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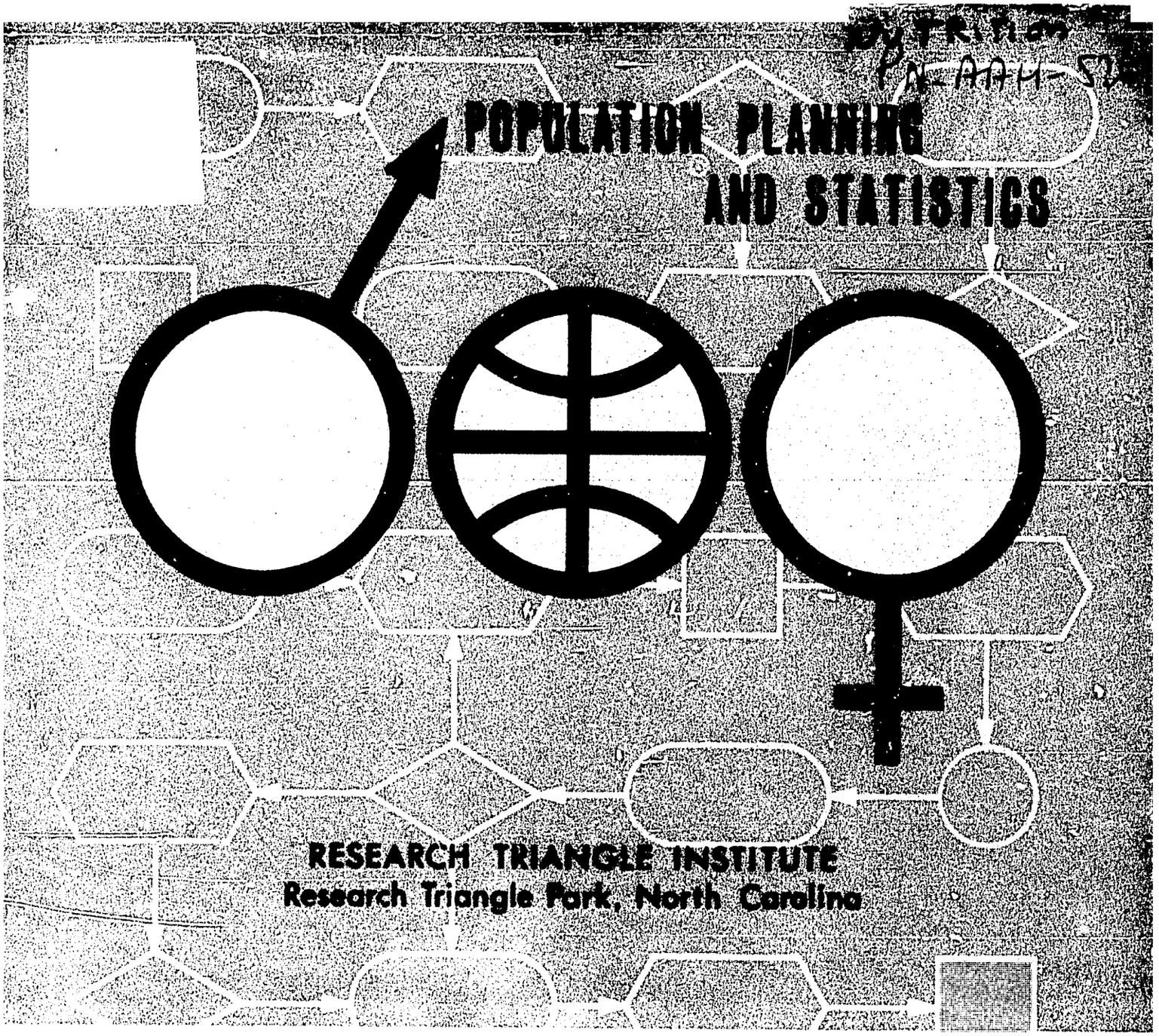


# TOPICAL INVESTIGATION AND ANALYSIS OF NUTRITIONAL SUPPLEMENTS IN FAMILY PLANNING PROGRAMS IN INDIA AND PAKISTAN

FOR NEAR EAST-SOUTH ASIA OFFICE OF POPULATION PROGRAMS
UNDER UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
CONTRACT NESA-460 OCTOBER 1970

PN-AAH-576

# REPORT ON TOPICAL INVESTIGATION

# AND ANALYSIS OF NUTRITIONAL SUPPLEMENTS IN

# FAMILY PLANNING PROGRAMS IN INDIA AND PAKISTAN

by

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# FOREWORD

This report is one of a series summarizing the analyses conducted by the Research Triangle Institute at the request of the Office of Population Programs, Near East-South Asia region (NESA/OPP), U. S. Agency for International Development. The format of each report is the same. It consists of two parts: a Summary and a Technical Report. The Technical Report provides greater analytical detail and documentation of secondary data searched under this work order. All supporting data, including extensively documented computer programs, can be requested through NESA/OPP.

Each report is based upon a modified systems analysis initiated by NESA/OPP for the purpose of dealing with operational questions faced by decision makers in the field.

Modified systems analysis means that the problem or question is first carefully structured, within a framework of relevant theory, pinpointing the hypotheses to be tested and the information required for testing. If the problem is complex, encompassing more than one hypothesis and entailing assemblage of a variety of information, the structuring must be sequential. Those hypotheses, the validity of which underpin the significance of others, are taken first, with the most critical heading the list. If, in proceeding sequentially through the list, evidence cannot be found to support an hypothesis in the sequence, the succeeding hypotheses would not be examined since a critical point upon which they depend does not hold.

Constraints of time and resources are imposed upon the analysis, for decision makers need results promptly and efficiently. To meet such

constraints, the analyst must answer the crucial question of whether or not it is cost-effective to refine the analysis further or to use more elaborate techniques. Thus, the information search cannot be exhaustive but rather is directive since it proceeds as far as needed to test the sequentially stated hypotheses.

Work Order SU-509

Title: Nutritional Supplements in Family Planning Programs in India and Pakistan

Approved by: A L Finkner

A. L. Finkner, Director
Statistics Research Division

## ACKNOWLEDGMENTS

Throughout the course of this project counsel and assistance has been given willingly and generously by staff of the U.S. Agency for International Development, Near East-South Asia Bureau and its component country desks. In particular, we wish to recognize the participation of Dr. R. Wade Jones and Mr. Michael Reardon of the NESA Office of Population Programs in formulating and advancing the project.

The two primary project consultants, Drs. Carl E. Anderson and Abdel R. Omran, of the School of Medicine and the School of Public Health, respectively, at the University of North Carolina at Chapel Hill, entered vigorously into development and execution of the research from the time of the first responses to NESA requests. Dr. Anderson prepared the basic material on nutritional status of the target populations. Dr. Omran developed the material on levels and causes of infant mortality and on the interrelations of infant mortality and fertility. Both were active discussants of the total report.

Other specialists with whom project results were discussed include Mr. W. Parker Mauldin, Vice President, The Population Council; Dr. John E. Gordon, Department of Nutrition and Food Science, Massachusetts Institute of Technology; Dr. Arnold E. Schaefer, Health Sciences and Mental Health Administration, National Institutes of Health; Dr. Carl Taylor, Johns Hopkins University, Dr. Aaron M. Altschul, U.S. Department of Agriculture, and the late Dr. Harold Frederiksen, U.S. Agency for International Development. Each of these persons graciously considered the approach and conclusions of this research and offered helpful criticisms.

Within the Research Triangle Institute numerous members of the staff assisted in one or another phase of the project, but particular note should be made of the contributions of Mrs. Eva Gerstel to the review of KAP studies and to the search for material on nutrition as a type of incentive to promote traffic at family planning clinics, of William Serow on vital rates in the Indian population, of Mrs. Dale Palmer on organizing the manuscript, and of several capable typists. The project director, Dr. Abraham David acted as a continuing source of support and strength to insure that the research moved ahead effectively.

# SUMMARY

## A. Purpose

Several propositions have been advanced linking nutrition interventions, especially through infants and mothers, to increased demand for family planning services and thence to reduction in fertility and population growth. Three propositions are central to the problem:

1) Where infant, child, and maternal nutrition is poor, improvement of their nutrition will reduce infant and early childhood mortality. This increase in survivorship motivates parents to reduce the number of births desired.
2) Where infant, child, and maternal nutrition is poor, providing free nutrition supplements at family planning clinics is an incentive that will increase the number of visitors to clinics, thus increasing contacts with "potential clients." This, in turn, will increase the number of family planning acceptors.
3) Where maternal nutrition is poor, improvement of nutrition, which reduces infant mortality, will lengthen the birth interval, which in turn will act to reduce birth rates in a given period to a limited extent.

The main objective of this study is to structure and test the functional relationships that might lead to acceptance or rejection of the above-stated basic propositions. Countries of the Near East - South Asia region comprise the environment within which this study is structured. The desired results of this study are the identification and evaluation of the relationships among nutrition, infant and child mortality, fertility and fertility control programs. The purpose is to show the effects on fertility and rate of population growth that might be expected from programs of nutrition intervention linked to family planning programs.

## B. Methodology

Methodology, as used in this investigation, refers to the systematic structuring of the problem to accomplish the objectives stated above. One method for structuring the complex relationships found in many human situations is through systems of equations. Sometimes it is helpful to outline such systems even while recognizing that all the needed data are not at hand. This has been done and is presented in the Technical Report. In addition, a simplified demographic model was developed and used to evaluate the short and long run demographic impacts of such policy.

Consistent with the methodology used, the specified objectives were met through formulation and testing of the four main hypotheses given below. The results of the analyses are presented in the context of the stated hypotheses.

## C. Hypotheses and Conclusions

This investigation makes the following assumptions about the people and fertility:

1) People act rationally in pursuit of what they perceive to be their best interest.
2) People will adopt family planning measures when:
   a) They do not <u>desire</u> another child immediately (or ever)
   b) They <u>know</u> that births can be controlled, safely, etc.
   c) They have <u>access</u> to acceptable, actual information and supplies, unimpeded by constraints of money, time, travel, etc.

It follows, then, that when family planning is not adopted it is because <u>another child</u> is wanted, or <u>knowledge</u> of family planning benefits is lacking, or there are <u>barriers</u> to acquiring the needed information and supplies for acceptable methods. The present investigation is concerned primarily with the first of these conditions, secondarily with the second, and not at all with the third.

A total of nine hypotheses were advanced and sequentially investigated. The hypotheses and results are detailed in the Technical Report, but are grouped into the four main hypotheses in this summary for brevity. Hypothesis four actually brings the three main hypotheses together in an effort to

quantitatively assess the net impact of the three main hypotheses on family planning objectives.

Hypothesis 1. Nutrition and Births

a) Desire for another child is directly related to the difference between desired family size and the number of surviving children. Thus, the higher the probability of survival of a newborn infant, the lower the desire for another child, other things being equal.

b) Desired family size is directly related to child and infant deaths experienced personally or anticipated from the experience of others, other things being equal.

c) Infant and child mortality is inversely related to nutritional level other things being equal.

Conclusions:

At the aggregate level it has been shown the reductions in infant mortality precede, rather than follow, reductions in birth rates. There is some evidence that the lag in decline in fertility following a decline in infant mortality is as little as one or two decades in some cases.

It has also been shown that low levels of nutrition during infancy and early childhood are associated with a distinctive pattern of death by cause as well as a rate of mortality that is substantially above the level found in areas where nutrition is adequate. Thus, it may reasonably be concluded that poor nutrition contributes to high levels of infant mortality.

Moving from the aggregate level to that of the individual couple, the data found on acceptors of family planning indicates that they have, by and large, reached or exceeded their desired family size and are therefore "ready" for family planning. Moreover, limited analysis of couples experiencing infant and child mortality suggests that those experiences may cause them to increase the size of the family they desire. Although little work has been done on it, it appears that couples do perceive changes in infant and child mortality.

Desired family size appears to also include desires as to the sex composition of offspring. A number of analyses indicate that fertility behavior in several countries, and India in particular, is entirely consistent with the hypothesis that families wish to be assured of having one or two sons who will survive the father (or even both parents).

Hypothesis 2. Knowledge of Family Planning and Nutrition

a) Knowledge of family planning is directly related to the amount of contact an individual has with a family planning clinic.

b) Contact with family planning clinics is directly related to being a family planning acceptor or to having other reasons for visiting the clinic.

c) The availability of a nutrition supplement at a family planning clinic is sufficient to induce a substantial number of non-family planning acceptors to visit the clinic. Some of those so exposed to increased knowledge of family planning will begin practicing it.

Conclusions:

It has been assumed in this study that a couple must know about family planning before they can decide to practice it. This study has, therefore, been concerned with whether making the distribution of a nutrition supplement to family planning clinics could increase the adoption of family planning. The answer appears to be yes, but only insofar as the other necessary conditions for adoption of family planning are met: namely, that a couple not desire another child at a given time and that access to the family planning clinic not be constrained by money, time, travel, etc. Granted the widespread nature of malnutrition, it is believed that couples would accept a nutrition supplement that was consistent with their dietary preferences. In the process of obtaining such a supplement at a family planning clinic and given a suitable promotion program at the clinic, they would increase their knowledge of family planning but would only accept it when they had no desire for another child at that time. Because the nutrition supplement would be likely to reduce infant and early childhood mortality over a period of years, it is expected that the distribution of such a supplement would, in time, increase the proportion of couples who desired no additional children at a given time and that thus, indirectly, the supplement given at family planning clinics would lead to increased practice of family planning--but only insofar as it was consistent with the achievement of desired family size.

Hypothesis 3. Nutrition and Fecundity

Fecundity, as a biological function necessary to the survival of the species, will be relatively insensitive to level of nutrition. Impaired fecundity can be classed as effects on fetal wastage--including spontaneous abortions and stillbirths, on infant mortality--especially the neonatal part, and on capacity to conceive.

Conclusions:

Improvements in nutrition where it is presently inadequate would doubtless lead to a larger number of fertile years and a lower incidence of fetal wastage and perinatal mortality by reducing the number of premature and low-birth-weight babies. Thus, fecundity--in demographic usage the capacity to conceive and bear a living infant--would be somewhat increased by improving the nutrition of poorly-nourished women.

In view of the high fertility prevailing in many areas now experiencing poor nutrition, however, it is not anticipated that improvements in maternal nutrition would greatly increase observed fertility. Their most immediate effect appears likely to be an increase in the efficiency of reproduction, so that fewer pregnancies are required to achieve a given family size.

During the postnatal period improvements in nutrition will increase the probability that mothers will have the capacity to nurse and otherwise maintain their babies in good health, thus lengthening the period between successive births. This, in turn, results in some reduction in the birth rate.

Insofar as improved maternal nutrition reduces the frequency with which parents experience a stillbirth or lose an infant or child, improved nutrition could be expected to work through the route of reduced experience with infant or child deaths to lower the desired family size.

Hypothesis 4. Balance Between Decreased Child Deaths and Lowered Fertility

The net impact of nutrition intervention will be to raise the rate of population growth in the short run (1-10 years), but this can be counteracted in the longer run by declining birth rates among families reacting to achievement of their desired family size as a result of lowered infant and child mortality, changes in fecundity and increased contacts with family planning clinics.

Conclusions:

A simple analytical system was developed to measure the effect of decreased early childhood mortality and decreased fertility upon overall population growth. The results are depicted in Figure A. Briefly, the results were that substantial reductions in infant and early childhood mortality could occur with minimal effect upon population growth for a period of up to 20 years and that reductions in fertility levels beginning a decade after reductions in early life mortality could more than offset increases in population attributable to the lower mortality levels.

