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Dietary Diversity: Implications for Obesity Prevention in Adult Populations:

A Science Advisory From the American Heart Association

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Abstract

"Eat a variety of foods," or dietary diversity, is a widely accepted recommendation to promote a healthy, nutritionally adequate diet and to reduce the risk of major chronic diseases. However, recent evidence from observational studies suggests that greater dietary diversity is associated with suboptimal eating patterns, that is, higher intakes of processed foods, refined grains, and sugar-sweetened beverages and lower intakes of minimally processed foods, such as fish, fruits, and vegetables, and may be associated with weight gain and obesity in adult populations. This American Heart Association science advisory summarizes definitions for dietary diversity and reviews current evidence on its relationship with obesity outcomes, eating behavior, and food-based diet quality measures. Current data do not support greater dietary diversity as an effective strategy to promote healthy eating patterns and healthy body weight. Given the current state of the

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ARTICLE INFORMATION

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science on dietary diversity and the insufficient data to inform recommendations on specific aspects of dietary diversity that may be beneficial or detrimental to healthy weight, it is appropriate to promote a healthy eating pattern that emphasizes adequate intake of plant foods, protein sources, low-fat dairy products, vegetable oils, and nuts and limits consumption of sweets, sugar-sweetened beverages, and red meats.

Keywords

AHA Scientific Statements; diet; eating behavior; healthy diet; obesity; prevention and control

First introduced in the early 20th century in response to the prevalence of nutrient inadequacies, “eat a variety of foods” is a long-standing public health recommendation in the United States and worldwide.[1–4] It is based on the premise that consuming a wide variety of foods will ensure an adequate intake of essential nutrients and, in turn, will lead to better diet quality and optimal health outcomes.[5,6] More recently, however, there is evidence that greater dietary diversity may be associated with suboptimal diet quality and higher food consumption and energy intake, particularly in middle-aged adult populations.[7–12] Poor diet quality and excess energy intake can negatively affect body weight and increase the burden of major chronic diseases such as cardiovascular disease and diabetes mellitus. Currently, there is a lack of consensus about what dietary diversity is and how it is best measured. This American Heart Association science advisory summarizes the definitions and measures used to describe dietary diversity and reviews the evidence from observational studies on dietary diversity and its relationship with food-based diet quality, body weight, and adiposity measures. We have also reviewed evidence from intervention studies evaluating the influence of dietary variety on dietary factors relevant to obesity, including satiation and patterns of food consumption. Finally, we provide recommendations for future research needed to inform dietary guidelines. The terms *dietary diversity* and *dietary variety* are considered to be synonymous and are used interchangeably.

LITERATURE SEARCH STRATEGY

A comprehensive literature search (January 2000–December 2017) of Medline was performed to identify English language articles on human subjects with the use of various combinations of the following search terms: *dietary variety*, *dietary diversity*, *food variety*, *diet quality*, *dietary patterns*, *eating behavior*, *energy intake, satiety*, *energy balance*, *obesity*, *body weight*, *weight change*, *weight gain*, and *waist circumference*. We also identified studies through a review of reference lists of published articles. Consistent with current nutrition guidance, which has shifted the concept of diet quality from nutrient adequacy to food-based recommendations, we have focused on studies using primarily food-based diet quality scores. The review was limited to observational and intervention studies conducted in participants ≥18 years of age.

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DEFINING AND MEASURING DIETARY DIVERSITY

Diet Variety in the Dietary Guidelines for Americans

The 2015–2020 Dietary Guidelines for Americans defined *diet variety* as a diverse assortment of foods and beverages across recommended food groups.[4] Prior editions of the Dietary Guidelines for Americans emphasized 5 food groups: vegetables, fruits, grain-based foods such as bread and pasta, dairy foods, and protein sources such as red meat, poultry, beans, eggs, and nuts.[13–16] The 2015–2020 Dietary Guidelines for Americans recommend choosing a variety of nutrient-dense foods across and within all food groups, with particular emphasis on variety of vegetables and protein sources.

Measures of Dietary Diversity in Nutritional Studies

The Table shows a summary of key concepts and definitions of dietary diversity metrics used in large observational studies.

