Maternal Nutrition Knowledge and Children's Diet Quality and Nutrient Intakes.
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Abstract

We found significant evidence that the more a mother knows about health and nutrition the better is the overall quality of her children's diet, for preschoolers more so than older children. We also found that a mother's years of schooling, smoking status, race, and ethnicity influence her children's diet. Our results imply that health and nutrition education may be more effective if targeted toward mothers with young children but directly toward school-age children. We assessed overall diet quality using the Healthy Eating Index, the U.S. Department of Agriculture's instrument for measuring overall diet quality incorporating 10 recommended nutritional guidelines.

Keywords: Child nutrition, child health, Healthy Eating Index, nutrition knowledge, household production theory, latent variable model.

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Summary

We found significant evidence that greater maternal knowledge of health and nutrition leads to better diet quality for preschoolers but not necessarily for school-age children after accounting for the influence of maternal background characteristics, health habits, and household characteristics. A mother's years of schooling benefits her child's diet quality because more highly educated women tend to have more nutrition knowledge. The results closely agree with previous findings on the maternal role in children's health and nutrition obtained from a variety of samples in developing countries. We also found strong diet effects within families that are generated by the health habits of individual family members. Significant evidence was found that maternal knowledge of health and nutrition influenced children's nutrient intakes and that such influence decreased as children grow older. Our results lead to the conclusion that health and nutrition education may be more effective if targeted toward mothers with young children but directly toward school-age children.

Dietary patterns established in childhood and adolescence may significantly influence the probability of acquiring certain chronic diseases in the future. The *Dietary Guidelines for Americans* also notes that "Healthful diets help children grow, develop, and do well in school" and recommends specific intake levels for all age groups above 2 years old. Healthy dietary habits established in childhood may also be carried into adulthood. Many health authorities, therefore, recommend that parents, teachers, and other influential adults guide children in developing healthful eating patterns and acquiring information on nutrition and diet-health relationships.

For these reasons, interest in understanding the determinants of the quality of children's diets is growing. Of particular interest to nutritionists and public health officials is the role of the mother's nutrition knowledge on the diet quality of her children. This relationship has special policy interest because provision of health and nutrition information is a major tool of agencies promoting more healthful diets among Americans. Evidence on the role of maternal nutrition information in children's diets would indicate the likely social return to the continued provision of nutrition information. The role of maternal nutrition information is also of interest to economists studying children's health issues. The question of whether information plays a role after accounting for parental and family background variables is still unanswered. Most previous studies have lacked either proper measures of information or controls for all relevant background characteristics to reach a definitive conclusion.

This report studies the influence of maternal nutrition knowledge, and other maternal and household characteristics, on the overall diet quality of U.S. children ages 2-17 years old and on the intakes of individual nutrients. Much of the existing research on the maternal role in children's health and nutrition is in the economic development literature, and only a few sources have provided direct evidence on the role of information. Relatively little is known in the U.S. context about the relationship between a child's diet and the nutritional knowledge of the person responsible for meal planning or preparation, usually the mother. The existing U.S. evidence linking parental nutrition knowledge and children's intake of nutrients is mixed. Lack of controls for measurement errors and endogeneity of parental nutrition knowledge may have contributed to these inconclusive results.

We based our analysis on the household production model used by economists to study health behaviors and outcomes among individuals. A mother's influence on household productivity through factors such as diet and the nutrition of children is also a crucial aspect of economic models of the family. In these models, consumers make different health-related decisions partly because access to and costs of acquiring health information and using it efficiently varies from one individual to another: the allocative efficiency effect. For example, higher incomes may make information more accessible, and greater education may enhance the efficiency of information use. Our study examines the sources, such as a mother's education, of the relationship between a mother's knowledge of nutrition and her children's nutritional outcomes.

The first phase of the study estimated the influence of maternal nutrition knowledge, and other maternal and household characteristics, on the diet quality of children ages 2 to 17. Diet quality is measured using the Healthy Eating Index (HEI), the U.S. Department of Agriculture's (USDA) instrument for measuring overall diet quality incorporating 10 recommended nutritional guidelines. We include children from ages 2 to 17, allowing us to examine whether parental influence on children's diets diminishes as children grow older. Most dietary experts, as well as the *Dietary Guidelines for Americans* advocate a diet that contains a variety of foods and nutrients. Consequently, a measure of overall diet quality is desirable for estimating maternal influence on behaviors that are closely related to future health outcomes.

The second phase of the study uses a nationally representative sample of U.S. households to estimate the effect of maternal health and nutrition knowledge on children's intakes of fat, saturated fat, cholesterol, fiber, sodium, calcium, and iron.

Both phases used a simultaneous equations framework to control for unobserved family heterogeneity that may contaminate single-equation estimates of such relationships. Another feature of this study concerns the measurement of information. USDA data provide mothers' responses to an extensive set of questions about nutrition and health that can be used to develop direct measures of mothers' knowledge of nutrition and health. Our information measures capture the actual stock of maternal nutrition knowledge as opposed to indicators of access to information. Using latent variable methods, we also account for measurement errors and endogeneity of maternal nutrition knowledge.

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Introduction

Dietary patterns established in childhood and adolescence may significantly influence the probability of acquiring certain chronic diseases as an adult (Kemm, 1987; McGill and others, 1997; McPherson, Montgomery, and Michaman, 1995; Nicklas, Farris, and Smoak, 1988). USDA's *Dietary Guidelines for Americans* notes that "Healthful diets help children grow, develop, and do well in school" and recommends intake levels for everyone over 2 years old (U.S. Dept. of Agr. and U.S. Dept. of Health and Human Services, 1995). Healthful dietary habits established in childhood may be carried into adulthood. Many health authorities, therefore, recommend that parents, teachers, and other influential adults guide children in developing healthful eating patterns and acquiring information on nutrition and diet-health relationships.

For these reasons, interest in understanding the determinants of the quality of children's diets and the pathways of their influence is growing among health professionals. Of particular interest to nutritionists and public health officials is the role of mothers' nutrition knowledge on the diet quality of their children. This relationship has special policy interest because provision of health and nutrition information is a major tool of agencies promoting more healthful diets among Americans (Thomas, 1991). Evidence on the role of maternal nutrition information in children's diets might indicate the likely social return to nutrition information provided by the government. The role of maternal nutrition information is also of interest to economists studying children's health issues. Specifically, an issue still being debated is the role of nutrition information after accounting for parental and family background (Behrman, 1995). Most previous studies have lacked either proper measures of information or controls for all relevant background characteristics to reach a definitive conclusion in this regard.

This report studies the influence of mothers' knowledge of nutrition, and other maternal and household characteristics, on the diet quality and nutrient intakes of U.S. children ages 2-17 years old. We do not focus on both mothers and fathers because of data limitations. Much of the existing research on mothers' role in their children's health and nutrition is in the economic development literature (Barrera, 1990; Behrman, 1995; Behrman and Wolfe, 1987; Haughton and Haughton, 1997; Kassouf and Senauer, 1996; Senauer and Garcia, 1991; Thomas and Strauss, 1992), and only a few have provided direct evidence on the role of information (Thomas, Strauss, and Henriques, 1991). Relatively little is known in the U.S. context about the relationship between a child's diet and the nutritional literacy of the person responsible for meal planning or preparation, usually the mother. The existing U.S. evidence linking parental nutrition knowledge and children's intake of nutrients is mixed (Colavito and others, 1996; Klesges and others, 1991). Lack of controls for measurement errors and endogeneity of parental nutrition knowledge may have contributed to these inconclusive results.

Our analysis is based on the household production model used by economists to study health behaviors and outcomes among individuals (Behrman and Deolalikar, 1988; Rosensweig and Schultz, 1983). A mother's influence on household productivity through factors such as diet and the nutrition of children is also a crucial aspect of economic models of the family (Behrman and Wolfe, 1987; Leibowitz, 1974; Taubman, 1977). In these models, consumers make different health-related decisions partly because access to and costs of acquiring health information as well as its efficient use varies from one individual to another: the allocative efficiency effect (Grossman and Kaestner, 1995). For example, higher incomes may make information more accessible and greater education may enhance the efficiency of information use. Our study examines the sources of the relationship between a mother's nutrition knowledge and her children's nutritional outcomes.

This study was done in two phases: The first phase of the study estimated the influence of maternal nutrition knowledge and other maternal and household characteristics on the diet quality of children ages 2 to 17. Diet quality was measured using the Healthy Eating Index (HEI), the U.S. Department of Agriculture's (USDA) instrument for measuring overall diet quality incorporating 10 nutritional recommendations. By including children from ages 2 to 17, we can examine whether parental influence on children's diets diminishes as children grow older. This is the first analysis, to our knowledge, to focus on overall diet quality that accounts for foods, nutrients, and variety, as opposed to the intake of individual nutrients only.

