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2015

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# Dietary Variety



## An Overlooked Strategy for Obesity and Chronic Disease Control

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### Introduction

The increased variety of energy-dense foods available in the U.S. has been implicated in the current obesity epidemic because greater food variety can amplify the pleasure associated with eating.<sup>1</sup> Accordingly, U.S. public health recommendations regarding dietary variety have been tempered recently to accommodate changing food landscapes.<sup>2</sup> In fact, limiting dietary variety has been recently explored as a strategy for promoting weight loss.<sup>3</sup> Despite the presumed risks of promoting variety and expected benefits of limiting variety in some categories, little consensus exists in the epidemiologic evidence to support this recommendation.<sup>4</sup> Moreover, as recommendations to consume a variety of foods from all food groups have been de-emphasized within the Dietary Guidelines for Americans (DGA), insufficient research has evaluated using variety as a behavioral strategy to promote long-term adherence to diet patterns favorably associated with weight control and chronic disease. Given the large proportion of U.S. adults who insufficiently consume nutrient-dense, plant-based foods,<sup>5</sup> rigorous evaluation of any strategy potentially able to shift individuals and populations toward healthier eating patterns they enjoy is worth considering. The purpose of the present commentary is to highlight existing research that supports a role for dietary variety for weight control and to consider the clinical and public health policy applications of this research going forward.

### The Unrecognized Benefits of Promoting Dietary Variety

Historically, dietary variety has been an important component of U.S. dietary guidance because it promotes nutrient adequacy.<sup>6</sup> However, as food landscapes have

changed, there is growing concern that greater variety may promote obesity by making highly palatable foods more enjoyable.<sup>7</sup> Dietary variety is consistently associated with excess adiposity in short-term animal and human trials,<sup>8</sup> but its impact on adiposity in epidemiologic studies and clinical trials is equivocal because factors like dietary quality<sup>9</sup> and portion size confound these associations.<sup>4</sup> We propose that increasing variety within some food categories, while limiting it in others,<sup>4,9</sup> may be an overlooked strategy to promote adherence to healthy dietary patterns (Figure 1). The robust associations between greater food variety and enhanced diet palatability<sup>1</sup> suggest that if variety recommendations are directed toward energy-poor, nutrient-dense foods, it may help individuals sustain reduced-calorie, satiating dietary patterns favorably associated with weight control.<sup>10</sup> Greater intake of these more-satiating items may simultaneously reduce consumption of nutrient-poor, energy-dense items while reducing feelings of deprivation associated with more-healthy eating patterns.<sup>11</sup>

### What We Know Now: Imperfect Understanding of the Associations Between Dietary Variety and Obesity

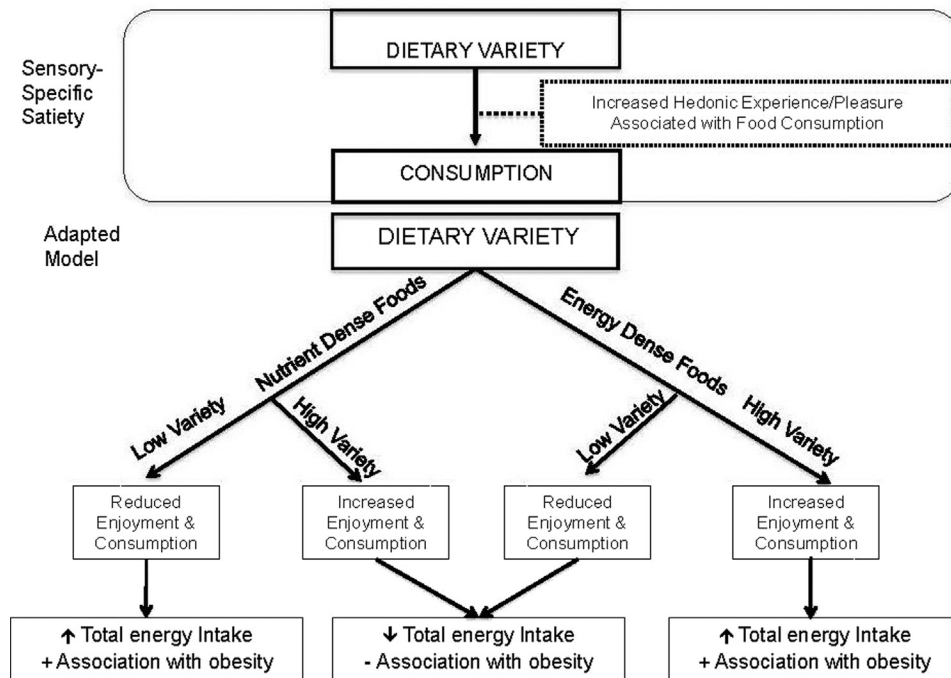
It has been challenging to make definitive conclusions about the role of dietary variety in obesity, in part because the definition and measurement of dietary variety differ across studies and this multifaceted construct is often crudely measured within a complex food landscape.<sup>4</sup> In particular, the implied association between dietary variety and obesity may have been oversimplified owing to the enmeshed constructs of dietary variety; quality (i.e., healthfulness); and proportionality (i.e., relative consumption amount), which have been difficult to measure simultaneously using extant methods.<sup>2</sup> Thus, given concerns about obesity, it was prudent to de-emphasize the importance of consuming a variety of all foods in the 2000 DGA<sup>2</sup> and onward. However, before definitive conclusions are made, it is critical to renew investigation into the role of dietary variety in obesity and related chronic diseases using measurement techniques able to disentangle variety, quality, and proportionality.

