UPDATE OF THE TOTAL DIET STUDY: SELECTED MINERALS IN FOODS SURVEY

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The Total Diet Study program allows the Food and Drug Administration (FDA) to monitor the levels of nutritional elements and contaminants in the United States food supply and to estimate the intake levels of these substances in the diets of selected age-sex groups. This program, which operates on a yearly basis, began in 1961 and underwent a significant revision in April 1982 to update the food list and diets, to increase the coverage of age-sex groups, and to analyze individual foods rather than food commodity groups.

Previous results from the Selected Minerals in Foods Survey, which is the portion of the Total Diet Study program that concerns nutritional elements, are summarized in Table 1. These results, obtained between 1974 and 1982, were based on diets developed from food consumption data of the 1965 U.S. Department of Agriculture (USDA) Household Food Consumption Survey. As indicated in Table 1, the diet of the adult male was adequate in calcium, phosphorus, magnesium, iron, potassium, manganese, and selenium; low in zinc and copper; and elevated in iodine and sodium. The dietary level of sodium included that from discretionary salt. The diet of the six-month-old infant was adequate in calcium, phosphorus, magnesium, zinc, potassium, manganese, and selenium; low in iron and copper; and elevated in iodine and sodium. The diet of the two-year-old child was adequate in calcium, phosphorus, magnesium, potassium, manganese, and selenium; low in iron, zinc, and copper; and elevated in iodine and sodium. The sodium levels of infant and toddler diets did not include that from discretionary salt. The major sources of iodine in these diets were the milk and dairy products commodity groups and the grain and cereal products commodity groups.

The current Total Diet Study program includes four collections per year, each from one of four geographical locations (east, west, south, and central). For each collection, the purchase and delivery of the foods takes four weeks, and the subsequent preparation and analyses of the food samples takes approximately two months. For each collection foods are obtained from three designated cities within the specified geographical area. The selected cities, which vary from year to year, represent standard metropolitan statistical areas and are in close proximity to FDA district offices.

Foods are sent to the Total Diet Laboratory in Kansas City, Missouri; those requiring preparation and/or cooking are sent to a contract kitchen and then returned to the Total Diet Laboratory for analyses. The three subsamples of each food from the three cities are composited prior to analyses. The concentrations of each nutrient or contaminant in each food from the four yearly collections are averaged. The food composition data are then merged with the food consumption data to estimate daily intake levels of the substances for the eight age-sex groups.

The analytical methods used to determine the eleven nutritional elements include inductively coupled plasma atomic emission spectroscopy (ICP-AES) for sodium, potassium, calcium, phosphorus, magnesium, iron, zinc, copper, and manganese; a colorimetric method for iodine; and atomic absorption spectrometry with rapid hydride evolution for selenium. Each series of 20-30 laboratory samples is accompanied by two blanks, one spiked laboratory sample, one laboratory sample in duplicate, and a standard reference material for each element. Questionable results require reanalysis of the entire series.

The 234 foods included in the Total Diet Study are based on results from the 1977-78 USDA Nationwide Food Consumption Survey (NFCS) and the Second National Health and Nutrition Examination Survey (NHANES II), which was conducted by the National Center for Health Statistics between 1976 and 1980. The Total Diet Study foods were selected on the basis of daily gram weight intake and frequency of consumption as indicated in these two national surveys. The 3700 foods in the NFCS data base and the 2600 foods in the NHANES II data base were aggregated according to food source and nutrient content. Foods within an aggregate that were consumed in the largest quantities were chosen to represent the aggregate. These aggregate representatives are the 234 Total Diet Study foods. The foods include dairy, meat, grain, fruit, and vegetable products, mixed dishes and soups, desserts, fats and sauces, sweeteners, beverages, and commercial infant foods and formulas. The diets developed for the eight age-sex groups contain typical quantities of these foods and have caloric values representative of these groups.

The results for the first two years (1982/83 and 1983/84) of the revised Total Diet Study are indicated in Table 2. Calcium was adequate for infants, teenage boys, and adult males, but low for the other groups. The calcium levels of the diets of teenage girls, adult women, and older women were especially low (61 to 71% of the Recommended Dietary Allowance (RDA)). Phosphorus was adequate for all diets, but a bit low (89% RDA) for the teenage girl. Magnesium was adequate for infants and toddlers, but low for teenagers, adults, and older adults. Magnesium was especially low (61 to 64% RDA) for teenage girls, adult women, and older women. Iron was low for infants, toddlers, teenage girls, and adult women. The latter three groups met only 56 to 59% of the RDA. Iron requirements were adequately met by teenage boys, adult men, and older men and women. Zinc levels were adequate for infants, teenage boys, and adult men, but low for other groups. The zinc levels of the diets of teenage girls, adult women, and older women were especially low (57 to 66% RDA). Iodine levels were high for all groups (1.7 to 6.6 times the RDA).

Major sources of iodine were milk and dairy products, fish, and various commercial products that were thought to contain iodine-containing food additives such as iodized salt, erythrosine (FD&C Red No. 3), iodate dough conditioners, and/or carrageenan. The iodine in milk and dairy products results from the use of iodine supplements in cattle feed (to prevent iodine deficiency and mistakenly thought to prevent various diseases a improve reproductive efficiency) and from the use of iodophor disinfectants used to clean cattle and dairy equipment. Because these diets do not contain iodine from discretionary iodized salt, the iodine levels reported here are underestimated for those who use this product.

