Dietary Screener in the 2009 California Health Interview Survey

(CHIS 2009)

November 2019

DIETARY SCREENER: CHIS 2009

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If you have a comment or question about this document, please contact the EGRP, RFAB, NCI, at RFAB@mail.nih.gov.

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1. Background

A new dietary screener was administered in the 2009 California Health Interview Survey (CHIS). The 2009 CHIS screener asks respondents for information about how frequently they consume foods in 10 categories. No portion size questions are asked.

This screener does not attempt to assess total diet. The questions allow researchers to gather information about intakes of fruits and vegetables and teaspoons of added sugars. In addition, a question on frequency of eating fast food is asked. Fruit and vegetable intake is quantified using the cup equivalents metric, based on the US Department of Agriculture's (USDA) MyPyramid Equivalents Database (MPED; version 2.0 for USDA Survey Foods, 2003-2004) and cited in the 2010 Dietary Guidelines for Americans.

You can view or print the 2009 CHIS screener from the National Cancer Institute's (NCI) Register of Validated Short Dietary Assessment Instruments

The 2009 CHIS Diet Screener is composed of QA09_C13 to QA09_C21 of the CHIS 2009 Adult Questionnaire. In addition to variables for these questions, the following variables were computed:

Table 1- 1 Computed variables for 2009 CHIS Diet Screener

Variable Name	Label
FRUIT	Unadjusted daily cup equivalents of fruits
FRIED_PO	Unadjusted daily cup equivalents of fried potatoes
VEG_OTH	Unadjusted daily cup equivalents of other vegetables
FV_NOBNS	Daily cup equivalents of fruits & vegetables excluding beans
FVNB2ADJ	Variance-adj daily cup equiv of fruits/veg excl beans
FV_NOFBN	Daily cup equivalents of fruits/veg excl French fries & beans
FVNFB2AJ	Variance-adj daily cup equiv fruits/veg excl French fries & beans
SUG_SODA	Unadjusted daily teaspoons of added sugar in soda
SUG_ENGD	Unadjusted daily teaspoons of added sugar in fruit/energy drinks
SUG_COFF	Unadjusted daily teaspoons of added sugar in coffee and tea
SUG_BEV	Unadjusted daily teaspoons of added sugar in all beverages
SUG_PAST	Unadjusted daily teaspoons of added sugar in pastries
SUG_ICRM	Unadjusted daily teaspoons of added sugar in ice cream
SUGAR2	Daily teaspoons of added sugar

Variable Name	Label
SUG2_ADJ	Variance-adj daily teaspoons of added sugar

These created variables are available on the CHIS Web site under "Public Use Data Files."

In CHIS 2009, we applied rules for excluding extreme data responses, described in Scoring Procedures. Scoring Procedures also describes the process of scoring the individual response data. A description and guidelines for the appropriate uses of the screener-estimated dietary intakes are found in Variance Adjustment. Validation results for the CHIS 2009 screener are presented in Validation Results.

NOTE: The dietary variables on the CHIS dataset are in their natural units. For analyses, however, they must be transformed to approximate normal distributions. For cup equivalents of fruits and vegetables, use the square root transformation. For teaspoons of added sugars, use the cube root transformation. After analyses, the results can be back-transformed for easier interpretation.

2. Scoring Procedures

How Analytical Scoring Procedures Were Developed

Scoring procedures were developed to convert the individual respondent's screener responses to estimates of intake. We created variables for amount consumed of each food group queried, and for amount consumed of total fruits and vegetables (cup equivalents) and added sugars (teaspoons). To do so, we used 24-hour dietary recall data from the National Center for Health Statistics (NCHS) National Health and Nutrition Examination Survey (NHANES) 2003-2006.

Conversion of frequency category to times per day

Data collected on the 2009 California Health Interview Survey (CHIS) Dietary Screener consist of frequency response and time unit: times per day, week, or month. We converted these responses to daily frequency values, denoted as N_{FGk} and shown below.

Table 2- 1 Daily frequencies

Time Period Reported	N_{FGk}: Daily Frequency
Day	As reported
Week	Reported frequency divided by 7
Month	Reported frequency divided by 30

Exclusion of extreme values

We examined each variable's distribution of values for times per day. For each dietary variable, values discontinuous with the overall CHIS distribution were excluded. The maximum daily acceptable value and the number of cases excluded are shown below.