The second phase of the study focused on individual nutrients and dietary components. Specifically, the effect of maternal knowledge of health and nutrition on children's intakes of total fat, saturated fat, cholesterol, fiber, sodium, calcium, and iron was estimated.

We used a simultaneous equations framework in both phases to control for unobserved family heterogeneity that may contaminate single-equation estimates of such relationships. Another feature of this study concerns the measurement of information. USDA data provide mothers' responses to an extensive set of questions about nutrition and health that can be used to develop direct measures of maternal knowledge of health and nutrition. Our information measures capture the actual stock of maternal nutrition knowledge rather than indicators of access to information (as in Thomas, Strauss, and Henriques, 1991). Using latent variable methods, we also account for measurement errors and endogeneity of maternal nutrition knowledge.

Children's Diet Quality and Nutrient Intakes in the Household Production Model

The household production model used by economists to study health behaviors and outcomes offers a rich framework for estimating and interpreting the determinants of children's nutrient intakes and diet quality (Behrman and Deolalikar, 1988; Strauss and Thomas, 1996). The model integrates biological, socio-demographic, and economic factors, all of which influence household production efficiency and consumption decisions. The basic idea behind this model is that households allocate time and goods to produce commodities, including the health of children and other family members, so as to maximize a joint utility function. Subject to technology, time, and income constraints, the household utility maximization generates individual and household demand functions for health, health inputs, and other consumption goods.

The reduced-form food and nutrient demand equations resulting from household utility maximization can be written as functions of a vector of prices **p**, income **I**, a vector of individual and household characteristics **x**, and unobserved household and individual effects, **u** (for example, Haughton and Haughton, 1997; Senauer and Garcia, 1991). The reduced-form nutrient demand functions resulting from the above maximization framework have the general form

$$\mathbf{c} = \mathbf{f}(\mathbf{p}, \mathrm{I} \mid \mathbf{x}, \mathbf{u}) \qquad (1)$$

where **c** is a vector of nutrients consumed.[1] Because a child's overall diet quality (measured here by the HEI) is a composite measure developed from the foods and nutrients consumed, its reduced form has an identical form given by

$$\mathrm{HEI} = f(\mathbf{p}, \mathrm{I} \mid \mathbf{x}, u). \qquad (2)$$

Most cross-sectional studies using the household production approach assume that prices are either fixed or captured by regional dummy variables and focus mainly on income and components of **x**. The usefulness of the household production approach in estimating functions of the above form is in guiding what should be included among **x**. With respect to child-health inputs and outcomes, the vector **x** has traditionally included four sets of variables: child's characteristics, parental characteristics, household characteristics, and community characteristics (Strauss and Thomas, 1996). Introducing mothers' knowledge of health and nutrition as an additional variable into the above equation reflects its role as a factor mediating part of the influence of the **x** variables on children's health and nutrition. The major question in this regard is whether the effects on health of some of the variables in **x** reflect differences in parental knowledge of health and nutrition. Consider, for example, the effect of education. Several studies from developing countries (Barrera, 1990; Kassouf and Senauer, 1996; Senauer and Garcia, 1991; Thomas and Strauss, 1992) cite a link between mothers' education and the nutritional status and health of their children. Yet education is seen as working mainly by improving allocative efficiency: education increases the mother's access to knowledge and information, enabling her to select a better input mix for more efficient child health production (Grossman and Kaestner, 1995; Thomas, Strauss and Henriques, 1991).

[1] In a fully specified household production model, the time and income constraints are expressed as a "full income" constraint that leads to reduced-form demand functions that contain wage rates (the value of time) and full or nonlabor income. In such a model, money income is subject to endogeneity because it reflects time allocated to work in the labor force. However, Senauer, Sahn, and Alderman (1986) found that empirical results are similar when either "full" or "money" income is used.

This view suggests that reduced-form health or health input equations estimated without explicit control for the effect of health knowledge may overstate the effect of education. Other characteristics that influence child health and nutrition, such as income, may also play a similar role partly through their effect on mothers' knowledge. These issues can be addressed by introducing a measure of mothers' nutrition knowledge into the reduced-form equations 1 and 2.

A key empirical issue in sorting out the maternal information effect concerns the potential endogeneity of any information measure. Any effect detected for mothers' information on children's diet quality may represent unobserved maternal and household factors that are influencing both. To some extent, such effects can be controlled by including parental background characteristics such as height, weight, and household characteristics in the HEI function or the nutrient intake equations. However, given that not all background characteristics are observable, children's diet quality and maternal information both need to be treated as jointly determined. In this case, equations 1 and 2 can be expanded and written as

$$(3) \quad HEI = f(\mathbf{p}, I \mid \mathbf{x}, K, u), \quad K = g(\mathbf{z}, v),$$

and

$$(4) \quad \mathbf{c} = \mathbf{f}(\mathbf{p}, I \mid \mathbf{x}, K, \mathbf{u}), \quad K = g(\mathbf{z}, v)$$

where K is a measure of mothers' knowledge of health and nutrition, $\mathbf{z}$ is a vector of knowledge determinants, and v is an unobserved individual effect that may be correlated with $\mathbf{u}$.

Data

Our studies used data from USDA's 1989-91 Continuing Survey of Food Intakes by Individuals (CSFII) and the companion Diet and Health Knowledge Survey (DHKS) (Cypel and others, 1996). For the HEI study, we used households that completed the 1989-90 surveys because the 1991 survey does not have calculated values for the Healthy Eating Index. For the nutrient phase, we used all 3 survey years.

The CSFII survey collects information on what, when, and where Americans eat and how much they eat. Each CSFII participant was asked to provide 3 consecutive days of dietary data. Dietary intakes of children under age 12 were provided by an adult, usually the parent. The first day's data were collected via an in-home interview using a 1-day dietary recall. The second and third days' data were collected using a self-administered 2-day dietary record. Social, economic, and demographic characteristics of survey participants are also included in the CSFII.

The CSFII uses a multistage, stratified selection procedure targeted at private households in the 48 contiguous States. In the 1989-91 surveys, 23,142 housing units were selected, which after screening resulted in 8,443 eligible households, of which 6,718 (79.6 percent) participated.

The DHKS was conducted as a telephone or in-person follow-up to the CSFII. One respondent, usually the household's main meal planner, was contacted about 6 weeks after collection of the dietary data and asked to answer questions about his or her knowledge of nutrition, diet, and health issues. Among the 6,178 households participating in the 1989-91 CSFII, 5,730 (85.3 percent) completed the DHKS.

Because the *Dietary Guidelines for Americans* are aimed at individuals age 2 and over, children between the ages of 2 and 17 were chosen for analysis. To explore the hypothesis that a mother's influence on her children's diets weakens with children's age, the analysis was conducted for two age groups: 2-5 and 6-17. Of the households with children in the two age groups, a large percentage had only a single child in one age group. To avoid intrafamily effects, we randomly selected one child from households with more than one child in an age group for all the analyses. After we eliminated observations with missing values, our final sample sizes were as follows: 308 preschool children and 538 school-age children for the HEI phase and 458 preschool children and 853 school-age children for the nutrients phase.

Table 1 contains the means and standard deviations for the variables used in the HEI study, separated into two age groups: 2-5 years old and 6-17. Table 2 reports similar descriptive statistics for children's intakes of seven nutrients. In conformity with the *Dietary Guidelines* units, we expressed fat and saturated fat intake by their percent contribution to a child's total energy intake per day. The intakes of the remaining five nutrients were expressed in a closely related unit, the nutrient-to-calorie density—grams of nutrient consumed per 1,000 kilocalories—employed widely in nutrition studies (Colavita and others, 1996; Lin, Guthrie, and Blaylock, 1996). These relative measures give us an assessment of the nutritional quality of children's diets. Details on the construction of the Healthy Eating Index are provided in the Appendix.

