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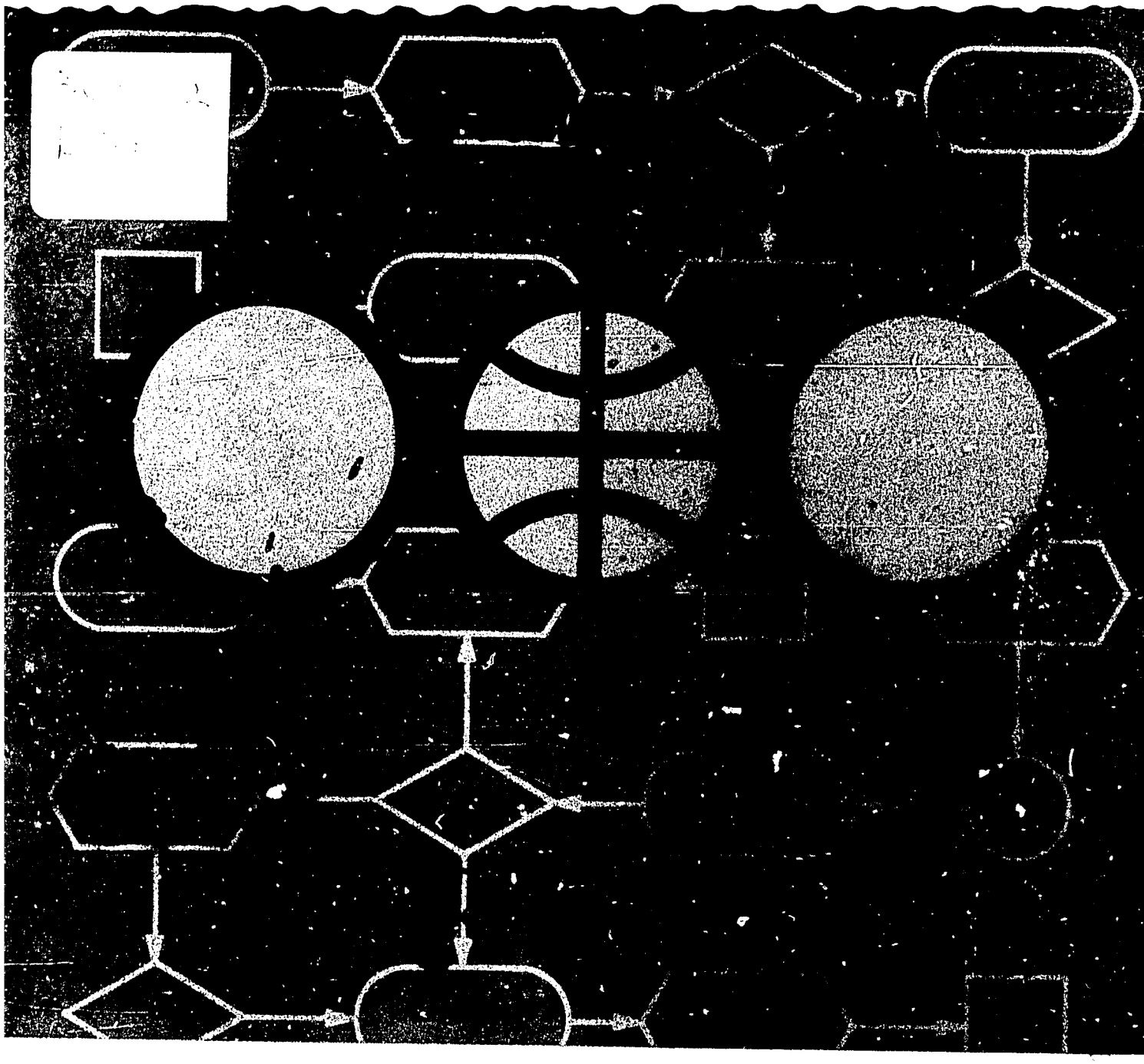

TOPICAL INVESTIGATION AND ANALYSIS OF PROMOTING FAMILY PLANNING THROUGH HEALTH SERVICES

FOR NEAR EAST-SOUTH ASIA/OFFICE OF POPULATION PROGRAMS
UNDER UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
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REPORT ON TOPICAL INVESTIGATION

AND ANALYSIS OF PROMOTING FAMILY PLANNING

THROUGH HEALTH SERVICES

by

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Project Leader

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FOREWORD

This report is one of a series summarizing the analysis 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 the secondary data searched under this work order. The secondary sources of supporting data are available and can be requested through NESA/OPP. Documentation of secondary data searched is presented in the References and Appendix C. Citations appearing in the References are those referred to in the text and Appendix B of the Technical Report, whereas those listed in Appendix C are works that have been searched, some in more detail than others, but whose content was deemed not as relevant as that of those cited in the References. Thus, the total volume of secondary data is reflected in the Reference lists and Appendix C.