Table 2- 2 Acceptable daily values

Food Group	Maximum Daily Acceptable Value	Number of Cases Excluded
Fruit	10	2
Fried potatoes	5	0
Other vegetables	10	0
Regular soda	8	7
Sports/energy drinks + Fruit drinks	11	1
Sugar in coffee and tea	12	5
Cookies, cake, pie, brownies	10	0
Ice cream	6	1

Estimation of median sex-age portion sizes

We estimated the median sex- and age-specific portion sizes for each food from 24-hour recall data in NHANES 2003-2006. The units used were specific to each food group: cup equivalents of fruits and vegetables for fruit, fried potatoes, and other vegetables, and teaspoons of added sugars for soda, energy/fruit drinks, coffee/tea, cookies/cake/pie/brownies, and ice cream. These portion sizes are denoted by P_k.

For fruits and vegetables, cup equivalents are defined in the US Department of Agriculture's (USDA) MyPyramid Equivalents Database (MPED; version 2.0 for USDA Survey Foods, 2003-2004) and cited in the 2010 Dietary Guidelines for Americans as:

- 1 cup raw or cooked vegetable or fruit
- 1/2 cup dried vegetable or fruit
- 1 cup vegetable or fruit juice
- 2 cups leafy salad greens.

Median portion sizes for fruits and vegetables are given as cup equivalents of fruits and vegetables:

Table 2- 3 Median Portion Size (Pk) in Cup Equivalents per Mention by Sex and Age for Fruits and Vegetables Analyses

Food Group	Age Group						
	18-27	28-37	38-47	48-57	58-67	68-77	78-99
Men							
Fruit (P_1)	0.867300	0.911790	0.867300	0.867300	0.813000	0.715500	0.713000
Fried potatoes (P_2)	0.622000	0.663435	0.548000	0.548055	0.545000	0.455000	0.444000
Other vegetables (P_3)	0.424210	0.475600	0.511000	0.537500	0.535714	0.515400	0.468600
Women							
Fruit (P_1)	0.764240	0.750000	0.739187	0.775915	0.742000	0.633000	0.632000
Fried potatoes (P_2)	0.480000	0.446660	0.444000	0.385000	0.455275	0.444000	0.320000
Other vegetables (P_3)	0.392600	0.440000	0.470974	0.481716	0.473689	0.447818	0.434007

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For added sugars, median portion sizes are given as teaspoons of added sugars:

Table 2- 4 Median Portion Size (Pk) in Teaspoons per Mention by Sex and Age for Added Sugars Analyses

Food Group	Age Group						
	18-27	28-37	38-47	48-57	58-67	68-77	78+
Men							
Regular soda (P_1)	11.601377	10.480288	10.327300	9.428160	8.994700	8.994700	7.889000
Fruit drinks + sports drinks (P_2)	8.559500	8.232800	10.264077	8.141300	7.558200	5.439624	5.439624
Cookies, cake, pie (P_3)	3.761000	3.756900	4.387860	3.735000	3.192000	3.230824	2.667387
Ice cream (P_4)	5.052000	5.262000	5.052000	4.680000	4.508965	3.691000	3.849000
Sugars in coffee/tea (P_5)	2.000124	2.000124	2.500155	2.484333	1.500000	1.488188	1.653277
Women							
Regular soda (P_1)	9.336096	8.947000	7.953000	8.617500	7.865340	7.295500	5.917000
Fruit drinks + sports drinks (P_2)	7.258570	7.493000	6.451665	6.230040	6.798000	4.536750	4.113113
Cookies, cake, pie (P_3)	2.661000	3.340980	3.651000	3.208920	2.821134	2.729500	2.572640
Ice cream (P_4)	3.509870	3.875520	3.300180	3.094000	2.949000	3.350500	3.300180
Sugars in coffee/tea (P_5)	2.000000	2.000124	2.000000	1.666770	1.500000	1.382000	1.000062

Creation of food-level variables

Food-level variables were created for each food queried by multiplying the individual's standardized daily frequency of intake by his/her sex-age specific portion size, denoted by:

$$\text{Estimated amount consumed daily of Food Group}_k = N_{FGk}P_1$$

Table 2- 5 Available food-level variables

Variable Name	Label
FRUIT	Unadjusted daily cup equivalents of fruits
FRIED_PO	Unadjusted daily cup equivalents of fried potatoes
VEG_OTH	Unadjusted daily cup equivalents of other vegetables
SUG_SODA	Unadjusted daily teaspoons of added sugar in soda
SUG_ENGD	Unadjusted daily teaspoons of added sugar in fruit/energy drinks
SUG_COFF	Unadjusted daily teaspoons of added sugar in coffee and tea
SUG_BEV	Unadjusted daily teaspoons of added sugar in all beverages
SUG_PAST	Unadjusted daily teaspoons of added sugar in pastries
SUG_ICRM	Unadjusted daily teaspoons of added sugar in ice cream