Table 1—Description of variables used in children's HEI study

Variable (unit)	Ages 2-5 Mean	Ages 2-5 Standard deviation	Ages 6-17 Mean	Ages 6-17 Standard deviation
Child's HEI (score)	65.44	12.44	62.64	11.74
Child's characteristics:				
Age (years)	3.48	1.09	11.04	3.52
Female (proportion)	.43	—	.52	—
Mother's nutrition knowledge:				
Nutrient Content Knowledge (score)	15.19	2.81	15.49	2.66
Diet-Health Awareness (score)	6.29	2.33	6.50	2.34
Mother's characteristics:				
Education (years)	12.30	2.43	12.24	2.57
Age (years)	29.79	5.57	36.53	6.71
Height (inches)	64.10	2.60	64.27	2.68
Weight (pounds)	147.11	34.51	153.31	36.85
Smoker (proportion)	.30	—	.28	—
Household characteristics:				
Income ($000)	22.17	20.52	25.68	21.33
Household size (number)	4.44	1.69	4.30	1.57
Race (White omitted) —				
Black (proportion)	.16	—	.16	—
Other[1] (proportion)	.02	—	.02	—
Hispanic (proportion)	.11	—	.10	—
Any member on a vegetarian diet (proportion)	.06	—	.03	—
Receives Food Stamps (proportion)	.30	—	.20	—
Receives WIC[2] benefits (proportion)	.19	—	.06	—
Region (Northeast omitted) —				
Midwest (proportion)	.29	—	.26	—
South (proportion)	.32	—	.36	—
West (proportion)	.18	—	.20	—
Urbanization (city omitted) —				
Suburban (proportion)	.46	—	.43	—
Nonmetro (proportion)	.23	—	.24	—
Year (1989 omitted) —				
1990 (proportion)	.51	—	.47	—
1991 (proportion)	.08	—	.09	—
Season (winter omitted) —				
Spring (proportion)	.18	—	.19	—
Summer (proportion)	.29	—	.27	—
Fall (proportion)	.28	—	.28	—
Intake recorded on weekend (weekday omitted)—				
Day 1 (proportion)	.23	—	.27	—
Day 2 (proportion)	.24	—	.30	—
Day 3 (proportion)	.31	—	.32	—
		Number		
Number of children	308	—	538	—

— = Not applicable.
[1]Asian/Pacific Islander, Aleut, Eskimo, or American Indian.
[2]Women, Infants, and Children.
Source: CSFII-DHKS, 1989-90, U.S. Department of Agriculture.

Table 2—Description of variables used in children's nutrient intakes study

Variable (unit)	Ages 2-5 Mean	Ages 2-5 Standard deviation	Ages 6-17 Mean	Ages 6-17 Standard deviation
Nutrient intake (per day):				
Total fat (percent of total calories)	34.47	5.98	34.73	5.63
Saturated fat (percent of total calories)	13.65	3.18	13.12	2.76
Cholesterol (gm/1000 calories)	.15	.07	.13	.06
Fiber (gm/1000 calories)	6.45	2.21	6.69	2.15
Sodium (gm/1000 calories)	1.70	.36	1.70	.33
Calcium (gm/1000 calories)	.59	.19	.50	.16
Iron (mg/1000 calories)	7.64	2.82	7.24	2.70
Child's characteristics:				
Age (years)	3.47	1.10	11.14	3.58
Female (proportion)	.45	—	.45	—
Mother's nutrition knowledge:				
Nutrient Content Knowledge (score)	15.61	2.70	15.82	2.62
Diet-Health Awareness (score)	6.21	2.44	6.46	2.38
Household characteristics:				
Race (White omitted)—				
Black (proportion)	.16	—	.16	—
Other[1] (proportion)	.03	—	.02	—
Hispanic (proportion	.11	—	.10	—
Female head (proportion)	.27	—	.30	—
Any member on a vegetarian diet (proportion)	.06	—	.05	—
Low-fat/low-calorie diet (proportion)	.05	—	.08	—
Receives Food Stamps (proportion)	.30	—	.22	—
Receives WIC[2] benefits (proportion)	.19	—	.07	—
Income[3] (percent)	174.10	173.50	208.40	203.40
Region (Northeast omitted) —				
Midwest (proportion)	.30	—	.29	—
South (proportion)	.34	—	.35	—
West (proportion)	.19	—	.20	—
Urbanization (city omitted)—				
Suburban (proportion)	.45	—	.43	—
Nonmetro (proportion)	.23	—	.27	—

See notes at end of tables

—Continued

Table 2—Description of variables used in children's nutrient intakes study—Continued

Variable (unit)	Ages 2-5 Mean	Ages 2-5 Standard deviation	Ages 6-17 Mean	Ages 6-17 Standard deviation
Mother's characteristics:				
Education (years)	12.23	2.45	12.22	2.56
Age (years)	29.66	5.76	36.66	6.86
Employment (full omitted) —				
Part employed (proportion)	.19	—	.19	—
Not employed (proportion)	.60	—	.44	—
Smoker (proportion)	.33	—	.30	—
Disease (proportion)	.04	—	.10	—
Received diet advice (proportion)	.05	—	.06	—
Survey characteristics:				
Year (1989 omitted) —				
1990 (proportion)	.35	—	.32	—
1991 (proportion)	.29	—	.31	—
1992 (proportion)	.07	—	.09	—
Season (winter omitted) —				
Spring (proportion)	.17	—	.18	—
Summer (proportion)	.31	—	.28	—
Fall (proportion)	.28	—	.27	—
Intake recorded on weekend — (weekday omitted)				
Day 1 (proportion)	.24	—	.26	—
Day 2 (proportion)	.23	—	.29	—
Day 3 (proportion)	.28	—	.31	—
		Number		
Number of children	458	—	853	—

— = Not applicable.

[1]Asian/Pacific Islander, Aleut, Eskimo, or American Indian.

[2]Women, Infants, and Children.

[3]Expressed as a percentage of the poverty threshold.

Source: CSFII-DHKS, 1989-91, U.S. Department of Agriculture.

Measuring Health and Nutrition Knowledge

We used responses from two sets of questions in the DHKS to develop measures of mothers' knowledge of health and nutrition. The first set of questions aimed to capture the "nutrient content knowledge" (NCK) of the respondents (table 3). Respondents were asked a series of questions about sources and occurrence of dietary fiber, cholesterol, and fat in common food items. For example, respondents were asked to identify which of two foods has the higher fiber content: fruit or meat, cornflakes or oatmeal, popcorn or pretzels. In general, there was broad agreement between the HEI and nutrient samples. However, respondents were more successful at correctly answering some questions than others. For example, over 90 percent of respondents from all samples knew that wheat bread has a higher fiber content than white bread but only 33 percent knew that liver has more cholesterol than T-bone steak. Other questions probed knowledge about different kinds of fat and the types of foods that contain fat and cholesterol. The NCK measure represents the number of correct answers a respondent gave to 21 such questions. Respondents in the HEI studies answered about 15 questions correctly while those in the samples for the nutrient intake analysis answered about 16 correctly. The second set of questions to assess mothers' knowledge of health and nutrition was aimed at their "diet-health awareness" (DHA). These questions take the general form: Have you heard about any health problems that might be related to how much of a particular nutrient (such as fat, fiber, salt, and so forth) a person eats? Nine such questions from the DHKS and their percent "yes" are listed in table 4. The DHA variable is the sum of positive responses for the nine questions. This measure is similar to Kenkel's (1991) health knowledge measure in a study of adult smoking, alcohol use, and exercise behavior. The average "awareness" level was about six for the mothers in all samples (tables 1 and 2).

Table 3—Nutrient content knowledge questions and percent responses

Question/answer	Correct responses by mother			
	HEI phase		Nutrients phase	
	Ages 2-5	Ages 6-17	Ages 2-5	Ages 6-17
	Percent			
Which has more fiber?				
Fruit or meat	81.8	82.7	82.8	83.9
Cornflakes or oatmeal	80.2	82.5	81.4	83.7
Whole-wheat bread or white bread	92.9	93.3	93.2	93.4
Orange juice or an apple	77.9	76.0	77.3	76.1
Kidney beans or lettuce	53.6	55.6	59.0	58.7
Popcorn or pretzels	68.5	73.8	69.0	72.6
Which has more cholesterol?				
Liver or T-bone steak	33.1	38.5	34.7	41.0
Butter or margarine	83.8	86.1	84.9	87.4
Egg whites or yolks	79.2	81.6	82.3	82.2
Skim milk or whole milk	95.5	97.6	96.5	97.1
Which has more fat?				
Regular hamburger or ground round	86.7	89.6	87.8	89.9
Loin pork chops or pork spare ribs	71.8	76.0	72.1	76.0
Hot dogs or ham	66.6	63.4	64.8	63.7
Peanuts or popcorn	89.6	92.2	90.4	93.3
Yogurt or sour cream	87.3	86.2	87.3	87.5
Porterhouse steak or round steak	52.3	54.5	53.5	55.7
Ice cream or sherbet	93.8	96.1	92.8	96.1
Roast chicken leg or fried chicken leg	98.1	97.8	98.0	97.8
Which kind of fat (saturated, polyunsaturated) is more likely to be a liquid rather than a solid? Or are they equally likely to be liquids?	26.9	29.0	24.9	29.1
Is cholesterol found in vegetables and vegetable oils, animal products, or all foods containing fat or oil?	35.1	35.7	32.3	37.1
If a food is labeled cholesterol-free, is it also low in saturated fat, high in saturated fat, or either?	64.9	60.8	65.7	61.7
	Number			
Number of children	308	538	458	853

Note: Correct answers are underlined.
Source: 1989-91 Diet and Health Knowledge Survey.

