HANDLS Dietary Diversity Measurements

The Count score for a given person was characterized by the average number of foods consumed in at least one-half of a serving equivalent for 21 subgroups over that person's two interviews. To avoid counting duplicate foods, items with same food code consumed within a 24-hour period were summed prior to determining if the equivalent was eaten. Counts for the solid fats, added sugars, and alcoholic drink food groups and for the cured and organ meat subgroups were excluded from the final count since the focus of this study was diversity among food groups considered healthful; a full listing of all subgroups may be found in Table 1. The final count was calculated by the total number of subgroups consumed divided by 21; theoretical score values range from 0 to 1. Lower scores mean that fewer of the food groups were consumed, and larger scores indicate that a larger number of food groups were consumed.

Evenness scores were first estimated using the Berry-Index (BI), defined as $1 - \sum_{i=1}^{n} s_i^2$, where s_i is the share of food i in the total amount of energy intake and n is the total number of food items consumed [1]. Theoretical scores range from 0 to 1, with lower scores indicating that most of a participant's daily energy came from a few food codes and higher scores indicating that a large number of food codes contributed equally to a participant's daily energy consumption.

Evenness scores were then estimated by incorporating health factors [HF]; health factors were assigned to each food subgroup based on the Dietary Guidelines for Americans, 2015-2020 [2], and are listed in Table 2. A weighted average based on the number of equivalents of each food subgroup in a given food code was used to determine the health factor for that food code. These health factors were then used to adjust the value of the Berry Index using the following formula from Drescher and colleagues [3]

$$HFBI = \frac{(1 - \sum_{i=1}^{n} s_i^2)(\sum_{i=1}^{n} hf_i \times s_i)}{\max_i(hf_i)} = \frac{(BI) * (HV)}{0.18009}.$$

Division by the maximum possible health factor value ensures that the theoretical scores range between 0 and 1, with higher scores indicating not only equal energy contribution from many food codes but also that the foods consumed were considered to be healthy. Scores decrease as the overall healthfulness of the foods decrease and/or the daily energy contribution shifts to a relatively small number of food codes.

Dissimilarity scores were found by finding the average distance between all pairs of foods consumed by an individual across 10 attributes relevant to cardiovascular health, reflecting selected nutrient composition, source, or processing of a food. The attributes included: animal protein, plant protein, whole grains, refined grains, eicosapentaenoic acid (EPA)/docosahexaenoic acid (DHA), dietary fiber, sodium, alcohol, solid fats, and oils. Each attribute was scored as either a 0 or 1 for every food code. Fiber, sodium, and EPA/DHA attribute scores were calculated based on the gram content of that attribute within a given food code. The other seven attributes were determined based on food subgroups with nonzero equivalents for a given food code; equivalents were taken from the USDA's FPED database. See Table 3 for definitions and cutoff points for each attribute.

Distance was calculated using Mahalanobis Distance (MD), a way to get the standardized distance between two points in multivariate space adjusting for the correlation among the variates [4]. It is defined here as $\sqrt{(\boldsymbol{x_i} - \boldsymbol{y_i})^T \Sigma^{-1} (\boldsymbol{x_i} - \boldsymbol{y_i})}$, where $\boldsymbol{x_i}$ is the vector of attribute values for food x, $\boldsymbol{y_i}$ is the vector of attribute values for food y, and Σ is the variance-covariance matrix among the attributes. Since all of the attributes were dichotomous, the covariance matrix used was calculated using a method proposed by Schweizer [5]. This method assumes that the observed dichotomous values are just indicators of a continuous normally distributed underlying latent construct. MD was chosen for this study to account for the fact that attributes were correlated. Most distances ranged from 0 to 1.5, with larger scores indicating that a person's diet consisted of foods with a greater variety of attribute values. While theoretical values of MD can range from 0 to ∞, larger values (≥ 3) are extremely unlikely. In this context, this is because MD essentially gives the number of standard deviations that a given food is away from the "attribute average," and most foods will fall within one or two standard deviations from this average.

