Do Time Trends in Food Supply Levels of Macronutrients Reflect Survey Estimates of Macronutrient Intake?

ABSTRACT

Background. Two types of data may be used to estimate trends in food and nutrient intake by the US population: per capita food supply estimates and survey estimates of individual intake. Because these data vary markedly in measurement goals and methods, we examined whether trends in food supply and survey intake estimates for fat, carbohydrate, and protein are reflective of one another.

Methods. The data selected for comparison included all available survey estimates of mean intake by the US population (i.e., periodic estimates from 1965 to 1988) and all available per capita food supply estimates from a comparable time period (i.e., annual estimates from 1965 to 1985).

Results. The two types of data generally did not reflect the same trends. Furthermore, expressing macronutrient levels as percentage of calories rather than in grams affected the trend relationships.

Conclusions. Our findings indicate that caution is needed in the selection and application of available data to estimate trends in macronutrient intake by the US population and in the interpretation of these data with regard to public health research, policies, and programs. (*Am J Public Health.* 1992;82:862–866)

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Introduction

The monitoring of the US population's dietary intake and nutritional status received considerable attention in the last decade.[1,2] In the next decade, nutrition monitoring will receive increased attention with the passage of the National Nutrition Monitoring and Related Research Act of 1990.[3] The estimation of trends in food and nutrient intake by US population groups, although not a measure of change in US population nutritional status per se, will continue to be a priority for several reasons. These data can be used to help (1) form national nutrition objectives and monitor progress toward their achievement[4–6]; (2) form national nutrition policies and interventions; and (3) form and, to a lesser extent, test hypotheses about the relationship between diet and certain chronic diseases, such as coronary heart disease[7–10] and cancer.[11–15]

Two types of data may be used to estimate trends over time in food and nutrient intake by the US population: (1) annual estimates of foods and nutrients available for consumption as measured from US food supply data (henceforth referred to as food supply estimates) and (2) periodic estimates of food and nutrient intake by individuals as measured from national food consumption surveys of individuals (henceforth referred to as survey intake estimates). Historically, the more frequent per capita food supply estimates, which are available from the turn of the century, have most often been used for this purpose.[7–16]

The main objective of this study was to examine whether trends in macronutrient levels of the food supply can be used as a surrogate indicator of trends in intakes of macronutrients by individuals. Fat, carbohydrate, and protein were selected for analyses because these measures are available from all the national food consumption surveys. These macronutrients are a current focus of dietary recommendations to the general public[17] and of research on diet and certain chronic diseases.[11,18] In addition, intake of these nutrients has been reported to be relatively stable throughout the seasons[19] and to have less intraindividual variation than a number of other nutrients.[20]

The second objective of this study was to examine the relationships between food supply and survey intake trends when macronutrients are expressed in gram amounts rather than as percentages of calories. This objective is particularly relevant to monitoring progress toward dietary recommendations that have been directed to the general public.

Methods

Description of Databases

Food supply estimates. The US Department of Agriculture's (USDA) Human Nutrition Information Service uses food disappearance data from the USDA's Economic Research Service and food composition data to calculate annual levels of nutrients available in the US food supply per capita per day. The Economic Research Service calculates annual amounts of several hundred foods that "disappear" into the food distribution system by subtracting data

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on year-end inventories, exports, industrial uses, farm inputs (seed and feed), and, until recently, military use from total supply data that include beginning-of-the-year inventories, production, and imports.[21] To obtain nutrient levels, the Human Nutrition Information Service multiplies the per capita disappearance estimates of these foods (retail weight) by the nutrient composition of the edible portion per pound of food.[22] For each nutrient, the levels are summed for all foods and then converted to a per day basis. Per capita food disappearance and nutrient estimates of the food supply include spoilage and waste that may occur in processing and marketing and in the home.[21,22] Foods used in pet foods are not deducted from these estimates.[21]

Survey intake estimates. Completed surveys that estimate food and nutrient intake by individuals for the US population include three USDA surveys—the 1965 to 1966 Household Food Consumption Survey (HFCS), the 1977–1978 Nationwide Food Consumption Survey (NFCS), and the 1987–1988 NFCS—and two US Department of Health and Human Services National Health and Nutrition Examination Surveys (NHANES) conducted by the National Center for Health Statistics (NCHS) from 1971 to 1974 and from 1976 to 1980. Despite some differences in sampling and measurement procedures among these surveys, all are designed to produce nationally representative data on food and nutrient intake by the US civilian, noninstitutionalized population.