Table 4—Mothers' responses to questions about their diet-health knowledge

Question	"Yes" responses by mother			
	HEI phase		Nutrients phase	
	Ages 2-5	Ages 6-17	Ages 2-5	Ages 6-17
Have you heard about any health problems that might be related to how much:		*Percent*		
Fat a person eats?	70.8	74.0	72.9	75.7
Saturated fat a person eats?	57.5	61.9	55.5	60.9
Fiber a person eats?	47.1	51.3	46.3	51.8
Salt a person eats?	81.5	88.8	82.1	86.7
Calcium a person eats?	63.6	63.9	61.6	63.8
Cholesterol a person eats?	85.7	85.9	83.0	85.5
Sugar a person eats?	80.5	80.9	79.0	80.9
Iron a person eats?	54.9	52.0	53.3	50.4
A person is overweight?	87.0	90.9	87.6	90.5
		Number		
Number of children	308	538	458	853

Source: 1989-91 Diet and Health Knowledge Survey.

Maternal Nutrition Knowledge and Children's HEI

Tables 5 and 6 give two alternative estimates for the preschoolers' and school-age children's HEI equations. Column 1 of each table reports results of the empirical HEI equation

$$HEI = \alpha_0 + \sum_{p=1}^{P} \alpha_p X_p + \beta_1 NCK + \beta_2 DHA + u, \tag{5}$$

estimated by ordinary least squares (OLS). Both NCK and DHA were included as variables capturing maternal nutrition knowledge, and X_p represents the other explanatory variables. The explanatory variables are listed in table 1. These can be grouped into four broad categories: mother's characteristics, child's characteristics, household characteristics, and survey-related controls. Of the broad groups of variables suggested by the household production model, we included all except prices and community characteristics. Both of these variables were unavailable in the CSFII/DHKS data. Instead, we included in our analysis dummy variables representing household region, urbanization, survey year, season, and whether the reported intake was for a weekend, to capture price and community effects.

The two children's characteristics included are sex and age. Several household characteristics were included to control for common family effects that may influence both the child's intakes as well as the mother's knowledge of health and nutrition. These characteristics include household income, household size, race, ethnicity, participation of a household member in the Food Stamp Program or in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and whether anyone in the household was on a vegetarian diet.

As the household production model suggests, a key variable that may affect a mother's knowledge of health and nutrition is her education level, represented in our analysis by the number of years of schooling. By including both the mother's education and information measures in the child's HEI equation, we can examine what effect, if any, a mother's education has beyond its information-enhancing role. A mother's age may capture the effects of learning and experience that remain after controlling for her education level. There has been some concern that maternal education and information effects may reflect maternal background characteristics (Behrman, 1995). We accounted for this possibility by including the mother's height and weight in the child's HEI equation.

One key variable suggested in the household production model, but overlooked in the children's health and nutrition literature, is maternal time preference. Several studies have emphasized that health habits as well as other human capital choices may be affected by an individual's time preference (Farrell and Fuchs, 1982; Grossman and Kaestner, 1995). An individual who places a higher value on current enjoyment may place less value on healthy habits, education, and information acquisition activities than those who place a higher value on future enjoyment. In the mother-child empirical context, this means a positive effect of maternal education or maternal health knowledge on child nutrition may be due to a mother's lower time preference which places a higher value on both her and her child's future health. To estimate the "true" education or information acquisition effect, one must control for maternal time preference. In this study, we used the mother's smoking status as such an indicator (Evans and Montgomery, 1994).

The standard errors reported in parentheses have been corrected for heteroskedasticity by White's procedure. Statistical significance of coefficient estimates were judged by two-sided t-tests at the 10-percent probability level.

The DHA coefficient indicates that maternal awareness of diet-health relationships significantly increases preschoolers', but not school-age children's, diet quality. On the other hand, the NCK coefficient is insignificant for preschoolers and significant in the equation for school-age children.

These OLS results highlight an important empirical question concerning the difference in the impact of our DHA and NCK variables. Given that both variables are measuring the same underlying information level, such differences could be due to measurement errors specific to each variable as well as the high correlation between NCK and DHA. In this case, it may be possible to improve the accuracy of estimated information effects by using a latent variable representation for maternal nutrition knowledge (Griliches, 1986). In this approach, the relationship between a set of error-ridden variables and the 'true' underlying variable they are attempting to measure is specified explicitly using measurement equations. In our case, these may be written as

(6)
$$NCK = \lambda_{10} + \lambda_{11}K + e_1$$
$$DHA = \lambda_{20} + \lambda_{21}K + e_2$$

where K is the true nutrition knowledge level underlying NCK and DHA, the λ's are unknown parameters, and e's are random measurement errors that are uncorrelated with each other and with K.

As noted earlier, a major focus of previous research has been to what extent information acts as a mechanism underlying the link between maternal and household characteristics and children's nutrition and health outcomes (Strauss and Thomas, 1996; Thomas, Strauss, and Henriques, 1991). To address this question and also to account for the possible effects of unobserved individual and family influences, we estimated a system of equations that treat children's HEI and mother's nutrition knowledge as jointly determined. A modified HEI equation can be written as

(7)
$$HEI = \alpha_0 + \sum_{p=1}^{P} \alpha_p X_p + \beta K + u,$$

where

(8)
$$K = \gamma_0 + \sum_{q=1}^{Q} \gamma_q Z_q + v.$$

Equation 6 was estimated along with equations 7 and 8 by maximum likelihood using the LISREL framework (Joreskog and Sorbom, 1989) for our samples of preschoolers and school-age children (see Appendix in Variyam and others, 1998, for the estimation procedure). Z_q includes all X_p variables in the HEI equation except child characteristics and the seasonal and weekend dummies. Z_q also includes four additional variables for identification. These variables indicate whether the mother has received dietary advice from a physician or a dietitian, the hours per day she spends watching television, the male head of household's education level, and whether the DHKS was conducted in person or by telephone. We expected these variables to capture sources of variations in maternal nutrition knowledge that are unrelated to children's diet quality. In tables 5 and 6, column 2, we report the HEI equation estimates, and in table 7 we report estimates for the maternal nutrition knowledge equations.

A parameter restriction is required to identify the scale of the latent "nutrition knowledge" variable K (Bollen, 1989, p. 239). We normalize the coefficient of K in the NCK measurement (equation 6) to one (i.e., λ_{11} = 1) so that NCK and K have the same scale; a unit change in K causes a unit change in NCK. The coefficient for DHA, λ_{21}, is free. All variables are expressed as deviations from their means, so the intercept coefficients in equations 6-8 are zero.

Table 5—HEI equation estimates for children ages 2-5

Explanatory variable	Ordinary least squares	Latent variable model
Mother's nutrition knowledge:		
Nutrient content knowledge	.262	—
	(.283)	—
Diet-health awareness	.925*	—
	(.365)	—
Nutrition knowledge level	—	2.716*
		(1.369)
Mother's characteristics:		
Education	-.462	-.726*
	(.342)	(.420)
Age	.323*	.221
	(.151)	(.172)
Height	.645*	.586*
	(.269)	(.282)
Weight	-.147*	-.074
	(.085)	(.117)
Weight squared ($\times10^{-3}$)	.413*	.218
	(.232)	(.321)
Smoker	-4.874*	-4.318*
	(1.519)	(1.655)
Child's characteristics:		
Child's age	-.892	-.904
	(.619)	(.617)
Female child	.962	1.029
	(1.241)	(1.296)

See notes at end of table.

—Continued

For preschoolers, the maternal information effect is positive and much larger with the endogenous latent variable model than in the OLS model (table 5). Given the estimates of λ's and β, we can infer the relationship between DHA or NCK, and the HEI. For example, the ratio β/λ_{21} gives the change in HEI score due to a change in maternal nutrition knowledge (K) that corresponds to an additional correct answer recorded on DHA. This ratio is estimated to be 3.757 (2.716/0.723). Therefore, a mother gaining information to answer an additional DHA question correctly would increase her preschooler's diet quality by about 3.75 points on the HEI scale according to the latent variable model. The comparable effect estimated by OLS is 0.93. The HEI equation under the latent variable model also has a higher R^2 of 0.28 than the HEI equation estimated by OLS which has an R^2 of 0.27.

