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STROKE (HP ADAMS, SECTION EDITOR)

Dietary Interventions to Lower the Risk of Stroke

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Abstract Stroke is a major cause of death and permanent disability in the USA; primary prevention and risk reduction are a critical health concern. A wealth of research investigated stroke risk factors, including primary hypertension, diabetes, and atrial fibrillation. Research has expanded to examine lifestyle factors, such as diet/dietary patterns, physical activity, cigarette smoking, and obesity distribution, as critical modifiable risk factors. Emerging evidence suggests diet/dietary patterns may lead to heightened risk of stroke. Despite a growing literature, research has yet to implement dietary interventions to explore this relationship within a US sample. This review discusses available clinical research findings reporting on the relationship among diet/dietary patterns, cardiovascular disease, and risk of stroke. We will assess challenges, limitations, and controversies, and address future research directions.

This article is part of the Topical Collection on *Stroke*

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Introduction

Stroke is the fourth leading cause of death and the leading cause of permanent disability in the USA. The direct and indirect costs related to stroke death and disability exceed $50 billion annually [1••, 2]. Primary stroke prevention through risk identification and control remain the first line strategy to decrease the burden of stroke [1••, 3]. Indeed, a wealth of research has documented the most important stroke risk factors, including hypertension, diabetes, atrial fibrillation, asymptomatic carotid artery stenosis, dyslipidemia as well as more novel factors including sleep, sickle cell disease, and postmenopausal hormone therapy. In recent years, a greater focus is being placed on lifestyle factors such as, physical activity, cigarette smoking, obesity, and diet/dietary patterns [4] in relation to stroke incidence. The American Heart Association (AHA) notes maintaining a healthy diet is one of the "best weapons for fighting CVD," [5••] and a significant contributor to stroke reduction [4, 6]. In fact, research has found that those "who practice a healthy lifestyle have an 80 % lower risk of a first stroke compared with those who do not," [7]. Maintaining a healthy diet is a critical determinant of health overall and of stroke at the individual and population level [8, 9]. Nevertheless, there remain considerable complexities and challenges understanding, defining, and testing optimal dietary habits and patterns.

Dietary research and intervention development, including collection and validation of dietary intake are both multifaceted and complex. There are many levels of complexity to understand the interaction of nutrients (i.e., nutrients are never eaten in isolation), and account for the influence of access, economics,

culture, and environment on diet/dietary patterns [9, 10]. Despite the obstacles, there is a growing body of literature examining individual nutrient intake including sodium, fat intake, cholesterol, vitamins, minerals, and other supplements along with dietary factors such as, fruit vegetable intake, animal protein, and beverage consumption [6, 11–17]. Unfortunately, much of the research findings are mixed and often inconclusive. Ding and Mozaffarian (2006) note, "optimal diet to reduce the incidence of stroke is not well established [and] further investigation of specific effects on stroke incidence is warranted," [11]. Furthermore, only a few dietary interventions investigating the effect of diet/dietary patterns and risk of stroke have been initiated. This review discusses available data and assesses challenges, limitations, and controversies to guide future research direction.

Key Epidemiological Studies Documenting Diet/Dietary Pattern and Cardiovascular Disease

Examining key epidemiologic research surrounding stroke and diet provides a foundation for the development of dietary interventions. The Framingham Heart Study (FHS) and the Nurses' Health Study (NHS) are the first longitudinal epidemiological studies to identify common factors and characteristics contributing to cardiovascular disease (CVD) and stroke incidence. The FHS was ground breaking, as it was the first to document long-term dietary patterns with risk of stroke using a 20-year follow-up period. FHS participants were asked to report the frequency of consumption of listed foods and beverages during the previous year using the Food Frequency Questionnaire (FFQ), a validated questionnaire. FHS found that those who increased fruit and vegetable consumption had a lower CVD risk ratio across all quintiles (P_{trend}=0.01) [18]. Every increment of three daily servings of fruits and vegetables was correlated with a 22 % decrease in risk of all types of stroke and TIA (age-adjusted risk ratio (RR), 0.78; 95 % confidence interval (CI), 0.62–0.98). Participants who ate more fat, including more saturated fat, were less likely than those with lower fat diets to develop ischemic stroke [18]. The FHS study had two noteworthy limitations, a homogenous population and limited exploration of possible confounding variables in analyses. Despite the limitations of FHS, it set a precedent for future diet and CVD research.

