Nutrition, Population, and Health: Some Implications for Policy

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When Malthus enunciated his "postulata"—"First, that food is necessary to the existence of man. Secondly, that the passion between the sexes is necessary and will remain nearly in its present state" (*1*)—and then surmised that the interaction between these two forces had implications for the quality of life, he joined a long tradition of human consciousness in which numbers of human beings and the utilization of resources were seen to be intimately related. Clearly, Malthus never envisioned the technological advances that enabled food production, at least in some parts of the world, to grow at relatively enormous rates; equally clearly, he did not understand the disproportionate strain on resources created by increasing affluence, independent of increase in population. Nonetheless, his attempt to explore intrinsic relationships between numbers of people and the quality of their existence was an attempt to place on a new intellectual plane connections that had been recognized implicitly much earlier.

Political realists had long known that both bigger armies and hegemony over larger populations implied more power but were in some ways also more problematic. The difficulty of ensuring supplies of adequate resources was recognized at least from the time of the Roman legions, and distribution of the harvest was one of the major political concerns of early Chinese dynasties. That Malthus should have tried to formulate the relationships between numbers and resources in terms of a "natural law" was perhaps only a sign of his time. In the 20th century, we are more concerned with paradox, uncertainty, and relativity, and therefore it may be a sign of our times that we reformulate these relationships in conclusions such as "the best birth control program is to feed children" (*2*).

In academic circles, population and food have often been discussed jointly. Questions frequently voiced include: Is the population problem really a nutrition problem?—that is, is the real difficulty one of having so many people on the globe that we will not be able to feed them all? Or, is the nutrition problem really a population problem?—that is, are there so many malnourished people because there are too many people? The short answer to both these questions is probably no. In the first case, it is now accepted that other resources, such as water, may be limiting factors long before worldwide food production is unable to keep up with population growth. In the second instance, it is clear that even in some of the areas where malnutrition is most severe and widespread, there is enough food to feed everyone if the problem of unequal distribution can be solved.

More recently, as scholars have discovered the impact of improved nutrition on health, we have been confronted with the question (*3*), "Did good nutrition cause the population problem?" In answer to this, one can only say maybe. Indeed, there is a logical connection between improvement in nutrition and increased survival. In contrast, there is an equal possibility that good nutrition can help solve the population problem. This is explicitly recognized in the suggestion of Wray and Brown (*2*) that feeding children can be viewed as a family planning measure, and in the theoretical formulation of the "child survival hypothesis." Further, since improved nutrition may produce a more alert, aware, educated, and productive population, it has significance far beyond its implications for demographic change.

The existence of biological interrelationships between nutrition, population, and health and their synergistic connections has led to the hypothesis that there may also exist synergisms among programs in these different areas (*4*, *5*). Providing combined services for health, nutrition, and family planning has been advocated to increase the efficiency and effectiveness of use of limited resources, on the premise that acceptance of one type of service will reinforce positive attitudes toward acceptance of others. Finally, there may be an inherent logic in grouping these three areas together; often, responsibility for providing services and planning of programs in all three areas falls within the same ministries and to the same professional groups (*6*). A narrow definition of broad social problems, implied by the frequent relegation of all these concerns to medical scientists, may, however, generate new sets of problems in mounting truly effective interventions.

A series of policy questions is stimulated by the complexity of nutrition, population, and health issues, and by the frustrations of limited professional, managerial, and resource bases for dealing with problems so deeply entwined with larger socioeconomic forces. These questions include: (i) What is the extent to which economic development can substitute for or make unnecessary specific attention to each problem? (ii) Is there any way in which programs can be effective if they focus on any single problem without being combined in a so-called "integrated attack"? (iii) Are there implications for developing countries in the fact that nutrition improved, health improved, and fertility rates decreased in the developed world long before there were policies or programs based on scientific understanding of biological interactions?

Policy-makers may be tempted to turn to the intrinsic relationships between nutrition, population, and health in an attempt to understand the processes that may exacerbate existing problems, and to develop intervention measures that may be undertaken in response. Yet the multiplicity of biological mechanisms and their complex relations to social settings must call into question the ability of scientific fact to provide answers to policy questions.

Nutrition, Population, and Health: Biological and Behavioral Relations

The quantifiable cause and effect relationships among nutrition, population, and health seem to fall broadly into two categories: biological and behavioral. The distinction, however, is not really so neat, as there are behavioral changes that are manifest through biological mechanisms, and there may even be biological mechanisms that effect behavioral changes.

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One of the most thoroughly explored of biological synergisms both on individual and population levels has been the relation between nutrition and infection (*7, 8*). Infection clearly worsens nutritional status by loss of nitrogen and depletion of body protein. The loss of iron and vitamin B_{12} and impaired absorption of vitamin A may be important in parasitic infections (*7*). Diarrhea and measles, both serious diseases in developing countries, are known to be two immediate precipitants of such nutritional disorders as marasmus, kwashiorkor, and xerophthalmia. It is also well known that poor nutritional status plays a large role in increasing both the susceptibility to and the severity of infection. Latham has summarized [some of] the physiological effects of malnutrition, including impaired leukocyte activity, antibody formation, cell-mediated immunity, and tissue integrity (*7*).