Count-Based Scores

Diet variety or diversity has traditionally been measured as counts of different foods or food groups consumed over a given period, typically 1 to 15 days.[6,17–19] Based on self-reported dietary assessments, such as food frequency questionnaires or dietary recalls, this widely used metric reflects the different sources of macronutrients and micronutrients within dietary patterns based on a list of food groups specified a priori. Dietary variety scores have been developed on the basis of individual foods and beverages or food groups. For example, a food variety score allocates points for each distinct food and beverage consumed within a given period. A food group variety score such as the Dietary Diversity Score[25] allocates points for each food group consumed over a prespecified period.

Evenness and Dissimilarity

Because count-based scores do not appropriately account for the differences in food characteristics (eg, nutrient content), one of the main hypothesized benefits of highly diverse diets, or for the relative allocation of energy across foods or food groups, new measures have been adopted from established diversity science describing diversity in ecological and economic systems. One such measure is evenness or diversification, which assesses the relative share of energy across foods consumed in one's eating pattern.[10,20–23] For example, an individual may consume many different foods per week, but a limited number of foods contribute to the majority of total energy intake (low evenness). In contrast, an individual may report a wider range of foods contributing to the total energy intake (high evenness). Evenness is commonly quantified with the Berry-Simpson index.[10,20–23] Variations of this metric include the relative distribution of foods by weight or volume.[21,22]

In addition to evenness, a diet dissimilarity score was developed to reflect the differences in food characteristics within a given eating pattern (Table).[10] For example, an individual's diet may be composed of relatively similar foods (eg, mostly plant foods) or dissimilar foods (eg, fruits, vegetables, baked goods, snacks, soda). A list of attributes used to assess dissimilarity among foods includes characteristics that are relevant to cardiometabolic health such as sodium and fiber content, food type (animal versus plant food), and level of food processing

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(eg, minimally, moderately, or highly processed). Similar to food count measures, evenness and dissimilarity can be expressed on the basis of individual foods or food groups.

Count, evenness, and dissimilarity may reflect different and complementary aspects of dietary diversity. In a study evaluating multiple diversity measures, a moderate positive correlation was noted between food count and evenness, and a weak inverse correlation was seen between dissimilarity and food count and evenness.[10] This suggests that each indicator provides unique insights into different dietary patterns that may be relevant to health outcomes. Understanding the different concepts and measures of dietary diversity is critical to improving our understanding of what a diverse diet is and how it may influence current dietary patterns that are relevant to obesity.

Dietary Quality Versus Diversity

In contrast to the concept of diet diversity, diet quality scores have been developed to assess diet healthfulness or adequate food consumption, typically as defined by dietary guidelines.[26–31] For example, the Healthy Eating Index (HEI)[32–34] was initially developed on the basis of the 1990 Dietary Guidelines for Americans, allocating higher points for adequate daily intake of grains, vegetables, fruit, milk, meat, total fat, saturated fat, cholesterol, and sodium and for greater variety of food items, assessed with simple food count.[35] Higher food-based diet quality scores, such as the HEI, Alternative HEI, and Dietary Approaches to Stop Hypertension, have consistently been associated with lower disease risk.[26–28]

Few previous studies have modified dietary diversity measures to reflect diet quality in addition to, or rather than, diversity.[6,22,36] These scores are not included as dietary diversity measures in this advisory. To appropriately delineate concepts that are central to dietary diversity and to assess their potential impact on diet quality and obesity outcomes, this advisory focuses on count; evenness; dissimilarity, defined from total food consumption; healthy foods only, including those consistent with current dietary guidelines; and less healthy foods.