A decade after the FHS, the Nurses' Health Study (NHS) began to better understand women's health with a primary focus on cancer prevention [19, 20]. A cohort of nurses was surveyed in 1976 and biennially thereafter. In 1986, the Health Professionals Follow-up Study (HPFS) was established and a second cohort of nurses enrolled in 1989 while in 1996, the second cohort's children were enrolled in a follow-up study, the Growing Up Today Study (GUTS). Over time, the NHS became the largest and longest ongoing observational cohort study [7, 19]. NHS examined many lifestyle factors, including assessing diet/dietary patterns prospectively and bi-annually. Study participants completed a 136-item FFQ. NHS findings identified two key dietary patterns, "prudent" and "western." The "prudent" diet consists of high intake of vegetables, fruit, legumes, fish, poultry, and whole grains while the "western" diet consists of high consumption of red meat, processed meat, refined grains, and sweets. Participants were categorized by how closely they adhered to each dietary pattern. When comparing the highest with lowest quintiles of the "western" pattern, the NHS reported greater than a 50 % increased risk [relative risk of 1.58 (95 % CI, 1.15–2.15; P_{trend}=0.0002)] for total strokes and 1.56 (95 % CI, 1.05–2.33; P_{trend}=0.02) for ischemic strokes. The "prudent" dietary intake was associated with a 22 and 26 % reduction in total and ischemic stroke, respectively [relative risks comparing extreme quintiles were 0.78 (95 % CI, 0.61–1.01) for total stroke and 0.74 (95 % CI, 0.54–1.02) for ischemic stroke]. Both the FHS and NHS triggered a shift in how researchers explore the relationship between diet/dietary patterns relating to CVD and risk of stroke. In particular, the FHS and NHS provided a foundation for exploring these relationships further, as examined in the Northern Manhattan Study (NOMAS).

The NOMAS recruited 3,183 participants prospectively to explore stroke risk factors in a multi-ethnic population in Northern Manhattan in New York City. NOMAS is the first study of its kind to examine stroke risk factors in a racially diverse population living in the same community. NOMAS conducted multiple sub-studies and secondary analyses to explore the association between various dietary factors and patterns with stroke risk, incidence, and mortality. At baseline, NOMAS participants completed in-person a modified Block National Cancer Institute food frequency questionnaire in English or Spanish to assess dietary patterns during the previous year [21]. Food responses were modified to include specific Hispanic dietary items. Using the FFQ, NOMAS investigators computed caloric intake and created dietary score of the following food groups: dairy, meat, fruits, vegetables, legumes, cereals, and fish. NOMAS findings examined the relationship of dietary factors including fat intake, sodium intake, and beverage consumption with risk of stroke.

In a sub-study, NOMAS examined the relationship between fat intake and risk of ischemic stroke. Cox proportional hazard models calculated risk of incident ischemic stroke for 3183 stroke-free community residents. On average, NOMAS participants consumed daily 1565 calories and 61 grams (g) of fat. Consuming daily total fat above 65 g significantly increases one's risk of ischemic stroke (HR 1.6, 95 % CI 1.0–2.7). In another analysis, NOMAS participants who consumed high sodium diets had an increased risk of stroke independent of vascular risk factors. Sodium intake was a continuous variable and was associated with a 17 % increase in stroke risk for each 500 mg consumed daily (1.17; 95 % CI, 1.07–1.27) [14]. Furthermore, consuming >4000 mg/day sodium associated

with 2.6-fold increase in stroke risk versus <1500 mg/day (95 % CI, 1.27–5.28) [22]. Despite NOMAS' findings, recent research found that salt intake might not be as deleterious as previously documented [23]. Future research is needed to investigate the effect of salt on stroke and other health outcomes [24].

