The Population Distribution of Ratios of Usual Intakes of Dietary Components That Are Consumed Every Day Can Be Estimated from Repeated 24-Hour Recalls[1–3]

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Abstract

Estimating the population distribution of the usual intake of a nutrient relative to that of another nutrient requires determination of individual-level ratios. If intake data are available on a per-day basis, as with 24-h dietary recalls, those ratios can be determined in 1 of 2 ways: as the usual ratio of intakes or the ratio of usual intakes. Each of these ratios has its own meaning and determination; the ratio of usual intakes is conceptually consistent with determinations obtained from FFQ data. We present a method for estimating the ratio of usual intakes that uses bivariate modeling of the 2 nutrient intakes in question. Application of the method to the NHANES data for the years 2001–2004 yielded estimated distributions for percent of usual energy intake from total fat, percent of usual energy intake from saturated fat, and usual sodium intake per 1000 kcal (4184 kJ) of usual energy intake. Distributions for both the total population and for age-gender subgroups were estimated. Approximately 60% of adults (>19 y) had a usual total fat intake that was within the recommended range of 20–35% of total energy, but only ~34% had a usual saturated fat intake <10% of total energy. The results changed only minimally when the other definition of usual intake, the usual ratio of intakes, was adopted. J. Nutr. 140: 111–116, 2010.

Introduction

A major purpose of dietary surveillance or monitoring is to evaluate dietary intakes relative to some standard. Standards may be averages, around which the population's intakes should be distributed, or thresholds, above or below which the population's intake should fall, but they are all established with regard to usual intake, generally defined as the long-run average daily intake over a period of time (1,2). This is important because diets vary considerably from day to day. Nonetheless, the primary assessment method used in dietary surveillance is the 24-h dietary recall (3), a method that inherently captures intake one day at a time and thus yields a large amount of within-person variation.

In previous work on estimating the proportions of the population meeting recommended dietary intake levels, investigators have either presented the distributions of the reported values (4) or have adjusted the variance of the distribution to exclude within-person variation (5–8). Only the latter methods successfully remove the within-person variation and produce distributions of usual intake that have approximately the correct spread or variance. However, these methods have heretofore been available only for intakes of single dietary components that are consumed nearly every day by nearly everyone [see Dodd et al. (9) for a review].

In dietary surveillance, it is often of interest to examine the population distribution of usual intake for a ratio of 2 dietary components. Examples include the distribution of intakes of saturated fat, total fat, or sodium, each expressed as a ratio of total energy intake. Estimating such distributions from national survey data that are based upon dietary intake reports from 24-h recalls is not trivial.

It has been noted previously (10,11) that there are 2 ways of describing the distribution of ratios of intakes. Likewise, 2 definitions of an individual's usual intake ratio are available. First, one could take the long-term mean of the daily ratio of intakes, which we will call the usual ratio (of intakes). Second, one could take the ratio of the long-term means of the daily intakes, which we will call the ratio of usual intakes. A simple (but rather extreme) example shows that these are different.

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[3] A Supplemental Appendix describing the statistical method used is available with the online posting of this paper at jn.nutrition.org.
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TABLE 1 Summary of the distribution of percent of usual energy intake from total fat in the total US population and selected age-gender subgroups, 2001–2004[1,2]

