Value of Food and Agriculture Organization data on food-balance sheets as a data source for dietary fat intake in epidemiologic studies[1,2]

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ABSTRACT The relationships between the per person supply (expressed as percent of total energy supply) of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs) obtained from 1979–1981 Food and Agriculture Organization (FAO) data, and the per person intake obtained from 52 individual dietary surveys performed in 19 countries, were examined. In particular, the ratio of PUFAs to SFAs (P:S) and the ratio of unsaturated fatty acids (MUFAs and PUFAs) to SFAs (U:S) obtained from both data sources were examined. Significant correlations ($P < 0.001$) were found between the two data sources for the P:S, U:S, SFAs, and MUFAs and PUFAs ($P < 0.02$) in 19 countries. It is concluded that the data on fat intake from the FAO are valid for use in epidemiologic studies. In view of the variability of the data, it is recommended to use them either expressed as percentage of energy or as ratios of the different components. *Am J Clin Nutr* 1992;56:716–23.

KEY WORDS Dietary survey, epidemiologic studies, FAO food-balance sheets, polyunsaturated to saturated fatty acid ratio, unsaturated to saturated fatty acid ratio

Introduction

Because of the uniqueness of covering food-disappearance data from 146 countries, *Food Balance Sheets* published by the Food and Agriculture Organization (FAO) of the United Nations are frequently used as a data source of estimated nutritional characteristics representative of a country (1). Significant relationships between saturated fatty acids (SFAs) and/or total fat intake obtained from FAO data, and breast (2, 3), colon, and prostate cancer mortality data (4) have been reported. Significant positive relationships between supply of SFA-rich foods and total, breast, prostate, rectum, colon, and lung cancer mortality (5) and between fish consumption and all-cause mortality (6) have been established.

Although being used widely, the database has often been considered unreliable because the data represent only the total supply of a given nutrient for each country, but not the real dietary intake of individuals. It does not take into account the amounts of household waste or spoilage and includes food used for purposes other than human consumption. Moreover, no information about probable differences in dietary habits related to sex, age, and economic status is given. Notwithstanding these limitations, the above-mentioned significant relationships imply the reliability of FAO data used for epidemiologic purposes. The aim of this study is to pursue this problem further by comparing the results of dietary surveys performed within countries with the values obtained from FAO food-balance sheets.

Materials and methods

The per person supply of subtypes of fatty acids—SFAs, monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs)—expressed as percent of total energy, was estimated from the food-balance sheets obtained from FAO for the period 1979–1981 (1). The validity of the data was examined by comparison with the mean intakes of the same subtypes of fatty acids collected from 52 individual dietary surveys carried out in 19 countries between 1975 and 1988. The analysis was performed for the ratio of PUFAs to SFAs (P:S) and the ratio of unsaturated fatty acids (MUFAs and PUFAs) to SFAs (U:S).

The actual quantities of intake of subtypes of fatty acids (g/d) vary with age and sex. Values expressed as a percent of total energy are, however, much less influenced by age and sex in a population (7–9), except for countries like Japan where westernization of dietary habits is occurring more rapidly in younger subjects (10, 11). At the same time, expression as a percentage of total energy minimizes the influence of wasting portions that differ between countries. Therefore, percent of total energy was considered a more adequate unit for comparison than was intake expressed in g/d (8, 12).

Dietary surveys

The data of the individual dietary surveys, which reported intakes of SFAs, MUFAs, PUFAs, and/or the P:S, were collected from 19 countries according to the following criteria.

Surveys carried out between 1975 and 1988 were selected. In principle, all studies found after an extensive search of the literature were included. One exception was made for a study per-

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Received November 7, 1991.

Accepted for publication March 17, 1992.

formed between 1972 and 1978, because the mean survey years were included within the above-mentioned time limits. Only surveys that were performed in apparently healthy target populations were included as well as control groups of case-control studies when the control subjects belonged to the normal, free-living population. The baseline phase of intervention studies was also included if the participants were thought to be healthy. When it became clear that the survey populations were not representative of the healthy population of the country, they were excluded. From this point of view the surveys done in Hawaii, because of their ethnic specificity, and those performed on Seventh-day Adventists, because of their special dietary habits, were excluded. The age range was limited to subjects aged > 18 y because it was difficult to collect data on children in some countries. Moreover, when fat intake is expressed as percent of total energy, the value obtained in children does not significantly differ from that of the adult population (8, 13, 14). Hence, the fat intake obtained from the adult population was considered representative of all age classes in each country. The surveys that only mentioned the mean age instead of the age range were also included if the participants were considered adults (≥ 18 y of age). As for the survey methods, studies using 24-h recall, dietary histories, and dietary records sometimes using weighing, were included and considered to be of equal value. Although food frequency questionnaires have also often been used, they were excluded if any other survey representative of the country was found. The mean values obtained from the different surveys were used. However, two studies were included, one from Canada and one from New Zealand, reporting the results with medians and not with means because they were unique dietary surveys.

Intakes of SFAs, MUFAs, and PUFAs were expressed as a percent of total energy. If these subtypes of fatty acids were not given as such, they were calculated from the given dietary intake in g/d and from the intake of total energy in MJ/d (or kcal/d) by use of the Atwater factor of 37.66 kJ/g fat.

The P:S calculated from mean SFA and PUFA intakes of a population is not identical with the P:S obtained as a mean of the individual intakes of the participants in a survey. Therefore the P:S, besides the one given from the surveys, was calculated from a set of SFAs and PUFAs (% of total energy or g/d). The former is referred to as reported P:S and the latter as calculated P:S. The U:S was calculated by using the same data sources.

Mean values of dietary fat intake for each country were calculated after weighing each survey by the number of participants, whenever more than one survey was performed. These means were used for the analysis. The analysis was performed including both sexes because dietary intake expressed as a percentage of total energy was not substantially different between sexes, as discussed above (7–9).

