**ReadMe file for ASA24-2016 to ASA24-2018**

**HEI-2010 Population Ratio Method**

This ReadMe file describes the methodology implemented in the SAS program, HEI2010\_ASA24-2016\_MC\_PopulationScore.sas. The principles underlying this approach are described in Freedman et al., J Nutr, 2008, 138(9):1725-9 ([see abstract in PubMed](http://www.ncbi.nlm.nih.gov/pubmed/18716176)). The provided SAS program, along with the required macros, calculate mean Healthy Eating Index-2010 (HEI-2010) component and total scores and corresponding standard errors and confidence intervals for a population, subpopulation, or group using 24-hour recall or food records data from ASA24-2016 or ASA24-2018. The specific instructions on how to successfully run the HEI procedure are within the provided SAS program.

The program can be adapted to calculate HEI-2010 scores for other data that use complex sampling strategy. The program has been tested using SAS, version 9.4.

Only participants aged 2 years and older should be included in calculations of HEI-2010 scores because the Dietary Guidelines for Americans were not designed for younger children.

**NOTE:** Another version of this program is also available. It uses the 2009-2010 National Health and Nutrition Examination Survey (NHANES) data as an example. Also, additional code that calculates HEI-2010 component and total scores at the individual level, for each day or multiple days of 24-hour recalls or food records are available on the [NCI Healthy Eating Index website](https://epi.grants.cancer.gov/hei/sas-code.html). Sample Analysis Files and Data Dictionaries can be downloaded from the [ASA24 Researcher website page](https://epi.grants.cancer.gov/asa24/researcher/sample.html). The data file should be in CSV format.

Because the HEI-2010 is a multi-dimensional construct involving 12 densities (amounts of food groups per 1,000 calories and ratios of fatty acids), a simple method for estimating standard errors is not available. In this code, a Monte Carlo simulation step is included for the calculation of standard errors; this step simulates the densities for 10,000 samples to allow stable estimation of the standard errors.

The SAS program includes four main sections:

1. Calculations at the individual participant level to obtain variables needed to calculate HEI-2010 scores.
2. Calculation of weighted means and a variance-covariance matrix and generation of a Monte Carlo dataset, enabling standard errors to be calculated.
3. Allocation of beans and peas (legumes) to Total Proteins and Seafood and Plant Proteins and/or Total Vegetables and Greens and Beans and application of the HEI-2010 scoring algorithm.
4. Calculation of mean HEI-2010 component and total scores and their standard errors and confidence intervals.

***Required dataset:***

* Totals file from ASA24-2016 or ASA24-2018

***Required macros:****available on* *the [NCI Healthy Eating Index website](https://epi.grants.cancer.gov/hei/sas-code.html).*

* [hei2010.beanspeas.allocation.macro.sas](https://epi.grants.cancer.gov/hei/sas-code.html)
* [hei2010.score.macro.sas](https://epi.grants.cancer.gov/hei/sas-code.html)

The 12 components of the HEI-2010 calculated by the macros are:

* Total Fruit (HEIX3\_TOTALFRUIT)
* Whole Fruit (HEIX4\_WHOLEFRUIT)
* Total Vegetables (HEIX1\_TOTALVEG)
* Greens and Beans (HEIX2\_GREEN\_AND\_BEAN)
* Whole Grains (HEIX5\_WHOLEGRAIN)
* Dairy (HEIX6\_TOTALDAIRY)
* Total Protein Foods (HEIX7\_TOTPROT)
* Seafood and Plant Proteins (HEIX8\_SEAPLANT\_PROT)
* Fatty Acids (HEIX9\_FATTYACID)
* Refined Grains (HEIX11\_REFINEDGRAIN)
* Sodium (HEIX10\_SODIUM)
* Empty Calories (HEIX12\_SOFAAS)

Some of these components come directly from ASA24-2016 and ASA24-2018 output, but others are created as part of the SAS program.

The ASA24-2016 and ASA24-2018 daily totals data provide the following components used directly in the calculation of HEI-2010: Total Fruit; Dairy; Whole Grains; Refined Grains; Saturated Fats and Sodium.

*Additional steps are necessary to create the remaining components that are a combination of variables: Total Vegetables; Greens and Beans; Whole Fruit; Total Protein; Seafood and Plant Proteins and Fatty Acids.*

**This program carries out 6 steps:**

1. **Reads in ASA24 daily totals data.**

The TOTALS file contains the values from the Food and Nutrient Database for Dietary Surveys (FNDDS) 2011-2012, and the Food Patterns Equivalents Database for USDA Survey Food Codes (FPED).