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 be examined since a critical point upon which they depend does not hold.

Constraints of time and resources are imposed upon the analysis, for decisionmakers 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-513

Title: Promoting Family Planning Through Health Services

Approved by: A L Finkner

A. L. Finkner, Director
Statistics Research Division

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SUMMARY

A. Purpose

This investigation is concerned with the potential that health services provide for the promotion of family planning. This area of interest has many implications; these include economies of shared facilities and personnel, behavioral aspects of combined programs, priority conflicts in joint operations, long-term effects of fertility arising from mortality reduction, etc. The general problem of determining an optimal program of family planning and health services is not only the two product optimization problem of economics but a feedback systems problem of sociology.

Specifically, the purpose is to structure, by means of systematic analysis, the principal factors that are required in the evaluation of the role which health services can perform in optimally realizing family planning objectives given the significant environmental circumstances extant in the NESA region.

Two premises underlie utilizing health services as a means of promoting family planning:

1) Provision of family planning through health service programs can cost-effectively take advantage of this delivery system to reach a clientele for adoption of contraception. This is an immediate effect.
2) Improving the general health of the population and specifically reducing infant mortality leads to a reduction in desired family size and the resulting reduction in actual family size. This is a long-term effect.

Primary emphasis is to be placed upon the development of a concise means of utilizing minimal information to evaluate health services in the pursuit of family planning program objectives.

B. Methodology

Two basic tasks were undertaken in parallel in the process of systematically structuring the investigation of health services in family planning. First, a series of hypotheses were identified and ordered in a sequential procedure for investigation. Secondly, three models were derived that include the significant variables and their interrelationships. These three models are--

1) A health effects model--a macro model that contains the major elements deemed necessary to describe the effects of improved health on fertility behavior.
2) A delivery system model--a micro model that contains the major elements of a delivery system. The delivery system is composed of various health and family planning programs.
3) A decision model--a multistage model (the solution of which would require dynamic programming) that incorporates the results of the health effects model and based on the delivery system model. The model is representative of the actual decision process followed by family planning decisionmakers.

An attempt was made to keep the models general in nature yet directed towards the task of evaluating the implications of the hypotheses resulting from the first task. The environmental conditions found in the NESA countries were defined and their implications for investigation using the models were determined. After these tasks were completed, a preliminary review of possible data was made to determine the feasibility of proceeding with parameter estimation followed by experimentation using the models. During this data review, quantifications of implications from certain hypotheses were made.

C. Summary Results

The results of this investigation--three models for analysis and a structure of hypotheses to be tested using these models--can best be summarized under two general headings: first, the long-term effects of health services upon fertility behavior through mortality reduction and, secondly, the health service system as a means of promoting family planning.

1. Mortality-Fertility Effects

The basic assumption underlying most health service programs is that increasing expenditures for health services realizes a reduction in mortality and morbidity. A review of aggregate data from 21 countries indicated that this expected relationship-in the case of infant mortality-takes the form illustrated in Figure A.

Various studies have revealed high correlations between declining infant mortality and reductions in fertility behavior (counter examples do exist, e.g., Mexico). Other studies have shown that the experience of a childhood death among low birth orders or early in a marriage lead to increases in the number of children everborn. Thus, it is assumed that the reverse relationship holds, i.e., that the general improvement of health with a reduction in mortality produces an associated decline in fertility behavior. The general forms of these relationships are illustrated in Figures B and C.

This last assumption was questioned during the investigation by attempting to identify the means through which an improvement in health causes individual couples to change their fertility behavior.