Additional NOMAS sub-studies examined beverage consumption (tea, coffee, soda, and alcohol) and stroke risk. A protective dose-response relationship was found between coffee and tea consumption and all-cause mortality while an inverse relationship for both caffeinated coffee and tea with all-cause mortality [16]. Individuals who drank diet soda every day had a 61 % higher risk of vascular events than those who did not drink soda [15]. Alcohol consumption proved to be an interesting finding; moderate alcohol consumption, up to two drinks per day, was significantly protective for ischemic stroke after adjustment for cardiac disease, hypertension, diabetes, current smoking, body mass index, and education (OR 0.51; 95 % CI, 0.39–0.67). Heavy alcohol consumption, consuming seven or more drinks per day, showed a statistically significant increased risk of ischemic stroke (OR, 2.96; 95 % CI, 1.05–8.29). NOMAS' sub-studies highlight the relationship between risk of stroke and dietary factors and patterns in large-scale multi-ethnic population with high follow-up, validated outcomes, and comprehensive collection of vascular and dietary factors [25]. NOMAS findings expand current knowledge of stroke epidemiology in racial-ethnic minority populations.

Dietary Patterns and Risk of Stroke

Large cohort epidemiologic studies lay the foundation to examine dietary patterns and the relationship to stroke risk. An additional NOMAS sub-study examined the relationship between consuming a Mediterranean diet and risk of ischemic stroke, myocardial infarction (MI), and vascular death. Mediterranean diet was defined as "high intake of fruit, vegetables, monounsaturated fat, fish, whole grains, legumes, and nuts; moderate alcohol consumption; and a low intake of red meat, saturated fat, and refined grains," [26]. A Mediterranean diet score was computed by the sum of food categories scores (range 0–9). A greater score indicated greater similarity to a Mediterranean diet. NOMAS reported that the Mediterranean diet score was inversely associated with risk of the composite outcome of ischemic stroke, MI, or vascular death (P_{trend}= 0.04) and with vascular death specifically (P_{trend}=0.02). Moderate and high Mediterranean diet score were marginally associated with decreased risk of MI while there was no association with ischemic stroke [26]. The Mediterranean diet score was associated with lower degrees of white matter hyper-intensity in the brain [27], a marker of small vessel damage and an important predictor of stroke, dementia, and brain death. NOMAS' analyses provide valuable findings in the role of diet and stroke incidence in a multi-ethnic population.

The Reasons for Geographic and Racial Differences in Stroke (REGARDS) and Brain Attack Surveillance in Corpus Christi (BASIC) are additional large epidemiological studies examining stroke risk factors and dietary patterns in racial-ethnic minority populations in the US. The USA is characterized by racial-ethnic and regional stroke disparities, primarily in the "Stroke Belt," the Southeastern region of the USA [28, 29•, 30]. Previous research has suggested that lifestyle choices, including dietary factors, are a cause of Stroke Belt disparities [30]. The Reasons for Geographic and Racial Differences in Stroke (REGARDS) is a national observational study investigating racial-ethnic, regional, and dietary patterns with risk of stroke [28, 29•] in the Stroke Belt. In 2003–2007, REGARDS recruited 30,239 participants who completed a 45-minute telephone interview and Block 98 version FFQ. Using factor analysis and food frequency data, REGARDS derived five dietary patterns from the cohort. They include, "convenience" (Mexican and Chinese food, mixed meat, and bean dishes), "healthy" (fruit, vegetables, fruit juice, cereal, fish, poultry), "sweets" (added fats, bread, chocolate, desserts, sweet breakfast food), "southern" (added fats, fried food, organ and processed meat, fatty milk), and "alcohol" (beer, wine, liquor, green leafy vegetables, salad dressings, nuts and seeds, coffee) [31••, 32].

