the epidemic of social isolation and loneliness, which provides a national framework for enhancing social connection [92]. During the COVID-19 pandemic, the Meals on Wheels program increased food security and diet quality among older adults and provided opportunity for social interactions with Meals on Wheels providers [93]. These findings suggest that programs targeting food security could also enhance social connections of older adults. There are several research opportunities in this area, including developing programs to improve awareness of social isolation and developing and testing the effects of tailored interventions targeting social isolation on diet and well-being of culturally and linguistically diverse groups of older adults.

To date, most dietary recommendations and nutrition education programs, overall and those focused on older adults, have not sufficiently included minoritized racial and ethnic populations, especially immigrants and those with limited English language fluency [94]. This gap presents an opportunity to expand diet recommendations and improve education programs for cultural, migratory, and dietary experiences among the rapidly growing and diverse aging population. This could include incorporating cultural and linguistic adaptations to dietary and nutritional interventions—e.g., integrating complementary and alternative medicine such as Chinese medicine into the nutrition counseling curriculum [95]. Other opportunities to understand and address the social contexts of diet and food choice include updating traditional food intake measures (e.g., food frequency questionnaires) to better capture a range of food items and dietary and cultural food preferences, the development of culturally relevant evidence-based nutrition interventions and monitoring the implementation and evaluation of local, state, and national programs and policies that impact healthy food behaviors and access to nutrition resources.

Conclusion

The aging process is highly heterogeneous and this heterogeneity merits consideration to optimize nutritional strategies that maintain health and independence in older age. This will require improving our understanding about not just what older adults should eat, but when and where in the life course to intervene, and how physiological factors (such as the microbiome) influence the impact of diet on human health. Tailored approaches should be balanced with public health goals, but cultural experiences and other social determinants of health must also be considered for the successful implementation and sustainability of evidence-based nutrition interventions in real-world settings [96]. By engaging multidisciplinary teams with expertise in the biological, clinical, and social aspects of aging and nutrition, comprehensive nutritional strategies that delay or prevent the onset of many diseases of aging can be developed, which will reduce the individual and public health burden of poor health for all older adults.

Author contributions

The authors' responsibilities were as follows – SBK and SLB: participated in workshop organization; MKS, LS, MK, LNĐ, and SLB: contributed to conceptualization and writing of the original draft; TEB and SBK reviewed and edited the manuscript; MKS: had primary responsibility for content; and all authors: read and approved the final manuscript.

Conflict of interest

MK has received research funding from Genentech. All other authors report no conflicts of interest.

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