1. **Creates additional required variables: WHOLEFRT, MONOPOLY, ALLMEAT, SEAPLANT, and EMPTYCAL10.**

Calculation note for WHOLEFRT: FWHOLEFRT sums up Citrus, Melons and Berries with Other Fruits to calculate total whole fruit (non-juice) consumption. (WHOLEFRT = F\_CITMLB + F\_OTHER).

Calculation note for MONOPOLY: MONOPOLY sums up monounsaturated and polyunsaturated fatty acids (MONOPOLY = MFAT + PFAT). To estimate the fatty acid ratio of unsaturated fatty acids to saturated fatty acids, the scoring macro divides this summed value by saturated fatty acids (MONOPOLY/SFAT (g)).

Calculation note for ALLMEAT and SEAPLANT:ALLMEAT sums together all animal and plant proteins, including meat, poultry, fish, eggs, nuts, seeds, and the soy variable (ALLMEAT = PF\_MPS\_TOTAL (oz) + PF\_EGGS (oz) + PF\_NUTSDS (oz) + PF\_SOY (oz)); while SEAPLANT sums together all fish and plant proteins, including fish, soy, nuts, and seeds (SEAPLANT = PF\_SEAFD\_HI (oz)+ PF\_SEAFD\_LOW (oz) + PF\_SOY (oz) + PF\_NUTSDS (oz)).

*An additional step is then required to determine how to include V\_LEGUMES in ALLMEAT and SEAPLANT (see Step 4).*

Calculation note for Empty Calories (EMPTYCAL10): EMPTYCAL10 sumps up three variables, ADDSUGC, SOLFATC, and EXALCCAL described below, to calculate Empty calories. The Empty Calories component of the HEI is calculated as a percentage of calories, so all of the variables that comprise empty calories need to be converted to units of calories.

ADDSUGC: Teaspoons of added sugar (ADD\_ SUGARS) are converted to calories using the conversion factor 1tsp=16kcal.

SOLDFATC: Grams of solid fat (SOLID\_FATS) are converted to calories using the conversion factor 1g=9kcal.

EXALCCAL: In the HEI-2010, energy from alcohol is considered to be empty calories, but only when alcohol is consumed beyond moderate amounts. The least restrictive of the two levels defined as moderate drinking in the Dietary Guidelines, 2 drinks per day (converted to 28 grams of ethanol), was used to set the threshold for counting alcohol as empty calories. A value of 2150 calories was used to energy-adjust the alcohol threshold, based on the estimated median energy intake of adults. Because 28 grams ethanol/2150 calories equals 13 grams ethanol/1000 calories, only amounts greater than 13 grams of ethanol/1000 calories are counted towards Empty Calories.

# Calculates weighted means and a variance-covariance matrix and generates a Monte Carlo dataset, enabling standard errors to be calculated.

This section of the code performs computations necessary for the calculation of standard errors.

1. Calculates the weighted means and the variance/covariance matrix for the dietary variables of interest.
2. A Monte Carlo data set with 10,000 rows is generated using the means and variance/covariance matrix from step i.
3. **Runs the macro to properly allocate the intakes of beans and peas (V\_LEGUMES) (NOT PF\_LEGUMES)** **to either Total Protein Foods and Seafood and Plant Proteins (ALLMEAT and SEAPLANT) or Total Vegetables and Greens and Beans (V\_TOTAL and V\_DRKGR).**

This section of the code calls the macro, [hei2010.beanspeas.allocation.macro.sas](https://epi.grants.cancer.gov/hei/sas-code.html).

This step results in 4 additional variables, named LEGUME\_ADDED\_V\_TOTAL, LEGUME\_ADDED\_BEANGRN, LEGUME\_ADDED\_ALLMEAT, and LEGUME\_ADDED\_SEAPLANT are all used in step 5.

Calculation notes for Legumes: Intake of LEGUMES, counts toward meeting the standard for the Total Protein Foods (and Seafood and Plant Proteins) components first. Once the Total Protein Foods standard is met, any additional amount of Legumes counts toward the Total Vegetables and the Greens and Beans components.

**NOTE:** Units for V\_LEGUMES as well as for the HEI components Total Vegetables and Greens and Beans are in cup equivalents, therefore, the cup equivalents are first converted to ounce equivalents of meat when they are counted for the Total Proteins and Seafood and Plant Proteins components, and are then converted back to cup equivalents when counted as vegetables.