INTERVENTION STUDIES ON SATIATION AND FOOD CONSUMPTION

Consistent with the notion of food dissimilarity, several short-term feeding studies in humans have evaluated the effects of various food characteristics such as flavor, texture, and appearance on satiation (ie, the process that leads to the cessation of eating and drinking).[7,8,37–41] The majority of the studies showed that serving a wider variety of foods led to an increase in food intake compared with serving a single food.[40,41] Evidence from previous studies suggests that relationships of dietary variety are likely mediated by sensory-specific satiety, the decline in pleasantness and desire to eat during the course of a meal. For example, an intervention in 21 normal-weight male participants (mean±SD age, 22±3 years) showed that adding ketchup or mayonnaise to French fries and vanilla or whipped cream to brownies during the second course of a meal decreased sensory satiety and increased ad libitum intake of these foods by nearly 40% compared with offering the same plain food a second time (mean±SD food intake, 512±227 g for the second course with added condiments versus 366±163 g for the second course without condiments).[42] Similarly, a 2-course feeding study including 23 US and UK adults (mean±SD age, 28.6±2.9 years)

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showed that serving sandwiches with different filling options (cheese or ham) during the second course of a meal increased ad libitum food intake by 30% compared with serving the same option provided in the first course (mean±SE food intake units, 11.7±1.0 for different fillings versus 9±1.0 for similar options).[37] Limited evidence from feeding studies to date suggests that greater diet diversity increases food consumption through amplifying sensory stimulation associated with multiple foods, delaying satiation.

One 8-week weight loss intervention examined the effect of varying the daily count of snacks on satiation and eating patterns. In this study, 30 overweight and obese adults (mean ±SD age, 50.9±8.4 years) were randomized to an unlimited number of snack options consumed less than once a day (ie, “everything in moderation”) or 1 highly liked snack option of their choice at any desired amount. Both options were within the daily caloric goal of 1200 to 1500 kcal/d. After 8 weeks, the group assigned to an unlimited variety of snack options consumed 25% more snack servings per week compared with those randomized to 1 snack option (mean±SD servings per week, 9.1±7.3 for the unlimited variety versus 7.3±4.2 for the 1-snack option). Although calorie restriction goals were achieved in both groups, a significant increase in sensory-specific satiety and monotony ratings over time was observed in participants assigned to the 1-snack option but not in participants assigned to a variety of snacks.[43,44]

DIET DIVERSITY CONCEPTS AND MEASURES: SUMMARY OF KEY FINDINGS

- There is no standardized measure for dietary diversity; self-reported dietary diversity has been defined in most studies as the count (ie, the number of food or food groups consumed over a specific period [1–15 d]).
- Other measures of dietary diversity include evenness (ie, the relative distribution of calories across individual foods) and dissimilarity (ie, the differences in food attributes relevant to health).
- Dietary diversity can be estimated on the basis of total food consumption as well as on selected food groups only (eg, variety of fruit or vegetable intake).
- In contrast to the concept of diet diversity, diet quality scores have been developed that assess diet healthfulness; that is, adequate food consumption, typically as defined by dietary guidelines.

DIETARY DIVERSITY, EATING PATTERNS, AND DIET QUALITY

Few studies have examined how dietary diversity may influence eating patterns or food-based diet quality scores. Among Iranian female students (n=289; age range, 18–28 years), greater dietary diversity score, assessed with a food group count based on 5 food groups (fruit, vegetables, grains, meat, and dairy), was positively associated with intakes of fruit, vegetables, whole grains, and dairy and inversely associated with intakes of refined grains and fast foods.[45] In a study including low-income women living in California (n=112; age

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range, 18–55 years), a greater variety of vegetable intake was positively associated with intakes of fruits and whole grains and with overall diet quality assessed with HEI scores.[46]

Findings from these relatively small investigations contrast with those of population-based observational studies. In a recent cross-sectional study using data from the National Nutritional Survey in southwest China (n=1105 participants; age, 18–59 years), investigators reported that mean daily consumption of 9 food groups included in the Chinese dietary guidelines (grains, vegetables, fruits, beans, meats, dairy, eggs, fish, and oil) was suboptimal across increasing categories of dietary diversity scores.[47] In particular, Chinese participants reporting greater dietary diversity did not meet recommended daily intakes for fruits, vegetables, fish, and dairy and exceeded recommended intakes of grains, meats, and oil.[47] These findings suggest no benefit of greater dietary diversity in diet quality and adherence to dietary recommendations among Chinese adults.[47]