A mother's nutrition knowledge, however, has a negative but statistically insignificant effect in the school-age child's HEI equation. If maternal influence on children's diet quality declines with age, especially after children start school, the statistical insignificance of maternal knowledge is not surprising. However, the negative sign and the relatively large size of the knowledge coefficient is troubling. We attempted many different specifications, including adding other identifying variables to the mother's knowledge equation but were unsuccessful in obtaining meaningful results. The central problem appears to be the lack of any variables that can sufficiently capture the variation in the mother's knowledge equation. The four variables we used successfully in the preschooler's equation: dietary advice, hours of television watching, male head years of education, and whether the survey was conducted in-person or by telephone were all statistically insignificant in the school-age children's equation. This statistical insignificance implies that we cannot adequately model and explain the variation in the nutrition knowledge equation. Thus, we feel that the coefficients in the equations for school-age children should be interpreted very carefully. Additional modeling research is clearly necessary, but perhaps this

Table 5—HEI equation estimates for children ages 2-5—Continued

Explanatory variable	Ordinary least squares	Latent variable model
Household characteristics:		
Log income	1.232	0.073
	(1.038)	(1.349)
Household size	.373	.072
	(.482)	(.538)
Black	-4.083*	-2.467
	(2.179)	(2.427)
Other race	2.068	5.722
	(4.910)	(5.578)
Hispanic	-1.379	1.898
	(2.349)	(3.323)
Food stamp participant	1.778	1.667
	(1.916)	(2.030)
WIC participant	.669	1.272
	(1.896)	(2.020)
Vegetarian diet	5.181*	4.231*
	(1.623)	(2.168)
Midwest	-1.556	-2.506
	(1.966)	(2.111)
South	-.593	-1.391
	(1.921)	(2.076)
West	-.621	-3.060
	(2.287)	(2.808)
Suburb	1.248	1.532
	(1.518)	(1.629)
Nonmetro	.537	-.193
	(1.726)	(1.966)
R^2	.270	.282

Note: Asymptotic standard errors are given in parentheses below the estimates. An asterisk indicates significance of the estimate at the 10-percent or lower level on a two-sided t-test. All models also include 13 dummy variables representing region and urbanization of the household, survey year, survey season, and whether any of the recorded 3-day intake was on a weekend; see table 1.

Source: Calculated by the Economic Research Service, USDA, using data from 1989-90 CSFII-DHKS.

dilemma will not be solved until more data become available. For the remainder of this section, we will focus on the preschooler model.

The latent variable model yields better results than the OLS model for preschoolers because the OLS model ignores the effects of other maternal and household characteristics that are transmitted through knowledge while the latent variable model accounts for such indirect effects. For example, both maternal education and household income have positive effects on maternal nutrition knowledge (table 7, column 1), confirming their role in increasing access to and use of information (Ippolito and Mathios, 1990). Comparing column 1 and column 2 estimates in table 5, one can see that after the knowledge-enhancing role of maternal education is taken into account, its remaining effect on preschoolers' diet quality is negative. This negative educational effect is different from the Thomas, Strauss, and Henriques (1991) finding that maternal education level may not influence Brazilian children's height. A possible explanation is that, in the United States, education enhances nutrition knowledge, but it may also increase the demand for convenience foods and food-away-from home, both of which may be of lower dietary quality (Lin, Guthrie, and Blaylock, 1996).

Height is a key variable used in many previous studies to control for maternal background effects (Behrman, 1995). In conformity with previous results, we find that maternal height is significantly related to diet quality

Table 6 —HEI equation estimates for children, ages 6-17

Explanatory variable	Ordinary least squares	Latent variable model
Mother's nutrition knowledge:		
Nutrient content knowledge	1.126*	—
	(.211)	
Diet-health awareness	.011	—
	(.229)	
Nutrition knowledge level	—	-3.587
		(2.685)
Mother's characteristics:		
Education	.087	1.339*
	(.230)	(.788)
Age	.022	.121
	(.083)	(.123)
Height	.295*	.432
	(.164)	(.265)
Weight	.071	-.023
	(.070)	(.060)
Weight squared ($\times 10^{-3}$)	-.257*	.047
	(.151)	(.314)
Smoker	-6.016*	-7.183*
	(1.101)	(1.670)
Child's characteristics:		
Child's age	-.035	-.042
	(.152)	(.155)
Female child	-2.971*	-3.000*
	(.905)	(.905)

See notes at end of table. — Continued

(Barrera, 1990; Haughton and Haughton, 1997; Thomas and Strauss, 1992). However, maternal height has no information-related effect, suggesting that it is capturing maternal background and endowment effects that do not influence information acquisition.[2]

Excepting Haughton and Haughton (1997), few other studies have used maternal weight as an explanatory variable. While Haughton and Haughton (1997) find a positive relationship between child nutrition and maternal weight, we find that maternal weight has an inverse relationship with children's diet quality through its influence on maternal nutrition knowledge. One explanation is that obesity may be discouraging mothers from investing further in acquiring and processing information. This conclusion is supported by the fact that the adverse influence is greater at higher weight levels. These opposite findings are clearly related to the fact that in developing countries, weight is a positive indicator of health because under-consumption of foods and nutrients related to weight is the major problem, at least in the populations studied. In industrialized countries, overweight or obesity is a negative indicator of health because the major nutrition problem is over-consumption of fat- and calorie-rich foods. Therefore, both results confirm the underlying relationship that maternal health endowment is positively related to children's nutritional outcomes.

Maternal smoking has a substantial negative effect on children's diet quality. The diets of children whose mothers smoke score approximately five HEI points lower than children whose mothers are nonsmokers. The effect is estimated rather precisely with a relatively low standard error. The sizable effect of maternal smoking status is also not related to information. This finding poses a challenge to nutrition educators because standard nutri-

[2]A quadratic term for maternal height was tried and found to be not significant.

Table 6—HEI equation estimates for children, ages 6-17—Continued

Explanatory variable	Ordinary least squares	Latent variable model
Household characteristics:		
Log income	0.827	1.852
	(.773)	(1.159)
Household size	.493*	1.124
	(.292)	(.556)
Black	-1.604	-9.326*
	(1.528)	(4.760)
Other race	-8.170*	-14.896*
	(3.962)	(6.881)
Hispanic	3.427*	-4.116
	(1.759)	(4.924)
Food stamp participant	.420	-.043
	(1.552)	(2.019)
WIC participant	-3.224*	-5.650*
	(1.787)	(3.117)
Vegetarian diet	2.768	4.403
	(2.183)	(3.203)
Midwest	-2.084	-.789
	(1.418)	(2.073)
South	.016	-.212
	(1.363)	(1.962)
West	-.417	2.793
	(1.552)	(2.817)
Suburb	-4.237*	-3.248*
	(1.106)	(1.624)
Nonmetro	-2.892*	.362
	(1.265)	(2.503)
R^2	.238	.220

Note: Asymptotic standard errors are given in parentheses below the estimates. An asterisk indicates significance of the estimate at the 10-percent or lower level on a two-sided t-test. All models also include 13 dummy variables representing region and urbanization of the household, survey year, survey season, and whether any of the recorded 3-day intake was on a weekend; see table 1.

Source: Calculated by the Economic Research Service, USDA, using data from 1989-90 CSFII-DHKS.

tion information programs are not likely to lower the dietary risk of children with smoking mothers. This result also has important policy implications given that earlier studies have found that smokers' diets are substantially worse than nonsmokers' (McPhillips, Eaton, and Gans, 1994). Another study of diet quality found that smokers score about three to four HEI points lower than nonsmokers (Variyam, Blaylock, Smallwood, and Basiotis, 1998). The present results show that this negative effect is transmitted to children with a similar, if not a higher, magnitude. Therefore, nutrition education programs need to target smokers, particularly those who are the main meal planners of their household, and alert them to the possible negative influence of their health habits on their children's diets.

In previous studies, children's age and sex have been included to capture possible gender and age discrimination in the allocation of household resources. To the extent that children's diets are under parental control, gender or age differences were not expected in our sample and none was found. Among household characteristics, there was a large, positive effect of about five points on the HEI scale for children from households where at least one member was on a vegetarian diet. As the *Dietary Guidelines for Americans* (1995) notes, vegetarian diets are consistent with its recommendations and can meet Recommended Dietary Allowances for nutrients. This result

Table 7—Estimates for mother's nutrition knowledge equation in the children's HEI study

Explanatory variable	Ages 2-5	Ages 6-17
Mothers' characteristics:		
Education	0.129*	0.282*
	(.065)	(.042)
Age	.041	.021
	(.027)	(.015)
Height	.021	.022
	(.049)	(.037)
Weight	-.038*	-.021
	(.018)	(.014)
Weight squared ($\times 10^{-3}$)	.097*	.070
	(.052)	(.039)
Smoker	-.189	-.234
	(.280)	(.220)
Received diet advice	1.684*	-.306
	(.603)	(.284)
Hours watching TV	-.190*	-.050
	(.082)	(.049)
Household characteristics:		
Log income	.414*	.149
	(.208)	(.161)
Household size	.144*	.125*
	(.086)	(.063)
Black	-.489	-1.586
	(.409)	(.298)
Other race	-2.106*	-1.613*
	(.895)	(.811)
Hispanic	-1.632*	-1.695*
	(.426)	(.344)
Food stamp participant	.081	-.080
	(.359)	(.295)
WIC participant	-.435	-.500
	(.332)	(.407)
Vegetarian diet	.483	.351
	(.349)	(.450)
Male head's education	.064*	.020
	(.029)	(.016)
In-person survey	.380	.468*
	(.264)	(.194)
R^2	.601	.458

Note: Asymptotic standard errors are given in parentheses below the estimates. An asterisk indicates significance of the estimate at the 10-percent or lower level. Each equation also includes 7 dummy variables representing region and urbanization of the household and the survey year; see table 1.

