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Dietary patterns and diet quality: approaches to assessing complex exposures in nutrition

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Introduction
Dietary patterns have increasingly become the focus of research in the field of nutritional epidemiology. This interest has increased due to the failure of single nutrient dietary intervention studies such as β-carotene and lung cancer,1 coupled with the success of “total diet” interventions such as the Lyon Diet Heart Study and the Dietary Approaches to Stop Hypertension trial.2,3 There has been significant growth in this area over the last 10 years and the emergence of dietary patterns in the nutritional epidemiology literature is reflected in the inclusion of dietary patterns in systematic reviews underpinning evidence-based dietary guidelines.4

Dietary patterns are of theoretical importance as they reflect multiple aspects or dimensions of diet simultaneously, that is, the total diet. A dietary pattern approach to nutritional epidemiology has advantages over single nutrient or single food approaches. From a biological perspective, it has the potential to capture interactions that may occur between a variety of food components and constituents, and from a public health perspective it can assist in the development of food-based dietary guidelines. There are two main approaches to assessing dietary patterns in epidemiological studies: namely “data-driven” or multivariate statistical approaches, and the use of dietary indices.5

Assessing dietary patterns – multivariate statistical approaches
Multivariate statistical approaches utilise the highly correlated nature of dietary intake variables. There are three main statistical methods currently used in the literature: cluster analysis, factor analysis and reduced rank regression. Cluster analysis describes variations in food intakes and separates people into mutually exclusive groups or clusters and aims to have people within clusters with as similar food intakes as possible and maximise the differences between clusters. While this method is intuitive from a public health and clinical perspective, in practice, its use in epidemiological studies has some disadvantages as it can result in limited statistical power, particularly in studies with smaller sample sizes or where the groupings result in clusters with small numbers of participants.

The more commonly used method is factor analysis which uses variations in food intakes to create “factors” or latent variables which are defined by the foods whose consumption are highly correlated with the factor. It can be considered to describe groupings of foods. For example, in the “Western” pattern identified in the Health Professionals Follow-up Study and the Nurse Health Study Cohort,6,7 participants who ate refined cereals were also more likely to eat high fat dairy products. One advantage of factor analysis over cluster analysis is that it generates a continuous variable for use as an exposure variable which can be used to maximise statistical power.

When using this method, it should be recognised that a person’s overall dietary pattern is most adequately represented by the combination of all the dietary patterns identified in the population. For example, if a study identifies two dietary patterns via factor analysis, a participant will have a score describing their intake of the foods for each of these patterns. Often the dietary patterns are investigated separately with the outcome of interest, but it is also important to investigate the impact of both patterns simultaneously.

A third multivariate statistical method has emerged in the literature, known as reduced rank regression (RRR).8 RRR analysis is a two-step process; firstly, variations in food intake are used to predict intermediate outcomes such as nutrient intakes, biomarkers of intakes, or biomarkers of the disease process. Secondly, the relationship between the dietary pattern scores and health outcome is tested. A potential weakness of much of the work done to date using RRR is that in most cases the first step of this analysis procedure has been conducted using cross-sectional data even if the associations with disease have been investigated longitudinally.

The application of this method is still recent and more work is required to fully explore its utility in nutritional epidemiology. Some studies have used nutrient intake as the intermediate or response variable, although a priori evidence may be lacking for strong relationships between nutrients and disease in some cases, one of the reasons for applying food-based dietary pattern approaches. It should also be acknowledged that not all studies will be able to use RRR, as it requires intermediate markers of exposure or disease. Further work is also required to determine whether the optimal use of the RRR method involves using biomarkers that reflect one disease progression pathway, with individual pathways modelled separately or whether there is an advantage to using multiple biomarker pathways in the same regression modelling.9
It is important to recognise that each of these multivariate methods addresses the issue from a different perspective and the particular method of choice will depend on the research question. RRR is able to combine the data-driven dietary pattern analysis with existing knowledge of diet–disease relationships and is particularly useful as a hypothesis-driven method for confirming pathways through which diet may act to alter disease risk. Cluster and factor analysis describe the variations in food intake in the population, resulting in a behavioural description of food intakes. They provide useful insight into the eating patterns evident within the population and can identify at-risk groups or patterns of behaviour.

Assessing dietary patterns – dietary indices or scores

The other main method of assessing dietary patterns is the use of dietary indices or scores determined by a priori dietary guidelines and recommendations. Diet indices represent a measure of healthy eating patterns and are known by various names, including diet quality indices or healthy eating indices. When based on dietary guidelines, they should represent the best available evidence and consensus of what constitutes a healthy diet. There are two commonly used diet scores, the Healthy Eating Index (HEI) and the Diet Quality Index (DQI), which have been designed based on the United States dietary guidelines. They are commonly used in other countries and often the cut-offs or criteria for specific components of the dietary index are altered to reflect local guidelines. There are also the Mediterranean diet scores, the Recommended Foods Score and a range of dietary variety or dietary diversity scores. These scores assess dietary quality in a variety of ways. Some focus on foods or food groups, others focus on nutrients while a number combine intakes of foods and nutrients to assess diet quality. One potential disadvantage of using dietary indices is the potential lack of variation in population dietary intakes and the fact that too few subjects are consuming an “optimal” diet which can make assessing associations with health outcomes problematic.

