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ASSESSING THE DIETARY EFFECTS OF THE FOOD STAMP PROGRAM

VOLUME I: CONCEPTUAL DESIGN

FINAL REPORT

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EXECUTIVE SUMMARY

This study is an assessment of the dietary effects of the Food Stamp Program (FSP). Volume I of this study is a conceptual design for an analysis of the dietary effects of the FSP, and Volume II presents empirical results from the estimation of econometric models of the dietary effects of the FSP. This model is based on the economic theory of consumer demand and relates nutrient levels to the food stamp benefit, cash income, and other relevant household characteristics.

In its most basic form, the proposed dietary model is conceptually straightforward and fairly simple to estimate. This basic model is estimated with household food use data from the 1979-80 Survey of Food Consumption in Low-Income Households. The dietary components examined are the household availability of the following nutrients: food energy, protein, vitamin A, vitamin C, thiamin, riboflavin, vitamin B_6, calcium, phosphorus, magnesium, and iron.

The principal findings from the estimation of the basic model are:

- Increases in both FSP benefits and cash income are associated with increases in household availability of nutrients.

- The estimated marginal effects of the food stamp benefit consistently exceed those of cash income. Specifically, estimates of the change in household nutrient availability due to a one-dollar increase in the food stamp benefit are 3 to 7 times the comparable estimates for cash income.

In addition to the basic model, two econometric models of selection bias are estimated for this study. Selection bias may occur because FSP participants may differ from other low-income households in ways that may make it difficult to isolate the dietary effects of FSP participation. The results of the selection bias models show little evidence of selection bias, and the estimated dietary effects of the food stamp benefit and cash income from the selection bias models are quite similar to those from the basic model.

Several additional technical econometric issues and model extensions are considered in Volume I of this report. They include:

- Multiple program participation. Because low-income households are able to participate in more than one program at a time, it is important to consider the impact of multiple program participation in analyses that want to isolate the effects of FSP participation.

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- Household versus individual-level FSP effects. The basic household model is modified to examine the intra-household allocation of FSP benefits.

- Functional form of the nutrient equations and specification testing. Given the long history of the food expenditure literature that shows the importance of considering different functional forms for models of food expenditure, it is important to examine carefully alternative functional forms for dietary models and to conduct specification tests to determine the best functional form.

- Scaling for household size and composition. Given that household size and composition are important predictors of household food expenditures and nutrient levels, models of dietary effects of the FSP need to consider the variety of household scaling procedures used in previous analyses.

- Dietary status versus nutritional status. It is important to note that dietary status is not synonymous with nutritional status, which is the focus of the FSP's objectives. A thorough determination of nutritional status involves a combination of dietary assessments, anthropometric measurements, clinical evaluation, and biochemical tests. While a study of the dietary effects of the FSP cannot be used to draw conclusions concerning the effects of the FSP on nutritional status, a thorough dietary status

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I. INTRODUCTION

Although the original aim of the Food Stamp Program (FSP) was to dispose of surplus agricultural goods, food stamp legislation during the 1970s emphasized the nutritional objectives "to safeguard the health and well being of the Nation's population by raising the level of nutrition among low income households." The current program is designed to raise the level of nutrition through the provision of coupons which can legally be used only to purchase food. Thus, the FSP is designed to increase food expenditures which, in turn, are expected to raise the level of nutrition of participating households.

The objective of this report is to assess the dietary effects of the FSP. Despite an existing large body of literature on the food expenditure and dietary effects of the FSP, it is useful to assess our current state of knowledge on this topic. The diversity of the existing literature with respect to the models developed and estimated, the data sets used, the outcome variables analyzed, and even the background of the researchers analyzing this topic have resulted in a similarly diverse set of empirical findings. To put these findings in perspective, this study provides a broad conceptual framework for analyzing the effects of the FSP and to estimate a specific model of the dietary effects of the FSP.

This report is organized in two volumes. This first volume is essentially the design of a conceptual framework in which to assess the dietary effects of the FSP. The major product of this volume is an econometric model of the relationship between dietary outcome measures and FSP participation. The second volume presents the empirical results of

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estimating the analytic model developed in Volume I and compares those results with the findings from previous studies.

This volume contains three chapters. The remainder of this first chapter provides a history of the FSP, describes briefly how dietary status differs from nutritional status, and discusses questions to address in an analysis of the dietary effects of the FSP. Chapter II of this volume presents an analytic framework for estimating the dietary effects of the FSP, reviews the data sets available for estimation, and summarizes the existing literature. The third chapter develops a model of the dietary effects of the FSP and discusses how to estimate such a model.

In addition, Volume I has two appendices: the first provides an example of household food consumption and discusses a problem associated with many previous analyses of the dietary effects of the FSP, and the second is an expanded discussion of the relationship between dietary status and nutritional status.

A. BACKGROUND OF THE FOOD STAMP PROGRAM

As the FSP has evolved over the years, it has moved increasingly from a program with an explicit objective to dispose of surplus agricultural commodities to a program that essentially provides income supplementation to the low-income population. This section describes the evolution of the program as background information for why it is important to assess the nutritional effects of the FSP.

The early food programs administered by USDA in the mid 1930s were commodity distribution programs with the dual objective of disposing of the food stocks the government had accumulated under legislation enacted to stabilize farm prices and of improving the nutrition of children and low-

income families. The first experimental FSP was authorized by the Potato Control Act of 1939 (MacDonald, 1977), whose primary objective was to ensure that program benefits were devoted solely to additional food purchases. Recipients were required to purchase a minimum number of stamps at their face value and then to receive additional free stamps. The stamps could be used to purchase food from authorized establishments. However, because the program was still tied to the disposal of surplus agricultural goods, the program was discontinued in 1943 when these surpluses disappeared during World War II.

The current FSP began in 1961 as a pilot program in eight areas. Eligible households purchased food stamps at a portion of their value, with the purchase price set at "normal food expenditures." The first nationwide FSP was established in 1964 (PL 88-525), with the same dual objective of earlier programs to dispose of surplus food stocks and to improve the nutrition of low-income households. Households were eligible to purchase stamps at a price less than their market value subject to income and asset limits and to work requirements.

The nutritional objectives of the FSP were given explicit priority over commodity distribution by the 1971 Amendments to the Food Stamp Act (PL 91-671), which greatly expanded the FSP in response to concerns about hunger in the 1960s. Food stamp allotments were increased, purchase requirements were reduced, and periodic adjustments in benefit levels linked to changes in food prices were instituted. In addition, recipients were allowed to purchase fractions of their monthly FSP allotments, thereby allowing more discretion over the size of the food budget and removing, in part, the potential barrier to program participation that a purchase

requirement represented to low-income households. This option represented the first major relaxation of the program's constraints on household consumption decisions.

Subsequent legislation, most notably the Food Stamp Act of 1977 (PL 95-113), emphasized further the nutritional objectives "to safeguard the health and well being of the Nation's population by raising the levels of nutrition among low income households." Despite this emphasis on the program's nutritional objectives, the most extensive of the changes authorized by the Food Stamp Act of 1977 was the elimination of the purchase requirement (EPR), which actually served to weaken the tie between program benefits and food purchases. After EPR was implemented in January 1979, families were not required to purchase their food stamp allotment but, instead, received only the bonus value of their benefits. The rationale behind this change was (1) the purchase requirement represented a significant barrier to FSP participation for some low-income households who did not always have funds available with which to purchase their FSP allotment and EPR was therefore expected to expand program participation among eligible nonparticipants and (2) most low-income households spend more on food than the bonus value of their FSP benefits anyway. EPR, however, constituted a significant program and policy shift in the FSP because it essentially removed the tie between FSP participation and the level of household food purchases. The end result of EPR was to increase the income supplementation component of the FSP by granting participating households greater discretion over their household budgets.

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In summary, the history of the FSP shows a change in program objectives from the disposal of surplus agricultural commodities characteristic of early versions of the FSP to current concerns about raising the level of nutrition among low-income households. Through a process of incremental reforms, largely implemented to expand program participation of low-income households, the FSP has come to function more as an income transfer program and less as a program linked to food consumption and, thus, nutrition. Yet, given the explicit nutritional objectives of the current FSP, it is important to determine what we know concerning the nutritional effects of the FSP.

B. RELATIONSHIP BETWEEN NUTRITIONAL STATUS AND DIETARY STATUS

Previous analyses of the FSP have examined a wide variety of measures of dietary status, such as household food expenditures, nutrient intake, and the availability of nutrients from food used by households. However, these measures are not synonymous with nutritional status, which is the focus of the FSP's objectives. This section discusses the measurement of nutritional status and how nutritional status relates to dietary status.[1]

Nutritional status is defined as the health condition of an individual as influenced by the intake and utilization of nutrients. It is influenced by how food is digested, transported, metabolized, stored in the body, and excreted. Malnutrition, which is impaired nutritional status, is defined as (1) undernutrition resulting from lack of sufficient food over a

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[1] Appendix B is a more detailed discussion of this topic and also includes an overview of health, dietary, and poverty status.

period of time, (2) overnutrition caused by an excess of food over time, (3) specific deficiency states resulting from a lack of individual nutrients, or (4) imbalance caused by a disproportionate amount of required nutrients in a balanced diet.

Many factors are known to affect nutritional status, including inadequate dietary intake, inadequate absorption, defective utilization, increased excretion, and increased requirements of one or more nutrients thought to be essential for good health. Ideally, an examination of each factor separately and in interaction with other nutrients, drugs, and environmental conditions would provide the best assessment of nutritional status. However, assessment of this type is rarely possible for either individuals or populations, and nutritional status is typically assessed by evaluation of a lesser number of factors.

In practice assessment of nutritional status includes measurement of (1) dietary, (2) biochemical, (3) anthropometric, and (4) clinical information. For example, various aspects of a person's medical and dietary history can suggest potential nutritional problems. Certain anthropometric measurements are well accepted as good indexes of growth and body protein and calorie stores. Clinical deficiency diseases are rare in the U.S., but there are some common physical abnormalities which are associated with nutritional deficiencies. Blood and urine analyses of nutrients and selected metabolites can provide information relevant to nutritional status. By evaluating information from multiple sources, qualitative and quantitative estimates of nutritional health can be made.

In the succeeding four subsections, we describe the dietary, anthropometric, clinical, and biochemical measures frequently used in nutritional status assessments of individuals.

1. Dietary Assessment

A nutritionally adequate diet is one which, on average, provides sufficient energy and essential nutrients in a timely fashion to meet nutrient and metabolic needs. Nutritional requirements differ among groups of individuals by age, gender, body size, and physiologic state. In addition, personal characteristics can influence nutrient needs, including metabolic efficiency, level of usual activity, health status, use of medications, vitamin/mineral supplements, type of contraceptive use, or smoking status.

The Recommended Dietary Allowances (RDA) are recommendations for the average daily amounts of nutrients that population groups should consume over a period of time and are the standards typically used to evaluate dietary adequacy. With the exception of food energy, the RDA are set at levels high enough to meet the nutritional requirements of nearly all healthy individuals in the population. Thus, intakes below the RDA do not necessarily imply inadequate nutrition. It should also be noted that the RDA standards have not been developed to identify nutrient needs of nonhealthy individuals.

Measures of dietary intake provide information on an individual's food consumption for a specific period of time and may be used to identify populations likely to be at risk of inadequate or improper nutrient intake. Dietary assessment methods typically available include 24-hour recalls, food frequencies, food records at the individual level, and 7-day food supply records at the household level. Food records and 24-hour recall require limited respondent memory and minimize the likelihood that the subjects will modify their food habits. However, these methods of

dietary assessment reflect current, rather than usual, diet. The three days of dietary data available in the 1977-78 and 1987-88 Nationwide Food Consumption Surveys are a distinct improvement over a single day of diet recall in assessing individual diets.

Several issues need to be considered with regard to measuring this component of nutritional status. First, methods of obtaining dietary intake data rely on individuals to maintain food records for a period of time or to recall food consumption from an earlier period. Noncooperation, nonresponse, recall bias, and measurement error are problems with both records and recall, calling into question the extent to which the data reflect a true picture of normal food consumption. Second, the short period over which much of the dietary data are collected raises questions as to the accuracy of the data as a reflection of true consumption, since there are likely to be day-to-day and seasonal variations in consumption patterns. Finally, for most nutrients, measurement of dietary intake alone is insufficient to assess the nutritional status of an individual. Rates of absorption, utilization, and excretion of nutrients vary across individuals, as do other lifestyle and health characteristics, which affect the requirements for most nutrients. Nevertheless, dietary intake data do provide a measure of the best nutritional state that can potentially be achieved since they represent the complete set of nutrients available to the individual.

2. Biochemical Tests

Inadequate dietary intake over a period of time will lead to impairment of the body's biochemical functions. Biochemical tests, which examine the level of nutrients, metabolites, and other components of body

tissue and fluids, provide an objective means of determining the level of nutrients processed by the body. Since the body can often adjust for short-term dietary inadequacies, biochemical tests generally indicate long-term nutritional problems.

Most laboratory techniques for assessing nutritional status measure (1) the nutrient level in the blood, (2) the urinary excretion rate of the nutrient, (3) urinary metabolites of the nutrient, (4) abnormal metabolic products, (5) changes in blood components or enzyme activities that can be related to intakes of the nutrient, and (6) response to a load, saturation, or isotopic test. Such laboratory tests comprise the majority of current biochemical nutritional assessments. However, tests for different nutrients are not equally valuable and have differing diagnostic capabilities.

As is true of the RDA for nutrients, standards for biochemical tests are not precise and tests are not available for a number of nutrients. However, the available biochemical tests have the advantage of providing information on likely areas of nutritional inadequacies based on the body's use of nutrients rather than simply the nutrients made available to the body through consumption. Information from biochemical tests is most useful when examined in conjunction with other measures of nutritional status.

3. Anthropometric Measurements

Certain body measurements are sensitive to changes in food intake and provide information on nutritional status. The most common are height, weight, and measures of body fatness. In particular, the assessment of growth and development in relation to age and sex and of triceps fatfold

can provide an indication of the overall nutritional status in infants and children. For weight and height, growth charts are used as the reference or standard against which individual or serial measures are made. Standards currently in use are published by the National Center for Health Statistics. For young children, weight-for-age, height-for-age, and weight-for-height standard tables are available.

Although weight, height, or triceps fatfold deficits may be indicative of any number of dietary deficiencies, they are most commonly associated with dietary inadequacies in total energy and protein intakes. Therefore, anthropometric measurements are useful indicators of energy and protein nutriture, particularly in growing children, but are less useful measures of nutritional status in the evaluation of other nutrients or for adults. Therefore, as with dietary and biochemical assessments, anthropometric assessments of nutritional status need to be corroborated with other indicators of nutritional status.

4. Clinical Evaluation

As discussed above, anthropometric measurements such as height and weight in relation to age may be an indication of the overall sufficiency of the intake of food energy and protein for children. Anthropometric measures, however, are less useful as indicators of inadequate levels of other nutrients. Other clinical signs, such as changes in the skin, hair, eyes, and mouth, are associated with inadequacies of particular nutrients. Even so, it is important to note that a wide variety of factors other than inadequate nutrition can produce clinical findings indicative of inadequate nutrition and the interpretation of clinical data is, to that extent, subjective. Nevertheless, clinical findings that are suggestive of

inadequate nutrition can be investigated further using other methods of nutritional status assessment.

5. Relationship of Nutritional Status Outcomes to Household Measures Typically Used in Analyses of the Food Stamp Program

Since the household is the unit of participation in the FSP, most analyses of nutritional effects of the FSP to date have examined dietary outcomes at the household level. The objectives of this section are to describe outcome variables used in previous analyses and to discuss how these different outcome variables are related to nutritional status.

Existing data sets used in previous analyses of the FSP provide information on (1) household food expenditure patterns, (2) food and nutrient availability at the household level, and (3) food and nutrient intake at the individual level. FSP analyses have used all of the above measures and have created other indices from each of the three kinds of information. The most common outcome measure used in analyses of the FSP is household food expenditures. Total food expenditures, the money value of food used at home, and food group expenditures have been used as outcome measures (West and Price, 1976; Davis and Neenan, 1979; Fraker, Devaney and Cavin, 1986). Frequently, the expenditure data are adjusted to reflect differences in household size, composition, and nutritional requirements.

Food and nutrient availability at the household level have been derived from different kinds of survey instruments. Largely, household food use data have been derived from the seven-day household food records available in the 1977-78 Low-Income Supplement to the Nationwide Food Consumption Survey and the 1979-80 Survey of Food Consumption in Low-Income Households (Basiotis et al., 1983; Devaney and Fraker, 1986). Measures of

household food use from these data bases include all food and beverages used from household food supplies and exclude food purchased and consumed away from home. The food use data are converted to nutrient availability, where nutrients are summed over quantities of food used over the period of household dietary data collection.

In two early studies, Madden and Yoder (1972) and Lane (1978) derived household dietary data from 24-hour at-home household recall data. The household respondent was asked to report amounts of food consumed (not prepared) by the household members during the 24-hour period prior to the interview. No attempt was made to estimate intake for individual family members. Foods consumed away from home were not included in these food intake totals.

Relatively few FSP analyses have examined actual intakes of FSP participants versus nonparticipants. In cases where individual dietary data have been used, dietary outcome measures have typically been specific to one household member who acts as a proxy for the household (Neenan and Davis, 1978). An exception to this is a study by Basiotis (1983), which examined intake data at the household level.