Source: Calculated by the Economic Research Service, USDA, using data from 1989-90 CSFII-DHKS.

and the result for smoking show how strong intra-family effects are generated by the health habits of individual members of the household.[3]

Other household characteristics are generally insignificant, except race. Diets of preschoolers in Black households are found to score about four points lower on the HEI scale than diets of children from White households. Given the potential effect of such higher dietary risk for preschoolers on their future health and schooling, this finding clearly indicates that nutrition education programs should target Black households for special attention.

The effects of nutrition information sources are as expected. Time spent watching television is inversely related to knowledge, possibly because it curtails more information-intensive activities like reading.[4] The effects of having received dieting advice from a physician or a dietitian, and the education level of the male head are both positive. We calculated a χ^2 statistic to test whether excluding the four variables used to identify the knowledge equation from the children's HEI equation is valid. The exclusion of each variable from the HEI equation could not be rejected at the 10-percent level. When TV hours and in-person survey variables, which had the relatively higher χ^2 values, were included in the HEI equation, the knowledge coefficient remained fairly stable at 2.274 although its standard error increased to 1.727. The results on the whole, therefore, seem to support the endogenous latent variable specification.

[3]When we included all preschool children from households with multiple preschoolers in the estimation sample (instead of selecting one child randomly from households with multiple preschoolers), the effects of maternal height, maternal weight, and a household member being on a vegetarian diet became insignificant. This finding is likely due to the correlation of these variables with unobserved maternal and household characteristic and, therefore, justifies our procedure of selecting one child randomly from households with multiple children. The knowledge coefficient estimate in this "full" sample (N=439) was 2.394 with a standard error of 0.071. Other results were similar to those reported in table 5, column 2.

[4]To ensure that the TV variable is capturing only the information effect and not the effect of a mother's level of physical activity, a dummy variable indicating activity level was included in equations 7 and 8 of the endogenous latent variable model.

Maternal Nutrition Knowledge and Children's Nutrient Intakes

We have shown that maternal knowledge has a significant influence on preschoolers' HEI, and now we explore which nutrients mother's knowledge affects the most. Table 2 lists the explanatory variables used in this analysis. Because the nutrients study and the HEI study were conducted in two phases, the specifications used are slightly different, with the HEI specification being more general. We grouped the explanatory variables into four broad categories: child's characteristics, household characteristics, mother's characteristics, and survey-related controls. Among the notable differences from the HEI study, controls for mothers' employment status were included to account for possible time allocation effects on knowledge and food preparation (Horton and Campbell, 1991) while maternal height and weight were not included.

Empirical Model

For the seven food components/nutrients (total fat, saturated fat, cholesterol, fiber, sodium, calcium, and iron), we jointly estimated a system of latent variable equations similar to the HEI study of the form:

(9) $$C_j = \alpha_{j0} + \sum_{p=1}^{P} \alpha_{jp} X_p + \beta_j K + u_j, \; j = 1,...,7,$$

(10) $$K = \gamma_0 + \sum_{q=1}^{Q} \gamma_q Z_q + v$$

(11) $$NCK = \lambda_{10} + \lambda_{11} K + e_1$$
$$DHA = \lambda_{20} + \lambda_{21} K + e_2$$

where K is a latent variable representing the mother's health and nutrition knowledge, C_j is the amount of jth nutrient, X_p and Z_q represent explanatory variables, α, β, and γ are the parameters to be estimated, and u and v are stochastic error terms distributed independently and identically across individuals but may be correlated across the equations for a given child-mother pair due to unobserved family heterogeneity. The estimation was carried out by the same maximum likelihood procedure used in the HEI study.

Estimates of the Nutrient Intakes and Knowledge Equations

As with the HEI equations system, the scale of the latent variable (K) is identified by normalizing the coefficient of K in the NCK measurement equation in equation λ_{11} to one (i.e., λ_{11} = 1) so that NCK and K have the same scale; a unit change in K causes a unit change in NCK. The coefficient for DHA, λ_{21}, is free. All variables are expressed as deviations from their means, so the intercept coefficients in equations 9-11 are zero.

Table 8 reports the estimates of the mother's latent knowledge equations for the two age groups (that is, equation 10). The most striking result is the positive and highly significant effect of a mother's education level on her health and nutrition knowledge for both groups. Because the scale of the latent variable is set by normalizing the coefficient for the NCK equation to one, any explanatory variable that affects K has an equivalent effect on NCK. This suggests that an additional year of education increases the NCK score of the mother of a 2- to 5-year-old child by 0.184 point. In elasticity terms, this implies that a 1-percent increase in education level leads to a 0.14-percent higher NCK score. Thus, our results provide direct evidence supporting the knowledge- and

Table 8—Estimates for mother's nutrition knowledge equation in the children's nutrient intakes study

Explanatory variable	Ages 2-5	Ages 6-17
Mother's characteristics:		
Education	0.184*	0.239*
	(.043)	(.032)
Age	.058*	.003
	(.015)	(.010)
Part-time employed	.763*	.326
	(.307)	(.211)
Not employed	.508*	.170
	(.261)	(.179)
Smoker	-.350*	-.354*
	(.180)	(.142)
Disease	-.084	.452*
	(.396)	(.217)
Diet advice	.499	-.053
	(.373)	(.271)
Household characteristics:		
Income (x 10^{-3})	1.680*	.758*
	(.687)	(.432)
Black	-.911*	-1.290*
	(.329)	(.236)
Other race	-.980	-.721
	(.608)	(.548)
Hispanic	-1.330*	-1.559*
	(.346)	(.267)
Female head	-.012	-.180
	(.280)	(.192)
Food stamp participant	-.553*	-.385*
	(.285)	(.230)
WIC participant	-.481*	-.276
	(.264)	(.304)
Vegetarian diet	.356	.234
	(.256)	(.260)
R^2	.544	.418

Note: Asymptotic standard errors are given in parentheses below the estimates. An asterisk indicates significance of the estimate at the 10-percent or lower level. Each equation also includes 8 dummy variables representing region and urbanization of the household and the survey year; see table 2.
Source: Calculated by the Economic Research Service, USDA, using data from 1989-91 CSFII-DHKS.

information-enhancing role of education, that is, the allocative efficiency effect stressed in previous studies (Grossman and Kaestner, 1995).

Other determinants that have consistent effects on mothers' nutrition knowledge include race, ethnicity, whether the mother is a smoker, household income, and whether a member of the household participates in the Food Stamp Program. The finding of lower knowledge levels for mothers who are Black or Hispanic compared with White and non-Hispanic mothers is similar to earlier results for all household meal planners (Carlson and Gould, 1994; Gould and Lin, 1994). Household income and smoking have the anticipated positive and negative effects, respectively. Age and employment status affect nutrition knowledge positively, but only for mothers of preschoolers.

Tables 9 and 10 present the estimates of the nutrient density equations for the two age groups (that is, equation 9). The R^2 is generally low because densities are computed from only 3 days of intake and, thus, have a sizable random component. A mother's health and nutrition knowledge has a beneficial effect on her child's diet if the