Selection of Data for Comparison

The data selected for estimating trends included all available survey estimates of daily mean intake by the US population (i.e., periodic estimates from 1965 to 1988) and all available estimates of daily per capita food supply levels from a comparable time period (i.e., annual estimates from 1965 to 1985). Also, survey intake estimates based on all seasons were used when available to compare with annual food supply estimates. Although in the 1965 to 1966 HFCS data on individual intakes was only collected in the spring of 1965, its results for food energy and macronutrients (fat, carbohydrate, and protein) are assumed to reflect mean intake for all seasons, because in the 1977–1978 NFCS the mean intake of these nutrients varied among the seasons by only 1% to 2%.[19] All intake estimates were based on 1 day of intake measured by a 24-hour recall.

Data Points for Trend Estimates

The data points used to graph food supply trends were based on USDA published values.[22] The data points used to graph survey intake trends were derived from computer analyses of the USDA and NCHS survey data tapes performed with the Statistical Analysis System (SAS).[23] The mean intake of macronutrients expressed as percentage of calories for the US population was calculated by averaging individual values. To provide results representative of the US population, we weighted the data from the 1977 to 1978 and 1987 to 1988 NFCS and two NHANES, using factors supplied with the data tapes to adjust for sampling fractions and nonresponse. The 1965 to 1966 HFCS data were weighted with factors generated by our computer staff that were assigned in the same manner as USDA published results (i.e., persons aged 20 to 64 years were counted twice to adjust for half-sampling).[24]

Comparison of Trend Estimates

Harvard Graphics software was used to prepare graphs with best-fit trend lines drawn through the data points for food supply and survey intake estimates[25] (Figure 1). In addition, the homogeneity of the slopes for the two types of trend estimates was assessed with the SAS General Linear Models procedure.[26]

During initial analyses, we observed large differences between two surveys conducted during a similar time period (the 1977–1978 NFCS and the 1976–1980 NHANES) when macronutrients were expressed as percentage of calories. Therefore, USDA and NCHS data points were not grouped together for estimation of these trends. Rather, the three data points from the USDA surveys, which spanned more years than the NCHS surveys, served as the basis for comparing food supply and survey intake trends. The data points from the two NCHS surveys are, however, shown on the graphs (Figure 1, D–F).

Results

Gram Amounts of Macronutrients

A comparison of trends over the last two decades in gram amounts of macronutrients for the two types of data is shown in Figures 1A to 1C. For fat, per capita US food supply estimates increased, whereas survey estimates of mean intake by the US population decreased (Figure 1A). For carbohydrate, per capita food supply estimates increased, whereas survey intake estimates changed little (Figure 1B). For protein, per capita food supply estimates increased, whereas survey intake estimates decreased (Figure 1C).

Thus, the two types of data did not reflect the same trend when these macronutrients were expressed in absolute amounts (tests of the null hypothesis for homogeneity of slopes, $P < .001$). To further examine these differences, we compared food energy time trends for the two types of data (Figure 2). We observed trend differences similar to those shown in Figures 1A to 1C: per capita food supply estimates increased, whereas survey intake estimates decreased.

The estimated levels of macronutrients and food energy from the food supply data were considerably higher than the estimated levels from the survey intake data. The ratios of food supply to survey intake estimates for comparable time periods ranged from approximately 1.5 to 2.3 for fat, 1.7 to 2.0 for carbohydrate, 1.2 to 1.5 for protein, and 1.5 to 2.0 for food energy.

Percentage of Calories from Macronutrients

A comparison of trends over the last two decades in percentage of calories from macronutrients for the two types of data is shown in Figures 1D to 1F. For fat, per capita food supply estimates generally changed little, whereas intake estimates from the USDA surveys decreased considerably (Figure 1D). For carbohydrate, per capita food supply estimates generally changed little, whereas intake estimates from the USDA surveys increased considerably (Figure 1E). For protein, per capita food supply estimates and intake estimates from the USDA surveys changed little (Figure 1F). Thus, the two types of data generally did not reflect the same trend when these macronutrients were expressed in relative amounts (test of the null hypothesis for homogeneity of slopes, $P < .01$).

Gram Amounts versus Percentage of Calories

Expressing macronutrients as percentage of calories rather than in grams affected the relationship between the food supply and survey intake trend lines. Specifically, how the data were expressed affected whether or not the trend lines for food supply and USDA survey intake estimates intersected for fat (Figures 1A and 1D), converged or diverged for carbohydrate (Figures 1B and 1E), or were at

