Comparison of estimates of the nutrient density of the diet of women and children in Uganda by Household Consumption and Expenditures Surveys (HCES) and 24-hour recall

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Abstract

Background. *Individual dietary intake data are important for informing national nutrition policy but are rarely available. National Household Consumption and Expenditures Surveys (HCES) may be an alternative method, but there is no evidence to assess their relative performance.*

Objective. *To compare HCES-based estimates of the nutrient density of foods consumed by Ugandan women (15 to 49 years of age) and children (24 to 59 months of age) with estimates based on 24-hour recall.*

Methods. *The 52 food items of the Uganda 2006 HCES were matched with nutrient content of foods in a 2008 24-hour recall survey, which were used to refine the HCES-based estimates of nutrient intakes. Two methods were used to match the surveys' food items. Model 1 identified the four or five most commonly consumed foods from the 24-hour recall survey and calculated their unweighted average nutrient contents. Model 2 used the nutrient contents of the single most consumed food from the 24-hour recall. For each model, 14 estimates of nutrient densities of the diet were made and 84 differences were compared.*

Results. *Models 1 and 2 were not significantly different. Of the model 2 HCES-24-hour recall comparisons, 67 (80%) did not find a significant difference. No significant differences were found for protein, fat, fiber, iron, thiamin, riboflavin, and vitamin B_6 intakes. HCES overestimated intakes of vitamins C and B_{12} and underestimated intakes of vitamin A, folate, niacin, calcium, and zinc in at least one of the groups.*

Conclusions. *The HCES-based estimates are a relatively good proxy for 24-hour recall measures of nutrient density of the diet. Further work is needed to ascertain nutrient adequacy using this method in several countries.*

Key words: Dietary intake, Household Consumption and Expenditures Surveys (HCES), micronutrients, nutrient density, 24-hour recall, Uganda

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Introduction

A common failing of national nutrition policy is the inability to measure the impact of nutrition interventions on the nutrition status of the population. A common cause of this failing is the lack of accurate and reliable dietary intake data. Dietary intake assessment may be conducted at the national [1], household [2], and individual [3] levels, depending upon the analyst's objective. At present, individual dietary intake survey data, such as directly observed, weighed food records, or, more commonly used, less expensive, and less complex, 24-hour recall food consumption survey data, have come to be regarded as the gold standards for measuring individual dietary intake for planning, monitoring, and evaluating public health nutrition interventions. However, because both of these methods are so complex and costly, neither of these types of dietary survey is commonly conducted. Instead, in many countries where 24-hour recall information is not available, information on food supply (rather than consumption), such as FAO Food Balance Sheet (FBS) [4] data, has been used to address the dietary intake information gap and assess national food security. Recently, secondary analysis of a variety of national household food consumption and acquisition survey databases—referred to collectively as Household Consumption and Expenditures Surveys (HCES)—have been used to measure food security [5], as well as to identify food fortification vehicles and estimate the additional micronutrient intakes predicted to result from national food fortification interventions [6].

In Uganda (as in many countries), using HCES to analyze food intake is challenging, and this method has weaknesses, including the lack of precision in quantifying the amount of food acquired that is actually consumed and the lack of recipes identifying all of the ingredients of prepared foods. Despite these weaknesses, HCES have several advantages relative to the 24-hour recall method, as shown in the "quick-and-dirty" comparative analysis of **table 1**. First, compared with designing and implementing a 24-hour recall survey, transforming an already existing HCES database involves relatively minor, incremental steps to develop and analyze a food intake analytic file. The training required is simpler, and it does not require special nutritional or dietary skills. Second, HCES are financed and routinely implemented every 3 or 4 years [7, 8]. Finally, this method can provide comprehensive data on actual intake for the entire household, not just for young children and women, who are usually the exclusive focus of 24-hour recall surveys. As a result, HCES may provide a more accurate characterization of the food intake of the national population.

Despite the recent improvements in 24-hour recall survey methods [9], some methodological issues and limitations are common due to sample design, power, dietary variations due to seasonality, the complexity of field logistics, and the high fieldwork costs incurred in implementing these surveys.