Creation of aggregate variables

A. Fruit and Vegetable Intake

For estimates of **fruits and vegetables** aggregated across all food questions:

$$E(\text{Fruits and Veg}^{1/2}) = b_0 + b_1(N_{FG1}P_1 + N_{FG2}P_2 + N_{FG3}P_3)^{1/2}$$

The cup equivalents of fruits and vegetables variable was square-root-transformed to approximate normality; N_{FGk} is the usual number of times per day an individual consumed food group k; k indexes the three fruit and vegetable food groups. P_k is the median portion size of group k. We calculated weighted least-squares estimates of the regression coefficients b_0 and b_1 on the adults (aged 18 and above) in the NHANES 2003-2006 sample, stratifying by sex and excluding extreme exposure values.

Estimation of b_0 and b_1: For cup equivalents of fruits and vegetables excluding dried beans and French fries, the sex-specific estimates of the parameters are:

Table 2- 6 Estimated Regression Coefficients for Sum of Foods Predicting Different Versions of Daily Cup Equivalents of Fruits and Vegetables, by Sex

Parameter	Men	Women
Summary Variable with French fries, excluding beans		
Intercept (b_0)	0.900416	0.763098
b_1	0.648026	0.673026
Summary Variable excluding French fries and beans		
Intercept (b_0)	0.907261	0.641925
b_1	0.774934	0.662708

B. Added Sugars Intake

For teaspoons of **added sugars**:

$$E(\text{Added sugars}^{1/3}) = b_0 + b_1 (N_{FG1}P_1 + N_{FG2}P_2 + \ldots + N_{FG5}P_5)^{1/3}$$

The teaspoons of added sugars variable was cube-root-transformed to approximate normality; N_{FGk} is the usual number of times per day an individual consumed food group k; k indexes the five added sugars food groups. P_k is the median portion size of group k. We calculated weighted least-squares estimates of the regression coefficients b_0 and b_1 on the adults (aged 18 and above) in the NHANES 2003-2006 sample, stratifying by sex and excluding extreme exposure values.

Estimation of b_0 and b_1: For teaspoons of added sugars, the sex-specific estimates of the parameters are:

Table 2- 7 Estimated Regression Coefficients for Sum of Foods Predicting Teaspoons of Added Sugars, by Sex

Parameter	Men	Women
Intercept (b_0)	1.434353	1.436804
b_1	0.605576	0.547127

Table 2- 8 Created aggregated variables

Variable Name	Label
FV_NOBNS	Daily cup equivalents of fruits & vegetables excluding beans
FV_NOFBN	Daily cup equivalents of fruits/veg excl French fries & beans
SUGAR2	Daily teaspoons of added sugar

Variance adjustment factors

In addition to these variables, we applied variance adjustment factors to create variance-adjusted versions of each for use in many analytical situations.

3.Variance Adjustment

Introduction

Dietary intake estimates from the California Health Interview Survey (CHIS) Dietary Screener are rough estimates of usual intake of fruits and vegetables and added sugars. They are less accurate than more detailed methods (e.g. 24-hour recalls). However, validation research suggests that the estimates may be useful to characterize a population's median intakes, to discriminate among individuals or populations with regard to higher vs. lower intakes, to track dietary changes in individuals or populations over time, and to allow examination of interrelationships between diet and other variables. In addition, dietary estimates from the CHIS could be used to augment national data using similar methods.

Variance-Adjustment Factor

What is the variance adjustment estimate and why is it needed?

Data from the CHIS Dietary Screener are individuals' reports about their intake and, like all self-reports, contain some error. The algorithms we use to estimate servings of fruits and vegetables and added sugars calibrate the data to 24-hour recalls. The screener estimate of

intake represents what we expect the person would have reported on his or her 24-hour recall, given what s/he reported on the individual items in the screener. As a result, the mean of the screener estimate of intake should equal the mean of the 24-hour recall estimate of intake in the population. (It would also equal the mean of true intake in the population if the 24-hour recalls were unbiased. However, many studies suggest that recalls underestimate individuals' true intakes).

When describing a population's distribution of dietary intakes, the parameters needed are an estimate of central tendency (i.e., mean or median) and an estimate of spread (i.e., variance). The variance of the screener, however, is expected to be smaller than the variance of true intake because the screener prediction formula estimates the conditional expectation of true intake given the screener responses, and in general, the variance of a conditional expectation of a variable X is smaller than the variance of X itself.