Subpopulation	*n*	Mean ± SE	Percentile						
			5	10	25	50	75	90	95
Males and females		%				%			
1–3 y	1515	32.57 ± 0.31	25.49	26.94	29.44	32.38	35.50	38.42	40.24
4–8 y	1701	32.30 ± 0.31	25.68	27.03	29.37	32.13	35.06	37.80	39.54
Males									
9–13 y	1061	33.27 ± 0.23	24.41	26.26	29.40	33.03	36.91	40.57	42.91
14–18 y	1424	32.98 ± 0.33	24.74	26.46	29.37	32.76	36.36	39.76	41.84
19–30 y	1100	31.98 ± 0.49	23.97	25.69	28.55	31.81	35.27	38.48	40.59
31–50 y	1466	33.41 ± 0.42	25.18	26.91	29.82	33.20	36.77	40.18	42.32
51–70 y	1252	35.01 ± 0.40	25.98	27.85	31.06	34.76	38.69	42.51	44.89
≥71 y	832	34.06 ± 0.34	24.62	26.57	29.90	33.78	37.92	41.89	44.41
≥19 y	4650	33.55 ± 0.24	24.95	26.73	29.76	33.29	37.05	40.72	43.03
Females									
9–13 y	1112	33.38 ± 0.36	24.94	26.69	29.68	33.19	36.84	40.34	42.54
14–18 y	1362	33.44 ± 0.51	25.01	26.74	29.72	33.23	36.93	40.44	42.62
19–30 y	1325	32.53 ± 0.43	24.39	26.08	28.95	32.32	35.90	39.23	41.37
31–50 y	1595	34.33 ± 0.42	25.69	27.48	30.58	34.11	37.86	41.45	43.66
51–70 y	1284	34.93 ± 0.35	25.94	27.78	30.95	34.66	38.65	42.44	44.74
≥71 y	860	33.94 ± 0.29	24.69	26.63	29.90	33.71	37.66	41.57	43.95
≥19 y	5064	34.03 ± 0.28	25.28	27.05	30.17	33.79	37.62	41.33	43.63
All persons									
≥1 y	17,889	33.56 ± 0.17	25.13	26.85	29.82	33.29	37.01	40.64	42.93

[1] Estimated from data on 17,899 participants in NHANES.
[2] Percent of usual energy intake from fat = 100 × [usual intake of fat (kJ)] / [usual intake of energy (kJ)].

Suppose that a person consumes on alternate days 10,000 kJ, of which 4000 kJ are from fat, and 6000 kJ, of which only 600 kJ are from fat. Using the usual ratio, the usual percent energy from fat is the average of 40 and 10%, i.e. 25%. Using the ratio of usual intakes, the usual fat intake is 2300 kJ, the usual energy intake is 8000 kJ, and their ratio is 29%.

The question of which definition is the more appropriate for purposes of dietary surveillance is not an easy matter to resolve,

TABLE 2 Summary of the distribution of percent of usual energy intake from saturated fat in the total US population and selected age-gender subgroups, 2001–2004[1,2]

Subpopulation	*n*	Mean ± SE	Percentile						
			5	10	25	50	75	90	95
Males and females		%				%			
1–3 y	1515	12.71 ± 0.15	9.05	9.78	11.04	12.57	14.23	15.82	16.85
4–8 y	1701	11.55 ± 0.18	8.37	8.99	10.10	11.43	12.88	14.26	15.14
Males									
9–13 y	1061	11.78 ± 0.12	8.31	9.01	10.23	11.67	13.23	14.68	15.62
14–18 y	1424	11.36 ± 0.12	8.16	8.82	9.94	11.26	12.67	14.03	14.88
19–30 y	1100	10.77 ± 0.22	7.71	8.34	9.44	10.70	12.04	13.30	14.13
31–50 y	1466	10.89 ± 0.16	7.79	8.43	9.52	10.80	12.16	13.48	14.30
51–70 y	1252	11.18 ± 0.14	7.83	8.52	9.69	11.07	12.55	13.99	14.86
≥71 y	832	11.03 ± 0.20	7.53	8.24	9.46	10.91	12.46	13.97	14.90
≥19 y	4650	10.95 ± 0.09	7.76	8.41	9.54	10.85	12.26	13.62	14.49
Females									
9–13 y	1112	11.76 ± 0.15	8.22	8.93	10.16	11.64	13.21	14.75	15.74
14–18 y	1362	11.26 ± 0.17	7.81	8.50	9.70	11.13	12.69	14.19	15.12
19–30 y	1325	10.79 ± 0.17	7.51	8.16	9.30	10.67	12.15	13.56	14.48
31–50 y	1595	11.15 ± 0.17	7.70	8.39	9.61	11.03	12.57	14.07	15.00
51–70 y	1284	10.94 ± 0.16	7.43	8.13	9.35	10.80	12.40	13.94	14.90
≥71 y	860	10.73 ± 0.15	7.12	7.84	9.10	10.60	12.19	13.79	14.79
≥19 y	5064	10.96 ± 0.12	7.50	8.20	9.41	10.84	12.39	13.89	14.85
All persons									
≥1 y	17,889	11.16 ± 0.07	7.76	8.45	9.63	11.03	12.55	14.03	14.98