The Pan American Health Organization's (PAHO) investigation of mortality in children showed that more than 50 percent of all investigated deaths had malnutrition as either an underlying or associated cause (*9*). In cases of death from diarrheal disease, malnutrition was generally an associated cause of death in 60 to 75 percent of the cases. Even in cities with sophisticated medical services, such as São Paulo, Brazil, 45 percent of all children who died had associated nutritional deficiency. It is also well known that the case fatality rates of common childhood diseases are very much higher where malnutrition is common. In Guatemala, the case fatality rate for measles was up to 400 times as high as that in industrialized nations (*10*).

Pilot field studies have borne out these relationships. In a well-known study in rural Guatemala, one village received supplemental feeding, another a program of preventive medicine and medical care, and a third served as a control. Death rates in children between the ages of 1 and 4 decreased over several years in all the villages. Although the numbers in the study were small, there was good evidence that mortality decreased most in the supplementally fed village (*10*). In addition, preschool children in the supplementally fed village showed decreased disease incidence and improved physical growth, whereas the preventive medicine and medical care program produced no effect on the frequency of illness and no improvement in physical growth (*10*).

Behavioral effects may be equally powerful in producing relationships that tie together nutrition, health, survival, and population dynamics. One way in which infection may decrease nutritional status is through traditional behaviors that deny food to sick children, withdraw them from the breast, or even prescribe purgatives and enemas. As another example, culturally dictated intercourse taboos during lactation may have more profound effects on fertility levels than the biological effects of lactation itself, especially where breast-feeding is so prolonged that menses have resumed in most mothers before babies are weaned. Depending on the nature and stringency of taboos and the rate at which they may be breaking down, behavioral factors potentially could have much more influence on nutrition and fertility than any strictly biological interactions. (*9, 11*). In another instance. Mosley suggested that the striking seasonal variations in conception rates in a chronically malnourished population could be attributed to changes in coital frequency related to climatic cycles and husbands' absences for seasonal farm labor rather than to intrinsic biological factors (*12*). He concluded that social and behavioral factors were likely to be far more important in producing fertility patterns than the biological effects of chronic malnutrition.

Finally, biological insults may become evident through their effects on behavior. It is now well recognized that malnourished children are frequently more passive, demand less attention, and interact less with their environment than their better nourished peers. This seems to produce a reinforcing phenomenon in which such children also receive less stimulation from their environment, less attention from their parents, less good parenting, more neglect, and perhaps more malnutrition, disease, and impaired performance than children who are well nourished from birth (*13*).

There may be other subtle biological-behavioral interactions of which we are not yet aware or have insufficient proof. A fascinating suggestion has been made that the hormone prolactin, secreted by the anterior pituitary in response to the suckling of an infant on its mother's breast, may have some role in initiating maternal behaviors (*14*). To date, this evidence is fragmentary, and the effects have been demonstrated only in animals, but it certainly seems possible that hormonal changes initiated by maternal behaviors could themselves foster and reinforce those very behaviors.

Clearly, behavior and biology act in mutually reinforcing ways to produce important patterns of health problems. A recent United Nations report (*15*) noted that "reproduction is a fundamental nutritional task of women." As diet, from infancy on, affects the reproductive capacity of women, and therefore, the health and survival of the following generation, the World Health Organization (WHO) added (*15*) that "the return for our proper investment in the nourishment of our children and especially of girls is inestimable." The very same U.N. report described the general situation in Africa as one in which female children of all ages were given food portions substantially smaller than boys were given, and the priority for their eating ranked just before the household dogs. Greiner found that, on the island of St. Lucia, a significant correlate of low weight for age was simply that the child was a girl (*16*). In Colombia, national statistics showed a malnutrition rate of 47.5 percent for boys and 64.6 percent for girls (*17*). In a part of Colombia where health indicators were, overall, better than the national average, the relative difference between boys and girls was even greater—19.7 percent malnurition rate for boys and 36.1 percent for girls (*17*). Discrepancies in death rates for male and female children are also reported. In the Punjab, figures for mortality in the first 5 years of life showed a death rate for females almost 150 percent that for males (*18*). These figures demonstrate a serious problem and the extent to which behavioral and biological interactions underlie nutrition, population, and health problems over much of the world.

Two specific areas in which biological and behavioral interactions are manifest and are closely linked to each other, to nutrition, population, and health issues, and to the current concerns of policymakers and health professionals are breast-feeding and child survival. Both are intimately tied to human well-being, and both are affected by patterns of socioeconomic development. While policymakers have long been concerned with morbidity and mortality, many have only recently begun to take interest in the possibility that national policies need to be developed to deal with infant feeding practices. These practices, especially breast-feeding, cannot be separated from problems of child survival; the two are biologically and socially intertwined.