In household FSP analyses, nutrient totals are used in numerous ways. The most common are as nutrient totals or totals as a proportion of some standard such as a household RDA. As with household expenditure measures, a number of authors have indexed household nutrient availability to reflect household size and composition differences. Measures of household food availability have also been scaled to reflect differing numbers of meals consumed by household members from the household food supply each week. Typically, scaling has assumed a 21-meal-per-week pattern.

Other indices of household dietary status have also been derived. Madden and Yoder (1972) calculate a household Mean Adequacy Ratio (MAR) from the household diet data. In this index, a Nutrient Adequacy Ratio (NAR) is calculated for each nutrient, which is nutrient intake as a percent of the RDA. Intakes above 100 percent of the RDA are truncated to 100 percent. The 10 NAR measures are then averaged to obtain the MAR. In addition, the separate NAR measures are often used as dependent variables in analyses of dietary status (e.g., Lane, 1978).

Johnson, Burt, and Morgan (1981) derive three measures of diet quality from household seven-day home food supply records. The Modified Diet Score is defined as the sum of the ratios of nutritive value per nutrition unit to the RDA for the adult male for seven nutrients and energy. This is a analogous to the MAR, using fewer nutrients, and using a nutrient requirement standardized person to represent the household. A second measure is the Minimum Nutrient Density Ratio (MINNDR). It is defined as the lowest of the seven nutrient density ratios, where a nutrient density ratio is the nutrient adequacy ratio for an individual nutrient divided by the nutrient adequacy ratio for food energy. A value of one is the norm; households with MINNDR less than one use food lower in nutrient density for one or more of the seven nutrients, while the converse is true for numbers exceeding one. Finally, a Food Energy Level is defined as the total energy value of food used from the household food supply divided by the number of adult male equivalents in the household, truncated to 150 percent of the RDA.

In assessing the usefulness of these dietary outcome measures, it is important to note that they attempt to measure only one component of

nutritional status, namely dietary status. Given that a thorough determination of nutritional status involves a combination of dietary assessments, anthropometric measurements, clinical data, and biochemical tests, studies of the dietary impacts of the FSP using the type of outcome measures discussed above cannot be used to draw conclusions concerning the effects of the FSP on nutritional status. This caveat, however, is not intended to downplay the importance of analyzing the dietary impacts of the FSP. A thorough dietary status assessment is an integral complement to anthropometric, clinical, and biochemical assessments of individuals. Analysis of food consumption data, as in most previous analyses of the FSP, enables professionals to understand nutrient inadequacies, imbalances, and excesses associated with specific dietary patterns.

C. RESEARCH QUESTIONS

The objective of the FSP is to increase the level of nutrition of low-income households through the provision of benefits that increase the food-purchasing power of participating households to a level sufficient to purchase a nutritious diet. The program design is based on the premise that benefits in the form of coupons would increase the food expenditures and nutrition of low-income households to a greater extent than would equivalent cash benefits. The reasoning behind this premise is that coupons, which can be used legally only to purchase food, provides an incentive for households to increase their food purchases, particularly those households that would have spent less than their coupon allotment on food in the absence of the FSP. However, the possibility has long been recognized that households may choose not to increase their food expenditures by the full amount of their coupons and, instead, may

substitute the coupons for food expenditures that would otherwise have been financed by money income, thereby using FSP benefits to free up money to spend on nonfood items.

Clearly the most important question to address in an analysis of the dietary effects of the FSP is to what extent the program raises the quality of diets of participating households.[1] Specifically, we are interested in comparing the diet quality for a household receiving food stamps to that for the same household if no FSP were available. In addition to these total effects of the FSP, a related question is the marginal effect of food stamp benefits on diet quality. That is, what are the dietary effects of an additional dollar of benefits and do coupon benefits affect diet quality to a greater extent than equivalent cash benefits?

A second major research question to consider in dietary analyses of the FSP is how the dietary effects of FSP participation are distributed within the household. Most, if not all, previous analyses of the FSP analyze the effects at the household level. However, it is quite possible that proportionately more benefits may accrue to some family members than to others. Many of the data sets currently available, such as the individual intake data from the Nationwide Food Consumption Survey and the Continuing Survey of Food Intakes by Individuals, lend themselves to an analysis of the intra-household allocation of FSP benefits.

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[1] The discussion here presumes that one overall measure of household diet quality is available, although, as discussed in the preceding section of this chapter and in Appendix B, a variety of dietary outcome measures have been used in analyses of the FSP.

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II. PREVIOUS ANALYSES OF THE DIETARY IMPACTS OF THE FSP

The primary goal of this chapter is to summarize the rather diverse body of literature on the dietary effects of the FSP. The first section of this chapter discusses an ideal analytic framework for the estimation of the dietary effects of the FSP and describes how the actual design of the FSP results in analyses that differ from the ideal. The second section summarizes briefly the data sets commonly used in the analyses of the FSP, and the final section of this chapter reviews the previous literature on the dietary effects of the FSP.

A. ANALYTIC FRAMEWORK FOR ESTIMATION OF THE DIETARY EFFECTS OF THE FSP

The basic objective of an analysis of the dietary effects of the FSP is to determine how the relevant dietary outcomes of FSP participants compare with what their dietary outcomes would have been had there been no FSP. An exact answer to this question is, of course, impossible since we cannot observe the behavior of individuals under two different regimes at the same time. However, other design options are available for measuring the dietary effects of the FSP.

A preferred design for estimating the dietary effects of the FSP is to compare the dietary outcome measures of FSP participants with the comparable outcome measures of a similar group of individuals who resemble the FSP participants in every way except one: they do not participate in the FSP. The fundamental method for achieving such comparability of the participant and nonparticipant groups is random assignment. Random assignment in the context of the FSP would involve the use of a random method to assign low-income households that are eligible to receive FSP benefits to participant and nonparticipant groups.

Random assignment is a preferred design option for an analysis of the dietary effects of the FSP because the basis for assigning eligible households to participant or nonparticipant status would be independent of any individual characteristics. However, the current FSP is not based on random assignment. The objective of the FSP is to increase the food-purchasing power of all low-income households to a level where they can afford a nutritionally adequate low-cost diet. FSP benefits are available to all households meeting the income and asset eligibility criteria, provided that certain household members fulfill work registration, job search, and other such employment requirements.

Despite the fact that FSP benefits are available to all low-income households that satisfy the FSP eligibility criteria, many households that are apparently eligible to receive benefits do not participate in the FSP. Data from the 1984 panel from the Survey of Income and Program Participation and the Food Stamp Program Statistical Summary of Operations show that approximately 40 percent of eligible households did not participate in the FSP (Doyle and Beebout, 1988). Consequently, data available for analyses of the dietary impacts of the FSP include observations on a self-selected group of low-income households receiving FSP benefits and on a group of FSP-eligible households not receiving FSP benefits (eligible nonparticipants).

Most analyses of the FSP interpret the group of eligible nonparticipants as a comparison group to the group of FSP participants. In the absence of a control group as with a true experimental design, a comparison group is critical for providing some information on what the dietary outcomes of FSP participants might be if there were no FSP.

However, the self-selection of households into the participant and eligible nonparticipant groups may lead to differences between the groups other than participation status, and it is important to control for such differences in order to obtain unbiased estimates of FSP effects. For example, although both the participant and eligible nonparticipant groups consist of low-income households, it is possible that, due to self-selection, one group may have a lower average income than the other.

The self-selection by low-income households into the participant and nonparticipant groups obviously deviates from the ideal random assignment model. This does not imply that such self-selection will necessarily bias the results of analyses of these data, but it may and it is important to consider how best to design an analysis such that the effects of the FSP can be isolated from the effects of self-selection.

If, in addition to FSP participation status, eligible nonparticipants differ from FSP participants only along exogenous, observed characteristics, a multiple regression model that accounts for the differences between participants and eligible nonparticipants provides unbiased estimates of the FSP effects. For example, a simple model of this type is the following:

$$Y = \alpha_0 + \sum_{i=1}^{K} \alpha_i X_i + \beta FSP + \varepsilon,$$

where Y is the dietary outcome, the X's are characteristics that are believed to be determinants of Y (e.g., income, age, education) and which may differ between FSP participants and eligible nonparticipants, FSP is a binary variable equal to one for FSP participants and equal to zero for eligible nonparticipants, the α's and β are unknown coefficients to be

estimated, and ε is the random error term, assumed to be independent of the X's. With this simple model, ordinary least squares regression can be used as the estimation procedure. The effect of the FSP is estimated to be β, which is the difference in the dietary outcome variable Y between FSP participants and nonparticipants, after controlling for the differences in observed characteristics (the X_i's).

This simple model deals only with differences in observed characteristics between FSP participants and eligible nonparticipants. A more fundamental problem occurs if the self-selection of households into the FSP is based on unobserved or unmeasured characteristics that also affect the dietary outcomes of interest (e.g., nutritional awareness). In this case, standard multiple regression techniques produce biased estimates of the FSP effects, and it is considerably more difficult to obtain unbiased estimates of program impacts. Chapter III of this volume and the empirical results presented in Volume II of this report focus on procedures to estimate dietary models of the FSP when self-selection may lead to confounding differences in unobserved characteristics between FSP participants and eligible nonparticipants.

In summary, the objectives and design of the FSP result in models of the dietary effects of the FSP that differ from the "ideal" random assignment framework. Most FSP analyses use a comparison group approach, where the dietary measures of FSP participants are compared to those of FSP-eligible nonparticipants, after controlling for other differences between FSP participants and eligible nonparticipants. Multiple regression techniques are the usual estimation procedures for estimating the dietary effects of the FSP. The ability of the traditional regression models to

isolate the dietary effects of the FSP from other factors, however, is limited by the extent to which the self-selection of FSP households results in unmeasured or unobservable differences between FSP participants and eligible nonparticipants.

B. REVIEW OF EXISTING DATA SETS

Several data sets are currently available and have been used for the estimation of the dietary effects of the FSP. Table 1 summarizes the most relevant of these data sets. For each of the major data sets listed in Table 1, the following issues are discussed in this section: (1) population groups sampled, survey design and methodology, sample sizes, and "age" of the data sets; (2) dietary outcome measures available; and (3) ability to address the major research questions discussed in Chapter I.

1. 1977-78 Low-Income Supplement to the Nationwide Food Consumption Survey

Probably the most widely used data sets for analyses of the dietary impacts of the FSP are those from the Nationwide Food Consumption Survey (NFCS). Seven nationwide surveys of household food consumption have been conducted by the U.S. Department of Agriculture (USDA). The Low Income Supplement to the Nationwide Food Consumption Survey (NFCS-LI) was conducted from November 1977 through March 1978 for a national probability sample of approximately 4,400 low-income housekeeping households.[1] An eligible household was defined as one either receiving food stamps or eligible to receive food stamps if they were to apply.

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[1] Housekeeping households are those with at least one person having 10 or more meals from household food supplies during the 7 days preceding the interview.

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TABLE 1

POTENTIAL DATA SETS FOR USE IN ANALYSES OF DIETARY EFFECTS OF THE FSP

Data Set Name	Sample Size Population Sampled Time Period	Dietary Outcome Variables Available	Additional Comments
1. Low-Income Supplement to the Nationwide Food Consumption Survey (NFCS-LI)	4,400 Households (Food Stamp Eligible) 1977-78	Household: o Money Value of Food Used At Home o Nutrient Availability (7 Day) Individual o 3-Day Dietary Intake	Pre-EPR
2. Survey of Food Consumption in Low-Income Households (SFC-LI)	2,900 Households (Food Stamp Eligible) 1979-80	Household: o Money Value of Food Used At Home o Nutrient Availability (7 Day) Individual: o One 24-hour Recall	Post-EPR
3. Nationwide Food Consumption Survey--Continuing Survey of Food Intakes by Individuals	2,120 Women ages 19-50 1,314 Children ages 1-5 (Income $\leq$ 130% PI) 1985	Individual: o 24-hour Dietary Recalls (repeated at 2 month intervals; up to 6 measures per respondent)	Post-EPR; Bimonthly FSP participation data; sample size declines over time
4. Nationwide Food Consumption Survey, 1987-88	3,600 Low-Income Household (target)	Household: o Money value of Food Used at Home o Nutrient Availability (7 Day) Individual o 3-Day Dietary Intake	Post-EPR

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The NFCS-LI provided detailed information on household food use. Household food use refers to food and beverages used from household food supplies during the seven days preceding the interview. Food purchased with cash, credit, or food stamps and food that was home-produced, received as a gift or payment for work, or received through other programs (e.g., WIC) are all included as part of household food use.

Household food use was determined by a seven-day recall in which interviewers recorded each food item used from household food supplies during the seven previous days. Respondents were contacted at least seven days prior to the actual interview and asked to maintain records of shopping lists, menus, grocery receipts, prices of foods, and labels to help them provide information on food use. The type of food, form (fresh, canned, or frozen), quantity used, price paid (if appropriate), and source (purchased, home-produced, gift or pay) were recorded for each item. Data were also collected on the number and types of meals (morning, noon, evening) and on snacks eaten from the household food supplies by both family members and nonrelated household members.

The money value of food used at home can be calculated by multiplying the quantity of each food item used by its respondent-reported price. Money values of food not purchased directly by the household (i.e. home-produced food or food received as a gift or pay) is valued at the average price per pound for that food item paid by households reporting its purchase and use. The money value of food used at home includes food used by household members, boarders, employees, and guests.

The availability of household food energy and other nutrients are calculated by summing the food energy and individual nutrient values of the

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individual food items used.[1] Nutrient composition values pertain only to edible portions of the food used from household food supplies, with some adjustments for vitamin losses during preparation.

Household-level data related to food behavior were also collected as part of the NFCS-LI. Demographics included household income, education of household heads, household size and composition, participation in the FSP, and participation in other federally sponsored food assistance programs, such as School Breakfast, School Lunch, and WIC.

Individual data were also collected in the NFCS-LI. After the household respondent finished giving household information on food use and other household characteristics, the interviewer recorded the preceding day's food intake as recalled by each sampled household member. The interviewer then asked each sampled member to keep a written record of food intake for the day of the interview and for the next day. Thus, up to three consecutive days of individual dietary data are available--one 24-hour recall and two one-day food diaries.

The dietary information collected on each individual included the type and quantity of each food or beverage, the time of day the food was consumed, the name of the eating occasion, and if the food was from household food supplies. If the food was consumed away from home, data were

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[1] The sources for the nutrient composition information include B. Watt and A. Merrill, "Composition of Foods...Raw, Processed, Prepared." U.S. Department of Agriculture, Agricultural Handbook 8 (revised), 1963; the supplements to the Agricultural Handbook (8-1, 1976; 8-2, 1977; 8-3,1978); and M.L. Orr, "Pantothenic Acid, Vitamin B_6 and B_{12} in Foods," U.S. Department of Agriculture, Home Economics Research Report No. 36, 1969. Some values in these reports were revised by the Nutrient Data Research Branch of HNIS to reflect the current state of knowledge of nutritive values.

collected on the location where the food was consumed, the type of service, and the cost. Additional information collected from individuals includes: if vitamins, mineral, or other dietary supplements were taken; if they were on a special diet; if the day's intake represented usual eating habits; if they were vegetarian; and a self-report of health status and physical handicaps.

Two major limitations of the 1977-78 NFCS-LI are that collection occurred prior to elimination of the FSP purchase requirement (EPR) and the data are currently 10 years old. With implementation of EPR in 1979, not only did the programmatic structure of the FSP change, but the nature of participants changed, as nearly 3 million persons were added to program roles in early 1979 and approximately 600,000 eliminated with incomes exceeding more restrictive limits. On the other hand, from a dietary assessment standpoint, the 1977-78 NFCS-LI has distinct advantages over other currently available data sets. In particular, the three days of individual dietary data are preferred to one day only and provide a much better estimate of usual intake.

2. 1979-80 Survey of Food Consumption in Low-Income Households

The Survey of Food Consumption in Low Income Households (SFC-LI) was conducted from November 1979 through March 1980 for a national probability sample of approximately 2,900 low-income housekeeping households eligible to receive FSP benefits. The survey was comparable to the 1977-78 NFCS-LI with respect to provision of detailed availability of information related to household food use. The same seven-day recall household food use methodology was used. However, the SFC-LI contains only one 24-hour dietary recall per person in the individual data base, which is a main

shortcoming of this data set given the considerable day-to-day variation in individual food intakes.

A major difference between the two surveys is the time of data collection. The objective of the 1979-80 SFC-LI was to provide information on changes in food use and dietary adequacy that were associated with increasing food prices and the EPR. Therefore, the SFC-LI data base is superior from the standpoint of examining current FSP structure, despite more limited individual level dietary data. However, the SFC-LI data base is also quite old for a current assessment of the dietary effects of the FSP.

3. Continuing Survey of Food Intakes by Individuals (CSFII) 1985, 1986

The CSFII is a longitudinal survey of U.S. households that contain one or more women ages 19 to 50 years of age. A household participates in the survey for one year, during which time a 24-hour dietary recall is administered six times at two-month intervals. The baseline interview is conducted in person, while the up to five follow-up interviews are conducted by telephone. At the end of a survey year, the existing panel of households is dissolved and a new panel selected. (The CSFII was not conducted during 1987 and 1988 while the Nationwide Food Consumption Survey was in the field. It is expected that the next panel will be collected in 1989). Core (all income) and low-income (income no greater than 130 percent of the poverty guidelines) samples are available for analysis. The primary respondents to the CSFII are age-eligible women (ages 19 to 50) and their children ages 1 to 5 years. In 1985, age-eligible men were surveyed only during the first data collection period, but not thereafter.