Food-based dietary indices have a number of advantages over those based on food and nutrient intakes. They retain the complexity of food intake and indirectly assess intakes of nutrient and non-nutrient components in food. In addition, developing a food-based score may lend itself to further adaptation to short methods of dietary assessment that focus on food intakes rather than detailed measures of dietary intake and therefore may be particularly relevant for use in monitoring and surveillance activities. Food-based diet indices also reflect the move toward food-based dietary guidelines and are most similar to the other data-driven methods of assessing dietary patterns.

At least two different dietary indices have been published already for use in Australia. These two indices take different approaches to the issue of diet quality. The Australian Recommended Foods Score by Collins et al. utilises the approach of Kant et al. while the Dietary Guideline Index uses an approach similar to that of the United States (US) dietary indices with nutrition indicators for each dietary guideline in the Dietary Guidelines for Australian Adults. As we can see from research in the US and elsewhere, different diet indices may have different aims or objectives and may be suited to different research questions or settings so that a “one size fits all” approach may not be necessary or desirable. However, it does require an understanding of each method and its appropriate application and an appreciation of the dietary assessment methodology required to underpin the dietary index.

Common issues and problems

A significant issue facing dietary pattern research is comparability across studies. For example, studies vary in their treatment of the underlying food groupings used in the analysis and inclusion of alcohol intake. Even if similar analytical approaches are used, how to interpret the results from different population groups where different dietary patterns have emerged is still an issue facing this field of nutritional epidemiology.

One of the methodological concerns facing dietary pattern analysis, which is of particular concern with multivariate approaches, is the application of initial decisions required around food groupings. Food groupings are usually based on nutrient content and usage but the number and types of foods used in these analysis approaches can make comparisons between studies difficult. Little methodological research has occurred in this area but the importance of decisions regarding food groups has been highlighted in the literature. McCann et al. conducted research comparing results of dietary patterns analysis using 36 broad food groups and 168 (mostly) single food items in dietary pattern analysis using factor analysis. They found that although the number and type of dietary patterns did not change, the relationship between the dietary patterns and cancer risk was substantially attenuated when using broad groups, suggesting that greater detail in food groupings is important. Therefore retaining a large number of foods and reducing the number of subjective decisions required seems preferable especially since the multivariate statistical approaches are actually data reduction techniques. This is more challenging when diet has been assessed using food records and recalls, when at least some level of food grouping must be applied by the investigator.

Another issue facing the assessment of dietary patterns is how to treat the intake of alcoholic beverages. This depends heavily on the research question. However, dietary behaviours are associated with alcohol intake and so it could make sense to include them in any dietary patterns analysis. Also, dietary indices often include alcohol intake depending on the dietary guidelines being applied. However, it should also be noted that, in practice when using cluster analysis, it will often result in a specific cluster, defined primarily by alcohol intake due to the fact that “extreme” intakes can unduly influence cluster pattern extractions. Similarly with factor analysis methods, different types of alcoholic beverages may occur in different dietary patterns. Overall, with data-driven approaches, it can make adjusting for the effects of alcohol problematic. As alcohol has specific effects in relation to many health outcomes, excluding alcoholic beverages from the dietary pattern analysis may be the only way to attempt to tease out the diet-specific effects.
One of the hypothesised advantages of the dietary indices approach to assessing dietary patterns is that it is easier to compare across studies. In theory this is true, however, this is not always the case. For example, while the Mediterranean diet (MD) scores used in the literature have been consistently associated with disease risk, it can be difficult to compare across studies. Most of the scoring methods used in existing MD scores are based on median intakes of the population under study which means that scoring highly on a MD score may mean different things in different population groups. Similarly, when existing dietary indices (such as the US DQI and HEI) are adapted and different criteria or cut-offs are applied, the resulting index is no longer comparable, that is, an individual’s score on the dietary index no longer reflects the same dietary intake profile.

Summary
The field of dietary patterns research to date has focused on the use of dietary indices and a small number of multivariate statistical approaches. Other approaches have been used intermittently in the literature such as linear discriminant analysis, but these have not been explored in detail. In addition, new methods focusing on meal patterns rather than dietary patterns per se, may provide unique insights to eating behaviours and health. It is clear that the emergence of new methods in the field of dietary patterns requires that statisticians and nutritionists work closely together to further develop and adequately test methods, and ensure their appropriate interpretation.

Measures of dietary patterns can be used in epidemiological studies either to investigate associations of overall healthy eating patterns with particular health outcomes or as a confounder when investigating other exposure-disease relationships. In behavioural research, they may be used to investigate interactions with other health behaviours or may be used to examine the determinants of healthy eating patterns where an integrated measure of diet can be used as the outcome of interest. Dietary indices, in particular, can be used in monitoring and surveillance to assess how well people comply with dietary guidelines, to monitor trends in the population over time, and to target diet and nutrition messages for the public. Dietary pattern analysis provides a novel and practical way to characterise total diet and measures of dietary patterns provide an integrated measure of nutrition behaviours that can be used in population health research.

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References