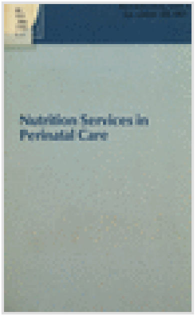

Nutrition Services in Perinatal Care (1981)

Pages
78

Size
5 x 9

ISBN
0309329922

Committee on Nutrition of the Mother and Preschool Child; Food and Nutrition Board; Assembly of Life Sciences; National Research Council

Nutrition Services in Perinatal Care

Committee on Nutrition of the Mother
and Preschool Child
Food and Nutrition Board
Assembly of Life Sciences
National Research Council

National Academy Press
Washington, D.C. 1981

1 0031

.1

This study was supported by Contract MC-R-110354-01-0 by the Bureau of Community Health Services, Health Services Administration, Department of Health and Human Services and by the National Foundation--March of Dimes.

COMMITTEE ON NUTRITION OF THE MOTHER AND PRESCHOOL CHILD

Roy M. Pitkin, *Chairman*
University of Iowa School of Medicine

W. Ann Reynolds, *Vice Chairman*
Ohio State University

Virginia A. Beal
University of Massachusetts

John L. Duhring
Medical College of Ohio

Frank Falkner
University of Michigan

George R. Kerr
University of Texas

Janet C. King
University of California, Berkeley

Alvin M. Mauer
St. Jude Children's Research Hospital

William N. Spellacy
University of Illinois Medical Center

ACKNOWLEDGMENTS

In the preparation of this report, the committee has benefited substantially from the contributions of a number of persons who worked with it in various aspects of the report. Lindsay H. Allen, Elizabeth Blakey, Preston V. Dilts, Jr., and Bonnie Worthington-Roberts assisted with nutritional requirements of pregnant and lactating women; Lewis A. Barness, Jo Anne Brasel, William C. Heird, Ellen Lindgren, Karyl Rickard, Philip A. Sunshine, and Ekhard E. Ziegler participated in considerations of nutritional requirements of newborn infants; and Mary Sue Brady, Karyl Rickard, and the late Edwin A. Gresham were helpful in developing the sections dealing with implementation of nutrition services in prenatal and postpartum care and implementation of nutrition services in neonatal care.

1 INTRODUCTION

Organization of perinatal health care services on a regionalized basis has received much attention over the past decade. The concept was addressed formally in a document developed by the Committee on Perinatal Health, composed of representatives of a variety of concerned disciplines under sponsorship of the March of Dimes, and published in 1976 under the title *Toward Improving the Outcome of Pregnancy--Recommendations for the Regional Development of Maternal and Perinatal Services*. The document outlined in considerable detail the characteristics and requirements appropriate for a three-level system of perinatal care. However, nutrition received virtually no attention. The Committee on Nutrition of the Mother and Preschool Child was asked to address this important influence on pregnancy outcome by identifying the personnel, competency levels, and support necessary to provide nutritional assessment, and education and services within such a regionalized system. In addition, in order to make its report understandable by itself, the committee felt it advisable to include a summary of the present knowledge and understanding of nutrition during pregnancy and the neonatal period. Thus, the purposes of this present document are to supplement the 1976 report of the Committee on Perinatal Health and to provide "state-of-the-art" information on nutrition in maternal and infant health.

Virtually all states have instituted some type of system of perinatal care organized along regional lines. Although the proposed three-level approach has not been accepted or adopted universally, in many instances it has served as the framework for development of a statewide or other regional plan (Berger *et al.*, 1976; Stern, 1977; Brown, 1978; McCarthy *et al.*, 1978; Harris *et al.*, 1978). In this regionalized concept, Level I perinatal units are those that provide services in smaller communities for essentially uncomplicated or normal maternity and newborn patients. Level II perinatal units are those located in larger urban or suburban hospitals where the majority of deliveries occur. They are capable of managing most obstetrical and newborn complications, but do not provide intensive newborn care nor the full range of consultants and supportive services found in the Level III units.

Level III hospitals are those institutions equipped to care for the most difficult perinatal problems of all varieties. In addition, they are mandated to conduct research and educational efforts at all levels. The reader is referred to *Toward Improving the Outcome of Pregnancy* and to the other references listed at the end of this chapter for detailed descriptions of the system. Within such regionalized systems, however, the necessity for, and the role of, nutritional efforts were not precisely defined. Clearly, however, different degrees of expertise are required for nutritional management of mothers and infants at the three levels of care. In order to fill this gap, the Committee on Nutrition of the Mother and Preschool Child undertook a study to develop guidelines for delivery of perinatal nutritional services and for training of personnel thus involved. This report is the result of that study.

The following chapters have been organized to briefly discuss current knowledge of nutritional requirements during the perinatal period. Secondly, delivery of nutritional services during the antepartum and newborn periods is outlined and needs are presented. Finally, areas needing additional research are identified. The implementation of a perinatal nutrition program is addressed in terms of the services required, the knowledge base and clinical skills necessary for the involved health professionals, and guidelines for the qualifications and continuing training of personnel. Standards are not attempted in this document, since they are the subject of other documents and future efforts.

REFERENCES

Berger, G. S., D. B. Gillings, and E. Siegel. 1976. The evaluation of regionalized perinatal health programs. Am. J. Obstet. Gynecol. 125:925.

Brown, F. B. 1978. The management of high-risk obstetric transfer patients. Obstet. Gynecol. 51:674-676.

Committee on Perinatal Health. 1976. Toward Improving the Outcome of Pregnancy. The National Foundation--March of Dimes.

Harris, T. R., J. Isaman, and H. R. Giles. 1978. Improved neonatal survival through maternal transport. Obstet. Gynecol. 52:294-300.

McCarthy, J. T., and L. J. Butterfield. 1978. Newborn country USA revisited. Rocky Mount. Med. J. 75:208-211.

Stern, L., ed. 1977. Regionalization of perinatal care. Seminars in Perinatology.

2 NUTRITIONAL REQUIREMENTS OF PREGNANT AND LACTATING WOMEN

The purpose of this section is to (1) summarize the nutritional requirements and problems of normal pregnant and lactating women and the high-risk pregnant woman and (2) make recommendations for the application of this information in perinatal nutritional management utilizing the regionalized system for perinatal care. The personnel needed for implementation of these recommendations will be addressed in Chapter 3.

NUTRITIONAL REQUIREMENTS OF NORMAL PREGNANCY

During pregnancy, the maternal requirement for all nutrients is increased. The Recommended Dietary Allowances (RDA) (Food and Nutrition Board, 1980) for nutrients for young adult nonpregnant, pregnant, and lactating women are shown in Table 1. The increases cover the accretion of nutrients in the fetus, placenta, uterus, breasts, amniotic fluid, and increased blood volume. An increase in maternal metabolic rate, and the metabolism of the fetus, also adds to the energy requirement for pregnancy. In addition, there is a "net" maternal weight gain of 2-4 kg, which is the difference between prepregnancy weight and postpartum weight. This net maternal gain is assumed to be maternal stores of fat, which are used to supplement the energy requirement for lactation (Hytten and Leitch, 1971). Assuming that net maternal gain is composed of adipose tissue, the cumulative energy cost of pregnancy is approximately 80,000 kcal (Food and Nutrition Board, 1980). This amounts to an additional 300 kcal per day. The 58-kg reference pregnant woman would therefore need 2,300 kcal per day. Women who are underweight at the onset of pregnancy, or who are at least moderately active, may require a higher energy intake.

TABLE 1 Recommended Daily Allowances for Young Adult Nonpregnant, Pregnant, and Lactating Women

Nutrient and Units	Nonpregnant	Pregnant	Lactating
Energy (kcal)	2,000	+300	+500
Protein (g)	44	+30	+20
Vitamin A (mg RE)	800	+200	+400
Vitamin D (mcg)	5	+5	+5
Vitamin E (mg and TE)	8	+2	+3
Vitamin C (mg)	60	+20	+40
Thiamin (mg)	1.0	+0.4	+0.5
Riboflavin (mg)	1.2	+0.3	+0.5
Niacin (mg)	13	+2	+5
Vitamin B_6 (mg)	2	+0.6	+0.5
Folacin (mg)	400	+400	+100
Vitamin B_{12} (mcg)	3.0	+1.0	+1.0
Calcium (mg)	800	+400	+400
Phosphorus (mg)	800	+400	+400
Magnesium (mg)	300	+150	+150
Iron (mg)	18	+30-60[a]	+30-60[a]
Zinc (mg)	15	+5	+10
Iodine (μg)	150	+25	+50

[a]This intake cannot be met by the iron content of habitual American diets; the use of a supplement is recommended.

The Food and Nutrition Board (1980) recommends 44 g of protein per day for the reference nonpregnant woman with an additional 30 g per day starting in the second month of pregnancy. As protein requirements vary with body size, individual protein needs should be calculated by allowing 1.3 g of protein per kilogram of nonpregnant bodyweight daily (King, 1975). Most pregnant women have no difficulty in meeting their protein requirements, and those on self-selected diets generally consume more than their theoretical requirements.

The additional recommended intakes of vitamins are needed to cover the amounts deposited in the fetus and for the metabolism of the additional carbohydrate, protein, and fat consumed by the mother. Assessment of vitamin status is difficult in pregnancy. The plasma, or serum, and urine levels of most vitamins change, due to expansion of plasma volume and changes in maternal metabolism.

For some vitamins, such as vitamin B_6 (Hillman, 1963) changes are suggestive of a deficiency state, but supplements seldom indicate any difference in pregnancy outcome. In general, it is assumed that the recommended intake of most vitamins can be met readily if a wide variety of foods is consumed. Clinical vitamin deficiencies are not often seen in pregnant women in the United States, although folic acid deficiency is the major exception.

Megaloblastic anemia due to folate deficiency occurs in a significant number of women in developing nations (Committee on Nutrition of the Mother and Preschool Child, 1978). In a recent study in an urban clinic, 16 percent of pregnant women had deficient red blood cell folate levels, and an additional 14 percent had low levels (Herbert *et al.*, 1975). Folate deficiency is best detected by measuring erythrocyte folate levels, although serum folate is frequently used. Neutrophils may also be hypersegmented with five or more lobes per cell. The relatively high incidence of folate deficiency symptoms in pregnant women is due to markedly increased metabolic demands for the vitamin, combined with an increased urinary excretion and limited dietary intake. Treatment can be achieved by 1 mg per day of folic acid. The RDA for pregnancy is 800 μg, which is twice that for nonpregnant women. Some authorities have recommended that an oral supplement of 300 (Herbert, 1977) to 800 μg (Scott, 1977) per day should be given during the last half of pregnancy.

Megaloblastic anemia due to a deficiency of vitamin B_{12} is relatively rare, but can occur in women consuming a vegetarian diet that excludes all animal products. Most commonly in the United States it occurs as pernicious anemia, where the intestinal absorption of the vitamin is impaired. Pernicious anemia must be diagnosed by Schilling test (Lamar *et al.*, 1965). Low-serum vitamin B_{12} levels in the absence of low-serum folate suggests a vitamin B_{12} deficiency; however, serum vitamin B_{12} levels may be low as a result of folate deficiency, so that folacin and vitamin B_{12} status should be assessed once a megaloblastic anemia is diagnosed.

The recommended daily allowances for calcium, phosphorus and magnesium, and the trace minerals iron, zinc, and iodine are also increased during pregnancy. It is relatively easy for the pregnant woman to obtain her requirements for phosphorus and magnesium by eating a well-balanced diet, and for iodine by using iodized salt. It is difficult to meet the recommended intake for calcium unless milk products are consumed regularly.

It is assumed that the greatly increased iron requirements of pregnancy cannot be met from dietary sources, or from the existing iron stores of many women (Food and Nutrition Board, 1980). The increased iron requirements are to cover deposition in the fetus and placenta, and blood losses at delivery. Daily iron supplements of 30 to 60 mg of elemental iron are recommended.

The complexities of diagnosing iron deficiency in pregnancy have been reviewed (Committee on Nutrition of the Mother and Preschool Child, 1978). A hematocrit below 30 percent or hemoglobin below 10 g/dl is considered to be indicative of anemia; a hematocrit of 33 percent or hemoglobin 11 g/dl defines a pregnant woman at risk of iron deficiency.

When nonsupplemented pregnant women are compared to supplemented pregnant women, there are lower bone marrow iron stores, serum iron levels and percent saturation of transferrin, and a greater total iron binding capacity and percent iron absorption (Svanberg *et al.*, 1975). Supplemented women should maintain constant serum iron levels and a saturation of transferrin above 20 percent. Some supplemented women, however, may still deplete their iron stores in the marrow even though iron-deficient erythropoiesis may not be evident (Svanberg *et al.*, 1975).

Plasma zinc levels decline by approximately 25 percent during pregnancy. This decline is regarded as physiological and probably is caused by the increase in plasma volume and a decline in serum albumin to which some zinc is bound. Zinc intakes of many pregnant women appear to be below the recommended level (Sandstead *et al.*, 1973; Krebs *et al.*, 1980). However, because of the absence of clinical or biochemical evidence of zinc depletion, zinc supplements usually are not provided to pregnant women.

Summary

Although the need for all nutrients is increased during pregnancy, oral supplements are not needed except for iron and possibly folic acid. Vitamin B_{12} supplements are needed for women eating vegetarian diets that exclude all animal products.

NUTRITION SERVICES

Prenatal nutrition counseling should be initiated at the first prenatal visit. Assessment of the nutritional status of a patient can be done by clinical or physical examinations, laboratory tests, or the collection of information on the woman's history (medical, obstetric, social, personal, and dietary). Information on appropriate assessment and counseling techniques is available (California Department of Health, 1975). At a minimum, the adequacy of weight gain should be determined by plotting weight gain at each visit on a prenatal weight grid. Dietary adequacy can be assessed by using a combined dietary history and a 24-h recall approach followed by an analysis of the general intake of basic food groups and/or calculations of specific nutrients. A personal food plan can then be developed for the patient, based on her previous diet and food preferences, and her life-style. Although a nutritionist would be of great value, this evaluation can be done by the physician, a well-trained nurse, or a paraprofessional.

NUTRITIONAL REQUIREMENTS DURING LACTATION

Throughout almost all of history, infant nutrition during the first 3 to 6 months of life has depended entirely on breast-feeding. The first half of the twentieth century saw the development, and subsequent widespread adoption in industrialized societies, of infant formulas containing milk from nonhuman sources. This pervasive tendency away from breast-feeding seems to have been reversed over the past decade, based on recognition of a number of physiological and psychological benefits conveyed to both mother and infant by the process (Jelliffe and Jelliffe, 1971; Mata, 1978). Current estimates in the United States indicate that half or more of newborn infants are breast-feeding upon hospital discharge.

Lactation imposes a number of demands on the maternal organism if milk of appropriate quantity is to be produced. Thus, nutritional support of the nursing mother is of continuing concern. The topic has been the subject of recent reviews (Filer, 1975; Pitkin, 1976).

Diet and Lactation in General

In poorly nourished women, the quantity of milk produced is somewhat reduced (Chavez *et al.*, 1975), but lactation does not cease except in severe malnutrition. With some exceptions the composition, or quality, of human milk is relatively independent of maternal intakes of the respective nutrients.

With restricted maternal energy intake, the fatty acid pattern of milk comes to resemble that of depot fat because of maternal fat mobilization, whereas increasing energy intake as carbohydrate leads to increased content of lauric and myristic acids (Filer, 1975).

The intake of dietary polyunsaturated fatty acids (Potter and Nestel, 1976; Hall, 1979) and water-soluble vitamins (Filer, 1975) does affect the concentration of these nutrients in milk. In contrast, the total protein content of milk seems to be maintained across a relatively wide range of maternal protein intakes, but it has been noted that the levels of two essential free amino acids, lysine and methionine, are reduced with protein-deficient diets (Filer, 1975).

Thus, milk quantity and quality seem to be maintained reasonably well within a wide range of maternal diets, presumably reflecting subsidy of lactation by maternal stores. However, the adequacy of maternal stores is frequently difficult to determine in the individual case, and it seems inappropriate for the lactating woman to be placed in the position of having to deplete her own nutrient stores to support lactation. Therefore, the Recommended Dietary Allowances of the Food and Nutrition Board are increased during lactation in order to cover the amount of nutrients secreted in breast milk.