Table 9—Intake equation estimates for children, ages 2-5

Explanatory variable	Total fat	Saturated fat	Cholesterol	Fiber	Sodium	Calcium	Iron
K	-0.965*	-0.620*	-0.016*	0.275*	-0.052*	0.010	-0.190
	(.482)	(.262)	(.006)	(.164)	(.028)	(.014)	(.221)
Child's age	-.036	-.240*	-.002	.197*	.013	-.018*	.013
	(.253)	(.134)	(.003)	(.087)	(.015)	(.008)	(.119)
Female child	-.023	.187	.006	.310	.027	.006	-.203
	(.552)	(.292)	(.006)	(.191)	(.033)	(.017)	(.259)
Mother not employed	-.478	-.132	.010	-.168	-.008	.017	-.048
	(.809)	(.439)	(.009)	(.276)	(.048)	(.024)	(.371)
Mother part-time employed	.268	.198	.010	.005	.025	.033	.396
	(.992)	(.538)	(.011)	(.339)	(.058)	(.029)	(.455)
Income (x 10^{-3})	.609	-.395	.026	-.057	-.023	-.078	1.014
	(2.377)	(1.290)	(.027)	(.812)	(.140)	(.070)	(1.090)
Black	1.153	.074	.006	-.002	-.010	-.075*	-.780*
	(1.027)	(.558)	(.012)	(.351)	(.060)	(.030)	(.471)
Other race	-3.490*	-1.644	-.007	.944	.150	.033	2.591*
	(1.863)	(1.011)	(.022)	(.636)	(.110)	(.055)	(.854)
Hispanic	-1.343	-.636	.017	1.074*	-.088	.028	-.320
	(1.231)	(.668)	(.014)	(.420)	(.072)	(.036)	(.564)
Female head	-.130	-.044	.005	-.283	.011	-.021	.224
	(.836)	(.453)	(.010)	(.285)	(.049)	(.025)	(.383)
Food stamp participant	-.956	-.865*	-.006	.133	-.026	-.027	.452
	(.927)	(.503)	(.011)	(.317)	(.054)	(.027)	(.425)
WIC participant	-.432	-.515	-.006	.389	.024	-.019	.358
	(.846)	(.459)	(.010)	(.289)	(.050)	(.025)	(.388)
Vegetarian diet	.278	-.226	-.006	1.292*	-.011	-.059*	-.332
	(.785)	(.426)	(.009)	(.268)	(.046)	(.023)	(.360)
Low-fat/low-calorie diet	-1.214	-0.569	-0.012	0.205	-0.134*	-0.054	0.618
	(1.276)	(.679)	(.014)	(.440)	(.075)	(.039)	(.596)
Midwest	1.259	.009	.007	.348	.110*	.003	-.157
	(.885)	(.480)	(.010)	(.302)	(.052)	(.026)	(.406)
South	1.070	-.353	.009	.321	.071	-.066*	-.224
	(.866)	(.470)	(.010)	(.296)	(.051)	(.026)	(.397)
West	.589	-.249	.017	.880*	.129*	-.026	.435
	(1.130)	(.613)	(.013)	(.386)	(.066)	(.033)	(.518)
Suburb	-.066	.342	-.009	-.406*	-.026	.022	-.141
	(.706)	(.383)	(.008)	(.241)	(.041)	(.021)	(.324)
Nonmetro	.217	.635	-.003	-.467	-.050	-.027	-.086
	(.834)	(.453)	(.010)	(.285)	(.049)	(.025)	(.382)
R^2	.085	.097	.174	.202	.088	.170	.097

Note: Asymptotic standard errors are given in parentheses below the estimates. An asterisk indicates significance of the estimate at the 10-percent or lower level. Each equation also includes nine dummy variables representing survey year, survey season, and whether any of the 3-day intake was on a weekend; see table 2. The R^2s are the squared correlation between observed and predicted intake values.

Source: Calculated by the Economic Research Service, USDA, using data from 1989-91 CSFII-DHKS.

Table 10—Intake equation estimates for children, ages 6-17

Explanatory variable	Total fat	Saturated fat	Cholesterol	Fiber	Sodium	Calcium	Iron
K	-0.350	-0.194	-0.013*	0.187*	-0.016	0.015	0.077
	(.321)	(.158)	(.004)	(.117)	(.019)	(.009)	(.154)
Child's age	.070	-.032	0	-.025	.005	-.009*	-.022
	(.054)	(.027)	(.001)	(.020)	(.003)	(.002)	(.026)
Child female	.792*	.206	0	.053	.016	.006	-.039
	(.381)	(.187)	(.004)	(.140)	(.023)	(.011)	(.185)
Mother not employed	-.751	-.408*	.002	.138	-.024	-.017	.294
	(.470)	(.231)	(.005)	(.171)	(.028)	(.013)	(.226)
Mother part-time employed	-1.018*	-.910*	-.006	.207	-.032	-.023	.335
	(.560)	(.275)	(.006)	(.204)	(.033)	(.016)	(.269)
Income (x 10^{-3})	-.507	-.239	.021	-.051	.044	-.043	.339
	(1.223)	(.600)	(.013)	(.446)	(.072)	(.034)	(.587)
Black	.231	-.112	.006	-.349	.109*	-.042*	-.246
	(.748)	(.367)	(.008)	(.273)	(.044)	(.021)	(.359)
Other race	-1.749	-1.498*	.003	.310	.070	-.034	1.362*
	(1.465)	(.719)	(.016)	(.534)	(.087)	(.041)	(.703)
Hispanic	-1.634*	-.633	.006	.518	-.017	.005	.324
	(.908)	(.446)	(.010)	(.331)	(.054)	(.026)	(.436)
Female head	-.549	-.234	-.009	-.054	-.018	.002	.441*
	(.501)	(.246)	(.005)	(.183)	(.030)	(.014)	(.240)
Food stamp participant	.221	.106	-.006	.422*	.012	-.003	-.367
	(.622)	(.305)	(.007)	(.227)	(.037)	(.017)	(.298)
WIC participant	1.790*	.431	.015*	.142	.052	-.003	.553
	(.796)	(.391)	(.009)	(.290)	(.047)	(.022)	(.382)
Vegetarian diet	-1.938*	-.801*	-.013*	1.507*	-.022	.008	.386
	(.688)	(.338)	(.008)	(.251)	(.041)	(.019)	(.330)
Low-fat/low-calorie diet	-.849	-.085	-.002	.464*	.068	.016	.280
	(.709)	(.348)	(.007)	(.261)	(.042)	(.020)	(.344)
Midwest	1.225*	.452	.005	-.087	-.018	.003	-.593*
	(.603)	(.296)	(.007)	(.220)	(.036)	(.017)	(.290)
South	.886	-.156	.002	-.127	-.072*	-.041*	-.457
	(.603)	(.296)	(.007)	(.220)	(.036)	(.017)	(.290)
West	.037	-.121	.022*	.541*	-.055	-.003	-.377
	(.658)	(.323)	(.007)	(.240)	(.039)	(.019)	(.316)
Suburb	-.008	.423*	.003	-.277	-.020	.024*	-.142
	(.490)	(.240)	(.005)	(.178)	(.029)	(.014)	(.235)
Nonmetro	-.174	.193	.002	.055	.010	-.007	-.457*
	(.543)	(.267)	(.006)	(.198)	(.032)	(.015)	(.261)
R^2	.073	.061	.117	.120	.053	.153	.047

Note: Asymptotic standard errors are given in parentheses below the estimates. An asterisk indicates significance of the estimate at the 10-percent or lower level. Each equation also includes nine dummy variables representing survey year, survey season, and whether any of the 3-day intake was on a weekend; see table 2. The R^2s are the squared correlation between observed and predicted intake values.

Source: Calculated by the Economic Research Service, USDA, using data from 1989-91 CSFII-DHKS.

coefficient for K is negative in the total fat, saturated fat, cholesterol, and sodium intake equations and positive in the fiber, calcium, and iron equations. This is because K and NCK have the same scale, and a higher NCK and, hence, a higher K, implies a higher knowledge level. A higher knowledge level, in turn, translates to a better diet by reducing (increasing) the intake of nutrients whose over-consumption (under-consumption) may cause health problems.

The coefficient estimates for K suggest that a mother's knowledge of health and nutrition have substantial beneficial effects on the diets of her preschool children. A higher level of maternal knowledge translates into significantly lower intakes of total fat, saturated fat, cholesterol, and sodium, and a significantly higher intake of fiber by 2- to 5-year-old children. In terms of magnitude, an increase in nutrition knowledge sufficient to answer one more NCK question correctly would cause a decline of about 1 percentage point in energy intake from all fat, a 0.6-percentage-point decline in energy intake from saturated fat, a decline of 16 milligrams of cholesterol intake per 1,000 calories, a decline of sodium intake by 52 milligrams per 1,000 calories, and an increase of fiber intake by 0.3 gram per 1,000 calories. Given such sizable effects for these nutrients, the lack of significant influence on calcium and iron intake of preschoolers is somewhat surprising. There may be several explanations for this finding. First, mothers may not perceive the underconsumption of calcium or iron as a serious problem and, secondly, these nutrients have not received the press attention of other dietary problems (for example, dietary fat and cholesterol). Another reason may be that calcium and iron can come from mineral supplements that are not reflected in the CSFII data.

The effect of mothers' knowledge on intakes wanes for children ages 6 and above. For this age group, an increase in mothers' nutrition knowledge is accompanied by a statistically significant reduction in children's intake of cholesterol and an increase in children's intake of dietary fiber. Fat and sodium intakes are not significantly affected by mother's knowledge. The knowledge effect on fiber is less for the 6-17 age group than for 2-5 year-olds while the effect on cholesterol is of similar magnitude.

Our empirical results strongly suggest that maternal nutrition knowledge has a positive effect on the diets of children, particularly for preschoolers. The effect of a mother's nutrition knowledge on the diets of her older children is less for several reasons. First, older children likely make more dietary decisions independently of their mother, and secondly, they tend to eat away from home more often and also receive a higher percentage of their total caloric intake from away-from-home food sources (Lin, Guthrie, and Blaylock, 1996). These results lead to the important conclusion that health and nutrition education may be more effective if targeted toward mothers with preschool children but directly toward school-age children.

