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Dietary Patterns and Trends in the United States: The UNC-CH Approach

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Over the past 2 decades our group of nutrition and economics researchers at the University of North Carolina at Chapel Hill has used a wide array of methods to study eating patterns and dietary trends. Our focus has been on characterising the way diet has changed over time and identifying some of the major factors underlying these trends. The complexity of this undertaking has led us to develop a number of unique systems for classifying foods and assessing the overall quality of diet. We have also addressed the challenges that exist when measuring changes in both the food supply and food-related behaviors over time. This paper summarises some of the methodological work related to food grouping, overall diet quality indices, and trends research as well as the challenges we still face in this arena.

Introduction

The study of food habits over time is complex. The complexity relates to the availability of thousands of foods in the food supply at any point in time and the wide range of ways that these foods are prepared and consumed. Moreover, the study of trends in food consumption must also consider changes in the food supply, expanding locations where food is served and consumed, as well as where food purchasing takes place. In addition, consumer behaviors, attitudes and knowledge related to diet and health change over time. In order to effectively examine dietary change and the reasons for these changes, our research group has developed a range of research techniques to allow us to measure the critical dimensions of the healthful diet and food-related behaviors across individuals and across time.

Contribution to the IUNS Committee II/2 Symposium on "Methodology to Identify and to Assess Eating Patterns".

Our work has benefitted from a large number of colleagues. The early research was undertaken in collaboration with David K. Guilkey and John S. Akin. Ruth Patterson and Kathleen Reidy played major roles in the development of the DQI and food grouping schemes, respectively. Others who contributed to our work include Dan Hungerford and Terri Carson as assistants in various processes, in particular Terri Carson was invaluable in the linkage of food files over time. Several programers provided a wide range of crucial assistance. These include Phil Bardsley, John Cromartie, Loren Watterson, Dan Blanchette and Kelly Gallagher. The authors are indebted to all of these colleagues and many others who are not mentioned. Finally, none of our work would have occurred without the assistance, both financial and technical of the US Department of Agriculture and the Kellogg Corporation.

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Measuring Diet in Relation to Health: the Diet Quality Index

The importance of the relationships between diet and health initially led our working group to examine the nature of food patterns at the population level and to ask if changes in dietary patterns were contributing to differences in nutritional risk over time. As the pervasive role of diet in health promotion has been better understood, a growing need to evaluate and monitor the *overall* healthfulness of diet and dietary patterns at the population level has emerged. Our research group has contributed to the development of summary measures of diet through development of the Diet Quality Index (DQI), a dietary assessment instrument which attempts to assess the overall healthfulness of diet (Patterson *et al.*, 1994a).

The challenges in developing composite measures of diet are many. One must first evaluate the scientific consensus regarding the most important aspects of diet and health. The elements of the composite may change as our knowledge of what constitutes a healthful diet changes/improves. One must measure and scale each dietary attribute. The DQI was based on the federal dietary guidance as articulated in *Diet and Health—Implications for Reducing Chronic Disease* published in 1989 by the National Academy of Sciences in the U.S. (NRC, 1989). The DQI scales eight distinct diet and health dietary recommendations (% kcal from total fat and saturated fat, mg of dietary cholesterol and sodium, servings of fruits/vegetables and grains/legumes, and % RDA for protein and calcium intakes) into a single index designed to reflect a risk gradient for major diet-related chronic diseases. The DQI includes measures of both food and nutrient exposures to capture information on the dietary pattern of an individual, since chronic diseases are not caused or cured by one nutrient or food, but by the overall dietary pattern. Details of the rationale, construction and validity of this DQI are published elsewhere (Patterson *et al.*, 1994a).

In particular, we have felt that dietary assessment focusing primarily on nutrients may be inadequate for several reasons. We purchase and consume foods, not nutrients. This suggests measures of overall diet quality should consider inclusion of measures of foods and food groups in addition to measures of nutrients or possibly other non-nutritive food components, as our ability to define and measure components (such as the various phytochemicals) develops over time. However, the complexity of this undertaking is significant. Unique at the time of the DQI development at UNC-CH, was the inclusion of estimates of fruit, vegetable and grain servings contributed by mixed dishes. For many researchers, the difficulty in measuring servings of food in meaningful ways from our complex food supply has hindered the development of summary dietary tools which include both food as well as nutrient measures.

As we look to the future, our research group plans to evaluate whether and how the DQI needs to be updated. Nutrients and food constituents considered crucial for health a decade ago (e.g. sodium) have diminished in importance while others have gained more importance (consumption of soy food, fruits and vegetables). The 1995 Federal Dietary Guidelines provide the most current consensus of foods and nutrients essential to good health. The Food Guide Pyramid presents a set of food group servings sizes that did not exist when the DQI was developed. Newer approaches have been developed to disaggregate mixed dish food codes in survey data to more accurately count the numbers of servings of food consumed by a given consumer. All of the above provide us with the opportunity to refine the DQI, a dietary assessment tool capable of measuring the variability in the quality and healthfulness of diet across the U.S. population.