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The CSFII-85 core sample contains approximately 1,300 households and 2,000 age-eligible respondents. The low-income sample contains approximately 1,900 households and 3,200 age-eligible persons. Because of sample attrition, fewer respondents have the maximum of six days of dietary data available. In addition, an unexpectedly high survey response rate for low-income households, coupled with insufficient funds to complete six interview waves, resulted in approximately one-third of the low-income households that participated in Wave 1 being dropped from Waves 2-6.

The household questionnaire requests information about the household as well as the individual. At the household level, information is obtained on sources and amounts of income, FSP participation, usual food expenditures, and adequacy of food eaten by the household. Participation status in other food assistance programs (School Lunch, School Breakfast, WIC) was collected for all household members. Household food expenditure information included three primary questions. The respondent was asked to estimate the amount of money spent for the household in supermarkets, meat markets, specialty shops etc. over the past two month period. The respondent was also asked to estimate the amount of this total spent for nonfood items such as cleaning supplies or pet food. The third question inquired about the usual amount of expenditure for all household members for food and beverages purchased away from home during the last two months.

The FSP participation questions ask if the household received government food stamps this month or the previous month. Since each respondent was surveyed every two months, for those who responded to all six waves, full household participation data are available. In each time period, the number of persons for whom the stamps were authorized was

queried, as was the total dollar value of stamps received. The household was asked the date at which food stamps were last received. The household was not asked if the amount the family spent on food was more than the value of the stamps.

The adult individual questionnaires request information on race/ethnicity, education, employment status, health status (including self reported weight, height, physical activity at work and at leisure, and pregnancy and lactation status), cigarette smoking, special diet use, and supplement use. Primary food preparers were asked a series of additional food preparation questions related to the addition of fat and/or salt.

Attempts were made to interview respondents on different days of the week to provide representative day of the week data. The seasonality of collected data is an improvement since no other survey has collected quantitative recall or diary data over more than one seasonal time period. If one wishes to average all data collected over a year for a given individual to reflect usual diet, then the CSFII dietary data should provide a strong estimate of usual diet. The potential difficulty with assessing usual diet in this manner is that FSP participation may shift over the period of time in which diet is sampled. A single 24-hour recall is still a poor representation, by itself, of usual diet. Where the objective of a cross sectional study is to classify a particular individual with respect to nutritional adequacy, the one day recall has serious limitations. At least two days are necessary in order to assess intraindividual variance and to improve measurement of usual diet.

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Household dietary data are not available from the CSFII. Therefore, estimates of household food use comparable to the NFCS estimates are not possible. The individual dietary data differ from the NFCS data in collection methodology, each having strengths and weaknesses. While a single wave of the CSFII data provides less accurate intake data than does the three-day intake of the 1977-78 NFCS-LI, the strengths of the CSFII are that the data are more current and for analyses that use more than one wave of intake data. Because the extent of other information used to assess dietary status is expanded from previous surveys to include self assessments of usual activity status, and smoking behavior, as well as height, weight, and pregnancy/lactation status, these data are more useful in assessing nutritional needs and intake relative to needs.

4. 1987-88 Nationwide Food Consumption Survey

The 1987-88 Nationwide Food Consumption Survey (NFCS-87) is an especially important data set since it provides the most recent data on household food use and individual food intake and it is likely to support most future analyses of the dietary effects of the FSP. The data collection started in spring of 1987 and continued through spring of 1988.[1]

The NFCS-87 is similar in design to the 1977-78 survey. Detailed information on household food use during the seven days preceding the interview are available, where household food use refers to all food and beverages used from household food supplies. Household socioeconomic and demographic characteristics and the food expenditure information are

[1] Unfortunately, the NFCS-87 data were not available at the time that the empirical analysis for this study was conducted.

comparable to the earlier surveys. Wording of the FSP participation questions differs somewhat from other surveys. Questions asked include:

- Did any member of your household receive food stamps in any of the past 12 months?
- Is your household receiving food stamps at the present time?
- Does everyone in your household receive food stamps at the present time?
- Who does not receive food stamps?
- On about what date did your household last get food stamps?
- What was the total amount of stamps you received at that time?

Also surveyed are use of donated cheese, butter, and margarine during the past three months, and purchases of these items within the past month.

In addition, as with the 1977-78 data, up to three days of food intake data will be collected for individuals. The food intake data will be from one 24-hour recall and two one-day food diaries and will include the same level of detail as the earlier survey: the type and quantity of each food or beverage, the time of day the food was eaten, the name of the eating occasion, whether the food was eaten at home or away from home, and, for food eaten away from home, where the food was eaten, the type of service, and the cost.

C. REVIEW OF LITERATURE

A large body of literature currently exists on the dietary effects of the FSP. Table 2 summarizes only selected multivariate analyses of the dietary effects of the FSP. These studies were selected because they are

based on a common sample--low-income households from the Nationwide Food Consumption Survey.[1] The advantage of summarizing the studies based on these data are threefold:

1. The data are nationally representative of low-income households, in contrast to data from specific states or regions.

2. NFCS data bases are the most frequently used in analyses of the FSP, and, hence, it is possible to compare findings of different studies. In addition, the 1987-88 NFCS is likely to be the major data base used in future analyses of the dietary effects of the FSP.

3. The model of the dietary effects of the FSP developed in the subsequent chapter is estimated with data on low-income households from the NFCS, and the empirical results are presented in Volume II of this report.

Despite the common data base used, the selected studies summarized in Table 2 do not provide a consistent set of findings concerning the dietary impacts of the FSP. Specifically, the findings range from no statistically significant or small positive effects of the food stamp benefit (Johnson, Burt, and Morgan, 1981; Basiotis et al., 1983) to strong positive effects (Allen and Gadson, 1983). This difference in findings is primarily the result of different model specifications. That is, studies that report small positive effects of the food stamp benefit on nutrient

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[1] In addition, only studies using data on household nutrient availability are summarized in Table 2. This is because only one known study has examined the actual intake of nutrients at the household level (Basiotis, 1983, which also examines household nutrient availability), and other individual intake analyses are so varied with respect to the target group examined, the data bases used, and the survey methodology that they are difficult to summarize in a concise manner.

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TABLE 2

SELECTED EMPIRICAL STUDIES ON THE DIETARY EFFECTS OF THE FSP

Study	Target Group and Data Base	Nutrients Examined	Relevant Independent Variables	Dietary Impacts of FSP Participation, Food Stamp Benefits, or Cash Income
Adrian and Daniel (1976)	U.S. low-income households. Nationwide Food Consumption Survey, 1965-66	Protein, vitamin A, calcium, iron, thiamin, vitamin C	Income includes FSP bonus	Income has a weak positive effect on availability of these nutrients.
Johnson, Burt, and Morgan (1981)	U.S. low-income households. Low-income Supplement to the Nationwide Food Consumption Survey,	Food energy, protein, calcium, iron, vitamin A, thiamin, riboflavin, vitamin C, vitamin A	Income includes the food stamp benefit, FSP participation included as a dummy variable	FSP participation has a positive and significant effect on two measures of diet quality. Marginal effects 1977-78 of income, which includes the food stamp benefit, are positive but small.
Basiostis et al. (1983)	U.S. low-income households. Low-income supplement to the Nationwide Food Consumption Survey, 1977-78	Food energy, protein, calcium, iron, Vitamin A, thiamin, riboflavin, vitamin C	Food expenditures, FSP participation, household income includes food stamp benefits	From the reduced-form results FSP participation has positive effects on availability of food energy, thiamin, and vitamin C. Marginal effects of income, which includes the food stamp benefit, are positive but small
Allen and Gadson (1983)	U.S. low-income households. Low-income Supplement to the Nationwide Food Consumption Survey, 1977-78	Vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B_6, vitamin B_{12}, calcium, iron, magnesium, phosphorus, calories, protein.	Income, food stamp benefit	Income has a small positive effect on availability of all nutrients; food stamp benefit has a larger effect than income on nutrient availability. However, nutrient elasticities with respect to income and the food stamp benefit are approximately equal.

availability are those that include the food stamp benefit as part of money income and, thus, constrain the marginal effect of the FSP benefits to be equal to the marginal effect of other money income. Two of these studies, however, also include a FSP participation variable in the nutrient equations and find large positive dietary effects of FSP participation (Johnson, Burt, and Morgan, 1981; Basiotis et. al., 1983). The one study in Table 2 that separated the food stamp benefit and other money income (Allen and Gadson, 1983) finds a larger absolute effect of the food stamp benefit than money income on household nutrient availability, although the income and benefit nutrient elasticities are similar in magnitude.

In general, the studies summarized in the table analyzed the dietary effects of the FSP using one or more of the following three approaches:

1. Food Stamp benefits and money income are presumed to influence food expenditures, which in turn affect household nutrient availability (Basiotis, 1983; Basiotis et al., 1983).

2. Participation in the FSP itself is presumed to affect household diet quality, and the food stamp benefit is included as part of money income which is an additional determinant of diet quality (Johnson, Burt, and Morgan, 1981).

3. FSP benefits and money income are considered separate determinants of household nutrient availability (Allen and Gadson, 1983).[1]

The diversity of the models specified and of the resulting estimates of the dietary effects of the FSP raises questions of how to model the dietary

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[1] The Adrian and Daniel study does not fall into any of these categories. In their study FSP benefits are part of their income variable and income is a determinant of household nutrient availability.

effects of the FSP and what are the issues associated with estimation of such a model. The following chapter of this report focuses on the development of a model of household behavior that leads to a system of nutrient equations in which income and the food stamp benefit are separate predictors of household nutrient availability. This specification is similar to that of the third approach discussed above. However the estimation of the model specified in the following chapter is considerably more complicated than the estimation procedure used by Allen and Gadson.

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III. A MODEL OF THE DIETARY EFFECTS OF THE FSP

The basic product of this chapter is an econometric model of the effects of FSP benefits on dietary outcome measures. This model is related to earlier studies discussed in the previous chapter but differs from them in some important respects. We first lay out the basic structure of the model and discuss the key characteristics of its specification, after which we discuss modifications of the specification to control for selection bias, other model specification issues, and to consider both individual and household-level effects. The empirical estimation of this model is the focus of Volume II of this report.

By its nature, this chapter is more technical than the other chapters in this report and frequently deals with technical econometric issues. These issues are important for the estimation of the dietary effects of the FSP. However, because of the technical econometric detail of this chapter, the first section is a nontechnical overview of the model developed to estimate the dietary effects of the FSP.

A. NONTECHNICAL OVERVIEW

The proposed model of the dietary effects of the FSP is based on the economic theory of consumer demand. That is, households are assumed to have preferences for consumption goods and they choose their consumption patterns based on their preferences, their available resources, and the prices of the consumption goods. In the context of a model of the dietary

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maximize utility derived from the consumption of food goods and the composite nonfood good subject to the constraint imposed by available household resources. The result is a series of demand equations for individual foods and for the composite nonfood good.

Nutrients enter into the model in that each food item consumed by the household has a known nutrient composition. Theoretically, the model could be estimated simply by estimating demand equations for each food item as a function of household income and FSP benefits. A nutrient data base then could be used to produce the nutrient content of each food item. However, this approach is impractical since there are hundreds of different food items, each with a different nutrient composition, and no data set has sufficient detail to support the estimation of food consumption equations for each food item. As a result, the essence of the discussion in this chapter is how to estimate the proposed dietary model of the FSP.

1. Econometric Issues Associated with Dietary Models of the FSP

Given the impracticality of estimating a complete set of food demand equations and using a nutrient data base to provide information on the nutrient composition of each food, it is necessary to consider alternative estimation procedures. One approach frequently taken in the literature is to aggregate the individual food goods into total food expenditures and to estimate an equation relating household nutrient levels to household expenditures.[1] With this approach, FSP benefits are

[1] Except for section C of this chapter, the specified nutrient equations are implicitly assumed to be nutrient availability equations, since the model developed is a household-level model and the data traditionally used in previous household-level analyses have been nutrient availability data.

assumed to affect food expenditures which, in turn, influence nutrient levels.

Two serious problems are associated with this approach. First, the inclusion of household food expenditures in the nutrient equations leads to a misspecified model and biased estimates of the effect of FSP benefits on nutrient availability. This is because this specification constrains the effect of FSP benefits and other money income on nutrient availability to be proportionate to their effects on total food expenditures, which is likely to be incorrect. The results of previous studies of the FSP generally find that FSP benefits have larger effects on food expenditures than does other income, and it is therefore likely that FSP benefits and other income also have different effects on the demand for individual food goods and nutrient availability.

The second problem associated with including household food expenditures in the nutrient equations is that food expenditures are an endogenous variable and traditional multiple regression estimation procedures result in biased parameter estimates. This problem can be addressed by using an estimation technique that allows for endogenous explanatory variables (e.g., instrumental variables), although the problem of specification bias discussed above would persist.

2. Proposed Estimation Procedure

The major issue resolved in this chapter is the proposed estimation procedure for the household-level model of the dietary effects of the FSP. The method proposed is the estimation of the "reduced-form" equations. In the reduced-form equations, nutrient levels are related to the food stamp benefit, cash income, and other variables that affect the

demand for food goods and, hence, the availability of nutrients. The estimated dietary effect of FSP benefits represents the combined effect on the demand for the individual food goods and the effect of food consumption on nutrient levels. Put another away, the FSP effects on nutrient availability occur via their impact on hundreds of individual food goods, even though those individual food goods are not used in the estimation.

3. Selection Bias

As discussed in Chapter II, FSP participants and eligible non-participants are self-selected groups of household. This self-selection of households into participant and eligible nonparticipant groups may lead to differences between the groups other than participation status, and it is important to control for such differences in order to determine accurately the dietary effects of FSP benefits.

The discussion on selection bias in this chapter develops in analytic detail two types of selection bias and outlines a model and estimation procedure to account for possible selection bias. The model developed includes the same reduced-form nutrient equations discussed above and an equation of the FSP participation decision of eligible households. The FSP participation equation and the nutrient equations would be estimated jointly to provide unbiased estimates of the dietary effects of the FSP.

4. Other Specification Issues

A number of additional model specification issues are discussed in this section of the chapter. These include multiple program participation, the importance of considering different functional forms in the estimation

of dietary models of the FSP and of paying more attention to specification testing, the estimation of marginal and total effects of the FSP, and procedures for controlling for household size and composition.

5. Household and Individual FSP Effects

In this section, the basic dietary model of the FSP is modified to examine how FSP benefits affect the nutrient intake of individuals within the household. The extensions of the basic model are quite straightforward: (1) the theoretical model is modified to allow for the food and nonfood preferences of individual household members; and (2) reduced-form nutrient intake equations are specified for individual household members. As before, the reduced-form equations relate nutrient intake to the food stamp benefit, cash income, and other household characteristics. The coefficients on FSP benefits in the nutrient equations can be compared across household members to assess whether FSP benefits are allocated equally within the household.

B. MODEL OF HOUSEHOLD FOOD CONSUMPTION

Our proposed model of the dietary effects of the FSP is based on the theory of consumer demand. That is, households are assumed to have preferences for consumption goods, represented by a utility function, and to choose consumption patterns based upon their available resources and the relative prices of the goods available to them.[1] The consumption

[1] In this section, the model developed is a household-level model. Section C of this chapter discusses an individual-level model of the dietary impacts of the FSP.

possibilities from which they must choose are given by the budget constraint.

In applying the consumer demand model, the first issue that arises is what exactly appears in the utility function--that is, what is it that individuals and households actually choose? For a study of the dietary effects of the FSP, it may appear best to take a direct approach and assume that levels of nutrients are in the utility function. In that case, demand equations for nutrients could be directly obtained from utility maximization. However, this does not seem to be a realistic assumption about household and individual preferences--households cannot, after all, consume nutrients directly (aside from vitamin pills), but must instead consume nutrients indirectly through purchases of specific food items. It would make a slight difference to assume that nutrients are in the utility function but that households have available only the "bundles" of nutrients available in specific foods; they would then choose foods so as to get the most preferred combination of nutrients. But putting food items into the utility function directly is virtually equivalent to such an approach and, in addition, is compatible with food preferences being derived from factors other than the demand for nutrients (e.g., taste, sight, smell, advertising, etc.)

1. Theoretical Model

Given this preliminary discussion, assume that the household chooses from J foods Q_j, $j = 1,\ldots,J$, and a composite nonfood good C. Write the utility function as:

(1) $U(Q_1,Q_2,\ldots,Q_J,C)$.

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Let Y be total cash income, excluding FSP benefits, B be the food stamp benefit, and P_j be the price of food good j relative to the price of C, with the latter representing the general price level. The budget constraint can be written as:

$$(2) \qquad Y + B = \sum_{j=1}^{J} P_j Q_j + C.$$

In other words, income plus FSP benefits must be spent on the J food goods and nonfood consumption.

Maximizing (1) subject to (2) leads to J different demand functions for the food goods which can be written in the form:

$$(3) \qquad Q_j = f_j(P_1, P_2, \ldots, P_J, Y, B), \quad j = 1, \ldots, J.$$

How do nutrients fit into this model? Assume that there are K nutrients N_k, k= 1,...,K, and that each unit of food good Q_j yields a_{kj} of nutrient N_k. The K nutrient equations can therefore be written as follows:

$$(4) \qquad N_k = \sum_{j=1}^{J} a_{kj} Q_j, \quad k = 1, \ldots, K.$$

Equations (3) and (4) constitute the "true" model of the determinants of nutrient levels. An increase in income or the food stamp benefit, for example, increases the quantity of each food good consumed (Q_j), though some may fall if they are inferior goods. Each Q that increases raises the amount of each nutrient, the amount depending upon the magnitudes of the a_{kj}'s.