As a result, the screener estimates of intake cannot be used to estimate quantiles (other than median) or prevalence estimates of true intake unless they are first adjusted so that they have approximately the same variance as true intake.

When is it appropriate to use variance adjustment estimates?

The appropriate use of the screener information depends on the analytical objective.

Table 3- 1 Suggested procedures for various analytical objectives

Analytical Objective	Procedure
Estimate mean or median intake in the population or within subpopulations.	Use the unadjusted screener estimate of intake.
Estimate quantiles (other than median) of the distribution of intake in the population; estimate prevalence of attaining certain levels of dietary intake.	Use the variance-adjusted screener estimate.
Classify individuals into exposure categories (e.g., meeting recommended intake vs. not meeting recommended intake) for later use in a regression model.	Use the variance-adjusted screener estimates to determine appropriate classification into categories.
Use the screener estimate as a continuous covariate in a multivariate regression model.	Use the unadjusted screener estimate.

How were the variance adjustment factors estimated?

We developed procedures to estimate the variance of true intake using data from 24-hour recalls, by taking into consideration within-person variability [1, 2]. We extended these procedures to allow estimation of the variance of true intake using data from the screener.

The resulting variance adjustment factors adjust the screener variance to approximate the variance of true intake in the population.

We used two external validation datasets to estimate the adjustment factors: the Eating at America's Table Study (EATS)[3] and the Observing Protein and Energy Nutrition Study (OPEN)[4]. The results indicate that the adjustment factors differ by gender for each dietary variable. Under the assumption that the variance adjustment factors appropriate to the California Health Interview Survey are similar to those in these external studies, the variance-adjusted screener estimates of intake should have variances closer to the estimated variance of true intake that would have been obtained from repeat 24-hour recalls.

Table 3- 2 Variance adjustment factors, by sex

Dietary Variable	Variance Adjustment Factors	
	Men	Women
Fruits and vegetables without dried beans (cup equivalents)	1.72	1.37
Fruits and vegetables without French fries and dried beans (cup equivalents)	1.73	1.39
Added sugars (tsp)	1.26	1.28

How are the variance adjustment factors applied?

The screener predicts intake on a transformed scale (i.e., the square root of cup equivalents of fruits and vegetables and the cube-root of teaspoons of added sugars). The variance adjustment factor is applied to predicted intake on the transformed scale. The results can then be back-transformed to obtain estimates in the original units.

Adjust the screener estimate of intake by:

- multiplying intake by an adjustment factor (an estimate of the ratio of the standard deviation of true intake to the standard deviation of screener intake); and
- adding a constant so that the overall mean is unchanged.

The formula for the variance-adjusted screener is:

$$\text{variance-adjusted screener} = (\text{variance adjustment factor})*(\text{unadjusted screener} - \text{mean}_{\text{unadj scr}}) + \text{mean}_{\text{unadj scr}}$$

A similar variance adjustment procedure is used to estimate prevalence of intakes for the 2000 NHIS in Thompson et al., [5].

Table 3- 3 Available variance-adjusted variables for CHIS 2009

Variable Name	Label
FVNB2ADJ	Variance-adj daily cup equiv of fruits/veg excl beans
FVNFB2AJ	Variance-adj daily cup equiv fruits/veg excl French fries & beans
SUG2_ADJ	Variance-adj daily teaspoons of added sugar

Attenuation of Regression Parameters Using Screener Estimates

When the screener estimate of dietary intake is used as a continuous covariate in a multivariate regression, the estimated regression coefficient will typically be attenuated (biased toward zero) due to measurement error in the screener. This "attenuation factor" [6] can be estimated in a calibration study and used to deattenuate the estimated regression coefficient (by dividing the estimated regression coefficient by the attenuation factor).

Table 3- 4 Estimated attenuation factors in the EATS and OPEN data

Dietary Variable	Attenuation factors for screener-predicted intake	
	Men	Women
(Square-root) Fruits and vegetables without dried beans (cup equivalents)	1.00	0.82
(Square-root) Fruits and vegetables without French fries and dried beans (cup equivalents)	1.02	0.87
(Cube-root) Added sugars	0.80	0.86

If the screener values are categorized into quantiles and the resulting categorical variable is used in a linear or logistic regression, the bias (due to misclassification) is more complicated because the categorization can lead to differential misclassification in the screener [7]. Although methods may be available to correct for this [8, 9], it is not simple, nor are we comfortable suggesting how to do it at this time.

