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90th Anniversary Commentary: Diet Quality Indexes in Nutritional Epidemiology Inform Dietary Guidance and Public Health

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Introduction

The 2012 article, "Alternative Dietary Indices Both Strongly Predict Risk of Chronic Disease," in *The Journal of Nutrition* by Chiuve and colleagues (1) contributed to a rapidly growing literature on the connections between dietary patterns, as defined by food-based diet quality indexes, and health outcomes. The paper first presented a revised Alternative Healthy Eating Index-2010 (AHEI-2010), with modifications based on the most recent clinical research at that time, and then examined relations between both the Healthy Eating Index-2005 (HEI-2005) and AHEI-2010 with chronic disease risk (including cardiovascular disease, diabetes, cancer, or nontrauma death). The results showed that the HEI-2005 and the AHEI-2010 were associated with 16% and 19% significantly reduced risks of chronic disease comparing the highest with the lowest quintile of diet quality, respectively. These pivotal findings served to advance dietary patterns research and dietary guidance, and highlighted the need for analyses that modeled dietary patterns to reflect the total diet, rather than using only a single marker of intake such as 1 nutrient or dietary constituent.

Relevance of Food-Based Indexes

By determining that both scores strongly predicted a reduced risk of chronic disease in 2 large, well-established cohorts, the Health Professionals Follow-Up Study and the Nurses' Health Study, the authors confirmed the importance of dietary patterns in disease prevention and further validated the relevance of food-based diet quality indexes, whether, as with the HEI-2005, the index was developed based on the underlying science and constructs defined in federal dietary guidance (2), or, as with the AHEI-2010, the index was based on a compilation of dietary predictors of health outcomes from epidemiology studies (1). Both indexes sought to define the parameters of an overall healthy diet while addressing the complexity of diet, the multicollinearity between dietary components, and allowing for direct translation into dietary recommendations. Although investigators (3–10) have been calling for more research to examine the effects of total diet in nutritional epidemiology, the methods used to define dietary patterns are quite varied, and include both data-driven (factor and cluster analysis) and science-driven (indexes and scores) approaches, which are not being applied consistently.

Need to Synthesize Research and Find Commonality

The fact that different methodologic approaches are often used to assess the relation between dietary patterns and health outcomes limits the ability to synthesize and compare findings, leaving policymakers without a readily interpretable body of science to draw upon for dietary recommendations. Therefore, analyses like this one by Chiuve and colleagues (1) that compared >1 diet quality index are especially useful. Such efforts created momentum for others to strengthen the scientific evidence base on dietary patterns. One of these was the Dietary Patterns Methods Project, which formed to examine, using systematic and standardized methods, the relation between the most commonly used diet quality indexes in the United States and cancer and cardiovascular disease mortality. These indexes included not only the AHEI-2010 and HEI-2010 (updated from the HEI-2005), but also the modified Mediterranean Diet Score (11), and Dietary Approaches to Stop Hypertension (DASH) score (12). A summary of this work completed in 3 large and diverse US cohorts found that all indexes strongly predicted a reduced risk of mortality, among both women and men, and in all cohorts (13). Continued growth in the field is indicated by a more recent meta-analysis of 15 studies that found that high-quality diets, as defined by HEI, AHEI, and DASH scores, were associated with a reduced risk of all-cause mortality, cardiovascular disease, cancer, and type 2 diabetes mellitus (14). The increasing number of these efforts illustrate the significance of the Chiuve et al. article and of dietary patterns in public health to help inform dietary guidance. Indeed, the 2015–2020 Dietary Guidelines for Americans focused on dietary patterns as the core of their conceptual model and framed their reviews, findings, and conclusions accordingly (15).

Need to Disaggregate or Deconstruct and Discriminate across Patterns

In Chiuve and colleagues' pooled analyses of women and men, the AHEI-2010 was more strongly associated with risk of major chronic disease than the HEI-2005 (1). It is important to try to understand these findings given that the intent of both indexes was to define a healthy diet. Although both indexes reflected similar key tenets, the HEI-2005 and AHEI-2010 were

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constructed based on somewhat different sets of dietary constructs and scoring approaches. As mentioned previously, the AHEI-2010 was based on predictors from earlier epidemiologic analysis—from these same cohorts—whereas the HEI-2005 was drawn from a broader scientific review of the nutritional epidemiologic literature for the Dietary Guidelines. On the one hand, as has been noted, illustrating that 2 diet quality indexes are strongly protective in epidemiologic analyses tends to further confirm the importance of dietary patterns in public health, because no matter how diet is defined in each food-based diet quality index, the relation is robust. However, perhaps more important than the similarities (emphasizing fruits, vegetables, whole grains, and limiting sodium) is understanding the details behind these differences, and where the indexes may diverge. Those areas with less concordance—such as the inclusion of a component for moderate alcohol intake in the AHEI-2010, and a component for adequate low-fat dairy in the HEI-2005—are intriguing for future index comparison research. Are the differences in the relation between the dietary pattern and health outcome due to true differences in the role of specific dietary components on disease risk (such as alcohol being protective for cardiovascular disease, but increasing risk of cancer; or dairy, including calcium and vitamin D, being protective for colorectal cancer)? Is 1 dietary component able to dominate (or dilute?) the dietary pattern to establish a meaningful difference? Is the goal to refine a diet quality index for each health outcome under analysis, or to allow for an index that can be compared across studies?

