NUTRITION AND HUMAN REPRODUCTION: RESEARCH NEEDS

Sandra L. Huffman
The Johns Hopkins University

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A primary concern of developmental planners has focused on the dilemma of excessive population growth and inadequate food supplies. Although the issue of nutrition and reproduction has numerous implications, there is as yet a rudimentary understanding of the mechanism through which nutrition affects reproductive performance and the means by which reproduction exerts an influence on nutritional status. The purpose of this paper is to outline the areas of inadequate knowledge and research priorities for nutritional and reproductive interrelationships.

Reproductive performance includes not only factors affecting fertility or the production of live births, but also the survival probability of those live born infants. The influence of reproductive performance on nutrition for our purposes will center on factors affecting maternal and infant nutritional status. We will not examine the issue of male reproductive behavior because its significance in the dynamics of nutrition and reproduction is minor.

There are several reasons why concern about the correlation between nutrition and reproduction has surfaced. Programs which attempt to limit fertility must first understand the constraints imposed upon reproductive performance. The role of malnutrition must be defined because of the potential for an increase in fertility and reproductive efficiency which may be achieved by nutritional supplementation programs (Mosley, 1978). Methods for improving reproductive efficiency should be sought because of the waste in human resources and human suffering involved.

At question still is whether nutritional differences lead to enough variations in reproductive performance to consider nutrition an important determinant of the latter (Menken, 1978). In order to assess this query, the biologic mechanisms through which malnutrition may alter reproduction should be discussed. Lack of or diminished reproductive capability may be influenced by nutrition through interaction with: (1) the length of the

reproductive span; (2) the pacing of pregnancies; (3) pregnancy outcome; and (4) the probability of infant survival. It is necessary to accertain the importance of each of these factors on total reporduction and the degree to which malnutrition is a significant influence on them.

The impact of reproduction of nutritional status is primarily based on the nutritional demands imposed by pregnancy and lactation. The maternal depletion syndrome is in part a result of the demands of recurrent pregnancy and lactation associated with high fertility (Gray, 1975). Any association between low maternal nutritional status and high rates of fetal wastage/infant mortality should be examined because of the resulting unnecessary biologic and social costs. Short spacing between births is frequently associated with poor infant nutritional status. Kwashiorkor, a condition of malnutrition caused by low intakes of dietary protein, originated from a term meaning "a disease that occurs when a child is displaced from the breast by another child" (Jelliffe, 1969).

Although the causes of malnutrition are numerous, any improvements that can be made in maternal or infant nutritional status through changes in reporductive patterns would be advantageous. Therefore, an understanding of how reproduction affects nutritional status is imperative.

Lactation is an important intervening variable which may influence or be influenced by nutrition. The nutritional status of the mother may influence her ability to lactate and the quantity/quality of breast milk she produces. The significance of breast milk for infant nutrition is immense, especially for infants in developing countries where appropriate weaning foods and uncontaminated water are lacking.

Nutrition becomes an important consideration in the search for appropriate fertility control measures within developing countries. Maternal nutritional status may be influenced by certain contraceptive techniques which increase requirements for specific nutrients by altering metabolic processes. It is necessary to assess whether certain contraceptives may be contraindicated for malnourished women. Another area of convern is how contraceptive techniques can influence breastfeeding patterns through changes in milk output, duration of lactation, or behavior of women.

Aside from the possible direct linkage between successful contraceptive usage and nutritional status, the use of family planning may itself be facilitated when associated with nutrition and health projects (Taylor, 1975). A long debated controversy centers on whether fertility control techniques will indeed be adopted as long as infant mortality is high. Malnutrition may, in part, be indirectly responsible for parental desires to have large numbers of children.

Nutritional Influences on Reproductive Performance

Reproductive Span

The female reproductive span begins with the onset of menarche and terminates with menopause. This is the period during which a woman is capable of reproduction. The length of the reproductive span can influence fertility by allowing more or less time for reproduction. A later age of menarche and an earlier age of menopause will reduce the time available for reproduction. If nutrition affects either of these two variables, then levels of fertility may be altered.

There is abundant evidence available in the literature to suggest an association between nutritional status and the onset of menarche (Burrell,

et al., 1961; Cagas and Riley, 1970; Dreizen, et al., 1967; Tanner and O'Keeffe, 1962; Tanner, 1968; Frisch, 1972; Kraiji-Cercek, 1956; Zacharias, et al., 1976). Frisch and McArthur (1974) have suggested that the onset of menarche is dependent on the attainment of a minimal weight for height. They hypothesize that menarche will not occur until a critical percentage body weight as fat has been reached.