First, no basis could be found for assuming that improvement in health per se would change the desired family size. Changes in desired family size most likely would result from shifts in the economic structure from agrarian to industrial or from shifts toward a "modern" social

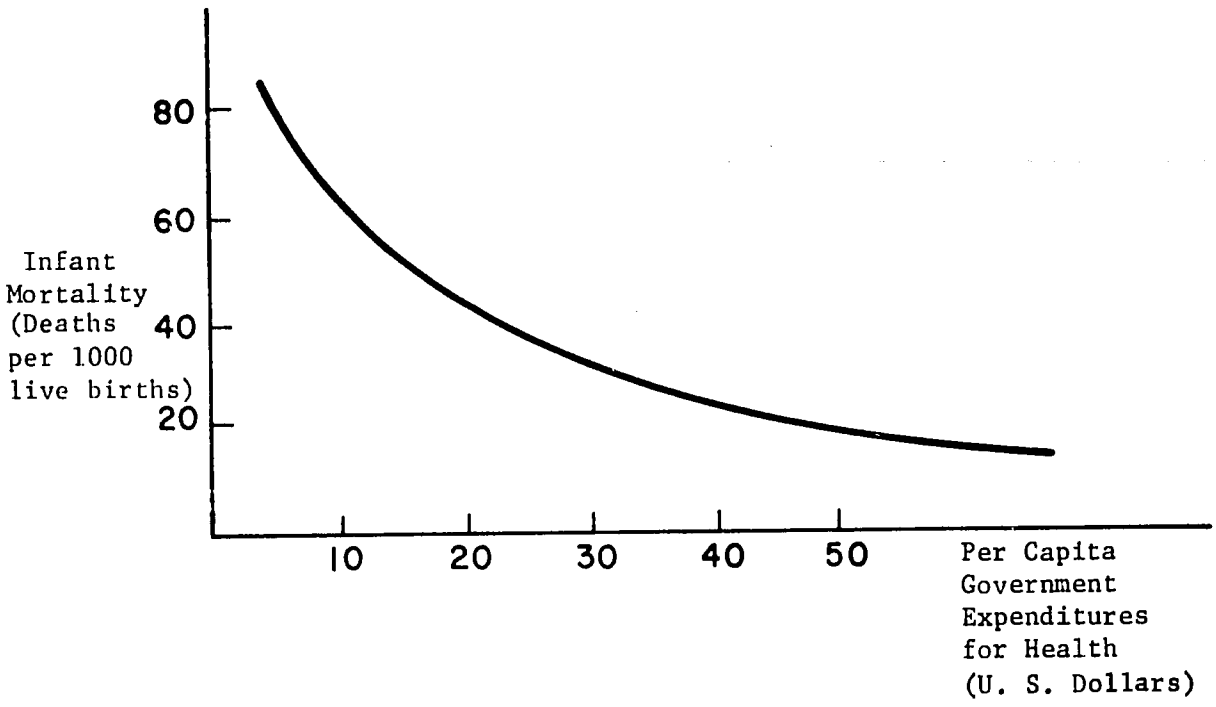

Fig. A. General Relationship Between Per Capita Government Expenditures for Health and Infant Mortality.