[1] Estimated from data on 17,899 participants in NHANES.
[2] Percent of usual energy intake from fat = 100 × [usual intake of fat (kJ)] / [usual intake of energy (kJ)].

because the decision may depend on biological knowledge that is often lacking. The usual ratio is simpler to calculate, but the ratio of usual intakes is conceptually consistent with the ratio that would be determined from FFQ, because they query long-term intake. For this reason alone, it is desirable to have a statistical method for estimating the ratio of usual intakes and deriving its distribution in the population from 24-h recall data.

Therefore, our purposes in this article are to describe the methodology for estimating the population distribution of the ratio of usual intakes and to apply the method to estimate the distributions of several ratios. A feature of the method is the ability to estimate distributions in subpopulations. Accordingly, we also present distributions according to selected age and gender groups. Finally, we compare the results of estimating the population distribution of the ratio of usual intakes with those for the usual ratio and shows that the difference was small in the examples.

Methods

Data. The data for this study were obtained from 17,889 participants in the 2001–2004 NHANES. All recalls obtained from individuals aged ≥1 y were included except those deemed unreliable by survey staff (297 individuals), those reporting breast milk consumption (39 individuals) because breast milk intake was not quantified, and 1 individual who reported fasting on the survey day.

Dietary intakes were assessed via computer-assisted, interviewer-administered 24-h recalls. In 2001, a single recall was requested from all individuals. In 2003–2004, 2 recalls were requested of all participants. The first dietary interview was conducted in a mobile examination center and the second was conducted 3–10 d later via telephone.

The NHANES has a complex, multistage, probability design. For this study, one of the authors (K.W.D.) created replicate weight sets suitable for the balanced repeated replication method of variance estimation. The replicate weights were based on the dietary survey weights accompanying the NHANES data files, which adjust for survey design, nonresponse, day of week, and any sequence effect in the second recall.

The NHANES 2001–2004 surveys were approved by the NHANES Institutional Review Board under protocol no. 98–12. Further information about the NHANES is available elsewhere (12).

Estimating the population distribution of the ratio of usual intakes. The method, described briefly here, is based on a joint bivariate model for the 2 nutrients (the numerator and the denominator of the ratio) in question. A more precise and technical description is provided in the **Supplemental Appendix**.

Each reported nutrient intake was first mathematically transformed to approximate normality using a Box-Cox (power) transformation. The transformation was chosen to minimize the mean squared error around a straight line fit to a weighted QQ plot using the sampling survey weights of each participant.

The data were then analyzed using a bivariate linear mixed effects model, including the following terms for each nutrient: an intercept (fixed effect), an indicator for whether the reported day was a weekday or a weekend (fixed effect), an indicator for the sequence number (first vs. second) of the report (fixed effect), indicators for age group (fixed effects), a subject-specific term (random effect), and a within-subject error term (random error). For the analysis of children's intakes, an extra covariate for gender (fixed effect) was included. For adults, men and women were analyzed separately.

The covariate weekday/weekend was included to accommodate the difference in intake that often occurs between the weekend (Friday to Sunday) and the rest of the week. The covariate sequence number was included to accommodate the possibility that participants report less fully on the second recall than on the first. The first recall was taken to be the unbiased report.

The covariate age group, which is a factor with several levels, was included to allow estimation of the distribution within specific age groups.