With an ideal data set, estimation of the model would pose no special difficulties. An ideal data set would contain information on all the Q_j's, for example, and on household income. In most cross sections, prices are assumed to be constant for all consumers and are consequently omitted. Thus, equations for each consumption good could be estimated as a function of income and the food stamp benefit, as in equation (3). However, in an ideal data set, equation (4) would not be required to be estimated because the a_{kj}'s would be known and available. They are, of course, known because they are used to estimate the nutrient content of the foods a household consumes in the first place. Since they are known, the estimates of (3) plus the known equations (4) could be used to determine the effect of income and FSP benefits on nutrient levels.

Unfortunately, an ideal data set does not exist nor could it. There are literally hundreds of Q_j's and literally thousands of a_{kj}'s. No data set is sufficiently rich to allow estimation of food consumption equations for each Q_j that has a unique set of a_{kj}'s. Thus, the approach is impractical.

2. Econometric Estimation

The usual approach to estimating the model depicted by equations (3) and (4) is to focus on the food good demand functions and to aggregate the food consumption equations. The most common method is to weight the food goods by prices and to aggregate them all into a total food expenditure equation. To estimate the equation requires multiplying equations (3) through by price and adding them up across goods. This causes no special difficulty, and hence, aggregate equations for (3) could be estimated. However, an equation for food expenditures does not allow

the use of equation (4) to determine the nutrients from food, for each of the individual Q_j's within the total food expenditure variable has a different a_{kj}, and hence, a different effect on each nutrient. In general, there is no fixed relationship between an increase in total food expenditures and each of the nutrients; the relationship depends upon what combination of the individual food groups is embodied in the rise in food expenditures.

One other approach to estimating the theoretical model taken in the literature has been to attempt to estimate (4) directly by regressing the availability or intake of each nutrient on household food expenditures. This is essentially a recursive model in which cash income and the food stamp benefit are assumed to affect household food expenditures and household food expenditures influence nutrient intake. The effects of the FSP, for example, are then traced through their impacts on food expenditures which, in turn, affect nutrient levels. However, this approach leads to model specification bias since there is no fixed relationship between household food expenditures and each nutrient. Specifically, the coefficient on total food expenditures in a nutrient equation would represent only some undetermined average effect of income and the food stamp benefit on nutrient levels.

This specification bias could have serious consequences for the estimation of the effect of food stamps on nutrient intake. When the food stamp benefit is separated from other income and entered separately into the food consumption equations (3), the results of past studies suggest that the FSP benefit may have a stronger effect on food expenditures than does other income. More important for present purposes, increases in food

stamp benefits may also have different effects on the individual Q_j's than do increases in other income. In this case the food expenditure coefficients in the nutrient equations will represent biased estimates of the effect of the food stamp benefit on nutrient availability, for those coefficients will only represent average effects of increases in other income and in the food stamp benefit. For example, if increases in the food stamp benefit lead households to consume more nutritious goods than do increases in other income, the food expenditure coefficients in the nutrient equations will lead to downward biases in the effect of the food stamp benefit. The single coefficient on total food expenditures in each of the nutrient equations constrains the effect of FSP benefits and other income to be proportionate to their effects on food expenditures, which may be incorrect.[1]

The same problem is seen if the expenditure coefficients are used to estimate nutrient levels for different households with different levels of FSP benefits and other income. Two households, one of whom has a high FSP benefit and low other income and one of whom has a low FSP benefit and high other income, may have identical food expenditures. One would therefore predict the two households to have identical nutrient levels. However, if the FSP benefit is spent on more nutritious foods than is other income, the household with the high FSP benefit will have the more nutritious diet, and hence, its nutrient level will be underestimated. The nutrient level of the other household will be overestimated.

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[1] Appendix A to this report includes a specific example of household food consumption that illustrates this specification bias.

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In addition to these difficulties, entering food expenditures on the right-hand-side of the nutrient equations in (4) would lead to a type of simultaneous-equations bias, as food expenditures are endogenous. Intuitively, this is obvious from equations (3) and (4), for there is no error term in (4)--it is an exact equation (i.e., if we used the nutritionists' matrix, we would know it exactly). Therefore, the error term in any estimated version of the nutrient equations must arise, if not from approximation error, then from the error in the food demand equations. Therefore, the coefficient on food expenditures will be biased upwards--high values of the error will lead to both high values of food expenditures and high nutrient levels.[1] This econometric problem can be circumvented by application of an instrumental-variables technique, two-state or three-stage least squares, or some other simultaneous-equations estimating technique. Of course, the problem of specification bias previously discussed would remain.

The problem of specification bias would be reduced if food consumption were aggregated into expenditure subgroups rather than into total food expenditures. Many data sets allow the reliable estimation of up to 12 or so individual subgroups of food expenditures. Entering these separate food expenditures into each of the nutrient equations would allow separate coefficients on each, which would capture those differences in the effects of income and FSP benefits on nutrient levels at different food expenditure levels and from different income sources that arise through

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[1] In a different sense, the problem is that food expenditures (E) do not belong in the equation, only Y and B do; and when E is used instead, there is a errors-in-variables problem because E is only a proxy for Y and B.

differences in the nutrient levels of the subgroups. However, some specification bias of unknown magnitude would remain because of the possibility that share of consumption of the different Q_j's within each group would shift as income, the food stamp benefit, and food expenditures rise, and would be different for increases in income and increases in the FSP benefit. The degree of bias induced by this problem would depend upon much variance there is in the nutrient content of the individual food items within each identified food group.

It should perhaps be noted that adding variables for income, for the food stamp benefit or FSP participation, or both, to the nutrient equations, in addition to household food expenditures or subgroup food expenditures, does not reduce the magnitude of the specification bias. In fact, the degree of bias probably increases in this case, for there is no reason for food expenditures to remain in the equation after income and FSP benefit variables are added directly.

3. Proposed Estimation Procedure

Given this extended discussion of the problems with estimating the nutrient equations (4) with aggregate or subgroup food expenditures in place of the Q_j's, the major issue is how to estimate the dietary effects of the FSP. The simplest and most straightforward method, which we favor, is by direct estimation of the reduced-form equations. Substituting the individual food demand equations (3) into the nutrient equations (4)--recall that the data do not allow us actually to estimate individual Q_j food consumption equations--one obtains nutrient equations of the form:

$$(5) \qquad N_k = g_k(P_1, P_2, \ldots, P_J, Y, B).$$

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Recognizing that prices will be constant and that other variables affecting the demand for food goods will be added to the equation, we can expect to estimate for each nutrient k a linear regression equation of the form:

$$(6) \qquad N_{ki} = \alpha_k + \beta_k Y_i + \delta_k B_i + X_i \phi_k + \varepsilon_{ki}$$

where Y is cash income, B is the food stamp benefit, X is a set of other variables thought to affect the demand for food goods and, hence, nutrient levels, and ε is an error term. The coefficients β and δ in this equation represent the combined effects of (1) the effect of income and the food stamp benefit on the demand for food goods and (2) the effect of food consumption on nutrient levels (the a_{kj}'s). The two effects cannot be separated out, but this is not necessary to determine the effect of the FSP. The key point is that the coefficients correctly capture the effects of income and bonus on nutrient levels working through the hundreds of individual food goods, even though those individual food consumption levels are not used in the estimation.

It should also be noted that there is no simultaneous-equations bias of the type discussed earlier, so no econometric problems arise from that source. In addition, each of the nutrient equations can be estimated separately and independently of the other nutrient equations, with no loss of efficiency and with no bias.[1]

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[1] At first glance, the system of K nutrient equations appears to be a set of seemingly unrelated regressions, which would imply that generalized least squares (GLS) would be the preferred estimation procedure. However, since the independent variables for each of the nutrient equations are identical, GLS and ordinary least squares estimation lead to identical results.

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It is not necessary to estimate any food expenditure equations, although they can be estimated at the same time as the nutrient equations. The individual food expenditure equations cannot be estimated, as already discussed, but subgroup or total food expenditure equations could be estimated. These estimates may shed some light on the sources of any differences that are obtained between the cash income and food stamp benefit coefficients in the nutrient equations, for they may be traced to differences in the effects of the two on aggregate food expenditures or on expenditure subgroups with different nutrient contents.

One additional issue associated with the reduced-form specification of equation (6) is the relationship between household income (Y) and the food stamp benefit (B). Given the design of the FSP where increases in household income leads to reductions in FSP benefits, there exists a negative relationship between income and benefit levels. This relationship, however, is not exact, due to two important factors: (1) the determination of FSP benefits allows for certain deductions from household income in the calculation of the FSP benefit, including the standard deduction, earned income deduction, dependent care expenses for work or job search and training activities, excess shelter expenses, and medical expenses of the elderly or disabled; and (2) among low-income households eligible to participate in the FSP, a large proportion do not participate.[1] As a result, there is less than a perfect negative correlation between household income and the food stamp benefit, and

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[1] As discussed in Chapter II, approximately 40 percent of eligible low-income households surveyed in 1984 did not participate in the FSP.

multicollinearity is not a significant problem in the estimation of the nutrient equations.[1]

4. Selection Bias

The problem of selection bias can arise in the estimation of nutrient equations just as it can arise in the estimation of food expenditure equations. As discussed in Chapter II, selection bias may occur because of potential unobserved differences between FSP participants and eligible nonparticipants that cannot be captured by measurable variables in the equation, but which are related to the propensity of a household to participate in the FSP. The fundamental problem is that no randomized experiment has been performed, for with random assignment participants and nonparticipants would be randomly and exogenously assigned to participant or nonparticipant status. In the real environment, individuals instead self-select themselves or are systematically self-selected by others into or out of the FSP for reasons that are very likely to be correlated with the potential food expenditures and nutrient levels on and off the program.[2]

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[1] Even with less than a perfect negative relationship between income and bonus, multicollinearity could still be a problem and would be exhibited by large standard errors for the estimated parameters. However, both income and the food stamp benefit are consistently found to be significant predictors of household food expenditures, implying that there is enough independent variation in these two variables to detect statistically significant effects.

[2] From a statistical point-of-view, the problem arises in food expenditure equations because the food stamp benefit, or a variable for FSP participation, is correlated with the error term in the regression. However, since the reduced form nutrient equations will have error terms that contain as one component those of the food expenditure equations, the same correlation must appear.

It is important to point out that there are in fact two types of selection bias, which we shall call Type A and Type B. The more commonly specified type of bias is that of Type A, where participants and nonparticipants in the FSP have different levels of food consumption, holding constant all other observed characteristics, even prior to participation in the FSP. In this type of selectivity, the problem arises because FSP participants and eligible nonparticipants differ, for whatever reason, in their initial level of food consumption.

Type B selection bias, on the other hand, allows for the possibility that FSP participants and eligible nonparticipants have different marginal propensities to consume food (MPC). In this case, those who end up participating and those who do not would have differently-sized increases in food expenditures if both were to participate. For example, if FSP participants have higher MPC's out of income than eligible nonparticipants even in the absence of the FSP, they will be more likely to participate in the FSP and will have bigger food expenditure increases from participation than nonparticipants.

Both types of selection bias can exist simultaneously and both are plausible for different reasons. Intuitively, it is likely that both types of selection bias would lead to upwardly biased estimates of FSP effects on food expenditures and nutrient levels. For Type A, FSP participants are those households that initially have greater preferences for food relative to eligible nonparticipants and food stamps are an important way for their preferences to be satisfied. Participants may therefore be disproportionately composed of households with high initial food expenditures, leading to an upwardly biased estimate of the effect of FSP. For Type B, those

with higher MPC's are more likely participate in the FSP--they "get more out of the program" in a different, and more direct, sense. This will lead to an upwardly biased estimate of the FSP because an estimated food expenditure equation will show a higher MPC out of the food stamp benefit than out of cash income for the "wrong" reasons--FSP participants may in truth have higher MPC's out of all income.

The following set of equations represent Type A selection bias in model form:

$$(7) \qquad N_{ki} = \alpha_k + \beta_k Y_i + \delta_k B_i + X_i \phi_k + \varepsilon_i$$

$$(8) \qquad P_i^* = Z_i \Psi + \nu_i$$

$$(9) \qquad P_i = 1 \text{ if } P_i^* \geq 0;$$

$$= 0 \text{ if } P_i^* < 0$$

where the subscript i denotes household i; Y_i is cash income; B_i is the food stamp benefit; X_i is a set of other variables affecting food consumption; Z_i is a set of variables affecting FSP participation; and P_i is an FSP participation dummy variable. We have specified only one nutrient equation, though a separate system could be written for each. As discussed previously, because the independent variables in equation (7) would be the same for each nutrient intake equation, nothing would be gained by estimating the nutrient equations jointly using a generalized least squares procedure; therefore, a system like that in (7) - (9) can be estimated separately for each nutrient.

If Type A selection bias occurs, the error terms ε_i and ν_i are correlated. If they are positively correlated, ordinary least squares

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(OLS) estimates of (7) yield estimates of δ that are biased upward; if they are negatively correlated, the opposite occurs. In Type B selection bias, it is assumed that different households have different MPC's out of the food stamp benefit. Adding a subscript to the coefficients on the FSP benefit, equation (7) can be rewritten as:

$$(10) \qquad N_{ki} = \alpha_k + \beta_{ki}(Y_i + \gamma B_i) + X_i\phi_k + \varepsilon_i.$$

In this model there is a single income variable, $Y + \gamma B$, where γ is the ratio of the bonus MPC to the cash-income MPC. The coefficient on this income variable, β_{ki}, is the MPC for income in general, and it has a subscript "i" to represent the fact that it is allowed to be different for different households. In particular, this model allows the MPC out of income to differ between FSP participants and eligible nonparticipants.

Selection bias occurs in this case if the error term ν_i in equation (8) is correlated with the marginal propensity to consume nutrients (MPN), β_{ki}. If they are positively correlated, OLS estimates of (10) yield coefficients on B_i which are upwardly biased estimates of the mean δ_{ki}. If they are negatively correlated, the opposite occurs.

Both models of selection bias can be estimated with similar maximum likelihood estimating techniques. That is, an FSP participation equation can be estimated jointly with the food expenditure equation, using a maximum likelihood estimation technique and allowing the error terms of the two equations to be correlated. In the case of Type B selection bias, the individual-specific MPN must be allowed to be distributed normally and to be correlated with the error term in the nutrient equation. The MPN must be inserted into the FSP participation equation, as it is hypothesized to

affect participation probabilities. The FSP participation and nutrient equations would then be estimated jointly allowing correlations of the error term in the FSP participation equation with both the error term in the nutrient equation and with the MPN in that equation.

In summary, given the absence of a random design in evaluations of the FSP, it is important to consider the potential problem of selection bias in trying to isolate the effects of FSP benefits from the effects of all other factors. It is also important to note, however, that previous studies of household food expenditures provide mixed evidence on the importance of selection bias. Findings from the Puerto Rico Nutrition Evaluation (Beebout et. al., 1985) indicate virtually no Type A selection bias for household food expenditures in Puerto Rico, while an analysis by Chen (1983) suggests some Type A selection bias is present. To the best of our knowledge, no analyses of the FSP have estimated the extent of Type B selection bias.

5. Other Model Specification Issues

Multiple Program Participation. The present welfare system includes a wide variety of transfer programs designed to meet the needs of particular population groups. The goals of these programs include, among other things, providing cash, food, shelter, and medical care assistance to the needy. Because households are able to participate in more than one program at a time, it is important to consider the impact of multiple program participation in analyses that want to isolate the effects of FSP participation. For example, many FSP households also receive AFDC benefits and include children that receive benefits from the National School Lunch and School Breakfast Programs, and regression models that do not adequately

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control for participation in these other programs will obtain biased estimates of the dietary effects of FSP benefits. That is, the estimated coefficient on the food stamp benefit will reflect, in part, the effects of participation in other welfare programs.

In the absence of selection bias, multiple program participation is fairly easy to incorporate into a model of the dietary effects of the FSP. In terms of the model developed above, binary variables for participation in the relevant programs or variables for the amount of subsidy received from the relevant programs would be added to the

(P_1 and P_2) that interact with FSP participation. Then equation (6) for the availability of nutrient k could be expanded as follows:

$$(11) \qquad N_{ki} = \alpha_k + \beta_k Y_i + \delta_k B_i + \lambda_{k1} P_{1i} + \lambda_{k2} P_{2i} + X_i \phi_k + \varepsilon_{ki},$$

where the variables P_1 and P_2 are added to the model to denote participa-

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A more complicated situation exists when the possibility of selection bias is considered in a model that accounts for multiple program participation. As discussed above, selection bias occurs because of differences between program participants and eligible nonparticipants that cannot be captured by measurable variables in the nutrient equations, but such unobserved differences are related to the propensity of a household to participate in a program. In the context of multiple program participation, a model that adequately accounts for potential selection bias must specify the appropriate program participation equations in addition to the nutrient equations. Specifically, suppose we are interested in a model that examines the dietary effects of FSP benefits and National School Lunch Program (NSLP) benefits, adjusting for possible selection bias from both programs. Formally, the model to be estimated is the following:

$$N_{ki} = \alpha_k + \beta_k Y_i + \delta_k B_i + \lambda_k SL_i + X_i \phi_k + \varepsilon_{ki}$$

$$P^*_{i1} = Z_{i1}\psi_1 + u_{i1}$$

$$P_{i1} = 1 \text{ if } P^*_{i1} \geq 0$$
$$= 0 \text{ if } P^*_{i1} < 0$$

$$P^*_{i2} = Z_{i2}\psi_2 + u_{i2}$$

$$P_{i2} = 1 \text{ if } P^*_{i2} \geq 0$$

$$= 0 \text{ if } P^*_{i2} < 0$$

where N_{ki} is the availability of the kth nutrient by household i, Y is cash income, B is the food stamp benefit, SL is the subsidy received from the

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NSLP, X is a set of other variables affecting nutrient intake, P_1^* and P_2^* are unobserved latent variables underlying the FSP and NSLP participation decisions, respectively, and Z_1 and Z_2 are sets of household characteristics that influence the program participation decisions. The following assumptions are made about the random disturbance terms ε, u_1, and u_2:

$$\varepsilon \sim N(0,\sigma^2)$$
$$u_1 \sim N(0,1)$$
$$u_2 \sim N(0,1)$$

$$\mathrm{cov}(\varepsilon,u_1,u_2) = \begin{bmatrix} \sigma^2 & \sigma_{\varepsilon u_1} & \sigma_{\varepsilon u_2} \\ \sigma_{\varepsilon u_1} & 1 & \sigma_{u_1 u_2} \\ \sigma_{\varepsilon u_2} & \sigma_{u_1 u_2} & 1 \end{bmatrix}$$

The correlation between the two program participation equations makes the estimation of this model of the dietary effects of the FSP quite difficult. A two-stage estimation procedure is necessary. In the first stage, a bivariate probit model for program participation would be estimated. The bivariate probit estimates would then be used in the second-stage estimation of the nutrient equations to obtain consistent estimates of the dietary effects of FSP and NSLP benefits.