The allocative efficiency hypothesis implies that education promotes better nutrition outcomes through the acquisition and use of information related to the health effects of nutrients (Grossman and Kaestner, 1995). In the nutrients intake study, we imposed this hypothesis by excluding a mother's education level from the children's intake equations so that education influenced intake only indirectly through the knowledge equation. This restriction can be tested by a likelihood ratio test. Such a test showed that the restriction could not be rejected at the 10-percent level for preschoolers (χ^2=4.92, df=7). While the restriction was rejected for the 6-17 age group, mothers' education did not have a statistically significant coefficient in any of the children's intake equations. These results, therefore, support the view that maternal education affects children's diets wholly through its positive effect on maternal knowledge of health and nutrition. Previous evidence in support of the allocative efficiency hypothesis has been mainly from nutrition and health studies of children in developing countries (Strauss and Thomas, 1996). Our results suggest that the relationship persists when the dietary problem is one of overconsumption rather than malnutrition. Further, our results are robust to fixed family effects since our models include several variables, including the mother's employment status, to control for such effects (Behrman, 1995; Behrman and Wolfe, 1987).

Turning to other factors influencing children's nutrient intakes, school-age girls had significantly higher energy intakes from fat than boys. Gender had no influence on any preschooler's nutrient intake densities. To the extent that children’s diets are under parental control, dietary differences between boys and girls are not expected. Therefore, the result for the 2-5 age group is not surprising. The higher fat energy for school-age girls may be related to their dietary patterns such as a greater tendency to skip relatively low-fat breakfasts and eating a higher proportion of meals and snacks outside the home (Lin, Guthrie, and Blaylock, 1996).

The effect of a mother’s employment status on both her nutrition knowledge and on her children’s intakes differs between the age groups and has some interesting implications. For preschoolers, the effect of mother’s employment status occurs mainly through nutrition knowledge while for school-age children, the effect occurs through time available for food preparation at home. School-age children with mothers employed part-time have significantly lower intakes of fat and saturated fat than those whose mothers are employed full-time. Mothers who work less may be able to exert more influence on the diets of their school-age children.

One variable with a systematic effect on nutrient intake densities for both age groups is whether any household member is on a vegetarian diet. This variable has a positive and significant effect on the fiber intake of all children with a stronger effect for those 6-17 years old. If a household member is vegetarian, the fiber intake of 6- to 17 year-olds increases by 1.5 grams per 1,000 calories. Concomitantly, the calories from fat and saturated fat of school-age children fall by 2 percentage points and 0.8 percentage point, respectively, and their cholesterol intake declines by 13 milligrams per 1,000 calories.

Older children in both age groups, but more so for preschoolers than school-age children, had lower calcium intake densities than the younger children in the group, possibly because older children drink less milk. Older preschoolers also tend to have lower saturated fat and higher fiber intake densities.

Significant racial differences exist in calcium intake densities. Black preschoolers were found to have 75 mg less calcium intake per 1,000 calories than White preschoolers, while Black school-age children had 42 mg less calcium intake per 1,000 calories than White children. Black school-age children also have significantly higher sodium intakes than White school-age children. Fat intake by Hispanic children was significantly lower than that by non-Hispanic children in the 6-17 age group, while fiber intake by Hispanic children ages 2-5 was significantly higher than that by 2- to 5-year-old non-Hispanic children. Overall, after accounting for other factors, including mothers’ nutrition knowledge, racial and ethnic effects on children’s diets were somewhat limited. This result is contrary to the findings for adults where strong racial and ethnic effects have been detected (Carlson and Gould, 1994; Gould and Lin, 1994).

Food Stamp Program participation by a household has beneficial effects on children’s diets. FSP participation is related to a lower saturated fat intake by 2- to 5-year-olds and a higher fiber intake by 6- to 17-year olds. The fat and cholesterol intakes of school-age children from households participating in the WIC program were significantly higher than those of children of the same age group from nonparticipating households, perhaps because WIC subsidizes egg consumption.

Conclusions

Using a nationally representative data set that allows us to develop unique instruments for measuring overall diet quality and nutrition knowledge, we found that the mother's knowledge of nutrition has a significant positive influence on preschool children's diet quality and children's dietary intakes and that such influence decreases as children grow older. These findings have growing significance as more nutrition researchers, economists, and policymakers are focusing on the determinants of children's diets. Among the numerous factors affecting diets and nutrient intakes, health and nutrition knowledge is one factor that can be manipulated by health authorities through the use of tools such as public information campaigns. Therefore, the potential impact of this factor on diets is of considerable policy interest.

In this study, we used household production theory to formulate empirical models of children's diet quality and nutrient intakes. Household production theory attributes a positive effect for education on health and nutrition outcomes through greater allocative efficiency, that is, the ability of the more educated to acquire and process a greater amount of health information than the less educated (Grossman and Kaestner, 1995). Thus, if the allocative efficiency hypothesis is valid, a mother's knowledge of health and nutrition should be positively related to her education level, and children's diet should be positively related to their mothers' knowledge of health and nutrition. Our results support this model for preschool children with respect to overall diet quality and nutrient intakes. For children older than 5 years, the evidence is less strong, although significant effects were found for cholesterol and fiber.

Our results suggest that some information-related racial and ethnic effects on child diet quality exist and that targeting non-White and Hispanic mothers for nutrition education is likely to increase diet quality of preschoolers. Our results also point to other powerful determinants of child diet quality that may need special attention from nutrition educators. Preschool children of mothers who smoke have significantly lower diet quality, although these mothers are as informed about nutrition and diet-health links as nonsmoking mothers. Therefore, special strategies may be needed to alert smoking mothers to the dietary risk facing their preschoolers. At the same time, having a member in the household who is on a vegetarian diet appears to significantly improve preschoolers' diet quality. The recent addition of vegetarian diets as a means to attain dietary goals in the *Dietary Guidelines for Americans* (1995) is therefore likely to help improve children's diet quality.

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Appendix: Measuring Diet Quality: The Healthy Eating Index

The HEI measures overall diet quality by evaluating an individual's diet against 10 dietary components reflecting recommendations in the *Dietary Guidelines for Americans* (U.S. Dept. of Agr., U.S. Dept. of Health and Human Services, 1995) and the *Food Guide Pyramid* (U.S. Dept. of Agr., 1992):

- Components 1-5 measure the extent to which a person's diet conforms to the *Food Guide Pyramid* serving recommendations for the grains, vegetables, fruits, milk, and meat groups.

- Components 6-10 measure the extent to which a person's diet conforms to the *Dietary Guidelines* recommendations for total fat, saturated fat, cholesterol, sodium, and variety.

An individual's diet was assigned a score of 0-10 for each of these 10 components in the following manner: For each of the five food group components of the HEI, individuals who consumed the recommended number of servings received a maximum score of 10. A score of zero was assigned for any food group where no items from that food group were eaten. Scores between zero and 10 were calculated proportionate to the number of servings consumed. For example, if the recommended number of servings was 8 and an individual consumed 4 servings, the component score for the individual is 5 points (one-half of 10).

The scores for fat and saturated fat were related to their consumption in proportion to total food energy. Fat intakes contributing to less than or equal to 30 percent of the total calories were given a score of 10. The score declined to zero when the proportion of total calories from fat was 45 percent or more. Linear interpolation was applied to fat intakes that contribute between 30 and 45 percent of total calories. Intakes of saturated fat were similarly scored with a score of 10 given to less than 10 percent of total calories from saturated fat and a score of zero for intakes that contribute to 15 percent or more of total calories.

Scores for both cholesterol and sodium were based on milligrams consumed in the diet. A score of 10 was given for cholesterol intakes less than or equal to 300 milligrams per day. Zero points were given for intakes at or over 450 milligrams. Intermediate scores were given for intakes between the two limits. For sodium, a maximum score was obtained for intakes less than or equal to 2,400 milligrams per day. A zero score was given for sodium intakes at 4,800 milligrams or higher. Again, intermediate scores for intakes between the two cutoff points were given proportionately.

Dietary variety was assessed by totaling the number of "different" foods eaten by an individual in amounts sufficient to contribute at least one-half of a serving in a particular food group. Food mixtures were broken into their component ingredients and assigned to relevant food groups. Similar types of foods were grouped together and counted only once in measuring the score for variety. A maximum score of 10 was awarded if 16 or more different food items were consumed over a 3-day period. A score of zero was given if 6 or fewer food items were consumed. Intermediate scores were awarded proportionate to consumption between the cutoffs.

An individual's HEI is the sum of these 10 component scores. Therefore, the range of HEI is 0-100. The mean HEI for our samples of preschoolers and school-age children was 65.4 and 62.6, respectively (table 1). For complete details on the construction of HEI, see U.S. Department of Agriculture (1995) or Kennedy and others (1995).