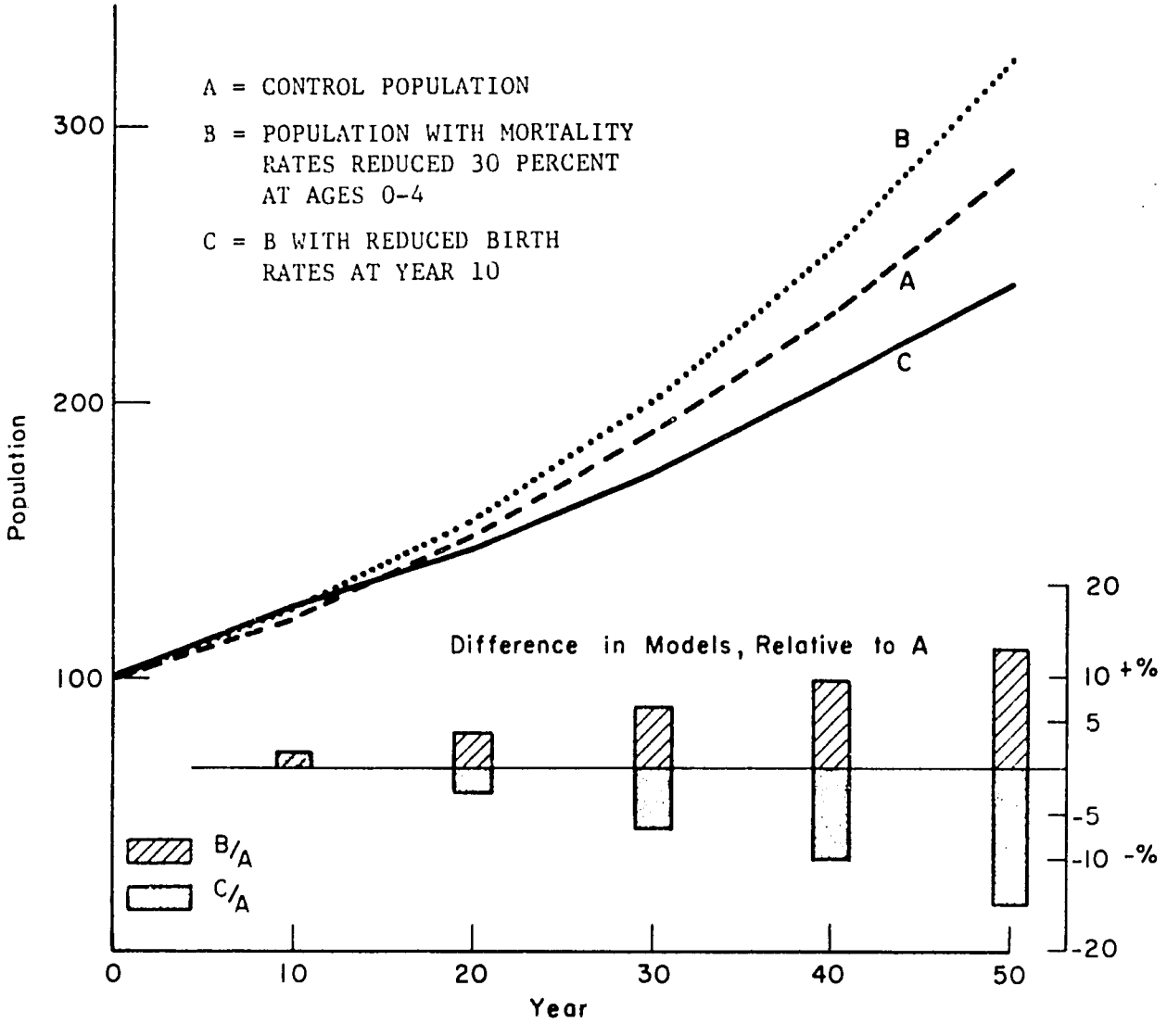


Fig. A. Relative Size of Total Population Under Assumed Declines in Infant Mortality and Subsequent Decline in Birth Rate.

No attempt has been made to separate the effect on birth rates of changes resulting from reduced early life mortality and those that might occur from the increased exposure of families to knowledge of family planning through the distribution of nutrition supplements at family planning clinics. These variables could be treated in a more sophisticated model, especially when empirical data on distribution of such supplements becomes available. Such an analysis might utilize a microsimulation model such as POPSIM, which has been developed and placed in operation at RTI.

The salient point from the modeling exercise is that significant reductions in early life mortality have relatively small impacts on total population growth for some 15 or 20 years. Such a time period is a rather long one in terms of the changes that might be brought about by family planning programs which are undergoing rapid change in both techniques and effectiveness.

## D. Recommendation

As a result of the foregoing investigation, it is recommended that nutrition intervention can be an effective means for reducing infant and early childhood mortality. It will not increase population growth substantially during the short term and it appears to be at least a precursor, and quite possibly a necessary condition, of substantial decline in fertility in less-developed countries.

It is noted, however, that since malnutrition is widespread in the target populations, substantial amounts of resources may be required--either to provide the necessary materials or to reallocate existing nutrients in the most effective manner. Moreover, nutrition interventions are but one program technique. Best results can usually be obtained by combining programs. In this case program efficiency would doubtless be improved if sanitation--to control intestinal parasites--and child health were linked with the nutrition intervention. Thus attempts to evaluate the cost-effectiveness of nutrition interventions can best be developed in conjunction with analyses of the relationships between family planning and health programs.

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# I. INTRODUCTION

## I.1 Background of the Problem

The Office of Population Programs, Bureau for Near East-South Asia of the Agency for International Development, with the general goal of reducing both period and cohort fertility and with limited resources at its command, wishes to evaluate the effectiveness of selective nutritional supplements for children and/or mothers as a policy instrument to influence rates of acceptance and continuance of contraception in the population of its service area. NESA/OPP further specifies primary concern with the nutritional status of the target populations and with the interrelations between nutrition and fertility, both immediate and long range. The desired results of this study are the identification and evaluation of the relationships among nutrition, infant and child mortality, fecundity, fertility, and fertility control programs for the purpose of showing what effects on rate of population growth might be expected from programs of nutrition supplements linked to family planning programs.

Three propositions are central to the problem:

a) Where infant, child, and maternal nutrition is poor, improvement of their nutrition will reduce infant and early childhood mortality. This increase in survivorship motivates parents to reduce the number of births desired.

b) Where infant, child, and maternal nutrition is poor, providing free nutrition supplements at family planning clinics is an incentive that will increase the number of visitors to clinics, thus increasing contacts with "potential clients." This, in turn, will increase the number of family planning acceptors.

c) Where maternal nutrition is poor, improvement of nutrition, which reduces infant mortality, will lengthen the birth interval, which in turn will act to reduce birth rates in a given period to a limited extent.

## I.2 Objectives

The main objective of this study is to structure and test the functional relationships that might lead to acceptance or rejection of the above stated basic propositions. The specific objectives include:

a) To seek quantitative estimates of the effects over time of reduced infant and child mortality upon fertility.

b) To seek quantitative estimates of changes in infant mortality resulting from reduced or altered patterns of fertility.

c) To identify causes of infant and child mortality that are associated with poor nutrition and seek data on number and rates of death from those causes.

d) To estimate the balance of positive and negative effects on fecundity of improvements in nutrition.

e) To estimate reductions in number and rates of death that might be associated with nutrition supplement programs.

f) To identify the role of a nutrition supplement program as an incentive for mothers to visit family planning clinics and to accept and continue using birth control.

## I.3 Methodology and Procedure

A total of nine hypotheses were advanced and investigated sequentially consistent with the overall approach to modified systems analysis. The hypotheses and results are detailed in Chapter II, but are grouped into four main hypotheses here. These main hypotheses are:

1. Nutrition and Births

   a) Desire for another child is directly related to the difference between desired family size and the number of surviving children. Thus, the higher the probability of survival of a newborn infant, the lower the desire for another child, other things being equal.

   b) Desired family size is directly related to child and infant deaths experienced personally or anticipated from the experience of others, other things being equal.

   c) Infant and child mortality is inversely related to nutritional level, other things being equal.

2. Knowledge of Family Planning and Nutrition

a) Knowledge of family planning is directly related to the amount of contact an individual has with a family planning clinic.

b) Contact with family planning clinics is directly related to being a family planning acceptor or to having other reasons for visiting the clinic.

c) The availability of a nutrition supplement at a family planning clinic is sufficient to induce a substantial number of non-family planning acceptors to visit the clinic. Some of those so exposed to increased knowledge of family planning will begin practicing it.

3. Nutrition and Fecundity

Fecundity--in demographic usage the capacity to conceive and bear a living infant--will be somewhat increased by improving the nutrition of poorly nourished women. During the postnatal period similar improvements in nutrition will increase the probability that mothers will have the capacity to nurse and otherwise maintain their babies in good health, thus lengthening the period between successive births. This, in turn, results in some reduction in the birth rate.

4. Balance Between Decreased Child Deaths and Lowered Fertility

The net impact of nutrition intervention will be to raise the rate of population growth in the short run (1-10 years), but this can be counteracted in the longer run by declining birth rates among families reacting to achievement of their desired family size as a result of lowered infant and child mortality, changes in fecundity and increased contacts with family planning clinics.

The hypotheses may be structurally represented through a system of equations. Sometimes it is helpful to outline such a system even while recognizing that all the needed data is not at hand. The following discussion presents one manner of structuring the interrelationships between nutrition and fertility. These equations have been simplified to focus on the variables being investigated in this study. The omission of other variables is indicated by ". . . ".

Change in population results solely from births and deaths when net migration is zero.

$$\Delta P = (B - D, \mid M = 0) \tag{1}$$

Births are a function of the desire for another child (DFAC) and knowledge of family planning (KFP), when other factors are unchanged.

$$B = f(DFAC, KFP, \ldots) \tag{2}$$

$$DFAC = f(DFS - SC), \ldots) \tag{3}$$

$$DFS = f(CD, \ldots) \tag{4}$$

Since it can be shown that deaths of infants and preschool children (CD) from certain causes are much more likely to occur among individuals who are poorly nourished, it is reasonable to write

$$CD = f(1/N, \ldots). \tag{5}$$

The foregoing set of equations links nutrition to deaths in early life and these in turn to desired family size and desire for another child which leads directly to additional births. If a couple does not desire another child, however, it is necessary that they have knowledge of family planning (KFP).

$$KFP = f(CC, \ldots) \tag{6}$$

$$CC = f(FPA, O, \ldots) \tag{7}$$

$$O = f(N, \text{other incentives}) \tag{8}$$

This set of equations shows the potential role of nutrition as an incentive that would bring families into contact with information about family planning.

$$D = (CD + \text{other deaths}) \tag{9}$$

Deaths are, by definition, the sum of child deaths plus all other deaths.

The variables employed in the foregoing equations are defined as follows:

$\Delta P$ = change in population between two time periods,

B = number of births,

D = number of deaths,

M = number of net migrants, which are of relatively little signifance for large populations, such as those of nations,

DFAC = desire for another child,

KFP = knowledge about family planning,

DFS = desired family size,

SC = number of surviving children,

CD = child and infant deaths experienced personally and anticipated from the experience of others,

N = nutritional level,

CC = contacts with family planning clinics,

FPA = number of acceptors of family planning,

O = other persons who come to family planning clinic.

The nature of the relations being sought between variables is shown in Figure 1. Nutrition in the target population is presently low and mortality is high (e.g., point A in Figure 1A). It is hypothesized that an increase in level of nutrition would shift the status of the population from A to B on the curve if the hypothesis is correct.

In Figure 1B, with infant and child mortality high, fertility will also be high (e.g., point F on curve A). A reduction in mortality from F' to G' might be accompanied by relatively little reduction in fertility (to G" from F") in the current period, but over time (curves B and C) larger reductions in fertility might be expected (to H" from G") even in the absence of further reductions in infant and child mortality.

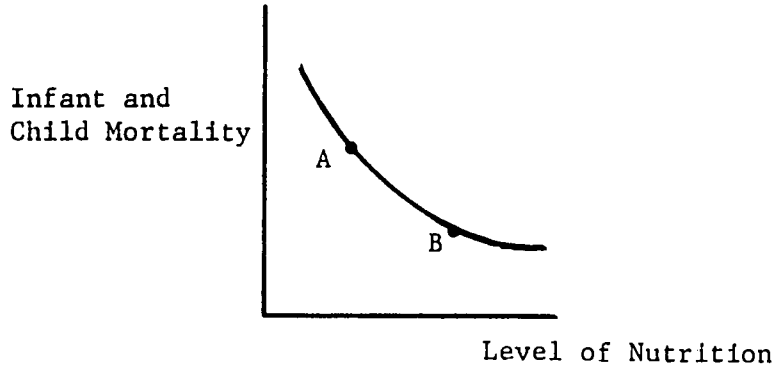
Figure 1C shows the expected relationship between nutrition and rate of population growth, both immediately and over time.

The approach for testing the several hypotheses to be investigated is outlined in Figure 2, the Flow Diagram of Work Elements. The possible inverse relation of nutrition to infant and child mortality was investigated first. Simultaneously, effort was directed to an investigation of nutrition as an incentive to adoption of family planning, and to the effect on fecundity of changes in nutritional status of mothers. Given the inverse relation of nutrition and infant and child mortality, it was planned that work proceed by two paths:

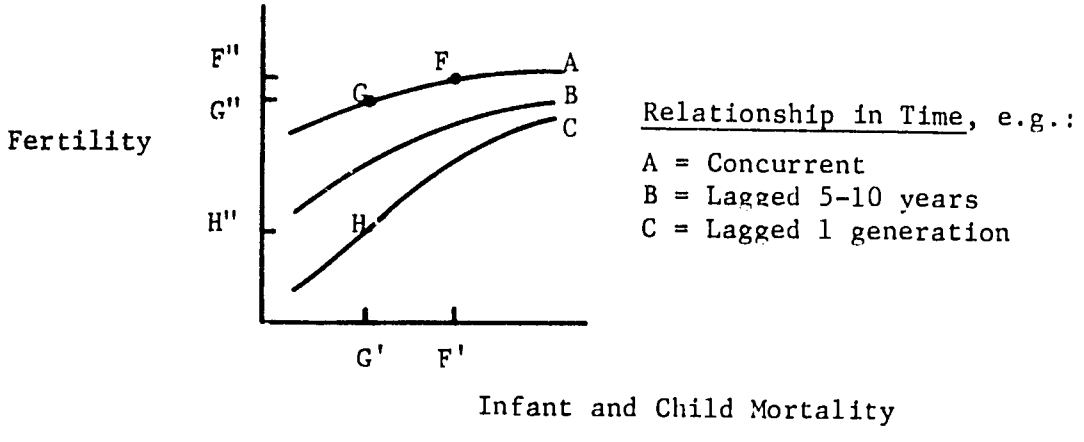
First, toward investigation of the relation between the level of infant and child mortality and fertility.

Second, toward identification of the specific causes of death that may be attributed to nutrition and toward estimation of the number of

A




B

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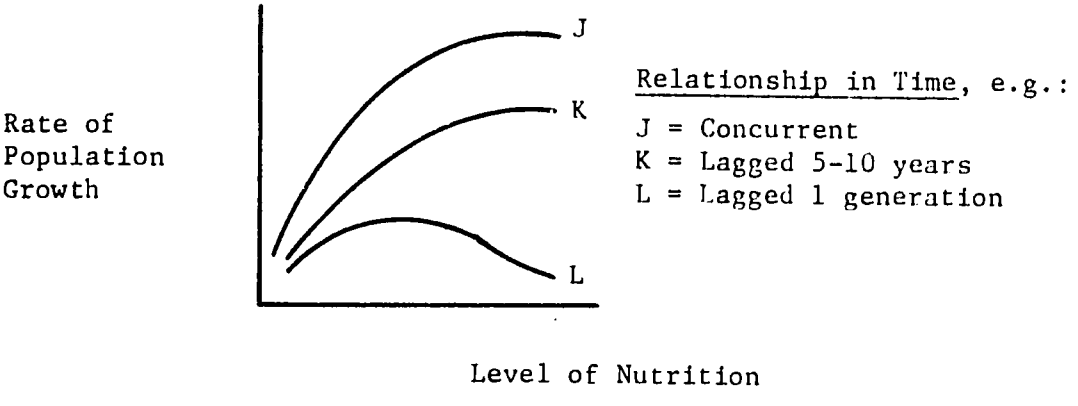


Figure 1. Diagram of Relations among Variables

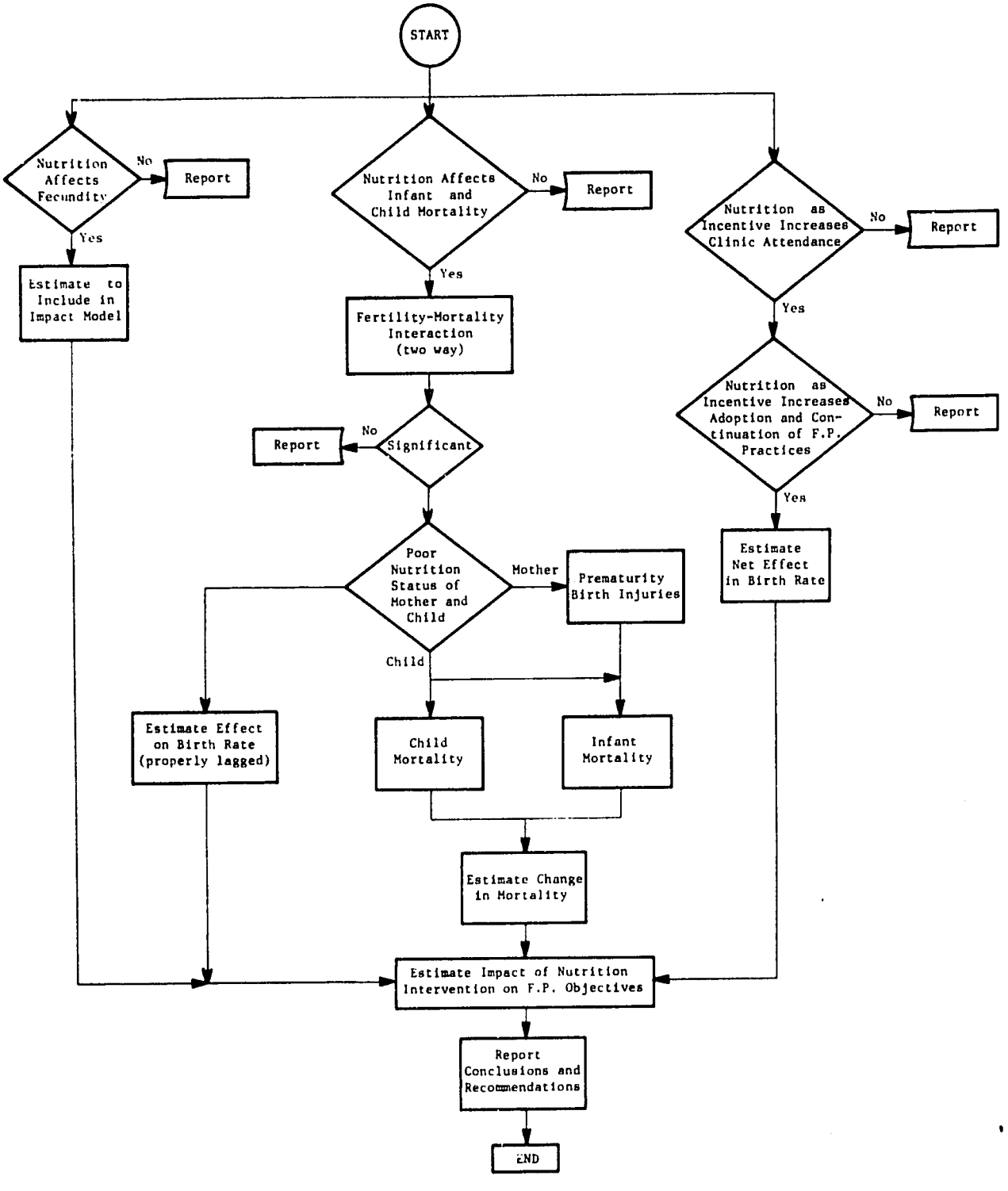


Figure 2. Flow Diagram of Work Elements

deaths that might be prevented by given changes in nutrition, via a nutrition supplement program.