FAO data

The published data for the period 1979–1981 was used (1). For each of the food items the per person supply of SFAs, MUFAs, and PUFAs (in g/d) was calculated from fat supply (in g/d) obtained from FAO data by using the food fatty acid composition table (15). Per person supply of each subtype of fatty acid was given as the sum of the values calculated from each food item containing the subtype of fatty acids. Subtypes of fatty acids in percent of total energy were thus obtained in g/d, multiplied by the Atwater factor, and divided by the energy supply in kJ/d. The P:S and U:S were estimated from the PUFA, MUFA, and SFA contents of each food item. The P:S obtained from the FAO data by dividing the amount of (vegetable fat − olive oil) − (coconut oil − palm oil) + fish oil was divided by (animal fat − fish oil) + (palm oil + coconut oil) was also calculated by using a second more simple method. By the same method, the U:S was obtained from the FAO data by dividing the amounts of (vegetable fat + fish oil) ÷ (animal fat − fish oil) + (coconut oil + palm oil).

Results

The list of dietary intakes of SFAs, MUFAs, PUFAs (as % of total energy and g/d), reported and calculated P-S and U-S ratios obtained from the survey data in 19 countries (16–60) are given in a table available upon request from the author. Fifty-two dietary surveys were available for the study. Among the 19 countries, 7 countries were represented by only one survey carried out in either one or two areas. **Table 1** shows the mean intakes of SFAs, MUFAs, PUFAs (% of total energy), P:S, and U:S obtained from the dietary surveys for each country, and the corresponding supplies and the ratios obtained from FAO data. Hungary has the highest intake of SFAs (26.2% of total energy), the lowest intake of PUFAs (3.0% of total energy) and therefore the lowest P:S (0.11). On the other hand, the supply of SFAs obtained from FAO data for Hungary was markedly lower and the P:S higher than the values obtained by dietary survey. New Zealand showed the lowest P:S from FAO data. Japan showed the highest P:S both from surveys (1.30, reported; 1.20, calculated) and FAO data (1.08). Almost the same findings apply to the U:S, with the highest in Japan from both data sources and the lowest in Hungary from surveys only. Mean dietary PUFA intakes from surveys were lower than those from FAO data, in contrast to SFA intakes, which were higher, either including or excluding Hungary. The level of significance of the differences in SFAs obtained from the two data sources centers around $P = 0.05$, being either slightly higher or lower than this limit value (Table 1).

The results of the univariate relationships between each component pair are given in **Table 2.** For the P:S, two comparisons were made for the analysis, one between the calculated P:S from surveys and the P:S from FAO data, and one between the reported P:S from surveys and from FAO data. The comparison of SFAs, MUFAs, and PUFAs produces significant positive relationships (SFAs and MUFAs, $P < 0.001$; PUFAs, $P < 0.02$) when all countries with data obtained are included. Both comparisons of P:S and U:S are also highly significant ($P < 0.001$). To examine the influence of the highest and lowest values, reanalyses were tested excluding two Asian countries (Japan and China) and Hungary. The values for Hungary obtained by dietary survey are more in line with the mortality data for ischemic heart disease and stroke (61, 62). Japan and China have diets that differ markedly from Western diets. The results showed better relationships for SFAs, PUFAs, calculated P:S, and U:S after the exclusion of Hungary; the comparisons for SFAs especially showed a significant improvement ($r = 0.93$, $P < 0.001$). All slopes of the regression line became closer to one except for MUFAs and PUFAs. After excluding Japan, China, and Hungary, the significant relationships did not change for the comparisons of P:S, U:S, and SFAs ($P < 0.001$); those of MUFAs became less significant ($P < 0.05$). On the other hand, regression lines showed different slopes between the analyses including and

TABLE 1
List of the countries in the study with mean per person intake of SFAs, MUFAs, PUFAs (% of total energy); reported and calculated P:S, and calculated U:S from the survey data, and supply obtained from FAO data*

Country	From surveys SFA (n = 19)	MUFA (n = 16)	PUFA (n = 19)	Reported P:S (n = 19)	Calculated P:S (n = 19)	Calculated U:S (n = 16)	From FAO data SFA (n = 19)	MUFA (n = 16)	PUFA (n = 19)	P:S (n = 19)	U:S (n = 16)
	% total energy						*% total energy*				
Australia	15.8	12.7	6.5	0.45	0.41	1.22	12.6	10.9	4.7	0.37	1.23
Belgium	17.4	15.3	7.6	0.51	0.43	1.31	16.7	15.9	7.0	0.42	1.38
Canada	13.8	—	4.1	—	0.31	—	11.8	—	6.3	0.53	—
China	5.8	9.0	4.6	0.66	0.89	2.58	4.0	5.0	3.0	0.75	2.00
Denmark	17.6	—	6.0	—	0.34	—	17.2	—	5.8	0.34	—
Finland	19.5	12.8	4.7	0.27	0.24	0.90	17.5	13.2	4.6	0.26	1.01
France	15.4	12.8	4.7	0.38	0.35	1.23	15.1	14.4	7.1	0.47	1.42
Germany	18.6	—	4.7	0.26	0.25	—	15.0	—	4.9	0.32	—
Hungary	26.2	12.9	3.0	—	0.11	0.61	12.6	12.8	5.4	0.43	1.44
Israel	10.4	11.1	8.1	0.89	0.82	1.84	9.1	10.2	9.0	0.98	2.10
Italy	13.0	15.6	4.8	0.39	0.37	1.58	10.2	14.5	6.3	0.61	2.03
Japan	4.8	8.0	5.9	1.30	1.20	2.80	6.6	8.6	7.1	1.08	2.38
Netherlands	17.0	14.4	6.4	0.41	0.38	1.20	17.8	17.7	6.7	0.38	1.38
Norway	14.8	13.0	7.1	0.53	0.50	1.36	15.3	13.5	6.8	0.44	1.33
New Zealand	17.9	15.5	4.6	0.19	0.20	1.12	18.3	13.1	4.3	0.24	0.95
Spain	10.5	16.4	6.0	0.58	0.58	2.17	9.6	14.5	7.5	0.78	2.28
Switzerland	16.5	13.4	5.9	0.39	0.36	1.17	17.3	14.5	6.8	0.40	1.23
United Kingdom	15.7	14.6	5.0	0.32	0.31	1.13	15.1	14.6	6.4	0.42	1.39
United States	13.5	14.1	6.1	0.46	0.44	1.48	14.6	15.2	8.6	0.59	1.63
All countries [$\bar{x}$ (SD)]	15.0 (4.9)	13.2 (2.3)	5.6† (1.3)	0.50 (0.27)	0.45† (0.26)	1.48 (0.59)	13.5 (4.1)	13.0 (3.1)	6.2 (1.5)	0.52 (0.23)	1.57 (0.45)
Excluding Hungary [$\bar{x}$ (SD)]	14.4† (4.1)	13.3 (2.4)	5.8 (1.2)	0.50 (0.27)	0.47 (0.26)	1.54 (0.56)	13.5 (4.2)	13.1 (3.2)	6.3 (1.5)	0.52 (0.24)	1.58 (0.46)