TABLE 3 Summary of the distribution of usual sodium intake relative to usual energy intake in the total U.S. population and selected age-gender subgroups, 2001–2004[1,2]

			Percentile						
Subpopulation	*n*	Mean ± SE	5	10	25	50	75	90	95
Males and females		*mg/1000 kcal*[3]				*mg/1000 kcal*			
1–3 y	1515	1392 ± 10	1041	1112	1234	1380	1537	1685	1779
4–8 y	1701	1509 ± 12	1166	1235	1355	1498	1652	1798	1893
Males									
9–13 y	1061	1551 ± 23	1208	1277	1396	1538	1688	1842	1937
14–18 y	1424	1513 ± 19	1198	1261	1372	1502	1644	1781	1865
19–30 y	1100	1505 ± 21	1192	1255	1366	1494	1633	1765	1855
31–50 y	1466	1551 ± 15	1233	1297	1408	1540	1682	1822	1911
51–70 y	1252	1608 ± 14	1261	1330	1452	1594	1750	1903	2003
≥71 y	832	1609 ± 20	1245	1316	1443	1594	1759	1921	2025
≥19 y	4650	1560 ± 8	1228	1294	1410	1547	1696	1844	1939
Females									
9–13 y	1112	1520 ± 18	1148	1220	1348	1505	1673	1838	1946
14–18 y	1362	1475 ± 21	1109	1182	1307	1460	1626	1789	1894
19–30 y	1325	1558 ± 22	1186	1258	1386	1541	1711	1880	1986
31–50 y	1595	1571 ± 20	1186	1263	1396	1554	1728	1901	2010
51–70 y	1284	1624 ± 14	1218	1297	1437	1604	1791	1977	2094
≥71 y	860	1618 ± 22	1195	1278	1423	1599	1790	1982	2107
≥19 y	5064	1588 ± 12	1195	1272	1407	1569	1749	1928	2043
All persons									
≥1 y	17,889	1554 ± 7	1187	1260	1388	1538	1702	1867	1973

[1] Estimated from data on 17,899 participants in NHANES.
[2] Usual intake of sodium (mg) per 1000 kcal of usual energy intake = 1000 × [usual intake of sodium (mg)] / [usual intake of energy (kcal)].
[3] 1 kcal = 4.184 kJ.

TABLE 4 Proportions in the total U.S. population and selected age-gender subgroups with usual intake of total fat equal to 20–35% of usual energy intake and proportions with usual intake of saturated fat less than 10% of usual energy intake, 2001–2004[1]

Subpopulation	*n*	Proportion with total fat = 20–35% of energy ± SE	Proportion with saturated fat <10% of energy ± SE
Males and females			
1–3 y	1515	0.72 ± 0.03	0.12 ± 0.02
4–8 y	1701	0.74 ± 0.03	0.23 ± 0.03
Males			
9–13 y	1061	0.63 ± 0.02	0.22 ± 0.02
14–18 y	1424	0.66 ± 0.02	0.26 ± 0.03
19–30 y	1100	0.73 ± 0.03	0.36 ± 0.05
31–50 y	1466	0.63 ± 0.03	0.34 ± 0.03
51–70 y	1252	0.52 ± 0.03	0.30 ± 0.02
≥71 y	832	0.58 ± 0.02	0.34 ± 0.03
≥19 y	4650	0.62 ± 0.02	0.33 ± 0.02
Females			
9–13 y	1112	0.63 ± 0.02	0.23 ± 0.03
14–18 y	1362	0.63 ± 0.03	0.30 ± 0.03
19–30 y	1325	0.69 ± 0.03	0.38 ± 0.03
31–50 y	1595	0.56 ± 0.03	0.31 ± 0.03
51–70 y	1284	0.52 ± 0.02	0.36 ± 0.03
≥71 y	860	0.58 ± 0.02	0.40 ± 0.03
≥19 y	5064	0.58 ± 0.02	0.35 ± 0.02
All persons			
≥1 y	17,889	0.62 ± 0.01	0.31 ± 0.02

[1] Estimated from data on 17,899 participants in NHANES.