The five REGARDS dietary patterns were examined in quartiles to determine the association of diet with stroke risk and demographic, socioeconomic, behavioral, and nutrient variables [31••]. Adjusting for age, race, geographic region, sex, and age, a greater adherence to the plant-based and sweets/fats dietary patterns was associated with a reduction in stroke risk. A greater adherence to the southern pattern was associated with an increased risk of stroke (39 % increased risk of stroke (hazard ratio, 1.39; 95 %CI, 1.05–1.84) comparing the highest quartile to lowest quartile (P_{trend}=0.009)). Neither the convenience pattern nor the alcohol/salads dietary pattern were associated with risk of stroke (P>0.05) while participants who adhered more closely to the healthy dietary pattern had the lowest stroke risk (hazard ratio, 0.71; 95 %CI, 0.56–0.91; P_{trend}=0.005) [31••]. Similar to the NOMAS study, a REGARDS sub-study found that higher adherence to a Mediterranean diet was associated with a lower likelihood of incident cognitive impairment, the core clinical attribute associated with the diagnosis of dementia [33]. REGARDS researchers concluded, "given the consistency of finding a dietary effect on stroke risk across studies, discussing nutrition patterns during risk screening may be an important step in reducing stroke," [29•, 31••]. A future research was recommended to conduct culturally specific diet interventions to help reduce racial and geographic disparities in stroke risk.

As documented in REGARDS [31••], convenient dietary patterns "have become a quickly growing and universal phenomenon" in the USA [36], often lacking in fruit,

vegetables, and whole grains but plentiful in fat and salt. NOMAS findings also indicated how elevated fat and salt intake may increase an individual's risk of stroke [14]. The Brain Attack Surveillance in Corpus Christi (BASIC) project is an ongoing stroke surveillance study focusing on Mexican Americans and non-Hispanic Whites [34] in Corpus Christi, Texas. BASIC uses active and passive surveillance to capture cerebrovascular cases (ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage) [35]. BASIC also explored the link between dietary patterns and risk of stroke by examining the association between the number of fast food restaurants and ischemic stroke in neighborhoods.

BASIC used census tract information to plot fast food restaurants and geocode home addresses for each stroke case [35], reporting 1247 completed ischemic strokes, 262 fast food restaurants, and 22 median fast food restaurants per census tract (interquartile range, 12–33). Adjusting for neighborhood demographics and socioeconomic status, there was a significant association between fast food restaurant density and stroke risk. BASIC reported the risk of stroke in a neighborhood increased by 1 % for every fast food restaurant (relative risk, 1.01; 95 % CI, 1.00–1.01). The relative risk of stroke between neighborhoods in the 75th percentile of fast food restaurants (N=33) and in the 25th percentile (N=12) was 1.13 (95 % CI, 1.02–1.25). BASIC findings suggest an association of the density of fast food restaurants and the number of ischemic stroke cases. A major limitation of BASIC's analysis lies in the ecological approach. Indeed, it is unknown whether the stroke cases consumed more fast food or just resided in neighborhoods with higher numbers of fast food restaurants. Nevertheless, BASIC suggests multifaceted variables may account for increased risk of stroke, encompassing both the individual and the influence of neighborhood factors, and suggesting the potential of future research to incorporate geocoding to better understand dietary habits, patterns, and environmental factors. BASIC's findings also raise the question of the socioeconomic profile of the neighborhood and healthy food availability [34, 35].