Breast-Feeding

Attention has recently been drawn to the importance of breast-feeding by court cases in which the practices of large corporations selling infant formulas have been alleged to be deleterious to the health of babies in the developing world.

At the same time, research and programmatic interests in breast-feeding have mushroomed in scientific and health-planning circles. This upsurge in activity has resulted in new findings, verifying traditional wisdom about the importance of mothers' milk for infant health, and new knowledge about the relation between breast-feeding and reproductive capacity (*19, 20*). There has been less systematic study of the precise relations between maternal nutrition and lactation.

The importance of breast-feeding for children's health has been emphasized by laboratory evidence on the biochemical, nutritional, immunological, and anti-allergenic properties of breast milk, as well as by epidemiological studies showing improved nutrition, health, and survival among breast-fed babies. It has become apparent that mothers' milk is not only precisely tailored to the nutritional needs of human infants, but is also a living fluid with active and passive factors to protect against infection. The truly remarkable nature of these properties is demonstrated by recent findings that secretory immunoglobulin A–producing cells in milk come originally from lymphocytes in the gastrointestinal tract of the mother. These cells respond precisely to the pathogens present in the immediate environment of the mother (and baby), travel to the breast, are excreted in the milk, are ingested by the baby (*20*), and protect the baby's gastrointestinal tract against the organisms most likely to threaten health at that particular instant. More elegant tailoring of host defenses to shifts in environmental threats could hardly be imagined. This precision certainly cannot be replicated by either prepared infant formulas or technical medical interventions such as immunizations or health care services.

Wray has reviewed studies conducted over the last century on infant mortality in breast- and bottle-fed babies in Europe and North America. These studies emphasized clear survival advantages in the breast-fed as compared to the bottle-fed at every point in history, up to and including Great Britain in 1946 (*21*). These benefits seemed to decrease over time, probably reflecting better nutrition and environmental sanitation, as well as better medical care in later years. In addition to overall mortality advantages, Wray noted that, for every disease category studied, breast-fed babies had morbidity rates lower than bottle-fed babies. Furthermore, he cited evidence that early breast-feeding might have protective effects after weaning; infants breast-fed in the first months of life seemed to fare better during the second half-year than babies artificially fed from birth.

Evidence on the health advantages of breast-feeding in present-day circumstances in developing countries has not been compiled as systematically, but there are strong indications from the PAHO study of morbidity and mortality in childhood and from the Khanna study in the Punjab that there is a similar advantage for breast-fed over bottle-fed babies (*18, 23*). Wray estimated that data from developing countries suggest that the risk of bottle feeding in the developing world is about the same as that 50 to 100 years ago in the developed countries (*18, 23*). During that period, the relative risks of mortality for the bottle-fed as compared to the breast-fed in different localities varied between 2 to 1 and 55 to 1.

Despite the emphasis of research attention on past trends in developed countries and current patterns in developing countries, evidence does exist suggesting that there is still a significant health-promoting effect of breast-feeding, even where sanitation and education levels are high. In 1971 and 1972 at a London hospital, only two of 608 (0.33 percent) children with gastroenteritis had been breast-fed even though 14 percent of matched control infants in the same community had been breast-fed (*24*). A study conducted in upstate New York in 1974 and 1975 by Cunningham (*25*) showed that breast-feeding was associated with significantly less illness during the first year of life, especially when such feeding continued beyond 4.5 months of age. In more than 13,000 patient-weeks of experience, less illness occurred among breast-fed babies in every disease category measured. There were significantly fewer hospital admissions among breast-fed infants, and an extremely wide difference in total episodes of illness between the bottle- and breast-fed babies. After adjustments were made for educational level, the conclusion was that the health advantages of breast-feeding were independent of socioeconomic status. Finally, data analyzed from a representative sample of over 7000 American 6- to 11-year-olds in the mid-1960's revealed that breast-feeding, along with birth weight and nutritional status, was an important correlate of cognitive development (*26*).

Breast-feeding, because of its physiological relation both to child health and to fertility, has become a point of intersecting interest between nutrition and population specialists. Rosa, using perhaps overly generous estimates of the extent and duration of urban breast-feeding, has calculated that, in developing countries in 1973, there were 40 percent more couple-years of protection against conception from lactation than from the services of family planning programs (*27*). Lactation inhibits fertility by prolonging postpartum amenorrhea; studies in nine countries reviewed by Van Ginneken showed a good correlation between length of lactation and length of postpartum amenorrhea (*28*).