Research within the area of nutrition and menarche includes the need for descriptive studies gathering height and weight data at menarche for different racial and ethnic groups (Frisch, personal communication). Animal studies should examine the biochemical mechanisms that result in the onset of menarche and how malnutrition may affect these mechanisms. Chowdhury, et al. (1977) have suggested that a short-term nutritional crisis may have caused a delay in the age of menarche in rural girls in Bangladesh. There is a need to examine whether the nutritional effect on the onset of menarche is related to long-term and/or short-term nutritional deprivation. Research should assess the effect of eating practices and nutrition during the perinatal period, infancy, and childhood on the age of menarche of girls of various racial and socio-economic characteristics (National Academy of Sciences, 1971, page 160).

Although menarche initiates the reproductive span, there is generally a period of temporary sterility associated with the first years after onset of menarche. Studies are needed to determine whether nutritional status affects the period of temporary sterility experienced once menarche has occurred. Research should assess the length of the anovulatory period in early and late maturing girls to determine whether late onset of maturity results in shorter or longer periods of anovulation (National Academy of Sciences, 1971).

The evidence for a nutritional effect on the onset of menopause is less definitive as that on the onset of menarche. One of the difficulties in

studying this issue is based on the lack of accurate age reporting in developing countries where malnutrition is prevalent. Broad based comparisons do illustrate that the age of menopause in developed countries is probably higher than that of women in developing countries. The median age of menopause among American women has been reported as 49.8 years (MacMahon and Worcester, 1966), compared to a median age of menopause of 44 years reported among women in the Punjab (India) by Wyon, et al., 1968. In a United States study, skinfold thickness was positively correlated with age at menopause (WHO, 1969). The only study available for developing countries which had accurate ages of women available due to a system of registered births was reported by Scragg (1973). He observed that the median age of menopause was 43.6 years in malnourished women compared to 47.3 years in well nourished women.

Menken (1978) stresses the need to focus on more detailed information about timing and determinants of menopause in different societies. Frisch (personal communication) suggests the need for more data on age at menopause, length of periods of pre-menopausal sterility, and height-weight of women at menopause by parity. There is also a need to assess how influential the role of nutrition is in comparison to genetic, racial, or ethnic variations in the age of menopause.

Pace of Pregnancies

Within the reproductive span, fertility is determined by the spacing of pregnancies. Any given pregnancy interval is composed of three component parts: (1) the period of temporary sterility (postpartum amenorrhea); (2) the time between onset of postpartum menses and conception (menstrual interval); and (3) the duration of gestation. In this section we will discuss the first two parameters as they are the variables most likely to affect the duration of the pregnancy interval.

Postpartum Amenorrhea

There is a period of temporary sterility following a birth of approximately two months that is associated with the hormonal status of pregnancy. This period of postpartum amenorrhea may be extended with the practice of lactation, although the mechanism responsible for the anovulatory state is as yet speculative. It appears that the hormone prolactin, which is produced and secreted in response to the suckling stimulus of the infant, may interfere with normal gonadotropic production and/or secretion to prevent ovulation (Delvoye, et al., 19??; Tyson, et al., 1978; Martin, 1977). It has also been suggested that beyond the hormonal effect, malnutrition may have an added influence on lengthening the duration of postpartum amenorrhea (Frisch and McArthur, 1974). This theory is based in part on the observation that amenorrhea has been observed among non-lactating women in famine times (Smith, 1945; Antonov), or in conditions of anorexia-nervosa (Crisp and Stonehill), Frisch (1975) has suggested that the maintenance of menstrual cycles among lactating women may be related to a critical percentage body weight as fat, in a mechanism similar to that proposed for the onset of menarche.