* All surveys were carried out between 1975 and 1988, and data from FAO are for the period 1979–1981. P:S, ratio of polyunsaturated to saturated fatty acids; U:S, ratio of unsaturated to saturated fatty acids.
† Significantly different from FAO data, $P < 0.05$ (paired t test).

excluding these three countries except for the comparison of PUFAs. In these two subanalyses the relationship for PUFAs was slightly less significant than for other variables ($P < 0.02$).

The relationship between the intake of saturated fatty acids obtained from FAO and from the survey data, both expressed as a percentage of energy, was also examined. For the 19 countries the regression equation, using FAO data as the independent variable, was $y = 2.99 + 0.89x$ ($r = 0.74$, $P < 0.001$). Once again Hungary was an outlier. With the exclusion of Hungary, the regression equation was $y = 1.80 + 0.93\,x$ ($r = 0.93$, $P < 0.0001$). Hungary is considered an outlier because the difference between survey and FAO data on SFAs was 4.1 SD outside of the mean difference of all countries and 8.7 SD outside the mean difference after excluding Hungary.

Figure 1 shows the relationship between the calculated P:S obtained from surveys and from FAO data. The regression lines were calculated from the means of the survey data and from the FAO data of each country shown in Table 1. P-S ratios for two

TABLE 2
Univariate relationships between the component pairs of SFAs, MUFAs, PUFAs (% of total energy); P-S and U-S ratios obtained from FAO data, and mean values calculated from survey data for each country*

Component pair FAO data	Surveys	All countries included n	b	a	t	r	P	Excluding Hungary n	b	a	t	r	P	Excluding Japan, China and Hungary n	b	a	t	r	P
P:S	Calculated P:S	19	1.004	−0.072	7.719	0.882	<0.0001	18	0.980	−0.045	8.346	0.902	<0.0001	16	0.638	0.073	6.827	0.877	<0.0001
P:S	Reported P:S	16	0.993	−0.029	7.982	0.906	<0.0001	16	0.993	−0.029	7.982	0.906	<0.0001	14	0.733	0.081	6.114	0.870	<0.0001
U:S	U:S	16	1.123	−0.287	5.895	0.844	<0.0001	15	1.089	−0.184	6.909	0.887	<0.0001	13	0.769	0.218	8.725	0.935	<0.0001
SFAs	SFAs	19	0.887	2.992	4.530	0.740	<0.001	18	0.925	1.801	10.152	0.930	<0.0001	16	0.769	4.254	6.696	0.873	<0.0001
MUFAs	MUFAs	16	0.615	5.213	5.394	0.822	<0.001	15	0.614	5.229	5.198	0.822	<0.001	13	0.455	7.601	2.429	0.591	<0.05
PUFAs	PUFAs	19	0.484	2.558	2.821	0.565	<0.02	18	0.435	2.982	2.827	0.577	<0.02	16	0.479	2.694	2.446	0.547	<0.02

* P-S ratio from FAO data was matched with calculated and reported P-S ratios from surveys. P:S, ratio of polyunsaturated to saturated fatty acids; U:S, ratio of unsaturated to saturated fatty acids; b, regression coefficient; a, constant.