Specific Nutrients

The additional dietary requirements for most nutrients during lactation are calculated from the volume of milk produced (which averages 850 ml/day) and the concentration of the nutrient in the milk.

The energy content of human milk averages 70 kcal/dl, and the conversion of maternal energy to milk energy is assumed to be 80 percent (Thomson *et al.*, 1970). The calculated energy need for lactation is therefore 750 kcal/day. However, it is assumed that the 3 kg of fat stored by the woman during pregnancy is lost during the first 3 postpartum months and that this fat provides 250 kcal/day to subsidize the energy requirements of lactation. The recommended allowance for additional energy during lactation is therefore 500 kcal/day. Women who gain less than 12 kg during pregnancy and/or nurse more than one infant and/or nurse for longer than 3 months may need more than the recommended increment of 500 kcal/day.

The protein concentration of human milk averages 1.2 g/dl in early lactation and tends to decrease with time over the first 6 months as the volume of milk increases. Thus an average daily production of 850 ml contains approximately 10 g of protein. To account for efficiency of conversion of dietary to milk protein (estimated at 70 percent) and the possibility of greater-than-average quantity of production, the recommended allowance for protein in the nursing mother is 20 g in addition to other needs.

Milk contains 25 to 30 mg/dl of calcium or approximately 250 mg in an average daily production of 850 ml. The additional recommended intake of calcium in lactation is 400 mg, after allowing for the incomplete absorption of dietary calcium.

The concentrations of water-soluble vitamins in milk generally correlate with levels in maternal plasma and correspondingly with maternal dietary intake. Levels of water-soluble vitamins in milk can be raised by increasing maternal intake (Filer, 1975). The recommended allowance for these nutrients is increased in lactating women to provide for their excretion in milk, as well as for the metabolism of the higher energy and/or protein intakes.

By contrast with the situation with water-soluble vitamins, the levels of fat-soluble vitamins in milk are relatively unaffected by maternal intake. Vitamin D is of particular note because its concentration (at least in fat-soluble form) is so low in human milk that the nursing infant cannot meet its estimated requirement from this source. A water-soluble form of vitamin D in human milk has been reported (Lakdawala and Widdowson, 1977), which would ostensibly increase the availability of vitamin D to the breast-fed infant. However, this report has not been confirmed.

The trace elements iron, fluoride, and zinc are present in relatively low concentrations in human milk and these levels are not affected by maternal dietary intake. There is evidence that the bioavailability of iron (Saarinen *et al.*, 1977) and zinc (Johnson and Evans, 1978) in human milk is greater than that in cow's milk. Sodium content, on the other hand, correlates with the level of maternal ingestion.

Supplementation of the Lactating Mother

Although the practice of prescribing multiple vitamin-mineral supplements to the nursing mother is widespread, the increased needs for most nutrients can be provided by a well-balanced diet.

Supplementation with iron, in amounts of 30-60 mg/day as simple ferrous salts, is recommended for all puerperal women (lactating or not) in order to replenish iron stores possibly depleted during pregnancy (Food and Nutrition Board, 1980).

Supplementation with other nutrients is generally unnecessary, except in cases of proved or suspected deficiency. These nutrients are most likely to be calcium and fat-soluble vitamins. A woman of high parity with closely spaced children is likely to be at greatest risk.

Nutritional Services

Dietary counseling for lactation should begin during the prenatal period when most women decide to breast-feed or bottle-feed. This counseling should be available in the physicians' office or in the prenatal clinic. The information could be provided by a well-trained nurse, paraprofessional, or preferably by a dietitian, if available.

NUTRITION AND THE HIGH-RISK PREGNANCY

Maternal preconception weight, and weight gain during pregnancy, rank second only to gestational age as determinants of birthweight.

Preconception Weight

Normative data with respect to standard weight for sex, height, and age are available from several sources and should be used to detect low and high preconceptual weight. The underweight obstetric patient has been defined as 10 percent or more below standard weight for height and age, and the overweight patient as 20 percent or more above the standard (Pitkin, 1977a).

The hazards presented by the woman entering pregnancy underweight have not been generally appreciated. The principal risk is delivery of a low-birthweight infant, with concomitant increased risk of perinatal mortality (Thomson and Hytten, 1966). An increased severity of toxemia has also been recorded (Tompkins *et al.*, 1955). When protein-calorie supplements were used to improve the pregnancy outcome of these patients, some were successful (Higgins, 1976), while others were less effective (Rush *et al.*, 1980).

The obese pregnant patient is at increased risk because of the association between obesity and such medical conditions as chronic hypertension, diabetes mellitus, and thrombo-embolism (Tracy and Miller, 1969). Virtually all authorities agree that dietary restriction sufficient to induce weight loss is potentially dangerous during gestation. However, opinion seems to be divided equally between those favoring a modest weight gain (6 to 9 kg), so that pregnancy is concluded with a net loss of weight, and those advocating a normal weight gain. There is no convincing evidence that restricted gain reduces the complications associated with obesity in pregnancy (Pitkin, 1977b). Arguments against dietary restriction of pregnant obese women include the potential risks of (1) deficiencies of nutrients other than energy, (2) impaired protein utilization at low-energy intakes (Oldham and Sheft, 1951), and (3) adverse effects of ketonemia on the fetus due to catabolism of maternal fat stores (Churchill and Berendes, 1969).

Weight Gain During Pregnancy

There is reasonable agreement regarding the amount of weight that should be gained by a pregnant woman. The National Research Council Committee on Maternal Nutrition has stated that a gain of 11 kg is compatible with normal pregnancy outcome (Committee on Maternal Nutrition, 1970). The pattern by which weight accumulates is of greater significance for patient management. Gain is minimal during the first trimester, increasing to 0.35-0.40 kg/wk during the last two trimesters (Pitkin *et al.*, 1972). For practical patient management, it is essential to recognize abnormalities in the pattern of weight gain while pregnancy is in progress. The following guidelines have been suggested (Pitkin, 1977a):

Inadequate gain:	Gain of 1 kg or less per month during the second or third trimesters.
Excessive gain:	Gain of 3 kg or more per month.

The use of graphs to record weight changes is of great value in early recognition of departures from normal.

Inadequate weight gain imposes an increased risk of delivering a low-birthweight infant, a risk magnified when it occurs in conjunction with low preconceptional weight (Jacobson, 1975). The rate of weight gain during the third trimester is a particularly important determinant of birthweight (Stein and Susser, 1975).

It has only recently been recognized that no cause-effect relationship exists between excessive weight gain during pregnancy and preeclampsia. While excessive weight gain due to the accumulation of extracellular fluid (edema) is a classic component of preeclampsia and eclampsia, it is now regarded as an *effect*, and not a *cause*, of preeclampsia (Pitkin, 1977a).

Excessive weight gain in pregnancy will normally result in excessive fat deposition, and if this fat is retained after pregnancy and lactation it may contribute to subsequent obesity.

Hyperemesis Gravidarum

Some degree of nausea and vomiting is a frequent concomitant of early pregnancy. Its etiology is not known with certainty, but circumstantial evidence suggests an association with hormonal influences, especially chorionic gonadotropin. Rarely, vomiting becomes so intractable as to lead to weight loss and fluid-electrolyte disturbances, in which case the terms of hyperemesis gravidarum or pernicious vomiting of pregnancy are applied.

The patient acutely ill with hyperemesis gravidarum is likely to be dehydrated, ketotic, hypochloremic, and hypokalemic. Immediate hospitalization and intravenous therapy to correct fluid and electrolyte imbalances are needed. Water-soluble vitamins should be added to intravenous fluids to ameloriate any likelihood of deficiency. When vomiting subsides, oral feedings may be initiated, beginning with small quantities of liquids and progressing through soft and bland foods. Oral vitamin-mineral supplements should be added. Careful psychological evaluation and emotional support are critical.

Chronic Hypertensive Disease in Pregnancy

About 30 percent of hypertension in pregnancy will persist after pregnancy and is categorized as essential hypertension or hypertension of unknown etiology. Essential hypertension is frequently confused with toxemia of pregnancy, since many young women first report for medical care when they are pregnant, and there has been no previous opportunity to diagnose hypertension. Rather difficult medical decisions must be made in these cases, because the therapy of these two diseases differs. When chronic renal disease exists, urinary protein losses may be as high as 5 g per day. However, dietary protein supplements are not usually necessary because the urinary losses comprise only about 5-7 percent of the usual protein intake. The general dietary recommendations would include a well-balanced diet containing a mixture of essential nutrients. Sodium restriction to about 200 mg/day may be indicated in essential hypertension. If thiazide or other diuretics are being used it should be acknowledged that potassium as well as sodium may be lost, and thus the patient should be counseled as to good dietary sources of potassium.

Toxemia of Pregnancy

Toxemia, or pregnancy-induced hypertension, is a syndrome characterized by hypertension, proteinuria, and edema. Toxemia affects about 7-8 percent of the obstetric population. It is found principally in young primigravidas, particularly of low socioeconomic status. The disease generally develops in the third trimester.

Uncomplicated edema of the lower extremities in pregnancy is a fairly common phenomenon and is not indicative of toxemia. This extravascular fluid is often mobilized in the evening when the woman is recumbent, resulting in nocturia. The swelling of the lower extremities may be caused by the pressure of the enlarging uterus on the veins returning fluid from the legs. When the edema is generalized, however, it would indicate that the kidneys are reabsorbing large amounts of sodium and the control of the extracellular fluid volume has been lost. With generalized edema there appears to be an increased sensitivity to renin, and some hypertension can be expected to develop.

The etiology of toxemia is unknown. Several causes have been suggested, including nutritional deficiencies, genetic predisposition, or immunological factors. Most agree that it is associated with a decreased uterine blood flow leading to a reduction in fetal nourishment. Of the nutritional causes, protein deficiency has been linked most frequently to toxemia (Committee on Maternal Nutrition, 1970). However, low protein intakes are often associated with poverty, poor health, poor eating and health habits, and emotional stress. Therefore, the link between protein intakes and toxemia is not clear, and evidence of the benefit of a high-protein diet in preventing the disorder is inconclusive. It has also been suggested that a low calcium intake might be associated with the etiology of toxemia, but this remains to be confirmed (Belizan and Villar, 1980).

Previously, attempts to treat toxemia have focused on three nutritional therapies--sodium restriction, diuretics, and dieting. Sodium restriction has failed to alter significantly blood pressure, weight gain, or proteinuria in gravid women and seems to have no place in treatment or prevention of toxemia (Pike and Smiciklas, 1972). Many studies have been performed on the use of diuretic drugs for prevention or treatment of toxemia. In most studies, the incidence of toxemia in the treated group is the same as the incidence in the untreated group. Toxemia is associated with a decrease in the intravascular volume due to peripheral vasoconstriction. Therefore, it seems unwise to treat the disorder by constricting the vascular volume further through forced kidney diuresis of sodium and water with diuretics (Committee on Maternal Nutrition, 1970). A definitive treatment would be to produce vasodilation and overcome the fundamental lesion of peripheral vasoconstriction. Diuretics, then, do not prevent or effectively treat toxemia and, in addition, are associated with reductions in birthweight. Similarly, restricted energy intake has not been found to prevent toxemia in high-weight-gain primigravidas.

Diabetes Mellitus

The diagnosis of diabetes mellitus in pregnancy is difficult because of the alterations that occur in blood glucose curves in normal gestation (Knopp *et al.*, 1978). Proper evaluation of the patient in terms of prior dietary intake, hours of fasting, time of day, time of blood samples, activity during the test, and laboratory methods are all critical to obtaining a valid result (Committee on Nutrition of the Mother and Preschool Child, 1978).

The nutritional requirements for patients with diabetes mellitus complicating pregnancy have not been studied extensively. Appropriate energy intake for the diabetic gravida is controversial. Since the allowance for normal pregnancy is approximately 36 kcal/kg, most authorities advocate this level for the diabetic. Others, however, suggest a lower intake, such as 30 kcal/kg (ideal weight) plus 300 kcal per day added during gestation.

The distribution of the calories should be 1.3 g/kg/day as protein (approximately 20 percent), 200-250 g/day as carbohydrate, and the balance of the energy as fat, with about 50 percent being of the mono- and polyunsaturated type (Williams, 1977a; Schulman *et al.*, 1978). Thus carbohydrates are not disproportionately reduced.

Efforts should be made to avoid large fluctuations of blood sugar during the day (Gabbe, 1975). Complex carbohydrates such as starches are recommended, since they are digested and absorbed more slowly than simple sugars. Each meal should contain both protein and carbohydrate to smooth out the blood glucose curve. Meals should be evenly distributed throughout the day. Pregnant diabetics are frequently treated with combinations of intermediate- and short-acting insulins, with dosages taken morning and evening. These women should consume 25 percent of their carbohydrate and calories at breakfast, 25-30 percent at lunch, 30 percent at dinner, and 15 percent as a bedtime snack to avoid early-morning hypoglycemia (Schulman *et al.*, 1978).

Part of the breakfast and lunch calories might be consumed as mid-morning and mid-afternoon snacks.

It is clear that individualized, expert care is needed for the nutritional management of the pregnant diabetic. On the basis of a nutritional history and assessment early in pregnancy, plus a physical, medical-obstetrical, and personal assessment, an individually adapted dietary plan should be developed by a skilled nutritionist as part of a health care team. It is likely that the diet will have to be modified as pregnancy progresses, in order to accommodate adjustments in insulin therapy, increasing caloric needs, and changes in food preferences and tolerance.

Kidney Diseases

Patients with severe kidney disease may have a large urinary protein loss during pregnancy. If the loss becomes massive, the serum proteins could fall to levels where their reduced osmotic pressure would allow water to move to extravascular spaces and anasarca would result. There is no information on the special dietary needs for these patients, but perhaps if extremely high protein losses occur an additional dietary protein intake may be needed. However, high protein intakes in the patient with impaired glomerular filtration may be hazardous in that blood urea levels may be elevated.

Multiple Pregnancy

Theoretically, the nutritional needs for the woman with more than one fetus should increase, as she has a larger blood volume and a larger placental and fetal mass. This would suggest that her requirements for energy, protein, iron, folacin, and other nutrients should be greater than for the normal pregnant woman. There are no published studies to document these increased needs however.

Pregnancy in the Intestinal Bypass Patient

As of November 1978, 31 pregnancies have been documented in 27 patients with prior intestinal bypass surgery for morbid obesity. Following such surgery there is generally a dramatic weight loss, followed by metabolic adjustments and decrease in nutritional status. In general, the outcome of pregnancies in these women is good, but small-for-date babies are probably more frequent than in the general population. The dietary management of these patients must be based on each individual's postoperative course, degree of weight loss, time since surgery, and blood chemistry.

Those patients with chronic ketonemia should be followed very carefully, since this could have an adverse effect on the fetus (Churchill and Berendes, 1969).

Adolescent Pregnancy

The overall incidence of adolescent pregnancy has increased steadily despite a declining birthrate in the general population. Pregnancy among teenagers is a serious public health problem with medical, health, social, psychological, and vocational implications for the mother and baby. Prolonged labors and low-birthweight infants are more common among adolescents, especially those 14 years old or younger (Merritt *et al.*, 1980). A high frequency of hypertensive disorders of pregnancy occurs in black adolescents, but is related to race rather than age (Spellacy *et al.*, 1978). Adolescents who conceive shortly after menarche seem to be particularly at risk, and an inverse relationship between postmenarche age and low birthweight has been demonstrated (Zlatnik and Burmeister, 1977). These difficulties probably result from the complex interaction among biological, social, and nutritional problems experienced by the pregnant adolescent rather than from one single factor.