The net impact of nutritional intervention on population growth rate would be observed after estimates of the positive and negative impacts of changes in infant mortality and fertility levels have been made. Changes in fertility levels are mainly due to increased desire for birth planning as a result of reduction in infant mortality; increase in clinic attendance is due to nutrition incentives and the resultant improved maternal health. This is also represented in Figure 2 where the three main prongs of the methodological approach are brought together at the modeling step, and conclusions are drawn about the nature of the relationship between nutrition and rate of population growth.

# II. RESULTS

This section reports the findings of this study about the several areas investigated. The four main hypotheses have here been separated into nine logical hypothesis areas.

## II.1 Aggregate Data on Birth Rates and Child Deaths

### Hypothesis II.1(a)

A decrease in birth rates is associated with a decrease in infant and preschool child mortality.

The history of major populations consistently shows declines in infant (and total) mortality and subsequent declines in birth rates over time. The reductions in mortality are attributed primarily to improvements in nutrition, increased stability or agricultural output, and secondarily to improvements in sanitation and health services. The reductions in fertility are attributed to changes in desired family size resulting from alterations in the economic and social structure (Thomlinson, 1965:15).

Examples of declines in infant mortality and fertility for Sweden, Chile, and Japan are shown in Figures 3, 4, and 5. The data vary in time spanned and in reliability, but do exemplify the decline in mortality followed by decline in fertility.

Changes in birth rates are a function of previous changes in death rates. Frederiksen (1966), using data from Ceylon, Mauritius, and British Guiana, examined the correlation between relative change in birth rates and relative change in crude death rates during a preceding period. He concluded that there were significant correlations, which generally diminished as the period of birth rate change grew more distant from that for death rate change. Since the comparisons were made among districts within each country, the more flagrant problems associated with inter-country comparisons were minimized in this comparison. (Although crude death rates were used, it should be recognized that such rates are closely related to levels of infant and early childhood mortality). Frederiksen also found high correlations between the rate of natural increase and subsequent relative changes in birth rates: "The districts with the

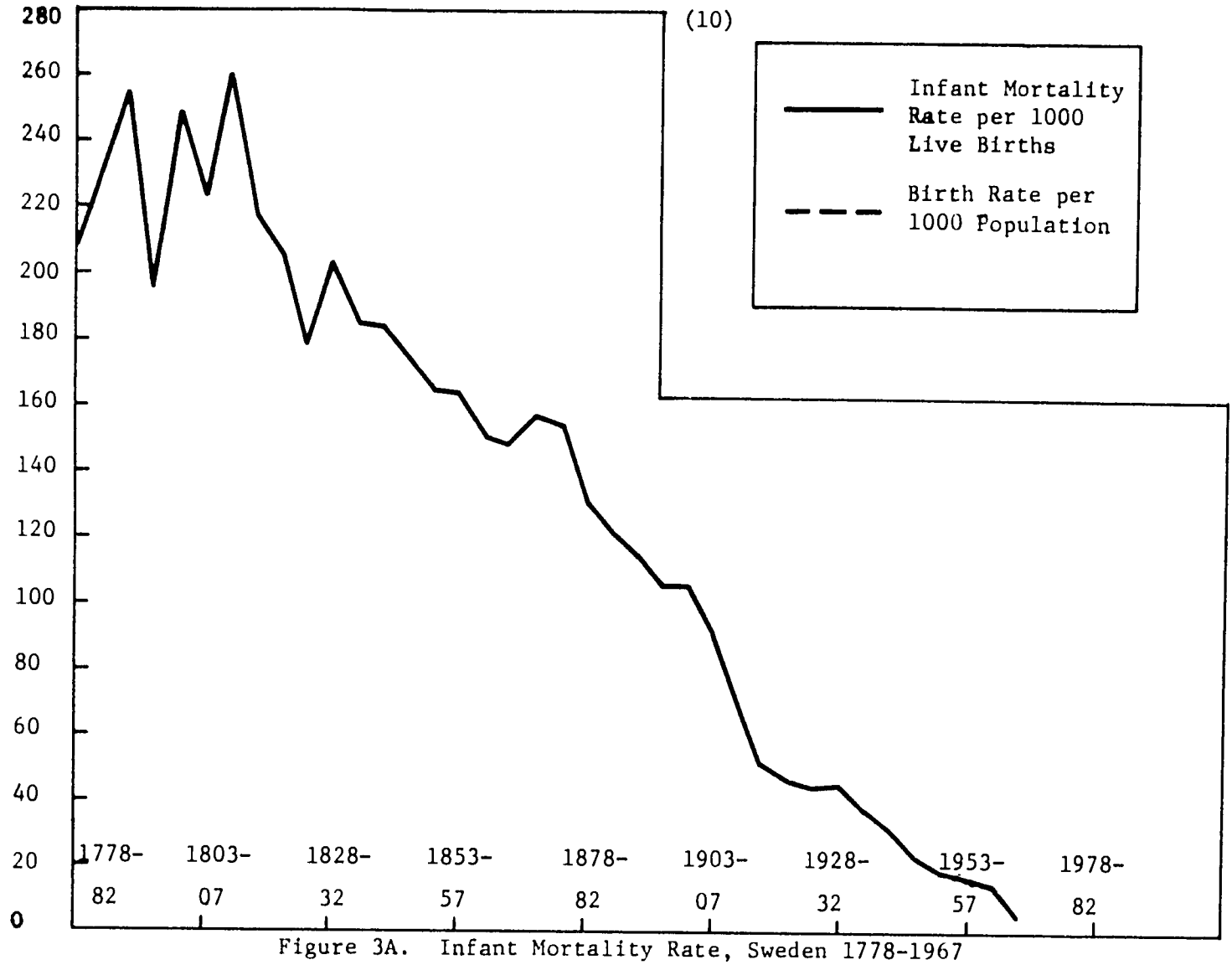


Figure 3A. Infant Mortality Rate, Sweden 1778-1967

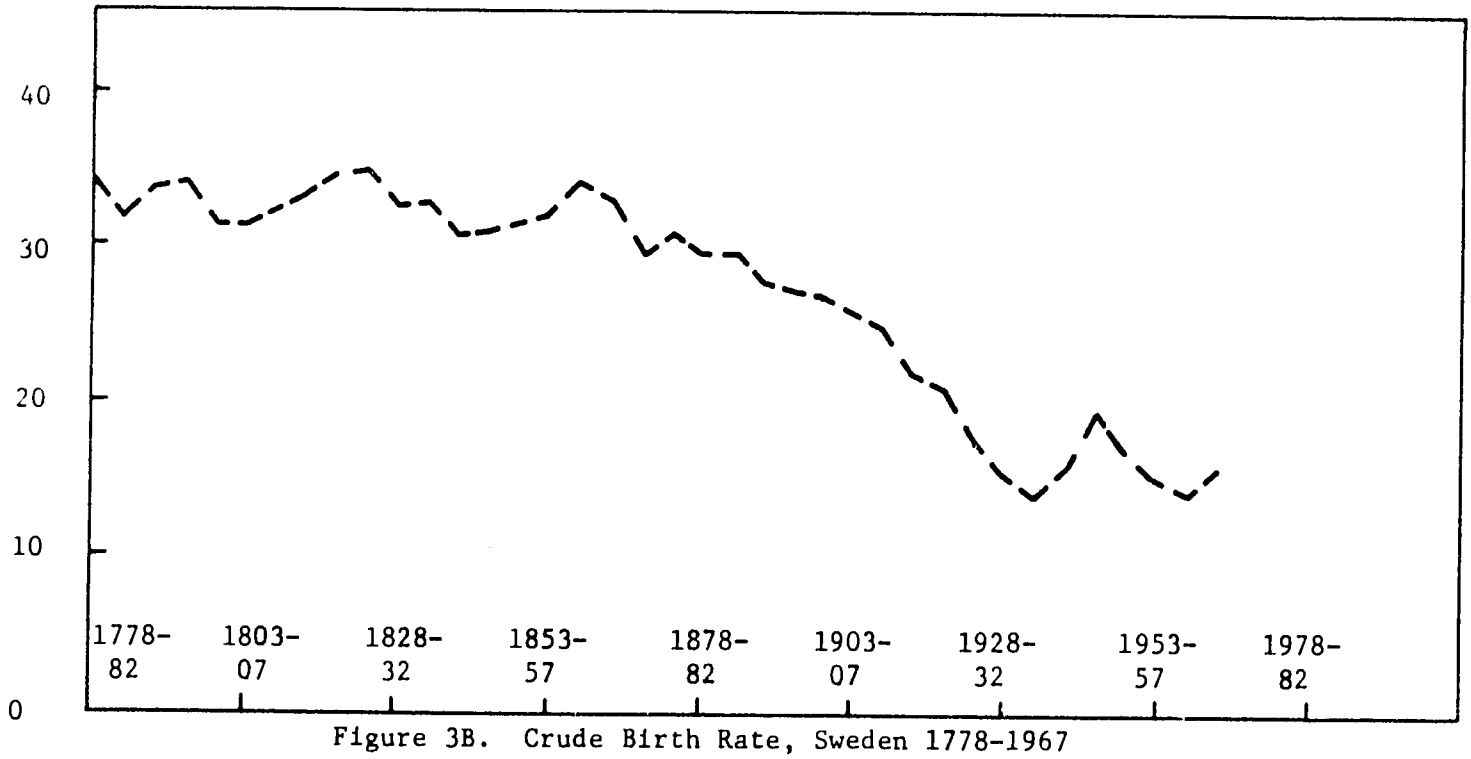


Figure 3B. Crude Birth Rate, Sweden 1778-1967

Source: Keyfitz & Flieger, 1968: pp. 36-37.

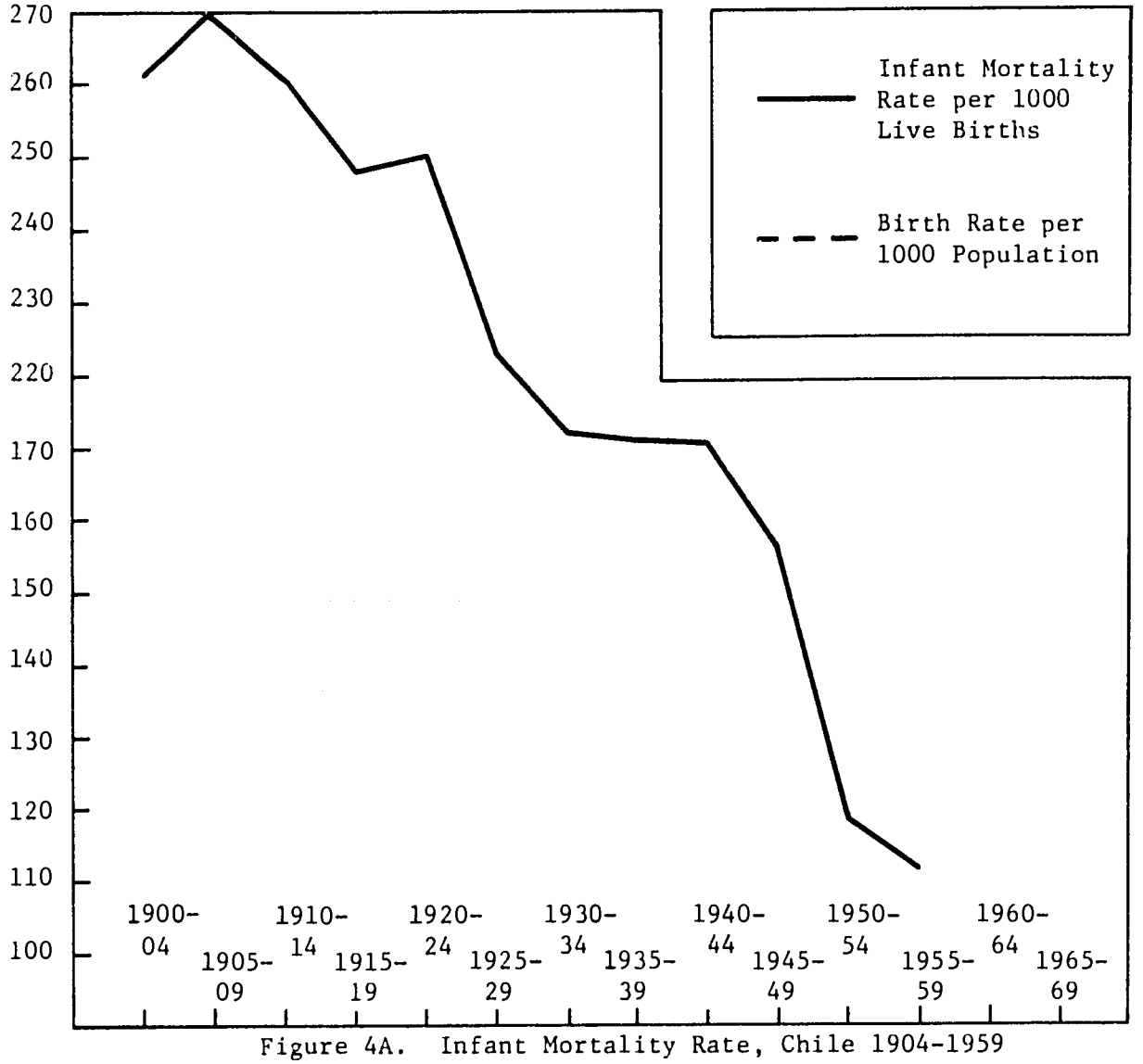


Figure 4A. Infant Mortality Rate, Chile 1904-1959

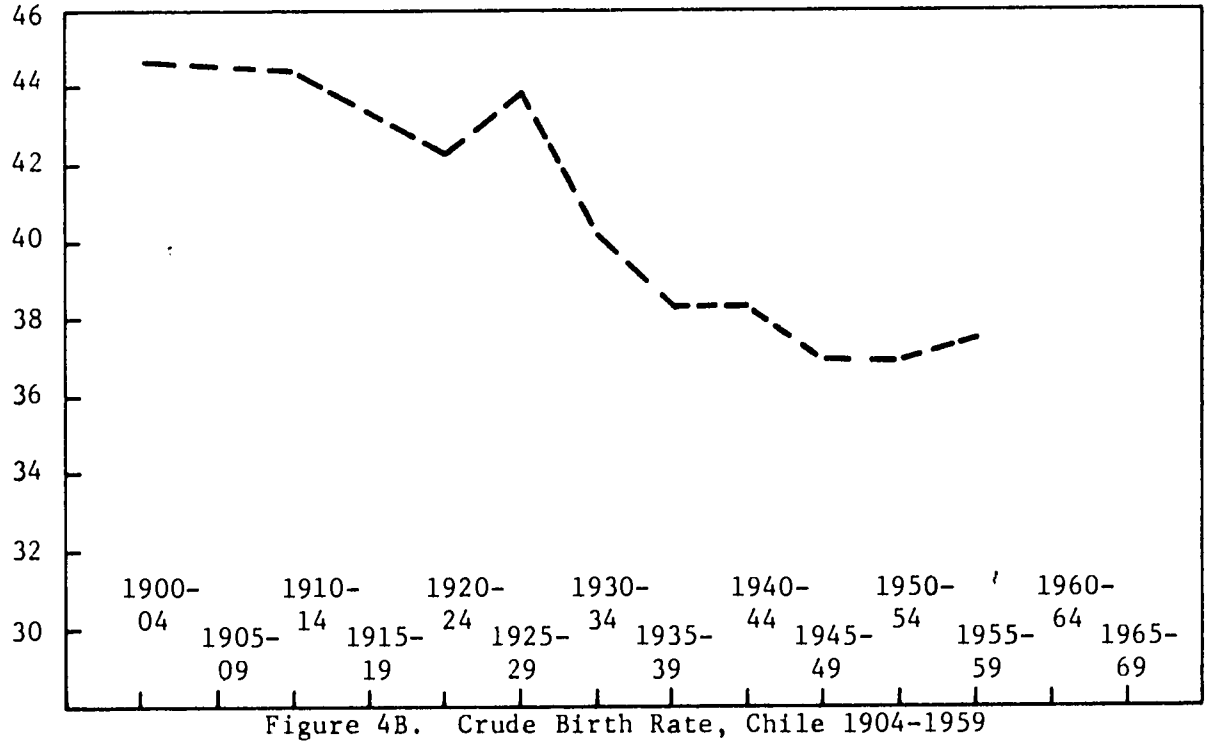


Figure 4B. Crude Birth Rate, Chile 1904-1959

Source: Collver 1965: Tables 16,17.