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0749-3797/\$36.00

<http://dx.doi.org/10.1016/j.amepre.2015.06.014>



**Figure 1.** Proposed relation between dietary variety and body adiposity: the Adapted Sensory-Specific Satiety Model of Eating Behavior.

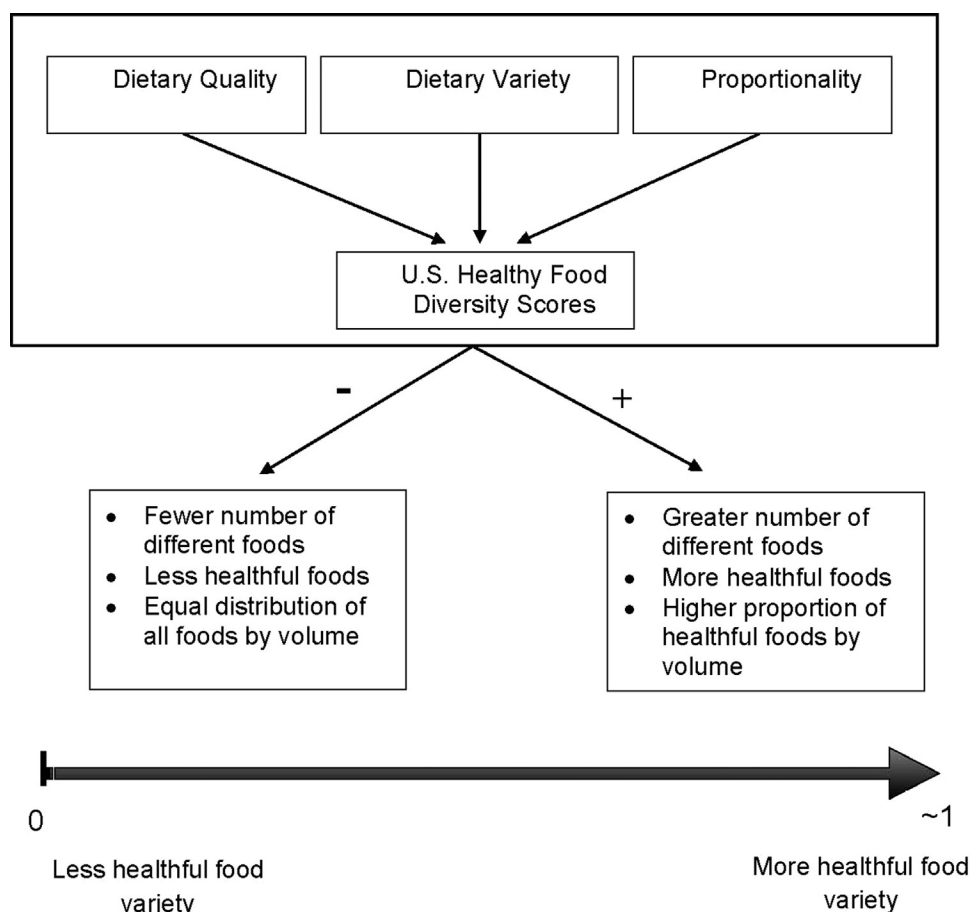
Note: This figure outlines the proposed association between dietary variety, energy intake, and body adiposity. Extending from the existing theory of sensory-specific satiety, the model hypothesizes that greater variety reduces sensory-specific satiety, thus increasing the pleasure associated with eating and increasing food consumption. However, the adapted model also proposes an interaction between dietary quality and total energy intake. Specifically, it posits that greater variety only promotes overconsumption and excess adiposity if individuals consume a variety of less healthful foods. Moreover, the model postulates that greater variety within nutrient-dense food groups will be associated with lower energy intake and decreased body adiposity by allowing individuals to derive pleasure from consuming a variety of nutrient-dense foods while simultaneously promoting physiologic satiety. Conversely, consuming a low variety of nutrient-dense foods may make adhering to healthful diet patterns more difficult, and lead to excess energy consumption from other sources.