In summary, multiple program participation is an important issue to consider in analyses of the dietary effects of the FSP. In the absence of potential sample selection bias, it is relatively straightforward to estimate a model that accounts for participation in more than one program. Incorporating potential sample selection bias in a model

accounting for multiple program participation leads to a more complicated model that involves, at the least, the estimation of a bivariate probit model.

Functional Form and Specification Testing. The issue of functional form in food expenditure analyses is an old one, and the relationship between income and food shares has been studied by economists since the time of Engel (1857). There has been a tremendous amount of research on the shape of Engel curves in the last 40 years, although most of it has not been directly concerned with the low-income population (Deaton and Muellbauer, 1980).

One of the findings of this research is that the most convenient form for estimation of food expenditure equations, the linear form, is poorly suited to some data sets. The MPC is not constant as income rises, but instead appears to fall in almost all data sets.[1] This can be an issue of significance in the estimation of the effects of FSP benefits, as the MPC out of the food stamp benefit should depend upon the level of other income in the household, contrary to the assumption of the linear model. A commonly specified model is the logarithmic form, which assumes constant elasticities of food expenditure in response to income. In the logarithmic form, the share of food in total expenditures and the MPC fall proportionately as income arises. This form implies that the MPC out of the food stamp benefit will be lower for those with higher levels of other income. Another functional form that has been found to fit the data

[1] An important exception to this are the findings from the Puerto Nutrition Evaluation, which showed a constant MPC for the income range of the low-income households in Puerto Rico.

reasonably well in some contexts is the Working-Lesser form in which the food expenditure share is a function of the log of income. Unlike the logarithmic form, this form allows the income elasticity for food to fall as income rises, which some data sets appear to indicate is the case.

Two implications of this functional form issue are important to note. First, it is important to extend the different functional forms used in the food expenditure literature to the specification of nutrient equations as well. There has been little work on the functional form of nutrient equations, and there is no reason to expect that their functional form will be the same as that of food expenditures. Nutrient levels are a linear aggregate of the different food consumption equations, and how the overall functional form of the nutrient equation is related to that of the food expenditure equation is unclear.

Second, more attention to specification testing and sensitivity analysis than has been the norm in previous analyses of the dietary effects of the FSP is needed. For functional form, the issue is what functional form fits the data the best. A large number of tools for model selection have been developed by econometricians in the last few years to address this issue, especially the construction of "goodness-of-fit" tests for nonlinear models. These tests can be used to discriminate between different nonlinear forms of the nutrient equations as well as for how well nonlinear models such as the selection bias model are fitting the data.

Marginal and Total Effects. Another issue of interest is the relation between the marginal and the total effects of the FSP on food expenditures and on nutrient levels. There are two possible reasons for differences in marginal and total effects of FSP benefits. One is that the

MPC is not constant over the range of income. As we have just noted, the past literature appears to indicate that such a linearity assumption is not usually warranted, for most data show that the MPC falls as income rises. Therefore, the marginal effect of an increase in the food stamp benefit may be less than the effect of the program as a whole. This can be determined by estimating logarithmic or other nonlinear food expenditure equations.

A second reason for a difference in marginal and total effects stems from the in-kind nature of the FSP transfer, for recipients are offered a fixed size of the benefit. The FSP will increase the food expenditures of those at low income levels more than those at high income levels if those at low income levels are less likely to be inframarginal--that is, less likely to be spending the benefit amount on food anyway. To the extent that this is a significant issue--that is, to the extent that the relevant range of FSP benefits that might be considered includes a significant number of noninframarginal households--it implies that increases in FSP benefits would have greater effects on food expenditure at high bonus levels than at low levels. At high benefit levels, a larger fraction of households will be noninframarginal and hence, a given increment in the food stamp benefit will have a bigger effect. This would work in the opposite direction to the first effect mentioned.

Scaling For Household Size and Composition. A consistent finding of previous research is that household size and composition have important effects on food expenditures and the availability of nutrients at the household level. Larger households and households with certain types of members (e.g., teenage males) have been found to consume greater quantities of food, resulting in higher food expenditures and greater availability of

nutrients than is found for households of other sizes or composition. Thus, it is critical to control adequately for household size and composition in dietary analyses of the FSP.

Two basic approaches are frequently used to control for household size and composition. The first approach involves the use of exogenously determined adult equivalent scales such that each person in the household is assigned a weight, with the weight for an adult male typically set to unity and the weights for the other household member reflecting the expenditure or nutrient needs of that member relative to an adult male. Household size in adult male equivalents is then simply the sum of the weights applied to each household member. For example, consider a household with four members, consisting of an adult male, adult female, teenage male, and teenage female. Suppose further that the relative weights for these household members using some exogenously determined adult equivalent scale are 1.0, .8, 1.1, and .85, respectively. Household size in adult male equivalents based on this scale is then 3.75 persons. The advantage of using the figure 3.75 rather than 4.0 as the measure of household size is that each persons is expressed in terms of a homogeneous unit (adult male) rather than in terms of individuals of various types (i.e., of different ages and sexes).

Several exogenously determined scales have been used in previous research.[1] They include scales based on nutritional and physiological requirements or behavioral scales estimated from data on household

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[1] By exogenously determined scales, we mean scales that are determined independently of the model specified. Such scales could be estimated from the data and subsequently used in the model.

behavior. Examples of the former include scales based on: (1) the relative needs for food energy or for other nutrients (Sydenstricker and King, 1921; Blanciforti, 1983; Smallwood and Blaylock, 1984; and Devaney and Fraker, 1986); (2) a set of minimum food requirement standards (Hymans and Shapiro, 1976); and (2) the relative recommended quantities of either the Thrifty Food Plan or the low-cost food plan (Long, 1987), which are food plans designed by the Human Nutrition Information Service of USDA and consist of nutritious meals while conforming, as much as possible, to the average consumption behavior of low-income households. Exogenously-determined scales that are based on household behavior, rather than the relative nutritional requirements of household members, are used in the studies by Price (1970), Buse and Salathe (1978), Basiotis et al. (1983), West and Price (1976), and Brown and Johnson (1983).

The second approach used to control for household size and composition in analyses of household food expenditures or nutrient availability is simply to include variables for the age and sex composition of the household as predictors in the specified model. With this procedure no a priori weights are assigned to the individual household members; rather, the estimation of the model results in parameter estimates that show the relative effects of different types of household members. Several previous studies have used this approach, including Adrian and Daniel (1976) and Basiotis et al. (1983).

C. HOUSEHOLD AND INDIVIDUAL EFFECTS

As is typical in studies of food expenditure, the assumption heretofore is that the household is the unit of analysis. Household food expenditures and nutrient levels, appropriately scaled for age and sex, are affected by household income and the food stamp benefit. In this section,

the basic model is modified to discriminate between different individuals within the household and how their nutrient intake levels respond to income and the food stamp benefit.

This issue is of considerable importance because there is no mechanism in the FSP to ensure that all members of the household obtain their fair, or proportionate share, of the incremental household food consumption made possible by FSP benefits. Of particular concern is whether the children in the family, who obviously do not control the allocation of the incremental food expenditures, obtain a proper share of FSP benefits. For children, it is also of interest to compare the per-dollar incremental nutrient level they receive from the food stamp benefit with the similar incremental nutrient level received from a targeted program such as the National School Lunch Program. The latter may have a stronger impact on childrens' nutrient intake, although this is not guaranteed if the household reduces its own expenditures on children in response to school lunches. It is also possible that the intra-household allocation of food expenditures would vary systematically with the overall level of household income and expenditures.

An additional issue of some interest is whether benefits from the FSP spill over to members of the household who are not members of the FSP-defined household unit. The FSP-defined household unit is based upon, among other things, a common cooking and eating facility. But if there are transfers of other resources going on between this unit and other members of the household, those levels of transfers could respond to the food stamp benefit. There may be some resulting "leakage" of the beneficial effects of FSP benefits to the members of the larger household unit.

These issues can be addressed best with individual data from the NFCS or the CSFII, which contain information on nutrient intake levels of individuals in the household. The individual data also have the advantage of representing more closely a measure of actual nutrient intake rather than of nutrient availability, as available in the household-level data.

To model household and individual effects, we modify the model discussed in the prior sections to allow for multiple members of the consumption unit. The simplest method of extending the model in this way is to allow the utility function to contain separate terms for the food consumption items for each member of the household. Letting Q_{jm} represent the age-sex-adjusted level of food consumption for good j for household member m (m = 1,...,M), the utility function can be written as:

$$(12) \qquad U(Q_{11},\ldots,Q_{J1},Q_{12},\ldots,Q_{J2},\ldots,Q_{1M},\ldots,Q_{JM},C)$$

where C is once again a composite nonfood consumption good. The budget constraint for the household is then:

$$(13) \qquad Y + B = C + \sum_{j=1}^{J} P_j\left(\sum_{m=1}^{M} Q_{jm}\right)$$

and the demand equations for each good for each member can be written in general form as follows:

$$(14) \qquad Q_{jm} = f_{jm}(P_1,\ldots P_J,Y,B) \quad j = 1,\ldots,J;\ m=1,\ldots,M$$

Again we assume that the true nutrient relationship is known, and that the nutrient-food matrix can be used to compute the nutrient level for

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nutrient k for each member m from that member's food consumption levels. The nutrient matrix is represented by:

$$(15) \qquad N_{km} = \sum_{j=1}^{J} a_{jk} Q_{jm}.$$

Substituting (14) into (15), solving down, assuming the prices to be constant in a cross-section, and linearizing the equation, we have the regression equation:

$$(16) \qquad N_{km} = \alpha_{km} + \beta_{km} Y + \delta_{km} B + X\phi_{km} + \varepsilon_{km} \quad k = 1,\ldots,K;\ m = 1,\ldots,M.$$

Thus, the model implies simply that we must regress each individual nutrient intake level on per capita household cash income and the food stamp benefit, as well as on other characteristics. The coefficients on the food stamp benefit in the equations for a given nutrient can be compared across different household members. Statistical tests for equality of the coefficients will determine whether there is an equal marginal allocation of the food stamp benefit across household members. If the coefficients are significantly different across members, a comparison of their relative magnitudes will indicate whose nutrient levels are relatively more or less affected.

The other characteristics in the regression should include any that are in the individual food good equations, which means that any characteristic affecting the tradeoffs in the utility function between the food consumption of different members should be included. This implies that each individual nutrient equation should not only contain variables for the characteristics of the individual himself or herself, but also household-level variables and variables representing the characteristics of

others in household. That is, the nutrient levels of a given member should depend upon the types of other members present in the household.

As in prior sections, several additional features of the model should be noted. As before, entering household food expenditures into the nutrient equations should be avoided, both because of bias from endogeneity and from specification bias. Also as before, estimation of the food expenditure equations is not necessary but would be of interest. In this case, aggregate or food subgroup expenditure equations for separate members of the household could be estimated. The results will indicate whether there are differences across members in the allocation of the food stamp benefit to food expenditures, which may shed light on the results obtained in the nutrient equations. Finally, the selection bias issues discussed in the preceding section also apply here. Since each nutrient equation for each household member can be estimated separately and independently of all the others, a separate selection bias model can also be estimated. Although the number of estimations would grow large if a large number of household members were examined, there is no difficulty in principle with estimating a large number of such models. A priori, one would expect that selection bias would be reduced when individual nutrient equations are examined, for the error terms in the individual nutrient equations are probably less correlated with household FSP participation propensities than the error term in the household-level nutrient equations. However, this is an empirical question that can only be answered by direct estimation.

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APPENDIX A

A SIMPLIFIED EXAMPLE OF HOUSEHOLD FOOD CONSUMPTION

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As discussed in Chapter III of the report, many previous analyses of the dietary impacts of the FSP have estimated a model in which FSP benefits and cash income, as well as other explanatory variables, are assumed to affect food expenditures, which, in turn, influence the dietary outcome measure. Program effects on the dietary outcome measure are then traced via their estimated effects on food expenditures and the estimated effect of food expenditures on the dietary outcome. The objective of this appendix is to provide an example of the relationship among cash income, the FSP bonus, household food expenditures, and nutrient intake to show how such a model leads to biased estimates of the effects of the FSP bonus and cash income on nutrient intake.

Consider a household of size one that chooses among three foods. The following table provides some hypothetical data on the food choices of this household.[1]

Food Consumption in the Absence of the FSP (lbs./week)	Price/lb.	Calories/lb.	$\Delta Q/\Delta B$	$\Delta Q/\Delta Y$
$Q_1 = 10$	$1.00	875	.20 lb.	.01 lb.
$Q_2 = 8$	$2.00	525	.10 lb.	.05 lb.
$Q_3 = 7$	$3.00	350	.01 lb.	.05 lb.

$\Delta Q/\Delta B$ = change in quantity consumed due to a $1.00 increase in bonus

$\Delta Q/\Delta Y$ = change in quantity consumed due to a $1.00 increase in cash income

[1] While the example provided is admittedly simple, the findings

However, the FSP bonus is not the only determinant of household food expenditures and nutrient intake. For example, the final column in the table shows the effect of a one-dollar increase in cash income (Y) on food consumption. From the price and food energy content data, we can again calculate the impact of changes in cash income on food expenditures and food energy intake:

$$(3) \qquad \frac{\Delta F}{\Delta Y} = (.01)(\$1.00) + (.05)(\$2.00) + (.05)(\$3.00) = \$.26$$

$$(4) \qquad \frac{\Delta K}{\Delta Y} = (.01)(875) + (.05)(525) + (.05)(350) = 52.5 \text{ Kcal}$$

Thus, the <u>true</u> change in the intake of food energy due to a one-dollar increase in cash income can again be calculated directly from the data and equals 52.5 kilocalories. It also would be estimated from the reduced-form regression model relating the intake of food energy to cash income (as well as the FSP bonus).

Now consider a regression model that attempts to estimate the effects of the FSP bonus and cash income on food energy intake using the model in which the FSP bonus affects food expenditures which, in turn, influence the intake of food energy. The model can be depicted as follows:

$$F_i = \alpha_o + \alpha_1 Y_i + \alpha_2 B_i + X_i \phi_1 + \varepsilon_{1i}$$
$$K_i = \beta_o + \beta_1 F_i + Z_i \phi_2 + \varepsilon_{2i},$$

where F_i = food expenditures of the ith household
K_i = intake of food energy
Y_i = cash income
B_i = FSP bonus

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$X_i Z_i$ = vectors of other variables influencing food expenditures and the intake of food energy, respectively

$\alpha_0, \alpha_1, \alpha_2, \phi_1, \beta_0, \beta, \phi=_2$ unknown parameters to estimate

$\varepsilon_1, \varepsilon_2$ = random disturbance terms

To get the estimated overall FSP and income impacts on the intake of food energy in this case involves multiplying the effects of the FSP bonus and cash income on food expenditures by the effect of food expenditures on food energy intake:

$$(5) \quad \frac{\Delta K}{\Delta B} = \frac{\Delta K}{\Delta F} \frac{\Delta F}{\Delta B} = (\beta_1)(\alpha_2)$$

$$(6) \quad \frac{\Delta K}{\Delta Y} = \frac{\Delta K}{\Delta F} \frac{\Delta F}{\Delta Y} = (\beta_1)(\alpha_1)$$

The second terms on the right hand side of equations (5) and (6) (α_2 and α_1) are simply the marginal propensities to consume (MPCs) out of food stamp benefits and cash income, respectively. As discussed above and shown by equations (1) and (3), these MPCs can be calculated directly from the price and change in quantity data in the table and are equal to .43 and .26, respectively.