Recent findings on the effect of malnutrition on the duration of post-partum amenorrhea illustrate conflicting results. Chavez and Martinez (1973) observed that durations of lactational amenorrhea were reduced from 14.0 to 7.5 when mothers were fed supplementary food. A problem with this study is that the infants of the supplemented mothers were also given supplementary feedings. Therefore, the diminished duration of postpartum amenorrhea may have instead been related to a decreased suckling by the infant rather than to an improvement in the mother's nutritional status. Saxton and Serwadda (1969) reported in a Tanzanian study that malnourished women experienced an average length of postpartum amenorrhea of eighteen months compared to nine

months of amenorrhea experienced by well-fed women. However, the two groups of women resided in different parts of the country, and customs such as other breastfeeding patterns may have also differed. Studies which did not contain such methodological problems were unable to find extreme variations in durations of postpartum amenorrhea by maternal nutritional status. Bongaarts and Delgado (1977) observed among Guatemalan women that the duration of postpartum amenorrhea varied by less than one month for malnourished women in comparison to well-nourished women. Chowdhury (1978) reported similar findings of variations in postpartum amenorrhea of less than one month's duration between women of various nutritional groups. Huffman, et al. (1978), were unable to differentiate women by weight to height measurements according to postpartum menstrual status. This study illustrates no minimal weight for height necessary for the maintenance of postpartum menstrual cycles among Bangladeshi women.

Before one can assess the mechanisms by which nutrition could lead to amenorrhea during lactation, it is necessary to (1) determine whether there is a causal relationship between postpartum amenorrhea and nutrition and (2) assess direct mechanisms by which the process of lactation leads to postpartum amenorrhea. Studies are needed to examine the associations of postpartum amenorrhea and nutrition when all other pertinent variables, such as suckling patterns, have been controlled for in varying populations. A means of assessing whether maternal nutritional status is related to postpartum sterility would include examining the duration of postpartum amenorrhea among non-lactating women of various nutritional states. This would eliminate the confounding factor of lactation and the influence of the corresponding hormonal mechanisms.

In order to determine the mechanisms involved in amenorrhea associated with lactation, there must be a concerted effort to identify: (a) feedback mechanisms controlling prolactin secretion in lactation, (b) the influence of prolactin on lutenizing hormone releasing factor (LHRF) and follicle stimulating hormone releasing factor (FSHRH) release and action, (c) the prolactin effect on ovarian steroidogenesis, (d) the prolactin effect on milk volume and quality, and (e) the neuro-transmitters regulating prolactin and gonadotropin release (Tyson, personal communication). Further studies are needed on the relationship between frequency and intensity of the nursing stimulus on prolactin response and to assess what infant factors affect suckling frequencies and intensity (Tyson, 1978).

Present studies are assessing the use of thyrotropin releasing hormone (TRH), which stimulates the secretion of prolactin, as a means of increasing the duration of postpartum amenorrhea while simultaneously increasing milk production. Further studies are needed to examine the relevancy of TRH administration on the augmentation of breast milk production, effects on fertility (Tyson, 1978), and influences on maternal and infant nutritional status.

Prospective studies on changes in nutritional status over time in relation to lactation and the onset of menses would help to clarify the role of maternal nutritional status in relation to postpartum amenorrhea. Such studies should also incorporate the assessment of frequency, duration, and intensity of suckling in order to determine the role of these factors in postpartum amenorrhea. Both maternal and infant factors affecting suckling patterns need to be assessed. These would include whether there is an association between poor production of breast milk and increased suckling by the infant or whether infant malnutrition results in an increased or decreased

frequency of suckling. The effect of infant supplementation on the suckling patterns should also be studied.

Menstrual Interval

Nutritional influences on the duration of the menstrual interval (fecundability) may act either on (1) the probability of ovulation or (2) the frequency of intercourse. Frisch suggests that malnourished women have high frequencies of irregular and anovulatory cycles (1975). According to this theory one would expect to find longer intervals from onset of menses to conception among poorly nourished women. Data from Bangladesh and Guatemala indicate that maternal malnutrition has little or no effect on the duration of the menstrual interval (Chowdhury, et al., 1978; Bongaarts and Delgado, 1978). Huffman (1977) observed no differences in irregularity of cycles according to maternal malnutrition in a cross-sectional study of lactating women in Bangladesh.

Effects of starvation on decreasing libido in both men and women are well known (Keyes, et al., 1950). Whether there is an association between chronic malnutrition and libido is still at question.

Research in this area should address the question of whether malnutrition affects coital frequency and the occurrence of ovulation. There is a need to assess the mechanisms by which changes in fecundity occur. Studies should assess regularity of ovulation and frequency of intercourse in relationship to variations in nutritional status.