Including a covariate in the model allows estimation of distributions in subpopulations and results in much greater precision than analyzing the model on only the subset of data from that subpopulation (13).

The subject-specific terms of the 2 nutrients were assumed to have a bivariate normal distribution, with 2 variances and a covariance estimated from the data. Likewise, the within-subject terms were assumed to be bivariate normal and independent of the subject-specific terms and required another 2 variances and a covariance to be estimated. The model parameters could be estimated, because many participants completed more than one 24-h recall. If there are no repeated determinations, then within-subject variance parameters could not be estimated. In the data from NHANES 2001–2004, 69% of the participants completed 2 24-h recalls.

The model was fitted to the data using the NLMIXED procedure in the statistical software package SAS and the sampling weights of each participant were incorporated into the analysis. The output yielded estimates of the fixed-effect and random-effect model parameters, including the within-subject covariances. Three runs of the NLMIXED procedure for each type of ratio were performed on children aged 1–8 y, males aged ≥9 y, and females ≥9 y.

Monte Carlo simulations were then run using the parameter values estimated from the model. These simulations generated usual intakes of each nutrient for a large number of pseudo-individuals (the details of these simulations are described in the Supplemental Appendix). The ratio of usual intakes was calculated for each pseudo-individual and, using the sampling weights, the percentiles of the distribution of ratios of usual intakes were estimated. SE were estimated using balanced repeated replication.

These procedures were used to estimate distributions for 10 age-gender subgroups. The distributions for men and women ≥19 y were estimated by combining the distributions of 4 finer age groupings according to the population proportion in each subgroup. Results are shown for the following ratios: total fat:energy, saturated fat:energy, and sodium:energy. Values in the text are means or proportions ± 1 SE, or estimated percentiles. The SAS code for performing these analyses is available at http://riskfactor.cancer.gov/diet/usualintakes/.

Estimating the population distribution of the usual ratio. The method for estimating the population distribution of the usual ratio is simpler than for the ratio of usual intakes, because it is based on the univariate distribution of the ratio of daily intakes rather than on the bivariate distribution of the numerator and denominator. Several methods can be applied directly to individuals' 24-h recall reported daily ratios (5,6,13) and would be expected to give very similar results. For this report, the one-part version of a method developed at the National Cancer Institute (13) was used.

Results

The estimated mean percentage of usual energy intake from total fat in the total population was 33.6 ± 0.2% and the median 33.3% (**Table 1**). The 5th and 95th percentiles were 25.1 and 42.9%, respectively. There was modest variation with age, with older persons tending to have a higher percentage intake and very little difference between men and women.

The estimated mean percentage of usual energy intake from saturated fat in the total population was 11.2 ± 0.1% and the median 11.0% (**Table 2**). The 5th and 95th percentiles were 7.8 and 15.0%, respectively. The youngest children (1–3 y) had the highest percentage; the percentage was lower in children aged 4–18 y and lowest in adults > 19 y, with little variation among adults by age group or between men and women.

The estimated mean usual intake of sodium per 1000 kcal (4184 kJ) of usual energy intake in the total population was 1554 ± 7 mg and the median was 1538 mg (**Table 3**). Intakes were lower among young children (1–3 y). Intakes were also slightly lower among younger adults (31–50 y) than older adults (>50 y). Differences between men and women were minor. Supplemental Tables providing SE for the individual percentile

TABLE 5 Comparison of the mean ratio of usual intakes to the mean usual ratio for percent energy from total fat in the total U.S. population and selected age-gender subgroups, 2001–2004[1]