The problem in equations (5) and (6) is to obtain an estimate of the impact of a change in food expenditures on the intake of food energy ($\Delta K/\Delta F$ or β_1). Using the actual data provided in the example, two different estimates come from even the simple example provided above. Using the data based on the FSP benefit, we see that a one-dollar increase

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In the absence of the FSP, this one-person household consumes 10 pounds of food one, 8 pounds of food two, and 7 pounds of food three. Food expenditures and the intake of food energy are:

Food Expenditures : $F = (10)(\$1.00) + (8)(\$2.00) + (7)(\$3.00) = \$47.00$

Food Energy : $K = (10)(875) + (8)(525) + (7)(350) = 15{,}400$

Now consider the introduction of a FSP, which provides a benefit equal to B (bonus). The hypothetical household above changes its food consumption after the receipt of the FSP bonus, as shown by the fourth column of the table, which shows the change in food consumption due to a one dollar increase in the FSP bonus. The actual change in food expenditures and the intake of food energy can be calculated directly from this example:

(1) $$\frac{\Delta F}{\Delta B} = (.20)(\$1.00) + (.10)(\$2.00) + (.01)(\$3.00) = \$.43$$

(2) $$\frac{\Delta K}{\Delta B} = (.20)(875) + (.10)(525) + (.01)(350) = 231 \text{ Kcal}$$

The figure of 231 is the <u>true</u> change in the intake of food energy due to a one-dollar increase in the FSP bonus and is calculated directly from the change in the quantities of food attributable to the one-dollar increase in bonus and the food energy content of the three food items. This figure would be estimated from the coefficient on the FSP bonus in a regression equation for the intake of food energy--the reduced-form regression model specified in Chapter III of the report.

in bonus leads to an increase in food expenditures of $.43 and an increase in the intake of food energy of 231 kilocalories. That is,

$$\frac{\Delta K}{\Delta B} = 231$$

$$\frac{\Delta F}{\Delta B} = .43$$

$$\Longrightarrow \frac{\Delta K}{\Delta F} = \frac{231}{.43} = 537.21,$$

which implies that the effect of a one-dollar change in food expenditures on the intake of food energy is 537.21 kilocalories. Using the data on the effects of a change in cash income, however, we see that a one-dollar increase in cash income leads to an increase in food expenditures of $.26 and an increase in the intake of food energy of 52.5 kilocalories, implying a different impact of a change in food expenditures on the intake of food energy of 201.92 kilocalories:

$$\frac{\Delta K}{\Delta Y} = 52.5$$

$$\frac{\Delta F}{\Delta Y} = .26$$

$$\Longrightarrow \frac{\Delta K}{\Delta F} = \frac{52.5}{.26} = 201.92.$$

Thus, there are two estimates of the effect of food expenditures on the intake of food energy (537.21 versus 201.92), due to the fact that the FSP benefit and cash income affect household food consumption in <u>different</u> ways. Both the increase in the FSP bonus and the increase in cash income increase food expenditures, but an equal increase in the bonus and income

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have different effects on food energy because they affect the consumption of the three food goods in different proportions.

In practice, a regression model will lead to an estimated effect of food expenditures on nutrient intake that is a weighted average of the different effects of the FSP bonus and cash income on the intake of food energy, with the weights being determined by the relative effects of the FSP bonus and cash income (as well as of any other independent variables) on the quantities of foods consumed. The effect of using this weighted average of the effects of the increase in food expenditures on the intake of food energy is to bias the estimated effects of the FSP bonus and cash income on food energy intake. This can be seen from equations (5) and (6), where using some average value of $\Delta K/\Delta F$ will lead to regression estimates of the impacts of the bonus and cash income on food energy intake that differ from the true effects.

To be specific, suppose the estimated effect of food expenditures on food energy intake ($\Delta K/\Delta F$) is a simple average of the two estimates that come from the example (i.e., (537.21 + 201.92)/2 = 369.57). Then, the model depicted by equations (5) and (6) yields regression estimates of the effects of the FSP bonus and cash income on the intake of food energy that differ from the true effects, as follows:

1. Effect of the FSP Bonus on Food Energy Intake:
   - o True Effect = 231.00
   - o Estimated effect from model (equation (5))

$$\frac{\Delta K}{\Delta B} = \left(\frac{\Delta K}{\Delta F}\right)\left(\frac{\Delta F}{\Delta B}\right) = (369.57)(.43) = 158.92$$

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2. Effect of Cash Income on Food Energy Intake:
   - o True effect = 52.50
   - o Estimated effect from model (equation (6))

$$\frac{\Delta K}{\Delta Y} = \left(\frac{\Delta K}{\Delta F}\right)\left(\frac{\Delta F}{\Delta Y}\right) = (369.57)(.26) = 96.09$$

The true effects and estimated effects are not equal and, more importantly, the estimates are not expected to be equal. In addition, in a more complex and realistic depiction of household food consumption, other factors in addition to the FSP bonus and cash income will influence household food choices and, hence, these factors will also influence the regression estimates of the effect of food expenditures on nutrient intake.

To summarize, the example provided in this appendix allows the exact calculation of the effects of the FSP bonus and cash income on the household intake of food energy. The estimated effects of the FSP bonus and cash income obtained from a model relating nutrient intake to food expenditures and food expenditures to the FSP bonus and cash income are not equal, in terms of expected values, to the true effects. The fundamental problem is that there is no fixed relationship between the increase in total food expenditures and nutrient intake; the relationship depends on the source of the increase in food expenditures, since the source of the food expenditure increase determines the increase in the consumption of the individual food groups which determines nutrient intake. A reduced-form model, on the other hand, leads to estimates of the effects of the FSP bonus and cash income on nutrient intake that are equal, in an expected value sense, to the true effects. This is because a reduced-form model includes the sources of the changes in food consumption directly in the nutrient equations.

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APPENDIX B

NUTRITIONAL OUTCOME MEASURES

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Previous analyses of the nutritional effects of the FSP have examined a wide variety of measures of dietary status, such as household food expenditures, nutrient intake, and the availability of nutrients from food used by households. However, these measures are not synonymous with nutritional status, which is the focus of the FSP's objectives. This appedix has two important and related components:

1. An overview of health, dietary, and poverty status
2. A discussion of the components of nutritional status, with emphasis on the various measures of dietary status that are used in nutritional analyses of the FSP.

A. OVERVIEW OF HEALTH, DIETARY, AND LOW-INCOME STATUS

The implicit assumption of the FSP is that by increasing in-kind income in the form of tied income transfers, food intake of individuals in participating households is increased, thereby improving nutritional status and health. However, the potential of the FSP for promoting health and reducing the relative risk of selected diseases within the low-income population depends on the extent to which differences in diet and nutritional status contribute to differences in normal physical development or excess risk of disease. This overview identifies major public health problems, describes the prevalence of such problems in the low-income population, and discusses the increased risk of disease that may be related to dietary patterns and nutritional status. Three major public health concerns are discussed: (1) adult health, (2) child health, (3) hunger, and (4) pregnancy outcome.

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1. Adult Health

In the U.S. population, age-adjusted death rates have generally declined over the past 30 years for chronic disease such as cardiovascular disease (heart disease and cerebrovascular disease) and diabetes. Death rates for the leading causes of adult death in 1982 ranged from a high of 139.5 for disease of the heart (139.5/100,000), 138.2 for cancer, 36.6 for accidents to lower values of 19.1 for strokes and 16.1 for chronic liver disease and cirrhosis (U.S. DHHS, 1986). Diet and nutritional status factors are thought to play a significant role in each of the following multietiology chronic disease states.

Adult Obesity. Adult obesity is a risk factor for coronary heart disease, non-insulin dependent diabetes mellitus (NIDDM), certain cancers, osteoarthritis and other medical problems. As measured in the second Health and Nutrition Examination Survey (NHANES II) data, 28 percent of adults 25 years of age or older were overweight. The condition was slightly greater in women (29.6) than in men (26.3) Obesity is particularly a problem among adult black women, where prevalence was approximately 60 percent for those 45 years of age and older.

Table B.1 provides data on the prevalence of obesity by age, sex, and poverty status, based on data from NHANES II. As indicated by these data, the prevalence of obesity is considerably higher for low-income women than for higher income women, although this association is not observed for men.

Obesity is a particular risk factor for diabetes, high-risk serum cholesterol, and hypertension. The relative risk of diabetes for obese persons is over four times that of nonobese persons in the 25 to 44 year age range. The relative risk drops to two in the 45 to 74 year range.

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TABLE B-1

PREVALENCE OF OBESITY BY AGE, SEX, AND POVERTY STATUS, 1976-80
(Percentages)

	Poverty	Nonpoverty
Females		
25-34 years	30.8%	20.5%
35-44 years	49.1	23.7
45-54 years	54.1	30.3
55-64 years	44.1	35.5
65-74 years	46.1	37.0
Males		
25-34 years	20.3	20.5
35-44 years	24.0	29.3
45-54 years	28.5	31.4
55-64 years	26.0	27.8
65-74 years	20.9	25.8

SOURCE: National Health and Nutrition Examination Survey II, 1976-80.

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Obese younger persons have nearly twice the relative risk of high risk serum cholesterols, and nearly 3.5 the relative risk for hypertension. Among older persons, the relative risk associated with obesity is smaller, approximately 1. for high risk cholesterol, and 1.6 for hypertension.

Non-insulin Dependent Diabetes Mellitus (NIDDM). The incidence of NIDDM has a strong genetic component and is strongly linked with obesity and exercise level. The primary treatment of NIDDM is dietary management. Using the NHANES II (1976-80) definition of diabetes, seven percent of the total adult population were diabetic, nearly all of whom had NIDDM, rather than the juvenile onset insulin dependent form of diabetes. The prevalence of diabetes increased with age, and was higher among the following groups: females (8.2 percent) versus males (6.6 percent), blacks (11.2 percent) versus whites (7.0 percent), and overweight (13.4 percent) versus not overweight (4.9 percent).

The following data from NHANES II show the percentage of individuals with diabetes by age and poverty status.

Age	Poverty	Nonpoverty
25-34 Years	2.4%	.5%
35-44 Years	8.9	2.5
45-54 Years	15.3	8.0
55-64 Years	22.3	11.9
65-74 Years	20.6	17.3

These data show that poverty status is associated with an excess risk of diabetes at all ages, particularly in the 55-64 year age range. In addition, the overall prevalence rate for low-income persons was 12.9 percent versus 6.8 percent for persons above the poverty level.

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Cardiovascular Disease. Although heart disease as a cause of death has declined significantly since the mid-1960's, it is still the leading cause of death in the United States. A number of factors have been associated with the decline in death rates due to heart disease, including improved medical care services, diagnosis and control of hypertension, decreased smoking, and changing food consumption patterns. A number of risk factors are associated with coronary heart disease, including elevated blood cholesterol, cigarette smoking, obesity, and elevated blood pressure.

Although there has also been a significant decline in the population level of serum cholesterol over the past 20 years, a significant number of persons still have elevated total cholesterol levels. NHANES II data indicate that population mean cholesterol levels were significantly higher in each successive age group until age 45-54 in men and 55-64 in women.

Moderate and high risk serum cholesterol cutpoints have been defined by age group by the NIH Consensus Development Panel.[1] Low income is not generally associated with higher-prevalence of elevated serum cholesterols, as shown by data in Table B.2 on percentages of individuals with high risk serum cholesterol by poverty status. With the exception of young white men, the poverty population has lower prevalence rates than do nonpoverty populations. However, prevalence rates in low-income and higher-income older females are still exceptionally high.

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[1] The levels of serum cholesterol that fall into the high risk category are: (1) for ages 20-29, serum cholesterol levels greater than 220 milligrams pr deciliter; (2) for ages 30-39 years, serum cholesterol levels greater than 240 milligrams per deciliter; and (3) for ages 40 and older, serum cholesterol levels greater than 260 milligrams per deciliter.

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TABLE B-2

PREVALENCE OF CHOLESTEROL LEVELS AT HIGH RISK BY AGE, SEX, AND POVERTY STATUS, 1976-80
(Percentages)

	Poverty	Nonpoverty
Females		
25-34 years	15.9%	17.9%
35-44 years	12.4	13.4
45-54 years	23.0	22.5
55-64 years	29.3	36.3
65-74 years	29.6	35.5
Males		
25-34 years	24.7	18.7
35-44 years	13.5	21.3
45-54 years	13.9	21.3
55-64 years	12.6	23.2
65-74 years	13.4	19.0

SOURCE: National Health and Nutrition Examination Survey II, 1976-80.

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Hypertension In NHANES II, persons were defined as hypertensive if the average systolic or diastolic blood pressure were at or above the 140/90 mm Hg level, or if they reported that they were taking antihypertensive medication during the medical interview. A number of genetic and environmental factors influence the incidence and treatment of hypertension, but the exact etiology of the disease is unclear.

A number of factors are associated with the prevalence of hypertension. Prevalence rates increase with age; young men are at greater risk than young women. However, after the age of 55 years, the prevalence is higher among females. Black persons are at higher risk than white persons of the same age and gender. The prevalence of hypertension increases with fatness. As in diabetes, not only absolute amount of body fat, but distribution of fat is associated with increased risk of hypertension. Risk of hypertension and NIDDM are higher when excess fat is deposited on the trunk (as measured by subscapular skinfold measure) than when it is deposited in more peripheral sites such as arms, legs, or hips.

As shown in Table B.3, the prevalence of hypertension is higher among low-income males and females at all ages than among nonpoverty populations. Although it has been hypothesized that excess obesity explains higher rates in the low-income population, the same excess risk exists for males and females and the prevalence of obesity among males does not differ greatly by poverty status.

Data on hypertension in Table B.3 also illustrate how common a disease and risk factor hypertension is. Even in the youngest age group, more than one quarter of low-income males have hypertension. Between 55 and 60 percent of all low income-men between the ages of 45 and 74, and

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TABLE B-3

PREVALENCE OF HYPERTENSION BY AGE, SEX, AND POVERTY STATUS, 1976-80
(Percentages)

	Poverty	Nonpoverty
Females		
25-34 years	11.3%	6.5%
35-44 years	27.8	17.9
45-54 years	41.8	38.7
55-64 years	61.0	51.0
65-74 years	72.5	66.9
Males		
25-34 years	26.8	20.1
35-44 years	35.7	27.8
45-54 years	54.8	42.6
55-64 years	56.8	52.3
65-74 years	60.5	60.5

SOURCE: National Health and Nutrition Examination Survey II, 1976-80.

nearly 75 percent of low-income females in the age range of 65 to 74 years have hypertension.

Cancer. The probability at birth of eventually developing cancer at major sites varies by gender and race. Probabilities in 1985 ranged from 36.2 percent in white males, 34.7 percent in black males, 34.0 percent in while females, and 29.2 percent in black females (Seidman et al., 1985). Despite lower incidence rates in blacks, relative five-year survival rates are consistency lower among blacks than whites.

Cancer is the second leading cause of death among U.S. adults. Since the length of time from initiation of the carcinogenic process to disease expression is very long, relationships to lifestyles and environmental factors are difficult to quantify. Cancers which have been related to diet include cancer of the stomach, rectum, colon, pancreas, breast, and uterus. Environmental factors may influence the initiation and/or the progressive development of cancer.

A number of dietary factors are thought to be involved in both cancer initiation and promotion. Candidates include total energy intake, fat, protein, cholesterol, dietary fiber, alcohol, selenium, carotene, and vitamins A, E, and C. Epidemiologic evidence supports total protein intake, fat, and total energy intakes as positive risk factors for cancer. Elevated intakes of alcohol and nitrite-cured foods have also been associated with increased risk. In contrast, a number of dietary constituents have been found to be protective against the occurrence of cancers in experimental animals. These include food sources of dietary fibers, selenium, carotene, Vitamins A, E, and C, and indole containing cruciferous vegetables.

Estimates of the incidence and prevalence of cancer are often based on the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program, and other data from the National Center for Health Statistics. Although age-adjusted rates are available by gender and race, few data exist on cancer risk by income status. Therefore excess cancer risk in low-income populations is at best estimated by prevalence of selected risk factors.

Osteoporosis. Primary osteoporosis is an age related disorder characterized by decreased bone mass and by increased susceptibility to fractures in the absence of other recognizable causes of bone loss. Complex cellular, physiologic, metabolic, and dietary factors determine bone health and the etiology of osteoporosis. Bone mass decline is a function of gender, age at menopause, race, and body weight for height. Women are at higher risk than men because of the generally smaller initial bone mass. Also, following menopause, bone loss is accelerated.

Dietary imbalances, low body weight, immobilization, prolonged bed rest and lack of exercise involving weight bearing have been shown to influence formation and resorption of bone. Therefore, calcium and vitamin D intake deficiency, low body weight, and low activity levels are risk factors for osteporosis. Although estrogen replacement therapy started at the time of menopause has been found to reduce resorption and retard postmenopausal bone loss, it has been estimated that women require about 1500 milligrams of calcium intake per day to maintain calcium balance. This level is currently nearly twice the RDA for calcium and more than three times the mean intake of calcium per day by U.S. adult females.

Complete estimates of the prevalence of osteoporosis are unavailable. At the 1984 NIH Concensus Development Conference, it was estimated that approximately 15-20 million persons (approximately 15 percent of the population) are affected. Blacks seem to have greater bone density throughout life and, hence, osteoporosis rates are higher in white women than black. Relative obesity may contribute to racial differences in females. It has been estimated that of individuals who live to 90 years, 32 percent of women and 17 percent of men will suffer hip fracture due to osteoporosis. Estimates of the prevalence of osteoporosis by income level are unavailable, although it is thought that a large number of white low-income women are at risk of osteoporosis.

Summary. Prevalence of health conditions directly or indirectly related to poor nutritional status are generally highest among the low-income population. Excess obesity is particularly a problem among low-income women, resulting in increased risk of obsesity-related diabetes, hypertension, and high-risk serum cholesterol. Prevalence rates of non-insulin dependent diabetes mellitus and hypertension are known to be higher among low income populations, but rates of elevated blood cholesterol are comparable across income groups.