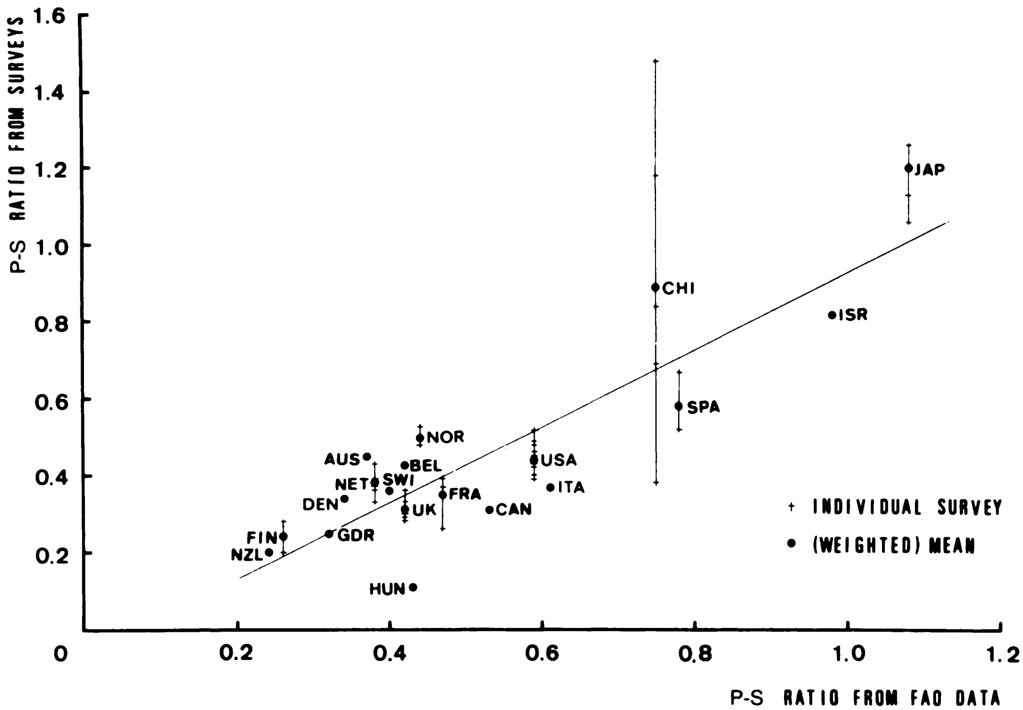

FIG 1. Correlation between the ratio of polyunsaturated to saturated fatty acids (P:S) calculated from polyunsaturated and saturated fatty acids (calculated P:S) obtained from 52 individual dietary surveys, 1975–1988, in 19 countries, and the P:S calculated from FAO data, 1979–1981. The regression line and univariate relationship is given between the weighed mean value calculated from dietary surveys of each country and the value obtained from FAO data. $y = -0.07 + 1.00x$. $n = 19$. $P < 0.0001$. $r = 0.88$. $t = 7.72$. AUS, Australia; BEL, Belgium; CAN, Canada; CHI, China; DEN, Denmark; FIN, Finland; FRA, France; GDR, German Democratic Republic; HUN, Hungary; ISR, Israel; ITA, Italy; JAP, Japan; NET, Netherlands; NOR, Norway; NZL, New Zealand; SPA, Spain; SWI, Switzerland; UK, United Kingdom; USA, The United States of America.

Mediterranean countries, Italy and Spain, were markedly overestimated and for two Asian countries, China and Japan, were markedly underestimated from FAO data. However, the values from the surveys in China varied within wide limits from 0.38 to 1.48. Italy and Spain were represented by one or two surveys only. A similar distribution was found for U:S in **Figure 2.** When the FAO P-S and U-S ratios obtained by the second method were used vs the survey P-S and U-S ratios, significance levels similar to those obtained by calculating the P-S and U-S ratios from the fatty acid composition of the food items were obtained. When the fatty acid composition of the FAO data was used, however, this resulted in slopes of the regression equation closer to unity, which is to be preferred (**Table 3**). It is apparent for the analysis of the data obtained by both methods that the data on PUFAs yield less satisfactory results than those on SFAs. This could be because vegetable fat is often hydrogenated and thus has become saturated when used for human consumption.

Discussion

The importance of studying the relationship between mortality and/or morbidity with nutrition on a global scale has been widely recognized (63). The Seven Countries Study revealed differences in dietary habits and cardiovascular disease mortality between countries and a significant relationship between nutrition and mortality (64).

For this purpose the *World Health Mortality Statistics Annuals* published by the World Health Organization (WHO) are widely used as a reliable data source of mortality in the world. The value of ischemic heart disease mortality obtained from the above data source was investigated and considered to be sufficiently reliable in most countries (65). For the study of worldwide nutrition, the food-balance sheets from the FAO of the United Nations are often used (2–6, 66, 67). It is interesting to note that the relationship between cardiovascular mortality (from WHO) and the P:S obtained from FAO showed a close relationship similar to the one found in the Seven Countries Study (66).

In this study the value of the FAO data as a source for the estimated mean per person intake of subtypes of fatty acids was examined. The study shows that the P:S and the U:S obtained from survey data and from FAO data are significantly and positively correlated.

FAO data, which show food disappearance, do not exclude household waste of food. The method used in this paper did not take this into account. Differences in wasting and cooking habits between countries may exist, especially between Asian and Western countries and between countries with different degrees of economic development. No information on differences in dietary habits related to sex, age, and economic status are provided by FAO data. The data obtained from the dietary surveys may also present problems with regard to their reliability. The data collected and used here may not have been representative