A cross-sectional study using national survey data on 35 237 households in Brazil showed a positive association between dietary diversity scores (estimated from 27 recommended food groups according to the Brazilian food guidelines) and household availability of nonrecommended foods such as refined sugar, sugar-sweetened beverages, cookies, and cakes.[11] Consistent with findings from the former study in China,[47] this study suggests that household availability of a wider variety of foods, as assessed by food group count, was positively correlated with availability of food sources of refined carbohydrates, with potential implications for obesity among Brazilian adults.[11]

In MESA (Multi-Ethnic Study of Atherosclerosis), greater dietary diversity assessed by food count and evenness was positively correlated with intakes of recommended nutrient-dense foods such as fruits, vegetables, and whole grains and nonrecommended foods such as processed meats, salty snacks, and sugar-sweetened beverages (n=2505; mean±SD age, 61.9±10.3 years) and weakly correlated with diet quality scores such as the Dietary Approaches to Stop Hypertension and the Alternative HEI (multivariate-adjusted correlation coefficients ranging from 0.04 to 0.20).[10] This suggests that within a diverse diet, as measured by either count or evenness, the potential benefit of nutrient-dense foods, such as fruits and vegetables, may be outweighed by high intakes of sodium, starch, and refined grains, leading to little benefit to overall diet quality. Notably, diet dissimilarity, a third metric of dietary diversity, was positively correlated with intakes of nonrecommended foods and inversely correlated with intakes of recommended foods, resulting in inverse correlations with diet quality scores (correlations between diet dissimilarity and Dietary Approaches to Stop Hypertension and Alternative HEI, −0.37 and −0.34, respectively).[10]

Overall, limited evidence shows no benefit to diet quality or diet healthfulness associated with increased food count or with a more even distribution of energy across foods, whereas findings from 1 observational study suggest that greater dissimilarity in foods consumed may be inversely associated with a healthy eating pattern. This body of evidence does not raise questions about the established benefits of greater food count for meeting nutrient requirements in resource-poor populations, particularly those with limited availability of nutrient-dense foods.[48–54] Rather, it highlights the need to evaluate how dietary diversity influences current eating patterns and health outcomes in populations exposed to an

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increasing variety of food choices. Given the shifts in dietary patterns resulting from urbanization and increased availability of low-cost processed foods in different countries, there is a need to understand the potential influence of the food environment and of key socioeconomic and cultural factors on the relationship between diet diversity and diet quality.

DIETARY DIVERSITY, BODY WEIGHT, CENTRAL ADIPOSITY, AND OBESITY

Two systematic reviews summarizing evidence from observational studies examining the association between dietary diversity and obesity outcomes have shown inconsistent results.[17,18] In a review including cross-sectional observational studies using food group count, 7 of 16 studies reported nonsignificant associations, 5 reported positive associations, and 4 reported inverse associations between dietary diversity scores and the prevalence of overweight and obesity.[17] This review included a meta-analysis of 8 studies (n=6091 participants) showing no overall association between food group count and overweight or obesity (pooled odds ratio for prevalence of overweight or obesity among the lowest compared with the highest diet diversity scores, 0.72; 95% confidence interval, 0.45– 1.16). Of note, the investigators indicated that there was substantial between-study heterogeneity and that subgroup analysis failed to identify key sources of discrepancies across studies.[17] Mixed results were also reported in a review of cross-sectional observational studies evaluating associations between dietary diversity and measures of body adiposity in healthy adult populations,[18] with 7 of 14 studies reporting nonsignificant associations, 3 reporting positive associations, and 4 reporting inverse associations between total dietary variety and adiposity. The same study reported that diet variety in recommended foods such as fruits, vegetables, and grains was inversely associated with body adiposity measures in 6 of 10 studies, whereas the remaining 4 investigations reported null or mixed findings.[18] In contrast, 6 of 9 studies reported positive associations between diet variety of nonrecommended foods such as snacks and sweets and body adiposity.[18] This suggests that there may be potential differences in associations of dietary diversity for healthier versus less healthy foods. Evidence from cross-sectional studies is limited by the cross-sectional design, which allows no inference about the temporality of the relationships and could be influenced by reverse causation.