Subpopulation	*n*	Ratio of usual intakes	Usual ratio	Difference
Males and females			%	
1–3 y	1515	32.57 ± 0.31	32.40 ± 0.32	−0.17 ± 0.09
4–8 y	1701	32.30 ± 0.31	32.09 ± 0.32	−0.21 ± 0.08
Males				
9–13 y	1061	33.27 ± 0.23	32.49 ± 0.23	−0.78 ± 0.15
14–18 y	1424	32.98 ± 0.33	32.50 ± 0.32	−0.48 ± 0.12
19–30 y	1100	31.98 ± 0.49	31.84 ± 0.44	−0.14 ± 0.14
31–50 y	1466	33.41 ± 0.42	33.18 ± 0.38	−0.22 ± 0.11
51–70 y	1252	35.01 ± 0.40	34.60 ± 0.40	−0.41 ± 0.16
≥71 y	832	34.06 ± 0.34	33.43 ± 0.36	−0.64 ± 0.14
≥19 y	4650	33.55 ± 0.24	33.26 ± 0.22	−0.29 ± 0.09
Females				
9–13 y	1112	33.38 ± 0.36	32.71 ± 0.36	−0.67 ± 0.09
14–18 y	1362	33.44 ± 0.51	32.87 ± 0.46	−0.58 ± 0.13
19–30 y	1325	32.53 ± 0.43	32.17 ± 0.41	−0.36 ± 0.10
31–50 y	1595	34.33 ± 0.42	34.02 ± 0.44	−0.30 ± 0.10
51–70 y	1284	34.93 ± 0.35	34.42 ± 0.32	−0.52 ± 0.12
≥71 y	860	33.94 ± 0.29	33.13 ± 0.28	−0.81 ± 0.13
≥19 y	5064	34.03 ± 0.28	33.60 ± 0.26	−0.43 ± 0.09
All persons				
≥1 y	17,889	33.56 ± 0.17	33.18 ± 0.17	−0.39 ± 0.05

[1] Values are means ± SE, estimated from data on 17,889 participants in NHANES.

TABLE 6 Comparison of the mean ratio of usual intakes to the mean usual ratio for percent energy from saturated fat in the total U.S. population and selected age-gender subgroups, 2001–2004[1]

Subpopulation	*n*	Ratio of usual intakes	Usual ratio	Difference
Males and females			%	
1–3 y	1515	12.71 ± 0.15	12.67 ± 0.15	−0.05 ± 0.05
4–8 y	1701	11.55 ± 0.18	11.50 ± 0.17	−0.05 ± 0.03
Males				
9–13 y	1061	11.78 ± 0.12	11.53 ± 0.13	−0.26 ± 0.06
14–18 y	1424	11.36 ± 0.12	11.21 ± 0.13	−0.15 ± 0.04
19–30 y	1100	10.77 ± 0.22	10.73 ± 0.21	−0.04 ± 0.05
31–50 y	1466	10.89 ± 0.16	10.77 ± 0.15	−0.12 ± 0.04
51–70 y	1252	11.18 ± 0.14	11.00 ± 0.15	−0.18 ± 0.05
≥71 y	832	11.03 ± 0.20	10.78 ± 0.21	−0.25 ± 0.06
≥19 y	4650	10.95 ± 0.09	10.82 ± 0.08	−0.13 ± 0.04
Females				
9–13 y	1112	11.76 ± 0.15	11.56 ± 0.15	−0.20 ± 0.03
14–18 y	1362	11.26 ± 0.17	11.08 ± 0.17	−0.18 ± 0.05
19–30 y	1325	10.79 ± 0.17	10.65 ± 0.16	−0.14 ± 0.04
31–50 y	1595	11.15 ± 0.17	11.05 ± 0.19	−0.11 ± 0.04
51–70 y	1284	10.94 ± 0.16	10.77 ± 0.16	−0.17 ± 0.05
≥71 y	860	10.73 ± 0.15	10.48 ± 0.15	−0.24 ± 0.05
≥19 y	5064	10.96 ± 0.12	10.82 ± 0.12	−0.15 ± 0.04
All persons				
≥1 y	17,889	11.16 ± 0.07	11.02 ± 0.07	−0.14 ± 0.02