The objective of this study was to test the use of HCES data for estimating the apparent individual nutrient density of a diet as a potential alternative to 24-hour recall. HCES data are comprehensive and routinely collected, and may provide reliable serial data to characterize dietary intakes among women of reproductive age and children from 24 to 59 months of age in Uganda.

Methods

Data collection

This study conducted a secondary analysis of the 2006 Uganda nationwide HCES data and the 2008 Uganda region-wide, single-day 24-hour recall food consumption survey data. The 2006 HCES was a national, multistage-stratified-random survey, providing a representative subnational sample for several different strata. A total of 3,700 households were surveyed. An integrated questionnaire [10] was used to collect 7-day recall estimates of the quantities (grams) and expenditures (Ugandan shillings) for food items consumed by households. The HCES list of food items was composed of 52 foods commonly consumed by Ugandans. The 2008 24-hour recall food consumption survey was a population-based, cross-sectional survey of women of reproductive age and children 24 to 59 months of age conducted in three regions of Uganda, the Central Region, represented by Kampala urban city, and the Southwestern and Northern regions, representing rural areas of Uganda. A total of 957 households were surveyed. Single-day 24-hour recall based on the multipass method [9] was used to collect quantitative information on food intake at the household level. Repeated dietary intake data collection was carried out on 10% of the targeted households in each region on a nonconsecutive day for purposes of validation and assessment of reproducibility, and for estimating the usual intakes. A qualitative food-frequency 7-day recall questionnaire was also administrated for the purpose of using the same HCES food list and enabling a more direct comparison of the results of the two surveys. **Table 2** summarizes the sample size of each target group for each survey.

TABLE 1. Criteria for comparing 24-hour recall surveys (24HR) and Household Consumption and Expenditures Surveys (HCES)

Criteria	24HR	HCES
A. Data quality		
Actual intake measurement		
1. Comprehensiveness: all household members included	—	+
2. Portion size served	+	—
3. Quantitative recipe composition	+	—
4. Food preparation methods	+	—
5. Source of food: "purchased, own production, gift, …."	+	—
6. Relies on memory	—	—
B. Data management and analysis		
1. Data management	+	—
2. Possibility of usual intake measurement	+	+
3. National population-based estimate	—	+
C. Survey implementation		
Interview administration		
1. Low respondent burden[a]	—	+
2. Time required[a]	—	+
3. Low cost[a]	—	+
4. Routinely implemented	—	+
5. No special skills required	—	+
6. Simple training method	—	+
D. Representativeness		
1. National level	—	+
2. Lower levels (regional, district)	+	+
3. Small-scale area	+	—

+ Criterion contributes positively, – criterion contributes negatively
a. Limiting HCES to food consumption section only.

TABLE 2. Sample sizes of the 2008 Uganda 24-hour recall survey (24HR) and the 2006 Uganda Household Consumption and Expenditures Survey (HCES) by target group and region

	Region							
	Kampala		Southwestern		Northern		Total	
Target group	24HR	HCES	24HR	HCES	24HR	HCES	24HR	HCES
Household	314	323	322	1,755	321	1,622	957	3,700
Women 15–49 yr	314	417	322	1,849	321	1,511	957	3,777
Women with children 24–59 mo	167	127	166	867	177	833	510	1,827

Inclusion criteria

Households located in Kampala urban city and in the Southwestern and Northern regions of Uganda were studied with the use of the HCES data. Households with women of reproductive age and/or with children 24 to 59 months of age were studied with the use of a single-day 24-hour recall survey.

Food composition table

The 2008 HarvestPlus/A2Z Uganda food composition table [11] was used to estimate edible portions or to convert portion size to ingredient weight and to estimate nutrient contents in foods and ingredients.