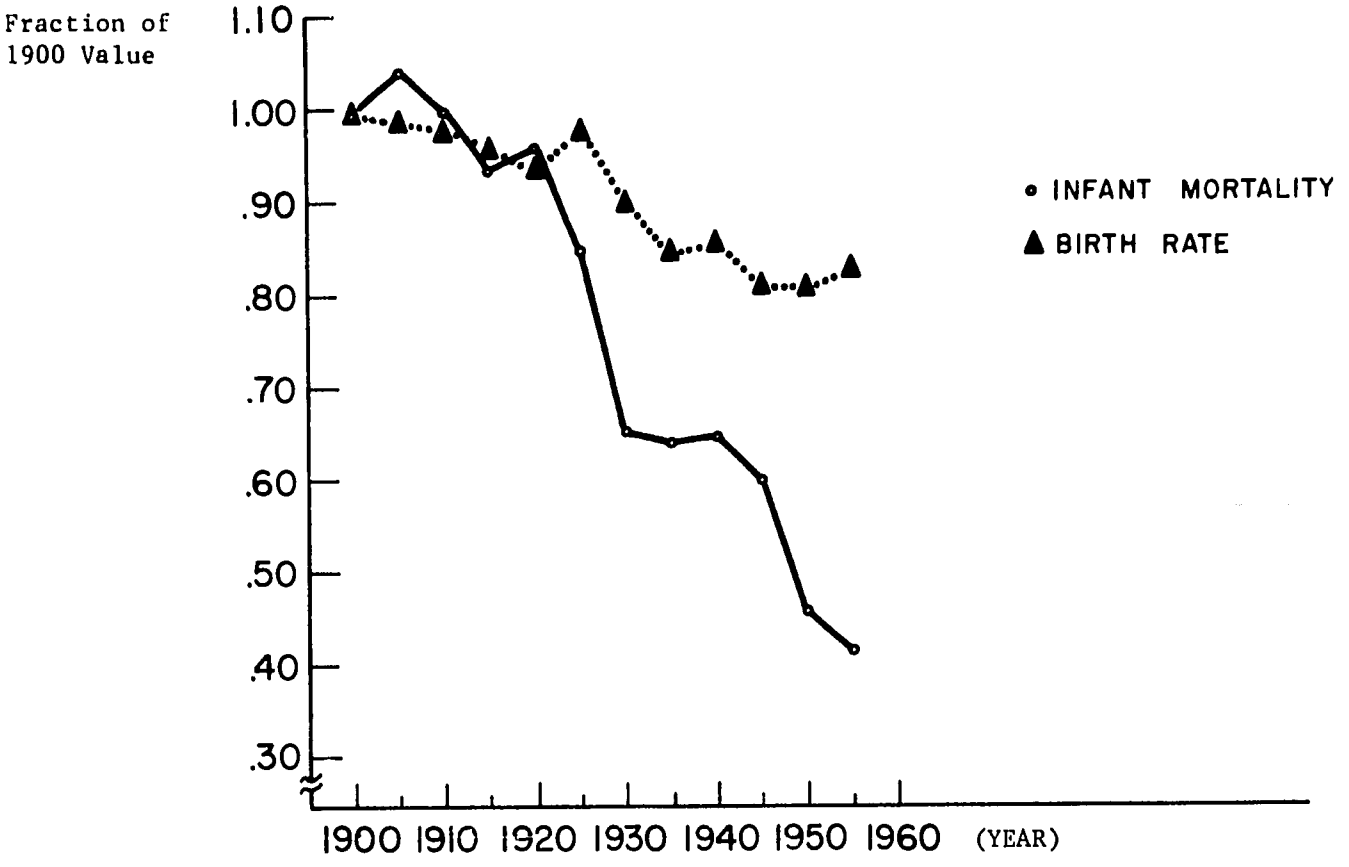

Fig. B. Typical Curves for Declining Mortality and Birth Rates As A Fraction of Their 1900 Values.

Source: [Ref. 66]