## The U.S. Healthy Food Diversity Index and Its Associations With Excess Adiposity and Metabolic Syndrome

We recently developed and evaluated the U.S. Healthy Food Diversity (US-HFD) index within adult National Health and Nutrition Examination (NHANES) participants to distinguish between dietary variety in healthful versus less healthful foods.<sup>12</sup> The validated index was designed to simultaneously measure dietary variety and DGA-defined dietary quality and proportionality to reduce the confounding associated with cruder measurements. The index positively correlates with other diet quality measures ( $r=0.35$ )<sup>12</sup> and maximizes as consumers select a greater (versus lesser) number of different foods; select foods from healthier (versus less healthy) food groups; and consume foods in proportions recommended by the DGA (versus equal amounts) (Figure 2).

Briefly, we found that when these components are examined together, more-healthful varied diets were inversely associated with multiple measures of body adiposity in a nationally representative sample of U.S.

adults.<sup>13</sup> After multivariable adjustment for demographic characteristics, physical activity, and energy intake, adults in the highest quintile of the index had 30%–50% lower odds of obesity, high waist to height ratio, and high android to gynoid fat ratio ( $p$ -trend  $< 0.01$ ). Taken together, these results provided foundational evidence that greater healthful food variety may protect against excess adiposity and may particularly influence metabolically detrimental fat distribution patterns associated with chronic disease risk. Subsequently, we also noted that greater variety within healthful food groups was associated with a lower odds of metabolic syndrome (OR=0.79, 95% CI=0.64, 0.98) and some of its components in the third versus first US-HFD tertile among NHANES participants.<sup>14</sup> Protective associations were observed for hypertension (OR=0.83, 95% CI=0.70, 0.995); abdominal obesity (OR=0.75, 95% CI=0.66, 0.86); and to a lesser extent impaired fasting glucose and low high-density lipoprotein ( $p$ -trend  $< 0.05$ ). The existing limited evidence collectively suggests that the pleiotropic effects of variety are exerted both directly through improved dietary quality and modulation of



**Figure 2.** Measuring total dietary variety: integration of dietary variety, quality, and proportionality in the novel U.S. Healthy Food Diversity index.

*Note:* This figure describes the different components utilized in the development of the U.S. Healthy Food Diversity index and illustrates how improvements in diet quality, proportionality, and dietary variety increase scores on this multi-dimensional index. The index is calculated using the following equation: US-HFD index =  $(1 - \sum s_i^2) \times hv$  where  $s_i$  = share of food item or food group  $i$  based on volume in the total diet,  $hv = \sum hf_i \times s_i$ , and  $hf$  = health factors of food groups informed by 2010 Dietary Guidelines for Americans. The index ranges from 0 to nearly 1, and eating a greater variety of foods or greater number of food shares within the food groups and amounts recommended by the Dietary Guidelines for Americans will maximize the index. A more detailed description of the derivation of the equation is provided in a previously published manuscript from Vadiveloo et al.<sup>12</sup> that describes the development and evaluation of the US-HFD index.

pathways involved in disease etiology and indirectly through reducing body fat. However, given the heterogeneous metabolic effects observed by race/ethnicity, further investigation in diverse populations is warranted.