[1] Values are means ± SE, estimated from data on 17,889 participants in NHANES.

estimates for these ratios and the estimated distributions for other ratios are available.[7]

The methodology described also allows estimation of the proportion of the population whose ratio of usual intakes falls within a chosen interval. An estimated 62 ± 1% of the population had a usual total fat consumption that was within the acceptable macronutrient distribution range for total fat (20–35% of energy) as set by the Institute of Medicine (14) (**Table 4**). The proportion meeting this recommendation was lowest in the 51- to 70-y age group, where only 52 ± 2% did so. Approximately 34% of the adult population's usual saturated fat consumption was <10% of energy, as recommended by the Dietary Guidelines for Americans (2). The proportion of children meeting that recommendation was smaller.

The difference between the estimated distribution of the ratio of usual intakes and the distribution of the usual ratio of intakes for the same 3 ratios was small (**Tables 5–7**). The differences were in both directions but very small compared with the quantity estimated. All differences were <3% of the estimated value.

Discussion

The method described in this article has provided for the first time, to our knowledge, estimates of the distribution of ratios of usual intakes of nutrients to usual energy intake for the U. S. population and age-gender subgroups. Ratios give more direct information on the quality of the composition of the diet consumed than is provided by absolute intakes of nutrients and distributions of such ratios have heretofore been unavailable.

For the 3 examples given, differences between men and women were minor. Thus, although absolute intakes of these nutrients differed substantially between men and women, after adjustment for energy intake, the intakes were very similar.

Because there are 2 different definitions of usual intake of a ratio, investigators may ask which to use and whether it matters which is used. The following formula provides the investigator with a method of judging whether the 2 definitions will lead to similar results. Denote an individual's ratio on a given day by x/y. If CV_y is the within-person CV of the denominator (expressed as a proportion, not as a percentage) and CV_x is that of the numerator, and if r_{xy} is the within-person correlation between the numerator and denominator, then:

$$\text{individual's usual ratio} \cong (1 + CV_y^2 - r_{xy} CV_x CV_y) \times \text{individual's ratio of usual intakes.}$$

This approximate result is obtained using Taylor's expansion and should provide reasonable accuracy for CV <0.75. It is similar to and mathematically consistent with the expression given by Krebs-Smith et al. (10), although those authors were concerned with ratios at the population level rather than at the individual level. The closer the bracketed expression is to 1.0, the closer the usual ratio will be to the ratio of usual intakes and, consequently, the closer the 2 methods of estimating the population distribution of usual intake will be for the ratio of nutrients in question. Data from repeat 24-h recalls in the Eating at America's Table Study (15) indicate that the within-person CV for energy is ~0.32, for saturated fat is 0.37, and for sodium 0.43 [Supplemental Table 1 in (11)]. The within-person correlations with energy were 0.78 for saturated fat and 0.71 for

TABLE 7 Comparison of the mean ratio of usual intakes to the mean usual ratio for sodium relative to energy intake in the total U.S. population and selected age-gender subgroups, 2001–2004[1]