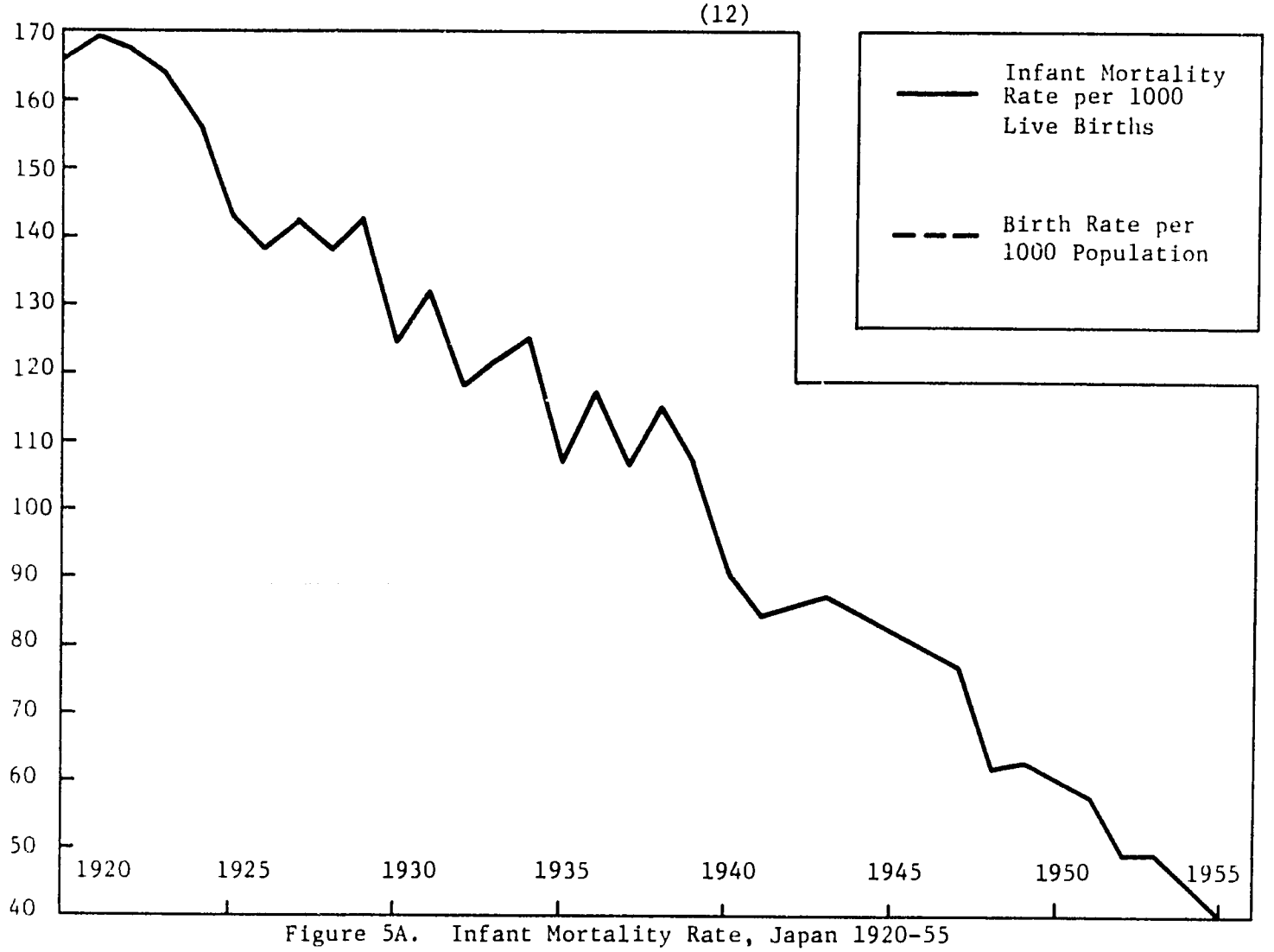


Figure 5A. Infant Mortality Rate, Japan 1920-55

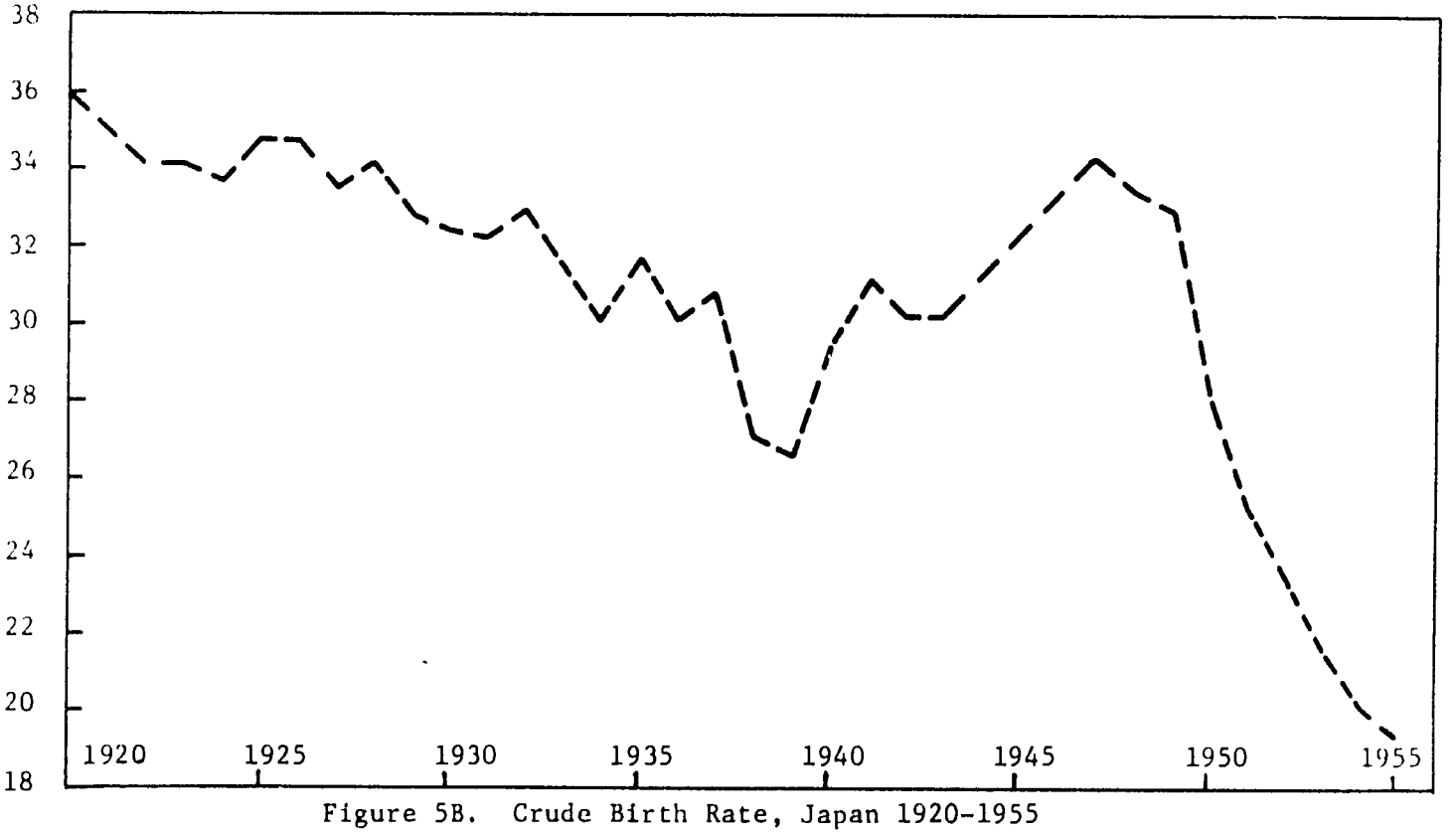


Figure 5B. Crude Birth Rate, Japan 1920-1955

Source: Taeuber, 1958: pp. 232, 286.

greatest excess of birth rates over death rates subsequently experienced the greatest decrease or the least increase in the birth rates. Thus, reductions in mortality still precede reductions in fertility." (1966:721).

Frederiksen also examined data for 21 countries at varying levels of economic and demographic development. These data yielded correlation coefficients of -0.70 to -0.80 between the rate of natural increase and the relative change in birth rate. The range in correlation coefficients resulted from statistical elimination of changes in marriage rate, product per capita, and population density. The results are fairly stable regardless of whether crude or refined demographic measures are used and Frederiksen concludes that his results are not merely the effect of a particular measure of change. He concludes, "A reduction in the death rate would seem to be a necessary, if not a sufficient, condition for a deliberate reduction in the birth rate, whether by spontaneous family planning or national population policy, regardless of economic system, political ideology, or religious doctrine." (Frederiksen, 1966:724).

It is Frederiksen's view that the discernible relation between fertility and levels of economic development has obscured less-readily observed relations between fertility and mortality.

Fertility has a statistically significant positive relation to levels of infant mortality after the effects of economic level (three measures) and population density have been eliminated statistically. Although this does not show infant mortality to be the cause of high fertility, it is not inconsistent with that line of argument (Heer, 1966).

Hypothesis II.1(b)

> The time lag between decline in infant mortality and that in birth rate can be estimated.

Examination of time series for a number of countries shows some with fairly distinct changes in trends of infant mortality and births. Among these countries, which show lags between the points of change of from 10 to 20 years, are:

a) Puerto Rico: 20 years (1930-50)

b) Chile: 20 years (1909-29)

c) Sweden: 15 years (1873-77 to 1888-92)

d) United Kingdom: 10 years (1901-11).

For other countries the points of change in trend are not distinct (at least in the time series examined) and estimation of the length of lag is more uncertain.

Given these and other records examined, we conclude it is not plausible to expect major declines in fertility without an accompanying, or preceding, fall in early childhood mortality. Application of the time lags between the decline of these two rates, however, to other areas is most difficult because many of those lags occurred in a "natural" situation, whereas the changes hoped for in the Near East - South Asia region would be the objective of priority programs of social change.

II.2 Perception of Change in Infant and Preschool Child Mortality

Hypothesis II.2

> Couples do perceive changes in infant and preschool child mortality.

The existence of a massive infant mortality in the target populations is a reality recognized within those groups as well as by outside observers. The question of perception of changes in infant mortality and of attitudes engendered by such changes is a relatively new one that is only now being asked explicitly in the target populations.

In his study of motivation in an Indian village, Poffenberger (1968b) reported that villagers seemed to be aware that generally fewer children died than in the past, but it was their opinion that there were still enough deaths of sons to make it risky to stop having children before at least two sons were grown.

One of the mechanisms for developing awareness was pointed out by Pareek (1970) in discussing the intensive study of the Khanna community by Gordon and Wyon. In this study women in groups discussed changes in their own infant mortality and fertility experience; the result, according to Pareek, was a quite clear perception by participants of mortality changes that had occurred.

These two items, among the best of those found speaking to the matter of perception of changes in infant and child mortality, suggest that not only do parents recognize such changes, but that there may be effective procedures for highlighting such changes in their minds.

Examination of a variety of other family planning literature on motivation and on knowledge, attitudes, and practices failed to yield any additional empirical data on perception of changes in levels of infant mortality.

II.3 Desired Family Size and Control of Fertility

Hypothesis II.3

> Fertility is controlled when desired family size is reached or exceeded.

Insight on this hypothesis can be gained from data on family planning acceptors. Statistics reported by Poffenberger (1968a) from six IUD acceptor studies in different parts of India indicate an average of 3.9 children for urban women at time of IUD insertion as compared with 4.7 children for rural women (U.S. AID, 1968). It is presumed, for most women, that family planning is accepted when they have exceeded or at least reached the number of living children desired. Since infant and child mortality rates in India are exceedingly high, one would expect couples to defer family planning until they are reasonably confident of the desired number of surviving children.

Other follow-up studies of acceptors are reviewed by an unpublished U.S. AID report (1970d). These are summarized in Tables 1 and 2. The sample size for these studies varied from 70 cases in one study to 40,335 in another; nine studies were from rural samples, eight were urban and the remaining were mixed samples. The effective family size for groups of acceptors of sterilization ranges between four and five children and for IUD acceptors it ranges from three to five. For the same groups, the number of children ever born ranges from nearly five to six and from 3.6 to more than seven. The main purpose of the review was to determine if any significant pattern emerged when the studies were combined. Five characteristics of family planning acceptors were consistently similar: parity, number of living children, sex of living children, and income. The main conclusions were that the most motivated couple is one that is literate, has a low income (that is, feels a need to limit births) and has four living children (with at least two surviving sons). Poffenberger in his review, reported above, reached very similar conclusions.

Table 1. Some Key Motivational Characteristics of Acceptors As Determined From Sterilization and IUCD Follow-Up Studies

| Follow-Up Studies STERILIZATION | Children | | Sex of Living Children | | Income (Average Monthly) Rupees | Literacy | |
|---|---|---|---|---|---|---|---|
| | Parity[2/] | No. Living | Boys | Girls | | Wife % Literate | Husband % Literate |
| | (2) | | (3) | | (4) | (5) | |
| 1. Demographic Research Center, Trivandrum, Sample: 40,335, (About 25% women (Urban,Rural) | 4.9 | 4.5 | - | | Below 100 | 80 | |
| 2. Univ. of Kerala, Trivandrum, Sample: 1,087 (200 women), (Urban/Rural) | - | 4.2 | 2.1 | 2.0 | App. 80 | 79 | |
| 3. Connonora, Kerala, Sample: 2,024 (443 women) (Urban, Rural) | 5.3 | 4.7 | 2.5 | 2.2 | App. 60 | 70 | 90 |
| 4. Vasectomy Comp. Mohanial Ganji, U.P Sample, Sample: 78 (Rural) | 6.0 | - | - | - | Below 50 | - | 49 |
| 5. Muzaffornager, U.P., Sample: 3,335 (15 women) (not known) | - | 5.0 | - | - | App. 100 | 65 | |
| 6. Lucknow, Dr. S.N. Sinha, Sample: 100, (Urban) | - | 4.65 | 2.5 | 2.1 | App. 180 | 54 | 76 |
| 7. CFPI, Dr. A.K Poddar, Delhi, Sample: 225, (Urban) | - | 4.6 | 2.7 | 1.9 | App. 230 | 40[1/] | 97[2/] |
| 8. Calcutta, Dr. K.C. Petnaik, H.R., Sharma & O.P. Vig., Sample: 824 (Urban) | 4.7 | 4.34 | 2.37 | 1.97 | App. 100 | - | 99 |
| 9. Belguam Dist., Mysore, Dr. A. P. Katti, Sample: 767 (Rural) | - | 5.2 | 3.0 | 2.2 | 56 (90% Below 100) | - | 60 |
| 10. Regional Health Office, Bangalore, Sample: 247, Rural | - | 4.4 | - | - | - | - | 39 |
| 11. Maerut District, U.P., Thomas Poffenborger Sample: 892 (Rural) | - | 4.7 | 2.9 | 1.8[3/] | - | - | - |
| 12. Boroda, Gujorat, S.B. Poffenberger, D. L. Sheth, Sample: 81 (Urban) | - | 4.5 | - | - | 138 | 66 | 97 |

1/ 20% college had 3.0 living children

2/ 30% college had 3.7 living children

3/ 23% of sample had 2-3 children and the boy/girl ratio was 2-1)

SOURCE: USAID, 1970d.

Table 2. Some Key Motivational Characteristics of Acceptors As Determined From Sterilization and IUCD Follow-Up Studies

| Follow-Up Studies IUCD | Children | | Sex of Living Children | | Income (Average Monthly Rupees | Literacy | |
|---|---|---|---|---|---|---|---|
| | Parity[2/] | No. Living | Boys | Girls | | Wife % Literate | Husband % Literate |
| (1) | (2) | | (3) | | (4) | (5) | |
| 1. CFPI, Murty (All India) Sample: 20,000 | 4 | 3.9 | - | - | - | 74* | - |
| 2. DTRC, A. A. Bhende & T. K. Roy, Sample: 452, Bombay (Urban) | 3.6 | 3.3 | 2 | 1.3 | 380 | 86 | 94 |
| 3. DTRC, S. P. Mohanty & S.L.N. Reo, Sample: 1,007, Bombay (Urban) | - | 3.0 | 1.9 | 1.1 | - | - | - |
| 4. Inst. of Eco, Growth, S.N. Agarwala, Sample: 867, New Delhi (Urban) | 5.2 | 4.5 | 2.5 | 2.0 | 175 | 69 | 89 |
| 5. CFPI, Kamala Reo, Sample: 70, New Delhi (Urban) | - | 4.4 | - | - | Below 200 | 57 | - |
| 6. Regional Health Office, Bangolore, H. K. Reo, Sample: 307 (Rural) | - | 4.6 | - | - | - | - | - |
| 7. PRAI, Rural U.P., Sample: 951, (Rural) | 6.5 | 4.1 | - | - | - | 10 | 39 |
| 8. Rural Loop Retention Survey, Karnal, G. B. Simmons & E. Wales, Sample: 829 (Rural) | 7.0 | 5.0 | - | - | - | 18 | 51 |
| 9. Rural Loop Retention Survey, Rohtak, Sheila Ward & G. B. Simmons, Sample: 821 (est.) (Rural) | 7+ | 5.0 | - | - | - | 18 | 54 |
| 10. Regional Health Office, Bhepal, Sample: 125, (not known) | - | 4.2 | - | - | Below 300 | 77 | - |
| 11. Gandhigraan, Madras, M. Kachityan | 4.8 | 3.9 | - | - | - | 39 | 75 |

* Illiterate women had 4.2 children; school edu. 2.8 & college 2.2

SOURCE: USAID, 1970d.