Very few good studies on the nutritional requirements of pregnant adolescents exist (Worthington, 1977). It is likely, however, that the nutritional needs of the adolescent who conceives before her longitudinal growth is complete are greater than those of girls who are 4 or more years postmenarche. If growth of the adolescent continues during pregnancy, higher protein intakes are recommended for the very young (Food and Nutrition Board, 1980). For pregnant adolescents aged 15-18 years, the allowance is 1.5 g protein/kg of bodyweight, and for younger girls, 1.7 g/kg is suggested. The needs for energy, vitamins, and minerals are also increased for younger pregnant adolescents. An estimate of the nutritional needs of the younger women can be made, by adding the recommended increment for pregnancy in older women to the RDA appropriate for the adolescent's age (Table 2). Since there are no differences between the recommended intakes for adults and adolescents for vitamins A, E, B_{12}, and folacin and for the minerals iron, magnesium, iodine, and zinc, the estimated needs for these nutrients will be the same as those of a mature pregnant woman (Table 1).

Nutritional Services for High-Risk Pregnant Women

The dietary intakes of all high-risk pregnant women should be assessed initially, and any dietary modification required

TABLE 2 Estimated Daily Nutrient Needs of Pregnant Adolescents Based on the Increment Suggested for Pregnancy in Mature Women

Nutrient and Units	Pregnancy Increment	Total Estimated Need 11-14 yr	15-18 yr
Energy (kcal)	300	2,500	2,400
Protein (g)	30	78 (1.7 g/kg)	82 (1.5 g)
Vitamin A (mg RE)	200	1,000	1,000
Vitamin D (mcg)	5	15	15
Vitamin E (mg TE)	2	10	10
Vitamin C (mg)	20	70	80
Thiamin (mg)	0.4	1.5	1.5
Riboflavin (mg)	0.3	1.6	1.6
Niacin	2	17	16
Vitamin B_6 (mg)	0.6	2.4	2.6
Folacin (mg)	400	800	800
Vitamin B_{12} (mcg)	1.0	4.0	4.0
Calcium (mg)	400	1,600	1,600
Phosphorus (mg)	400	1,600	1,600
Magnesium (mg)	150	450	450
Iron (mg)	30-60[a]	30-60[a]	30-60[a]
Zinc (mg)	5	20	20
Iodine (mg)	25	175	175

[a] This intake cannot be met by the iron content of habitual American diets; the use of a supplement is recommended.

should be made as a modification of their usual diet. In addition, the nutritional status for some nutrients should be evaluated biochemically, and this information should also be considered when dietary modifications are suggested. Dietary and biochemical evaluations should be made periodically throughout gestation to determine whether further modification is needed. All pregnant adolescents should be considered to be at high risk. Therefore, their dietary habits should be thoroughly assessed at the first prenatal visit, and counseling initiated as soon as possible.

ALTERED NUTRITIONAL HABITS AND ABUSES DURING PREGNANCY

Drug Abuse

The number of births to mothers addicted to various drugs appears to be rising sharply in some urban areas of the United States. Among the substances abused by women are heroin, LSD, barbiturates, amphetamines, and marijuana. Also, former heroin addicts may be participating in methadone treatment programs.

Study of the effect of drug abuse on pregnancy outcome has been limited primarily to investigations on heroin and methadone. In animal studies, administration of heroin or methadone appears to reduce birthweight and increase fetal wastage (Buchenauer *et al.*, 1974; Jones and Chernoff, 1978), but no malformations have been attributed to these two drugs. Babies born to these mothers experience withdrawal symptoms that tend to be more severe and last longer in the infants of methadone-treated women than those addicted to heroin (Reddy *et al.*, 1971).

Most studies show that barbiturates cross the placenta and cause physiological dependence in the fetus (Desmond *et al.*, 1972). When the drug is withdrawn at delivery, the newborn is at risk of experiencing mild tremors. This usually occurs about 3-4 days after delivery. Other commonly abused drugs such as LSD, amphetamines, cocaine, and marijuana do not appear to accumulate in the fetus, and there is no strong evidence that these drugs cause chromosomal damage or teratogenicity in humans (Lang, 1972). However, the placental membrane is very permeable to most drugs during early pregnancy (Lang, 1972); such drugs, therefore, remain suspect.

Of all the drugs commonly abused, heroin and methadone seem to have the most direct and devasting effects on the course of pregnancy. However, drug addiction is often associated with other habits or conditions that influence fetal growth, such as poor nutrition, poor health, smoking, and alcoholism. The potential effects of drug addiction on later growth and development of the infant have not been studied.

Smoking

A strong and consistent relationship between maternal smoking during pregnancy and reduced birthweight has been demonstrated in numerous studies. On the average, infants of smokers weigh 150 to 250 g less than those of nonsmokers; the reduction tends to be greater in heavy smokers (>15 cigarettes/day) than moderate smokers (<15 cigarettes/day) (Davis *et al.*, 1976). Epidemiological studies suggest that perinatal mortality also increases directly with the level of maternal smoking during pregnancy (Meyer and Ionascia, 1977). These deaths seem to be associated with abruptio placentae, placenta previa, and premature and prolonged rupture of membranes.

The mechanism(s) by which cigarette smoking adversely affects fetal welfare has been the subject of many studies. Retardation in fetal growth could be due to a direct effect of the toxic substances inhaled in tobacco smoke (e.g., carbon monoxide or cyanide) on the fetus (Pettigrew *et al.*, 1977) to an indirect effect mediated through a restriction of the mother's own weight gain (Rush, 1974), or to nicotine's acute activation of adrenergic discharge and subsequent vasoconstriction (Quigley *et al.*, 1979). Some evidence suggests that more than one factor may be involved (Desmond *et al.*, 1972).

The consequences of this fetal growth retardation on long-term physical growth and intellectual function is not clear. Some studies suggest that the children of smoking mothers are shorter in height at 11 years of age than the children of nonsmoking mothers (Meredith, 1975). This reduction in stature could be related to environmental variables present postnatally rather than to growth retardation in utero, however.

Alcohol

Chronic, heavy use of alcohol during pregnancy can alter growth and morphogenesis. A specific pattern of malformations involving prenatal onset growth retardation, development delay, craniofacial anomalies, and limb defects is recognized as the fetal alcohol syndrome (FAS) and occurs at a rate of about three to five live births/1,000 (Clarren and Smith, 1978). The consumption of about 90 ml absolute alcohol or more per day (e.g., about four average drinks) is considered to represent a risk to the fetus. The FAS is only established clearly as a complication of chronic alcoholism, a condition associated with many unfavorable influences on health, making it impossible to state with certainty whether or not ethanol is the specific teratogen. Certain observations suggest that moderate alcohol consumption may adversely affect fetal growth and development (Hanson *et al.*, 1978), but these data require confirmation. Therefore, at the present time it is not possible to state a level of ethanol consumption that can be regarded as safe during pregnancy.

Chronic use of alcohol can have secondary effects on nutrition. Alcohol can affect appetite and replace food, and, therefore, nutrients in the diet. Also, alcohol has been shown to decrease absorption of some nutrients. The possible role of secondary nutrient deficiencies on the expression of FAS is not known.

Because the nutritional status of alcoholics tends to be poor, it is prudent to give vitamin-mineral supplements to women who admit to chronic alcohol use during pregnancy.

Caffeine

Caffeine has been consumed by man for centuries in coffee and tea. In modern times caffeine has been added commercially to food items; cola beverages comprise the largest and most significant source of caffeine from foods.

Caffeine consumption is quite variable, but can be high in women consuming large amounts of coffee, tea, or cola. Caffeine, however, does not appear to be a strong teratogen. Retrospective studies of more than 14,000 mothers on whom caffeine histories were obtained revealed no association between caffeine intakes and abnormalities in offspring (Food and Drug Administration, 1979). One study (Weathersbee *et al.*, 1978) has suggested that high levels of caffeine (greater than 600 mg/day--about 6 cups of instant coffee or 12 12-oz colas) may have caused spontaneous abortions and premature births. However, other variables associated with caffeine consumption, such as smoking, may have contributed to the effect on reproductive performance.

Although the evidence is limited, moderate intakes of caffeine, i.e., about 3 cups of coffee, seem to present no special risk during human pregnancy.

Megadoses of Vitamins

Oral intakes of high amounts of vitamins, greater than 100 times the recommended intake, have become popular with some persons. Hypervitaminosis A and D have been shown to be teratogenic in animals (Giroud, 1968). The threat from high intakes of water-soluble vitamins to fetal development is probably considerably less than that of the fat-soluble vitamins, but limited evidence suggests that vitamin dependency can be induced in the offspring when maternal intakes are high (Nandi *et al.*, 1977). In general, then, it is probably wise to counsel against vitamin supplements greater than the Recommended Dietary Allowances during pregnancy.

Veganism

Vegetarian diets may be comprised of only plant foods, i.e., vegan diet, or may merely exclude meat, poultry, or fish, i.e., an ovo-lacto vegetarian diet. The latter type can be adequate in all nutrients and represents no risk to the pregnant woman as long as the diet includes a variety of legumes, nuts, dairy products, eggs, whole grain products, fruits, and vegetables. The vegan diet, on the other hand, will be lacking vitamin B_{12} and other nutrients found in high concentration in animal food sources. These include vitamin B_6, riboflavin, iron, calcium, and zinc. A vegan diet is not advisable for pregnant or lactating women. In the event that vegan diets are followed, the nutrient content of the diet should be carefully evaluated and nutrient supplements prescribed where indicated.

Pica

Pica is the ingestion of substances normally not considered to be foods, such as starch, clay, dirt, or coal. There are reports that this practice increases during pregnancy, but this is very difficult to confirm. Of the various substances ingested, starch-eating appears to be the most common and is most prevalent among black women, particularly during pregnancy (Lackey, 1978; Snow and Johnson, 1978). Parotid enlargement and gastric and small bowel obstructions have been ascribed to excessive use of laundry starch. Hypochromic anemia, apparently due to reduced iron intake and absorption, has occurred in black women whose diets consisted chiefly of cornstarch (Reddy *et al.*, 1977). Because ingestion of nonfood items may impair nutrient utilization as well as replace food sources of nutrients, it should be strongly discouraged during pregnancy.

Nutritional Services

The nutritional intake of any woman who admits to or is suspected of altered habits or abuses should be thoroughly and carefully evaluated, preferably by a nutritionist or dietitian. If a nutritionist is not available, the initial assessment could be done by a physician or office nurse and the patient could be referred to a nutritionist/dietitian for in-depth nutritional counseling if needed.

REFERENCES

Belizan, J. M., and J. Villar. 1980. The relationship between calcium intake and edema-, proteinuria-, and hypertension-gestosis: An hypothesis. Am. J. Clin. Nutr. 33:2202-2210.

Buchenauer, C., M. Turnbow, and M. A. Peters. 1974. Effect of chronic methadone administration on pregnant rats and their offspring. J. Pharmacol. Exp. Ther. 189:66-71.

California Department of Health. 1975. Nutrition During Pregnancy and Lactation. 108 pp.

Chavez, A., C. Martinez, H. Bourges, M. Coranado, M. Lopez, and S. Basta. 1975. Child nutrition problems during lactation in poor rural areas. *In* Proc. 9th Int. Congr. Nutr. Mex.

Churchill, J. A., and H. W. Berendes. 1969. Intelligence of children whose mothers had acetonuria during pregnancy. Pages 30-35 *in* Perinatal Factors Affecting Human Development. Pan Am. Health Org., Washington, D.C.

Clarren, S. K., and D. W. Smith. 1978. The fetal alcohol syndrome. N. Engl. J. Med. 298:1063-1067.

Committee on Maternal Nutrition, Food and Nutrition Board. 1970. Maternal Nutrition and the Course of Pregnancy. National Academy of Sciences, Washington, D.C., 241 pp.

Committee on Nutrition of the Mother and Preschool Child, National Research Council. 1978. Laboratory Indices of Nutritional Status in Pregnancy. National Academy of Sciences, Washington, D.C. 185 pp.

Davis, D. P., O. P. Gray, P. C. Ellwood, and M. Abernethy. 1976. Cigarette smoking in pregnancy: Associations with maternal weight gain and fetal growth. Lancet 1:385-387.

Desmond, M. M., R. P. Schwanecke, G. S. Wilson, A. Yasunaga, and I. Brugdorff. 1972. Maternal barbiturate utilization and neonatal withdrawal symptomatology. J. Pediatr. 80:190-197.

Filer, L. J. 1975. Maternal nutrition in lactation. Clin. Perinatol. 2:353-360.

Food and Drug Administration. 1979. Caffeine, Consumer Exchange Meeting, Jan. 31.

Food and Nutrition Board, National Research Council. 1980.

Recommended Dietary Allowances, 9th ed. National Academy of Sciences, Washington, D.C. 185 pp.
Gabbe, S. G. 1975. Application of the scientific rationale to the management of the pregnant diabetic. Semin. Perinatol. 2:361-371.
Giroud, A. 1968. Nutrition of the embryo. Fed. Proc. 27:163-184.
Hall, B. 1979. Uniformity of human milk. Am. J. Clin. Nutr. 32:304-312.
Hanson, J. W., A. P. Streissguth, and D. W. Smith. 1978. Effects of moderate alcohol consumption during pregnancy. J. Pediatr. 92:457-460.
Herbert, V., N. Colman, M. Spivak, E. Ocasio, V. Ghanta, K. Kimmel, L. Brenner, J. Freundlich, and J. Scott. 1975. Folic acid deficiency in the United States: Folate assays in a prenatal clinic. Am. J. Obstet. Gynecol. 123:175.
Herbert, V. 1977. Anemias. Pages 79-89 *in* M. Winck, ed. Nutrition Disorders of American Women. Wiley-Interscience, New York.
Higgins, A. 1976. Nutritional status and the outcome of pregnancy. J. Can. Dietet. Assoc. 37:17-35.
Hillman, R. W., P. G. Cabaud, D. E. Nilsson, P. D. Arpin, and R. J. Tufano. 1963. Pyridoxine supplementation during pregnancy. Clinical and laboratory determinations. Am. J. Clin. Nutr. 12:427-430.
Hytten, F. E., and I. Leitch. 1971. The Physiology of Human Pregnancy, 2d ed. Blackwell Scientific, Oxford. 599 pp.
Jacobson, H. 1975. Weight and weight gain in pregnancy. Clin. Perinatol. 2:233-242.
Jelliffe, D. B., and E. F. P. Jelliffe. 1971. The uniqueness of human milk. An overview. Am. J. Clin. Nutr. 24:1013-1024.
Johnson, P. E., and G. W. Evans. 1978. Relative zinc availability in human breast milk, infant formulas and cow's milk. Am. J. Clin. Nutr. 31:416-421.
Jones, K. L., and G. F. Chernoff. 1978. Drugs and chemicals associated with intrauterine growth deficiency. J. Reprod. Med. 21:363-370.
Jones, K. L., and D. W. Smith. 1975. The fetal alcohol syndrome. Teratology 12:1-10.
King, J. C. 1975. Protein metabolism during pregnancy. Clin. Perinatol. 2:243-254.
Knopp, R. H., A. Montes, and R. Worth. 1978. Carbohydrate and lipid metabolism. Pages 35-88 *in* Laboratory Indices of Nutritional Status in Pregnancy. National Academy of Sciences, Washington, D.C.

Krebs, N. F., K. M. Hambridge, C. C. Lyle, S. F. Freeland, P. Chanmugan, and C. E. Casey. 1980. Dietary intake of zinc during pregnancy by middle-income women. Western Hemisphere Nutrition Congress IV, p. 82. (abstract)

Lackey, C. J. 1978. Pica--a nutritional anthropology concern. Pages 121-129 *in* E. E. Bauwens, ed. The Anthropology of Health, 2d ed. C. V. Mosby Co., St. Louis.

Lakdawala, D. R., and E. M. Widdowson. 1977. Vitamin D in human milk. Lancet 1:167-168.

Lamar, C., B. H. McCracken, O. N. Miller, and G. A. Goldsmith. 1965. Experiences with the Schilling test as a diagnostic tool. Am. J. Clin. Nutr. 16:402-411.

Lang, S. Y. 1972. Does LSD induce chromosomal damage and malformation? A review of the literature. Teratology 6:75-90.

Mata, L. 1978. Breast-feeding: Main promoter of infant health. Am. J. Clin. Nutr. 31:2058-2065.