Subpopulation	*n*	Ratio of usual intakes	Usual ratio	Difference
Males and females			*mg/1000 kcal*[2]	
1–3 y	1515	1391.7 ± 10.4	1393.6 ± 11.4	1.9 ± 5.3
4–8 y	1701	1509.3 ± 12.2	1521.8 ± 12.3	12.5 ± 4.7
Males				
9–13 y	1061	1550.5 ± 23.0	1558.5 ± 24.0	8.0 ± 8.0
14–18 y	1424	1513.3 ± 18.5	1525.6 ± 18.1	12.3 ± 5.3
19–30 y	1100	1504.6 ± 21.0	1519.0 ± 20.6	14.4 ± 4.9
31–50 y	1466	1551.4 ± 14.6	1571.9 ± 15.1	20.5 ± 6.1
51–70 y	1252	1607.9 ± 14.1	1624.7 ± 15.0	16.8 ± 6.0
≥71 y	832	1609.2 ± 20.1	1617.3 ± 21.2	8.1 ± 6.9
≥19 y	4650	1560.4 ± 8.4	1577.4 ± 7.5	17.0 ± 5.2
Females				
9–13 y	1112	1519.7 ± 18.4	1539.3 ± 18.8	19.6 ± 5.3
14–18 y	1362	1475.4 ± 20.6	1491.4 ± 20.2	16.0 ± 6.4
19–30 y	1325	1557.8 ± 21.5	1576.9 ± 22.9	19.2 ± 5.2
31–50 y	1595	1570.8 ± 20.0	1590.9 ± 19.9	20.1 ± 4.7
51–70 y	1284	1624.4 ± 14.0	1641.9 ± 14.4	17.4 ± 5.0
≥71 y	860	1618.3 ± 21.7	1632.1 ± 20.8	13.8 ± 7.0
≥19 y	5064	1587.8 ± 12.0	1606.3 ± 12.1	18.4 ± 3.8
All persons				
≥1 y	17,889	1553.5 ± 7.0	1569.6 ± 6.0	16.1 ± 2.6

[1] Values are means ± SE, estimated from data on 17,889 participants in NHANES.
[2] 1 kcal = 4.184 kJ.

sodium [Supplemental Table 1 in (11)]. Thus, the bracketed expression above for the saturated fat:energy ratio is equal to 1.010 and for the sodium:energy ratio is 1.004, values that are close enough to 1 that one would expect very little difference between the methods. That the values are so close to 1 is due to the relatively high correlation between numerator and denominator, together with the similarity in their CV.

As predicted by the above formula, the results presented in Tables 6 and 7 show very little difference between the 2 methods for the saturated fat:energy ratio and the sodium: energy ratio. Table 5 shows that the difference was also small for the total fat:energy ratio. The formula predicts, however, that differences could be more important in other situations. For example, in a case where the denominator has a high CV and the numerator has little or no correlation with the denominator, one might expect larger differences. Thus, ratios of micronutrients, such as vitamin C, to energy may display larger differences.

In view of the possibility of larger differences being found between the 2 methods, it would seem appropriate to identify if and when one of the definitions is more appropriate. As mentioned in the Introduction, this choice is difficult in the absence of relevant biological information. For example, high intakes of saturated fat are considered deleterious and it is recommended that Americans consume <10% of energy from such fatty acids. What is less clear is whether this ratio of 10% of energy should not be exceeded on a diurnal basis or over time. If each day's ratio has some relevance, then the usual ratio may be more appropriate. If, however, the relevant ratio is the proportion of all energy consumed over a long period of time derived from saturated fat, then the ratio of usual intakes may be more appropriate. For most ratios of interest in nutrition, biological information to guide choosing the most relevant ratio is not yet available. It may be that one or the other method will be found to be more appropriate for some ratios than others. Most nutritionists we have questioned have stated a preference for the ratio of usual intakes, perhaps reflecting an intuition that this term better reflects the steady state of an individual. As mentioned earlier, the ratio of usual intakes has the added advantage of being conceptually consistent with determinations based on food frequency data.

The method described can be applied to data gathered by repeated 24-h recalls on nutrients or other dietary constituents that are consumed nearly every day by nearly everyone in the population. The method is intended for use on quite large datasets with sample sizes of at least 1000 or more, especially if distributions in population subgroups are to be estimated. If one is interested in the distribution of a total population only, then a sample of several hundred may suffice.

On occasion there is a need to examine the population distribution of the ratio of an episodically consumed food or nutrient (one that is not typically consumed every day) to another food or energy. For example, one may be interested in cholesterol intake from eggs as a proportion of total cholesterol intake. In such cases, the required statistical modeling becomes more complex. Methods using an extension of the 2-part model described by Kipnis et al. (16) are now being developed to allow the estimation of these types of distributions.

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