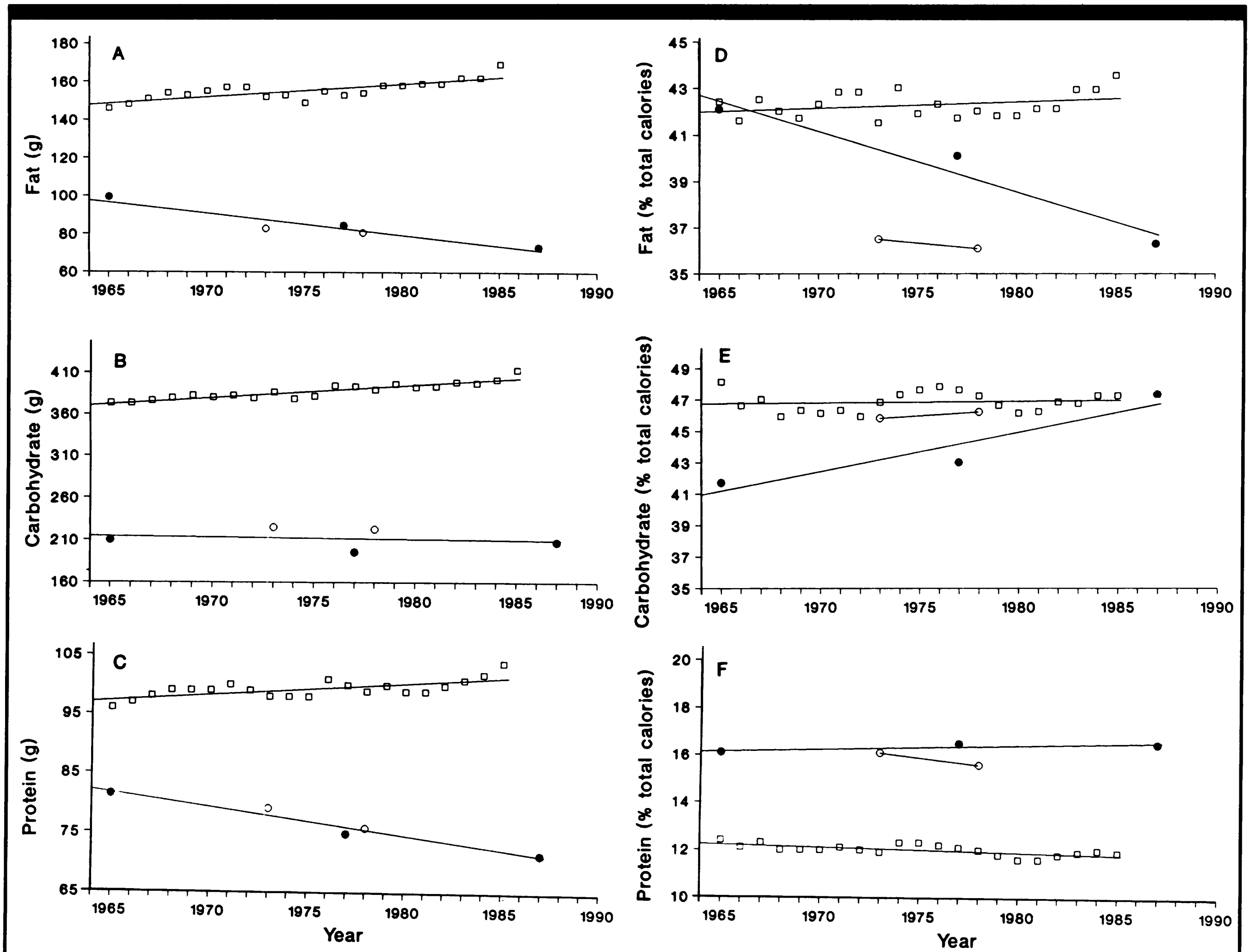

FIGURE 1—(A–C) Trends in per capita US food supply levels of macronutrients in grams (□) versus survey estimates of mean intake of macronutrients in grams by the US population (US Department of Agriculture [USDA], ●; National Center for Health Statistics [NCHS], ○). (D–F) Trends in per capita US food supply levels of macronutrients as a percentage of calories (□) versus survey estimates of mean intake of macronutrients as a percentage of calories by the US population (USDA, ●; NCHS, ○). Tests of the null hypothesis for homogeneity of slopes were (A) $P < .0001$; (B) $P < .001$; (C) $P < .0001$; (D) $P < .0001$; (E) $P < .001$; (F) $P < .01$.

higher or lower levels for protein (Figures 1C and 1F). Thus, for these three macronutrients there was no consistent pattern for these trend line relationships.

Discussion

It has been shown previously that when macronutrients are expressed in absolute amounts, per capita food supply estimates of macronutrients for a given time period tend to be considerably greater than survey intake estimates.[1] Two factors contribute to the observed differences: (1) Actual consumption may be overestimated when food supply data are used because certain food losses and waste are not deducted,[24,25] and (2) actual consumption may be underestimated when individual survey intake data are used because of bias and other inaccuracies with self-reports.[27] Yet despite these observed differences, it has been assumed that trends over time in these two types of estimates would be similar, and thus the historically more frequent food supply estimates of foods and nutrients have been used as a surrogate indicator of trends in intake by individuals. Our study showed, however, that for macronutrients the two types of data generally did not reflect the same trends, and that results may be influenced by how the data are expressed. Individual trends and relationships among trends may differ when macronutrient intakes are expressed as percentage of calories because (1) the interrelationship among the macronutrients is stronger than when they are expressed in grams, and (2) more than twice as many calories are contributed by fat as are contributed by protein and carbohydrate.