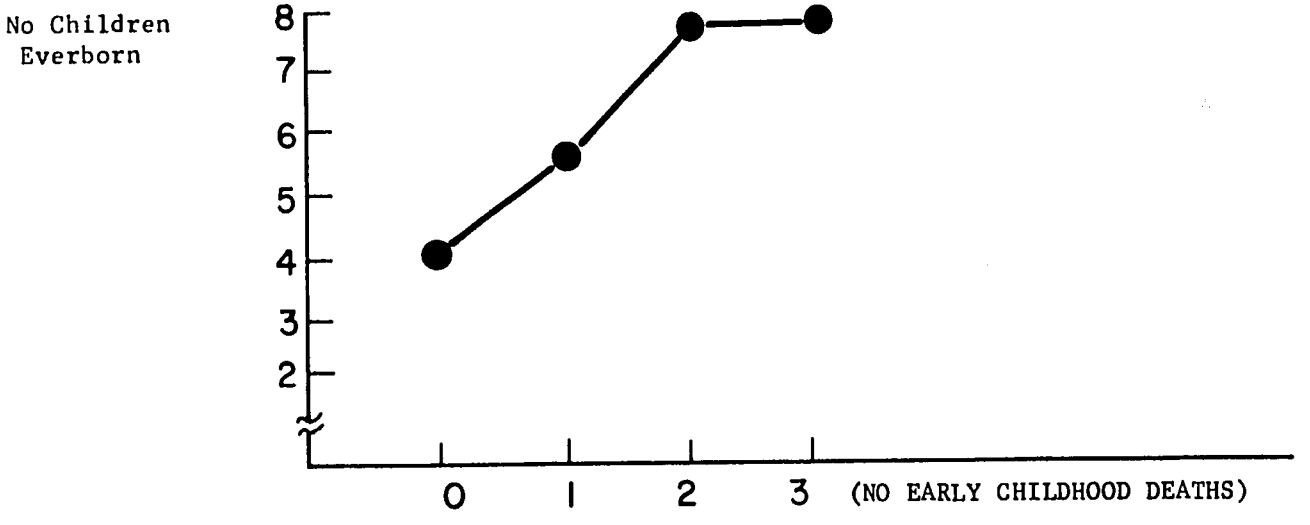

Fig. C. Children Everborn as a Function of Early Childhood Losses.

Source: [Ref. 16]

structure with associated norms. Thus, improvement in health affects the "excess" births couples have in order to compensate for those children who will die prematurely. In addition, improved health both increases the fecund period and reduces maternal mortality. The resulting change in total population is the net effects of (a) changes in "planned" pregnancies due to awareness of decreasing childhood mortality, (b) changes in accidental pregnancies arising from an increase in the length of the fecund period, and (c) changes produced by a larger maternal population resulting from decreasing maternal mortality.

Changes in the number of planned pregnancies arise from two sources: First, among those couples not experiencing early childhood loss, their realization that childhood mortality is decreasing could alter the "excess" births that they plan. The change in the excess will generally lag the mortality decrease due to delays in sensing and communicating the decrease. Only when there is an "over-anticipation" of the decrease will the resulting action--fewer excess births--exceed that justified by the actual mortality decline. Second, there will be a decrease in the number of couples who experience early child loss with a resulting decrease in the number of excess children born as a reaction to this loss. Studies indicate that under certain conditions, one child or more may be added for each child lost.

The various health-related terms affecting total population were incorporated into a model and estimated; the results indicate that a decline in mortality could produce either a net gain or loss in population. Further studies to improve these estimates are needed; the most sensitive term is the number of excess children produced as a reaction to early loss.

Since inconclusive results were found for this initital estimate, an attempt was made to evaluate the effects upon total population given certain declines both in infant mortality and birth rates. In addition, the birth rate decline was assumed to lag the mortality decline by a given number of years. No assumption of causality was made; this evaluation simply indicated what would happen if these conditions were met. The general results for one set of conditions are shown in Figure D.