There is some suggestion that lactation may affect the menstrual interval by altering tubal and uterine function. It has been proposed that there is an increased likelihood of the ova being lost between the ovary and the tube, an increased likelihood of defective ova which are non-susceptible to fertilization, a decreased likelihood of fertilized ova to nidate under the influence of lactation (Coutinho, 1971 see Jain IUSSP). These possibilities should be examined.

Outcome of Pregnancy

After conception, nutrition may affect: (1) the probability of the conception resulting in a live birth, (2) the condition of the pregnancy, or (3) the quality of the birth as it affects infant survival. The outcome of pregnancy will affect the duration of the birth interval and subsequently the total fertility rates as well as the probability of infant survival leading to the production of reproducing offspring.

There is some evidence suggesting a correlation between malnutrition and rates of stillbirths. During the hunger famine in Holland in 1944-1945, Stein and Susser (1975) illustrated that there was a slight increase in the number of stillbirths. However, this increase was not associated with decreased dietary intake. Maternal stature, which may reflect a woman's previous nutritional status, has been associated with an increased incidence of stillbirth (Baird, 1952, see maternal nutrition in the course of pregnancy).

Rates of early fetal wastage for developing countries have not been observed to be higher than those in countries of the developed world (Mosley, 1977). There are methodological problems that prevent clear comparisons between such populations, but it would appear that at present there is no evidence available to suggest that malnutrition is related to an increased tendency of early fetal wastage.

Lactation may affect the likelihood of spontaneous abortions through hormonal mechanisms related to the lactation process . Swenson has shown that in Bangladesh lactating women who experienced a pregnancy within twelve months of their last birth were more likely to have the subsequent pregnancy result in a fetal wastage (Swenson, 1976). Whether this association is related to maternal nutritional status, the practice of lactation, or other factors is as yet open to question.

There is a need to compare reproductive performance in nations with low rates of fetal loss to those with high rates (National Academy of Sciences, 1971). The intrauterine environment should be studied with respect to maternal malnutrition and intrauterine infection. Rates of fetal wastage should be examined in relation to gestational age, birth order, maternal age, maternal health, and maternal nutritional status. Research in this area should examine the impact of various states of malnutrition on the developing fetus according to the length of gestation. This is necessary to assess the timing of the nutritionally most vulnerable period for the developing fetus so that supplementation programs can be aimed to correspond with this period. Appropriate means to prevent malnutrition prior to and during pregnancy should be explored.

Another area of concern is whether malnutrition affects the condition of the pregnancy. This includes such topics as toxemia, nutritional deficiencies such as anemia, and illnesses experienced by the mother during her pregnancy. There is need to clarify the relationship between the incidence of toxemia and socio-economic status, nutritional status, dietary and health habits, and the availability of health care (National Academy of Sciences, 1971). Little is known about the effects of parity and spacing on complications of pregnancy and delivery. Basic research should examine changes in body composition during pregnancy and the composition of the placenta in relation to its function (Chopra, 1972). Studies on the relationship of hematologic status to the course and outcome of pregnancy should also be initiated. The relationship of preconceptual and interpregnancy care on hematologic status is also necessary (National Academy of Sciences, 1971).

A special issue related to the condition of the pregnancy is that of adolescent pregnancy. Little information is available on the earliest age of pregnancy in relation to menarche and the state of adolescent growth. There

is a need for careful longitudinal studies of premenarchial girls followed to the end of the growth period. Also of interest is the relation of (1) post-menarchial growth to fertility, (2) effects of pregnancy on post-menarchial growth, (3) impact of early pregnancy on adult stature, (4) comparison of early and late maturers as to their biological risk of pregnancy, (5) effects of mother's biological immaturity on the fetus, and (6) how super-imposing the growth process affects metabolism and nutrient requirements (National Academy of Sciences, 1971).

The role of the quality of the birth reflects the chances for infant survival. One of the major associations with neonatal death is low birth weight. If the mother has been malnourished during pregnancy, the subsequent infant born of low birth weight (small for date) has an increased risk of mortality.

The association between nutritional status and gestational age of the infant should be assessed. Weight gain during pregnancy, especially in developing countries, should be measured in order to determine whether the pattern of weight gain parallels that in the United States or whether it differs according to the length of gestation. Hormonal changes during pregnancy need to be measured in relation to the supply of nutrients to maternal metabolism and to the fetus. Changes in absorption and retention of nutrients during pregnancy should also be assessed along with the metabolic effects of calorie restriction during pregnancy and the relation to fetal development. (N.A.S. Little is known on the special requirements of multiple pregnancies.