Dietary Intervention and Stroke Risk

Data from NOMAS and REGARDS provide evidence suggesting a Mediterranean dietary pattern may be impactful in decreasing stroke risk. However, changing dietary behavior is not a simple process and implementation of dietary interventions to study specific dietary choices is inherently complex. While several clinical trials document the effect of dietary factors and patterns for the risk of stroke, less research exists examining the implementation of dietary interventions to impact stroke risk reduction and stroke prevention. The Prevención con Dieta Mediterránea (PREDIMED) is a large-scale Spanish randomized controlled trial whose aim was to examine the effect of different types of the Mediterranean diet on primary prevention of cardiovascular events (myocardial infarction, stroke, or death from cardiovascular causes). In 2003, PREDIMED recruited 7,447 participants who were randomly assigned to one of three groups: Mediterranean diet with supplemental extra-virgin olive oil (VOO), Mediterranean diet with nuts, and control diet which received instruction on low fat consumption. The two groups randomized to the Mediterranean diet interventions received intensive education to follow the Mediterranean diet and supplemental foods. PREDIMED used a general medical questionnaire and a 137-item validated FFQ to measure dietary habits and patterns. Adherence to the Mediterranean diet and change in dietary habits was documented [37].

PREDIMED found both Mediterranean-diet groups reduced the incidence of major cardiovascular events for individuals of high CVD risk [38]. There was an "absolute risk reduction of approximately three major cardiovascular events per 1000 person-years, for a relative risk reduction of approximately 30 % for cardiovascular death, a myocardial infarction or a stroke, among high-risk persons who were initially free of cardiovascular disease," [37, 38, 39••]. PREDIMED findings suggest a causal role of the Mediterranean diet, primarily extra-virgin olive oil and nuts, in CVD prevention and reduction. Despite PREDIMED's striking findings, there is concern about the generalizability globally and specifically to US populations. Indeed, the baseline diet of most trial participants was similar to the Mediterranean diet intervention. The Mediterranean diet is widely prevalent among its sample population whereas a similar diet may not be applicable to other non-Mediterranean countries. Critics note that the Mediterranean diet is similar to the "prudent" diet, since both include high intake of fruits, vegetables, monounsaturated fat, and nuts. Economic and geographical factors in the USA severely limit access to these types of foods [11, 40••]. Additionally, adherence to recommended dietary patterns and supplemental foods was judged by self-report and objective measurements clinical outcomes were not measured. PREDIMED stratified race and ethnicity by "White (from Europe), Hispanic (from central or South America), and other." These racial-ethnic categories are not compatible with US racial-ethnic composition [41], particularly considering the cardiovascular disease burden among "Hispanic" and PREDIMED's "other" categories [42••]. Despite these limitations, PREDIMED suggests "a potentially greater benefit of the Mediterranean diet as compared with Western diets," [39••]. The Mediterranean diet may in part explain the "lower cardiovascular mortality in Mediterranean countries than in northern European countries and the United States," [39••]. PREDIMED findings suggest that both Mediterranean-diet groups reduce disease risk compared to the control group [37, 38, 39••].

Another ongoing effort which incorporates both behavioral change and dietary intervention is the Stroke Health and Risk

Education (SHARE), a primary stroke prevention and behavioral intervention in the bi-ethnic community (Mexican Americans and European Americans) in Corpus Christi, Texas [43, 44]. The study aims to promote healthy lifestyle factors and reduce stroke risk factors by implementing a culturally sensitive, church-based, multi-component, motivational enhancement intervention. The focus of the intervention is reducing sodium, increasing fruit and vegetable intake, and increasing physical activity as key modifiable stroke risk factors. Dietary habits are self-identified using the Block 2005 FFQ, including additional food items that are common in a Hispanic diet. Investigators calculated average daily sodium intake by summing from all foods, fruit, and vegetables servings from average total daily cups of intake.