Table 1. Mean daily equivalents (± standard errors) consumed for each food group by HANDLS study population

Food group	Mean ± SE Equivalents	Food group	Mean ± SE Equivalents
Total Fruit	**0.745 ± 0.022 cups**	**Total Protein foods**	**6.539 ± 0.084 oz**
Citrus, melons, berries	0.116 ± 0.008 cups	Total Meat, poultry, fish[1]	5.146 ± 0.073 oz
Other fruits	0.338 ± 0.013 cups	Meat	1.202 ± 0.040 oz
Juices	0.291 ± 0.014 cups	Cured meat[1]	1.243 ± 0.033 oz
Total vegetables	**1.329 ± 0.021 cups**	Organ meat[1]	0.032 ± 0.007 oz
Dark green	0.166 ± 0.008 cups	Poultry	1.686 ± 0.045 oz
Total red and orange	0.280 ± 0.007 cups	Seafood high in n-3 fatty acids	0.236 ± 0.019 oz
Total starchy	0.470 ± 0.012 cups	Seafood low in n-3 fatty acids	0.747 ± 0.036 oz
Other vegetables	0.361 ± 0.009 cups	Eggs	0.668 ± 0.016 oz
Legumes	0.052 ± 0.004 cups	Soy products	0.035 ± 0.004 oz
Total grains	**5.439 ± 0.064 oz**	Nuts and seeds	0.482 ± 0.033 oz
Whole grains	0.668 ± 0.021 oz	Legumes	0.208 ± 0.016 oz
Refined grains	4.771 ± 0.062 oz	**Oils**	**25.657 ± 0.384 g**
Total Dairy	**1.154 ± 0.023 cups**	**Solid fats**[1]	**34.672 ± 0.482 g**
Milk	0.494 ± 0.015 cups	**Sugars + Beverages**[1,2]	**19.766 ± 0.328 tsp**
Yogurt	0.039 ± 0.004 cups	**Alcoholic drinks**[1]	**0.509 ± 0.035 drinks**
Cheese	0.621 ± 0.015 cups		

Abbreviations: HANDLS - Healthy Aging in Neighborhoods of Diversity across the Life Span, SE – standard error.
[1] Excluded from count score. [2]Includes non-alcoholic beverages *other than* water.

Table 2. Health values of foods.

Food group	equivalents per week[1]	%	Health value
1. Total Fruit[2]	14	**10.8**	
Citrus, melons, berries	7	*50.0*	*0.108x0.5=0.054*
Other fruits	4	*28.6*	*0.108x0.286=0.031*
Juices	3	*21.4*	*0.108x0.214=0.023*
2. Total vegetables	17.5	**13.5**	
Dark green	1.5	*8.6*	*0.135x=0.086=0.012*
Total red and orange	5.5	*31.4*	*0.135x0.314=0.042*
Total starchy	5	*28.6*	*0.135x0.286=0.039*
Other vegetables	4	*22.9*	*0.135x0.229=0.031*
Legumes	1.5	*8.6*	*0.135x0.086=0.012*
3. Total grains	42	**32.4**	
Whole grains	21	*50*	*0.324x0.50=0.162*
Refined grains	21	*50*	*0.324x0.50=0.162*
4. Total Protein foods	39	**27.0**	

Meat, poultry, eggs[4]	26	*66.7*	*0.270x0.667=0.180*
Seafood high & low in n-3 fatty acids	8	*20.5*	*0.270x0.205=0.055*
Soy products, nuts, and seeds	5	*12.8*	*0.270x0.128=0.035*
5. Total Dairy[5]	21	**16.2**	
Milk	1	*33.3*	*0.162x0.333=0.054*
Yogurt	1	*33.3*	*0.162x0.333=0.054*
Cheese	1	*33.3*	*0.162x0.333=0.054*
6. Oils	0.125 C	**0.1**	0.1
Equivalents/ week	129.625	100	

[1] Based on 2000 kcal diet from 2015-2020 Dietary Guidelines for Americans [2].[2] Values based on 2015-2020 Dietary Guidelines for Americans which states at least half of the recommended amount of fruits should come from whole fruits [2]. Since citrus was one of the Basic Seven food groups in 1940s, this group was weighted more heavily. The value of 7 suggests one equivalent serving of citrus per day.[3] Reflects consumption of adults from scientific report 2015-2020 Dietary Guidelines for Americans [2]. [4] Excluded cured and organ meats. [5]There is no recommendation for dairy subgroups in the Dietary Guidelines for Americans, 2015-2020. Equivalents were distributed equally across the subgroups based on the following rational. The Scientific Advisory Report of dietary guidelines for 2015-2020 noted that the U.S. population consumes the recommended 3 cup equivalents per day as 53 percent fluid milk, 45 percent cheese, and 2 percent as yogurt [6]. These data support approximately equally consumption of milk and cheese. Yogurt consumption is low but research that documents the benefits of yogurt with respect to heart health [6].