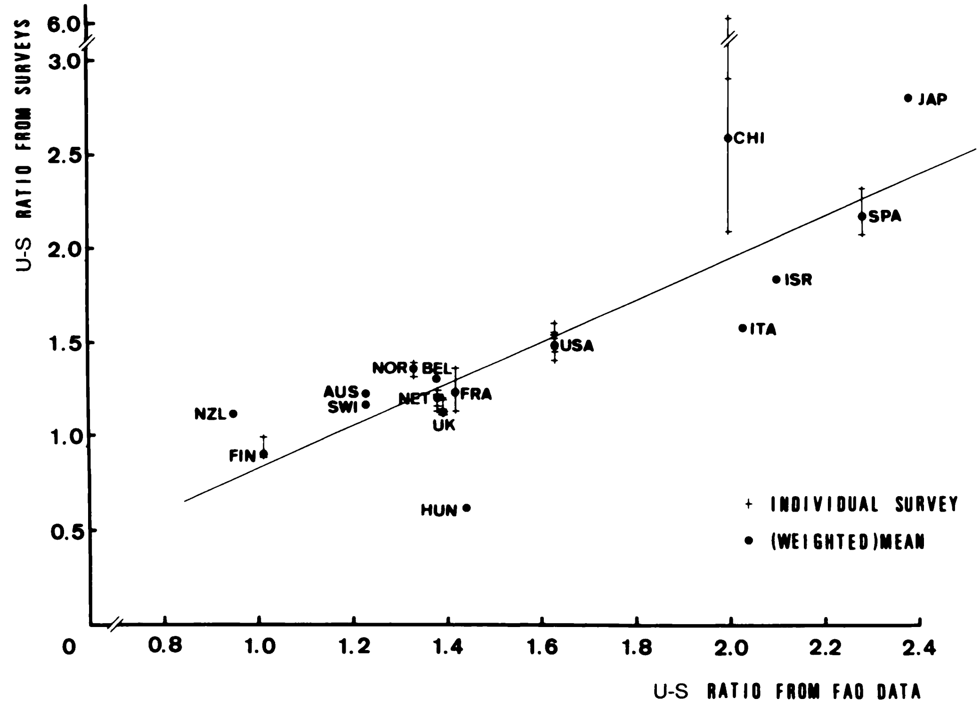

FIG 2. Correlation between the ratio of unsaturated fatty acids to saturated fatty acids (U:S) calculated from polyunsaturated, monounsaturated, and saturated fatty acids obtained from 42 individual dietary surveys, 1975–1988, in 16 countries, and the U-S ratio calculated from FAO data, 1979–1981. The regression line and univariate relationship is given between the weighed mean value calculated from dietary surveys of each country and the value obtained from FAO data. $y = -0.29 + 1.12x$. $n = 16$. $P < 0.0001$. $r = 0.84$. $t = 5.90$. AUS, Australia; BEL, Belgium; CAN, Canada; CHI, China; DEN, Denmark; FIN, Finland; FRA, France; HUN, Hungary; ISR, Israel; ITA, Italy; JAP, Japan; NET, Netherlands; NOR, Norway; NZL, New Zealand; SPA, Spain; SWI, Switzerland; UK, United Kingdom; USA, The United States of America.

of the country and truly randomized studies are the exception rather than the rule. In fact, the P:S obtained from China varied within considerably wide limits. This makes it almost impossible to assign a valid mean P:S to this country. The localization of the areas where the studies were performed may have affected the results because dietary habits show considerable variation within a country as well as between countries and so does the mortality related to dietary habits (68). Nevertheless, intakes and supply of the subtypes of fatty acids and their ratios demonstrated the presence of significant positive relationships between the two independent data sources. Survey data on food consumption are also not without problems. The lack of comparability of various studies, because of differences in methodology, has been pointed out in the conclusions of the Belgian Interuniversity Research on Nutrition and Health (BIRNH) study (69). Evidence exists showing that in many surveys an underreporting of total energy intake has occurred (70, 71). As a result, data on macronutrients should preferably be expressed as percent of energy or as ratios. This reduces but does not eliminate the differences because it presumes that the errors are of equal magnitude for all food constituents.

The data on the dietary intake of PUFAs did not show as close a relationship as the data for SFAs and MUFAs. The narrower distribution of intake and supply of PUFAs compared with SFAs and MUFAs might obscure the real relationship, and some dietary surveys reported the intake of linoleic acid only instead of total PUFAs. The P:S reported in The Second National Health and Nutrition Examination Survey (NHANES II), which was the nationwide individual dietary survey carried out in the United States during 1976–1980, was 0.42 (7). Even when the increased intake of PUFAs of US populations during the 1970s and 1980s is considered (8), the value is smaller than both the mean reported and calculated P-S ratios (0.46 and 0.44, respectively) used in this study. And it is also less than the calculated P:S from FAO data (0.59). The mean of the supply of PUFAs from FAO data, excluding Hungary, of which the data did not appear reliable, as discussed before, was greater than the mean of the intake from the survey data but the difference was not statistically significant (Table 1). On the other hand, SFAs showed the opposite result, the intake surpassing the supply significantly ($P < 0.05$). The P:S could be affected by these differences in the behavior of SFAs and PUFAs between intake and supply, but nevertheless the relationship remained highly significant. Because of a lack of standardization on how to estimate and report PUFA intakes, the PUFA supply obtained from FAO data may have been underestimated. Another problem is that the P:S and PUFA intake have increased markedly in several countries during recent years while the intake of SFAs has decreased (7, 8, 68).

Among the countries examined, the data set for Hungary showed considerable discrepancy on SFAs and PUFAs between intakes obtained from the dietary survey and the supply from FAO data. The very low P:S obtained from the survey data seems to offer a better explanation for the high and increasing mortality from cardiovascular disease and total cancer in this country than