Several components of SHARE's intervention reinforce "healthy" behaviors and lifestyle. The intervention includes "self-help materials (including a motivational short film, cookbook/healthy eating guide, physical activity guide with pedometer, and photo novella), five motivational interviewing calls, two tailored newsletters, parish health promotion activities and environmental changes, and a peer support workshop," [43, 44]. The SHARE intervention aims to reinforce a healthy diet to reduce risk of stroke [43, 44]. SHARE's enrollment, data collection, and analyses are still underway. Additional research is warranted to explore how dietary intervention can impact stroke risk in a longitudinal race-ethnic diverse US sample.

Challenges and Controversies

Studying the role of diet and impact of intervention on stroke prevention continues to have numerous challenges. In 2010, the American Heart Association's (AHA) Strategic Planning Task Force created a comprehensive report, "Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The AHA's Strategic Impact Goal Through 2020 and Beyond," to discuss major advances and challenges in the field of cardiovascular health research [42••]. The report highlighted three areas of improvement to better understand which dietary factors and patterns to reduce CVD and stroke incidence. First, dietary data collection and measurement continue to be a limitation of all diet-related trials. Previous research, editorials, and commentaries highlighted significant qualitative and quantitative limitations [45–47], including measurement error since most assessments rely on memory and estimation. Bias also becomes a prevalent factor dependent on the time period, the ease of the instrument, and the patient population at hand. Despite FFQ-derived data accurately predicts risk of CVD, critics note the need for methodology improvements [45, 46, 48, 49]. Leading cancer epidemiologists recommend improving FFQ measures with computer-administered questionnaires with guided instructions and images, additional questions on dietary behaviors in questionnaires, and collect real-time food consumption using cell phone applications [50•]. In addition to the challenges of measuring diet, it is difficult to categorize and analyze dietary patterns. Researchers frequently compute an a priori dietary score, such as score-based index analyses, or a posteriori analyses, such as factor or cluster analysis, to identify patterns and trends [10, 49]. Technology improvements may allow for more accurate and sophisticated data collection and analysis; continued research is needed.

Second, "diet is a complex constellation of multiple factors," [42••]. As aforementioned, dietary nutrients are not eaten in isolation and may have different interactions with various biological, chemical, and sociocultural components. Physiological mechanisms are important; however, sociocultural and socioeconomic factors are key features as well. For example, food scarcity, geographic barriers, cultural barriers, and the interface between genes and environment all contribute to one's diet. The NOMAS, REGARDS, and BASIC findings demonstrate the "social patterning" of dietary habits and stroke incidence. These sociocultural factors may present an opportunity for broader intervention in areas, such as improving health literacy and policy approaches to improve access to healthier food options such as fruits and vegetables.

Third, "there is no single biomarker or other objective metric to examine heart healthy diet/dietary patterns. Research is ongoing to characterize objective measures of diet. In the past, research used lipoprotein profiles, blood pressure, and blood glucose metrics. Research has grown to develop objective biomarkers of dietary intake based on stable isotope ratios. O'Brien and colleagues (2014) used covariate-adjusted linear models to examine biomarker associations for marine food intake with chronic disease risk factors in Alaskan Yup'ik people. They found that the nitrogen isotope ratio (δ(15)N) of red blood cells (RBCs) is a valid measure in the study population for evaluating associations with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which research indicates may lower individual risk of stroke [51]. The AHA committee recommended dietary metrics should include dietary habits beyond risk factors and move explore dietary patterns based on foods rather than nutrients. For example, several trials have focused on changing an isolated dietary factor. However, this is not translatable to dietary intervention or real-world settings. Several studies highlight the importance of vitamins for cardiovascular health, but the Vitamin Intervention for Stroke Program (VISP) found no advantage to high-dose B vitamin replacement in patients with elevated homocysteine [52, 53]. The Physicians' Health Study II found no differences between the multivitamin and placebo groups in overall cognitive performance or verbal memory [54]. The Trial to Assess Chelation Therapy (TACT) found no significant difference in recurrent cardiovascular events with multivitamins compared with placebo [53]. Inconsistent

results regarding single dietary factor change or adjustment further underscore the interaction of nutrients and compounds [53]. The AHA committee strongly focuses on whole foods and dietary patterns rather than isolated and specific nutrients.