Table 3: Definitions of food attributes.

Attribute	**Categories**	**Criterion to Assess**
Animal protein source	Yes - Coded as 1[1] No – Coded as 0	USDA Food Patterns Equivalent Database food subgroups[2] • Protein Foods, Meat • Protein Foods, Poultry • Protein Foods, Seafood High in EPA/DHA • Protein Foods, Seafood Low in EPA/DHA • Protein Foods, Eggs • Dairy, Milk • Dairy, Yogurt • Dairy, Cheese
Plant protein source	Yes - Coded as 1[1] No – Coded as 0	USDA Food Patterns Equivalent Database food subgroups[2] • Soy Products • Nuts and Seeds
Food processing: Whole grains	Yes - Coded as 1 No – Coded as 0	USDA Food Patterns Equivalent Database food subgroups[2] • Whole Grains
Food processing: Refined grains	Yes - Coded as 1 No – Coded as 0	USDA Food Patterns Equivalent Database food subgroups[2] • Refined Grains
Fiber	Initially coded as: High - Coded as 1 Moderate - Coded as 2 Low - Coded as 3 No Fiber: Coded as 0 For analysis coded as: High to moderate fiber - Coded as 1 Low to No fiber - Coded as 0	Comparison of fiber content to the amount in serving size. • FDA defines serving size as the amount of food typically consumed in one sitting for that food and they are determined using Reference Amounts Customarily Consumed (RACC) and procedures described in 21 CFR 101.12(b) and 21 CFR 101.9(b) respectively.[3] • Using FDA labeling criterion per serving[3] **High fiber** food is defined as ≥5 grams of fiber; **Moderate fiber** food is defined as 1.26 – 4.9 grams of fiber; **Low fiber** food is defined as ≤ 1.25 grams of fiber
Sodium	Initially coded as: High - Coded as 1 Moderate - Coded as 2 Very Low- Coded as 3 No sodium - Coded as 0 For analysis coded as: High to moderate sodium - Coded as 1 Very Low to No sodium - Coded as 0	Comparison of sodium content to the amount in serving size. • FDA defines serving size as the amount of food typically consumed in one sitting for that food and they are determined using Reference Amounts Customarily Consumed (RACC) and procedures described in 21 CFR 101.12(b) and 21 CFR 101.9(b) respectively.[3] • Using FDA labeling criterion per serving[3], **High sodium** food is defined as >140 milligrams of sodium; **Moderate sodium** food is defined as 36 mg – 140mg; **Very low sodium** food is defined as ≤ 35 mg of sodium

Alcohol	Yes - Coded as 1 No – Coded as 0	Using USDA Food Patterns Equivalent Database food groups[2], only foods listed under Alcoholic Drinks Components to be used to categorize foods as having alcohol or not.
Eicosapentaenoic acid (EPA) Docosahexaenoic acid (DHA)	Initially coded as: High - To be coded as 1 Low - To be coded as 2 No EPA+ DHA be coded as 0 For analysis coded as: High EPA/DHA- Coded as 1 Low to No EPA/DHA- Coded as 0	Comparison of total EPA+DHA content to the amount in serving size. **High EPA+DHA** food is defined as having ≥ 0.90 grams of EPA+DHA per serving[4] **Low EPA +DHA** food is defined as having 0.01 – 0.89 grams of EPA+DHA per serving[4]
Oils	Yes - Coded as 1 No – Coded as 0	USDA Food Patterns Equivalent Database food groups[2] Oils
Solid fats	Yes - Coded as 1 No – Coded as 0	USDA Food Patterns Equivalent Database food groups[2] Solid fats

[1]If a given food code had a nonzero equivalent value in *at least* one of these subgroups, the corresponding attribute was assigned a value of "1" for that food code. If all qualifying subgroups had zero equivalents, the corresponding attribute for that food code was assigned a value of "0". [2]Food Patterns Equivalents Database 2013-14: Methodology and User Guide [7]. [3]Food Labeling: Serving sizes of Foods That Can Reasonably Be Consumed at One Eating Occasion; Dual-Column Labeling; Updating, Modifying, and Establishing Certain Reference Amounts Customarily Consumed; Serving size for Breath Mints; and Technical Amendments: Guidance for Industry Small Entity Compliance Guide [8].[4]Food Sources of Omega-3 Fats Factsheet [9].

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