### Using Behavioral Strategies to Improve Dietary Habits and Promote Health

Consideration of alternative approaches to combat unhealthy eating patterns is integral, as dietary modifications to prevent and treat obesity have experienced limited success. The rigidity of many diet plans is both difficult to sustain and tedious, leading to diet attrition and a return to less healthful eating habits.<sup>11</sup> However, behavioral approaches that consider individuals' innate preferences and biases have been shown to improve diet adherence. For example, consumers

are subconsciously influenced by defaults and convenience, and merely placing healthier foods at the beginning of a line or providing consumers with a healthier version of a food unless they specify otherwise can improve diet quality.<sup>15,16</sup>

Similarly, increasing dietary variety in some categories has promise as a powerful behavioral tool to promote dietary change. Multidisciplinary research suggests that individuals have an innate preference for variety and also perceive greater variety when there are more colors, textures, flavors, and temperatures.<sup>7,17</sup> Therefore, beyond increasing the number of healthful foods available, using different food preparation techniques to enhance perceptions of variety may help sustainably increase intake of nutrient-dense, plant-based foods. Dietary adherence may be further improved because increasing consumption of healthful foods rather than specifically limiting

the intake of others reduces the burden of intentional restriction. However, utilizing dietary variety to improve weight outcomes will be maximally effective by also limiting variety within less healthful foods (e.g., added sugars) to diminish how rewarding these foods are over time, potentially resulting in reduced intake.

### Public Health Policy Applications of the U.S. Healthy Food Diversity Index

Research on dietary variety has important implications for national dietary guidance, surveillance, and health disparities. U.S. dietary variety guidelines have been modified considerably over the past three decades, shifting from overarching guidelines endorsing variety within all food groups to cautious endorsement of variety within a select and often insufficient number of food

groups (Figure 3). Furthermore, the rationale for recent variety recommendations was related to supporting nutritional adequacy rather than toward promoting diets protective against obesity. Importantly, the US-HFD index allows for the development of simple, evidence-based guidelines to promote or restrict variety within different food groups to support weight control and chronic disease prevention. Although more research is needed before guidelines are developed, a recommendation such as “Choose and prepare a greater variety of plant-based foods to make healthy eating more enjoyable” may make a variety guideline more actionable.

Additionally, because the US-HFD index concurrently measures dietary variety, quality, and proportionality and is sensitive to small changes, it may complement existing surveillance techniques that monitor U.S. dietary patterns. Furthermore, examining secular and longitudinal

changes in dietary variety and body adiposity at the population level could provide information for food manufacturers and policy-makers, respectively, trying to create market and environmental solutions for obesity. Because the US-HFD index differs by race/ethnicity, it may also be relevant for identifying and addressing health disparities in obesity.

### Promising Areas of Inquiry for Future Research

Emerging evidence regarding the potential benefits of dietary variety in promoting healthier eating patterns underscores the importance of continued investigation into the role of healthful dietary variety in the behavioral management of obesity and related chronic disease. Ongoing research using the US-HFD index in longitudinal and experimental study populations is paramount to establish a robust relationship among

YEAR	VARIETY GUIDELINE
1980	Eat a variety of foods
1985	Eat a variety of foods
1990	Eat a variety of foods
1995	Eat a variety of foods
2000	Choose a variety of grains daily, especially whole grains. Choose a variety of fruits and vegetables daily.
2005	Consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit the intake of saturated and <i>trans</i> fats, cholesterol, added sugars, salt, and alcohol.
2010	Eat a variety of vegetables, especially dark-green and red and orange vegetables and beans and peas.  Choose a variety of protein foods, which include seafood, lean meat and poultry, eggs, beans and peas, soy products, and unsalted nuts and seeds.  Increase the amount and variety of seafood consumed by choosing seafood in place of some meat and poultry.