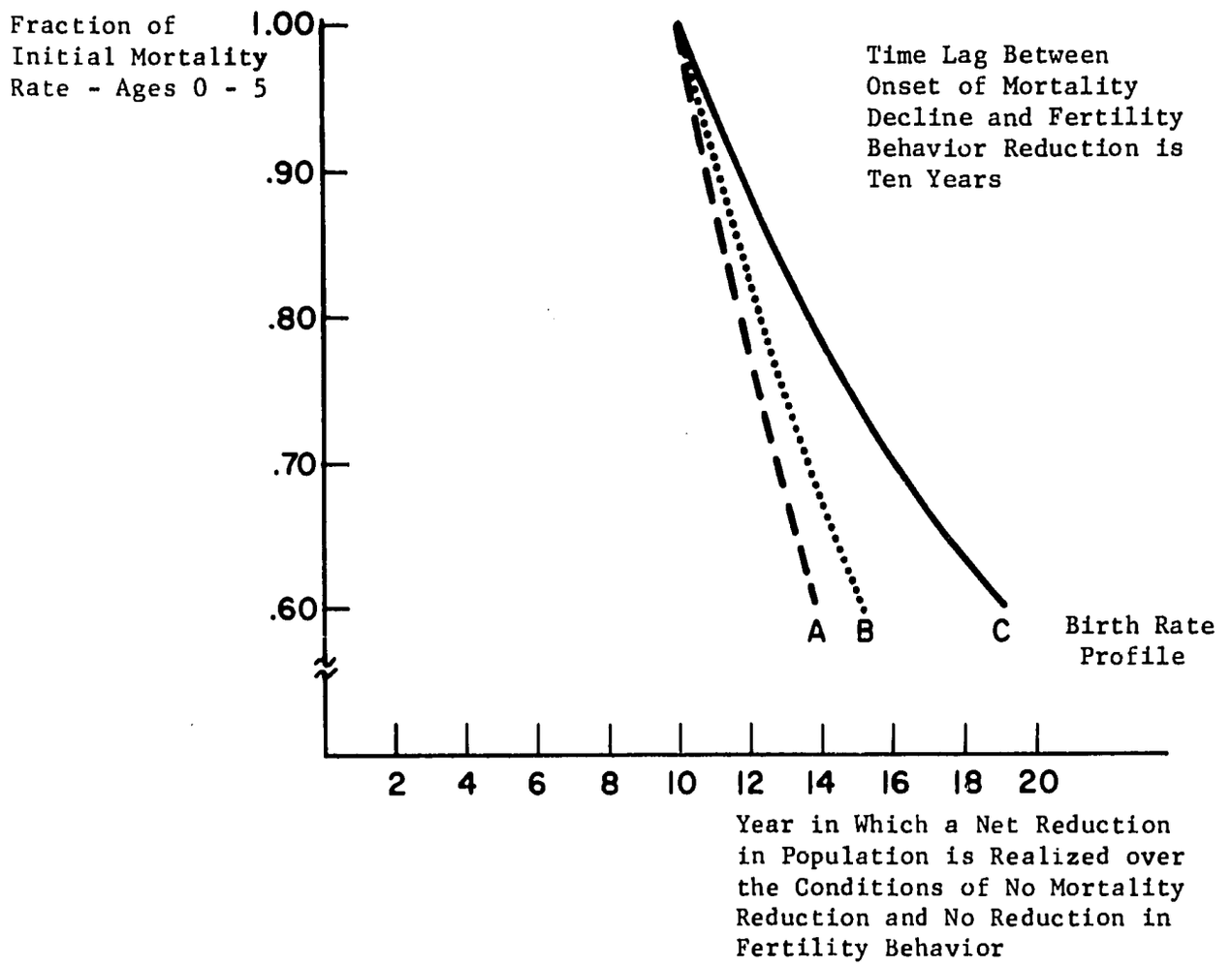

Fig. D. Effects of Reduction in Mortality and Fertility Behavior on Population Size

Birth Rate Profiles

A - 1.5 times the Chile 1964 rates.
B - Chile 1964 rates.
C - 0.5 times the Chile 1964 rates.

2. Health Services as a Delivery System

Alternative means of delivering services should be evaluated by how well each alternative satisfies some performance measure. In family planning several performance measures have been proposed, e.g., number of acceptors, couple-years-of-protection, married couples of reproductive age reached, and births averted. The measure births averted was adopted as the basic objective of this study's delivery system analysis model.

The desired alternative is that one which maximizes the number of births averted given certain limitations in available manpower and funds. For a family planning program integrated in a health service setting, the manpower requirements and cost factors per service would differ from a free standing family planning program. In addition, the actual contraceptive effectiveness of the two programs could differ as could their potential clientele.

The delivery system analysis model incorporates these considerations into a mathematical form that allows determination of the best allocation of family planning funds among potential health service programs--both rural and urban--and a separate family planning effort. The model considers--

a) Limitations in program operations due to available manpower and due to available operational budgets.

b) Limitations in the spread of family planning information arising from available trained manpower and budgets, attitudes toward the various types of services, and the general attitudinal climate of the country.

c) Limitations in the potential population that could become clientele.

The data available from various programs both within and without the United States were reviewed to determine whether satisfactory estimates of model parameters could be obtained. No one source of data was found that could provide the needed estimates; many sources were

found that provided certain portions. However, because of insufficient detail concerning data definition, comparison of data between these different sources should be undertaken only with great reservations. The incorporation of these various data into one model should be undertaken with caution and the necessary reservations attached to the results.

A final model for analysis of health services contributions to family planning was defined. The basic task facing a family planning decisionmaker is where to allocate this year's funds. This process, however, occurs each year and one year's actions and results affect the following year's decision. The best solution for one year may not be the best solution if a longer term viewpoint is taken. For example, if short-term results are desired, a program stressing minimal training and conventionals might be undertaken, whereas, longer-term considerations would dictate training for IUD insertions.

In addition to the year-to-year nature of decision processes involved, the actual process of contraceptive adoption by a culture goes through phases. This series of changes occurring in the community might best be serviced by a program that adapts to different environments with different strategies.