Factors that may contribute to differences between food supply and survey intake trends include differences in the way the two types of data are collected and in the way individual data points are derived. With regard to the former, plausible explanations have been proposed for the increase in food supply estimates of fat over the last two decades that are not observed with survey intake estimates of fat over this time period. For example, the waste portion of fats and oils that is included in the food supply estimates, but not the survey intake estimates, has increased during the past two decades.[21] The growth of away-from-home eating places, especially fast-food restaurants, has contributed to this increase, as establishments that deep-

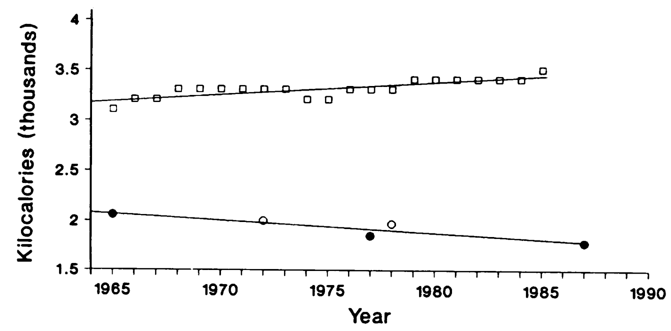

FIGURE 2—Trends in per capita US food supply levels of food energy (□) versus survey estimates of mean intake of food energy by the US population (US Department of Agriculture, ●; National Center for Health Statistics, ○). Test of the null hypothesis for homogeneity of slopes was $P < .0001$.

fry foods can generate significant amounts of fat waste.[21] Furthermore, any increase in the practice of trimming away visible fat from retail meat cuts by the US population should be reflected in individual survey intake estimates but would not be reflected in food supply estimates, because the food supply estimates include all fat on retail meat cuts.[22]

The differences in the two data collection methods with regard to waste may also contribute to the different food energy trends observed with the two types of data and to the different trends observed when nutrients are expressed in absolute amounts. An increasing discrepancy between food supply and survey intake estimates of food energy over time has also been noted in Japan and other countries.[28] It has been suggested that the discrepancy increases as the economy of a country, and thus its food system, becomes more extensive and complex, with more opportunities for loss or waste within the system.[28] The survey estimates may be more reflective of true energy intake trends than are food supply estimates. The observed decline in food energy intake by the US population is consistent with other dietary study results for a similar time period.[29]

Procedural and other differences in how individual data points are derived over time, however, could also contribute to the observed food supply and survey intake trends. Ideally, for trend analyses, study populations should be defined identically, sampling procedures should be equivalent, and measurement procedures should be identical.[30] In the real world, all of these conditions can rarely be met, and thus an assessment of the impact of population, sampling, and measurement differences is needed. Consideration of the representativeness of survey samples with respect to response rates is also needed. For example, it is unknown whether the weighted data of the 1987 to 1988 NFCS, which had a low response rate, provide unbiased estimates.

Even seemingly subtle differences in procedures used to estimate food disappearance or food intake over time, or in procedures used to estimate food intake during a similar time period, should be considered in these assessments. For example, it is possible that certain coding differences between the 1976–1980 NHANES and the 1977–1978 NFCS contribute to the substantially different results for fat intake as percentage of calories (36.1% and 40.1%, respectively).[31] In the 1976–1980 NHANES, a majority of respondents reported and were coded as trimming all visible fat from meat and not eating poultry skin. In contrast, in the 1977–1978 NFCS the majority of respondents were coded under a single code that combined responses for eating visible fat and poultry skin and for "not specified"; fat consumption for the "not specified" responses was assumed.

Insight into trends in macronutrient intake by the US population might also be gained by considering studies that do not individually comprise nationally representative samples together with surveys that do. One such analysis by regression of 171 studies conducted in the United States from 1920 to 1984 showed a decline in percentage of calories from fat from approximately 40% in the 1960s to approximately 37% to 38% during the period from 1980 to 1985.[29] However, in such analyses trends may be influenced by a few large studies and the studies may not be independent measures if a common food composition database is used.

We conclude that extreme caution is needed in the use of available data to estimate trends in macronutrient intake by the US population and in the interpretation of these data with regard to public health research, policies, and programs. We recommend that the role of food supply data as a surrogate indicator of trends in food and nutrient intake by individuals should be reviewed because of our study's findings and the additional data points now available from periodic large-scale surveys and the USDA Continuing Surveys of Food Intakes by Individuals. However, because of procedural and other differences among these surveys, the use of these data to assess trends will depend on additional studies that continue to try to distinguish between real and apparent changes in intake. □

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