Meredith, H. V. 1975. Relation between tobacco smoking of pregnant women and body size of their progeny: A compilation and synthesis of published studies. Human Biol. 47:451-472.

Merritt, T. A., R. A. Lawrence, and R. L. Naeye. 1980. The infants of adolescent mothers. Pediatr. Ann. 9:32-49.

Meyer, M. B., and J. A. Ionascia. 1977. Maternal smoking, pregnancy complications and perinatal mortality. Am. J. Obstet. Gynecol. 85:31-34.

Nandi, B. K., A. L. Majumder, and K. Halder. 1977. Effects of high intake of vitamin C by the guinea pig in pregnancy and lactation on the tissue levels of the vitamin in their offspring. Int. J. Vit. Nutr. Res. 47:200-205.

Oldham, H., and B. B. Sheft. 1951. Effect of caloric intake on nitrogen utilization during pregnancy. J. Am. Dietet. Assoc. 27:847-854.

Pettigrew, A. R., R. W. Logan, and J. Willocks. 1977. Smoking in pregnancy--effects on birth weight and cyanide and thiocyanate levels in mother and baby. Br. J. Obstet. Gynecol. 85:31-34.

Pike, R. L., and H. A. Smiciklas. 1972. A reappraisal of sodium restriction during pregnancy. Int. J. Gynecol. Obstet. 10:1-8.

Pitkin, R. M., H. A. Kaminetzky, M. Newton, and J. A. Pritchard. 1972. Maternal nutrition: A selective review of clinical topics. Obstet. Gynecol. 40:773-785.

Pitkin, R. M. 1976. Nutritional support in obstetrics and gynecology. Clin. Obstet. Gynecol. 19:489-513.

Pitkin, R. M. 1977a. Obstetrics and gynecology. Pages 401-421 *in* H. A. Schneider, C. E. Anderson, and D. B.

Coursin, eds. Nutritional Support of Medical Practice. Harper & Row, New York.
Pitkin, R. M. 1977b. Nutrition during pregnancy: The clinical approach. *In* M. Winick, ed. Nutritional Disorders of American Women. Wiley-Interscience, New York.
Potter, J. M., and P. J. Nestel. 1976. The effects of dietary fatty acids and cholesterol on the milk lipids of lactating women and the plasma cholesterol of breast-fed infants. Am. J. Clin. Nutr. 29:54-60.
Quigley, M. E., K. L. Sheehan, M. M. Wilkes, and S. S. C. Yen. 1979. Effects of maternal smoking on circulation, catecholamine levels and fetal heart rates. Am. J. Obstet. Gynecol. 133:658-690.
Reddy, A. M., R. B. Harper, and G. Stern. 1971. Observations on heroin and methadone withdrawal in the newborn. Pediatrics 48:353-358.
Reddy, C. M., D. Wright, and E. P. Crump. 1977. Starch eater's anemia. Am. J. Dis. Child. 131:926-927.
Rush, D. 1974. Examination of the relationship between birthweight, cigarette smoking during pregnancy and maternal weight gain. J. Obstet. Gynecol. Br. Commonw. 81:746-752.
Rush, D., Z. Stein, and M. Susser. 1980. A randomized controlled trial of prenatal nutritional supplementation in New York City. Pediatrics 65:683-689.
Sandstead, H. H. 1973. Zinc nutrition in the United States. Am. J. Clin. Nutr. 26:1252-1260.
Saarinen, U. M., M. A. Siimesand, and P. R. Dallman. 1977. Iron absorption in infants: High bioavailability of breast milk iron as indicated by the extrinsic tag method of iron absorption and by the concentration of serum ferritin. J. Pediatr. 91:36-39.
Schulman, P. K., M. T. Gyves, and I. R. Merkatz. 1978. Role of nutrition in the management of the pregnant diabetic patient. Semin. Perinatol. 2:353-360.
Scott, D. E. 1977. The anemias of pregnancy. Pages 1-16 *in* Gynecology and Obstetrics, vol. 1. Harper & Row, New York.
Snow, L. F., and S. M. Johnson. 1978. Folklore, food, female reproduction cycle. Ecol. Food Nutr. 7:41-49.
Spellacy, W. N., C. S. Mahan, and A. C. Cruz. 1978. The adolescent's first pregnancy: A controlled study. South. Med. J. 71:768-771.
Stein, Z. A., and M. W. Susser. 1975. The Dutch famine, 1944/45, and the reproductive process. 1. Effect on six indices at birth. Pediatr. Res. 9:70-76.
Svanberg, B., B. Arvidsson, A. Norrby, G. Rybo, and L.

Solvell. 1975. Absorption of supplemental iron during pregnancy--a longitudinal study with repeated bone-marrow studies and absorption measurements. Acta Obstet. Gynecol. Scand. Suppl. 48:87-108.

Thomson, A. M., F. E. Hytten, and W. Z. Billewicz. 1970. The energy cost of human lactation. Br. J. Nutr. 24: 565-572.

Thomson, A. M., and F. E. Hytten. 1966. Nutrition in pregnancy and lactation. Pages 104-107 *in* G. H. Beaton and E. W. McHenry, eds. Nutrition, A Comprehensive Treatise, vol. III. Academic Press, New York.

Tompkins, W. T., D. G. Wiehl, and R. Mitchell. 1955. The underweight patient as an increased obstetric hazard. Am. J. Obstet. Gynecol. 69:114-127.

Tracy, T. A., and G. L. Miller. 1969. Obstetric problems of the massively obese. Obstet. Gynecol. 33:204-208.

Weathersbee, P. S., L. K. Olsen, and J. R. Lodge. 1972. Caffeine and pregnancy. Postgrad. Med. 62:64-69.

White, P. 1974. Diabetes mellitus and pregnancy. Clin. Perinatol. 1:331-347.

Whiting, J., S. Whitman, L. Bergner, and S. Patrick. 1978. Additives and low birth-weight: A quasi-experimental study. Am. J. Public Health 68:676-678.

Williams, S. E. 1977. Nutritional therapy in special conditions of pregnancy. Pages 55-92 *in* B. S. Worthington, J. Vermeersch, and S. R. Williams, eds. Nutrition in Pregnancy and Lactation. C. V. Mosby Co., St. Louis.

Worthington, B. S. 1977. Nutritional needs of the pregnant adolescent. *In* B. S. Worthington, J. Vermeersch, and S. R. Williams, eds. Nutrition in Pregnancy and Lactation. C. V. Mosby Co., St. Louis.

Zlatnik, F. J., and L. F. Burmeister. 1977. Low gynecologic age: An obstetric risk factor. Am. J. Obstet. Gynecol. 128:183-186.

3 IMPLEMENTATION OF NUTRITION SERVICES IN PRENATAL AND POSTPARTUM CARE

Each of the levels of the proposed regional perinatal care system requires varying degrees of nutrition intervention by professionals with different qualifications and competences. In uncomplicated pregnancies, nutritional needs are reasonably well defined (see chapter 1) and can usually be handled by the physician without special training or expertise in clinical nutrition, or by a competent nurse. Women at high risk, however, require more sophisticated techniques, both in analysis of the problem and in nutritional management. Optimal care necessitates the early recognition of patients at risk for nutrition-related health problems and assurance that their subsequent care will include provision of the appropriate nutrition services.

The following discussion will deal with the nutrition services recommended for each level of perinatal care, the health team providing these services, and the qualifications of these personnel.

LEVEL I

By definition, a Level I facility services individuals in sparsely populated or geographically isolated areas and is capable of providing care at a minimum level of complexity. Thus, primarily uncomplicated pregnancies or those with minor complications (such as iron deficiency anemia) are served at Level I. Prior to hospitalization for delivery, nearly all prenatal care at this level is provided in physicians' offices or in prenatal clinics. In many instances, the physician and nurse constitute the health care team, since a dietitian/nutritionist is not usually available. However, the Committee on Perinatal

Health (1976) recommended that all Level I units have an active formalized relationship with a regional center for the support of in-service education, patient and service consultation, and general support of perinatal services. Such a relationship should include access to nutrition consultation.

Preventive services should be an important component of a Level I unit. Many of the risk factors for suboptimal reproduction performance are established well in advance of pregnancy (see chapter 1) when health professionals have limited opportunity to address them. Rather, they must be addressed through ongoing nutrition education and food assistance programs directed at the population at risk. These programs should be designed by health professionals, but implemented through the public school systems, family planning clinics, community health programs, voluntary organizations serving youth, and other such agencies that serve the public.

Nutrition Services in a Level I Unit

- Evaluate current dietary practices.
- Counsel on nutrient needs during pregnancy and dietary practices to meet these needs.
- Refer, as necessary, to community resources such as food assistance programs, income maintenance, educational programs in home management, etc.
- Monitor and interpret clinical data such as hemoglobin level, blood pressure, and urine protein.
- Identify risk factors (see Table 3).
- Consult with or refer to Level II or III units those patients deemed at high risk.
- Provide information and advice on breast-feeding or alternative methods of feeding.
- Counsel on nutrient needs during lactation.

Personnel Requirements in Level I Units

1. For Consultation

Registered dietitians/nutritionists should be available for consultation and for providing in-service and outreach training. Nutrition consultants and other health care team members should have experience in counseling regarding the nutritional needs of pregnant women, normal newborn babies, and lactating mothers and should be aware of community nutrition resources including food assistance programs, elibigility requirements, and the process of application.

2. Prenatal Care

Nutrition counseling is most appropriately provided during the first prenatal visit. The attending physician or nurse should be capable of providing this service. If problems are encountered, consultation may be required. Such patients should be evaluated frequently and given assistance as may be required.

For women who wish to breast-feed, preparation should begin during pregnancy. These women require adequate information on nutrient intakes that will support lactation without undue depletion of maternal stores and instruction in techniques of breast-feeding, commonly associated problems, and appropriate action to solve such difficulties. Such information should be provided by the physician or nurse.

3. Postpartum Care

A registered dietitian will be involved in providing food service and should be able to assist in assuring provision of nutritional needs in the hospital setting and to help in patient education and referral to community nutrition resources if necessary.

Attending nurses and physicians should be capable of providing support and assistance in the techniques of breast-feeding and in overcoming common obstacles that may arise. They should also be able to provide nutrition education for the patient.

Knowledge Base and Clinical Skills Required in Level I Unit

Much of the knowledge and many of the skills required at this level are necessary for the early identification, treatment, and referral of patients with major nutritional problems.

- Comprehensive maternal nutritional care with emphasis on the normal pregnant woman:
  - Knowledge of the nutrient requirements for normal pregnancy and the diet patterns (including ethnic variations) that will meet these needs.
  - Knowledge of the major physiological changes that accompany pregnancy and the effect of these changes on laboratory indices of nutritional status and clinical indices of health status.
  - Knowledge of the normal weight-gain patterns during pregnancy and the significance of deviations from this pattern, such as the influence on infant birthweight.
  - Knowledge of the impact of chronic disease on nutritional status of the pregnant women and fetus.

- Knowledge of the impact of alternative dietary practices such as vegetarianism, highly restricted diets, megavitamin ingestion, and pica on nutritional status and an understanding of the methods for correcting the associated nutritional problems.
- Ability to use the medical history and physical examination for identifying women at nutritional risk at the onset of and during the course of pregnancy (see Table 3).
- Ability to assess current dietary intake and suggest appropriate changes in accordance with the food habits and financial constraints of the client.
- Knowledge of the nutrient needs for lactation, techniques of breast-feeding, and common obstacles that may interfere with successful breast-feeding.

• Continuity of care in outpatient and community settings.

TABLE 3 Maternal Risk Factors

Risk factors at the onset of pregnancy

1. Adolescence: less than 3 years post menarche
2. Three or more pregnancies within 2 years
3. Past reproductive performance characterized by abortions, pregnancy complications, low-birth-weight infants, or perinatal loss
4. Economic deprivation
5. Unusual dietary practices
6. Heavy smoker (more than 20 cigarettes per day)
7. Excessive alcohol intake (chronic use of more than 5 oz whiskey per day or its equivalent from beer or wine), or history of binge drinking
8. Drug addiction
9. Chronic systemic diseases
10. Prepregnant weight below 85 percent standard height and weight (less than 60 in. in height and 100 lb in weight) or obesity above 120 percent of standard weight for height

Risk factors during pregnancy

1. Hemoglobin below 11 g/dl; or hematocrit below 33 percent
2. Inadequate weight gain (less than 1 kg/month)
3. Excessive weight gain (3 kg/month) possibly associated with fluid retention

Risk factors following pregnancy

1. Nutritional demands of lactation

- Ability to utilize and coordinate available community resources.
- Knowledge of federally funded food assistance programs for low-income women, eligibility requirements, and the process of application.

• Communication and teaching.
- Ability to provide organized nutrition and breast-feeding in-service for expectant parents and for the health care team in the hospital and the community.

• Continuing education.
- Continued acquisition of knowledge to remain abreast of scientific advances.
- Ability to incorporate new knowledge into a care plan.

LEVEL II

Those pregnancies presenting risk factors of a degree that cannot be managed at a Level I unit should be referred to a Level II or III unit. Level II units are capable of providing all those services for normal pregnancies that are available in Level I and, in addition, can provide for the majority of complicated obstetrical problems. Such cases usually may be managed on an outpatient basis. The health care team consists of physicians, nurses, and dietitians/ nutritionists. The team should have a procedure for identifying and referring to the dietitian/nutritionist those patients who need specialized nutritional consultation. In addition, they should have methods for monitoring on a continuous basis the result of specific interventions.

Nutrition Services in a Level II Unit

• Provide full range of services required for Level I.

• Evaluate and manage such conditions as marked weight deviations, pregnancies complicated by medical disease (diabetes mellitus, renal, cardiac or hypertensive disease), anemia not responsive to iron therapy, toxemia, inappropriate fetal growth for gestational disease.

• Consult and refer as required.

• Provide organized in-service education for the health care team within the hospital (physicians, nurses, etc.) in order to maintain competence in providing nutrition related health services.

Personnel Requirements in Level II Units

Prenatal Care--Outpatient and Inpatient

- Dietition/nutritionist: Must meet the requirements for membership and registration in the American Dietetic Association, have 6 months of clinical experience, and have graduate nutrition training (or intensive in-service training at the graduate level) in the nutritional care of high-risk pregnancies. A master's degree is highly desirable.
- Board-certified obstetricians and registered nurses trained and experienced in the management of high-risk pregnancies and related nutrition problems and capable of identifying those cases requiring the consultation of a qualified dietitian/nutritionist.

LEVEL III

Level III units are large urban or regional hospitals, associated with medical centers. Their functions include the care of normal and high-risk patients. They provide more comprehensive care for seriously ill patients than Level I and II centers and should provide consultative as well as referral services for these facilities.

In addition to patient care, Level III units are responsible for the preparatory and continuing education of professionals and for research in such areas as basic and clinical nutrition, nutritional needs during pregnancy and lactation, and management of nutrition-related problems during pregnancy.

Because certain complications of pregnancy may require comprehensive intensive care for the mother as well as the newborn immediately following birth, the Committee on Perinatal Health (1976) has recommended that such obstetric patients be transferred to Level III units prior to delivery. These conditions include severe preeclampsia and eclampsia, intrauterine growth retardation, labor at less than 34 weeks gestation, anticipated severe neonatal infection, anticipated need for major surgery and such conditions as unstable diabetes mellitus, serious cardiorespiratory or renal disease, malignancy, severe unresponding infection, and severe hemoglobinopathy.

Nutrition Services in Level III Units

• Provide full range of prenatal services for normal and complicated patients as described for Level I and II.

• Evaluate and manage for nutritional care of pregnant women with complex medical and surgical problems such as unstable diabetes mellitus, chronic renal disease, cardiac problems, chronic lung disease, and intestinal bypass. An available management option is total parenteral nutrition.

- Screen for nutrition problems.
- Monitor and assess nutritional status.
- Develop and implement management plans.
- Provide instructional resources for special dietary modifications.

• Develop and implement continuity of nutrition care plans; this includes coordination and referral to local agencies with food and nutrition resources.

• Provide counseling for dietary modifications and followup.