The duration of postpartum amenorrhea has long been known to differ widely between various groups of lactating women. A study of French women showed an average lactational amenorrhea of only 58 days (*29*), while reports from Central Africa and rural Bangladesh showed lactational amenorrhea averaging around 18 months (*12*). While explanations of this phenomenon used to focus on the nutritional status of the mother, it now appears that these differences are probably not largely nutritional. Much of the difference in length of amenorrhea can probably be ascribed to the pattern of nursing itself; suckling throughout the day and night with no supplementary bottles, pacifiers, or solid foods allows for sufficient stimulation of prolactin production to continue suppression of ovulation. That this level of suppression may operate as well in better-nourished mothers is demonstrated by a small study done on "natural mothering" American women (*20*). These mothers nursed around the clock on demand and used no pacifiers or supplementary feedings for 5 months. In 29 nursing experiences, an average of 22.8 months of breast-feeding provided a mean of 14.6 months of lactational amenorrhea. This mean value was far higher than that usually reported for well-nourished nursing mothers and approached that for Asian and African women. This finding highlights the need to attend to the pattern of nursing rather than mere presence or absence of nursing in predicting effects on fertility.

If nutritional status does not necessarily explain wide differences in postpartum lactational amenorrhea between divergent populations, there might still be effects of nutritional status on fertility within a basically homogeneous population. Bongaarts and Delgado attempted to assess this relationship and were able to document only a small effect of nutritional status on duration of postpartum amenorrhea (*30*); the higher the nutritional status on a combined index of four parameters, the shorter the duration of postpartum amenorrhea, but only by about 11 percent. Nutrition had no effect

on the length of time required for conception after the return of menses. Mosley cites evidence from Bangladesh showing similar small differences—a prolongation of amenorrhea by only about 6 percent in the most poorly-nourished as opposed to the most well-nourished groups (*12*). These data also confirmed that there was no difference in waiting time to conception after the appearance of menses between women of different nutritional status (*31*). Neither the study by Delgado and Bongaarts nor the evidence from Bangladesh included an investigation of the breast-feeding patterns of different nutritional groups. Systematic differences in length or frequency of suckling that correlated with the nutritional status of the mother might be sufficient to explain the small differences found in length of postpartum amenorrhea. Although the available evidence is imperfect, it appears that nutritional status plays a minor role in determing differences in intervals between births compared to that played by behavioral changes (*11, 12, 30*). In turn, these behavioral changes may be closely tied to social changes. In Java, for example, postpartum abstinence and prohibition of intercourse during lactation are apparently weakening customs, accompanied by changes in traditional breast-feeding practices (*9*).

Those who wonder whether improved maternal nutrition might not be counterproductive by wiping out the contraceptive effects of lactation are asking the wrong question. Their presumption is probably based on a misapprehension of the relation between biology and behavior. Since the pattern of suckling is probably more important in producing prolonged amenorrhea—and contraception—than the nutrition of the mother, there is likely little to be lost and much to be gained, in the health of mothers and babies, by ensuring better nutrition for pregnant and nursing women. Since the fertility-reducing effects of lactation seem so sensitive to changes in duration of suckling and patterns of breast-feeding, it appears possible that the health-promoting effects of breast-feeding can be retained even if fertility-reducing effects are lost. In fact, it may be that patterns of breast-feeding change long before the practice of breast-feeding is abandoned wholesale by populations.

As concern about cessation of breast-feeding has mounted among health professionals and policy-makers, attempts have been made to determine the reasons for the decline in breast-feeding in the developing world. These assessments always mention the desire of women to work outside the home and to be free of breast-feeding in order to take advantage of newfound opportunities. While these may be reasons to abandon breast-feeding for some women, they appear to be important for only a very tiny minority. The little evidence that exists on women's choices for breast-feeding or bottle-feeding hardly substantiates the inclusion of the work factor as a major determining consideration. As a result of the casual assertion of this unproven assumption, guilt and doubt have been created; women feel sentenced to a limbo where, in order to achieve expansion of their personal options, they have to deprive their children of optimal biological and psychological mothering.

This is not necessarily the case, and the evidence that does exist may, indeed, point in the opposite direction; it is precisely in those societies where women's options have expanded the most that breast-feeding is now on the increase. For instance, in the United States the low point in breast-feeding was reached in the late 1960's, when only one-fifth of women breast-fed their children. By 1975, however, 33 percent of women were breast-feeding their infants at 1 week of age, a level not seen since about 1950 (*32*). In Sweden, where a woman's option to work outside the home or not is quite flexible, breast-feeding has been remarkably resurgent with the encouragement of several government programs. In 1975 in Uppsala, 78.8 percent of infants were completely breast-fed at 1 month, with 39.4 percent still completely breast-fed at 4 months of age. The parallel statistic for 4-month-olds in 1971 was only 6 percent (*33*). In Finland, statistics from 1972 showed similar patterns of breast-feeding both in mothers employed and not employed outside the home; about one-fifth of the mothers breast-fed for 1 month or less; and about one-third were still breast-feeding at 3 months in both groups (*34*). In France, a national study analyzing patterns of more than 11,000 births demonstrated that working mothers breast-fed slightly more often than nonworking mothers (*35*).