HCES data processing

Food selection. In HCES data, the Individual Consumption by Purpose (COICOP code 01.1) was used to classify food commodities into 52 food groups and subgroups [12]. The food list items were adapted and further elaborated to include subgroups. Detailed data—such as the ingredients of prepared foods, food preparation methods, and food waste—which are needed for more precise selection of food commodities from the food composition table, were not collected. As a result, the food item categories that the HCES used to transform food quantities into nutrient intakes (using the food composition table) were generally more broad and commodity-like than those identified in the 24-hour recall. To enable these categories to be matched closely and unambiguously to the food composition table, we matched the 24-hour recall to the HCES (in two different ways) to provide the more refined food categorizations with their more inclusive and carefully constructed nutrient content estimates. For example, the HCES food item list includes the food subgroup "beans," but the nutrient content of "beans" can vary widely, depending upon the specific type of bean. For instance, bean type "white dried, boiled" has 90 mg of calcium, 3.7 mg of iron, and 2.7 mg of zinc per 100 g, whereas bean type "kidney fresh, boiled" has 31 mg of calcium, 1.7 mg of iron, and 0.6 mg of zinc per 100 g. This matching procedure not only results in more specific food types, it also, in effect, introduces adjustments (for food preparation methods, edible portion, and waste) to provide estimates based on more food-like and less commodity-like categories to address this commonly cited shortcoming of the differences in nutrient content of, and the imprecise nature of, the HCES. The approach assumes that the food categories of the respondents to the 24-hour recall survey provide a good proxy for the food categories of the respondents to the HCES. To ensure a closer match between the likely food consumption patterns of the respondents in the two surveys, we made independent matches by region, target population, and food group, for a total of 312 independent food matchings and transformations. (52 food groups × 3 regions × 2 target populations).

Given the exploratory nature of this work and the importance of better understanding the potential significance of the food list in affecting the comparability of the 24-hour recall and HCES nutrient intake estimates, we thought it prudent to apply two methods for matching the food item lists and recreating that of the HCES. Model 1 was composed of the four or five most commonly consumed foods (as measured by both frequency and quantity consumed) by region and by age group using the 24-hour recall survey results. Model 2 used the single most commonly consumed food (the most frequently cited food or the food that was consumed in largest quantity) by region and by age group using the single most popular 24-hour recall survey food.

Edible portion and nutrient content estimate. In model 1, the unweighted average of the conversion factor and the nutrient contents of the four or five most commonly consumed foods were used to estimate the conversion factor and the nutrient contents for each selected food. In model 2, the corresponding conversion factor and nutrient contents from the food composition table of the most commonly consumed food were used to identify the conversion factor and nutrient contents of the selected food.

AME estimate. The Food and Agriculture Organization (FAO) Adult Male Equivalent (AME) unit method [13] was used to adjust the estimated household intakes in terms of adult equivalent for predicting the dietary intake for women of reproductive age and for children 24 to 59 months of age. The adjusted values were then used to make comparisons with the results of 24-hour recall for both of these target populations.

HCES- and 24-hour recall-based estimates of the *nutrient density of the diet.* The nutrient contents per 2,000 kcal of edible portion of each consumed food were calculated. The macronutrients studied were protein, fat, and fiber; the minerals were iron, calcium, and zinc; and the vitamins were vitamin A, B_1, B_2, B_3 (niacin), B_6, B_9 (folate), and B_{12}. For HCES data, nutrient density was calculated for women of reproductive age and for children 24 to 59 months of age using the corresponding AME factors. Dietary reference intakes for contributions to energy from protein (4 kcal), carbohydrate (4 kcal), and fat (9 kcal) [14] were used to estimate total energy intake.

Identification of outliers for HCES and 24-hour recall. Descriptive statistics (including the means, medians, standard deviations, and scatter plots) for each amount of food and/or ingredient consumed, and of the nutrient density of each nutrient per age group and region, were analyzed to validate the amounts of foods consumed. SPSS EXPLORE [15] was used to identify outliers. Food quantity outliers (i.e., extremely low or extremely high food quantities) in the HCES data were adjusted using the regional average monetary cost per 100 grams corresponding to each food in each region together with information from the Food Frequency Questionnaire (FFQ) data for 24-hour recall.

Validation of suitability of HCES data. Because nutrient intake data are typically not symmetrically distributed, we used two nonparametric tests that have significantly higher power for analyzing unimodal distributions to test the significance of the differences in the nutrient density. We compared the medians and distributions of the estimated nutrient densities from the two surveys by the Mann-Whitney and Kolmogorov-Smirnov tests [16], respectively, with a significance level of .05. Model 2 results were compared with the 24-hour recall median estimates, rather than those of model 1, because they were more highly correlated with 24-hour recall values and required fewer assumptions. Differences between the two surveys in the percentile distributions of the nutrient densities were also assessed.