2. Child Health

Child mortality and morbidity. Major sources of mortality for younger children in the United States (1985) are accidents and adverse effects, cancer, congenital anomalies, homicide, and diseases of the heart (U.S. DHHS, 1986). Pneumonia and influenza, ranked as the second cause of death in 1950, are no longer among the top five causes of death. Improvements in access to health care and living conditions in low income popu-

acquired postnatal malnutrition. Fetal growth retardation (small for gestation age low birth weights) is associated with depressed cell-mediated immunocompetence which has been shown to persist for periods of months to years (Chandra, 1986). Thus, small for gestational age children are at increased risk for compromised immune status and are particularly in need of balanced dietary intake. Deficiencies in protein, as well as vitamins A, E, B_6 and folate, iron, zinc and trace minerals (copper, selenium, iodine) have been associated with reduced immunocompetence in adults and children. Obesity has also been shown to be related to increased frequency of respiratory infection and post operative wound infection.

Virtually no morbidity data exist to document an association between low income and reduced immunocompetence in children. However, fetal growth retardation is more prevalent in low-income women; mean dietary intakes of related nutrients are frequently, but not always, lower in children from low income households. Thus, it seems feasible that improved immune function and reduced susceptibility to infectious childhood diseases may be another area in which health benefits may be achieved through improved nutritional status of pregnant women, infants, and children of school age.

Anthropometric status. The primary health status outcome associated with diet and nutritional status in children is achievement of appropriate growth and development. Child health is typically measured in terms of 1) appropriate gains in height and weight for younger children, 2) biological maturation at an appropriate chronological age, and 3) a renewed height and weight growth spurt among adolescents. A chronic and mild dietary inadequacy will result in growth retardation, reflected in a

slowing of the linear growth (stunting). Height for age will be low, but weight for height will be normal. Acute, short term dietary inadequacies are associated with reductions in weight for age, without concurrent height retardation (wasting).

Socioeconomic status has a strong relationship with growth and development. Based on data from NHANES II, Table B.4 presents the percent of children below the National Center for Health Statistics growth chart 5th percentile of height for age and weight for height by age, sex, and poverty status. In nearly all age groups, low-income status is associated with an increased prevalence of both low height for age and low weight for height in 6-9 year old males and 2-5 year old females. The effect on height for age is most dramatic. In particular, among two to five year olds, approximately 11 percent of low-income males and 15 percent of low-income females fell below the fifth percentile of height for age, indicating growth retardation.

Biochemical Status of Children. Monitoring of anthropometric status does not necessarily reflect metabolic function. Therefore, assessment of child health often includes measures of hematological and nutritional biochemistry data to reflect other aspects of nutritional status.

Serum albumin is a blood protein which reflects protein-energy nutriture. Although one might expect differences by poverty status, data from NHANES II indicate that no differences were found between those above versus below poverty.

Clinical and biochemical tests of iron status in NHANES II indicate that the prevalence of iron deficiency was greater in low-income children

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TABLE B-4

PERCENT OF CHILDREN LESS THAN THE NCHS FIFTH PERCENTILE OF HEIGHT FOR AGE AND WEIGHT FOR HEIGHT BY AGE, SEX, AND POVERTY STATUS, 1976-80

	Females		Males	
	Poverty	Nonpoverty	Poverty	Nonpoverty
Height for Age				
2-5 Years	14.7%	5.3%	11.1%	5.3%
6-11 Years	6.8	4.0	6.8	3.6
12-17 years	7.3	2.7	7.5	4.4
Weight for Height				
2-5 Years	3.3	2.5	2.1	2.4
6-9 Years	1.1	2.4	6.9	2.3

SOURCE: National Health and Nutrition Examination Survey II, 1976-80.

and youth than among higher-income counterparts. Among 1 to 2 year olds, 20.6 percent of children living in low-income households had impaired iron status, as compared with 6.7 percent of 1 to 2 year olds from higher income households. The prevalence in below poverty 3 to 5 year old males was 13.7 percent versus 3.9 percent in above poverty 3 to 5 year old males. Among teenage women, the prevalence of impaired iron status ranged from 8.7 percent for low-income females to 3.1 percent in nonpoverty populations.

Clinical symptoms of zinc deficiency include growth retardation, mental lethargy, and delayed wound healing. Although serum or plasma zinc levels are not precise estimates of zinc nutritional status, such levels were measured in NHANES II and are thought to be related to zinc nutritional status. These data indicate that zinc impairment was more prevalent in low-income children. Although absolute percentages were relatively small, the prevalence of low zinc levels was generally higher for low-income than for higher-income children.

In summary, evidence exists which supports a higher prevalence of impaired immune function, low height for age and weight for age, and abnormal iron and zinc biochemistry in children from low-income households. All conditions may be related to some aspects of inadequate diet and nutritional status among these children.

3. Hunger and Poverty

Of all dietary related health problems, the consequences of hunger are the most difficult to define and characterize. While hunger may be either a short term or longer term sensation caused by not having enough food, various forms of under- and malnutrition are the long term health consequences of chronic hunger. Undernutrition is the consequence of the

consumption of an insufficient quantity of food or a lack of one or more essential nutrient. Undernutrition is a continuum through which a person may pass from health into malnutrition. Malnutrition in general is the impairment of health resulting from a failure to meet the physiological nutrient requirements of an individual. It may be caused by not enough food, or the improper balance of foods. Malnutrition is closely related to, but differs from, hunger.

Despite efforts of the Joint Nutrition Monitoring Evaluation Committee (JNMEC) to evaluate national surveys providing data on the dietary and health status of the American population, no accurate estimate of the extent of hunger, or any resulting health consequences of hunger, are available. The Presidents Task Force on Food Assistance notes that hunger is more prevalent among three categories of persons: the traditional poor, particularly single female headed households, children, and the elderly; two adult households in which long periods of under- or unemployment have stressed the ability to purchase sufficient food; and the urban homeless.

The sampling plan for NHANES did not include persons without an address. Therefore, the health data from these surveys underreport the effects of chronic hunger in the U.S. In the 1977-78 Nationwide Food

mately 20 percent of the RDA lower than those not indicating food insufficiency. However, the NFCS sampling scheme also underreports the homeless, thus underestimating the prevalence and potential health implications of hunger.

The health impacts of chronic hunger include health problems described earlier. Poor nutrition in pregnant women results in low birthweight and infant mortality. Poor nutrition in infants causes stunted growth and development. Poor nutrition in children and adolescents can result in impaired immune function and growth retardation. In adults, undernutrition contributes to being underweight and the increased mortality associated with extreme underweight, infectious diseases, and increased rates of selected chronic diseases such as osteoporosis and iron deficiency anemia. Rates of pulmonary tuberculosis are reported to be considerably higher than in the population at large. Consumption of diets appropriate for the treatment of selected chronic diseases requiring special diets (diabetes, hypertension) is a problem for the hungry. This is likely to result in higher rates of disease-specific morbidity for these individuals. It should be expected that any morbidity or mortality associated with low-income status should be present at higher rates among persons suffering from chronic hunger.

4. Pregnancy Outcome

Maternal Morbidity and Mortality. The importance of adequate maternal nutrition during pregnancy is primarily associated with successful pregnancy outcome relative to full term delivery and infant birthweight in excess of 2,500 grams. However, pregnancy does impose a small risk of maternal death and morbidity. Two sources of maternal mortality and

morbidity are preeclampsia and eclampsia--forms of toxemia of pregnancy characterized by hypertension and proteinuria. Although accurate national estimates are unavailable for these conditions of pregnancy, it has been estimated that the mortality rates for toxemias of pregnancy range from 3.8 per 100,000 live births in higher-income populations, to 5.9 in middle income, and 11.9 in low-income populations (NAS, Maternal Nutrition and the Course of Pregnancy, 1970). It is likely that early prenatal care, thus earlier detection and treatment, are responsible for part of the difference in mortality rates. But, while the etiology of toxemia is currently uncertain, a direct role for nutrition is possible. A number of researchers have implicated general malnutrition and a combination of nutritional deficiencies. Since a variety of nutritional deficiencies have been reported in toxemic women, dietary supplementation may have a positive impact in reducing the frequency of toxemias of pregnancy in malnourished women (Worthington-Roberts, 1986) and have an impact on related morbidity and mortality in low-income women of childbearing age.

Low Birthweight As a Source of Infant Morbidity and Mortality. Low birthweight is a major determinant of infant mortality in the United States. Most infant deaths occur during the neonatal period (within the first four weeks of life) and are primarily the consequence of inadequate fetal growth, as indicated by low birthweight (less than 2,500 grams). Inadequate fetal growth is a result of poor fetal growth during some or all of the pregnancy (intrauterine growth failure), prematurity (duration of pregnancy less than 37 weeks from the last menstrual period), or both. The risk of mortality increases as birthweight decreases. Very low birthweight infants, less than 1,500 grams, are at highest risk. Low birthweight also

increases the risk of infant morbidity. The association of neurodevelopmental handicaps and congenital anomalies with low birthweight has been well established; low birthweight infants are also susceptible to a wide range of other conditions such as lower respiratory tract infections, learning disorders, and complications of neonatal intensive care interventions.

National low birthweight data by level of income are very limited. The major source of low birthweight data, the National Center for Health Statistics Vital Statistics Registration System, continuously compiles data from birth certificates, but does not collect information by income or socioeconomic status. Proxies such as education or race are often used to reflect socioeconomic status. Therefore, it has been difficult to determine the independent effects of poverty. A review of the literature clearly indicates that low socioeconomic status (defined as social class, income, education, or census tract) is associated with increased risk of low birthweight and preterm delivery.

The literature suggests that the risk of low birthweight attributed to low income is related to consequences of low income, rather than low income per se. For example, socioeconomic status may affect health practices and the extent and timeliness of seeking prenatal care. Low-income women are more apt to have inadequate preconceptual and prenatal nutrition leading to low maternal weight gain and small for gestational age infants.

Low preconceptual weight is another low birthweight risk factor. In a seeming contradiction, low-income women tend to weigh more than affluent women. Although several studies have shown that supplementation

during pregnancy can increase birthweight, the strong positive association between maternal weight gain during pregnancy and infant birthweight is less pronounced if preconceptual maternal weight is adequate. However, despite the greater weight and amounts of stored fat among low-income women, they also have smaller lean body mass, an important source of fetal nutriture. Coupled with the fact that low-income women are more apt to have inadequate preconceptual and prenatal nutritional and dietary status, they continue to be at high risk for adequate pregnancy outcome.

Other health and dietary practices, such as use of alcohol, tobacco, caffeine, or drugs have adverse effects on birthweight and pregnancy outcomes. Alcohol consumption is strongly positively associated with income and more low-income women are total abstainers, so this dietary behavior is a smaller source of risk among low-income women. However, smoking prevalence is greater in low-income than in higher-income groups, thus placing low-income women at higher risk in this area. Smoking has an independent negative impact on pregnancy outcome and increases selected dietary needs to compound the effect on pregnancy outcome.

Therefore, although the etiologies of maternal mortality and low infant birthweight are multifactorial, both areas of health problems are present in larger proportions of low-income populations than in more affluent population groups. Both areas present a significant area of health risk which may be ameliorated by improved nutritional status.

B. DIMENSIONS OF NUTRITIONAL STATUS

The discussion above attempts to identify some of the relevant public health problems and risk factors that are disproportionately prevalent in the low-income population. This section attempts to clarify

the meaning of nutritional status and to discuss how it is related to nutritional outcomes that have been used in previous analyses of the nutritional effects of the FSP.

Nutritional status can be defined as the health condition resulting from the sum of processes by which individuals ingest and utilize food substances. It is influenced by how food is digested, transported, metabolized, stored in the body, and excreted.

Malnutrition, which is impaired nutritional status, has been defined as (1) undernutrition resulting from lack of sufficient food over a period of time, (2) overnutrition caused by an excess of food over time, (3) specific deficiency states resulting from a lack of individual nutrients, or (4) imbalance caused by a disproportionate amount of required nutrients in a balanced diet.

Primary malnutrition refers to inadequencies and imbalances in the diet, in either quantity or quality of foods consumed. Secondary malnutrition is the increased risk of malnutrition which results from disease and disability. The following are factors which are known to affect the risk of impaired nutritional status:

- Inadequate intake
- Inadequate absorption
- Defective utilization
- Increased excretion
- Increased requirements

A fairly large number of nutrients are thought to be essential in human diets to provide energy and support normal metabolic function.

Ideally, assessment of each parameter separately, and in interaction with other nutrients, drugs, and environmental conditions, would provide the best picture of nutritional health or status. Assessment of this type is rarely possible for either individuals or populations. Therefore, nutritional status is typically assessed by evaluation of a lesser number of parameters. Selection of elements depends on why the information is needed, the necessary levels of specificity and sensitivity, and the level of available resources. No single biochemical or physical measure allows a comprehensive statement of nutritional status.

Assessment of nutritional status typically includes measurement of (1) anthropometric, (2) biochemical, (3) clinical, and (4) dietary information. For example, various aspects of a persons medical and dietary history can suggest potential nutritional problems. Certain anthropometric measurements are well accepted as good indexes of growth and body protein and calorie stores. Clinical deficiency diseases are rare in the U.S., but there are some common physical abnormalities which are associated with nutritional deficiencies. Blood and urine analyses of nutrients and selected metabolites can provide information relevant to nutritional status. By evaluating information from multiple sources, qualitative and quantitative estimates of nutritional health can be made.

In the succeeding four subsections, we describe the dietary, anthropometric, clinical, and biochemical measures frequently used in nutritional status assessments of individuals.

1. Dietary Evaluation of Nutritional Status

A nutritionally adequate diet is one which, on average, provides sufficient energy and essential nutrients in a timely fashion to meet

nutrient and metabolic needs. Nutritional requirements differ among groups of individuals by age, gender, body size, and physiologic state. For example, additional nutritional requirements are imposed by physiological requirements associated with pregnancy, lactation, and increased rates of growth and development among infants, young children and adolescents. The RDA are recommendations for the average daily amounts of nutrients that population groups should consume over a period of time. In addition, personal characteristics can influence nutrient needs, including metabolic efficiency, level of usual activity, health status, use of medications, vitamin/mineral supplements, type of contraceptive use, or smoking status. Therefore, differences in the nutrient requirements of individuals are unknown. The RDA (with the exception of food energy) are established to meet the requirements of nearly all in the population. It should be noted that the RDA standards have not been developed to identify nutrient needs of nonhealthy individuals.

Dietary assessment methods typically available to those examining FSP impacts include 24-hour recalls, food frequencies, and food records at the individual level, and 7-day food supply records at the household level. Food records and 24-hour recalls require limited respondent memory and minimize the likelihood that the subjects will modify his/her food habits. However, these methods of dietary assessment reflect current, rather than usual, diet. The three days of dietary data available in the 1977-78 and 1987-88 Nationwide Food Consumption Surveys are a distinct improvement in assessing individual diet over the single day of diet recall available in surveys such as NHANES I (1971-74), NHANES II (1976-80), or the Survey of Food Consumption in Low Income Households (1979-80).

While population mean estimates of dietary adequacy may be obtained from large populations providing a single day of dietary data, estimates of a single day of dietary intake have little correlation with the overall nutritional status of a given individual. Because of the extent of day-to-day intake variability, the potential for misclassification is large. Three consecutive days of dietary data provide a better estimate of usual diet for the individual, but still may not capture weekend, weekday, or seasonal differences. Food frequencies such as are available in the HANES data sets provide a more descriptive, qualitative assessment of usual diet. However, even quantified food frequency instruments do not provide accurate estimates of consumption quantities. So, although a better descriptor of usual diet, a food frequency instrument needs to be used in conjunction with other dietary assessment tools if one of the study objectives is to assess usual long term diet and quantities of nutrients usually consumed with a degree of precision.

For most nutrients, measurement of dietary intake alone is insufficient to assess nutritional status of an individual. Rates of absorption, utilization, and excretion vary across individuals, as do other lifestyles and health characteristics which affect the requirements for most nutrients. In populations, dietary assessment can provide mean estimates of nutrient intake levels of groups, but cannot provide a true overall picture of nutritional status either. In the discussions which follow, we identify the extent to which measures of dietary intake are well correlated with biochemical or anthropometric measures of nutritional status.

As an overview of the current dietary status of the U.S. population, Table B.5 presents mean percentages of the RDA consumed in population groups by poverty status and race. In addition, we present the population percentages consuming more than 70 percent of the RDA for given nutrients. The data represent actual consumption data taken from the three day averages available from the 1977-78 NFCS. Although the population mean values of many nutrients are well above the recommended allowances in many cases, a significant proportion of the population have intakes less than 70 percent of the RDA.

2. Anthropometric Evaluation of Nutritional Status

As mentioned in section A of this appendix, the primary health status outcome of importance in children associated with diet and nutritional status is achievement of appropriate growth and development. In adults the identification of underweight and overweight are important as predictors of risk for selected disease states. Both growth and the state of body fat are related to food consumption behavior. Therefore, the assessment of anthropometry is an important dimension of nutritional status.

Certain body measurements are sensitive to changes in food intake and can provide one index of nutritional well-being. The most common are height, weight, and various measures of body fat. Data are used in two ways. In static assessment, data from an individual are compared to normative population-base standards. In contrast, repeated measurements over time are used to provide an index of response for that individual to changes in diet and the environment.