In Newcastle, England, only 3 of 122 bottle-feeders chose the bottle because (they stated) it would enable them to return to work (*36*). In a comparison of 100 breast-feeding and 100 bottle-feeding mothers, the need to work or pursue activities outside the home did not appear among the ten most commonly given reasons for bottle-feeding (*37*). In addition, this study demonstrated that about half of the women had decided on the method of feeding their baby before they even became pregnant. Feeding decisions appeared to be related to family expectations, social norms, and prior education of the mother, not to the immediate situation of her pregnancy (*37*).

Furthermore, Berg cites evidence (*38*) that very few women in developing countries actually participated in the paid labor force, making it unlikely that their infant-feeding decisions were based on job opportunities. In fact, only 15 percent of nonnursers in the West Indies, and only 10 percent in Singapore, were employed (*38*). The lack of correlation between women working and their deciding not to breast-feed was further demonstrated in Almroth's review of commonly given reasons for weaning; work was cited as a factor in no more than 6 percent of the women in each of five countries studied (*39*).

In St. Vincent, West Indies, Greiner found that of the seven factors most highly correlated with early weaning from the breast, none had to do with the mother's employment. The strongest correlation with early weaning was short interval to subsequent birth (*16*). In Yugoslavia, resumption of work as a cause for weaning was given by 5 percent of urban women and less than 3 percent of rural women (*40*). In Egypt, of the five causes that accounted for 99.6 percent of all weaning, working was not even mentioned. The single most common cause was, once again, another pregnancy (*41*). Even women who work far from home do not necessarily abandon breast-feeding, but may adapt patterns of breast-feeding to their new life-style and increase the practice of mixed feeding (*42*). The nature and pattern of women's work and its relation to infant health must be understood better before sweeping generalizations become entrenched in both the medical and public-policy literature.

Child Survival

The central piece in the puzzle of interacting biological and behavioral factors may well be child survival. Not only is the survival of offspring closely linked, behaviorally and biologically, to both nutrition and reproduction, but no other factor is so central to the quality-of-life issues that underlie the need for socioeconomic development. While there are many possible combinations of dietary patterns and population density that lead to satisfactory life-styles, there is no question that a high level of childhood mortality lowers the quality of life. Even in societies accustomed to high mortality and high fertility, the death of a

child is still a major blow that may cause deep but unexpressed grief (*9*).

Fifty percent of the children die before age 5 in parts of Africa, with protein and calorie malnutrition either the major or secondary cause of most of these early deaths (*43*); a major study of Latin America shows similar patterns of morbidity and mortality (*23*). These facts underline the urgency of learning what factors are associated with decreased or increased probability of child survival. As poor nutritional status seems to be a key determinant of childhood illness and death, one might legitimately ask what factors cause early childhood malnutrition.

Wray reported that children from larger families were more likely to be malnourished than those from smaller families (*7*). Greiner found similar associations with low weight for age in infants (*16*); the most significant correlate was weaning from the breast at an early age, and this was closely related to an early subsequent pregnancy. Also important were more living siblings and, independently, more dead siblings. The infants from larger families also had more diarrhea, a leading cause of death. In Colombia, the probability of malnutrition increased with birth order; not only were children from large families particularly at risk, but the later children in those families were most especially at risk. The ninth child in a family bore about twice the risk of malnutrition as the first child (*17*).

There is evidence from the long-term Khanna study in the Punjab that not only the number of children, but also their spacing significantly affected the risk of early mortality; more closely spaced children were more at risk of illness and death (*44*). Taylor *et al.* cite evidence that neonatal, infant, and second-year mortality were greatest when the birth interval was less than a year (*5*). Hueneman, in a study for WHO, examined the effects of high parity and short birth-spacing on poor health, and concluded that a short birth interval, on the whole, was more detrimental than high parity (*45*). Brown noted that increasing parity had its most detrimental effect on the child when combined with maternal malnutrition (*46*). The mother, of course, was most likely to be malnourished when she was subjected to repeated pregnancies and prolonged lactation without any reproduction-free interval. This cycle of steadily worsening maternal health was referred to by Jelliffe as the "maternal depletion syndrome," and contributes to low birth-weight in infants, poor performance in lactation, and high rates of morbidity and mortality (*47*).

It has long been conjectured that rates of childhood illness and death were not only influenced by, but also strongly influence, the number of children produced. From the observation in many countries that falling death rates generally preceded a fall in birth rates by a variable but substantial period of years, it was presumed that enhanced survival would eventually lead to a perception that fewer children were necessary per family to ensure any desired number of surviving offspring (the "child survival hypothesis"). This was postulated as a societal phenomenon; changes in perception of the risk of childhood mortality would relate to the overall social experience, not just to an individual's experience as a parent, and in fact, there is evidence that this is so (*48*). Studies in Africa showed a decreased desire for additional births as the rate of childhood mortality in the community lessened (*48*), and similar relationships between lowered fertility and lowered mortality have also been noted in the Philippines. (*7*).