TABLE 3
Comparison between FAO and survey data on dietary fat consumption*

Component pair FAO data	Surveys	All countries included					
		n	b	a	*t*	*r*	*P*
(VF + FF)/(AF − FF)	calculated P:S	19	0.558	0.103	7.196	0.868	<0.0001
(VF + FF − OO)/(AF − FF)	calculated P:S	19	0.637	0.086	9.292	0.914	<0.0001
(VF + FF − OO − SO)/(AF − FF + SO)	calculated P:S	19	0.681	0.079	9.147	0.912	<0.0001
(VF + FF)/(AF − FF)	reported P:S	16	0.570	0.120	7.579	0.897	<0.0001
(VF + FF − OO)/(AF − FF)	reported P:S	16	0.652	0.104	12.214	0.956	<0.0001
(VF + FF − OO − SO)/(AF − FF + SO)	reported P:S	16	0.694	0.100	11.443	0.950	<0.0001
(VF + FF)/(AF − FF)	U:S	16	1.128	0.738	5.523	0.828	<0.001
(VF + FF − OO)/(AF − FF)	U:S	16	1.154	0.789	4.809	0.789	<0.001
(VF + FF − OO − SO)/(AF − FF + SO)	U:S	16	1.240	0.776	4.865	0.793	<0.001
AF − FF (g/d)	SFA	19	0.117	4.172	5.432	0.797	<0.001
AF − FF + SO (g/d)	SFA	19	0.115	4.179	5.317	0.790	<0.001
AF − FF (% of energy)	SFA	19	0.511	2.598	5.732	0.812	<0.0001
AF − FF + SO (% of energy)	SFA	19	0.503	2.603	5.567	0.804	<0.0001
VF + FF (g/d)	PUFA	19	0.042	3.598	2.466	0.513	<0.05
VF + FF − OO (g/d)	PUFA	19	0.058	3.078	3.143	0.606	<0.01
VF + FF − OO − SO (g/d)	PUFA	19	0.056	3.205	2.985	0.586	<0.01
VF + FF (% of energy)	PUFA	19	0.179	3.351	2.754	0.555	<0.02
VF + FF − OO (% of energy)	PUFA	19	0.232	2.885	3.393	0.635	<0.01
VF + FF − OO − SO (% of energy)	PUFA	19	0.225	3.043	3.208	0.614	<0.01

* VF, vegetable fat; FF, fish fat; AF, animal fat; OO, olive oil; SO, saturated oils (coconut oil and palm oil); P, polyunsaturated fatty acid; S, saturated fatty acid; U, unsaturated fatty acid; *b*, regression coefficient; a constant.

the P:S obtained from FAO data (61, 62). Comparison of the dietary intake of saturated fatty acids expressed as a percentage of energy also demonstrated a high degree of correlation between the FAO and the survey data ($P < 0.001$). Hungary was an outlier and the correlation improved considerably after its exclusion ($P < 0.0001$).

Japan has the highest P-S and U-S ratios of the countries included in the study. The fat intake of the Japanese population is increasing and westernization of dietary habits is occurring (10, 11). Therefore, it is difficult to determine the standard intake of subtypes of fatty acids of this population in the period 1979–1981 from the limited surveys available. A P:S of 1.13 was reported as an estimated value calculated from the National Nutrition Survey of Japan in 1980, which was a nationwide household survey (11). This value is closer to the FAO data than is the mean value of the survey data used here. Therefore, reliability of FAO data may have been underestimated because the data collection and analysis did not take into account the chronological changes of dietary habits. From this point of view our study failed to collect sufficient numbers of dietary surveys. A comparative study that estimated the fiber supply of 38 countries by using FAO data and survey data did not calculate the correlation between the data obtained from both sources (72). For future use of FAO data it is recommended to use values of food nutrients as percent of energy or ratios, for instance, as representations of the P-S and U-S ratios. As shown in Table 3, the use of such ratios improves both the correlation and the regression coefficients of the equations relating dietary intake obtained from surveys to the values obtained from food-balance sheets provided by FAO.

In conclusion, notwithstanding its limitations, FAO data can be considered as a valid data source for dietary fat intake in epidemiologic studies on the relationship between cancer, cardiovascular disease, and nutrition. Whether this can be extrapolated to other food items and to total energy intake remains to be investigated. More attention should be paid to international standardization in order to improve the comparative value of different nutritional surveys. The possibility of refining the FAO data on food-balance sheets should also be examined. This is particularly important in view of the key role played by nutrition as a major determinant of the health of populations.

References

1. Food and Agriculture Organization of the United Nations. Food balance sheets. Rome, 1984.
2. Gray GE, Pike MC, Henderson BE. Breast-cancer incidence and mortality rates in different countries in relation to known risk factors and dietary practices. Br J Cancer 1979;39:1–7.
3. Prentice RL, Kakar F, Hursting S, Sheppard L, Klein R, Kushi LH. Aspects of the rationale for the Women's Health Trial. J Natl Cancer Inst 1988;80:802–14.
4. Hursting SD, Thornquist M, Henderson MM. Types of dietary fat and the incidence of cancer at five sites. Prev Med 1990;19:242–53.
5. Kesteloot H, Lesaffre E, Joossens JV. Dairy fat, saturated animal fat, and cancer risk. Prev Med 1991;20:226–36.
6. Joossens JV, Kesteloot H. Fish consumption and health status. In: Somogyi JC, Hötzel D, eds. Marine foods. Basel, Karger: Bibl Nutr Dieta 1990;46:37–44.
7. Block G, Rosenberger WF, Patterson BH. Calories, fat and cholesterol: intake patterns in the US population by race, sex and age. Am J Public Health 1988;78:1150–5.
8. Stephen AM, Wald NJ. Trends in individual consumption of dietary fat in the United States, 1920–1984. Am J Clin Nutr 1990;52:457–69.
9. Kornitzer M, Bara L. Clinical and anthropometric data. Blood chemistry and nutritional patterns in the Belgian population according to age and sex. Acta Cardiol 1989;44:101–44.