• Provide consultation services for Level I and II facilities.

• Provide in-service and outreach nutrition education for health professionals.

• Monitor and evaluate results of nutrition intervention.

Personnel Requirements in Level III Units

Personnel requirements are essentially the same as for Level II but require advanced clinical prenatal nutritional experience in the care of high-risk pregnant women.

Nurses participating in the Levels II and III setting will usually have more experience in the monitoring of high-risk pregnant women. Additional experience in nutrition counseling, management, and nutritional status is required of the dietitian/nutritionist.

Knowledge Base and Clinical Skills Required in Level II and III Units

• Comprehensive maternal nutritional care with emphasis on the high-risk pregnant woman.

- Knowledge of physiologic and metabolic changes associated with pregnancy and diagnostic implications for high-risk conditions.
- Knowledge of the effects of chronic disease on the course of pregnancy.
- Knowledge of the principles of diet therapy in terms of pregnancy and/or lactation complicated by chronic disease.

- Ability to provide nutrition counseling for patients needing diet modifications in accordance with nutrient requirements, the individual's food habits, and financial constraints.
- Ability to detect, monitor, and manage the nutritional problems associated with high-risk pregnancies.
- Ability to assess the effectiveness of nutrition interventions in high-risk pregnancy.
- Ability to function within the framework of a multidisciplinary care team recognizing that the service of many disciplines are essential for comprehensive care.

● Continuity of care in outpatient and community settings.
- Ability to assess the family's need for available community services and agencies that provide food and nutrition resources.
- Ability to provide prenatal and interconceptual continuity of nutritional care that utilizes available community services and agencies.

● Communication and teaching.
- Ability to communicate to other professionals and families the importance of nutrition in the promotion of health.
- Ability to obtain a nutrition history that includes information regarding past and present eating habits as well as the social setting associated with feeding.
- Ability to provide nutrition counseling that effectively deals with the nutritional needs of the patient and is within the capability of the mother or other primary caretaker at home.
- Ability to provide organized nutrition educational programs for the health care team in the hospital and in the community.

● Continuing education and evaluation of care.
- Continued acquisition of knowledge to remain abreast of scientific advances.
- Ability to incorporate the new knowledge into a nutritional care plan.
- Ability to prospectively evaluate safety and effectiveness of the implemental nutrition program.

RECOMMENDATION

In considering the implementation of nutrition services in maternity care it needs to be recognized that several areas of professional and public education must be expanded. These include expanded public education activities in regard to the optimal preparation for and health care during pregnancy and expanded professional education activities in regard to nutritional problems encountered during pregnancy. It is particularly important that the health professional who will be delivering the nutritional services be adequately prepared to do so. Furthermore, health professionals involved need to appreciate their role as a team member and how they should interact with other essential health care providers. Training opportunities for physicians, nurses, and dietitians/nutritionists will assist in preparing them to optimally provide these services in a mutually beneficial and cooperative manner that serves the best interests of the patients involved.

BIBLIOGRAPHY

American Dietetic Association. 1972. Position paper on nutrition services in health maintenance organizations. J. Am. Dietet. Assoc. 60:317.

Barness, F. E., ed. 1978. Ambulatory Maternal Health Care and Family Planning Services. Policy, Principles, Practices. American Public Health Association, Washington, D.C. 276 pp.

Bureau of Personal Health Services. n.d. Suggested Guidelines and Standards for Maternal and Perinatal Nutritional Care. Michigan Department of Public Health. 26 pp.

Committee on Obstetric Practice. 1977. Standards for Ambulatory Obstetric Care. The American College of Obstetricians and Gynecologists. 23 pp.

Committee on Perinatal Health. 1976. Toward Improving the Outcome of Pregnancy. The National Foundation-March of Dimes. 36 pp.

Russell, K. P., S. H. Gardiner, and E. E. Nichols. 1975. A conceptual model for regionalization and consolidation of obstetric-gynecologic services. Am. J. Obstet. Gynecol. 121:756.

Ryan, G. M. 1977. Regionalizing perinatal health services in Massachusetts. N. Engl. J. Med. 196:258.

Task Force on Nutrition. 1978. Assessment of Maternal Nutrition. The American College of Obstetricians and Gynecologists. 25 pp.

U.S. Department of Health, Education, and Welfare. 1978. Guide for Developing Nutrition Services in Community Health Programs. DHEW Publ. No. (HSA) 78-5103. 45 pp.

World Health Organization. 1978. Risk Approach for Maternal and Child Health Care. WHO Publ. No. 39. Geneva.

4 NUTRITIONAL REQUIREMENTS OF NEWBORN INFANTS

The purpose of this section is to present current knowledge concerning the nutritional requirements of infants in the neonatal period and how these requirements might be modified by specific abnormalities. The provision of optimal nutrition to well and sick neonates will be discussed with particular emphasis on methods for feeding the critically ill newborn. For the purpose of this discussion, the neonatal period is defined as the first 28 days of extrauterine life.

The consideration of necessary nutritional services will be done under two headings, the normal and abnormal neonate. For both groups, there will be a discussion of nutritional requirements, and feeding practices. In some areas, it will be evident that further knowledge is required. These research needs will be identified.

THE NORMAL NEONATE

Care for the normal neonate will be provided at Level I, II, and III units of perinatal care. The stay is generally brief after birth, rarely extending more than 3 or 4 days. There may be some variability, depending on the hospital custom as to the amount of time the infant and mother will spend together during the immediate postpartum period.

Nutritional Requirements and Feeding Methods

The two methods available for feeding the normal neonate are breast-feeding and formula-feeding by bottle. Any woman with the least inclination toward breast-feeding should be encouraged to do so, and assistance should be provided by nurses, physicians, nutritionists, and other health workers. Expectant mothers should be instructed in the advantages of breast-feeding and should be prepared for nursing during the prenatal period. The encouragement to nurse should not extend to coercion, and women should not be made to feel guilty because they elect not to breast-feed.

Among the advantages of breast-feeding are (1) immune and antiinfective factors are present in fresh human milk and are absent or deficient in all human milk substitutes; (2) absorption of trace minerals such as iron and zinc are enhanced in the breast-fed infant; (3) no supplemental feedings are needed for at least 4 months in the breast-fed infant; (4) the biological value of human breast milk protein is high; (5) mother-infant bonding is enhanced; (6) allergy to human breast milk is extremely rare; and (7) electrolyte content of human milk is low, decreasing the need for supplemental water (American Academy of Pediatrics, 1978). Other advantages attributed to breast-feeding, such as low incidence of infant obesity, are less well documented. Breast-fed infants may be supplemented with vitamin D, iron, and fluoride.

In the event that the mother does not wish to nurse or cannot nurse for emotional, social, physical, or economic reasons, she should be taught how to bottle-feed the infant.

Cow's milk is the basis for most formulas, but sometimes soy protein isolate is substituted in special situations.

For formula use, cow's milk is modified in infant formulas for several reasons.

1. Whole cow's milk contains protein and electrolytes in concentration that are too high for the young infant. Cow's milk must, therefore, be diluted with water.

2. The caloric content of the diluted milk is increased to the equivalent of cow's or human milk by the addition of carbohydrate. Lactose is already present in cow's milk, and the addition of lactose permits the use of a single sugar. Lactose may cause acidification of the intestinal contents, leading to fewer gram-negative organisms and better calcium absorption.

3. Substitution of saturated fat by vegetable fats increases fat absorption.

4. Heat processing decreases the likelihood of allergic response and increases absorption of the protein of cow's milk.

For these reasons, a commercially prepared formula modified in its major components is preferable to an evaporated or whole milk formula for the young infant. In addition, vitamins and iron are added to many formulas, eliminating the need for these nutrients as supplements to the diet. Some formulas are modified to make the protein quality more like that of human milk. Proof that such further modification is beneficial to the term infant has not been conclusively demonstrated.

An objection to commercial formulas is their expense. Powdered or concentrated formulas are somewhat more expensive than evaporated milk formulas made with added sugar and vitamins, but they may cost less than whole milk formulas in some geographical areas. Infants fed evaporated milk or whole milk formulas require iron supplementation. Some infants may not tolerate any form of cow's milk protein, and others may be intolerant of lactose. These infants should be fed soy-based formulas that contain sucrose as the carbohydrate.

THE ABNORMAL NEONATE

Infants of the following categories will be considered abnormal for the purposes of this discussion: an otherwise healthy infant who is small for gestational age, a premature infant, and a sick infant of any birthweight. Some infants with minor deviations from normal may be cared for at Level II centers. This discussion will focus on the services needed for those infants requiring Level III care in newborn intensive care units.

Nutritional Requirements

The ultimate goals of nutritional management for the abnormal neonate are restoration and continuing support of metabolic functions and provision of requirements for growth. The majority of nutritional problems involve the small and immature infant. The nutritional needs of the sick infant of any weight are complex and variable, dependent upon the severity and type of disease. This section, therefore, will emphasize primarily the nutritional requirements of the small infant.

In most small infants, particularly in the most immature ones and those with significant disease, growth is unlikely to resume for a period of days and sometimes weeks. During this period replacement of ongoing losses, and restoration and maintenance of homeostasis, are the primary goals of nutritional management (Brady *et al.*, 1978). Water, energy (in the form of glucose), Na, K, and Cl are most commonly administered during the first perinatal feedings and followed by increases in dietary quantity and quality as indicated by clinical progress. Although losses of other body constituents occur, there are no immediately threatening consequences from these losses. Nevertheless, it seems prudent to attempt to replace these losses, especially if enteral feedings cannot be established within a few days of birth.

Choice of Formula A formula for premature infants should provide all nutrients that are essential or beneficial for the infant in amounts not falling short of, nor exceeding appreciably, the requirements for these nutrients. However, nonnutritional considerations should also be taken into account in choosing a formula. For example, human milk provides some protection against certain infections that formulas do not provide. Psychosocial considerations related to provision of expressed human milk by women to their premature infants are also of importance, as are considerations of availability and microbiologic safety. In weighing these various aspects against each other, some neonatologists believe that certain nutritional shortcomings of human milk for the small premature infant are more than counterbalanced by the advantages of human's milk, both nutritional and nonnutritional. Other neonatologists feel that the nutritional disadvantages of human milk and problems in its procurement are serious and prefer, therefore, formulas specifically designed for small premature infants.

Areas of Disagreement Some aspects of nutritional management of premature infants are controversial (Barness, 1975). The following represents a listing of these areas of controversy:

1. *Rate of weight gain and chemical composition of gain.* One view is that every attempt should be made to provide sufficient nutrients for catch-up growth and then proceed along channels of growth the infant would have followed had the pregnancy continued until term. The opposing view holds that fetal growth cannot be duplicated and that rate and composition of gain are irrelevant so long as the infant remains free of overt disease. A third view holds that there is a risk of overfeeding and excessive growth.

2. *Requirements for certain amino acids.* Whether a dietary intake of cystine is required and at what level, if any, has not been established. This question relates

to the controversy regarding the use of unmodified cow's milk protein or mixtures of nonfat skim milk and demineralized whey in formulas.

An optimal intake of tyrosine has not been established. Whether taurine, which is present in human milk in considerable amounts and virtually absent from formulas, is essential, or is desirable for the premature is not known, but some workers believe that it may be beneficial for infants.

3. *Appropriate intakes of vitamins D and E are a matter of controversy.*

4. *The age at which iron should be provided and in what amounts is not settled.* Many believe that it should be given from 2 weeks on, or as soon as enteral feedings are established, in a dose of 2-3 mg/kg of bodyweight. Others believe that iron is so toxic that it should be withheld until 2 to 3 months of age (Barness, 1975).

Feeding Methods

There are two general approaches to the feeding of the small or sick newborn. The first involves feeding by mouth or other modifications of enteral feeding to provide nutrition through the gastrointestinal tract. In some infants, however, it is impossible to provide adequate nutrition enterally, and, therefore, it is necessary to feed the infant with partial or total parenteral nutrition. Each of the alternative enteral and parenteral methods have specific indications, contraindications, and complications. There are also special requirements for personnel skills and support facilities for proper use of these methods for feeding abnormal neonates. These needs will be described.

Alternative Methods of Enteral Feeding

The ability to coordinate sucking, swallowing, and breathing is not well developed until the infant is at least 34 weeks of gestational age and at times is delayed beyond that time. Prematurely born infants, as well as infants who are ill, especially those who have respiratory distress, abdominal distention, or infection, often lack the capabilities to take feedings by nipple. Therefore, alternate techniques have been developed to provide appropriate nutrition enterally.

Intermittent Gavage Feedings The most commonly used alternative method of providing nutrition is intermittent gavage feeding by which a catheter is passed either orally or nasally into the stomach. The position of the tube is checked by injecting a small bolus of air in order to determine if air is entering the stomach and not the esophagus or respiratory tract. Aspiration is usually performed to record the volume of the material in the stomach prior to each feeding. The formula is then introduced and allowed to flow into the stomach by use of gravity rather than forced injection.

In some nurseries, a nasogastric tube is inserted and left in place. Intermittent feedings are accomplished in a fashion similar to those of the intermittent orogastric gavage technique, except that the intermittent insertion and removal of the catheter does not take place. There are advantages and disadvantages to each of these methods. It is felt that the tube that is left in place has the advantage of avoiding respiratory embarrassment or apnea, which can occur any time an orogastric tube is passed. The disadvantages of a tube that is left in place are that the catheter may become stiff, may be an irritant, and may allow gastroesophageal reflux to occur readily.

The initial oral feeding of the immature infant usually consists of sterile water (Barness, 1975). If this is tolerated, then the formula or breast milk is given to the infant. The amount of feeding that the infant can initially tolerate is outlined in Table 4; however, this table is only a rough guide to the approach of feeding, and smaller or greater amounts may be used, depending upon the baby's maturity.

Continuous Nasogastric Feedings Continuous nasogastric feeds have also been infused. This technique allows the infant to have a continuous infusion without overdistending the stomach and is beneficial in those infants who seem to have a problem with gastric retention, gastroesophageal

TABLE 4 Initial Feeding of Low-Birthweight Infants

Birth wt (g)	Feeding (ml)
1,000 or less	4-6
1,001-1,499	6-8
1,500-1,999	8-15
2,000-2,500	15-20

SOURCE: M. Davidson, 1970.

reflux, or delayed gastric emptying. In very-low-birthweight babies, especially those less than 1,500 g, it may be necessary to increase the caloric concentration so that enteral fluid intake is maintained at a level that does not cause adverse gastrointestinal symptoms.

Several complications of this technique have been recognized, including contamination of the formula that has been left out in room air for longer than 2 h, aspiration that is not suspected, and irritation of the upper gastrointestinal tract.

Transpyloric Feeding In order to avoid the complications of the continuous nasogastric feeding, a technique called transpyloric feeding has been developed. A catheter is placed through the nose into the stomach and the infant is placed on its right side, thus allowing the tube to gradually enter the upper small intestine and come to rest either in the duodenum or jejunum. With this method, there is a constant infusion of milk, and a relatively high-volume intake can be given without causing gastric distention, reflux, or aspiration of the feeding. Techniques have also been developed wherein the end of the catheter is weighted with mercury, gold, or other appropriate material that facilitates the passage of the catheter into the small intestine. A small amount of air inserted when the catheter is being passed also tends to facilitate the passage of the tube.

The transpyloric technique of feeding has allowed physicians to use feedings continuously and increase the volume of fluid that the infant can tolerate more rapidly than is possible either with the intermittent or continuous nasogastric feedings. This is especially beneficial in very-low-birthweight infants and in those infants who have other complications, such as hyaline membrane disease or other respiratory or cardiac problems.

Complications that have been encountered include colonization of the upper gastrointestinal tract with pathogenic organisms, duodenal or jejunal perforation, jejunal-jejunal intussusception, necrotizing enterocolitis, and decreased efficiency of digestion. When the stomach is bypassed and food is placed directly in the small intestine, the normal events of digestion may be bypassed and suboptimal digestion may ensue. In addition, a dumping syndrome may also be produced. This is especially true if a hyperosmolar milk is used.