Future Direction of Research

Evidence remains limited and inconsistent regarding dietary patterns associated with risk of stroke. Critics have noted, "the effect of diet on the development of stroke has recently achieved much interest by various research groups, but with inconclusive results," [10]. Given the uncertainty of much of the data, physicians often turn to the United States Department of Agriculture (USDA) and the United States Department of Health and Human Services' (HHS) "Dietary Guidelines for Americans" as well as the AHA dietary guidelines to inform high-risk cardiovascular disease and stroke patients on recommended eating habits [42••, 55••]. A recent AHA report (2014) highlighted the Dietary Approaches to Stop Hypertension (DASH)-like eating plan and the Mediterranean diet as being likely to "reduce stroke risk" [55••]. The DASH-like eating plan, derived from the DASH a controlled feeding trial [56] includes, "≥4.5 cups of fruits and vegetables per day, ≥two 3.5-oz servings of fish per week (preferably oily fish), ≥three 1-oz-equivalent servings of fiber-rich whole grains (≥1.1 g of fiber per 10 g of carbohydrate) per day, <1500 mg of sodium per day, and 36 oz of sugar-sweetened beverages per week," [42••]. Similarly, a Mediterranean diet is plant-based, supplemented with nuts with moderate to low fat and sodium intake [10, 13]. The PREDIMED study demonstrates that a Mediterranean diet consisting of ≥four tablespoons of olive oil daily, ≥three servings of tree nuts and peanuts per week, ≥three servings of fresh fruit daily, ≥two servings of vegetables daily, ≥three servings of seafood (preferably fatty fish) per week, ≥three servings of legumes per week, ≥two servings of sofrito (sauce made with olive oil, tomato, garlic, onion, herbs) per week, eating lean white meat instead of red meat, and ≥seven glasses of wine with meals per week for habitual drinkers [37], is likely to reduce the incidence of major cardiovascular events for individuals of high CVD risk [37]. Despite these findings, further research is needed as "few randomized trials with clinical outcomes have been conducted," [55••]. Meschia and colleagues continue, "Diet and exercise [both key elements of a healthy lifestyle] are notoriously challenging to study with the same rigor as drugs or devices. It is easier to convince a patient to take a pill than to radically change his or her lifestyle. Nonetheless, we must expect the same standards of evidence for lifestyle interventions," [55••]. The AHA report signals the need to further explore dietary interventions to lower the risk of stroke.

Additional dietary interventions are warranted; however, improving and optimizing diet assessment is essential. Data collection should optimize objective and self-report measures of dietary intake at which they occur and should be applicable to for diverse populations. Further development is needed to create better instruments, by using innovative technologies and advanced statistical and analytic techniques to investigate diet and stroke. Critics have noted the potential of personalized nutrition, the study of dietary factors, and patterns with individuals' genomic makeup rather than context of public health recommendations [11, 40••]. In addition, future clinical trials may incorporate wearable technologies, a technological innovation with an increasing consumer market. Interventions should aim to address factors that impact diet beyond food choice, such as food access and the role of the community to reduce stroke risk.

Conclusion

In the last decade, substantial longitudinal, observational, and clinical studies investigated the association of dietary factors and risk of stroke; however, research has yet to determine a dietary intervention to reduce risk of stroke, incidence, and mortality within the context of the USA. To meet the AHA's goal of improving America's cardiovascular health by 20 % by 2020, new strategic directions must be implemented using multi-level approaches that incorporate research, clinical practice, public health, communities, and advocacy [42••] to better predict and prevent stroke incidence.

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Compliance with Ethics Guidelines

Conflict of Interest Bernadette Boden-Albala, Lauren Southwick, and Heather Carman declare that they have no conflict of interest.

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