There is also evidence that child mortality experience has a strong influence on the attitudes and behaviors of individual couples. In Bangladesh, studies have shown a positive relation between the death of a child and the probability of a birth in the following year; these factors were associated in both infant and early childhood deaths (*49*). The use of contraception was also postponed when women experienced a child's death (*5, 33*). Teitelbaum (*50*) reported on a study conducted in Cairo that indicated that, although upper-class women experienced the death of a child less often than did lower-class women, child loss still resulted in an increase in desired family size and fertility. When families experienced a relatively equal number of child deaths shortly after marriage, the tendency for more educated women to have fewer children ceased to exist. In the study, 63 percent of the mothers lost either the first or second child during the first 4 years of marriage. Since these child losses occurred early in the reproductive cycle, sufficient time remained for replacement effects to operate in all social classes (*50*).

Biological effects of early infant loss that increase fertility are also possible when breast-feeding is prolonged and practiced in such a way that lactational amenorrhea accounts for a significant amount of child spacing. In this case, an early infant death would end the mother's lactation and her protection from pregnancy. When most babies are breast-fed, however, malnutrition is unlikely to occur very early; babies who are not breast-fed contribute disproportionately to infant mortality rates, and the mothers of these babies are not biologically protected from ovulation in any case. Thus, the biological as opposed to the behavioral effects of infant mortality on fertility occur to an important extent only when (i) breast-feeding is common, (ii) breast-feeding is practiced in such a manner that it prevents ovulation, (iii) breast-feeding is prolonged, and (iv) when there is, nonetheless, a high level of early infant mortality among breast-fed babies. The circumstances in which all these conditions prevail must be fairly limited.

Very little information is available about the differential effects on fertility, if any, of childhood mortality in the neonatal, postneonatal, and early childhood periods; nor are there any data on whether the sex of the lost child bears any relation to the incentives for child replacement behavior. According to Taylor *et al.* (*5*), current knowledge suggests that the "child survival" effect is likely to be strongest in situations "where mortality is falling rapidly, where fertility decline has begun, and where family planning is becoming available." As these situations obtain in a greater and greater percentage of developing countries, improving child survival is likely to have effects in reducing fertility for increasing numbers of couples.

Policy

When politically responsible leaders are confronted with critical problems of health and nutrition, a demand for government action is generated. This, in turn, creates a need for some attempt at policy-making, from which several sets of predictable responses arise. One of these is for politicians and planners to turn to the scientific community for guidance in understanding real relationships and the proper paths for policy. The politically disengaged scientific community frequently answers that not enough information is yet available to make definitive assessments of the interactions of different variables. The next response is, then, a call for more research. Many scientists, intrinsically conservative in terms of deciding when the facts are adequate to prove the case, often resort to the argument that certainty of knowledge, from which one could, theoretically, create policy, has not yet been achieved. This argument is advanced

even though absolute proof is an impossible goal. Political and economic opponents of any advocated changes are, of course, happy to espouse the scientists' argument, extremely powerful in a technologically oriented society, that proof is not yet adequate, definitive, or sufficiently general to create policy.

The uncomfortable fact, however, is that more research on the interactions of specific biological and behavioral variables is unlikely to provide definitive answers from which proper policy will automatically flow. This is because there are so many intersections of biological and behavioral trends, so many distortions created by social, economic, and political factors, that understanding even some of the real relationships between any few factors is unlikely to predict the overall outcome of policy intervention in any given situation. Predicting the outcome of policy choices in a universal, generalizable fashion on the basis of individual biological and behavioral factors may be essentially impossible.

It appears that policy must be made not only on the basis of biological interrelations, but also from the perspective of very specific value judgments. In the areas of health, nutrition, and population, it may be necessary to return to traditional humanitarian and egalitarian values as a basis for policy designed to improve the quality of life and increase the real options available to human beings.

Athough there are clear, large-scale relationships between breast-feeding and infant health and breast-feeding and postpartum amenorrhea, problems exist in attempting to make use of research into specific biological mechanisms. There are at least five reasons why it is hard to base policy on any particular set of scientifically derived facts.

1) Scientific studies designed to elucidate basic interrelationships generally focus on one or two links in a chain of causality. This is done in order to create a very tight case for the influence of one variable on another. As a result, any given study is likely to deal competently with only a small portion of the interactions which affect and are affected by any set of policies. Policy is, of necessity, a more general tool than research, and covers a much broader set of interactions. This discrepancy cannot be overcome by joining together many separate studies to provide a panorama of biological and behavioral effects. Different assumptions, protocols, experimental populations, and research designs in the various studies make such a solution impossible. The interrelationships investigated by different scientists in different places at different times have not been developed to be stacked one on the next to produce a coherent edifice of answers to large biological and behavioral questions.