Gastrostomy Feedings Gastrostomy feeds, which were originally used in the care of infants who were receiving assisted ventilation, are used less frequently in intensive care nurseries. In fact, the use of transpyloric feedings have all but obviated the need for gastrostomies except in those neonates who require surgery of the gastrointestinal tract. The gastrostomy tube allows rapid decompression of the G.I. tract, especially when thick, tenacious mucous is present. After the infant begins to demonstrate appropriate gastrointestinal motility and capability to ingest feedings, the gastrostomy tube can be used as a mode of introducing enteral feeds, at least for the first several weeks following surgery. Some surgeons leave the tube in place for several weeks until the infant has demonstrated the capability to take feedings by mouth or until any reconstructive surgery has been completed.

Parenteral Nutrition

Total parenteral nutrition (TPN), i.e., provision of all nutrients solely by the parenteral route, became a reality approximately a decade ago with the demonstration that animals could be maintained solely with parenteral nutrients for up to a year (Dudrick *et al.*, 1968). Subsequently, apparently normal growth and development of an infant with little remaining small intestine was demonstrated (Wilmore and Dudrick, 1968). Today, TPN is used routinely in infants with intractable diarrhea as well as in patients with many surgically correctable lesions of the gastrointestinal tract (Heird and Winters, 1975). In addition there is some interest in the possibility of maintaining sick, prematurely born infants with or without overt gastrointestinal disease solely with parenteral nutrients.

Since the nutrient infusate required to provide full nutrient requirements is necessarily hypertonic, it must be infused into a large vessel with rapid flow. In general, this is accomplished by placing a catheter through either the internal or external jugular vein into the superior vena cava. The nutrient mixtures are then infused at a constant rate into this catheter. There is little doubt that infants who receive nutrients by this technique retain nitrogen and exhibit increases in both weight and length (Heird and Winters, 1975). Further, there is little doubt that the technique has been responsible for improving the survival of selected groups of infants. For example, the mortality of patients with gastroschisis, as well as patients with intractable diarrhea, was approximately 90 percent prior to the advent of TPN, whereas the mortality today is less than 10 percent.

This change in mortality has come about solely by prevention of starvation; no beneficial effect on the underlying disease process, per se, has been demonstrated other than indirectly through the improved nutritional status.

Despite its obvious nutritional efficacy, the technique of total parenteral nutrition has been associated with a number of complications. These generally can be classified as those resulting from the infusate (metabolic complications) and those resulting from the presence of the in-dwelling catheter.

Concern for both the metabolic and catheter-related complications resulted in waning of enthusiasm for the central vein technique of total parenteral nutrition, particularly for the prematurely born infant without intrinsic gastrointestinal disease. In these infants the incidence of metabolic complications appears to be greater. Further, it appears to be more difficult to prevent infection. Thus, the technique of "partial parenteral nutrition" with delivery of "partial" nutrient requirements by peripheral vein infusion is being used with increasing frequency. This technique differs very little from the usual intravenous therapy regimen for such infants; instead of infusing only 10 percent glucose, this solution is used with varying amounts of amino acids. At reasonable fluid intakes, this regimen provides only approximately half the caloric intake generally thought to be necessary for optimal growth. Larger volumes are sometimes administered (greater than 150 ml/kg of bodyweight per day) or an intravenous fat emulsion is added either to replace part of the glucose or in addition to the usual 10 percent glucose.

A regimen providing 2.5 g/kg of bodyweight per day of amino acids and 60 kcal/kg per day as glucose in comparison to 60 kcal/kg of bodyweight per day without amino acids has been shown to result in nitrogen retention and perhaps to reduce weight loss during the first week of life (Anderson *et al.*, 1979).

Indications for Parenteral Nutrition Parenteral nutrition is indicated for most patients who are unable to tolerate enteral feedings for a significant period of time. The definition of "significant period of time" varies from infant to infant. Little argument can be advanced for the use of parenteral nutrition in term infants of appropriate size who are unable to tolerate enteral feedings for a period of 2-3 days. However, even this short period without nutrient intake is likely to result in significant depletion of the limited endogenous stores of the small premature infant (Heird and Anderson, 1977).

In deciding upon the appropriate means of providing parenteral nutrition (i.e., peripheral vein or central vein TPN), consideration must be given to what can be achieved by each method. The typical patient with respiratory distress syndrome, for example, can usually be fed by the end of the first week of life. Because a parenteral nutrition regimen delivered by peripheral vein usually will maintain existing body composition with respect to protein and fat components for this period of time, central vein TPN is unnecessary. However, many infants (e.g., those with gastroschisis) are intolerant of enteral feedings for at least 2-3 weeks or longer. Such infants are ideal candidates for central vein TPN. In infants with necrotizing enterocolitis who usually are not fed for at least 10 days, the choice between peripheral and central vein TPN is more difficult. Factors that should be considered in the choice of regimen include: (1) the infant's size, (2) the age at which the disease develops, and (3) the clinical course prior to development of necrotizing enterocolitis. The larger infant who develops the disease within the first few days of life and in whom there is a reasonable possibility of maintaining peripheral vein infusion for up to 2 weeks might be assigned to a peripheral vein regimen. The smaller infant who develops the disease later in life after a clinical course necessitating continuous intravenous infusions is less likely to tolerate peripheral infusions for an additional 2 weeks and is also likely to be nutritionally depleted. In this situation, central vein TPN seems a more logical choice.

Use of Intravenous Fat Emulsions Once the decision to institute parenteral nutrition is made and the route of delivery is decided upon, a decision must be made concerning the use of intravenous fat emulsions. It is now well established that infants who receive fat-free TPN over an extended period of time may develop essential fatty acid deficiency (Anderson *et al.*, 1979; Friedman *et al.*, 1976). Moreover, the smaller infant in whom rate of growth is rapid seems to develop essential fatty acid deficiency very quickly, i.e., within a few days. The amount of fat emulsion necessary to prevent essential fatty acid deficiency (i.e., approximately 1 g/kg/day) is considerably less than the amount generally used (i.e., 3-4 g/kg/day).

While use of the larger amounts of fat apparently has not resulted in adverse effects, several theoretical possibilities must be considered. First, the rate of utilization of intravenous fat emulsions appears to be variable

(Gustafson *et al.*, 1972). Both clearing from the bloodstream (Forget *et al.*, 1975) and subsequent metabolism to glycerol and free fatty acids are decreased in newborn infants (Andrew *et al.*, 1976). In general, immature infants and small for gestational age infants utilize intravenous fat less well than normal-term infants (Shennan *et al.*, 1977).

Intravenous administration of large doses of lipid to both animals and adult human volunteers has been associated with decreased pulmonary diffusion capacity, presumably secondary to accumulation of small lipid droplets within the pulmonary capillaries (Greene *et al.*, 1976). Metabolism of intravenous fat emulsions results in increased plasma concentrations of free fatty acids, which compete with bilirubin and other substances for binding to albumin (Thiessen *et al.*, 1972). Thus, use of large doses of intravenous lipid is potentially hazardous for infants with pulmonary disease and/or hyperbilirubinemia.

In general, a dose of 1 g/kg per day is likely to be safe for almost all infants, provided it is administered as slowly as possible. Larger doses should be used with caution, particularly in patients with underlying pulmonary disease, infection, or hyperbilirubinemia (Heird and Winters, 1975).

Requirements for Successful Parenteral Nutrition Successful parenteral nutrition cannot be achieved by approaching the technique as an extension of routine fluid therapy. This is particularly true for central vein TPN and may be equally true for peripheral vein TPN. However, realization that the technique requires dedicated personnel as well as specialized facilities minimizes the complications in patients requiring this form of nutritional management. In most cases, this is best achieved through what has been termed the "team approach."

The key member of a parenteral nutrition "team" is a physician who assumes responsibility for all aspects of the technique. The individual filling this role should have sufficient time to supervise the day-to-day details of a parenteral nutrition program and also to educate both junior and senior staff concerning the intracacies of parenteral nutrition, as well as the potential advantages and disadvantages of the technique. Increasingly, larger institutions are establishing nutrition support teams with full-time directors. This practice should markedly improve the overall practice of parenteral nutrition as well as overall nutritional management of hospitalized patients.

An additional member of the parenteral nutrition team is a nurse assigned to work exclusively in the area of parenteral nutrition or with the nutrition support team. This individual's duties can be primarily educational, especially in institutions in which house patients requiring parenteral nutrition are in several units throughout the hospital. Alternatively, this individual can be responsible for all nursing aspects of the care of patients requiring parenteral nutrition. Such duties include the frequent dressing changes required with central vein TPN as well as assisting the responsible physician in other aspects of the program.

Another absolute requirement for successful parenteral nutrition is a flexible system for mixing the nutrient infusates. In many institutions these solutions are mixed routinely and stored until used. While obviously more economical, this practice cannot be recommended for pediatric patients. It provides no means of changing the infusate in response to biochemical monitoring; nor does it allow for provision of special requirements of individual patients. Further, the long-term stability of many of the components of the usual nutrient infusate is unknown. This requirement implies that a pharmacist or similar individual trained in aseptic mixing techniques be available and able to devote considerable time to preparation of the infusates; it also implies that special facilities needed for aseptic fluid preparation be available.

Additional requirements for successful parenteral nutrition during the perinatal period are multiple conveniently located laboratory facilities. In general, the chemical monitoring required for pediatric patients receiving parenteral nutrition mandates availability of microchemistry laboratory facilities. Although routine microbiological cultures of the nutrient infusate or routine blood cultures as suggested by some are unnecessary, the availability of a responsive microbiological laboratory is a necessity.

Contraindications to Parenteral Nutrition There are few, if any, absolute contraindications to use of parenteral nutrition in the perinatal period. However, since there are short-term complications of the technique and since the long-term effects have not been studied extensively, the technique should not be used indiscriminately. There seems to be little indication for using parenteral nutrition during the first 24 to 48 h of life unless the infant clearly has a condition that will preclude enteral feedings for a much longer period of time (e.g., the patient with gastroschisis). Also, insertion of a central vein catheter for only a few days of TPN should be avoided if at all possible.

Complications of Parenteral Nutrition Complications of parenteral nutrition generally can be classified as two types: those related to the technique of infusion (catheter-related complications) and those resulting from the infusate (metabolic complications). The catheter-related complications of central vein TPN, all related to presence of the in-dwelling catheter, include thrombosis, dislodgement of thrombi, and infection. This category of complications with peripheral vein TPN includes skin and subcutaneous sloughs due to infiltration of the hypertonic infusate. Infection with peripheral vein TPN is usually secondary to a contaminated infusate.

There are also two general types of metabolic complications: those related to the infant's metabolic capacity for the various components of the nutrient infusate and those related to the infusate per se. Since the infusates used for both peripheral and central vein delivery are qualitatively similar, the complications related to the infusate should be similar. Carbohydrate intolerance is the most frequently encountered metabolic complication in the newborn period. While most infants can easily tolerate glucose loads of 10-15 g/kg/day, some particularly immature infants are intolerant to doses as small as 5 g/kg/day. With both routes of delivery, electrolyte and mineral disorders usually are due either to provision of too much or too little or to increased urinary losses secondary to osmotic diuresis.

The group of metabolic complications related to the infusate, usually to the amino acid mixtures used (Table 5), are more troublesome. No amino acid mixture currently available results in a completely normal plasma amino acid pattern. Concern for this problem, which may be largely theoretical, is based on the long-established relationship between mental retardation and abnormal plasma amino acid concentrations in patients with various inborn errors of metabolism. Also of concern is the fact that no commercially available amino acid mixture contains sufficient amounts of the insoluble amino acids cystine and tyrosine to meet the infant's needs for these possibly essential amino acids.

Monitoring Requirements for Parenteral Nutrition Careful monitoring of the patient receiving parenteral nutrition

TABLE 5 Metabolic Complications of Total Parenteral Nutrition and Their Most Common Cause

Metabolic Disorder	Usual Cause
1. *Iatrogenic disorders*	
Hyperglycemia	Excessive intake (either excessive concentration or increased infusion rate)
	Change in metabolic state (e.g., sepsis, surgical stress)
Hypoglycemia	Sudden cessation of infusion
Azotemia	Excessive nitrogen intake
Electrolyte disorders	Excessive or inadequate intake
Mineral (major and trace) disorders	Excessive or inadequate intake
Vitamin disorders	Excessive or inadequate intake
Essential fatty acid deficiency	Failure to provide essential fatty acids
2. *Disorders due to suboptimal nitrogen source*	
Acid-base disorders (hyperchloremic metabolic acidosis)	Use of hydrochloride salts of cationic amino acids
Hyperammonemia	Inadequate arginine intake
Abnormal plasma aminograms	Amino acid pattern of nitrogen source
3. *Hepatic disorders*[a]	
Elevated transaminases	Unknown
Hyperbilirubinemia	

[a]Cholestasis, often with hyperbilirubinemia, is encountered frequently. The cause of this disorder is unknown but it seems to be reversible.

is necessary to detect complications and to document food intake and clinical results. Adequate clinical monitoring usually requires that the patient be housed in an intensive care or a semiintensive care unit. The nursing observation necessary to prevent infiltration of the parenteral infusate delivered by peripheral vein and to assure proper long-term function of the central vein catheter generally cannot be provided in the usual clinical setting. Adequate monitoring also requires personnel familiar with the intricacies of intravenous infusion apparatus, including the many varieties of constant infusion pumps.

While not an absolute necessity, special units for housing patients requiring parenteral nutrition are desirable. Existing intensive care units can be used, although the increased nursing care required for TPN is generally not as great as that required in intensive care units. However, the underlying clinical condition necessitating parenteral nutrition often mandates intensive care facilities. Alternatively, special "semiintensive care" units can be established.

Monitoring

While it is important to monitor all infants for adequacy of nutritional intake during the first 28 days, it is critical that the monitoring in small or sick neonates be done frequently and with close attention to detail. Sequential measurements needed for this monitoring in the Level III nurseries include the following:*

Food Intake An organized system for summarizing all important nutritional data is mandatory for efficient decision making. A flow sheet to provide the easily accessible information required for good surveillance should include the daily volume of intake of parenteral (intravenous) and/or enteral (oral or tube feedings) fluids. The total fluid intake should be presented in relationship to other data, such as the kind and concentration of formulas, route of feeding, the amount fed, any gastric residuals, emesis, stool frequency and description, and the vitamin and mineral supplementation. To facilitate review, the data are presented in relationship to weight to provide information regarding hydration and probable weight gain. Fluid limitations necessitated by such diseases as heart failure or limited gastric capacity need especially close monitoring of the total fluid and energy intake.

The less complicated and medically stable neonate who can take adequate oral volume for size and is gaining at an acceptable rate does not need further monitoring of energy intake. Likewise, close calculation of the intake

---

*Also see Table 6.

TABLE 6 Variables to be Monitored During Intravenous Alimentation with Suggested Frequency of Monitoring

	Suggested Frequency[a]	
Variables to be Monitored	Initial Period	Later Period
A. *Growth variables*		
Weight	Daily	Daily
Length	Weekly	Weekly
Head circumference	Weekly	Weekly
B. *Metabolic variables*		
1. Blood measurements		
Plasma electrolytes	3-4 X Weekly	Weekly
Blood urea nitrogen	3-4 X Weekly	Weekly
Plasma Ca, Mg, P	2 X Weekly	Weekly
Acid-base status	3-4 X Weekly	Weekly
Serum protein (PEP or albumin)	Weekly	Weekly
Liver function studies	Weekly	Weekly
Hemoglobin	2 X Weekly	2 X Weekly
2. Urine Glucose	4-6 X Daily	2 X Daily
C. *Prevention and detection of infection*		
1. Clinical observations (activity, temperature, etc.)	Daily	Daily
2. WBC count and differential	As indicated	As indicated
3. Cultures	As indicated	As indicated

[a]Initial period refers to that period in which a full glucose intake is being achieved; the later period implies that the patient has achieved a metabolic steady state. In the presence of metabolic instability, the more intensive monitoring outlined under initial period should be followed.

of other nutrients is unnecessary, because they can be predicted from a knowledge of the composition of feedings and the vitamin and mineral supplementation.