10. Lands WE, Hamazaki T, Yamazaki K, et al. Changing dietary patterns. Am J Clin Nutr 1990;51:991-3.
11. Ueshima H, Tatara K, Asakura S. Declining mortality from ischemic heart disease and changes in coronary risk factors in Japan, 1956-1980. Am J Epidemiol 1987;125:62-72.
12. McKeown-Eyssen GE, Bright-See E. Dietary factors in colon cancer: international relationships. Nutr Cancer 1984;6:160-70.
13. US Department of Health and Human Services. Nutrition monitoring in the United States. US Department of Health and Human Services, 1989. [DHHS publication (PHS)89-1255.]
14. Khoury PR, Morrison JA, Laskarzewski P, et al. Relationships of education and occupation to coronary heart disease risk factors in schoolchildren and adults: the Princeton School District study. Am J Epidemiol 1981;113:378-95.
15. The Science and Technology Agency, eds. Fatty acids, cholesterol, vitamin E composition table of Japanese food. Tokyo: Ishiyaku Shuppan Publishers, 1990 (in Japanese).
16. Baghurst KI, Crawford DA, Worsley A, Record SJ. The Victorian Nutrition Survey: intakes and sources of dietary fats and cholesterol in the Victorian population. Med J Aust 1988;149:12-5, 18-20.
17. Kesteloot H, Geboers J, Joossens JV. On the within-population relationship between nutrition and serum lipids: the B.I.R.N.H. study. Eur Heart J 1989;10:196-202.
18. Brisson J, Verreault R, Morrison AS, Tennina S, Meyer F. Diet, mammographic features of breast tissue, and breast cancer risk. Am J Epidemiol 1989;130:14-24.
19. Yu SZ, Lu RF, Xu DD, Howe GR. A case-control study of dietary and nondietary risk factors for breast cancer in Shanghai. Cancer Res 1990;50:5017-21.
20. Zhou BF, Wu XG, Tao SQ, et al. Dietary patterns in 10 groups and the relationship with blood pressure. Chin Med J 1989;102:257-61.
21. Chen HZ, Zhuang HZ, Han QQ, Chen B. The relationship between serum lipid levels and nutrient intake in healthy inhabitants of urban and rural Shanghai. Chin Med J 1989;102:60-6.
22. Yao CH, Hao EH, Wu YY, Dong L. Dietary survey in Beijing in 1983. Chin Med J 1985;98:439-41.
23. Vartiainen E, Dianjun D, Marks JS, et al. Mortality, cardiovascular risk factors, and diet in China, Finland, and the United States. Public Health Rep 1991;106:41-6.
24. Helms P, Jørgensen IM, Paerregaard A, Bjerrum L, Poulsen L, Mosbech J. Dietary patterns in Them and Copenhagen, Denmark. Nutr Cancer 1982;4:34-40.
25. Seppänen R, Strand R, Burton RK. Dietary patterns in Parikkala and Helsinki, Finland. Nutr Cancer 1982;4:41-9.
26. Pietinen P, Uusitaro U, Vartiainen E, et al. Dietary survey of the FINMONICA Project in 1982. Acta Med Scand Suppl 1988;728:169-77.
27. Pietinen P, Hartman AM, Haapa E, et al. Reproducibility and validity of dietary assessment instruments. I. A self-administered food use questionnaire with a portion size picture booklet. Am J Epidemiol 1988;128:655-66.
28. Riboli E, Péquignot G, Repetto F, et al. A comparative study of smoking, drinking and dietary habits in population samples in France, Italy, Spain and Switzerland. I. Study design and dietary habits. Rev Epidémiol Santé Publique 1988;36:151-65.
29. Warnet JM, Cambien F, Vernier V, et al. Relation between consumption of alcohol and fatty acids esterifying serum cholesterol in healthy men. Br Med J 1985;290:1859-61.
30. Jost JP, Simon C, Nuttens MC, et al. Comparison of dietary patterns between population samples in the three French MONICA nutritional surveys. Rev Epidémiol Santé Publique 1990;38:517-23.
31. Heinemann L, Heine H, Assmann A, et al. Risk factors in the population of the GDR-MONICA Study (1983/1984). Acta Med Scand Suppl 1988;728:144-9.
32. Biró G. Nutrition and cardiovascular risk: the Hungarian experience. Acta Cardiol 1990;45:3-14.
33. Kaufmann NA, Dennis BH, Heiss G, Friedlander Y, Kark JD, Stein Y. Comparison of nutrient intakes of selected populations in the United States and Israel: the Lipid Research Clinics Prevalence Study. Am J Clin Nutr 1986;43:604-20.
34. Ueshima H, Iida M, Shimamoto T, et al. Dietary intake and serum total cholesterol level: their relationship to different lifestyles in several Japanese populations. Circulation 1982;66:519-26.
35. Sato S. Dietary and serum fatty acid compositions among six Japanese populations. Jpn J Public Health 1990;37:498-508 (in Japanese).
36. Ueshima H, Hirao Y, Ishikawa M, et al. Problems on dietary habits and serum lipids in clerical workers of a large city for prevention of cardiovascular disease. J Jpn Assoc Cerebrocardiovasc Dis Control 1987;22:185-9 (in Japanese).
37. Van Beresteyn EC, Winkeldermaat HJ, Ten Have-Witjes A, Neeter R. Nutrition and nutritional state of 50 to 60 year-old women in Ede: a risk factor for postmenopausal osteoporosis? Voeding 1985;46:258-61 (in Dutch).
38. Baecke JAH, van Staveren WA, Burema J. Food consumption, habitual physical activity, and body fatness in young Dutch adults. Am J Clin Nutr 1983;37:278-86.
39. Löwik MR, Westenbrink S, Hulshof KF, Kistemaker C, Hermus RJ. Nutrition and aging: dietary intake of "apparently healthy" elderly (Dutch Nutrition Surveillance System). J Am Coll Nutr 1989;8:347-56.
40. Westenbrink S, Löwik MR, Hulshof KF, Kistemaker C. Effect of household size on nutritional patterns among the Dutch elderly. J Am Diet Assoc 1989;89:793-9.
41. Bloemberg BP, Kromhout D, Obermann-De Boer GL, Van Kampen-Donker M. The reproducibility of dietary intake data assessed with the cross-check history method. Am J Epidemiol 1989;130:1047-56.
42. Van 't Veer P, Kok FJ, Brants HA, Ockhuizen T, Sturmans F, Hermus JJ. Dietary fat and the risk of breast cancer. Int J Epidemiol 1990;19:12-8.
43. Berns MAM, de Vries BJ, Katan MB. Dietary and other determinants of lipoprotein levels within a population of 315 Dutch males aged 28 and 29. Eur J Clin Nutr 1990;44:535-44.
44. Simonsen T, Vårtun Å, Lyngmo V, Nordøy A. Coronary heart disease, serum lipids, platelets and dietary fish in two communities in Northern Norway. Acta Med Scand 1987;222:237-45.
45. Flaten H, Høstmark AT, Kierulf P, et al. Fish oil concentrate: effects on variables related to cardiovascular disease. Am J Clin Nutr 1990;52:300-6.
46. Paulin JM, McNab IM, Simpson FO, Gillies ME, Spears GFS. What do middle-aged New Zealanders eat? A dietary survey in 50-54 year olds in south Canterbury and north Otago. NZ Med J 1988;101:159-62.
47. González CA, Torrent M, Agudo A, Riboli E. Hospital versus neighbourhood controls in the assessment of dietary risk factors. Int J Epidemiol 1990;19:354-61.
48. Morabia A, Raymond L, Hollenweger V, Zurkirch MC, Rieben A. Assessment of the nutrient intake in a random sample of the adult population of the canton of Geneva based on a dietary history questionnaire. Rev Epidémiol Santé Publique 1987;35:102-16.
49. Nelson M, Black AE, Morris JA, Cole TJ. Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. Am J Clin Nutr 1989;50:155-67.
50. Thomson M, Fulton M, Elton RA, Brown S, Wood DA, Oliver MF. Alcohol consumption and nutrient intake in middle-aged Scottish men. Am J Clin Nutr 1988;47:139-45.
51. Fehily AM, Barker ME, Thomson M, et al. The diets of men in four areas of the UK: the Caerphilly, Northern Ireland, Edinburgh and Speedwell studies. Eur J Clin Nutr 1990;44:813-7.
52. Cade JE, Barker DJ, Margetts BM, Morris JA. Diet and inequalities in health in three English towns. Br Med J 1988;296:1359-62.