Results

The mean, standard deviation, and median energy intake among women of reproductive age and children 24 to 59 months of age estimated by 24-hour recall and HCES models are shown in **table 3**. Across all regions and both target groups, the median energy intake of the HCES and 24-hour recall estimates were very similar. In all 18 measures (3 methods, 3 regions for each of 2 target populations), HCES model 1 estimated lower median energy intake relative to both model 2 and the 24-hour recall-based estimates. All three methods found the same regional rankings of the women's median energy intakes; the Northern region had the lowest, the Southwestern the highest, and Kampala was intermediate. For children, the results follow the same order with the exception of HCES-Model 2, which reported higher energy intake for children of Kampala than for children of the Southwestern region.

Table 4 (women of reproductive age) and **table 5** (children 24 to 59 months of age) show the median nutrient densities of the diet for each nutrient by region and by data source, together with the estimated Mann-Whitney and Kolmogorov-Smirnov p values for the difference in the medians of the model 2 HCES and the 24-hour recall. Only four (9%) of the median nutrient densities were found to be different in model 1

TABLE 3. Energy intake among women of reproductive age and children 24–59 months of age by region and data source

	Data source									p^c	p^d
	24HR			HCES model 1[a]			HCES model 2[b]				
Region	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	24HR vs. model 2	24HR vs. model 2
Women of reproductive age											
Kampala	2,149	761	2,256	1,834	954	1,972	2,108	972	2,020	.546	.602
Southwestern	2,185	894	2,826	1,845	808	1,976	2,152	913	2,559	.510	.554
Northern	1,773	962	2,074	1,678	913	1,942	1,745	978	1,976	.787	.853
Children 24–59 mo											
Kampala	1,150	592	1,315	1,008	606	1,247	1,053	671	1,291	.846	.873
Southwestern	1,633	990	1,581	1,125	854	1,570	1,002	950	1,297	.547	.524
Northern	1,010	559	1,215	970	558	1,085	997	625	1,159	.731	.716

24HR, 24-hour recall survey; HCES, Household Consumption and Expenditures Survey

a. HCES model 1: selection of the different foods based on 4 or 5 commonly consumed foods according to the 24HR.

b. HCES model 2: selection of the different foods based on the most consumed foods according to the 24HR.

c. Difference between medians, Mann-Whitney test.

d. Difference between distributions, Kolmogorov-Smirnov test.

TABLE 4. Nutrient density (per 2,000 kcal) for each nutrient among women of reproductive age by region and data source[a]