To the best of our knowledge, only 3 studies have prospectively examined associations of dietary diversity and obesity outcomes. In 1 secondary analysis including data from 183 overweight and obese participants in an 18-month weight loss trial (age range at baseline, 21–65 years), increasing diversity in intakes of low-energy-dense foods (<4.186 kJ/kcal·g $^{-1}$), assessed with food count, was associated with a decrease in body mass index after 6 and 18 months (≈−0.2 kg/ m^2; P<0.05).[55] In this analysis, diversity in intakes of high-energy–dense foods (>12.56 kJ/3.0 kcal·g^{-1}) was not associated with change in body mass index.[55] Two observational studies investigated prospective associations in Chinese and US adults. After 5 to 9 years of follow-up, Chinese adults (n=732; age range at baseline, 25–74 years) reporting greater diversity in intakes of snacks, but not grains, vegetables, fruits, meats, or beverages, had 45% greater odds of being overweight (odds ratio, 1.45; 95% confidence interval, 1.06–1.98) compared with those reporting lower diversity in snack consumption.[56] The second study including 2505 multiethnic US adults (mean±SD age at baseline,

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61.9±10.3 years) reported no significant association between total food count or evenness and change in abdominal obesity after 5 years of followup.[10] In this analysis, participants in the highest quintile of dissimilarity scores had 120% greater gain in waist circumference compared with those in the lowest category (mean change in waist circumference in extreme diet dissimilarity scores, 2.0 [95% confidence interval, 1.5–2.6] and 0.9 [95% confidence interval, 0.3–1.6] for quintiles 5 and 1, respectively). Associations with dissimilarity scores are consistent with evidence from feeding studies showing that exposure to foods with different characteristics led to increased energy intake, which may partially explain gain in waist circumference over time. Overall, data from large observational investigations do not support benefits of a greater variety of foods from different food groups on achieving or maintaining a healthy weight.

Significant limitations in previous studies may have contributed to the inconsistency across prior findings. First, there were substantial differences in the number of foods and food groups used to estimate dietary diversity, limiting comparability of study findings. For example, in review studies using the Dietary Diversity Score, the number of food groups selected to assess dietary diversity across different studies ranged from 5 to 24.[17] In addition, there was considerable variation in the types of food groups included in the score. For example, although several studies based their estimation on 5 traditional food groups (fruits, vegetables, meat or protein sources, dairy, and grains), others have expanded their estimation to incorporate a broader range of food groups such as sweets, snacks, and caloric beverages. Careful consideration of dietary diversity measures and what these measures are designed to reflect—total, healthier, or less healthy food dietary diversity—is crucial to allow appropriate interpretation and comparison across studies. In addition, nearly all previous investigations used single-count measures to assess dietary diversity, a measure that may not fully account for potentially relevant aspects of dietary diversity.

In addition to limitations of diversity measures, several studies lacked statistical adjustment for potentially relevant factors, including sociodemographics and lifestyle. The use of unadjusted or parsimonious statistical models raises the potential for substantial confounding in measures of associations with obesity outcomes. On the other hand, although adjustment for energy intake is often used in nutritional studies to reduce measurement error in dietary measures,[57] evidence from feeding studies suggests that calorie intake could be an important mediator in the relationship between diet diversity and obesity. Thus, adjustment for energy intake may lead to excessive attenuation of potential associations. In addition, several prior studies were limited by their small sample size and the use of convenience samples (eg, female university students in Iran, low-income women living in South Africa), hence limiting the statistical power and generalizability of their results. Finally, most prior studies provided cross-sectional data with limited evidence for causal inference. Thus, appropriately powered prospective investigations with careful consideration of relevant confounders and intermediate factors are needed to provide accurate assessment of relationships between dietary diversity and obesity end points.