Anthropometric Changes It is important to classify the newly born infant by both weight and gestational age in order to predict more reliably its nutritional needs. An infant of adequate birthweight (ABW) weighs 2,500 g or greater, and an infant of low birthweight (LBW) weighs less than that amount. By estimates of gestational age and the use of fetal growth standards, the LBW infant can be further characterized as preterm infants (PTI) or small for gestational-age infants (SGA).

These divisions are necessary, because the postnatal growth patterns of the three groups are different.

Normal-term and SGA infants lose about 4 percent of their body weight after birth, with the maximum loss at 2-3 days. However, PTI may lose as much as 14 percent of their body weight after birth, mostly related to water loss, with a maximum loss at 9 days (Martell, 1979).

The majority of PTI, if otherwise normal and receiving good care, will exhibit catch-up growth and attain similar size to PTI by 3 years of age (Cruise, 1973). Hence, they have a very rapid growth velocity after birth. SGA infants can be divided into at least two groups; those who do catch up and those who do not. Growth catch-up seemingly ceases around 18 months of age. This characteristic can be determined clinically as some SGA will spurt ahead and others will not, given good care and adequate feeding (Brandt, 1978; Falkner, 1978).

Nude weight at a specific time of day related to feeding schedule is recorded daily in the newborn nursery using regularly calibrated infant scales. Weekly weighing is necessary after discharge from the nursery for an additional 28 days. In PTI, the weight attained for age is recorded. For LBW infants, velocity growth in weight is recorded. Thus, gains or losses in weight (increments or decrements over time) are indicators of nutritional status that need monitoring, especially in LBW infants (Falkner, 1973).

Length must be measured accurately by trained personnel. The method requires two people and a measuring board or table adapted for this purpose (Falkner, 1961). Accuracy is particularly needed to determine increase in length. Length is measured at birth and subsequently weekly while the LBW infant is in the nursery.

Head circumference must be measured accurately using a narrowback steel or waterproof tape. Measurements are recorded in relation to age for ABW infants. Measurement should be taken every 3 days for all LBW infants and in other infants if skull growth is suspected to be abnormal (Falkner *et al.*, 1962). Head circumference measures in

LBW infants demonstrate an interesting growth pattern. At birth, the LBW infant's head circumference is very small, but by 3 months of age head circumference size is similar to that of ABW infants. The phenomenon is clearly explained by comparing the 3-monthly *increments* with those of the ABW infant. Whereas after 3 months of age the two curves are very similar, there is markedly more rapid head circumference growth among the LBW infant in the first 3 months to achieve this catch-up. The value of inspecting true incremental data is borne out by such considerations. The number of suspected cases of developing hydrocephalus reported by anxious and conscientious neonatal care personnel is much reduced with this knowledge.

If charts are used for ABW infants, the most appropriate are those derived from the NCHS standards (1977) for weight, length, and head circumference. For LBW infants, a word of caution: There are several errors incorporated in widely used fetal growth standards. These errors are mainly due to the incorporation of data from many infants who died as neonates and evidence that vaginal bleeding in early pregnancy has been taken for the last menstrual period, thus upsetting the gestational age estimation. Naeye and Dixon (1978) have recently published a full description of this problem together with new standards and charts for weight, length, and head circumference.

Clinical Observation The need for experienced and skilled nursing personnel in the newborn nursery is vital. Weight gain, for example, if plotted on appropriate charts may indicate achievement or lack of expected weight gain. The composition of this gain (or loss) is important, since fluid retention or dehydration may be involved. Hence the need for experienced clinical observation in addition to recording of weight patterns.

There are often very subtle changes in the clinical appearance of a neonate that, in fact, may be indicative of such a serious and potentially fatal complication as meningitis and sepsis. Experience and expertise in observation by the nursing personnel is needed.

Personnel Needs The personnel needed for provision of nutritional services will vary between the Level II and III centers. Currently available personnel in the intermediate and intensive care nurseries, respectively, include neonatologists, general pediatricians, pediatric nurses with experience in intensive care nurseries, and in some centers a dietitian or nutritionist. The management of nutritional problems in the intermediate and especially intensive care nurseries is so complex and special to these units that additional training in nutrition is needed for the physicians and nurses involved in providing perinatal care. Additional training for dietitians and nutritionists in the special medical problems found in critically ill neonates will facilitate the provision of more adequate nutritional support services. Dietitians/nutritionists with master's degrees and clinical experience in pediatric nutrition will have necessary background to utilize more readily the additional newborn training, and become an integral part of the care teams in nurseries.

Perinatal pediatric nutrition fellowships of several months duration can provide specialized learning experience to enable the dietitian or nutritionist to understand the scope and complexities of perinatal care so that they can provide the quality nutrition services to meet the specialized needs of the high-risk newborn infant. Intensive short courses in nutrition of several days duration could increase the awareness of neonatologists and nurses to the need for careful nutritional surveillance and intervention and also define the role of the dietitian and nutritionist in the neonatal unit.

REFERENCES

American Academy of Pediatrics. 1978. Breast-feeding. Pediatrics 62:591-601.

Anderson, T. L., C. R. Muttart, M. A. Bieber, J. F. Nicholson, and W. C. Heird. 1979. A controlled trial of glucose versus glucose and amino acids in premature infants. J. Pediatr. 94:947-951.

Andrew, G., G. Chan, and D. A. Schiff. 1976. Lipid metabolism in the neonate. I. The effects of intralipid infusion on plasma triglyceride and free-fatty acid concentration in the neonate. J. Pediatr. 88:273-278.

Barness, L. A. 1975. Nutrition for the low birth weight infant. Clin. Perinatol. 2:345-352.

Brady, M. S., E. L. Gresham, and K. Rickard. 1978. Nutritional care of the low birth weight infant requiring intensive care. Perinatal Press 2:125-131.

Brandt, I. 1978. Growth dynamics of low birth weight infants with emphasis on the perinatal period. Pages 564-574 *in* F. Falkner and J. M. Tanner, eds. Human Growth, vol. II. Plenum, New York.

Calloway, D. H., and H. Spector. 1954. Nitrogen balance as related to caloric and protein intake in active young men. Am. J. Clin. Nutr. 2:405-412.

Committee on Nutrition, American Academy of Pediatrics. 1977. Nutritional needs of low birth weight infants. Pediatrics 60:519-530.

Committee on Perinatal Health. 1976. Toward Improving the Outcome of Pregnancy. The National Foundation-March of Dimes. White Plains, N.Y. 33 pp.

Cruise, M. O. 1973. A longitudinal study of low birth weight infants. Pediatrics 51:620-628.

Davidson, M. 1970. Formula feeding of normal term and low birth weight infants. Pediatr. Clin. N. Am. 17: 913-928.

Dudrick, S. J., D. W. Wilmore, H. M. Vars, and J. E. Rhoades. 1968. Long term parenteral nutrition with growth, development, and positive nitrogen balance. Surgery 64:134-142.

Falkner, F. 1961. Office measurement of physical growth. Pediatr. Clin. N. Am. 8:13-18.

Falkner, F., A. J. Steigman, and M. O. Cruise. 1962. The physical development of the premature infant. I. Some standards; with certain relationships to caloric intake. J. Pediatr. 60:898-899.

Falkner, F. 1973. Long-term developmental studies: A critique. *In* Early Development. Research Publication of the Association for Research in Nervous and Mental Disease 51:416-418.

Falkner, F. 1978. Implications for growth in human twins. Pages 400-402 *in* F. Falkner and J. M. Tanner, eds. Human Growth, vol. I. Plenum, New York.

Forget, P. P., J. Fernandes, and P. H. Begemann. 1975. Utilization of fat emulsion during total parenteral nutrition in children. Acta Pediatr. Scand. 64:377-384.

Friedman, Z., A. Danon, M. T. Stahlman, and J. A. Oates. 1976. Rapid onset of induced hyperlipemia and pulmonary function. Pediatrics 58:640-648.

Greene, H. C., D. Hazlett, and R. Demarec. 1976. Relationship between intralipid-induced hyperlipemia and pulmonary function. Am. J. Clin. Nutr. 29:127-135.

Gustafson, A., I. Kjellmer, R. Olegard, and L. Victorin. 1972. Nutrition in low birth weight infants. II. Repeated intravenous injections of fat emulsion. Acta. Pediatr. Scand. 61:149-158.

Heird, W. C., and T. L. Anderson. 1977. Nutritional requirements of low birth weight infants and methods for their delivery. Pages 3-40 *in* L. Gluck, ed. Current Problems in Pediatrics. Year Book Medical Publishers, Chicago.

Heird, W. C., and R. W. Winters. 1975. Total parenteral nutrition: The state of the art. J. Pediatr. 86:2-16.
Martell, M. 1979. Centro Latinoamericano de Perinatologia y Desarrollo Humano, Montevideo (personal communication).
Munro, H. N. 1964. General aspects of the regulation of protein metabolism by diet and by hormones. Pages 381-481 *in* H. N. Munro and J. B. Allison, eds. Mammalian Protein Metabolism. Academic Press, New York.
Naeye, R. L., and J. B. Dixon. 1978. Distortions in fetal growth standards. Pediatr. Res. 12:987-991.
National Center for Health Statistics. November 1977. Growth Curves for Children, Birth-18 Years. Vital and Health Statistics, DHEW Publ. No. (PHS) 78-1650, Ser. II, No. 165.
Nutrition Committee, Canadian Pediatric Society and Committee on Nutrition, American Academy of Pediatrics. 1978. Breast-feeding. Pediatrics 62:591-601.
Peden, V. H., C. L. Witzleben, and M. A. Skelton. 1971. Total parenteral nutrition (Letter to the Editor). J. Pediatr. 78:180-181.
Roche, A. In preparation. Velocity growth in monthly increments for weight, length, height, birth to 3 years, 2-18 years, and head circumference six monthly increments birth to 3 years. Fels Research Institutes.
Schreiner, R. L., M. R. Glick, C. D. Nordschow, and E. L. Gresham. 1979. An evaluation of methods to monitor infants receiving intravenous lipids. J. Pediatr. 94: 197-200.
Shennan, A. T., M. H. Bryan, and A. Angel. 1977. The effects of gestational age on intralipid tolerance in newborn infants. J. Pediatr. 91:134-137.
Thiessen, H., J. Jacobsen, and R. Brodersen. 1972. Displacement of albuminbound bilirubin by fatty acids. Acta Pediatr. Scand. 61:285-288.
Wilmore, D. M., and J. S. Dudrick. 1968. Growth and development of an infant receiving all nutrients by vein. J. Am. Med. Assoc. 203:860-864.
Winters, R. W., W. C. Heird, R. B. Dell, and J. F. Nicholson. 1977. Plasma amino acids in infants receiving parenteral nutrition. *In* H. L. Greene, M. A. Holliday, and H. N. Munro, eds. Clinical Nutrition Update: Amino Acids. American Medical Association, Chicago.

5 IMPLEMENTATION OF NUTRITION SERVICES IN NEONATAL CARE

Nutritional care of the healthy neonate rarely poses any significant problems and consists primarily of assisting the mother in the care of her child. Nutritional management and procedures for feeding the high-risk or abnormal neonate, however, vary considerably in complexity and often require highly specialized personnel and facilities. The nutritional care necessary to prevent deterioration of the very sick neonate requires knowledge of specific nutritional needs and a capability to provide alternative methods of feeding that are suitable for the specific conditions of stress encountered in individual patients.

The implementation of perinatal nutrition services may be approached conceptually by first recognizing the need for administrative support, then by formulating a working or functional system, and finally implemented by obtaining the services of adequately trained personnel. Cooperative efforts by the Department of Nutrition and Dietetics and the Neonatal-Perinatal Division of the Department of Pediatrics can help document this need at the administrative level. The development of a feeding protocol and a system for summarizing pertinent nutritional data (flow sheets) is essential for efficient decision making in the intermediate and intensive neonatal care units.

Nutrition in-service education for all members of the health care team, including new or temporary staff (e.g., nurses, physicians, house officers, students), assures the most effective use of the nutritional data and provides a supportive coalition for the implementation of nutrition services.

The implementation of perinatal nutrition services first requires a recognition by hospital administration that there is an important need for such services so that subsequent employment of appropriately trained staff can take place. An important characteristic of these staff members is that they can work within a multidisciplinary team and enjoy sharing their knowledge through educational services to all those involved in perinatal care.

LEVEL I

Level I units provide uncomplicated neonatal care for infants of appropriate gestational age who are products of a normal-term pregnancy (Committee on Perinatal Health, 1976). Level I units should be capable of managing unexpected complications that arise suddenly after birth and are of such severity that immediate transfer to Levels II or III is not possible. This care usually consists of stabilization of the infant until he/she can be transferred safely. Babies may be returned from Level II or III units for continuing care after their acute problems have been resolved.

The physician and nurse constitute the health team at this level. Registered dietitians/nutritionists should be available for consultation and for providing in-service and outreach training.

Nutrition Services in Level I Units

- Provide structured programs to support breast-feeding efforts in the hospital and following discharge.
- Evaluate and manage the nutritional care of the normal infant.
    - Screen for nutrition problems.
    - Monitor and assess nutritional progress.
    - Provide routine feeding instructions for the primary caretaker.
    - Adjust for minor food and nutrition related problems (e.g., over- or undernutrition, anemia).
    - Identify referral and consultative resources for more complex nutritional enigmas.
- Provide for continuity of nutrition care; this includes referral to local agencies with food and nutrition resources when necessary.
- Provide organized in-service nutrition education (normal nutrition throughout the first years of life) for the health care team.

Personnel Requirements for Level I Units

Nutrition consultants and the health care team should have experience in providing for the nutritional needs of lactating mothers and in the feeding of newborn babies. They should be aware of federally funded food assistance programs, eligibility requirements, and the process of application.

Attending nurses should be capable of providing emotional support and technical assistance in the art of breast-feeding and understand the solutions to common problems that obstruct successful breast-feeding. The nurse and physician are the ones primarily responsible for educating the mother in the subsequent care of her child.

Knowledge Base and Clinical Skills Required in Level I Units

- Comprehensive pediatric nutritional care, with emphasis on the normal infant.
  - Knowledge of the nutrient requirements of normal infants at each stage of development, including the behavioral expectations and psychosocial implications for the family unit.
  - Knowledge of the nutrient composition of infant formulas and human milk.
  - Ability to evaluate and manage the nutritional care of normal infants.
  - Ability to recognize abnormal growth and developmental patterns in order to adjust the feeding program appropriately or make referrals if needed.
  - Knowledge of the nutrient requirements of the lactating mother.
- Continuity of care in outpatient and community setting.
  - Ability to utilize and coordinate available community services and agencies that provide food and nutrition resources.
- Communication and teaching.
  - Ability to obtain a current feeding history and provide normal infant nutrition counseling, including information regarding the hygienic care of nursing bottles and formula preparation.
- Continuing education.
  - Continued acquisition of knowledge to remain abreast of scientific advances.
  - Ability to incorporate new knowledge into a care plan.

LEVEL II

Level II units provide care for normal neonates and for mildly to moderately ill infants with such conditions as respiratory distress syndrome, unstabilized respiratory function, hyperbilirubinemia, hypoglycemia, and infections that require special care. The care team who defines the nutrition care plan includes the physician, nurse and dietitian/nutritionist, and other allied health personnel. One experienced nurse should have the designated responsibility of teaching mothers how to care for their infants upon discharge from the hospital.

Because Level II units will vary widely in capabilities, the personnel requirements are discussed along with those for Level III.

Nutrition Services in Level II Units

- Provide all services available in Level I units.
- Evaluate and manage nutrition care of mildly to moderately ill infants in the newborn intensive care unit as well as some high-risk infants requiring followup throughout the first year of life.
- Develop and implement continuity of nutrition care plans to be utilized after discharge from the intensive care nursery; this includes coordination and referral to local agencies with food and nutrition resources.
- Provide nutrition counseling for the mother or other primary caretakers.
- Provide a structured program to support breast-feeding of the sick infant as an available option.
- Provide organized in-service education for the health care team within the hospital setting (physicians, nurses, etc.)