Nutrient	Data source	Kampala Median	Kampala p value[b] 24HR vs. model 2	Kampala p value[c] 24HR vs. model 2	Southwestern Median	Southwestern p value[b] 24HR vs. model 2	Southwestern p value[c] 24HR vs. model 2	Northern Median	Northern p value[b] 24HR vs. model 2	Northern p value[c] 24HR vs. model 2
Protein (g)	A2Z 24HR	47	0.713	0.752	46	0.814	0.805	62	0.084	0.079
	HCES Model 1[d]	41			43			44		
	HCES Model 2[e]	40			43			44		
Fat (g)	A2Z 24HR	36	0.957	0.928	23	0.643	0.684	44	0.874	0.766
	HCES Model 1[d]	37			29			44		
	HCES Model 2[e]	35			28			43		
Fiber (g)	A2Z 24HR	25	0.540	0.498	39	0.610	0.589	35	0.510	0.491
	HCES Model 1[d]	23			27			28		
	HCES Model 2[e]	29			32			29		
Calcium (mg) Ref. 694[f]	A2Z 24HR	225	0.045	0.038	329	0.650	0.624	513	0.720	0.802
	HCES Model 1[d]	299			313			510		
	HCES Model 2[e]	304			319			511		
Iron (mg) Ref. 24	A2Z 24HR	10	0.782	0.764	13	0.674	0.705	18	0.519	0.531
	HCES Model 1[d]	9			10			13		
	HCES Model 2[e]	9			10			14		
Vitamin C (mg) Ref. 29	A2Z 24HR	103	0.074	0.081	167	0.048	0.041	56	0.000	0.000
	HCES Model 1[d]	134			136			158		
	HCES Model 2[e]	135			136			158		
Thiamin (mg) Ref. 0.76	A2Z 24HR	0.97	0.670	0.592	1.23	0.051	0.057	1.50	0.894	0.857
	HCES Model 1[d]	0.73			0.83			1.10		
	HCES Model 2[e]	0.72			0.82			1.10		
Riboflavin (mg) Ref. 0.76	A2Z 24HR	0.93	0.784	0.814	1.04	0.842	0.840	0.90	0.541	0.546
	HCES Model 1[d]	0.89			0.91			0.75		
	HCES Model 2[e]	0.89			0.90			0.75		
Niacin (mg) Ref. 9	A2Z 24HR	13	0.862	0.901	12	0.878	0.862	15	0.048	0.050
	HCES Model 1[d]	10			11			10		
	HCES Model 2[e]	10			11			10		
Vitamin B_6 (mg) Ref. 0.90	A2Z 24HR	2.22	0.796	0.758	2.97	0.888	0.859	1.56	0.521	0.532
	HCES Model 1[d]	2.11			2.37			2.12		
	HCES Model 2[e]	2.11			2.37			2.12		
Folate (µg) Ref. 267	A2Z 24HR	381	0.048	0.035	449	0.037	0.041	429	0.075	0.079
	HCES Model 1[d]	290			329			393		
	HCES Model 2[e]	292			325			390		
Vitamin B_{12} (µg) Ref. 1.7	A2Z 24HR	0.91	0.891	0.869	0.00	0.000	0.001	0.00	0.000	0.001
	HCES Model 1[d]	1.00			0.77			0.93		
	HCES Model 2[e]	0.96			0.72			0.91		
Vitamin A (µg) Ref. 298	A2Z 24HR	480	0.078	0.067	478	0.082	0.088	244	0.065	0.074
	HCES Model 1[d]	398			376			170		
	HCES Model 2[e]	400			377			169		
Zn (mg) Ref. 6.80	A2Z 24HR	5.77	0.889	0.901	6.84	0.574	0.569	9.29	0.043	0.042
	HCES Model 1[d]	5.14			5.29			6.82		
	HCES Model 2[e]	5.14			5.29			6.82		

a. Shaded cells represent significant differences ($p < .05$).
b. Difference between medians, Mann-Whitney test.
c. Difference between distributions, Kolmogorov-Smirnoff test.
d. HCES model 1: selection of the different foods based on four or five commonly consumed foods according to 24-hour recall (24HR).
e. HCES model 2: selection of the different foods based on the most commonly consumed foods according to 24HR.
f. The reference value is the ideal nutrient density to satisfy the Estimated Average Requirement (EAR) for a woman of reproductive age with a 2,400-kcal intake (i.e., EAR/2,400 kcal × 2,000).

TABLE 5. Nutrient density (per 2,000 kcal) for each nutrient among children 24 to 59 months of age by region and data source[a]