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RECOMMENDATIONS FOR FUTURE RESEARCH ON DIETARY DIVERSITY

As summarized above, the scientific evidence to date does not support benefits of greater dietary diversity for optimal diet quality or healthy weight. Research in this field has been limited by the use of single count-based measures and by inconsistencies in the number and types of foods or food groups included in the estimation. There is a need for standardized, reliable measures defining what diet diversity is and what aspects of diversity may maximize benefits to health outcomes. This may be achieved by assessing multiple aspects of dietary diversity, defined on the basis of a wide range of foods and food groups, both healthy and unhealthy, and evaluating their potential influence on diet quality and health outcomes. Future research should include stratification by food healthfulness to help identify key food groups that could be targeted to help achieve and maintain healthy weight over time. Additional studies are needed to investigate whether potential health benefits from increasing diet variety of recommended food groups (eg, fruits and vegetables) may extend beyond increasing the quantity of consumption.

There is also a need for robust, well-designed prospective studies assessing the relationship between dietary diversity and clinical, metabolic, and cardiovascular outcomes. Despite evidence of substantial disparities in the prevalence of obesity, little is known about how dietary diversity may influence obesity in underserved populations, including blacks and Hispanics. Given the established cultural variation in eating patterns, examining dietary diversity in different racial/ethnic and low-income groups is necessary to identify potentially vulnerable groups and to inform specific recommendations about potential limits to dietary diversity and the contexts that may lead to poor diet quality and weight gain. Additional studies should also evaluate temporal trends and cultural and socioeconomic determinants of diet diversity.

Finally, there is a critical need to better understand how specific aspects of dietary diversity may influence food and beverage choices, appetite, satiation, and energy intake, particularly in the long term. Understanding such mechanisms is particularly important to help inform interventions and intentional approaches to eating to promote healthy dietary patterns at appropriate calorie levels in both normal-weight and overweight adults.

CONCLUSIONS

The preponderance of evidence does not support the notion of dietary diversity as an effective strategy to promote healthy eating patterns and healthy body weight. Limited evidence suggests that dietary diversity may contribute to increased energy intake, suboptimal eating patterns, and weight gain in adult populations. Given the current state of the science on dietary diversity and the insufficient data to inform recommendations on specific aspects of dietary diversity that may be beneficial or detrimental to healthy weight, it is appropriate to promote a healthy eating pattern that emphasizes adequate intake of plant foods, protein sources, low-fat dairy products, vegetable oils, and nuts and limits consumption of sweets, sugar-sweetened beverages, and red meats.[31]

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SUMMARY

- Evidence from observational studies to date does not support benefits of greater dietary diversity for healthy weight or optimal eating pattern.
- Short-term feeding studies show that exposure to a variety of foods may reduce sensory-specific satiation, increasing energy intake and food consumption in adult populations.
- Limited evidence from observational studies suggests that greater dietary diversity is associated with greater energy intake, suboptimal eating patterns, and weight gain in adult populations.
- Given the current state of the science on dietary diversity, it is appropriate to promote a healthy eating pattern that emphasizes adequate intake of plant foods, protein sources, low-fat dairy products, vegetable oils, and nuts and limits consumption of sweets, sugar-sweetened beverages, and red meats.

Appendix

Disclosures

Writing Group Disclosures

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Jennifer L. Dearborn	Yale School of Medicine	None	None	None	None	None	None	None
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Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
	Science and Policy	effectiveness, fatty acids)†; Gates Foundation (Global Dietary Database)†						
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Reviewer Disclosures

Reviewer	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
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Michael Miller	University of Maryland	None	None	None	None	None	None	None

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Table.

Measures of Dietary Diversity in Nutritional Studies

	Concept/Definition	Description	Example
Count1[6,17–19]	Dietary diversity as the consumption of a number of food items	The number of foods or food groups consumed during a given period	An individual consuming a large number of foods in 1 wk (high count) vs a lower number of foods in 1 wk (low count)
Evenness[10,20–23]	Dietary diversity as a relatively balanced allocation of calories or foods in one's diet	The relative distribution of calories across individual foods	An individual with a more evenly distributed energy or food intake across foods consumed (high evenness) vs with only a few foods contributing most of the energy intake (low evenness)
Dissimilarity[10,24]	Dietary diversity as the consumption of foods with distinct characteristics or attributes	The differences in food attributes relevant to health, (eg, fiber, sodium, or *trans* fat content)	An individual consuming foods that are relatively similar (eg, mostly plant foods) vs a wide variety of dissimilar foods (eg, fruits, vegetables, baked goods, snacks, soda)

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