The final model--the decision model--includes considerations for the sequential decision process and the dynamic nature of the environment. Similar to the delivery system model, the decision model considers:

a) Manpower and budget limitations, now as a function of previous decisions.

b) Informed population as a function of previous program activities.

c) Potential population, also as a function of previous program effectiveness.

The results of exercising this model, given the necessary data, would indicate the optimal series of decisions to be made relative to the allocation of budgets over time among several programs (e.g., urban, rural health services, and free standing family planning) and activities within those programs (e.g., operations, information, and training).

The data necessary for the decision model are similar to that of the delivery systems model and the comments about validity, relevancy of such data also apply.

D. Conclusions and Recommendations

This investigation has produced three models and a series of hypotheses which, if used as a basis for further studies, should answer the question relative to the role of health services in promoting family planning. Since serious reservations exist about the adequacy of data required for model estimation, the following two recommendations are made.

1) Since the major reason given for using health services as a means of family planning promotion is the mortality-fertility effect, and since the data available for that model appear nearly adequate, it is recommended that a complete information search be performed on those aspects of the problem which have not been searched previously. The efforts of Rulison [Ref. 17] provide several insights into the causal relations between mortality and fertility behavior. The cost-effectiveness of health service programs per se needs to be investigated.
2) Since significant data inadequacies exist for the delivery systems and decision models, it is recommended that only the decision model be developed and professional opinion be utilized to augment the available data. Using the model, data, and professional estimates, a series of computer experiments should be undertaken to determine
(a) the sensitivity of the model to data variation, and
(b) optimal sequences of decisions for various environmental conditions, e.g., optimal series of decisions for 10 years in a country having a highly educated, urbanized

culture with an established health infrastructure versus the same decisions in a rural, average-educated culture with no infrastructure. The experiments should provide indications of what field experiments are required to acquire the data to further verify the hypotheses.

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Chapter I

THE PROBLEM

I.1 Aspects of Health Services as a Family Planning Medium

An apparent conflict between family planning and health services in the shortrun lies both in their opposite contributions to the attainment of reduced population growth and in their competition for the limited resources of men and money. If reduced population growth is the primary objective, then it would appear that health services should be sacrificed until attainment of this goal has been realized.

This is a simplification of the problem since improved health may contribute to the reduction of birth rates; evidence from developed countries suggests that, with improved health and decreased infant mortality, births decline. There are, also, complementary relationships between health and family planning services. Thus, there is the possibility both that the provision of health services may provide an entree to certain clients for the implementation of family planning programs and that health improvement may lead to reduced fertility.

Two premises underlie utilizing health services as a means of promoting family planning:

a) Provision of family planning through health services programs can cost-effectively take advantage of this delivery system to reach a clientele for adoption of contraception. This is an immediate effect.

b) Improving the general health of the population and specifically reducing infant mortality leads to a reduction in desired family size and the resulting reduction in actual family size. This is a long-term effect.

Advantages that have been stated for using health services as a means for promoting family planning include--

a) "Funds from more than one source may be pooled for the ultimate strengthening of both types of services. . . . More patients can be reached, thus providing greater community coverage. . . . Utilization of existing resources and personnel will help to prevent duplication" [Ref. 1].

b) "Integration of family planning and maternal and child health services is the way by which comprehensive maternal health care can be best provided for the individual woman. Care for girls and women of the child-bearing age should be provided in a longitudinal way--preconceptional, antepartal, postpartal, and interconceptional. . . . To remove one part of comprehensive care is to artificially separate and fragment it for the individual woman. Family planning may be so separated from the rest of maternity care that its potential availability and effectiveness becomes reduced" [Ref. 2].

c) "Periodic visits for child care provide an opportunity for continuous supervision, often required for successful family planning" [Ref. 3].

d) "Permanent MCH services with broad health interests are able to provide the continuity and follow-up that are desirable for family planning efforts. Single-purpose campaign efforts have met with initial success, only to flounder later because of the lack of follow-up services. Perhaps even more important, a long-standing community contact is desirable for overcoming initial ignorance and apathy" [Ref. 4].

e) "Favorable attitudes inherent in the provision of health services--including the important element of patient confidence--can be transferred to family planning personnel and their programs; or in those cases where the same personnel are utilized for both services, the favorable attitude will extend to both efforts" [Ref. 5].

f) "Provision of both services together within the same setting allows a degree of anonymity to the hesitant client" [Ref. 5, 6].