		Kampala			Southwestern			Northern		
Nutrient	Data Source	Median	p value[b] 24HR vs. Model 2	p value[c] 24HR vs. Model 2	Median	p value[b] 24HR vs. Model 2	p value[c] 24HR vs. Model 2	Median	p value[b] 24HR vs. Model 2	p value[c] 24HR vs. Model 2
Protein (g)	A2Z 24HR	48	0.620	0.714	46	0.970	0.927	62	0.089	0.086
	HCES Model 1[d]	41			46			46		
	HCES Model 2[e]	41			46			46		
Fat (g)	A2Z 24HR	41	0.571	0.612	31	0.518	0.530	42	0.636	0.672
	HCES Model 1[d]	38			31			50		
	HCES Model 2[e]	36			29			49		
Fiber (g)	A2Z 24HR	20	0.084	0.081	36	0.887	0.892	34	0.075	0.080
	HCES Model 1[d]	22			25			27		
	HCES Model 2[e]	29			31			29		
Calcium	A2Z 24HR	322	0.065	0.074	415	0.082	0.080	353	0.072	0.074
(mg)	HCES Model 1[d]	386			373			422		
Ref. 749[f]	HCES Model 2[e]	392			378			424		
Iron (mg)	A2Z 24HR	10	0.916	0.887	12	0.845	0.829	17	0.548	0.551
Ref. 10	HCES Model 1[d]	9			10			14		
	HCES Model 2[e]	9			10			14		
Vitamin C	A2Z 24HR	78	0.042	0.048	176	0.076	0.071	61	0.038	0.036
(mg)	HCES Model 1[d]	126			128			132		
Ref. 41	HCES Model 2[e]	128			128			132		
Thiamin	A2Z 24HR	0.98	0.560	0.548	1.21	0.091	0.089	1.49	0.521	0.516
(mg)	HCES Model 1[d]	0.74			0.80			1.01		
Ref. 0.72	HCES Model 2[e]	0.73			0.80			1.01		
Riboflavin	A2Z 24HR	1.11	0.410	0.397	1.15	0.350	0.364	0.94	0.240	0.312
(mg)	HCES Model 1[d]	1.02			0.89			0.76		
Ref. 0.72	HCES Model 2[e]	1.02			0.89			0.76		
Niacin (mg)	A2Z 24HR	13	0.651	0.641	12	0.881	0.872	15	0.048	0.039
Ref. 9	HCES Model 1[d]	10			11			10		
	HCES Model 2[e]	10			11			10		
Vitamin B_6	A2Z 24HR	1.67	0.670	0.702	2.88	0.547	0.558	1.56	0.748	0.732
(mg)	HCES Model 1[d]	2.00			2.30			1.87		
Ref. 0.72	HCES Model 2[e]	2.00			2.30			1.87		
Folate (μg)	A2Z 24HR	366	0.075	0.071	464	0.085	0.087	442	0.584	0.579
Ref. 227	HCES Model 1[d]	290			350			429		
	HCES Model 2[e]	295			342			418		
Vitamin B_{12}	A2Z 24HR	1	0.042	0.039	0.3	0.047	0.051	0	0.000	0.002
(μg)	HCES Model 1[d]	3			1			1		
Ref. 1.4	HCES Model 2[e]	2.62			0.62			0.56		
Vitamin A	A2Z 24HR	455	0.078	0.064	516	0.038	0.040	271	0.042	0.037
(μg)	HCES Model 1[d]	407			428			189		
Ref. 499	HCES Model 2[e]	409			429			189		
Zn (mg)	A2Z 24HR	6.01	0.741	0.786	6.58	0.802	0.811	9.28	0.775	0.814
Ref. 12.23	HCES Model 1[d]	5.18			5.63			7.25		
	HCES Model 2[e]	5.18			5.63			7.25		

a. Shaded cells represent significant differences ($p < .05$).
b. Difference between medians, Mann-Whitney test.
c. Difference between distributions, Kolmogorov-Smirnoff test.
d. HCES model 1: selection of the different foods based on four or five commonly consumed foods according to 24-hour recall (24HR).
e. HCES model 2: selection of the different foods based on the most commonly consumed foods according to 24HR.
f. The reference value is the ideal nutrient density to satisfy the Estimated Average Requirement (EAR) for a child 12 to 83 months of age with a 1,231-kcal intake (i.e., EAR/1,231 kcal × 2,000).

and model 2 HCES. In Kampala and the Southwestern region, fiber was found to be different in both population groups.

Out of the total of 84 comparisons for model 2 (14 nutrients and 3 regions for each of 2 populations), 67 (80%) of the medians were not statistically significantly different from those estimated from 24-hour recall data. Regardless of regions and target groups, no significant differences in the medians were found for 7 of the 14 nutrients: protein, fat, fiber, iron, thiamin, riboflavin, and vitamin B_6. Nutrient densities of riboflavin and niacin were similar in the diets of all regions and age groups.

HCES models significantly overestimated vitamin B_{12} for all regions and for children 24 to 59 months of age and women of reproductive age (except for Kampala) (p <.05) but underestimated calcium among children in Kampala, zinc among children in the Northern region, vitamin C in some of the strata, and folate among women in Kampala and the Southwestern region.

Interestingly, the nutrient densities of iron, zinc, thiamin, and folate for both populations and of calcium for women of reproductive age were lower in Kampala than in the two rural regions. This was also evident for the content of fiber. The diet in the Southwestern region had higher densities of vitamins C and B_6. The diet in the Northern region had higher densities of fat, iron, and zinc. Higher vitamin B_{12} density was found in Kampala among both target groups. The Northern region had a higher vitamin C density for all target groups.