LEVEL III

Level III units will provide care for normal infants and for all types of maternal-fetal and neonatal illnesses and abnormalities. These units will provide a full range of resources and expertise necessary for the management of major newborn complications. A Neonatal Intensive Care Unit will be staffed and equipped to treat critically ill infants, including those requiring intravenous therapy and total parenteral alimentation (hyperalimentation). Certain high-risk conditions of neonates are listed in Table 7.

Most Level III units will be engaged in teaching and training of medical students, interns, residents, nurses, and dietitians/nutritionists. They will also conduct research related to neonatal physiology, pathology, and nutrition.

TABLE 7 Complex Medical and Surgical Conditions That Complicate Nutrition Management of the Neonate

Prematurity (less than 37 weeks gestational age)
Low birth weight (less than 2,500 g)
Respiratory distress or apnea
Congenital anomalies of the gastrointestinal, renal, hepatic, cardiovascular, and central nervous systems
Maternal diabetes
Inborn errors of metabolism
Sepsis, peritonitis, meningitis
Maternal eclampsia or preeclampsia
Maternal systemic disease or infection
Excessive or intractable diarrhea or vomiting
Necrotizing enterocolitis
Seizure disorders
Perinatal hypoxia

The primary nutrition care team is comprised of the neonatologist, nurse, and registered dietitian/nutritionist.

Nutrition Services in Level III Units

- Provide full range of services for normal and complicated neonatal care; provide consultation services for Level I and II facilities.
- Evaluate and manage nutritional care of infants with complex medical and surgical problems in the newborn intensive care unit as well as certain high-risk infants requiring followup throughout the first year of life.
    - Screen for nutritional problems.
    - Monitor and assess nutritional progress.
    - Develop and implement management plans.
    - Provide instructional resources for breast-feeding of the sick infant.
- Develop and implement continuity of nutrition care plans after discharge from the intensive care nursery; this includes coordination and referral to local agencies with food and nutrition resources.
- Provide nutrition counseling for mother or other primary caretaker.
- Provide organized in-service education for the health care team within the hospital (physicians, nurses, etc.)
- Provide outreach education for community resources.
- Prospectively evaluate safety and effectiveness of implemented nutrition programs.

Personnel Requirements for Level III Units

The personnel necessary for provision of nutritional management will differ depending upon the intensity of care required. Currently available personnel in intermediate and intensive care nurseries include neonatologists, pediatricians, pediatric nurses, and, in some centers, a registered dietitian/nutritionist. Because the management of nutritional problems in intensive care and many intermediate care nurseries is often so complex and unique, additional training in nutrition for physicians and nurses will facilitate the provision of more adequate nutritional care. Registered dietitians/nutritionists with graduate nutrition education, which includes advanced courses in pediatric nutrition, physiology, biochemistry, and statistics, with advanced clinical pediatric training, or with clinical experience in pediatric nutrition should be an integral part of the care team in all Level III nurseries and in those Level II facilities where the patient population so dictates.

Collaboration between the physician and dietitian/nutritionist is essential for the development of a useful feeding protocol. The physician provides insight regarding medical constraints and individual patient variation, while the dietitian provides further understanding of the physiological and biochemical bases for nutrient requirements and nutrient composition of feedings. A dietitian, who has the nutritional management of the critically ill newborn infant as primary responsibility, will coordinate and assure provision of adequate nutritional care while the infant is in the hospital and facilitate the continuity of nutritional care following discharge. The dietitian/nutritionist also will serve as a resource for continuing nutrition education for professional staff and students both within the hospital and the community. An important responsibility shared by the dietitian is a prospective evaluation of the effectiveness of such programs for the provision of nutritional care.

Another essential teammate and collaborator is the nurse, who generally assumes the role of primary caretaker. Because of this responsibility, the nurse usually will develop the greatest skill for utilizing the variety of feeding techniques that are available and will interpret the infant's progress for the parents.

For those Level II facilities serving as regional referral centers and for all Level III centers, the neonatologist is responsible for the supervision and delivery of primary neonatal care.

Pediatrician: Must be board-eligible and preferably certified by the American Board of Pediatrics. In most Level II centers, they will be the primary physician for infants with a broad spectrum of illness not referred to Level III services. For patients with less serious neonatal illness, they may serve as a consultant to the family physician who is providing primary care. The pediatrician must be familiar with the nutritional limitations imposed by prematurity, as well as the methods for dealing with commonly encountered nutrition problems of moderately sick infants.

Neonatologist: Must be board-eligible in pediatrics, but also subboard qualified (or certified) in the speciality of neonatal-perinatal medicine. This requires the completion of 2 or 3 years of pediatric residency training in an institution approved by the American Board of Pediatrics. An additional 2 years of training in neonatology is required in a program that meets the specific requirements of the Pediatric Sub-Board of Neonatal-Perinatal Medicine. During this time the trainee must be instructed in normal and abnormal aspects of fetal and neonatal growth, development, and nutrition. This encompasses maternal, fetal, and neonatal nutrition and the associated physiologic, pathophysiologic, biochemical, pharmacologic, and adaptive processes.

The neonatologist is expected to have participated in an active research as well as clinical program so that he/she has an understanding of experimental design and methods of statistical evaluation of data. Furthermore, he/she must have experience with both short- and long-term implications and sequelae of caretaking practices and how they might ultimately contribute to the child's subsequent interactions with society.

Nurse: Must meet the qualifications necessary to function successfully in a newborn special care unit and must obtain additional in-service nutrition training, including a description of feeding techniques, the system for nutrition data collection, and methods for monitoring nutrition progress, and an explanation of feeding protocols, formula selection, and vitamin and mineral supplementation. Attendance at short courses in nutrition (2 or 3 days duration) can increase the awareness of nurses to the need for careful nutritional surveillance and intervention and support the role of the dietitian/nutritionist in the neonatal unit.

Dietitian/Nutritionist: Must meet the requirements for membership and registration in the American Dietetic Association and have at least 6 months of hospital clinical experience; graduate nutrition education that includes advanced courses in pediatric nutrition, physiology, biochemistry, and statistics; and advanced clinical pediatric training or clinical experience in the nutritional care of critically ill newborns, women, and infants with complex medical and surgical problems. A master's degree is highly desirable.

Perinatal-pediatric nutrition fellowships provide the highly specialized learning opportunities that enable the dietitian/nutritionist to understand the scope and complexities of perinatal care. This background is necessary so that the individual can provide the quality nutritional services required to meet the needs of high-risk obstetric patients, sick newborn infants requiring intermediate or intensive care, and those children who may remain in nutritional jeopardy during the early years of life. In most instances this experience cannot be obtained in a few weeks but generally requires at least 4 to 6 months of training. Subsequent refresher courses of 2 to 3 days duration update knowledge of perinatal-neonatal nutrition and afford a source of continuing education for the experienced dietitian.

Knowledge Base and Clinical Skills Required in Level II and III Units

- Comprehensive perinatal-pediatric nutritional care with emphasis on the care of the high-risk infant.
  - Knowledge of the physiological and biochemical bases of the nutrient requirements of preterm and term infants, the feeding limitations at each stage of development, and the psychosocial implications for the family unit.
  - Ability to recognize abnormal growth and developmental patterns.
  - Knowledge of the complex medical and surgical problems commonly managed in Level II-III intensive care nurseries, including the nutritional therapy and feeding limitations imposed by these conditions.
  - Knowledge of alternative feeding techniques and the nutrient composition of specialized feedings such

as parenteral nutrition solutions for premature and seriously ill infants.*

- Ability to evaluate and manage the nutritional care of seriously ill infants (see Table 7) utilizing appropriate screening, monitoring, and assessment methods for determining nutritional progress.
- Ability to plan and execute appropriate nutritional care plans considering the limitations inherent in different medical and surgical conditions, feeding techniques, and nutrient composition of feedings.
- Ability to function within the framework of a multidisciplinary care team recognizing that the services of many disciplines are essential for comprehensive care.

● Continuity of care in outpatient and community settings.

- Ability to assess the family's capacity for continuing a nutritional care plan after the infant's discharge.
- Ability to develop and implement continuity of nutrition care plans after discharge from the intensive care nursery, utilizing available community services and agencies that provide food and nutrition resources.

● Communication and teaching.

- Ability to communicate to other professionals and parents the importance of nutrition in the promotion of health.
- Ability to obtain a nutrition history that includes information regarding past and present eating habits as well as the social setting associated with feeding.
- Ability to provide nutrition counseling that effectively deals with the nutritional needs of the patient and is within the capability of the mother or other primary caretaker at home.
- Ability to provide organized nutrition educational programs for the health care team in the hospital and in the community.

● Continuing education and evaluation of care.

- Continued acquisition of knowledge to remain abreast of scientific advances.
- Ability to incorporate new knowledge into a nutritional care plan.

---

*At Level II the knowledge base and the clinical skills are generally similar, although the severity of the illness may be less. The dietitian in the Level II facility does not need to be as familiar with parenteral solutions and certain complex surgical and medical problems.

- Ability to prospectively evaluate safety and effectiveness of implemental nutrition program.

Recommendation

A strong nutrition component is essential in providing high-quality neonatal health care, particularly for the critically ill infant. Special attention should be given to providing appropriate undergraduate training in neonatal nutrition within schools of medicine and nursing as well as ongoing provisions for in-service and postgraduate education for professionals. A qualified dietitian/nutritionist should be an integral part of the health care team in Level III nurseries and in those Level II facilities where the patient population so dictates. Coordination of the functions of the physician, nurse, and dietitian/nutritionist in all institutions providing care to sick neonates is required for the best provision and monitoring of specialized nutritional services and for a program of continuing nutrition education.

REFERENCES AND BIBLIOGRAPHY

Brady, M. S., E. L. Gresham, and K. Rickard. 1978. Nutritional care of the low birth weight infant requiring intensive care. Perinatal Press 2:125-131.

Committee on Nutrition, American Academy of Pediatrics. 1980. On the feeding of supplemental foods to infants. Pediatrics 65:1178-1181.

Committee on Perinatal Health. 1976. Toward Improving the Outcome of Pregnancy. The National Foundation-March of Dimes. 38 pp.

Evans, G. M., R. L. Schreiner, and R. Bruks. 1977. The development of a newborn intensive care flow sheet: A team approach. Med. Rec. News 48:82-87.

Fomon, S. J., E. E. Ziegler, and H. D. Vazquez. 1977. Human milk and the small premature infant. Am. J. Dis. Child. 131:463-467.

Fomon, S. J., L. J. Filer, Jr., T. A. Anderson, and E. E. Ziegler. 1979. Recommendations for feeding normal infants. Pediatrics 63:52-59.

Rickard, K., and E. Gresham. 1975. Nutritional considerations for the new born requiring intensive care. J. Am. Dietet. Assoc. 66:592-600.

Rickard, K., M. S. Brady, and E. Gresham. 1980. Feeding the low birth weight infant. II. Role of the dietitian.

Continuing Education Services. The American Dietetic Association, Chicago.

Ziegler, E. E., R. L. Biga, and S. J. Fomon. In press. Nutritional requirements of the premature infant. *In* R. M. Suskink, ed. Symposium on Pediatric Nutrition. Raven Press, New York.

Ziegler, E. E., A. M. O'Donnell, S. E. Nelson, and S. J. Fomon. 1976. Body composition of the reference fetus. Growth 40:329-341.

Ziegler, E. E., and J. E. Ryu. 1976. Renal solute load and diet in growing premature infants. J. Pediatr. 89:609-611.

6 RESEARCH NEEDS

MATERNAL

Normal Pregnancy

- Definition of the relationships between energy intake, energy expenditure, and gain in weight during gestation.
- Determination of protein retention, and therefore dietary needs, during pregnancy, in particular the apparent discrepancy between theoretical calculations and experimental (nitrogen balance) studies.
- Further delineation of the relationship of maternal iron status to maternal health and infant outcome.
- Determination of the effects of varying intakes of vitamin B_6, folacin, zinc, selenium, and other limited supplements on pregnancy outcome.
- Identification of the effects of differing calcium and vitamin D intakes during gestation on maternal and infant calcium stores.
- Development of accurate and efficient means of assessing nutritional status and providing dietary counseling by health care providers who are not professional nutriionists.

Lactation

- Identification of the effects of lactation on maternal nutritional status.
- Definition of the relationships between maternal nutritional status and quantitative aspects of milk production.
- Identification of normal patterns of maternal weight changes, as a reflection of energy balance, during lactation.
- Determination of the effect of maternal energy

restriction on milk quality with particular respect to lipid profiles and content of ketone bodies.

- Determination of the relationship between maternal protein intake and milk amino acid patterns.
- Correlation of milk composition with weight gain during the preceding pregnancy.
- Determination of mammary transfer of environmental contaminants.
- Determination of the effect of differing maternal intakes of water-soluble vitamins, sodium, and trace elements on corresponding levels in milk and in the breast-fed infant.

High-Risk Pregnancy

- Estimation of optimal weight gain and pattern of weight gain in women entering pregnancy under- and overweight.
- Determination of the effects of maternal total parenteral nutrition on fetal metabolism and development.
- Identification of the effects of various sodium and potassium intakes on nutritional status of women with chronic hypertension.
- Definition of the relationship of diet, with particular reference to protein, vitamin B_6, sodium, and calcium, to the frequency and severity of preeclampsia.
- Estimation of energy and protein needs in pregnancies complicated by diabetes mellitus and chronic renal disease.
- Determination of any relationship of maternal vitamin B_6 status with gestational diabetes or preeclampsia and chromium status with gestational diabetes.
- Measurement of nutrient stores, particularly those of folacin, vitamin B_{12}, and ascorbic acid, in women conceiving shortly after cessation of oral contraceptive therapy.
- Estimation of nutrient needs in women with multiple pregnancies.
- Determination of alterations in nutritional requirements of pregnancy during early (less than 15 years) and late (16-18 years) adolescence in relation to those of adult women and delineation of pregnancy influences on females whose own growths are not yet completed.
- Characterization of dietary patterns to nutritional status in different groups of pregnant adolescents with respect to life-styles and socioeconomic backgrounds.

Altered Nutritional Habits and Nutritional Abuses

- Identification of the effects of smoking and alcohol consumption on nutritional status in pregnancy and differentiation of neonatal influences on a nutritional versus a toxic action.
- Determination of the effects of caffeine ingestion on pregnancy outcome.
- Correlation of the effects of drug-nutrient interactions on maternal nutritional status.
- Determination of the relationship between maternal water-soluble vitamin intake in excess of requirements to perinatal metabolism.
- Correlation of various types of vegetarian diets in pregnancy on maternal and fetal nutrient stores.
- Characterization of the extent and pattern of pica among pregnant women of various social and ethnic groups.

Maternal Nutrient Intake and Birthweight

- Further delineation of the effects of preconceptional weight and pregnancy gain in weight on birthweight.
- Development of simple and reliable means of documenting compliance in supplementation-intervention studies and methods of separating supplementation from replacement effects.

NEONATAL

Normal Newborn

- Identification of personal and psychological factors involved in the selection of breast versus formula feeding.
- Characterization of the development of taste preferences during neonatal life and early infancy.

Abnormal Newborn

- Differentiation of nutrient requirements for premature infants versus those small for gestational age.
- Determination of the effects of different rates of weight gain in both premature and SGA infants in subsequent growth and development.
- Identification of amino acid requirements, particularly those for cystine, tyrosine, and taurine, in premature infants.

• Determination, insofar as possible in view of inherent difficulties in experimental design, of the short- and long-term effects of feeding premature infants by intermittant gavage, continuous nasogastric, transpyloric, and gastrostomy techniques.

• Determination of the long-term effects of total parenteral nutrition in newborn infants and comparison of peripheral versus central routes and total versus partial quantities.

• Comparison of fat emulsions and nonlipid parenteral solutions with respect to effect on pulmonary function, nitrogen metabolism, membrane lipids, vitamin E, and prostaglandins.

• Development of standardized biochemical means of monitoring parenteral nutrition.

• Definition of nutrient requirements with both oral and parenteral feeding, especially for protein, vitamins, and minerals, in infants of less than 1,500 g.

• Characterization of milk composition differences following premature and term births.