53. McClean R, McCrum E, Scally G, et al. Dietary patterns in the Belfast MONICA Project. Proc Nutr Soc 1990;49:297–305.
54. Beaglehole R, Trost DC, Tamir I, et al. Plasma high-density lipoprotein cholesterol in children and young adults. The Lipid Research Clinics Program Prevalence Study. Circulation 1980;62(Suppl 4): 83–92.
55. Haffner SM, Knapp JA, Hazuda HP, Stern MP, Young EA. Dietary intakes of macronutrients among Mexican Americans and Anglo Americans: the San Antonio Heart Study. Am J Clin Nutr 1985;42: 1266–75.
56. Willett WC, Sampson L, Browne ML, et al. The use of a self-administered questionnaire to assess diet four years in the past. Am J Epidemiol 1988;127:188–99.
57. Folsom AR, Jacobs DR, Luepker RV, et al. Nutrient intake in a metropolitan area, 1973–1974 vs 1980–1982: the Minnesota Heart Survey. Am J Clin Nutr 1987;45:1533–40.
58. Kushi LH, Folsom AR, Jacobs DR Jr, Luepker RV, Elmer PJ, Blackburn H. Educational attainment and nutrient consumption patterns: the Minnesota Heart Survey. J Am Diet Assoc 1988;88: 1230–6.
59. Must A, Otradovec CL, Jacques P. Consumption of fish and shellfish by a non-institutionalized elderly population in New England. J Am Diet Assoc 1988;88:715–7.
60. Van Horn LV, Ballew C, Liu K, et al. Diet, body size, and plasma lipids-lipoproteins in young adults: differences by race and sex. The Coronary Artery Risk Development in Young Adults (CARDIA) Study. Am J Epidemiol 1991;133:9–23.
61. Kesteloot H. Changing trends in mortality. In: Yamori Y, Strasser T, eds. New horizons in preventing cardiovascular diseases. Amsterdam; Excerpta Medica 1989;101–10.
62. Kesteloot H, Yuan X-Y, Joossens JV. Changing mortality patterns in men. Acta Cardiol 1988;43:133–9.
63. Stamler J. Opportunities and pitfalls in international comparisons related to patterns, trends and determinants of CHD mortality. Int J Epidemiol 1989;18(suppl 1):S3–18.
64. Keys A, Menotti A, Karvonen MJ, et al. The diet and 15-year death rate: the Seven Countries Study. Am J Epidemiol 1986;124:903–15.
65. Joossens JV, Kesteloot H. The value of ischemic heart disease vital statistics since 1968. Acta Cardiol 1989;44:389–405.
66. Shaper AG, Marr JW. Dietary recommendations for the community towards the postponement of coronary heart disease. Br Med J 1977;1:867–71.
67. Schatzkin A, Piantadosi S, Miccozzi M, Bartee D. Alcohol consumption and breast cancer: a cross-national correlation study. Int J Epidemiol 1989;18:28–31.
68. Joossens JV, Geboers J, Kesteloot H. Nutrition and cardiovascular mortality in Belgium. Acta Cardiol 1989;44:157–82.
69. Kesteloot H. Nutrition and health: the conclusions of the B.I.R.N.H. Study. Acta Cardiol 1989;44:183–94.
70. Livingstone MBE, Prentice AM, Strain JJ, et al. Accuracy of weighed dietary records in studies of diet and health. Br Med J 1990;300: 708–12.
71. Mertz W, Tsui JC, Judd JT, et al. What are people really eating? The relation between energy intake derived from estimated diet records and intake determined to maintain body weight. Am J Clin Nutr 1991;54:291–5.
72. Bright-See E, McKeown-Eyssen GE. Estimation of per capita crude and dietary fiber supply in 38 countries. Am J Clin Nutr 1984;39: 821–9.