Influences of Reproduction on Nutritional Status

Pregnancy and lactation impose severe nutritional demands on the mother. During pregnancy extra energy is needed for the growth of the fetus, placenta, and associated maternal tissues and for the increased cost of movement for the heavier mother (WHO, 1973, WHO Technical Report Series Number 522, "Energy and Protein Requirements," Geneva). Total energy needs of a pregnancy are thought to be about 80,000 Kcal, of which about one-third is thought to be accounted for by fat deposition (FAO/WHO, 1973). Lactation is considered to be 90% efficient; in other words, energy requirements for the mother will be closely equal to that of the milk produced. If a woman produces on the average 850 ml of milk per day with an energy value of about 600 calories, a mother would need about 670 Kcal of energy from food. In developed countries when fat storage is laid down during pregnancy, the requirement may be less because of the calories available from fat stored in the mother. Mothers with less stored fat and those who breastfeed for an extensive period of time need a greater food intake during lactation to meet the extra caloric demands (WHO, 1973)

Protein requirements during pregnancy and lactation also increase because of the need for protein to fulfill the nitrogen content of the fetus, fetal membranes, and maternal tissues (WHO, 1973). Increased protein requirements during lactation are those needed for milk production.

As discussed previously, there is a strong association between mother's weight gain during pregnancy and birth weight illustrated in the Guatemalan studies. At question is whether protein or calorie deficits are more important in producing low birth weight babies. Habicht et al. (1974) illustrated that when mothers were supplemented during pregnancy

with calories and protein, the birth weights of their children increased as caloric consumption increased. Protein consumption had no effect on birth weight.

The increasing demands on maternal stores as the number of pregnancies increases may result in maternal malnutrition. There has been association in the literature between high parity and low maternal weight for height and the prevalence of anemia (Venkatachalem, 1962). When diets are insufficient, maternal nutritional status may deteriorate with increasing parity since a woman is unable to build up her fat reserves to maintain an adequate weight for height ratio. Anemia may occur because of the requirements for iron needed for the growing fetus, thus, high parity women are also prone to anemia.

One of the problems involved in assessing the effects of reproduction on nutrition is that of the association between high fertility rates and low socio-economic status within a malnourished population. Factors that appear to be caused by reproductive patterns may in fact be due to low socio-economic status. Nutritional status of children is also often related to the mother's pattern of fertility. Children in larger families have been found to be more malnourished than those in smaller families in developing countries (Bailey, 1964; Rao and Gopalan, 1969). There are again problems in assessing this because of the interrelationships between high fertility and socio-economic status. There is a need to examine the pathways by which high fertility is associated with poor child nutrition.

It has been suggested that pregnancy risks are extremely high during adolescence because of the competing demands of both growth and pregnancy. These risks include premature labor, low birth weight, high neonatal mortality, excessive toxemia of pregnancy, iron deficiency anemia, pelvic

disproportion, and prolonged labor (National Academy of Sciences, 1971, page 149). Recent information, however, suggests that the majority of the problems associated with adolescent pregnancies are not due to youth but rather to low socio-economic status. Support for this assertion is that births among women in their late teens have become progressively less hazardous in developed countries as obstetrical care has improved and general socio - economic conditions have increased.

There is a need to examine further the effects of short and long birth spacing on maternal and infant health and the mechanisms by which these factors operate. Research in this area should also examine the obstetric performance of adolescents to determine whether nutrition plays an important role. With the increasing use of induced abortion throughout the developing world, there is also a need to assess whether induced abortion has an effect on maternal nutritional status and the effects of maternal nutritional status on the complications of induced abortion (National Academy of Sciences, "Nutrition and Fertility Interrelationships," 1975).

Lactation

Biological Factors

The effect of maternal nutritional status and dietary intake on the quality and quantity of breast milk is an unsettled issue. Most studies reveal that women in developing countries produce a lesser volume of milk than women in developed countries (Chavez, 19??; Bailey, 1964; Gopalan, 19??). The quality of the milk produced seems to be very similar, especially with relation to the proportion of protein, calories, and fats found in the milk.

