

Usual Dietary Intakes: The NCI Method

Risk Factor Monitoring and Methods Branch Applied Research Program

Researchers at the National Cancer Institute (NCI) and elsewhere have developed a method to estimate usual dietary intakes of foods and nutrients. This method can be used to:

- estimate the distribution of usual intake for a population or subpopulation;
- assess the effects of individual covariates on consumption; and
- predict individual intake for use in a model to assess the relationship between diet and disease or other variable.

The premise of the NCI method is that usual intake is equal to the probability of consumption on a given day times the average amount consumed on a "consumption day." The exact methods used for dietary components that are consumed nearly every day by nearly everyone differ slightly from those used for dietary components that are episodically consumed.

For episodically-consumed components, a two-part model is used. The first part estimates the probability of consumption using logistic regression with a person-specific random effect. The second part specifies the consumption-day amount using linear regression on a transformed scale, also with a person-specific effect. Parts I and II are linked by allowing the two person-specific effects to be correlated and by including common covariates in both parts of the model. Intake data from 24-hour recalls provide the values for the dependent variable, while average daily intake estimated from a food frequency questionnaire (FFQ) may be incorporated as one of the covariates. Other covariates (e.g., gender, age, race) may be included, particularly if there is interest in subpopulations. The resulting estimated model parameters can then be used to estimate distributions or as input to further analyses, depending on the application of interest (see bullets above). For dietary components that are consumed daily by most persons, the process is the same, except that the probability part of the model is not needed because the probability of consumption is assumed to be 1.

Has the NCI Method Been Validated?

Evidence for the validity of the method as it relates to estimating the distribution of usual intakes of episodically-consumed components has been published in a series of papers in the *Journal of the American Dietetic Association*. More recently, the use of the method to estimate the distribution of usual intakes of components consumed nearly daily by nearly all persons has been described in *Statistics in Medicine* and the *Journal of Nutrition*.

Analyses establishing the method's validity for predicting individual usual intake for use in regression analyses (e.g., to examine relationships between diet and health) have also been published.

See the reverse for citations for these papers.

What Part Does the Frequency Instrument Play in the NCI Method? Under What Circumstances Is It Helpful?

The NCI method involves using data from two or more 24-hour recalls as well as covariates, which may include data from an FFQ such as the NHANES 2003-2006 Food Frequency Questionnaire (formerly called the Food Propensity Questionnaire). A frequency instrument can substantially improve the power to detect relationships between dietary intakes as predictor variables and other variables. The magnitude of improvement depends on the proportion of zeroes in the report of the dietary component, with the FFQ having a greater impact for those with a large number of zero intakes.

When applying the method to estimate usual intake distributions, satisfactory results can generally be obtained without the FFQ as a covariate. However, there are conditions under which the FFQ may help, particularly for estimating the tails of the distributions.

How Does the NCI Method Compare to Other Methods?

For dietary components consumed nearly daily by nearly all persons, various methods have been proposed to estimate either the distribution of usual intakes or to predict individual-level usual intake for use in regression analyses. To date, no other unified methods that estimate usual intake of episodically-consumed foods from 24-hour recall data have been available that are appropriate for use both in estimating distributions and in analyses of diet-health associations.

Two other methods have been developed to estimate the distribution of usual intake of episodically-consumed components with a few days of 24-hour recalls. The simplest uses the within-person mean and usually leads to biased estimates of the prevalence of either inadequate or excess intake. This is because this method does not:

- account for reported days without consumption or for consumption-day amounts that are positively skewed;
- distinguish within-person from between-person variation;
- allow for the correlation between the probability of consumption and the consumption-day amount; or
- relate covariate information to usual intake.

The Iowa State University (ISU) method for estimating the distribution of episodically-consumed components uses modeling and meets most of the challenges noted above. However, it does not allow for correlation between probability and amount and cannot incorporate covariate information.

The NCI method was designed to meet all of these challenges and as such is an improvement over previous methods. It allows efficient estimation of usual intake distributions of daily and episodically consumed components for populations and subpopulations and prediction of individual intake for use in regression analyses. In the absence of such methods, analyses relating intakes to health have often used reported rather than predicted usual intakes, leading to biased estimation.

Further Information

Dodd KW, Guenther PM, Freedman LS, Subar AF, Kipnis V, Midthune D, Tooze JA, Krebs-Smith SM. Statistical methods for estimating usual intake of nutrients and foods: a review of the theory. *J Am Diet Assoc* 2006; 106(10):1640-50. Review.

Subar AF, Dodd KW, Guenther PM, Kipnis V, Midthune D, McDowell M, Tooze JA, Freedman LS, Krebs-Smith SM. The food propensity questionnaire: concept, development, and validation for use as a covariate in a model to estimate usual food intake. *J Am Diet Assoc* 2006; 106(10):1556-63.

Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, Guenther PM, Carroll RJ, Kipnis V. A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. *J Am Diet Assoc* 2006; 106(10):1575-87.

Kipnis V, Midthune D, Buckman DW, Dodd KW, Guenther PM, Krebs-Smith SM, Subar AF, Tooze JA, Carroll RJ, Freedman LS. Modeling data with excess zeros and measurement error: application to evaluating relationships between episodically consumed foods and health outcomes. *Biometrics* 2009;65(4):1003-10.

Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, Krebs-Smith SM, Subar AF, Dodd KW. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: The NCI method. *Stat Med* 2010; 30; 29(27):2857-68.

Freedman LS, Guenther PM, Dodd KW, Krebs-Smith SM, Midthune D. The population distribution of ratios of usual intakes of dietary components that are consumed every day can be estimated from repeated 24-hour recalls. *J Nutr* 2010;140(1):111-6.

Freedman LS, Guenther PM, Dodd KW, Krebs-Smith SM, Midthune D. A population's distribution of Healthy Eating Index-2005 component scores can be estimated when more than one 24-hour recall is available. *J Nutr* 2010; 140:1529-1534.

Visit <http://riskfactor.cancer.gov/diet/usualintakes/> for details about the NCI method, SAS macros, tables of food intakes for the US population, and the 2003-2006 NHANES FFQ.

Concepts related to estimating usual dietary intakes are reviewed in the NHANES Advanced Dietary Analyses Web Tutorial at <http://www.cdc.gov/nchs/tutorials/dietary/index.htm>