Calculation note regarding conversion of cup equivalents to ounce equivalents:One-fourth cup equivalent of Legumes is equal to a 1-ounce equivalent of Total Protein Foods and Seafood and Plant Proteins. Thus, the number of cup equivalents of Legumes is multiplied by 4 to convert to ounce equivalents of Total Protein Foods and Seafood and Plant Proteins.

# Runs the HEI-2010 scoring macro which calculates intake density amounts and calculates HEI-2010 component and total scores and their standard errors and confidence intervals.

This section of the code calls the macro, [hei2010.score.macro.sas](https://epi.grants.cancer.gov/hei/sas-code.html)

1. This step uses the Monte Carlo dataset with the beans and peas allocated from step 4 and calls the HEI-2010 scoring macro which calculates intake density amounts and HEI scores.
2. Univariate and means procedures are used to compute one HEI-2010 total score and one set of HEI-2010 component scores and their standard errors and confidence intervals for the group, subgroup, or population.

Below are the HEI-2010 Component Scoring Standards. For more information on HEI components, see [Comparing Versions of the HEI](https://epi.grants.cancer.gov/hei/comparing.html) on the NCI website.

**HEI–2010**[**1**](http://epi.grants.cancer.gov/hei/developing.html#f1) **Components & Scoring Standards**

|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **Max points** | **Standard for maximum score** | **Standard for minimum score of zero** |
| **Adequacy:** |  |  |  |
| **Total Fruit**[**2**](http://epi.grants.cancer.gov/hei/developing.html#f2) | 5 | ≥0.8 cup equiv. per 1,000 kcal | No Fruit |
| **Whole Fruit**[**3**](http://epi.grants.cancer.gov/hei/developing.html#f3) | 5 | ≥0.4 cup equiv. per 1,000 kcal | No Whole Fruit |
| **Total Vegetables**[**4**](http://epi.grants.cancer.gov/hei/developing.html#f4) | 5 | ≥1.1 cup equiv. per 1,000 kcal | No Vegetables |
| **Greens and Beans**[**4**](http://epi.grants.cancer.gov/hei/developing.html#f4) | 5 | ≥0.2 cup equiv. per 1,000 kcal | No Greens and Beans |
| **Whole Grains** | 10 | ≥1.5 oz equiv. per 1,000 kcal | No Whole Grains |
| **Dairy**[**5**](http://epi.grants.cancer.gov/hei/developing.html#f5) | 10 | ≥1.3 cup equiv. per 1,000 kcal | No Dairy |
| **Total Protein Foods**[**6**](http://epi.grants.cancer.gov/hei/developing.html#f6) | 5 | ≥2.5 oz equiv. per 1,000 kcal | No Protein Foods |
| **Seafood and Plant Proteins**[**6**](http://epi.grants.cancer.gov/hei/developing.html#f6)**,**[**7**](http://epi.grants.cancer.gov/hei/developing.html#f7) | 5 | ≥0.8 oz equiv. per 1,000 kcal | No Seafood or Plant Proteins |
| **Fatty Acids**[**8**](http://epi.grants.cancer.gov/hei/developing.html#f8) | 10 | (PUFAs + MUFAs)/SFAs ≥2.5 | (PUFAs + MUFAs)/SFAs ≤1.2 |
| **Moderation:** |  |  |  |
| **Refined Grains** | 10 | ≤1.8 oz equiv. per 1,000 kcal | ≥4.3 oz equiv. per 1,000 kcal |
| **Sodium** | 10 | ≤1.1 gram per 1,000 kcal | ≥2.0 grams per 1,000 kcal |
| **Empty Calories**[**9**](http://epi.grants.cancer.gov/hei/developing.html#f9) | 20 | ≤19% of energy | ≥50% of energy |

**1:** Intakes between the minimum and maximum standards are scored proportionately.

**2:** Includes fruit juice.

**3:** Includes all forms except juice.

**4:** Includes any beans and peas not counted as Total Protein Foods.

**5:** Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.

**6:** Beans and peas are included here (and not with vegetables) when the Total Protein Foods standard is otherwise not met.

**7:** Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods.

**8:** Ratio of poly- and monounsaturated fatty acids to saturated fatty acids.

**9:** Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 grams/1000 kcal.

1. **Displays and saves the** **results** **in the specified output folder** **(see notes in the provided SAS program).**
   1. The program saves total score and set of component scores for the population/group of interest, together with minimum and maximum values, standard errors and confidence intervals. An option is provided to export the results into a CSV file that can be opened in Excel.
   2. Print

This step is included as a data check. The min and max can be compared to the bounds of HEI-2010 scores – if any scores <0 or >100, this is a red flag.

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