The question of whether supplementation will increase the quantity of milk is still open. Studies by Chavez, et al., in Mexico (1975) and Gopalan in India (1960) illustrated that when the diets were supplemented, the volume

of milk increased somewhat but there was little or no change in the composition of the milk. Edozian in Africa (1975) was able to increase the production of milk by 200 cc per day with increments in protein intake of 75 grams. Much of the unresolved questions center on the difficulty in measurement of total milk output under normal conditions. Most studies have been conducted in hospital settings where fixed feeding schedules have been enforeed. Even when carried on in the field under normal circumstances, it is difficult to asses whether one is accurately able to determine the amount of milk output. Wray (1978) states that much more information is needed in order to clarify any quantify the relatives effects of calorie versus protein deficiences on human milk production.

Further research is needed to: (a) determine the extent to which milk production can be improved by better maternal nutrition, especially in chronically malnourished women; (b) to clarify and quantify the relative effects of calorie versus protein deficiencies on human milk production; and (c) to assess the effect of nutrition on the quality, auantity, and duration of lactation and the effects of these three factors on the duration of lactation and on the immune mechanisms of the infant (Wray, 1978).

Weight changes during lactation need to be measured for women in various parts of the developed and developing world. This should be done in order to assess the effect of lactation on maternal nutritional status. The enhancement of maternal nutritional status as a factor which might increase breatfeeding behavior, especially amoung women in the developing world, should be studied further. There is a need to estimate the energy loss in mothers who do not breastfeed to assess whether they are more likely to retain weight gained during pregnancy than breastfeeding mothers (Tyson, personal communication).

The association between breastfeeding and infant nutrition should also be examined. There is a need for comparative studies of the pattern of mortality associated with infant feeding in both developing and developed countries. It is also essential to assess obesity patterns between breast and bottle fed infants

especially in the developed world.

One of the prime research needs related to improving infant nutritional status is the question of when to introduce supplementary feeding. It is necessary to assess the potential tradeoff between the effect of infant supplementation for meeting infant nutrient requirements and the effect of infant supplementation on curtailing the duration of postpartum amenorrhea. If the infant is supplemented at four to six months, his/her nutritional status may be enhanced over that of unsupplemented infants becuase the quantity of breast milk is usually inadequate to meet the growing demands of infants above these ages. However, coexistent with the supplementation is the problem of food contamination and access to weaning foods appropriate for the infant's nutritional needs.

The increase in foods eaten by the infant would also be likely to result in his/her suckling to be diminished. As illustrated in numerous studies, mothers of fully breastfed infants exhibit longer durations of amenorrhea than those who supplement their infants (Berman, 1972 Potter, et al., 1965). Subsequently shortened pregnancy intervals will result for mothers who feed their infants supplements in comparison to those who fully breastfeed their children. The disadvantages to the infant of being displaced completely at the breast by a subsequent sibling need to be off-balanced by the need for additional supplements. Although this area of concern presents numerous methodological difficulties, it represents one of the significant practical issues facing nutritionists in developing countries.

A research issue related to this problem is that of maternal supplementation and increased breast milk production. If maternal supplements can improve breast milk output, it may be more advantageous to eliminate infant supplementation in favor of maternal supplementation. If the infant were able to consume an adequate supply of breast milk, the problems of inadequate weaning foods and contamination effects would not be present. There would also be the added advantage of extending the mother's period of infertility associated with the

increased duration of full breastfeeding. Research in this area should concentrate on assessing the most appropriate means of improving infant nutrition in order to increase the probability of infant survival.

Behavioral Factors

Aside from the biological factors associated with lactation, research needs to include the examination of socio-cultural aspects of breastfeeding behavior. Some of the issues which should be addressed include: (1) the ageparity distribution at time of employment following delivery; (2) educational level and income of breastfeeding versus bottle feeding mothers; and (3) the cost of bottle feeding in comparison to the cost of breastfeeding (costs of weaning foods compared to the added nutrient requirements of the mother and the foods she would consume to meet these requirements) (Tyson, personal communication). There is a need to assess traditional practices of breastfeeding and whether (personal communication) suggests the need for longitudinal and cross-sectional research on the behavioral factors affecting breastfeeding behavior with particular regard to policy issues such as: (1) contraceptive use, (2) availability and prices of milk and infant foods (3) nature of women's employment opportunities. (4) medical professional influences (modern and traditional), and (5) knowledge and beliefs of the mother. Small pilot projects should be attempted to enhance the extent and length of breastfeeding in urban and rural areas. There is a need for in-depth cost-benefit analyses of breastfeeding. Behavioral modeling would facilitate the understanding of the joint interaction between child care organizations, labor force participation, type of job selected, and breastfeeding behavior and fertility (Popkin, 1978).