From data of this nature, it may be inferred that at certain levels of attained fertility (generally three or more living children) family planning is adopted in the target populations.

II.4 Determinants of Desired Family Size

Hypothesis II.4(a)

Couples alter desired family size as a result of changes in infant and preschool child deaths.*

Shafick Hassan (1966) has considered the effect of childhood mortality on fertility in a study of nearly 2,700 Egyptian women in Cairo. He found that childhood mortality experience raises both actual and desired family size regardless of socioeconomic variables. The postponement of contraceptive practices to high parity is one of the most significant characteristics of the women with child death experience.

Hassan found 80 percent of the deaths among the first three birth orders and 38 percent within the first four years of marriage. He concluded that it is the early traumatic experience with child death that predisposes bereaved mothers to inflate both their actual and "ideal" fertility performance. See Figure 6. Inspection of these figures suggests that the effect of mortality on desired family size becomes more pronounced at higher levels of education.

Arguing that childhood mortality is an independent cause of differential fertility, Hassan cites the following reasons for higher fertility among those experiencing child loss:

a) Because the experience typically comes in the early years of family formation, child death is perceived as a threat to the family that can only be offset by continued, deliberate efforts to reproduce.

b) By the time the survival of the desired number of children is assured, e.g. when about four children have survived the critical first five years, the reproductive period is virtually over.

c) The lack of predictability about the future survival of children, coupled with the pessimistic outlook that prevails in the immediate environment, heightens the psychological or emotional need for many children.

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* Information on the reciprocal relation, of fertility patterns on infant and child mortality has also been assembled. Since these relations are generally well-established, showing that infant mortality is higher at the extremes and lower in the middle levels of fertility behavior, they have not been covered in this document, but can be made available on request.

Hassan concludes that the untimely death of low parity children provides the " . . . stimulus to motivate couples to compensate very rapidly so that physiological sterility or old age tend to have no restrictive effect on fertility performance" (Hassan, 1966:7).

Insofar as Hassan's inferences are applicable to other parts of the Near East-South Asia region one can conclude that reduction in infant and preschool child mortality would, at the very least, prevent goals for desired family size from being raised by mortality experience.

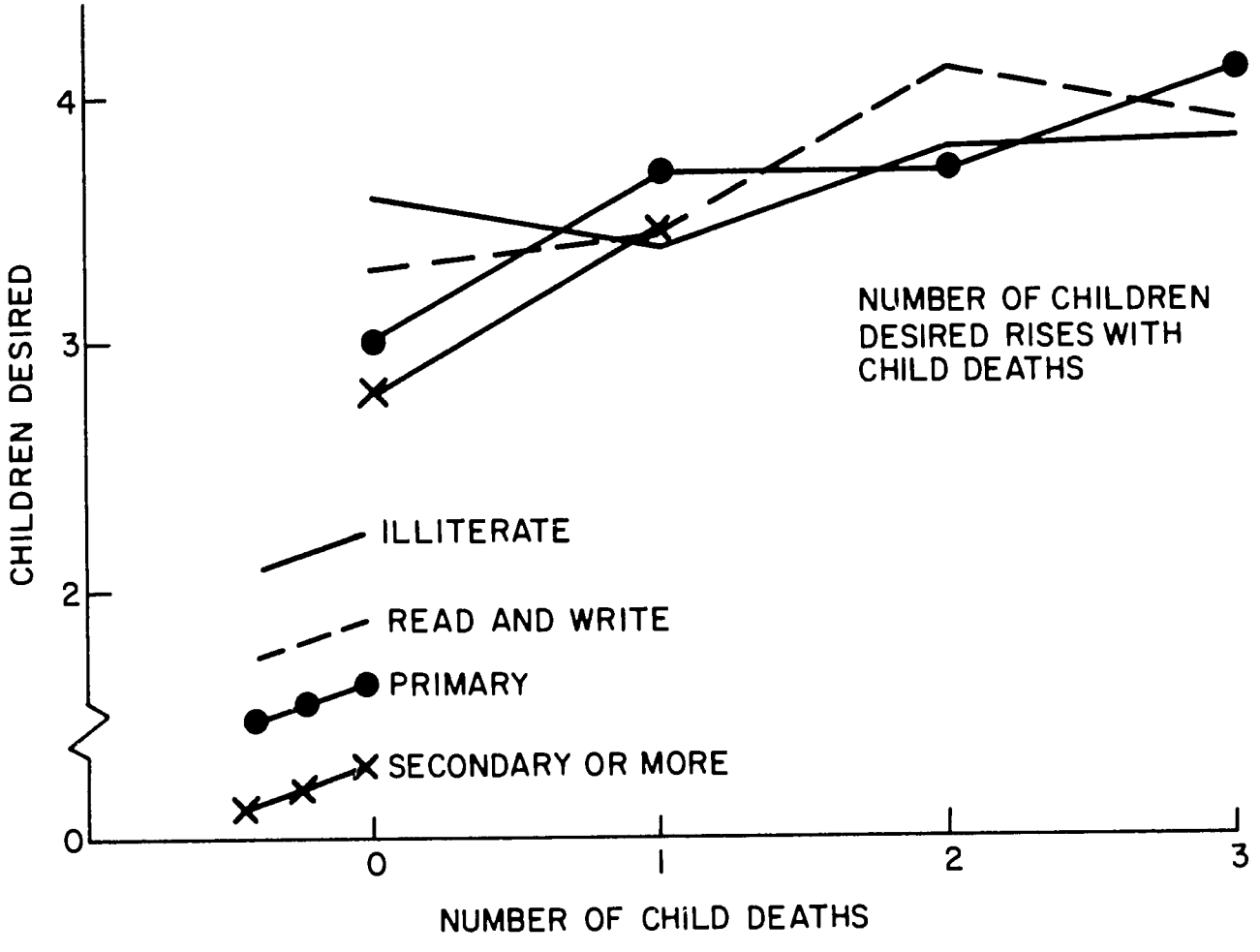


Figure 6. Child Deaths and Desired Family Size

Hypothesis II.4(b)

Family planning is more likely to be adopted when the survival of at least one son is assured.

The proposition that fertility is maintained at a high level in the face of high infant and child mortality in order to assure the survival of one or more sons is an often-heard item of conventional wisdom with respect to the target populations. Although direct proof of this proposition is difficult, to date the following inferences, consistent with the surviving son proposition, have been made:

a) Preschool mortality is higher for girls than boys in both India and Pakistan, as well as for some other countries of the Near East-South Asia area. This contrasts with the records for presently developed countries (even for Sweden of 1778-82) and for most developing nations. (Keyfitz and Flieger, 1968; Pakistan Ministry of Health, 1965; May and Heer, 1968, citing Visaria, 1963; Moseley, et al., 1968:tabs. 8-11). In the face of the generally higher survival of girls in most other countries, it appears that the scarcity of resources in the target populations coupled with the stated preferences of families for sons, results in differential care and consequent higher mortality of girls relative to boys at preschool ages. Observed mortality between the sexes is consistent with the surviving son proposition.

b) Data from KAP studies strongly suggests that desired family size is not merely a number of children desired, but must be supplemented by their sex distribution. Specifically, families in many parts of the Near East-South Asia region, and particularly in India, wish to insure that one or more sons will survive to provide economic security for the parents and to perform certain religious rites. Although direct proof of this proposition is lacking, there are several pieces of supporting data that are consistent with it.

c) Family planning acceptors in India have three to five living children including two or more boys. Those accepting sterilization average a larger effective family size than those adopting IUCD's. (See Tables 1 and 2.)

d) Given existing levels of infant and child mortality, high fertility is necessary to insure son survivorship at the time the father would

reach age 65. The effective family sizes cited above are large enough to assure son survival for almost all families (May and Heer, 1968).

- Based upon a model to simulate fertility behavior given mortality schedules and reproductive goals, reductions in infant and child mortality at levels of life expectancy below 30 years increased the intrinsic rate of natural increase, but when life expectancy exceeded 50, further reductions in preschool death rates reduced the intrinsic rate of increase because at these levels of death son survivorship had been assured and the new births fell more rapidly than the number of deaths of existing children. At intermediate levels of life expectancy, reductions in the infant and child death rate had little effect, and intrinsic rates of natural increase were maximized (Heer and Smith, 1968).

Because of the high level of mortality during the first two years of life, the probability of a father being survived by his son increases rapidly as the child passes through this period. For example, using the U. N. Model Life Table with Mortality Level 50 (expectation of life at birth equals about 45 years), a father aged 25 has about a 60 percent chance of being survived by his new born son, a 72 percent chance of being outlived by that son when he reaches age one, a 75 percent chance at age two, and a 77 percent chance at age 5. A 30 year old father with sons aged 5 and 0 can expect to be survived by a son 90 percent of the time (Immerwahr, 1967: tab. 2). When the reduced levels of mortality that can be expected over time are taken into account, Immerwahr concludes that between 74 and 81 percent of fathers can expect to be outlived by one son aged 2 when the father is aged from 22 to 32. When there are two surviving sons these percentages exceed 90 (1967: tab. 3).

Nothing in the foregoing material is inconsistent with the proposition that surviving sons are a sine qua non for the Indian Family (and possible for the Pakistani Family) and for the adoption of family planning in these target populations. Utilizing a simulation model, May and Heer (1968) demonstrate that the requisite number of sons, given the mortality and fertility levels of 1951-60, are not going to be born until women have borne an average of 5.1 children, of which approximately 3.2 will be surviving. This model probably overstates the required fertility, however, because of the

assumption a son must survive to the father's 65th birthday. In a population of moderate life expectancy, such as that of India, only about half of men aged 20 will live to age 65 (Keyfitz and Flieger, 1968:659). Immerwahr relaxes this constraint, assuming, instead, that a son must survive to the age at which the father dies. Since the two studies do not employ the same measures, it is difficult to make comparisons, but it appears that at comparable levels of parameters, Immerwahr's assumptions would result in a larger proportion of families attaining the surviving son condition.

It is obvious that the probabilities of attaining surviving son status are quite sensitive to the infant and early childhood mortality schedules that are assumed. Both Immerwahr (1967) and Heer and Smith (1968) deal with this in terms of various levels of mortality from the U. N. Model Life Tables, with the latter indicating that population growth is maximized at intermediate levels of life expectancy. Heer and Smith made an attempt at relaxing their assumption of son surviving at father's age 65, altering it to: both parents dead at father's potential age 65 or at least one surviving son. This resulted in slightly lower rates of natural increase.

The preceding studies have assumed that no measures for family planning would be adopted by a family until it had achieved the required number of surviving sons, but that completely effective family planning, such as sterilization, would be practiced following the birth of that number of sons. Accepting the same schedules of mortality and survivorship goals as the preceding studies, O'Hara (1970) has simulated the effects on population growth rate of a more sophisticated approach to the use of family planning in connection with the achievement of survivorship goals. His contribution has been to examine the effect on rates of population increase of postponing decisions to have additional children until it is more fully apparent that an additional son is needed to insure a surviving son at father's age 65. O'Hara proposes a two-step contraception strategy in which, for each parental situation, it is first estimated whether the number of existing sons provides a 95 percent probability of a son surviving to the father's age 65. If the situation provides this probability, the parents will refrain from having an additional child. If it does not provide this probability, the decision to have an additional child, and when, is based upon minimizing the total number of additional children depending on whether they are (a) born now, (b) born later if an existing

Table 3

Comparison of Models of Birth Planning for Achieving 95 Percent Probability of Having a Surviving Son at Father's Age 65

| United Nations Model Life Table | | Fertility at 18, children every 2.5 years until sufficient sons are living or 12 children have been born. | | | |
|---|---|---|---|---|---|
| | | Sterilization--no more births. | Contraception--but resume child bearing to replace sons who die. | Minimize number of births necessary to achieve sufficient sons. | Minimize number of births, but always have another child whenever no son is living. |
| Mortality Level | Expectation of Life at Birth | Heer-Smith 1 | O'Hara/Heer S/C | O'Hara - Optimal A95 | O'Hara - Suboptimal C |
| | | Net Production Rate | | | |
| 30 | 35.0 | 2.02 | 2.12 | 1.74 | 1.74 |
| 50 | 45.0 | 1.91 | 2.01 | 1.47 | 1.54 |
| 70 | 55.0 | 1.79 | 1.87 | 1.38 | 1.49 |
| 90 | 65.8 | 1.80 | 1.88 | 0.91 | 1.31 |
| 100 | 70.2 | 1.65 | 1.67 | 0.91 | .96 |
| | | Average Age at Motherhood | | | |
| 30 | 35.0 | 26.5 | 27.0 | 26.8 | 26.8 |
| 50 | 45.0 | 24.5 | 25.0 | 32.2 | 29.6 |
| 70 | 55.0 | 23.8 | 24.4 | 34.9 | 29.7 |
| 90 | 65.8 | 23.0 | 23.3 | 33.1 | 27.5 |
| 100 | 70.2 | 21.8 | 21.9 | 35.3 | 20.8 |
| | | Intrinsic Rate of Natural Increase (percent) | | | |
| 30 | 35.0 | 2.72 | 2.79 | 2.09 | 2.09 |
| 50 | 45.0 | 2.68 | 2.80 | 1.21 | 1.48 |
| 70 | 55.0 | 2.47 | 2.56 | 0.93 | 1.34 |
| 90 | 65.8 | 2.59 | 2.71 | -0.28 | 0.98 |
| 100 | 70.2 | 2.32 | 2.35 | -0.25 | -0.19 |

Source: O'Hara, 1970: Tables 1 and 3.

son dies. O'Hara concludes that "if full advantage is taken of the flexibility permitted by contraception, parental achievement of old-age security goals is compatible with rates of natural increase that begin declining at quite high mortality levels and reach a tolerable pace at moderately low mortality levels" (1970:9). A comparison of the results of this modeling is shown, for selected mortality levels, in Table 3. These figures indicate differences among the models that become increasingly distinct as mortality levels decline, and if the population can be persuaded that the rational decision rules will, indeed, provide them with the estimated degree of son survivorship.

O'Hara's ultimate conclusions are that given the two assumptions that suitable means of family planning are available and that old-age security is the major reason for parents having children, then, as mortality levels decline, rational parents following simple rules of behavior designed to provide couples with 95 percent confidence that they will have a surviving son at father's age 65 will, in fact, have a pattern of fertility considerably below those presently observed in countries such as India and found in simulations such as those by Heer and Smith.

In connection with all the simulations reported here, decreasing mortality--increasing expectation of life at birth--is the basic parameter. Of the many patterns of mortality decrease that may lead to increasing expectation of life at birth, those patterns emphasizing decreases in death rates of population in the early years of life, especially ages 0-4, are particularly efficient in that they raise the number of surviving children without increasing the number of surviving fathers.

The inferences discussed above have been based upon completed research. A project is currently being undertaken by Reppeto (1970) who will investigate the hypothesis that parental preference for children of a particular sex significantly affects fertility levels in certain less-developed countries. This study will assume that the preference for sons has been adequately documented in previous sociological studies. In testing the hypothesis, Reppeto expects to compare the behavior of women who have achieved the desired number of sons with those who have not achieved that number. Detailed fertility-pregnancy histories will be the source of data for the empirical test. A sample of cases will be taken from several less-developed countries in which the people are believed to exhibit a preference for male children.

These data will be analyzed separately for each country; the work is expected to be completed late in 1970.

Another project now underway will, among other things, repeat the analysis made by Hassan, but using data from other countries, including Turkey, Lebanon, Iran, India, and possibly Pakistan, Taiwan, and the Philippines .This will be done in an epidemiological study of human reproduction being sponsored by the World Health Organization and coordinated by Dr. Abdel R. Omran, Carolina Population Center, University of North Carolina, Chapel Hill.

## II.5 Effects of Nutrition on Infant and Preschool Child Deaths

### Hypothesis II.5

Nutritionally-caused deaths can be identified and their number can be estimated.

### II.5.1 Identifying Causes of Death Related to Nutrition

The distribution of deaths of infants and young children by cause differs markedly between countries with generally good nutrition contrasted with those having generally poor nutrition.

The typical pattern of causes of death in developed countries is one of rapidly decreasing death rates from the first day of life onwards through the first year reaching a low point during the first five to nine years of life. The first fatalities after birth result from difficulties and injuries to the infant during labor and from congenital abnormalities making it difficult or impossible for an individual to survive. Most deaths attributable to these causes have occurred by the end of the first month of life. Postneonatal infant mortality is quite low relative to neonatal mortality and is attributable largely to respiratory infections and accidents, such as suffocation.

By contrast, in the less-developed countries, although neonatal mortality is high relative to that in the developed countries, it results largely from the same causes. During the postneonatal period, in less developed countries, not only is the level of death greatly higher than in the developed countries, it also results from different causes: there is a much higher incidence of respiratory diseases, gastroenteritis, including diarrhea, and infectious diseases, such as smallpox, measles, and whooping cough. It should be noted that these infectious diseases are not generally fatal in the developed countries; they appear to become so in the less developed countries because of the malnourished state of individuals contracting these diseases.