**Figure 3.** The history of the dietary variety guideline in the Dietary Guidelines for Americans, 1980–2010.

Note: This figure briefly outlines the evolution of the variety recommendations in the Dietary Guidelines for Americans over time. Over the 30 years, guidelines for variety progressively became tailored toward specific food groups as compared to their inception.



dietary variety, obesity, and metabolic health. Notably, there are a number of emerging areas of future inquiry that warrant mention.

### Reducing Variety of Less Healthful Foods and Increasing Variety of Healthful Foods

A critical component of weight control is reducing energy intake by consuming less, which is implied in the DGA by describing food groups to encourage, moderate, and limit. However, merely limiting food intake may not be sustainable for many individuals. In fact, experimental trials have found it challenging to maintain long-term compliance among individuals randomized to a reduced variety arm of a clinical trial.<sup>18</sup> Adherence may be improved if dietary variety in healthful foods increases concurrently with dieting. Utilizing these behavioral techniques warrants consideration in both clinical and research settings to help the large proportion of individuals attempting to sustainably lose weight.

### Diverse Populations and Health Disparities

Evaluating the associations among the US-HFD index, adiposity, and metabolic health in particular socioeconomic and ethnic groups at higher risk for obesity and related disease is an important future research direction. Additionally, although it is beyond the scope of the existing US-HFD index, a similar methodology is recommended for assessing these associations in children. Finally, the proportion of individuals following vegetarian dietary patterns for religious, cultural, health, or ethical considerations has increased substantially. Future work should consider developing and evaluating algorithms relevant to these special populations.

### Early Intervention

It is likely that childhood is a critical window during which exposure to dietary habits have the potential to shape lifelong dietary habits, health trajectories, and disease etiologies. Importantly, given that more than one third of children's energy intake is consumed in school food environments, applying principles of healthy variety to the National School Lunch and Breakfast programs, competitive foods, and vending machines may help to improve the food intake of children.

### Underlying Mechanisms

Although our research has generated a number of important hypotheses, further investigation is needed to elucidate the underlying pathways that may be responsible for the beneficial effects of greater dietary variety on adiposity and metabolic health. Greater variety may favorably influence adiposity through a number of potential pathways. First, greater consumption of energy-

poor, nutrient-dense foods may displace intake of energy-dense, nutrient-poor foods. The matrix of nutrients found in nutrient-dense foods may also play a role in regulating the metabolic environment, the insulin-glucose axis, or hormonal or psychological mechanisms related to appetite control. Finally, the observed heterogeneity in metabolic responses by race/ethnicity suggests that genetic and sociobehavioral factors may modify some of the proposed pathways.

### Conclusions

The role of dietary variety in weight control has been overlooked, in part because existing measurement tools have been unable to adequately capture the intertwined concepts of dietary variety, quality, and proportionality necessary for analyzing Western diets. The development of the novel US-HFD index addresses a critical gap in the field of diet assessment and provides evidence that deemphasizing the importance of dietary variety in achieving and maintaining a healthful dietary pattern may be maladaptive for long-term weight control. Further, dietary variety may promote the continuity of healthful dietary patterns by enhancing the pleasure associated with eating. The US-HFD index provides a necessary framework for future research questions pertaining to the benefits of dietary variety in obesity management and chronic disease.

Arousing interest in this previously dormant research area has the potential to develop this understudied topic and inform national recommendations regarding dietary variety. Although recommendations promoting dietary variety must be evidence-based and judiciously worded, research demonstrates that eating a variety of healthful foods is favorably associated with body adiposity, and thus it may be prudent to capitalize on this strategy in the behavioral management of obesity.

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The authors would like to thank Marion Nestle, PhD, MPH, for her valuable insights on translating research on dietary variety toward relevant public health nutrition policy.

This project was supported by the American Heart Association Founder's Predoctoral Fellowship (12PRE9320023) awarded to Vadiveloo. The study sponsor had no role in study design; collection, analysis, and interpretation of data; writing the report; or the decision to submit the report for publication.

No financial disclosures were reported by the authors of this paper.

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