Butz (1978) states that there is a need for research at the household level to determine the direction of causality in the correlation between women's work activities, wages, level of education, and breastfeeding.

Research is needed to identify particular factors in family surroundings that governments can alter to induce women to maintain their time and energy spent breastfeeding even as total overall prime allocation patterns change drastically (Butz, 1978). Research should aim at discovering how the supply of effective substitutes for breastfeeding can be made available. Butz has delineated six questions which summarize the concern for breastfeeding trends: (1) What are the characteristics of populations most at risk to declines of breastfeeding? (2) What factors are responsible for these declines? (3) What factors might be altered by public policy to prevent or arrest declines? (4) What is the aggregate effect on breastfeeding that can be expected to result? (5) What is the cost of the policy? (6) What are the policy's significant effects? (Butz, 1978) Data should be collected to facilitate understanding of the reasons for declines in breastfeeding during socio-economic development and to elicit interventions useful in stemming these declines (Butz and Habicht, 1975).

Fertility Control Programs

Because of the increasing spread of contraceptive techniques throughout the developing world where nutritional status is minimal, there is a need to assess the significance of various contraceptive methods on maternal nutritional status. Although there have been numerous studies on the role of oral contraceptives in relation to specific vitamin levels in developed countries, there is a paucity of literature for most of the developing world. The changes in levels noted for women in the developed countries include alterations of the following elements: Vitamin A, ascorbic acid, Vitamin B_{12}, Vitamin B_6, folic acid, thiamin, riboflavin, iron, copper, and zinc (Prasad, et al., 1978). The principal elements that have elicited concern are those of folic acid and Vitamin B_6 because of observed deficiencies among women on oral contraceptive therapy. The significance for women in developing countries is especially disconcerting since serum levels of these vitamins may already be minimal when contraception is first initiated. Mechanisms responsible for the above changes in nutrient levels and any associated physiologic significance should be delineated.

Side effects associated with oral contraceptives differ in some respect in developing versus developed countries. Such occurrences as dizziness and burning sensations in the extremeties have been noted at a high frequency among users in Bangladesh, although they are seldom mentioned by women in developed countries (CRL, 1977). Such symptoms may be caused by nutrient deficiencies. It is therefore possible that the malnourished woman may be preconditioned to be less able to tolerate the physiologic changes occurring through the ingestion of oral contraceptives as easily as well nourished women. This issue deserves special attention.

With the increasing use of oral contraceptives by adolescents, there is a need to address the effects of oral contraceptives on post-menarchial growth (National Academy of Sciences, 1971).

There is also a need for systematic collaborative research on the effect of steroidal contraception and lactation. Research in the area should include: (1) whether combined estrogen-progesterone contraceptives affect lactation and, if so, by how much, (2) what effects the low-dose estrogens have on lactation, (3) whether steroidal methods have long-term effects on infants through any passage in the breast milk, and (4) how soon after delivery steroidal contraception should be initiated, with regard to the effects on infant nutritional status if steroidal contraception leads to diminished lactation (Buchanan, 1977). Another area worthy of attention is the extent to which oral contraceptives have enhanced or competed with the effects of breastfeeding in developing nations (Osteria, 1978).

The impact of prolonged use of intrauterine devices on maternal nutritional status needs to be examined (Omran, 1971, "The Health Scheme in Family Planning," Carolina Population Center, A. R. Omran). Specifically, the problems of anemia, pelvic inflammatory disease, and effects of IUD on lactation should be studied.

The influence of progestational injectables on nutritional status is unknown. Some studies have pointed to an enhancement or lack of effect on milk production (Koetsawang, S., Chiemprasert, T. Kochananda, P., Clinical Proceedings of IPPF, Southeast Asia and Oceanic Regional Medical and Scientific Congress, Sydney, Australia, August 1972, page 84). A recent study in Bangladesh, however, suggests that milk production may be diminished by the progestational injectables (Parveen, et al., 1977).