Etiology and Prevention; Personalized Medicine and Public Health

Chiuve and colleagues included thoughtful discussion about the inherent challenges regarding how to balance the seemingly conflicting goals regarding etiology and public health. Although an index can be optimized for different outcomes, and components may be added, eliminated, or weighted accordingly, a focus in dietary patterns research has been on having common indexes so results can be compared, interpreted, and translated to dietary guidance. However, as Chiuve et al. emphasized, these interests can be integrated so that the findings can help to identify the most "scientifically sound dietary recommendations." Despite concerns that some have voiced about the emergence of dietary patterns being a movement away from etiology, there is evidence that the study of dietary patterns, or the totality of diet, can strengthen models for scientific understanding in that they more accurately consider the role of whole body metabolism, the interrelations between foods and nutrients consumed, and more appropriately inform the influence of individual dietary components within the context of the total dietary pattern. Questions regarding etiology and prediction to inform dietary guidance are equally relevant; they can, and should, inform one another.

Other Questions Remain

Since the article by Chiuve and colleagues was published (1), dietary patterns research has continued to evolve. Along with the questions raised by the authors about score construction, aggregation and disaggregation, and personalized medicine and public health, additional questions and applications have emerged. These include how to explore the multidimensionality within dietary patterns, how to model dietary patterns over time, how to integrate with patterns related to other exposures, and how to link to relevant attributes of the food system.

Multidimensionality. Efforts to further explore how multidimensionality might be examined within models examining disease outcomes are ongoing. For example, visualization of patterns with radar graphs (16) readily illustrates that when a unidimensional score (from 0 to 100 points) is used, the same number on that scale can represent fairly different intakes. There are multiple ways to eat healthy, and unhealthy, diets. Thus, in modeling the relation between dietary patterns and health outcomes, questions emerge such as, is there a subset of "core" components that are required, or sufficient, to capture the association with a health outcome or are all aspects equally required? Are there ways to combine data-driven approaches with science-based approaches, to use cluster analysis to identify different clusters within very high-quality diets (as defined by dietary indexes)? In addition, are there other components that should be considered within an index beyond the set of input variables generally used (food-based constructs), and might these include different levels of granularity beyond food groups, such as specific core foods, or foods-as-eaten? How should the richness of the data or pattern be balanced with overall goals of data reduction? How should an index best evaluate overconsumption, given that index algorithms do not typically lower scores when a standard is exceeded (such as for grains or meat/protein foods)?

Dynamism. Along with the questions about the complexity of dietary patterns, there are equally relevant questions about their dynamism. This refers to the potentially changing eating patterns for any individual over time. Most analyses, like those of Chiuve and colleagues, have been based on diet assessment at a single point in time, often because of study design limitations. However, increasingly, researchers are interested in understanding and modeling dietary intake over the life course (17). Approaches to eating may change over time, based on developmental phase, environment, health status, and other factors. Researchers are tackling these questions, including determining how to apply time-varying models for dietary behavior, consider the appropriate interval for estimating usual intake, and identify potential windows or periods of transition for targeted interventions. Similarly, there are considerations regarding how meal timing and frequency over long and short periods of time, fasting, and foods eaten together may influence metabolism and other biological parameters (18). These questions cannot be answered by epidemiologic cohorts that use FFQs alone because of the level of data aggregation and lack of detail regarding types of food and timing of consumption, so more efforts are needed to apply dietary recalls and food records, in addition to FFQs, to allow for dietary data with the necessary granularity as well as inputs for episodically consumed foods (19).

Exposure patterns. In addition to enhanced specificity with dietary data, models with health outcomes would benefit from the addition of other fully articulated behavior and environmental exposures. Thus, just as diet is complex and multidimensional, it exists and interrelates with other complex and interrelated exposures that should be considered over a lifetime to assess how the totality of exposures relate to health. New approaches are needed for exposome research such as the development of models to account for more multidimensional data and dynamic data across the life course, the creation

of robust systems for data sharing, and the promotion of collaboration involving diverse teams of researchers (20). Other methodological challenges, beyond assessment and standardized methodology and analysis, would include more complex systems-oriented approaches that consider measures of other related exposures and their interactions within the context of dietary patterns.

Food system. It has long been noted that dietary patterns within a population reflect the food available within a food system (21). Although many cultures and communities are no longer severely constrained by food availability and food *quantity* owing to advances in agriculture and other technologies, ensuring and supporting a secure and sustainable food system with adequate food *quality* continues to be a goal for current and future generations. The HEI-2010 was applied to the US food supply (from 1970 to 2010) and the analyses revealed that the current US food supply could not support all Americans eating a diet that aligns with federal dietary guidance (22). The US food supply in 2010 received a score of 55 out of 100 total points. This significant gap is particularly troublesome given the high rates of diet-related chronic diseases among the population. Moving toward a food system that is more conducive to healthy eating requires consideration of a range of factors and policies that influence supply and demand, including environmental sustainability (23). Another recent analysis further extended the application of diet quality indexes to examine their relation with environmental sustainability and food waste (23).

Conclusion: Importance of Dietary Patterns in Research and Dietary Guidance Going Forward

As detailed in the findings from Chiuve and colleagues (1), food-based diet quality indexes such as the HEI and the AHEI have moved understanding of dietary patterns forward and provided evidence beyond single foods or individual nutrients. Analyses illustrating the importance of dietary patterns in reducing chronic disease risk can be used to inform dietary recommendations going forward. Individuals with diets that align with dietary guidance may reduce their risk of chronic diseases. Further refinement will likely include research to elucidate the variations within these dietary patterns by identifying and strengthening common features; deconstructing variations in components; and considering the benefits and limitations of disease-specific indexes and scores (24). Additional efforts could examine the multidimensionality and dynamism of dietary patterns, and further integrate other exposure patterns and relevant attributes of the food system. The systematic application of dietary patterns in nutritional epidemiology can inform dietary guidance and lead to improved public health.

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