2) Intervening social, economic, and behavioral relationships may be more powerful in determining the outcome of changes in a biological system than the intrinsic biological relationships themselves. Sexual abstinence and intercourse taboos, for example, are sometimes more significant than lactational amenorrhea in preventing short birth intervals (*9, 28*). Mosley noted that coital frequency and nursing patterns were more important in determining the length of postpartum, pregnancy-free intervals in Bangladesh than the biological relationships determining ovulation, conception, and the ability to carry a pregnancy to term (*12*). Butz and Habicht, after examining the interactions between nutrition and health and their effects on fertility, came to the following general conclusion (*11*):

> For particular individuals the biological dependencies of fecundity and fertility on nutrition, health, and lactation, can vary a great deal. For groups of individuals, however, a negative relationship between health and nutritional status and fertility measures clearly emerges. It is therefore clear that behavioral factors are considerably more important at the population level.

3) There are too many potentially overriding biological relationships that may distort, obscure, or even reverse the conclusions reached by any one limited-focus study. In a recent paper (*51*), Knodel attempted to estimate the effect of decreased breast-feeding on infant mortality and fertility, and to estimate the net result of these effects on increased or decreased child survival to age 1. Unable to predict with precision changes in child survival due to decreased breast-feeding, Knodel noted that, in any case, in bottle-fed babies a net increase in survivors to age one might be completely negated by increased mortality in bottle-fed babies after age one—that is, child survival might appear increased at age 1, but decreased at some other arbitrary vantage point, perhaps age 5. Furthermore, this calculation gave no weight to the health and productive capacity of those who did survive, more of whom might have experienced malnutrition due to inadequate early feeding practices.

4) The relative weight of individual biological determinants in any given relationship may be time- and location-specific. As a result, similar biological changes may lead to opposite long-term effects in different circumstances. An example of this is the actual fertility outcome of interacting forces generated by the experience of child mortality. Singarimbun and Hull noted that in Java, behavioral and psychological motivations for increased fertility do operate in response to child loss (*9*). It appeared, however, that even with motivation to increase fertility, lower socioeconomic groups, whose deprivations included impaired health status, had a lowered ability to respond biologically and a much higher level of unwanted infertility. The net result in the specific situation of central Java, might be that high child mortality did not produce an actual increase in fertility although it might have increased the parents' desire for children. The very improvements in health services and standards of living which would decrease rural child mortality might, therefore, also increase fertility in this population; the behavioral motivation for fertility might become more translatable into the birth of children by improving the health of adults and their capacity for reproduction. In such a situation, decreased child mortality would, in fact, go hand in hand with increased levels of fertility. This effect would not belie the theory that decreased child loss decreases the desire for children; it would merely demonstrate that, in one specific environment, interrelationships operate in such a way as to produce a paradoxical outcome. A similar situation might be predicted for central Africa, where levels of infertility, probably secondary to gonorrheal infection in women, are estimated to be 30 percent or higher (*52*).

5) The meaning of any biological correlation may not be what it first seems. In Knodel's calculations, for instance, several different assumptions about the impact of declining breast-feeding on child mortality rates and fertility rates each predicted a small increase in the numbers of survivors to age 1 (*50*). This increased survival, however, was contingent on an even greater number of live births. One might initially predict that increasing the numbers of survivors to age 1 would have a dampening effect on fertility through the mechanism of the child survival hypothesis. However, many more children need to be born and to die to produce the small increase in survivors. Thus, if social perceptions of child mortality are important in initiating decreased fertility, the transition may never occur; along with more survivors there are also even more nonsurvivors, producing a higher mortality rate. The strength of the association between perception of child mortality and

fertility behavior could also vary greatly in the circumstances outlined. Any number from 1.6 to 8 more births for every one extra survivor could produce the same absolute number of increase in survivors to age one (*51*). These figures imply widely differing child mortality rates and perhaps widely differing incentives for reproduction. Thus, calculation of increased numbers of surviving children might not really tell anything about fertility motivation or fertility behavior, even in the face of well-documented child survival effects.

In addition to the problematic role of biological facts in determining policy choices, other important implications of interrelationships emerge.

1) Certain types of policy choices may have more payoffs than others. For example, any intervention which decreases the nutrition and health discrimination to which female children are subject is likely to have the most positive effects on the health status of mothers and children and on the consequent fertility reduction. For example, the Promotora program in Colombia, designed as a health delivery system for rural areas, treated male and female children equally. The evaluation of the program showed that malnutrition decreased 12 percent in boys, but 31 percent in girls, among whom the problem was initially much more prevalent (*17*).