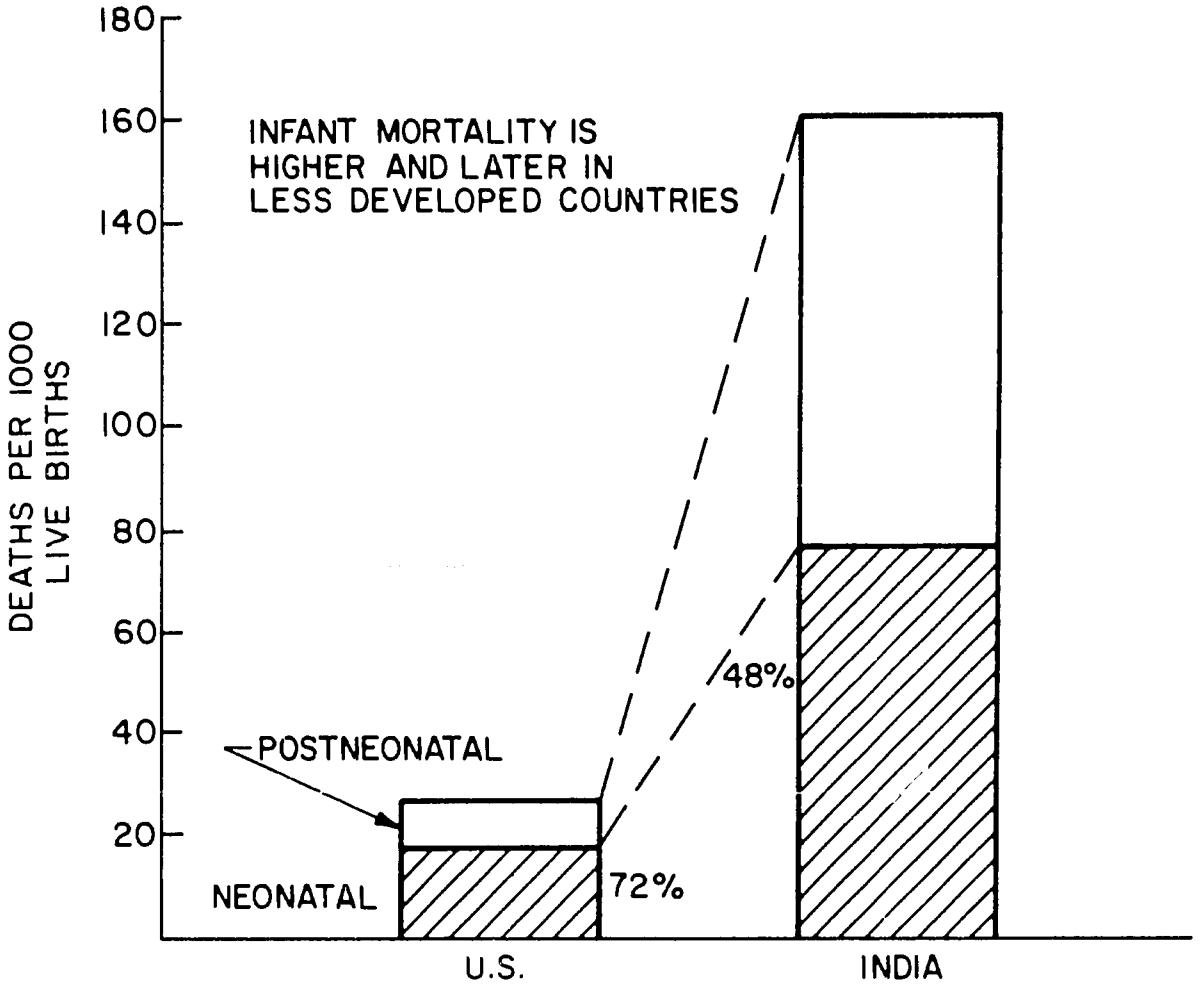


Figure 7. Timing of Infant Mortality, U.S. and India

Because mortality between one and four years of age is so significant in many developing countries, and lowers their life expectancy at birth by several years, many writers have come to realize that preschool mortality is at least as sensitive as infant mortality as an indicator of change in health and social conditions in a country.

To illustrate the sensitivity of this index, the statistics from a field study in rural India are compared with those for the United States:

| Mortality Ratio: India/U.S. | |
|---|---|
| Infant | 6 |
| Second Year | 27 |
| Fifth Year | 5 |

Although death rates in India are higher at all ages, they are proportionally <u>much</u> higher during the second year of life (Gordon, <u>et al</u>., 1963:347).

Gordon, et al. (1967) report that in rural north India, 70 percent of all deaths at ages one through four occur during the second year of life.

> "One of the conventional methods of measuring the magnitude of malnutrition has been by level of mortality between one and four years of age. It is noticeable that countries with a known high prevalence of malnutrition also have a high level of preschool mortality . . . . The peak of such mortality occurs during the second year of life because when children are weaned the available diet becomes inadequate without a mother's milk. This is also aggravated by the occurrence of weanling diarrhea which is a malnutrition-diarrhea complex that is responsible for the high fatality in the second year of life." (Omran, 1970:1-19-20).

A careful study in four Guatemalan villages yielded the following distribution of causes of death for 222 deaths of children under age 15 during 1956-57 (Behar et al., 1958):

| | |
|---|---|
| Malnutrition and disorders of the digestive system | 34% |
| Respiratory diseases and whooping cough | 25% |
| Congenital and diseases of early infancy | 20% |
| Ill-defined and miscellaneous causes | 21% |

Similar results can be found in a preliminary report on a major investigation of childhood mortality in Latin America which will study causes of death for some 35,000 deaths of children under age five in the late 1960's in 13 areas of Latin America. (Puffer and Serrano, 1969:17). In one area nearly half of deaths at ages six months through four years had measles as the underlying cause and two-thirds of these included a pre-existent nutritional deficiency. In another area 39 percent of deaths were due to measles. Combined data for four areas show nutrition deficient in 56 percent of child deaths at ages 6-59 months. Nutrition was related to death as follows:

| | Percent |
|---|---|
| Underlying cause | 10 |
| Contributory cause | 31 |
| Consequence of underlying cause | 15 |

Banik, et al. (1967) in a longitudinal study of 1000 children during their first two years of life, report nearly three-fourths of illnesses were of respiratory or gastrointestinal origin and that 35 percent of infant deaths were associated with acute diarrhea and nearly 20 percent with pneumonia.

In their intensive study of the Khanna area in Punjab, Gordon and Scrimshaw (1965) found neonatal deaths to be largely caused by difficulties associated with birth or diseases resulting from unsanitary care, such as tetanus. Postneonatal deaths, however, were largely the result of diarrheal diseases and such infections as pneumonia, measles, tuberculosis, and typhoid fever. At ages 1-11 months the causes and rates were:

| Cause | Rate per 1000 live births |
|---|---|
| Diarrhea | 27.8 |
| Pneumonia | 10.7 |
| Prematurity | 10.7 |
| Measles | 2.8 |
| Typhoid | 2.1 |
| Tuberculosis | 2.1 |

During the second year of life, diarrhea was responsible for one-third of deaths and measles, tuberculosis, typhoid fever, whooping cough, and pneumonia collectively accounted for another third of deaths.

The import of the several studies reported above is that certain types of causes of death are far more prevalent among infants and preschool children in populations in which malnutrition is known to be prevalent. Improvement of nutrition in such populations cannot be expected to eliminate these diseases, but it can be expected to make the children less susceptible to dying from them.

II.5.2 Estimating Numbers of Nutritionally-Caused Deaths

Granted the approximations that run through the literature estimating the extent of malnutrition in the target populations, the following exercise can be only an example to show the magnitude of the potential nutrition problem. Given a current estimate of the population of India, and assuming the age distribution reported in the 1961 Census (Keyfitz and Flieger, 1968), one estimates children aged 0 to 14 at 222 million in 1970:

| Age | Number | Percent |
|---|---|---|
| 0 | 22,200,000 | 4* |
| 1-4 | 66,600,000 | 12 |
| 5-9 | 72,150,000 | 13 |
| 10-14 | 61,050,000 | 11 |
| 0-14 | 222,000,000 | 40 |
| All Ages | 555,000,000 | 100 |

*Est. from 1961 Census

Assuming three children per family means 74 million families. Of these, it is estimated on the basis of information examined in this study that one-half are malnourished. These families contain some 111 million children under age 15; of these 44.4 million are in the critical years under age five. AID has plans for reaching some 15 million of the 111 million in fiscal year 1971. It is readily apparent that a nutrition program designed to meet nutritional needs throughout the population of children could require huge resources.

Carrying the example a step further, using data from Section II.5.1 on proportions of deaths by cause, let us assume that 30 percent of deaths at ages 0-5 could be attributed to illness following upon malnutrition. Then, using estimates of death rates by age prepared for this project, it can be estimated that the malnourished 44.4 million children under age 5 will experience 3.37 million deaths of which 1.0 million might reasonably be associated with malnutrition and preventable by appropriate nutrition interventions. These nutrition-related deaths at early ages would be 9.67 percent of all deaths in the year.

## II.6 Levels of Nutrition

### Hypothesis II.6

Levels of nutrition are low in the target population.

It has been shown above that greater malnutrition is associated with higher levels of infant mortality and that this in turn is associated with higher levels of fertility. Now it is appropriate to describe the low level of nutrition in the target population.

1. General

The overall picture of malnourishment among the populations of the less-developed countries is one of a poor diet due to insufficient nutrients because of low income. This lack of food is exacerbated

by ignorance and misinformation regarding the preparation of foods and the appropriate diets for infants and young children. The outstanding nutritional need is additional protein; this is followed closely by needs for additional vitamins and minerals. The protein insufficiency is particularly crucial since it is believed to affect both physical and mental development and that certain of its consequences are irreversible. The protein efficiency of diets--in terms of the balance among the several amino acids--is of particular concern, since in certain cases nutritional status may be improved by altering the proportions of diet components already available locally or by changing preparation practices.

It is apparent, of course, that malnutrition is defined by an inadequate supply of one or more of several nutritional components, including calories, protein, animal protein, iron, vitamins, etc. Naturally, standards vary according to the age, sex, and pregnancy/lactation status of the individual. The nutritional standards against which malnutrition is measured are generally derived from standards proposed by the British Research Council and the (U.S.) National Research Council.

2. India

The U.S. AID Mission in India has concluded that "the vast majority of Indian preschool age children and pregnant-lactating mothers suffer from severe deficiencies in the essential nutrients" (Gulick, 1969:9). Based upon his review of the literature and conversations with specialists, Anderson (1970) concluded that malnutrition is widespread in India and affects as much as one-half of the population.

The problem of deficiency diseases in India is enormously complicated by the paucity of statistical evidence of their distribution. A reasonably complete and accurate picture of malnutrition in India is, in Anderson's view, presently difficult if not impossible with the data available.

Anderson (1970) also notes, "the dietary in India is extremely complex due to the many ethnic groups, languages, cultures, and deeply-rooted prejudices for or against certain foods." Superimposed are deeply-seated religious taboos and complications that make the correction of nutritional deficiencies very difficult.

The most important cereals in India are rice, wheat, and the various millets. Rice is eaten by more than half of the population of India. As in other parts of Asia, the practice of mechanical milling prevails over the older method of hand pounding with the consequent removal of thiamine (Vitamin $B_1$). As an example of the consequences of differences in food preparation methods, Anderson points to the technique of parboiling rice that retains much of the thiamine; this technique is prevalent in parts of the country but not all of it.

Despite all the complications and apparent differences in the diets of various groups in India, according to May (1961) differences in the various Indian diets are actually superficial and originate chiefly in different methods of preparing the various foods, rather than in the actual composition of nutrients.

According to Gopalan (1970) nearly 20 percent of the children between one and five years of age belonging to the poorer socio-economic groups suffer from overt protein-calorie malnutrition. This syndrome occurs chiefly in children receiving a faulty diet after weaning, and essentially because of starchy foods consumed in families that cannot afford to purchase milk. "According to the Ministry of Health in New Delhi, the southern states Andhra Pradesh, Tamil Nadu, Kerala, and Mysore have the greatest amount of protein-calorie deficiency." (Anderson, 1970). Gopalan (1970), after surveying some 15,000 preschool children, concluded that more than 90 percent of children had calorie intakes below the required level. Of these 57 percent were deficient only in calories while another 35 percent were deficient in both calories and protein. Gopalan views the major problem as the calorie deficiency because in such cases protein otherwise usable for building and repairing tissue will be diverted to maintenance of calorie requirements, which in turn results in protein deficiency.

A second major deficiency in the Indian diet is that of Vitamin A (May, 1961; Gopalan, 1970). Anderson (1970) reports that the Ministry of Health in New Delhi indicates that the states of Orissa (eastern portions), Bihar, Andhra Pradesh, Tamil Nadu, and Kerala were particularly deficient in Vitamin A. The significance of this deficiency is that, if allowed to persist, it leads irreversibly to blindness, although either small or massive dosages given before the point of irreversibility are a sure remedy.

Iron deficiency, leading to anemia, is a major health problem in India, particularly among young expectant mothers. It is estimated that 54 percent of expectant mothers are anemic (Gopalan and Raghavan, 1969). Cowan (1970) reports that folic acid, a source of iron, is commonly deficient in pregnant mothers in the Punjab, as indicated by severe hemorrhaging. The child born in such circumstances seldom survives. Hemoglobin surveys carried out by the Indian Council of Medical Research in six regions of the country showed that 52 percent of "toddlers" among poor socioeconomic groups have hemoglobin below a recommended 10.8 grams percent (Gopalan and Raghavan, 1969:64).

3. Pakistan

Although the elements of a balanced diet are present in East Pakistan, malnutrition is believed to affect the health and well-being of at least one-half the children, especially the newborn and preschool children (Anderson, 1970). West Pakistan is a subhumid, wheat-growing area while East Pakistan is a humid, rice-growing area. In East Pakistan cereals, mostly rice, provide 71 percent of the calories. The importance of food-preparation practices is again noted by Anderson (1970) who reports that rice is typically prepared by parboiling in East Pakistan thus preserving its thiamine content and preventing beri beri, which could be expected to increase if the use of milled rice increases without a concomitant program of fortification.

Although there is little information on the diets of pregnant women and infants, it is reported by May (1961) that they occupy a secondary place at the table of a low-income family. This point is also developed in the nutrition survey of East Pakistan (Pakistan,

Ministry of Health, 1966:1). This points up the importance of considering not only the average nutrient intake for a population group but the variation from that average by particular subgroups.

Anderson (1970) reports that a conference with staff of the SEATO-Cholera Research Laboratory resulted in the following listing of nutritional deficiencies in order of importance:

| | |
|---|---|
| First | Protein insufficiency |
| Second | Iron deficiency (Anemia) |
| Third | Vitamin deficiencies |
| Four | Iodine deficiency (Goiter) |

The Nutritional Survey of East Pakistan found 60 percent of households were below the recommended allowance for protein intake (Pakistan, Ministry of Health, 1966:4).

The same nutrition study reported that, on the average, more than one-third of the population suffered from iron-deficiency anemia. This level rises to 60 percent among pregnant and lactating women and 45-50 percent among children.

Vitamin A deficiency, leading to blindness if untreated, is reported to be most severe in preschool children, especially boys, and to be the cause of total blindness or death among 0.6-0.8 percent of the population in addition to a larger number of partially debilitated persons (Pakistan, Ministry of Health, 1966:6-7).

Goiter, usually resulting from iodine deficiency, is estimated to affect up to 25 percent of the population of East Pakistan, especially in the northern sections of the area. The fact that goiter is prevalent in spite of the closeness of the area to the sea and the levels of consumption of seafoods has led to the proposition that other agents are at work in this disease and that iodine supplements alone may not be sufficient to eradicate it.

## II.7 Nutrition as an Incentive

### Hypothesis II.7

> The availability of a nutrition supplement at a family planning clinic can increase the number of family planning acceptors.

As noted earlier, it is assumed that people act rationally and that they will adopt family planning only when they do not desire another child immediately, they know that birth can be controlled, and they have access to the needed information and supplies. The hypothesis posed here deals with the possible role of nutrition as an incentive for increasing the knowledge that birth can be controlled.

Given the prevalence of malnutrition existing in the NESA region, and assuming that the nutrition supplement offered at family planning clinics is acceptable to the population based upon their dietary preferences, etc., then it is reasonable to assume that some of the population having ready access to the family planning clinic will come there to receive a nutrition supplement. It is only during 1970 that a demonstration program to supply a nutrition supplement at a family planning center has been started. When data from that program become available it will be possible to qualify the foregoing comment.

It is reasonable to suppose that increasing the number of persons coming to family planning clinics will increase the number who are aware of the family planning program and of some parts of its content. (Although such clinics may be an important source of family planning information, one cannot ignore the substantial amount of extended information that is passed on by word of mouth within the family and community). Of the persons coming to the family planning clinic because they can receive a nutrition supplement there, the proportion who will accept and adopt family planning measures will, by the assumptions made above, depend upon the proportion who do not desire another child at this time. Whatever this proportion may be in the basic population, given the arguments made in the foregoing sections, that proportion may be increased as infant and early childhood mortality is decreased. Thus, one could expect a rise in the proportion of acceptors from among those who came initially for nutrition supplements as the program continued over time. Reasoning that with

high infant mortality, desire for another child will be large, it is reasonable to assume that the increased knowledge of family planning would have little direct effect upon adoption of family planning but that as the nutrition supplement itself had its effect, and the desire for another child immediately was reduced and desired family size was reached (and even lowered in other women) that the family planning clinic would experience an increase in adopters.