Levels of sodium, potassium, copper, manganese, and selenium in the Total Diets are compared with Estimated Safe and Adequate Daily Dietary Intakes (ESADDIs) in Table 2. The sodium levels of these diets did not include discretionary salt (that added at the table). However, items made according to a recipe contained added salt if specified by the recipe, and many of the commercially prepared food items contained added salt. The sodium levels of the diets were within the ESADDI ranges except for the diets of the toddler and teenage boy, which exceeded the ESADDI range. Potassium levels were within the ESADDI ranges, except for the infant diet, which exceeded the upper range. Copper levels were below the ESADDI ranges for all age-sex groups. Manganese levels were within ESADDI ranges for toddlers, teenage boys, adult males, and older males; above the range for infants; and below the range for teenage girls, adult women, and older women. Selenium levels were within the ESADDI ranges for all age-sex groups.

Results for the third year (1984/85) of the Total Diet Study are undergoing review, and results of the fourth year should be available by July 1986. At that point, the yearly results from 1982/83 to 1985/86 will be analyzed to determine if any significant trends in nutrient intake are apparent. Preliminary results from the first three years, which have not yet been statistically evaluated, indicate that sodium levels of the diets have been decreasing by about three percent per year and that iodine levels dropped about 50% between the second and third years.

The toxic elements arsenic, cadmium, lead, and mercury are also routinely analyzed in the Total Diet Study as part of the contaminants program. The results for these elements and other contaminants are evaluated and reported by the Division of Chemical Technology of the FDA. The data for the first two years of the revised Total Diet Study indicated that the levels of lead, mercury, and cadmium in daily diets were below the provisional tolerable intakes established by Food and Agricultural Organization/World Health Organization. Provisional tolerable levels for arsenic have not been established, but the levels found in the Total Diet Study were acceptable.

The Total Diet Study is part of the National Nutrition Monitoring System. The Selected Minerals in Foods Survey of the Total Diet Study allows for continued yearly monitoring of the typical levels of nutritional elements in foods and diets. The unique features of this survey are that it provides yearly data; it includes some nutritional elements (e.g., copper, manganese, selenium, and iodine) not evaluated in other surveys; and the values are obtained from direct laboratory analyses.

The results from the Selected Minerals in Foods Survey assist FDA in making policy decisions concerning manufacturing and agriculture practices, nutrient fortification, and use of food additives. For example, the high levels of iodine noted in previous Total Diet Studies and seen in current results uphold FDA's decisions to limit the levels of iodine in permitted food additives and to not allow for any new food additives containing iodine. FDA has also encouraged the dairy industry to use only the amount of iodine feed supplement and iodophor solutions necessary for their respective functions and to avoid excess. With regard to sodium and the concern about the association of this element with

hypertension, FDA has encouraged industry to reduce the levels of sodium in food products. As mentioned, preliminary results from the first three years of the revised Total Diet Study indicate trends that might be consistent with industry compliance to FDA requests.

Samples from one Total Diet Study collection in 1985 were forwarded to the Division of Chemical Technology in Washington, D.C. and analyzed by ICP-AES for several additional elements of interest to FDA. These elements included aluminum, molybdenum, cobalt, nickel, vanadium, and strontium. The results for aluminum have been submitted for publication. They indicated rather modest intakes of this element in comparison with previous reports of aluminum consumption. Major dietary sources of aluminum were processed cheese containing an aluminum additive, baked products containing aluminum additives in the baking powder, and tea. A paper concerning the data for molybdenum, cobalt, nickel, vanadium, and strontium is undergoing agency clearance.

The Selected Minerals in Foods Survey will continue on a yearly basis to monitor the levels of eleven nutritional elements in the food supply and in the diets of eight age-sex groups. Of special concern are the low levels of calcium, magnesium, iron, zinc, copper, and manganese and elevated levels of sodium and iodine in the diets of selected age-sex groups. We anticipate the addition of two nutritional elements, molybdenum and nickel, to the Selected Minerals in Foods Survey in the near future.

Table 1

Results from the Selected Minerals in Foods Survey, 1974-82*

(% RDA)	adult male	6-month infant	2-year child
Ca	135-149	153-187	92-111
P	209-223	235-251	129-141
Mg	94-102	197-203	113-115
Fe	179-210	31-68	51-79
Zn	83-93	100-142	81-96
I	213-551	364-1152	230-1040
(comparison with ESADDI)			
Na	high+	high	high
K	OK	high	high
Cu	low	low	low
Mn	OK	high	OK
Se	OK	OK	OK

* Pennington, J.A.T., et al., J. Am. Diet. Assoc. 84(7):771-780, 1984.
\+ Includes discretionary salt.

Table 2

Results from the Selected Minerals in Food Survey, 1982/83 & 1983/84*

(% RDA)	Ca	P	Mg	Fe	Zn	I
6-11 mo f&m+	137	194	169	79	105	400
2 yr f&m	80	106	103	56	74	657
14-16 yr f	61	89	64	59	66	280
14-16 yr m	95	137	74	96	104	473
25-30 yr f	71	122	62	58	64	180
25-30 yr m	105	192	82	159	108	347
60-65 yr f	62	110	61	102	57	167
60-65 yr m	82	156	70	144	84	227

(comparison) with ESADDI)	Na	K	Cu	Mn	Se
6-11 mo f&m	OK	HIGH	LOW	HIGH	OK
2 yr f&m	HIGH	OK	LOW	OK	OK
14-16 yr f	OK	OK	LOW	LOW	OK
14-16 yr m	HIGH	OK	LOW	OK	OK
25-30 yr f	OK	OK	LOW	LOW	OK
25-30 yr m	OK	OK	LOW	OK	OK
60-65 yr f	OK	OK	LOW	LOW	OK
60-65 yr m	OK	OK	LOW	OK	OK

*Pennington, J.A.T., et al., J. Am. Diet. Assoc., in press, July 1986.
+ f = female; m = male.