Even though the estimated regression coefficients are biased (due to measurement error in the screener or misclassification in the categorized screener), tests of whether the regression coefficient is different from zero are still valid. For example, if one used the SUDAAN REGRESS procedure with fruit and vegetable intake (estimated by the screener)

as a covariate in the model, one could use the Wald F statistic provided by SUDAAN to test whether the regression coefficient was statistically significantly different from zero. This assumes that only one covariate in the model is measured with error. When multiple covariates are measured with error, the Wald F test that a single regression coefficient is zero may not be valid, although the test that the regression coefficients for all covariates measured with error are zero is still valid.

4. Validation Results

In the Eating at America's Table Study (EATS)[3] and the Observing Protein and Energy Nutrition Study (OPEN) [4], staff in NCI's Risk Factor Assessment Branch (RFAB) assessed the validity of created aggregate variables from the 2009 CHIS Dietary Screener. In these studies, multiple 24-hour recalls (24HR) in conjunction with a measurement error model were used to assess validity. The screeners used in these studies included questions similar but not identical to those in CHIS 2009. We have constructed parallel variables based on the data available and the scoring algorithms developed for CHIS 2009. For added sugars, questions answered on the Diet History Questionnaire (administered in both studies) were used as proxies for the screener items.

Estimates of cup equivalents of fruits and vegetables and teaspoons of added sugars in EATS and OPEN are shown below. The cup equivalents are based on the US Department of Agriculture's (USDA) MyPyramid Equivalents Database (MPED; version 2.0 for USDA Survey Foods, 2003-2004) and cited in the 2010 Dietary Guidelines for Americans.

Table 4- 1 Estimates of cup equivalents of fruits and vegetables and teaspoons of added sugars in EATS and OPEN

Variable/Survey	Men (median intake)		Women (median intake)	
	Recalls	Screener	Recalls	Screener
Fruits and vegetables, excluding legumes (cup equivalents)				
EATS	3.23	2.78*	2.35	2.38
OPEN	3.48	2.80*	3.03	2.48*
Fruits and vegetables, excluding legumes and French fries (cup equivalents)				
EATS	3.04	2.67*	2.26	2.32
OPEN	3.38	2.71*	2.95	2.43*
Added sugars (teaspoons)				
EATS	17.4	18.7*	11.7	12.7*
OPEN	17.4	16.7	13.2	11.6*

*Screener significantly different from 24-hour recall (24HR; $p < 0.05$).

These validation results suggest that dietary exposure estimates computed for the CHIS 2009 using the screener may be misestimates of the actual intakes. For fruits and vegetables, the underestimates ranged from 0 (nonsignificant) to 2/3 cup equivalent per day. For added sugars, misestimates ranged from 0.7 (nonsignificant) to 1.6 tsp per day. While statistically significant, the relative differences are small. Differences by gender for all variables seen with 24HR data were reflected in the screener estimates. Thus, the screener estimates may best be used to estimate approximate levels of these exposures and relative differences among demographic groups. The estimates may be less useful for populations with ethnic diets, including Asian and possibly Latino populations.

Table 4- 2 Estimated correlations between the screener and true intake for cup equivalents of fruits and vegetables and teaspoons of added sugars in EATS and OPEN, at the individual level

Variable	Men	Women
Fruits and vegetables, excluding legumes (cup equivalents)		
EATS	0.61	0.51
OPEN	0.55	0.75
Fruits and vegetables, excluding legumes and French fries (cup equivalents)		
EATS	0.62	0.53
OPEN	0.56	0.76
Added sugars (teaspoons)		
EATS	0.59	0.70
OPEN	0.71	0.61

The square of the correlation between screener and true intake (R-square) represents the percentage of variability in true intake that is explained by the screener. Overall, about 25 to 50 percent of the variability in the true intake of fruits and vegetables and added sugars will be captured by the screener questions. Thus, although significant error may be associated with these estimates of diet, we believe the exposure estimates still substantially reflect what individuals are actually consuming.

Validation results for the OPEN Multifactor Screener, which includes a similar fruit and vegetable component, are reported in detail in [10].

National estimates based on the 2000 NHIS Multifactor Screener are presented and compared with other national data in [5].

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CHIS 2005 estimates of fruit and vegetable intake from the 2005 CHIS screener are presented and compared with national 24-hour recall data in [11].

National estimates using added sugars screener questions from the 2005 NHIS Five-Factor Screener compared to NHANES 24HR-derived estimates of added sugars intake are in [12].

The OPEN, NHIS, and earlier CHIS screeners are available in NCI's Register of Validated Short Dietary Assessment Instruments.

5. References

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