II.7.1 Nutrition Intervention Programs

The ultimate nutrition intervention program is, of course, a marked increase in the per capita income of low-income families throughout the world. But, as Gulick (1969:12) has calculated for India, if real per capita income increased by three percent per year it would still take some thirty years for those in the lowest income brackets to achieve the level of income presently associated with ability to purchase an adequate diet. Obviously, thirty years is time enough for another generation to be born and reproduce itself--perpetuating most of the deficiencies to which the present generation is subject. Moreover, since income gains are often unevenly distributed, Gulick expects a core group of some 160 million persons in India to remain malnourished for the "foreseeable future."

Granted that elimination of poverty is a slow route to reduction of malnutrition, is there an alternative? It is the opinion of Altschul (1969) that new food technologies provide opportunities for cost-effective interventions to improve the nutritional status of low-income populations. Among such technologies he includes fortification to improve the nutritive quality of a present food by, for example, adding iron to salt, or selected amino acids to the major cereal grains. Another tactic, more useful perhaps in urban areas, is the development of soft drinks providing protein and other nutrients. Demonstration projects to fortify wheat in Tunisia, rice in Thailand, and corn in Guatemala are currently being sponsored by AID (AID, 1969a:18).

A complementary strategy for improving nutrition involves changing the dietary practices of the target populations with respect to both preparation of individual foods and development of menus for family members of various ages. This program can be a part of both adult and child

education, but it is especially the focus of "mothercraft" and nutrition education centers (AID, 1969a:12).

Chafkin (n.d.) reports on his review of material prepared by Francis Gulick and of the situation as he found it in India. He finds need for more data on the nutritional status of the population in order to devise effective programs.

He finds Vitamin A deficiency geographically widespread and apparently not related to income level.

Noting that Kerala has low infant mortality, in spite of high degree of poverty, Chafkin speculates that the high ratio of animal to plant protein may be responsible. He also notes data on income elasticity of demand for various food products: namely that it tends to be high for the high quality foods; i.e. the people know in part what is good for them and will consume it if their income rises enough.

Possible nutrition strategies include emphasis upon

a) Pilot programs,

b) Education,

c) Mortality reduction,

d) Weaning age subgroup,

e) Fortification,

f) New marketing channels.

Then he notes the need for better objectives in order to pick a strategy or combination of them. Among the questions he raises is "Can an AID nutrition program be specifically designed to increase the effectiveness of the family planning program?" (Chafkin, n.d.:6).

He believes nutrition intervention for preschoolers would "probably reduce" the child mortality rate, and that this is "probably an important precondition for a successful family planning program." He suggests the goal of a program as reduction of child mortality by 30 percent during the fourth Five Year Plan. He faults the outline of that plan for being vague and not specifying the linkages and strategies. He computes sizes of target groups. A suggested program device would be weaning food stamps "to be presented to mothers obtaining family planning help." (Chafkin, n.d.:9). He then outlines a specific program to achieve his stated objective.

### II.7.2 Health Programs

1. Delivery Kits

Given that the great majority of babies in the target populations are delivered at home, there appears to be merit in the delivery kit technique employed by Yang, et al. (1969) in Korea. The kit, containing selected basic supplies for use in home delivery, and materials for registering the birth, was given to expectant mothers. (Whether an instrument for cutting the umbilical cord should be included in the kit rests upon disagreement as to the prevalence of septic measures in cutting the cord, with Gulick (1969:6) citing reports on the Khanna study of the early '60's saying that sickles are used and the wound is plastered with cow dung or ash, while Pareek (1970) says that such practices are no longer the rule and that generally scissors are used after being ritually purified in boiling water. Proper methods here would help reduce tetanus neonatorum (Cf. Lal, 1962:80 on circumcision and neonatal tetanus).

Of significance to the present project is the report that infant mortality (presumably neonatal mortality) was lower among kit users than among the control group.

2. Diarrhea Kits

One of the problems associated with diarrhea in the less-developed countries is that some of the conventional wisdom leads mothers to take just the wrong actions in trying to cure a sick infant or child, e.g., lowering fluid intake and removing pulses from the diet. If a delivery kit can be successful, it is possible that a diarrhea kit might also serve the purpose of reducing the number of mothers undergoing the loss of a child, and because the cure may be fairly dramatic, a kit might build prestige for the organization supplying it. The kit might consist of simple instructions, probably pictorial, a supply of vitamins and minerals sufficient for an average treatment period, some form of protein concentrate, a simple source of calories and perhaps a drug to reduce the activity of the gastrointestinal tract. Instructions should also include material on introducing new foods into the baby's diet. Kits could be made available through clinics, midwives, or perhaps even through commercial channels, though they might

need a subsidy to place them within the reach of a low-income population. As a last step, kits should be packaged in a container having some further utility to the recipient.

It has been suggested (Gordon, 1970) that a highly effective force for change in less developed countries is credibility developed through personal concern between program workers and the target population, such as that shown between health workers and their clients. Nutrition interventions involving instruction and education to enable the villager to attain a better diet appear to have some of this personal concern component. Other interventions, such as fortification, have little of this, but nevertheless can significantly affect nutritional status. As is often the case, it is probable that combinations of interventions will yield the most effective strategies. Gordon also notes that the group aged 4-24 months is one of the most difficult in which to improve the nutrition because they must be reached through their family. But it is also the group in which marked reductions in mortality can accompany improved nutrition.

## II.8 Nutrition and Fecundity

### Hypothesis II.8

> Fecundity, as a biological function necessary to the survival of the species, will be relatively insensitive to level of nutrition.

Fecundity--defined as the capacity to conceive and give birth to a live baby--can be separated into phases of conception, gestation, and delivery. Material on the influence of nutrition on conception is relatively scarce, probably in part because of the difficulties in getting suitable data for human populations. Some observations have been made of "natural" experimental situations, such as the severe nutrition deficiencies accompanying the siege of Leningrad and late stages of World War II in Holland. In the latter case menstruation stopped in one-half the women and became highly irregular in about one-quarter of the urban women reported on (Smith, 1947). The effect of this on conception, however, is not direct and simple, because ovulation can occur in the absence of menstruation. In sum, conception is probably impaired by severe malnutrition, but this relationship does not appear to have been the subject of much quantitative research.

The gestation and delivery aspects of the fecundity-nutrition relationship have received much more extensive examination. Numerous studies have been carried out in which groups of women subject to differences in nutrition are compared and contrasted with respect to the course and outcome of their pregnancies. In general, it can be concluded that varying degrees of malnutrition will increase spontaneous abortions, stillbirths, low-birth-weight babies, prematurity, obstetrical difficulties, and neonatal mortality.

The National Research Council (1970a, 1970b, 1970c) has published a major review and a bibliography of the literature on maternal nutrition and pregnancy.

Overall, it appears that in the target populations improved nutrition will lower the age of menarche and hasten other physical developments making a woman capable of conception. It will also improve her capacity for carrying a child to term and for nursing a child. On the other hand, observing the high levels of fertility characterizing countries like India and Pakistan in which malnutrition is known to be widespread, it does not appear reasonable that improvements in nutrition could raise overall fertility significantly. Insofar as improved maternal nutrition reduces fetal wastage and mortality in early life after birth, it appears likely to make the entire reproductive process more efficient. It might also mean that couples would achieve the number of surviving children they wished with fewer pregnancies and at an earlier age. In sum, the changes in fecundity anticipated to result from improved maternal nutrition are not deemed to exert a significant effect upon the entire social and physical environment that determines fertility in the less developed countries.

## II.9 Impact of Nutrition on Population Growth

### Hypothesis II.9

The impact of nutrition intervention on population growth can be estimated for short- and long-run periods.

This section reports the results of three simple models of population growth over a 50-year period under varying assumptions about birth and death rates.

1. Modeling Procedure

Because some of the most important effects of improved nutrition on death rates might be expected to occur in single years of age, the modeling procedure treated the population by single year of age. Age-specific death and birth rates were applied to the population at each age to yield deaths and births during a given year. Births were summed for all age groups and that total became the cohort of infants, aged 0, during the next time period.

Within the population established for the 50-year period, certain measures of population change were computed. These included crude rates of birth, death, and natural increase, a youth dependency ratio, and the size of the population aged 0-5 and 0-15. Average population for a two-year period was employed in computing the foregoing crude rates. The youth dependency ratio was defined as the ratio of population aged 0-14 divided by population aged 15-65.

Three models were used in simulating population changes. The first was based on data representing the population and vital rates of India in 1961; this was designated Model A. In Model B, death rates at ages 0-4 were lowered for all fifty years of simulation. Model C combined with Model B a reduction in birth rates at year 10.

Since many simple arithmetic operations were required, a short computer program was prepared for making the necessary calculations. It is flexible and yields results in about ten seconds of computer time (IBM 360/75).

2. Basic Data

The basic data on population and vital rates by 5-year age group were taken from Keyfitz and Flieger, World Population (1968). In

order to operate with these data on a year-by-year basis the 5-year age groups were distributed to single years and the birth and death rates for each 5-year age group were applied to the population by single year of age in that group. The exception to this procedure was for the population aged 0-4; for this group death rates by single year of age were approximated and the level was set so that infant mortality and the total deaths for the five years approximated those reported in other sources (Serow, 1970).

Vital rates used in the simulations are compared in Tables 4 and 5.

Table 4

Death Rates for Ages 0-4, Used in Simulations of Population Change

| | Sex | | | | | |
|---|---|---|---|---|---|---|
| | Male | | | Female | | |
| | Model | | Percent | Model | | Percent |
| Age | A | B,C | Decrease | A | B,C | Decrease |
| 0-1 | .14611 | .10228 | 30 | .15206 | .10645 | 30 |
| 1-2 | .06079 | .04256 | 30 | .07821 | .05480 | 30 |
| 2-3 | .01127 | .00789 | 30 | .01369 | .00959 | 30 |
| 3-4 | .00382 | .00267 | 30 | .00601 | .00421 | 30 |
| 4-5 | .00364 | .00255 | 30 | .00573 | .00401 | 30 |

Based on the review of the causes of death in infants and preschool children, we believe it is not unreasonable to propose that a reduction in death rates at ages 0-4 of as much as 30 percent could be achieved by nutrition interventions that provided individuals in this age group with minimum adequate amounts of protein, calories, and vitamins A, C, and the B complex. Causes of death that would be most affected by better nutrition include diarrhea, other

Table 5

Birth Rates and Total Fertility Rates Used in Simulation of Population Change

| Age | Models A,B | Models C | Percent Decrease from A,B |
|---|---|---|---|
| 10-14 | .00107 | .00040 | 63 |
| 15-19 | .15385 | .07400 | 52 |
| 20-24 | .28183 | .20700 | 27 |
| 25-29 | .26119 | .21600 | 17 |
| 30-34 | .20133 | .18800 | 7 |
| 35-39 | .13675 | .13400 | 2 |
| 40-44 | .05303 | .05400 | (2) |
| 45-49 | .01882 | .00800 | 57 |
| 50-54 | .00246 | - | - |
| Total Fertility Rate | 5.55 | 4.41 | 21 |

gastrointestinal disorders, measles, whooping cough, and certain respiratory diseases. This does not mean the diseases would no longer occur, but that they would no longer be lethal in as many cases. The actual pattern of decreases by age might be more likely to involve a larger decrease during the second year of life than in other years, but for the present purposes the reduction in death rates has been made proportionally in each of the first five years of life. The proportion of population surviving to five years of age is relatively insensitive to the year within the age group in which the reductions are concentrated, or whether they are spread equally in all years.

The initial age-specific fertility rates chosen approximate those for India in the early 1960's. The ones for Model C were based largely on those for Chile, hopefully a model toward which Indian rates might plausibly move, in 1964 taken from Keyfitz and Flieger (1968). Those age-specific rates yielded a total fertility rate of 4.41, 21 percent lower than the comparable figure for

India. Achievement of the rates used for Model C would be a substantial accomplishment but one that does not seem beyond the realm of possibility.

3. Results

The results of this modeling exercise are most concisely summarized in Table 6 and Figure 8, which show the changes in

Table 6

Effect of Altered Vital Rates on Relative Population Size

| | Model | | |
|---|---|---|---|
| Time | Control A | Reduced Mortality B | Reduced Mortality and Fertility C |
| 1 | 100 | 100 | 100 |
| 10 | 122 | 124 | 124 |
| 20 | 151 | 157 | 147 |
| 30 | 188 | 200 | 176 |
| 40 | 231 | 254 | 208 |
| 50 | 285 | 322 | 243 |

relative size of total population when death rates or death and birth rates are altered. Comparing the relative increases in populations A and B it is apparent that the 30 percent reduction in death rates at ages 0-4 has little effect for at least 20 years: population B is not quite four percent larger than population A at that time, although both have increased by more than 50 percent because of the relatively high fertility prevailing in the basic population. Beyond 20 years, however, the enlarged cohorts resulting from lower death rates are in the midst of their reproductive years; the result is a widening in the relative difference of total population so that at the end of 50 years population B is 13 percent larger than population A. It is obvious that a reduction in death rates at early ages should cause the sorts of changes reported here. What is less obvious,

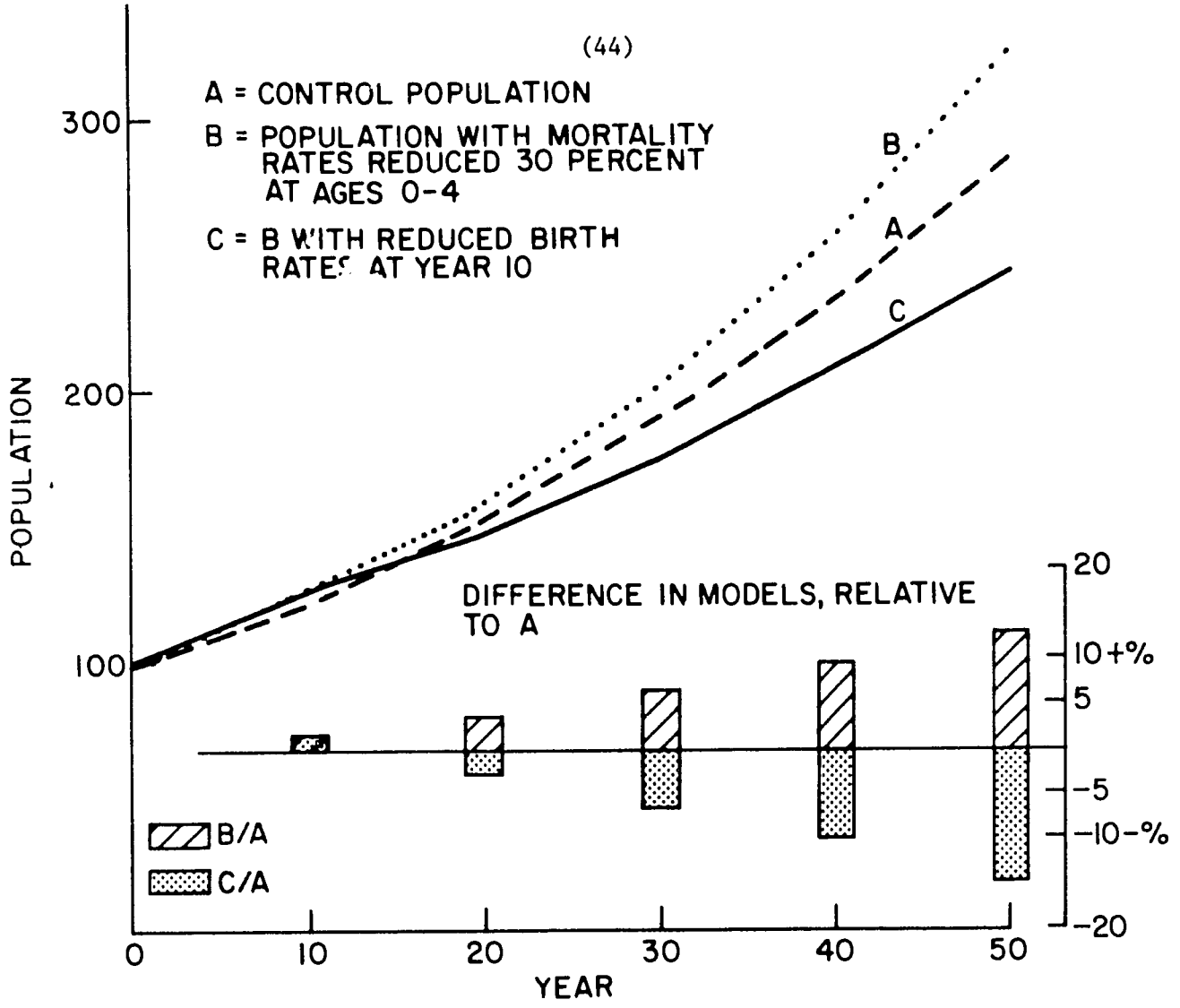


Figure 8. Relative Size of Total Population Under Assumed Declines in Infant Mortality and Subsequent Decline in Birth Rate

is that those changes are of relatively small magnitude in affecting total population size for about two decades. Considering the rapid changes in state-of-the-art with regard to family planning, 20 years might well be a very long time in terms of the development and implementation of more effective family planning programs.