Height, Weight, and Length. The assessment of growth and development in relation to age and sex can provide an indication of the overall

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TABLE B-5

NUTRIENT INTAKE AS A PERCENT OF THE RDA AND THE PERCENTAGE OF INDIVIDUALS WITH INTAKE GREATER THAN 70 PERCENT OF THE RDA, SELECTED NUTRIENTS, 1977-78

	Poverty		Nonpoverty	
	Whites	Blacks	Whites	Blacks
Protein				
Mean as a Percent of the RDA	159	167	165	169
>70% RDA	95	95	97	97
Vitamin A				
Mean as a Percent of the RDA	128	155	130	162
>70% RDA	63	63	69	70
Vitamin B6				
Mean as a Percent of the RDA	74	74	75	75
>70% RDA	45	48	50	50
Vitamin B12				
Mean as a Percent of the RDA	161	190	172	189
>70% RDA	79	78	86	83
Vitamin C				
Mean as a Percent of the RDA	125	138	149	152
>70% RDA	68	74	74	76
Calcium				
Mean as a Percent of the RDA	86	71	89	72
>70% RDA	55	44	60	44
Magnesium				
Mean as a Percent of the RDA	82	71	85	74
>70% RDA	58	44	64	47
Iron				
Mean as a Percent of the RDA,				
Males	123	104	134	125
Females	81	82	78	79
>70% RDA,				
Males	89	61	68	66
Females	52	54	50	50

SOURCE: Nutrition Monitoring in the United States, 1986.

nutritional status in infants and children. Growth charts are used as the reference or standard against which individual or serial measures are made. Standards currently in use are published by the National Center for Health Statistics. In children, weight for age, height for age, and weight for height standard tables are available. Although a single measure can assess the current location in the distribution for a given child, multiple measures of height and/or weight are necessary to assess adequate growth of individual children. A single measure does not indicate if the child is at the correct percentile for genetic potential, or if dietary supplementation would shift placement on the growth grids. During periods of growth, anthropometric measurements obtained at 2-month intervals are appropriate.

Although height and/or growth deficits may be indicative of any number of dietary deficiencies, they are most commonly association with dietary inadequacies in total energy and protein intakes. Underconsumption of energy and protein (measured during the appropriate time frames) are well correlated with stunting and wasting. Therefore, anthropometric measurements are useful indicators of nutritional status, particularly in growing children, but are less useful measures of nutritional status in the evaluation of other nutrients. Because growth is a sum of numerous metabolic functions, other systems may be impaired far sooner than will measures of overall growth. Therefore, as with dietary status, anthropometric assessments and indications of malnutrition need to be corroborated with other indicators of nutritional status.

Skinfolds and Circumferences. Anthropometry has also been used to measure protein nutriture. For example, arm circumferance has been used as an indicator of both calorie and protein stores. However, depressed values

occur only at the later stages of protein-calorie malnutrition. A more sensitive measure of protein status, arm muscle circumference, is determined by considering both triceps skinfold and arm circumference measures. From these measures, midarm muscle circumference (MAMC) can be estimated mathematically or by use of nomogram (Gurney and Jellifee, 1973). Such estimates are less than perfect measures of protein status, however, as neither the thickness of the upper arm bone nor fat compressibility (which is greater in females and the obese) is taken into account. To the extent that long term protein intake and change in protein intake for individuals in metabolically stressful situations can be estimated by dietary intake methodology, dietary measures should correlate well with midarm muscle circumference estimates of protein status.

In adults, height and weight are usually not the anthropometric measures of interest. Rather, adult nutritional status is often judged by estimation of the degree of obesity. Obesity is not synomomous with overweight. Obesity refers to excess body fat, while overweight refers to pounds of weight which may include, fat, bone, and or muscle. An athlete may have a high relative weight for height relative to a standard reference weight table. However, the weight is frequently associated with increased muscle mass, rather than fat. Anthropometry is used to distinguish between weight attributable to lean body mass versus fat.

Since approximately one half of the total body fat is in the subcutaneous layer, measurements of subcutaneous fat by skinfold measure can be used to give an estimate of body fat. Triceps skinfold has been used in numerous nutrition surveys as an indirect measure of body fatness and as an indirect measure of calorie stores and/or deficit. While dietary

deficiency can be monitored through a number of measurements, obesity is measured to reflect dietary excess or imbalance with respect to nutrient needs. Skinfold measures are inexact reflections of total body fat, but provide easily obtained, inexpensive measures of relative under- or over-nutrition and intake. Measures are used in children and adults. Where the assessment of total body fatness is of importance, collection of skinfold measures from more than one body location (for example, triceps, biceps, suprailliac, subscapular) provides better correlation with total body fatness than does one skinfold measure alone.

Fatness is also assessed as mathematical computations of body height and weight in adults. For example, the Body Mass Index, defined as height in meters divided by weight in kilograms squared, is thought to be a reasonable estimate of fatness in adult males. In the same equation in females, fatness is raised to the 1.5 or 1.6 power, rather than squared, to reflect body fatness. Such measures are indirect estimates of anthropometry. The equations are derived from population estimates, but nutritional assessment of a given individual is more precise when direct measurements are available.

Nutritional status assessment of fatness as a relative risk factor for chronic disease states now often includes assessment of the relative distribution of body fat. Such assessments are predictive of risk of selected diseases, (e.g., those with predominantly upper body fat are at higher risk of diabetes than those whose fatness is predominately of the lower body type).

Dietary deficiencies correlate well and can be predictive of growth failure or underweight in children and adults. However, a number of other

metabolic considerations influence the correlation between diet and obesity. For example, a fairly extensive epidemiologic literature exists which indicates that a large number of obese persons consume fewer, rather than more, calories than normal weight counterparts. Metabolic environmental theories may help explain this seeming contradiction. An adaptive metabolic pathway may exist in which obese persons metabolize and store energy consumed more efficiently than thinner peers. Also, studies with children, in particular, indicate that obese persons may have considerably lower levels of exercise and activity than thin peers. Thus among the obese, lower caloric intake might still be greater than energy needs in light of metabolic and energy expenditure conditions. Reduced food intake also puts the obese person at greater risk of underconsumption of other essential nutrients. Therefore, the presence of obesity, measured by anthropometry, should not be considered to be synonymous with overconsumption of energy and nutrients. Dietary patterns alone cannot be used to reflect extent or patterns of dietary fatness.

3. Clinical Evaluation of Nutritional Status

Prolonged malnutrition can have an impact on the physical development of the individual. As discussed above, anthropometric measurements such as height and weight in relation to age provide an indication of the overall sufficiency of the intake of food energy and protein, particularly for infants, children, and adolescents. Anthropometric measures, however, are less useful as indicators of inadequate levels of other nutrients. Some clinical signs, such as changes in the skin, hair, eyes, and mouth, are associated with inadequacies of particular nutrients. Even so, it is important to note that a wide variety of factors other than inadequate

nutrition can produce clinical findings indicative of inadequate nutrition and the interpretation of clinical data is, to that extent, subjective. Nevertheless, clinical findings that are suggestive of inadequate nutrition can be investigated further using other methods of nutritional status assessment.

The following are clinical symptoms of importance in nutritional status assessment (Grant, 1979):

- Hair changes associated with protein-calorie malnutrition.
  - -- Lackluster--dull, dry, brittle, wirelike
  - -- Thinness, sparseness--fine, silky, and sparse with wider gaps between hairs
  - -- Dyspigmented--lightening of normal hair color, more evident distally, rare in adults
  - -- Flag sign--alternating bands of light and dark along the length of hair in young children
  - -- Easy plucability--small clumps pulled out with moderate force and no pain
- Face
  - -- Diffuse depigmentation--general lightening of skin color; in protein calorie malnutrition
  - -- Nasolabial seborrhea--scaling with dry, greasy, gray or yellowish threadlike materials around the nostrils; associated with riboflavin, niacin, or pyridoxine deficiency
  - -- Moon-face--rounded prominence of cheeks; present in kwashiokor
- Eyes
  - -- Pale conjunctiva--pale eyelid lining, and whites of eyes; in anemia
  - -- Bitot's spots--dry, grayish, yellow or white foamy spots on the whites of the eyes; vitamin A deficiency
  - -- Conjunctival xerosis--inner lids and whites of eye appear dull, dry, roughened, and pigmented; vitamin A deficiency
  - -- Corneal xerosis, keratomalacia--cornea changes associated with vitamin A deficiency

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- o Lips
  - -- Angular stomatitis, angular scars, cheilosis--cracks or scars at corners of mouth, vertical lip cracks and ulcers; associated with riboflavin, niacin, iron, and pyridoxine deficiency
- o Tongue
  - -- Etrophic filiform papillae--atrophied taste buds; associated with folate, niacin, riboflavin, iron, or B_{12} deficiency
  - -- Glossitis--tongue is beefy red, painful, taste buds atrophied; associated with niacin, folate, riboflavin, iron, B_{12}, pyridoxine, and tryptophan deficiency
- o Teeth
  - -- Mottled enamel--white or brownish patches; associated with fluorine excess
- o Gums
  - -- Spongy, bleeding--purplish or red, bleeding easily with slight pressure; associated with poor hygiene and vitamin C deficiency
- o Glands
  - -- Thyroid enlarged; associated with iodine deficiency
- o Skin
  - -- Xerosis--general dryness with fine lines and shedding of branlike scales; associated with vitamin A or essential fatty acid deficiency
  - -- Follicular hyperkeratosis--two primary types associated either with vitamin A or vitamin C deficiency
- o Muscular and Skeletal Systems
  - -- Muscle wasting--decreased in protein-calorie malnutrition
  - -- Rachitic rosary, epiphysial enlargement, frontal and parietal bossing--enlargement (lumps) on ribs, long bones, front and side of head in infants; associated with vitamin D and calcium deficiency

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- o Nails
  - -- Koilonychia--concave spoon-shaped nails in older children and adults; associated with iron deficiency
- o Internal Symptoms
  - -- Mental confusion, motor weakness, bilateral calf tenderness--associated with thiamine deficiency
  - -- Loss of vibratory sense, loss of ankle and knee jerks--associated with vitamin B_{12} deficiency
  - -- Cardiac enlargement--may occur in anemia and thiamine deficiency

As with dietary and anthropometric assessment, clinical assessment alone is generally insufficient to determine if explicit nutritional deficiencies are causal. However, when dietary imbalances are determined to be the cause of clinical symptoms, it is certain that either severe dietary imbalance has been present in the short term and/or chronic less severe long term undernutrition.

4. Biochemical Assessment of Nutritional Status

Inadequate dietary intake over a period of time will result in the impairment of the body's biochemical functions. Biochemical tests, which examine the level of nutrients, metabolites, and other components in body tissues and fluids, are useful in assessing the biochemical component of nutritional status. Since the body is able to adjust for day-to-day or short-term dietary inadequacies, biochemical measures reflect usual dietary patterns of adequacy, inadequacy, or excess.

Most laboratory techniques for assessing nutritional status measure (1) the nutrient level in the blood, (2) the urinary excretion rate of the nutrient, (3) urinary metabolites of the nutrient, (4) abnormal metabolic products, (5) changes in blood components or enzyme activities that can be

related to intakes of the nutrient, and (6) response to a load, saturation, or isotopic test. Such laboratory tests comprise the majority of current biochemical nut9itional assessment. However, tests for different nutrients are not equally valuable and have differing diagnostic capabilities. For example, direct tests of water soluable vitamins in the blood are more sensitive than are indirect tests of metabolites in the urine.

The following are some of the biochemical tests conducted to evaluate and monitor nutritional status:

- o Protein assessment: serum albumin, prealbumin, and nitrogen balance.
- o Cholesterol assessment: measurement of total serum cholesterol, with follow-up measures of tryglyceride, very low-density lipoprotein, low-density lipoprotein, and high-density lipoprotein.
- o Iron assessment: hemoglobin, hematocrit, serum iron, and percent transferrin saturation.
- o Water Soluble Vitamins
  - -- Vitamin B_{12} and folate assessment: serum B_{12} and folate concentration
  - -- Thiamin assessment: urinary excretion, measurement of transkelotase activity
  - -- Riboflavin assessment: urinary excretion, measurement of erythrocyte glutathione reductase activity
  - -- Niacin assessment: urinary excretion
  - -- Vitamin B_6 assessment: urinary excretion, measurement of erythrocyte transaminase activity
  - -- Vitamin C assessment: urinary excretion, measurement of leucocyte ascorbate concentrations
- o Fat Soluble Vitamins
  - -- Vitamin A assessment: measurement of serum or plasma retinol
  - -- Vitamin D assessment: measurement of serum vitamin D levels
  - -- Minerals: Calcium, Magnesium, and Zinc. Assessments are not easy to determine from biochemical tests

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5. Relationship of Nutritional Status Outcomes to Household Measures Typically Used in Analyses of the Food Stamp Program

Since the household is the unit of participation in the FSP, most analyses of nutritional effects of the FSP to date have examined food and nutritional outcomes at the household level. The objectives of this section are to describe outcome variables used in previous analyses and to discuss how these different outcome variables are related to nutritional status.

Household nutritional status has been measured in different ways. Existing data sets provide information on (1) household food expenditure patterns, (2) food and nutrient availability at the household level, and (3) food and nutrient intake at the individual level. FSP analyses have used all of the above measures and have created other indices from each of the three kinds of information. The most common outcome measure used in analyses of the FSP is household food expenditures. Total food expenditures, the money value of food used at home, and food group expenditures have been used as outcome measures (West and Price, 1976; Davis and Neenan, 1979; Fraker, Devaney and Cavin, 1986). Frequently, the expenditure data are adjusted to reflect differences in household size, composition, and nutritional requirements. Food and nutrient availability at the household level have been derived from different kinds of survey instruments. Largely, household food use data have been derived from the seven-day household food records available in the 1977-78 Low-Income Supplement to the Nationwide Food Consumption Survey and the 1979-80 Survey

and exclude food purchased and consumed away from home. The food use data are converted to nutrient composition, where nutrients are summed over quantities of food used over the period of household dietary data collection.

In two early studies, Madden and Yoder (1972) and Lane (1978) derived household dietary data from 24-hour at-home household recall data. The household respondent was asked to report amounts of food consumed (not prepared) by the household members during the 24-hour period prior to the interview. No attempt was made to estimate intake for individual family members. Foods consumed away from home were not included in these food intake totals.

Relatively few FSP analyses have examined actual intakes of FSP participants versus nonparticipants. In cases where individual dietary data have been used, dietary outcome measures have typically been specific to one household member who acts as proxy for the household (Neenan and Davis, 1978). The 24-hour dietary recall has been the most frequently used measure of dietary status.

In household FSP analyses, nutrient totals are used in numerous ways. The most common are as nutrient totals or as a proportion of some standard such as a household RDA. As with household expenditure measures, a number of authors have indexed household nutrient availability to reflect household size and composition differences. Measures of household food availability have also been scaled to reflect differing numbers of meals consumed by household members from the household food supply each week. Typically, scaling has assumed a 21-meal-per-week pattern. Such scaling

arbitrarily assumes a particular meal and snack pattern followed by an unknown proportion of the U.S. population.

Other indices of household nutritional status have also been derived. Madden and Yoder (1972) calculate a household Mean Adequacy Ratio (MAR) from the household diet data. In this index, a Nutrient Adequacy Ratio (NAR) is calculated for each nutrient. It is defined as the sum of nutrients consumed from the home supply, divided by the household RDA for the following 10 nutrients; food energy, protein, calcium, phosporous, iron, vitamin A, thiamin, riboflavin, niacin, and vitamin C. Intakes above 100 percent of the RDA are truncated to 100 percent. The 10 NAR ratios are then averaged to obtain the MAR. Lane (1978) uses the separate NAR measures as dependent variables in her study of nutritional "achievement."

Johnson, Burt, and Morgan (1981) derive three measures of diet quality from household seven-day home food supply records. The Modified Diet Score (MDS) is defined as the sum of the ratios of nutritive value per nutrition unit to the RDA for the adult male for seven nutrients and energy. This is a analogous to the MAR, using fewer nutrients, and using a nutrient requirement standardized person to represent the household. The Minimum Nutrient Density Ratio (MINNDR) is defined as the lowest of the seven nutrient density ratios. Nutrient density of the diet is determined by dividing the amount of nutrients by the number of 1,000 kilocalorie units provided by the household diet; the nutrient density of the RDA is determined by dividing the allowances for nutrients by the number of kilocalorie units in the food energy allowance. Finally, the nutrient density of the diet is divided by the nutrient density of the RDA. A value of one is the norm; households with MINNDR less than one obtain food lower

in nutrient density for one or more of the seven nurients; while the converse is true for numbers exceeding one. Finally, a Food Energy Level (FEL) was defined to reflect the total energy value of food used from the household food supply, divided by the number of adult male equivalents in the household, truncated to 150 percent of the RDA.

In assessing the usefulness of these nutritional outcome measures, it is important to note that they attempt to measure only one component of nutritional status, namely dietary status. Given that a thorough determination of nutritional status involves a combination of dietary assessments, anthropometric measurements, clinical data, and biochemical tests, studies of the nutritional impacts of the FSP using the type of outcome measures discussed above cannot be used to draw conclusions concerning the effects of the FSP on nutritional status. At best, these studies can be used to assess the impacts of the FSP on dietary status. This caveat, however, is not intended to downplay the importance of analyzing the dietary impacts of the FSP. A thorough dietary status assessment is an integral complement to anthropometric, clinical, and biochemical assessments of individuals. Analysis of food consumption data, as in most previous analyses of the FSP, enables professionals to understand nutrient inadequacies, imbalances, and excesses associated with specific dietary patterns.