Discussion and conclusions

This study is among the first to compare nutrient density estimates from household and individual food consumption data. It has found remarkable similarities between HCES and 24-hour recall estimates of median energy intakes and of nutrient densities of fat, fiber, iron, zinc, thiamin, riboflavin, and vitamin B_6.

We counsel caution, however, for two reasons. First, these results are likely to be a reflection of the homogeneity of dietary patterns in Uganda, where the main sources of energy and nutrients are primarily starchy foods (plantain), tubers (cassava, Irish potatoes, and sweet potatoes), legumes (beans, groundnuts, and peas), nuts, and seeds [17]. Second, not only are the dietary patterns relatively homogeneous, but the levels of consumption of these staples by Ugandans are high.

Table 3 shows that there is variation in the intrahousehold distribution of potential food fortification vehicles among women of reproductive age and children 24 to 59 months of age in Uganda [18]. As one would expect, regardless of data sources and regions, women had a higher energy intake than children. This finding is consistent with the assumption made in using the AME to calculate intrahousehold food distribution. This is an important finding, and it justifies the use of HCES, which include a broad, nationally representative sample of respondents within households, in light of the difficulty of collecting 24-hour recall data from every household member in larger households [19]. The external validity of this finding is uncertain, however. It may have external validity only in countries that have diets that are similar to those of Uganda, consisting predominantly of foods that are simple, commodity-like, and not highly processed.

The results revealed some differences between HCES and 24-hour recall estimates. Although others have reported that household dietary data tend to overestimate consumption [20], with the exception of vitamins B_{12} and C, our results showed the opposite. In general, the 24-hour recall estimates of the intakes of energy, protein, vitamin A, folate, niacin, zinc, and calcium were higher for at least one of the groups. Differences between estimates by HCES and 24-hour recall may be due to any of the following: the method by which foods were selected, especially for the HCES categories of "other foods," "other fruits," and "other meats," which are imprecise, residual, catch-all categories subject to substantial errors in estimating the proportion of wastage and conversion factors to edible portions; the inequitable distribution of food among household members, with children 24 to 59 months of age and women of reproductive age consuming relatively less of these foods; difficulty in determining and defining "human consumption," which has a potentially major impact on the HCES-based estimates due to the possibilities of stockpiling food and related issues; and various other issues related to methods and measurements, such as inadequately applying probing during 24-hour recall, or, for both methods, the use of nonstandardized and unreliable local measurement units.

HCES model 1 (composed list of four or five foods commonly consumed) and model 2 (the most commonly consumed food) were developed and compared to provide insight into determining how detailed the HCES food item list should be. The close conformity of the HCES model 1 and model 2 estimates suggests that a simple food list (at least for countries with dietary patterns similar to Uganda) should be sufficiently short to capture the most commonly consumed foods [21].

Our results revealed that there are considerable regional variations in nutrient intake levels [17]. Nutrient densities of iron, zinc, thiamin, folate, and fiber were lower in Kampala than in the two rural regions. This suggests that the urban inhabitants of Uganda have substituted sugar and refined flours, which are low in these nutrients, for traditional grains and cereals. In contrast, the higher nutrient density of vitamin B_{12} in Kampala suggests that the diet contains a higher proportion of foods of animal origin. These differences are as expected and are primarily an artifact of the HCES food item list, which specifically identified calf's liver (a vitamin B_{12}–rich food) and guava (a vitamin C–rich food). Among women of reproductive age in Kampala, calcium density estimated by HCES was significantly higher than that estimated by 24-hour recall. This may, in part, reflect the tendency of more social class-conscious urbanites to over-report higher-status dairy products, especially fresh milk, which was the only calcium-rich food commonly selected in the HCES. In contrast, the 24-hour recall food list included okra leaves, which have half the calcium content of milk.

The higher densities of vitamins C and B_6 in the Southwestern region are probably associated with the consumption of fruits and vegetables that are rich in these nutrients. The densities of fat, iron, zinc, and vitamin A were higher in the Northern region than in the other two regions. The higher fat density may be linked to the distribution of oil by the World Food Programme, and the higher mineral density to the type of grain consumed in this region, where the diet is low in plantain, maize, and cassava.