Aside from the direct association of nutrition and contraceptive techniques, also of interest is the programmatic aspect of fertility control projects. Some feel that the incorporation of maternal nutrition and family planning programs with basic health services offers an increased opportunity for success in each (Chopra, 1972). Research is needed to assess whether combining nutrition and family planning programs does actually result in increased usage and/or effectiveness (Hueneman, 1973). There is still a need to study delivery systems integrating nutrition, health, and family planning and the effectiveness of this concept (National Academy of Sciences, 1977).

The issue of whether people will use family planning when infant mortality is high also deserves attention. Research must trace the complex interrelationships implied in the child survival hypothesis, especially in relation to nutrition and family planning (National Academy of Sciences, 1977). Research programs should include attempts to assess the indirect effects of increased child survival on reproductive potential. These critical issues could be resolved by a concerted research program within ten to fifteen years (National Academy of Sciences, 1977).

There is a need to assess the association between changing roles of women brought on by or enhanced by family planning programs on infant nutrition (Mosley, 1978). Due to changes in labor force participation, women may have less time for child care, although more money may be available for food. It is necessary to determine whether the increased food purchases do filter down to the infant.

Conclusion

One of the research needs stressed by the National Research Council Committee on World Feed and Nutrition (1977) was "How much of an effect will improved diet have on the reproductive components in the span of one generation." This paper has summarized the areas of research necessary to answer the question. An issue of practical concern is where the priority in research should be given in order to resolve this issue in the near future.

A prime issue raised by Frisch (1978) is that of whether a slower rate of growth, resulting in a later onset of menarche, is related to a subsequently shorter and less efficient reproductive span; and if so, whether these effects are reversible after growth has been attained.

Mathematical models can be helpful for arranging the priorities for suggested research addressing this issue. Menken's and Bongaarts'(1978) computer simulations illustrate that in terms of ultimate effects on fertility levels, the role of age at menarache, memopause and the rate of spontaneous abortions is minimal. More important effects are those of fecundability, postpartum amenorrhea, and the incidence of sterility.

Trussel (1978) suggests the need to assess the relative importance in the duration of the birth interval comparing variations in fecundability and postpartum amenorrhea. The significance of nutrition in determining the incidence of anovulation, irregular ovulation and frequency of intercourse deserves special attention. Basic research on the mechanisms involved should be pursued.

Chopra (1972) states that since so much of the knowledge about the importance of nutrition in relation to maternity is fragmentary and incom-

plete, the importance of further research can scarcely be overemphasized. This is especially true with regard to the need for decreasing the incidence of stillbirths and improving maternal and infant nutritional status. Increasing birth weight among populations in developing countries would be a primary step to bettering nutritional status and ultimate survival of infants. Therefore research which attempts to develop programs to improve maternal nutrition during pregnancy should receive top priority.

Applied research which focuses on reversing the trend of declining breastfeeding throughout the world should be supported. The benefits for both improved infant nutrition and decreased fertility are obvious. The assessment of methods for increasing milk output while maintaining and improving maternal nutritional status should be given primary emphasis.

As these lines of research are carried out, a corollary area which can be assessed simultaneously is the question of the child survival hypothesis. The NRS study team emphasized the importance of knowing the effect of

> increased child survival on reproductive potential (NAS, 1977)

as it "would permit sounder choices among nutrition and development strategies by disentangling past and future effects on fertility arising from improved nutrition, socioeconomic change, and the delivery of birth control technology."

Methods for improving the acceptance of fertility control techniques based on physiologic factors such as lactation and nutritional deficiences need also be of primary concern to researchers. Any means which can be applied to help women in developing countries who want to limit their fertility to do so, should be attempted. If a limiting factor is malnutrition, it is obvious that improving the nutritional status of contracepting women

represents an action that can be taken at present until more suitable contraceptive techniques are available.

An understanding of the mechanisms by which malnutrition can result in diminished reproductive performance will aid population planners in their attempts at reducing fertility. Unwanted increases in fertility which may result from supplementation programs (of either mothers or infants) can be considered beforehand and methods for coping with and/or preventing these possible occurrences sought.

With a primary developmental goal of improving the quality of life, mechanisms for reducing infant mortality should be given highest attention. Whether or not declines in infant mortality rates lead to increases in the desire for family planning, the social benefits of efficient reproduction necessitate the improvement in the probability of infant survival. Any means by which changes in reproductive patterns can aid in this goal need to be supported.

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