How Does One Measure the Dietary Patterns of Interest? Food Groups and Other Measures of Interest

A variety of ways exist to describe patterns of food consumption. One might measure single foods, food groups or foods by level of processing. One might also measure food use by where foods are purchased or consumed—at home vs. away from home, by time of day or as part of specific meal or snack patterns. These possibilities led our working group to the development of a variety of tools to describe dietary patterns, including a nutrient sensitive food grouping system (Popkin *et al.*, 1989), a two-step method of disaggregating food group consumption to better explain food group trends (Haines *et al.*, 1990), the use of cluster analysis to describe food intake patterns (Atkin *et al.*, 1986; Bisgrove *et al.*, 1989), as well as to describe the location of food consumption at-home and away-from-home (Haines *et al.*, 1992), and by meal/snack typology (Siega-Riz *et al.*, 1997).

Since our research objectives were to understand (and predict) health-related changes in diet at the population level, it was necessary to understand the attitudes and factors driving food consumption practices. To do so, our research group developed a food grouping system which summarised intakes of foods in a nutritionally meaningful way. The complexity of eating behavior has led most researchers to use simple food grouping systems such as those measuring intakes of 8–10 food groups such as starchy staples (cereal based foods), meats, dairy products and so forth. We have felt that this approach aggregated foods into too few food groups to pick up important shifts in eating behavior and that this approach missed key food trends that had important implications for health. For instance, many studies have examined overall dairy or milk consumption whereas the health effects of consuming higher and lower fat milks and butter or margarine on health are quite different.

The UNC-CH food grouping system was developed by further disaggregating the major food groupings used by the U.S. Department of Agriculture by fat and dietary fiber composition. Nutrient thresholds were used to separate major food groups into more distinct, nutrient-based food groups. At the time of the food group development, most of the media attention and public concern focused on foods high and low in fat and fiber. Thresholds were derived to reflect meaningful quantitative differences in intakes of each dietary component, as well as different consumer behaviors, such as the presence vs. absence of skinning of poultry, or the trimming of visible fat from meats. A number of papers have been published which present our approach (Popkin *et al.*, 1989, 1996). Examples of the capabilities of the food grouping system are multiple. For example, the food grouping system has been very good in describing the transition from whole milk to reduced fat dairy products as well as from higher to lower fat meat, fish and poultry alternatives. Adoption of low fat and fat free vs. regular salad dressings can be tracked as can growth in artificially sweetened carbonated and non-carbonated beverages.

In addition to describing dietary patterns with the use of an array of food groups, our working group has also used cluster analysis to help us to characterise dietary patterns. As contrasted with factor analysis, cluster analysis has the strength of assigning individuals into a single unique pattern (cluster), based on criteria designated by the researcher. We have used cluster analysis to describe food intake patterns in studies of the elderly and infants (Atkin *et al*., 1986; Bisgrove *et al*., 1989), food energy consumed at home vs. at multiple away from home locations (Haines *et al*., 1992) and lifestyle patterns (Patterson *et al*., 1994b). As examples, the clustering process groups individuals by consumption of similar quantities of foods, or calories consumed at each of the multiple at home and away from home food locations. Cluster analysis is able to handle the multidimensional nature of diets by considering large numbers of food and/or food groups consumed as well as very large sample sizes. The researcher can assign a desired number of clusters, or can test to find the maximum fit. But, in our opinion, interpretability and the ability to define similar clusters at more than one point in time provide limits to the utility of cluster analysis defined food patterning methods.

As presented above, much of the focus of our eating and meal patterning work has been on the more traditionally epidemiologic evaluation of one vs. multiple days of dietary intake or behavior. Another avenue to pursue in the future would be to examine the impact of differences in distribution of food and eating patterns within a day. This issue is important but represents another dimension of eating pattern research. We have examined only two aspects of this. One is a focus on the breakfast meal in terms of the percentage of individuals who consume breakfast shifting from 1965 to 1991 and the types of foods consumed at breakfast during the same time period (Haines *et al*., 1996; Siega-Riz *et al*., unpubl.). Another aspect has been to look at meal patterning over a 3-day period and examine normal and abnormal patterns and their nutritional implications (Siega-Riz *et al*., 1997).