The crude rate of natural increase for the population in Model A is about 2.2 percent per year with little variation over the 50-year period. (See Figure 9 ). In the population of Model B this rate rises to 2.4 percent as a result of lower early-life mortality, while in the Model C population, the crude rate of natural increase declines sharply in the ten years following the fertility

reduction to a level of 1.8 percent per year, and then drops more slowly, to 1.6 percent in the 50th year. The stability of this rate in population A suggests that the rates of birth and death are reasonable approximations of the rates prevailing. The significant declines, from 2.2 to 1.6 percent show that the drops in fertility rates would have important impacts on the population. Indeed, a smaller reduction in fertility would nevertheless offset the increase in population growth resulting from lower death rates at ages 0-5.

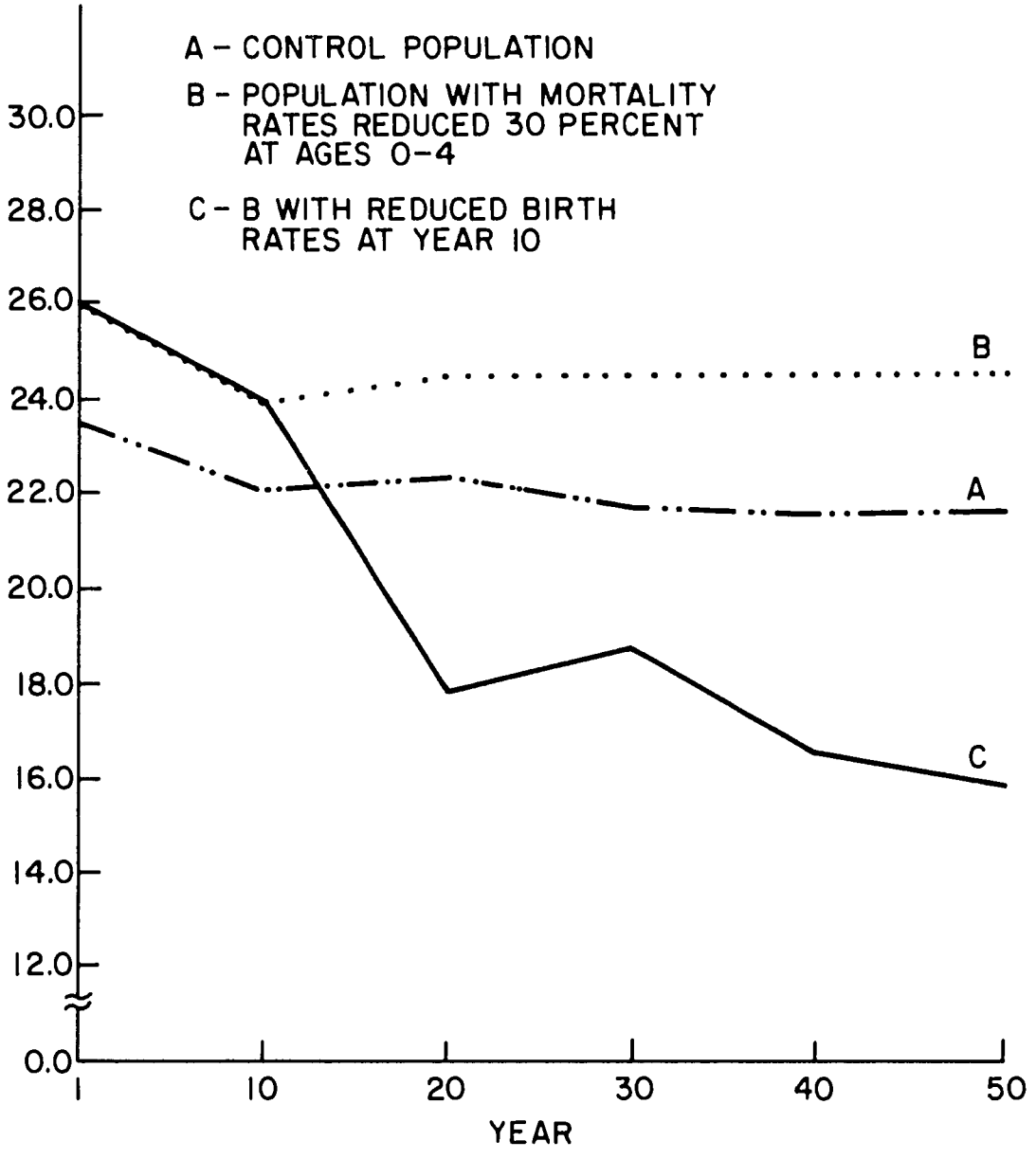


Figure 9. Crude Rate of Natural Increase (Per 1000 Population)

Another measure of population change due to alterations of vital rates is the relative size of population ages 0-5. This measure is shown in Figure 10 and indicates that a reduction in death rates from the levels of Model A to those of Model B would raise the size of this age group by less than seven percent during the first 20 years following the change in death rates. If, in addition, a reduction in birth rates could be expected, as in the case of Model C, then this age group could easily be decreased in size. The decrease, which is associated with reductions of fertility used in Model C, ranged from 15 to 28 percent during the 40 years following reduction of birth rate at year 10.

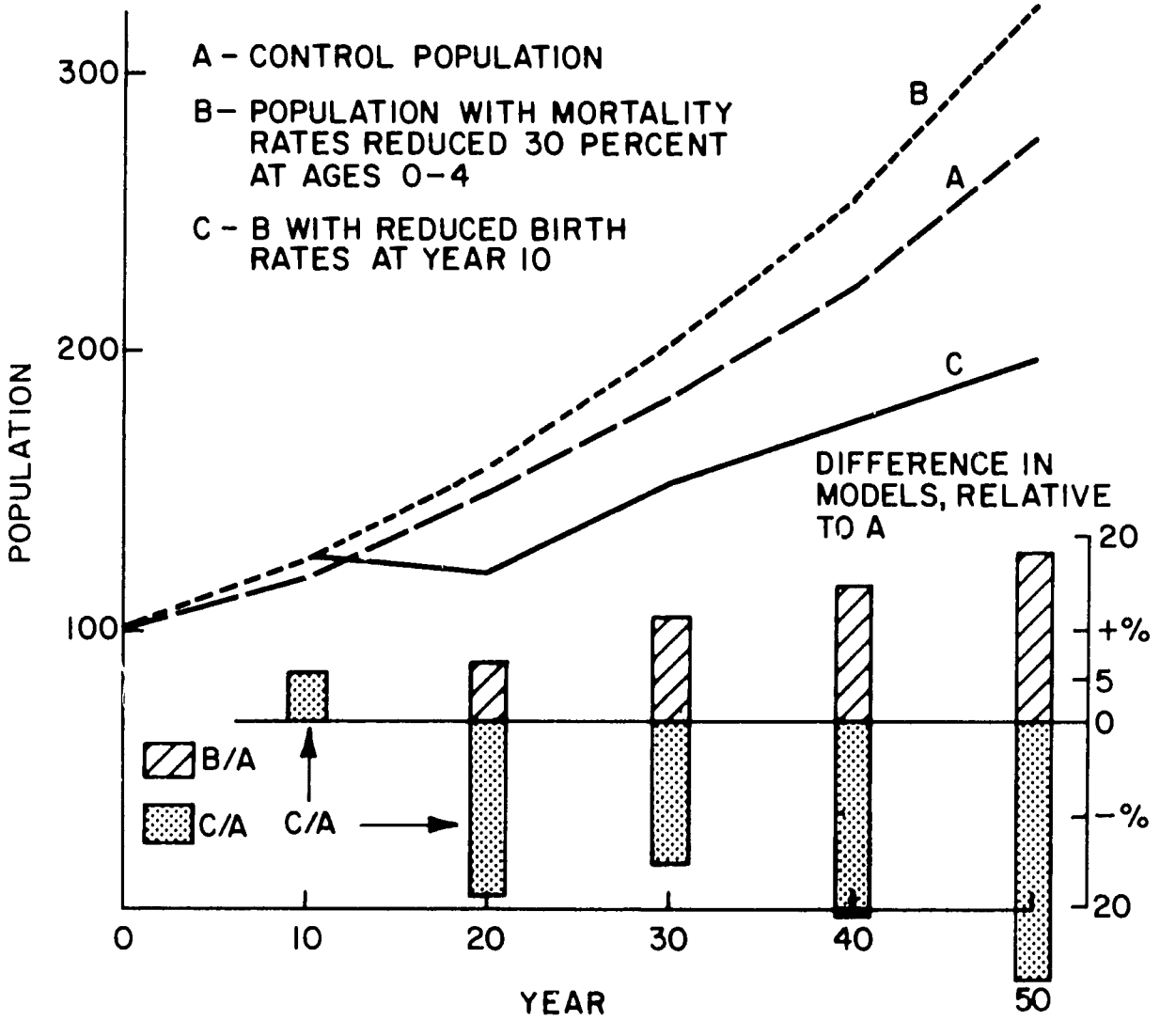


Figure 10. Relative Size of Population Aged 0-5

A fairly sensitive indicator of the changes worked by altered levels of birth and death rates is the youth dependency ratio, which states the population aged 0-14 as a proportion of the population aged 15-65--the group that would support the dependents. In the initial population this ratio was at .766. For Model A it remained within the range .75 - .77. For Model B, with lower death rates at ages 0-4, this ratio rose to .82 and ended at .81. For Model C, with lower death and birth rates, the ratio rose to .81 and then fell to .62 at the end of 50 years. Thus, the effect of reduction of fertility in early life is considerably outweighed by the effect of changes in fertility.

As the final step in relating this simulation of effects of early-life death rates on fertility, abbreviated life tables were prepared for the populations of Models A and B. The objective of calculating life tables was to link this exercise with the simulations performed by Heer and Smith (1968) and by O'Hara (1970), and in which the parameter linking mortality with fertility is expectation of life at birth. This linkage is complicated by the substantial differences in the patterns of death rates, from the Model Life Tables used in their analyses, and those employed here. Models A and B-C yielded expectations of life at birth of 48.2 and 51.1 years, respectively. This increase of 2.9 years in expectation of life is equivalent to that which might occur over a period of about six years, according to the assumptions made in setting up the Model Life Tables (United Nations, 1956:28). In comparing the changes in infant mortality rates with those in the Model Life Tables, however, it appears that a comparable amount of reduction in those rates in the Model Life Tables would ordinarily require a period of some 17-20 years. Such a time period is associated, in those Tables, with a change in life expectancy at birth of about ten years. Thus, the changes in infant mortality postulated for this simulation, while totaling only 2.9 years, appear to be equivalent to changes in expectation of life totaling about ten additional years when distributed across all population age groups.

A pessimistic interpretation of these two inconsistent interpretations of the effect of the assumed mortality change is that a change in expectation of life at birth of 2.9 years, raising it to age 51.1 could lower the net reproduction rate by as little as 0.03 of a percentage point, from 1.43 to about 1.40. If a more optimistic interpretation, using a ten-year change in life expectancy, is made, then the change in net reproduction rate is estimated at 0.05 of a percentage point. Neither interpretation yields a substantial change in the rate of population growth. Both interpretations, however, rest upon an assumed initial expectation of life of 47.5 years.

As both Heer and Smith and O'Hara have shown, their respective simulations are quite sensitive to the levels of death rate from which changes occur. With the O'Hara model, rapid decline in the rate of net reproduction begins just above a life expectancy of 57.6 years (Model Life Table 75); this is the level to which the death rates of Models B and C would bring the population under the more optimistic interpretation above. Naturally, the best manner of resolving these uncertainties of interpretation would be through an actual simulation run, utilizing the Heer-Smith and O'Hara models and programs; this could be a next step in research.

The salient point from the modeling exercise is that significant reductions in early life mortality have relatively small impacts on total population growth for some 15 or 20 years. Such a time period is a rather long one in terms of the changes that might be brought about by family planning programs which are undergoing rapid change in both techniques and effectiveness.

# III. CONCLUSIONS AND RECOMMENDATIONS

## III.1 Conclusions

Throughout this investigation it has been assumed that fertility behavior was rational. Little investigation is needed to see that this at best is only partly true and, indeed, as Mauldin (1970) has pointed out, may be primarily the adventitious result of biological/emotional activities in many populations. Because of this assumption, results have been stated in terms more bald and simple than they may exist in reality; the reader should make allowance for this. But the assumption of rationality appears to be a fulcrum necessary for inducing changes in fertility behavior; its size and importance in particular populations is open to assessment.

1) Infant mortality decline appears to precede declines in birth rates although the clarity with which this can be discerned varies from country to country.
2) The time lag between the onset of decline in infant mortality and that in birth rate has been as little as from 10 to 20 years in some countries.
3) Change in levels of infant mortality are certainly perceived between generations and appear to be perceived within shorter time spans, especially where programs are structured to bring the topic under discussion in the target population.
4) Family planning is most generally adopted only after the desired family size is reached or surpassed. Thus, reductions in the desired family size being sought can contribute to adoption of family planning.
5) Desired family size appears to rise as women experience deaths among their own infants and children. It may be inferred that it would not rise in the absence of such experience.
6) Acceptance of family planning depends not only upon achievement of a desired family size but also upon the survival of one or more male children. This may be inferred from the higher rates of survival for male children compared to females in the target populations (while in most populations male survival is below

female), from expressed norms about the need for surviving sons and from several studies simulating fertility behavior under the assumption that a high assurance of son survival is desired. The fertility behavior of the target populations is not inconsistent with the results of these studies.

7) Although the relations between nutrition and infection are complex, it is reasonable to attribute to poor nutrition a part of the high infant and child death rates observed in the target population. This is particularly true for diseases, such as measles, diarrhea, and other gastrointestinal disorders, that cause a large proportion of deaths in the malnourished target population but are not comparably lethal in better-nourished populations.

8) On the basis of limited data about the nutritional status of the target populations, it may be concluded that substantial problems of malnutrition beset as much as one-half of the people, but that due to cultural and educational factors the impact of poor nutrition weighs especially heavily upon the population of preschool-age, with the exception of nursing infants in their first months of life.

9) Nutrition intervention (e.g. food supplements, or nutrition education) can serve as an incentive for persons to visit a family planning center and thus to become more knowledgeable about family planning. Given the assumption of rationality that has been made about fertility behavior, however, such knowledge is expected to result in adoption of family planning only when the number of children begins to approach desired family size.

10) Malnutrition lowers fecundity through increased fetal wastage and infant mortality. It may also, when diet is sufficiently poor, impair the capacity to conceive. Overall, programs to improve nutrition in the target populations are expected to increase reproductive efficiency in the sense of raising the ratio of live births of normal weight to conceptions. But such increases in fecundity are not expected to lead to significant

rises in fertility because fertility is already quite high in the target populations, because improved survival in late pregnancy and in the neonatal period will lower parents' experience with mortality of offspring, and because where a child is wanted, attempts to produce it will continue in spite of fecundity impairments, nutritional or otherwise.

11) Assuming nutrition can be improved in the target population, it was concluded, on the basis of a simple population model, that fairly sizeable (30 percent) reductions in mortality at ages 0-4 would increase total population growth relatively little above its present, rapid rate for nearly two decades. After that, larger cohorts entering the reproductive years would result in more rapid rises in growth. On the other hand, a reduction in total fertility rates of some 20 percent, even occurring as late as 10 years after the reduction in mortality, could more than offset rises in population due to lowered mortality at ages 0-4. Although the latter population would still be reproducing at a rate much above replacement, the important conclusion is that reductions in mortality at ages 0-4 need not be viewed as imposing an insuperable burden on the means of subsistence in the short run and that there is a period of years in which family planning programs can operate to counteract them.

III.2 Recommendations

As a result of the foregoing investigation, it appears that a nutrition intervention can reduce infant and early childhood mortality and that such reductions do not increase population growth substantially in the shortrun. While some evidence appears to support the relationship between a decline in infant and child mortality and a decline in fertility, a causal relationship has not been demonstrated at this time.

It is noted, however, that since malnutrition is widespread in the target populations, substantial amounts of resources may be required--either to provide the necessary materials or to reallocate existing nutrients in the most effective manner. Moreover, nutrition interventions are but one program technique. Best results can usually be obtained by combining programs. In this case program efficiency would doubtless be

improved if sanitation--to control intestinal parasites--and child health were linked with the nutrition intervention. Thus attempts to evaluate the cost-effectiveness of nutrition interventions can best be developed in conjunction with analyses of the relationships between family planning and health programs.

Assuming a given level of funding for nutrition programs, it is recommended that these resources be concentrated, as much as possible in experimental/demonstration situations focused on the nutrition of children aged 4-18 months and that base line and subsequent data be collected to permit estimation of such factors as changes in death rates by age and cause, birth order, and number of, levels of, changes in fertility by age, parity, marital status, breastfeeding practices and child mortality experience.

The findings of Robert Reppeto, from his analysis of pregnancy history data should be obtained when they become available, in late 1970 or thereafter.

A replication of the analysis by Shafick Hassan of the effects of infant mortality on desired family size would be appropriate, with the aim of confirming his results with data from other areas, such as Morocco, and Turkey. Data for these areas is already available according to Mauldin (1970).

A seminar should be held to discuss the findings todate. The summary and conclusions of such seminar should be produced and disseminated to recipients of this report.

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