2) It may be possible, through deliberate policy, to reinforce social perceptions of intrinsic relationships that have been elucidated by research. This idea is endorsed by Taylor *et al.* (*5*) who advocate that social and psychological recognition of reduced risk of child mortality can be enhanced by integrated program designs, thus encouraging the trend toward reduced fertility.

3) Butz and Habicht concluded that, since behavioral factors seem overriding in determining the outcome of nutrition and population interactions, policy may be best facilitated by introducing changes in the environment to create social "disequilibria" (*11*). In theory, this would force changes in social values and demands; for example, if one created a new social situation that suddenly placed a premium on better nourished children, the demand for nutrition and health services would increase. In point of fact, the clash of modernizing technologies, institutions, and social forces with traditional modes of life is a common occurrence in developing countries, reaching farther into the hinterlands daily. Fewer and fewer are remaining untouched by the distortions of "development." It may be possible, therefore, to utilize disequilibriums already introduced into social systems to reinforce desired changes and to teach communities to recognize and demand opportunities for improved quality of life.

4) Policy should not be based on mythology. This seems especially important when considering attitudes toward breast-feeding. The often stated construct in which women's careers and lifestyle aspirations conflict with the best interests of their children is an unfair, perhaps demoralizing, and totally unsubstantiated assertion. Ironically, it is one frequently made by policy-makers and scientists who normally demand a much more careful reading of the evidence before they are willing to draw sweeping conclusions. In this instance, however, it has been acceptable to make far-reaching pronouncements with very little evidence. The facts that exist clearly imply that breast-feeding per se is not incompatible with the role of a modern woman in a modern society. When policy choices have been made that favor breast-feeding, and support for those policies has been forthcoming from government, the extent and duration of breast-feeding is impressive.

Finally, it should be apparent that as interventions designed to affect the health of populations become more and more the extended province of a whole series of professionals, including economists, sociologists, administrators, government planners, and politicians, all ought to be bound by the injunction traditionally reserved for the medical profession: "First, do no harm." If we are going to tamper with relationships fundamental to health, reproduction, and survival, this must be done in congruence with humanitarian and egalitarian ends, and not merely on the basis of some long path of biological associations of whose predictive value we are basically uncertain. The promotion of child survival must be recognized as an intrinsic good, and the powerful capability of breast-feeding to further that end should ensure that it, too, receive the concerted attention of all who hope not only to do no harm, but to effect tangible benefits for health, nutrition, and human well-being.

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tion and reproduction. Other considerations are whether the dividing lines between high, medium, and low nutritional status in these studies were chosen in a way that revealed true functional differences, and whether the range of nutritional states represented by the study groups were wide enough; that is, were enough well-nourished women included to demonstrate within-group nutritional effects on reproductive capacity?
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Immunization Against Infectious Disease

Active immunization programs are endangered by complacency and litigation.

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The purpose of this article is to examine the current status of immunization against infectious diseases in man, including the relative importance of immunization in the control of infectious disease in the United States in this century, the efficacy and safety of vaccines, present problems with immunization programs, and prospects for the future.

Types of Immunization

There are two basic forms of immunization, passive and active. Passive immunization is the process by which whole serum or the antibody-containing fraction of serum from a human or animal known to be immune or hyperimmune to the disease in question is administered to a susceptible host. Passive immunization is of use only when exposure has just occurred or is imminent within the next few days or weeks, for the reason that the antibody proteins transferred from one individual to another are gradually broken down over a period of weeks or at the most a few months, and disappear. After their disappearance, the individual is again susceptible to the disease.

Passive immunization has been useful in the prevention of a few diseases. The administration of human immune serum globulin to a susceptible individual who has been exposed to measles or to hepatitis A is associated with clear-cut protection. Some protection is also afforded against hepatitis B and against poliomyelitis. Antitoxin made in horses and in man has some effect in preventing tetanus in a susceptible individual with a tetanus-prone wound, and it is likely that diphtheria antitoxin offers some protection against that disease. In other conditions the benefits of passive immunization are less clear.

Active immunization is the induction of an individual's own immunity by inoculation with the offending organism or some part or product thereof that has been treated in such a way as to induce clinical immunity without producing the full-blown disease. For five reasons active immunization is superior to passive immunization. First, the duration of protection, like that of the natural diseases, is frequently lifelong. With others, length of immunity is measured in years requiring infrequent booster inoculations for maintenance of protection. Second, protection is ever present and does not require recognition of exposure (in up to 50 percent of cases of tetanus in the past the inciting wound was unnoticed or too trivial to warrant attention). Third, with few exceptions serious reactions to active immunization are rare. With animal serums employed in passive immunization, serum sickness is frequent and immediate anaphylactic shock occasionally occurs; even with products of human serums anaphylaxis has been reported. Fourth, the protective efficacy of active immunization exceeds that of passive immunization, and in many instances approaches 100 percent. Fifth, active im-

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