Dietary Trends Research

The study of dietary behavior becomes more complex when one wishes to capture population-level *trends* in diet of nutritional importance. Historically, the USDA and a variety of researchers have described dietary trends using estimates of nutrients available from food supply data. Food supply estimates do not reflect what Americans actually consume, so one of the priorities of our research group has been to develop methods to describe food consumption trends using actual food consumption data. To that end, we have developed a system to link multiple USDA survey data sets, using dietary intake data collected from independent cross-sectional samples of individuals including data from the USDA 1965 and 1977–78 Nationwide Food Consumption Surveys, the 1989–91 and 1994–95 Continuing Survey of Food Intakes by Individuals. This effort involved a variety of challenges and problems faced by those involved in dietary trends work which we review briefly.

Creating a trends analysis file using survey data required attention to address a variety of critical issues. For example, limitations of existing trends work include: (1) use of non-comparable dietary assessment methods; (2) use of non-comparable food composition databases; (3) use of non-comparable samples of individuals; and (4) sparse trends work for nutrient-sensitive food groups, food or eating patterns. We addressed the following challenges in creating the trends analysis files:

1. What are the dietary assessment method similarities and dissimilarities across the USDA surveys?

2. Are the same food coding systems used across surveys? If not, is there a way to link food codes in one time period with another? How well are new foods in the food supply, changes in breeding, fortification, etc. represented in the food coding system?
3. How representative is each survey sample of the population at large?
4. Which nutrient database is used in each time period? Are differences over time due to changes in the food supply or improvements in measuring the nutritional component of interest or something else?
5. How should foods be grouped in a way that is meaningful from a nutrition and health point of view, and how can we assure that the same foods are grouped in the same food groups at each point in time?

Two critical problems in studying food trends relate to the large number of changes in both the overall food composition tables (relative to food coding, the number of foods included, the descriptions of foods) and changes in chemical analysis of nutrients and food constituents. Large changes have occurred in the U.S. food supply since 1965. New products and existing product differentiation have broadly expanded consumer purchase options. Other database differences reflect differences in the composition of foods referred to by the same name (e.g. the fat composition of pork products has shifted based on breeding and feeding practices, or the fortification profiles of brand name ready-to-eat cereals have changed). Combination dishes may be disaggregated or described differently at different points in time. New estimates of the yields from raw food ingredients into cooked, edible portions may influence the nutrient profiles of each food.

Over time, major improvements have been made in the analysis of many nutrients and food components such as dietary fiber and Vitamin E. Many nutrients and constituents of food have been added to the database since 1965. The researcher creating a trends database is faced with the decision of whether to use the most current (and accurate) nutrient data for foods consumed in all time periods, vs. using the nutrient data available at the time of each survey, knowing that these data best reflect the product formulation of the time, but that they also contain less precise measures of the nutrients in question.

We have studied the issues of procedural differences between the different survey years (relative to changes in the nutrient databases, etc.) as has a group of scholars at the USDA (Guenther *et al.*, 1994; Popkin *et al.*, 1996). The USDA concluded that differences in interview procedures and food coding had little effect on estimates of all nutrients. Weight conversions and nutrient data changes affected some nutrients more than others. For example, the Bridging Survey found that adoption of the most recent nutrient database resulted in a maximum of 4 grams of fat difference (based on 24 h intake), or less than 1% of energy from fat in intakes reported in the 1977 and 1987 survey. This difference resulted from real differences in nutrient composition of foods between time periods. In contrast, differences in B6 values resulted from improvements in food composition data, rather than real changes in foods.

Many food consumption trends studies have been based on poorly linked cross-sectional surveys which do not account for such differences in the food and nutrient composition tables. The use of non-comparable nutrient databases can lead to spurious trends or can over- or underestimate an existing trend. Nutrient database issues, ignored in earlier research, need to be considered in interpreting dietary trends.

The UNC-CH trends approach has first been to link the survey data sets with a common food composition table. This involved undertaking the painstaking work of linking the food codes for each food consumed in each survey year to comparable foods at subsequent time periods throughout the set of nationally representative surveys developed by the USDA. This allows us to categorise the same foods into the same food groups at each point in time. The USDA generated linkage codes were used to link food codes from 1977 and later, but on a food-by-food basis, we recreated this food code linkage step to also link 1965 food codes. After consideration of the tradeoffs, our working group decided to use the most recent USDA food composition table nutrient values to calculate nutrients from foods consumed in each time period. With common food codes, nutrient database and food grouping criteria in place, the trends data set can provide estimates of intakes of food, nutrients, servings of grains, fruits, vegetables and DQI scores for survey respondents from 1965 to 1995.

The Future

As noted earlier, we plan to revise our Diet Quality Index to allow us to incorporate new knowledge about the relationships of diet and health and disease as well as new technology related to manipulation of recipes and our enhanced ability to work with large data sets. In addition, we will begin to work with collaborators in other countries, in particular China and Russia, to develop meaningful food grouping and diet quality indices for those countries.

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