Although the diet of the Northern region was poor in natural sources of vitamin A, the higher nutrient density of vitamin A suggests that the oil that is being distributed by the World Food Programme is fortified with vitamin A. Some milk powder is also distributed in the Northern region, which explains the higher intake of calcium by women of reproductive age. The HCES finding of lower protein intake in the Northern region compared with 24-hour recall estimates is difficult to explain.

Tables 4 and **5** show the reference values for the nutrient densities required to satisfy the Estimated Average Requirements of children and women of reproductive age, respectively. Clearly, the current diets of both groups are highly inadequate in calcium and vitamin B_{12}. Children receive insufficient vitamin A and zinc, and women of reproductive age receive inadequate iron. No inadequacies of either vitamin B_6 or folate were found. It is interesting to note that the findings are consistent across the HCES and 24-hour recall, as well as with the conclusions of the 24-hour recall based on absolute intakes [17]. This analysis shows the strengths and promise of using HCES to identify nutrient inadequacies based on nutrient density.

This study focused on a particular potential shortcoming of HCES: those due to the length and/or composition of the food list can result in unreliable estimates of food and nutrient intakes. The specific source of this potential problem is an HCES food item that is inadequately specified so that the analyst who is responsible for identifying the nutrient content of each HCES food item entry must exercise discretion and use his or her judgment to identify the "best" food composition table entry to use in making the nutrient intake estimate. There is a need to develop a more systematized approach—with more explicit criteria, procedures, and guidelines—to improve these activities to ensure the accuracy and reliability of the food and nutrient intake estimates. This study provides evidence that when this potential shortcoming is addressed by developing an explicit and specific rule by which to make the selection of the food composition table (matching it with 24-hour recall survey-identified categories), its impact on the estimated nutrient density of the diet is relatively minor. In addition, the comparisons of model 1 and model 2 demonstrate the robustness of this finding. In countries that do not have individual food consumption survey data to inform how best to structure the procedure for identifying the "best" food composition table entry for a particular HCES category, a combination of consultation with local food and nutrition experts and conducting a regional, small-scale sample food consumption survey should be considered.

This comparative analysis had three major limitations. First the survey covered two different periods. The 24-hour recall was conducted from May to September 2008 and the HCES from April 2005 to April 2006. The 2-year difference in the period of data collection may introduce bias in food consumption. This bias, however, is likely to be negligible during this period in Uganda, as changes in food consumption patterns are likely to occur only over a substantially longer period of time (e.g., 10 years or more [22]), and there were no major structural changes in Uganda's economy, social fabric, or demographics over this period.

Seasonality is another issue that may introduce systematic discrepancies between the estimates of the two surveys, because food consumption is likely to vary depending on the season and the timing of food aid distribution. This is unlikely to distort the findings presented here, however, because the implementation period of both surveys coincided with food aid program distribution in northern Uganda.

A third limitation of the analysis is the difference in the samples and the fact that they are from different surveys. Although the sampling frame and the sample size of the 24-hour recall survey provide statistically representative estimates of the regions from which they were drawn, only not for the country as a whole, they shared a common sampling frame; they both used the sampling frame of the Uganda Population and Housing Census of 2002, both defined enumeration area or cluster the same way, and both used the same selection technique to choose each enumeration area based on the probability proportional to size method.

The study results demonstrate that in Uganda, HCES data are a close proxy for 24-hour recall data in estimating nutrient density—an important indicator of the quality of the diet. Moreover, in the case of this HCES in Uganda, the results are promising in that their general policy-relevant diagnostic results are highly consistent with those of the 24-hour recall survey: they identify the same major nutrient inadequacies and generally identify the same order of magnitude of those inadequacies. These findings suggest, therefore, that there is promise that HCES may be able to provide a more readily available, routinely updated, and less expensive alternative or complementary source to 24-hour recall for empirical data with which to undertake diagnostics and develop policies, and thereby help to address the food consumption information gap that has prevented nutrition policy-making in so many countries from becoming more evidence-based. The next step in assessing this promise and arriving at a more general conclusion about being able to use HCES as an alternative or complement to 24-hour recall survey in Uganda is to ascertain how well HCES captures nutrient intake adequacy. Finally, we urge similar comparative analyses of HCES and 24-hour recall data in other countries.

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