g) "Incorporating family planning in a health service program provides the field worker with several reasons for visiting a home; the breadth of services implied by a total program facilitates field worker acceptance and legitimatizes periodic visits" [Ref. 4].

h) "The positive aspects of health services provides satisfaction to both customer and staff worker. The resulting increase in staff gratification and morale will be reflected in reduction of personnel turnover and increased performance effectiveness" [Ref. 5, 6].

i) "Certain economies can be realized through the multiple utilization of resources" [Ref. 5, 6].

j) Finally, until childhood mortality is reduced, the average family will continue to bear large numbers of children hoping thereby to thus insure a living son for their old age regardless of the pressures exerted by family planning programs.

The counter arguments to incorporating family planning in health services stress the contention that, because of the importance of family planning and population control, they should receive the greatest possible emphasis. This implies that responsibility should be assigned at the highest possible level within government and not diluted by being included with any health services; that responsibility at even the lowest level of worker should not be shared with other activities since family planning would not receive the needed priorities; and that programs, services, etc. would not be developed quickly or in sufficient quality and quantity if integrated with health services. This contention results from the management principle of effectiveness resulting from organizational specialization.

In most instances, health services are not fully staffed so that the inclusion of family planning on an already over extended staff would

prove detrimental to both. It is also argued--counter to item (a) above--that the funds available would be greater for a separate autonomous program versus those available for a shared endeavor.

In those countries where there is not an established health service infrastructure, the time delay associated with waiting until such a structure is available is not compatible with the urgency of population control.

Delivery of health care in developing countries is often realized under conditions (e.g., large outdoor clinics with excessive caseloads and minimal doctor-patient exposure) that are not favorable to the changing of attitudes inherent in the adoption of family planning. The entire attitude complex surrounding family planning is different from that of health services and--counter to item (e) above--although the transference of high level of confidence may be achieved in some cases, that is not always the case [Ref. 7].

Review of these comments, opinions, etc., indicates two basic aspects to this problem: (1) the short-term considerations involved in the use of health services as a medium for family planning programs and (2) the long-term effects of health services upon family planning motivation through the intermediate variable of mortality. Utilization of health services--the short-term aspect--is basically a problem in cost-effectiveness where the efficiency and effectiveness of the joint operations must be determined. In general, the important considerations here include operational aspects, potential clients and costs--aspects which are amenable to analysis using the tools of management science. The long-term effects, however, lie more in the domain of sociology, demography, and other behavioral sciences.

I.2 The Structure of Hypotheses for Investigation

The two basic premises underlying advocating health services as a means of promoting family planning provide at least eleven basic hypotheses to be investigated. The sequential structure of these hypotheses for investigation is composed of two parallel efforts conducted simultaneously. Even if health improvement is a cost-effective means of reducing birth rates, the delivery system aspects must be investigated to determine how

family planning should be incorporated for short-term gains. The resulting hypothesis framework is portrayed in Figure 1, "Basic Hypotheses for Analyzing Health Services as a Means of Promoting Family Planning".

The eleven hypotheses can be summarized as follows:

H1: There is a significant relationship between health service expenditures and declines in mortality. Although the relationship in question is the basic reason for all health programs and is generally "known" to be true, the many variables intervening between expenditure, utilization, and mortality reduction operating in a developing country necessitate investigation of the existence and impact of this relationship.

H2: There is a significant relationship between declines in mortality (and in particular, infant mortality) and declines in fertility.

H3: Expenditures on health services are a cost-effective means of reducing fertility. This hypothesis is based upon the quantification of results from H1 and H2. In essence, it questions whether health effects alone are so significant in fertility behavior that they justify financial support as a family planning activity.

H4: Significant numbers of health service clients will adopt family planning practices when offered within the health service program. This is the first of the hypotheses concerned with the short-term (health services as a delivery medium) effect.

H5: Health service clients are effective contraceptors. Since users of health services exhibit an awareness of community resources, and the necessity of taking action to change one's "fate", they may have a predisposition to such programs as family planning that promotes a higher degree of use-effectiveness. In addition, these health service clients are seen at opportune times (post-partum) or are seen often thereby enhancing this use effectiveness.

H6: Health service programs are a cost-effective means of delivering family planning. This hypothesis is a first test of whether

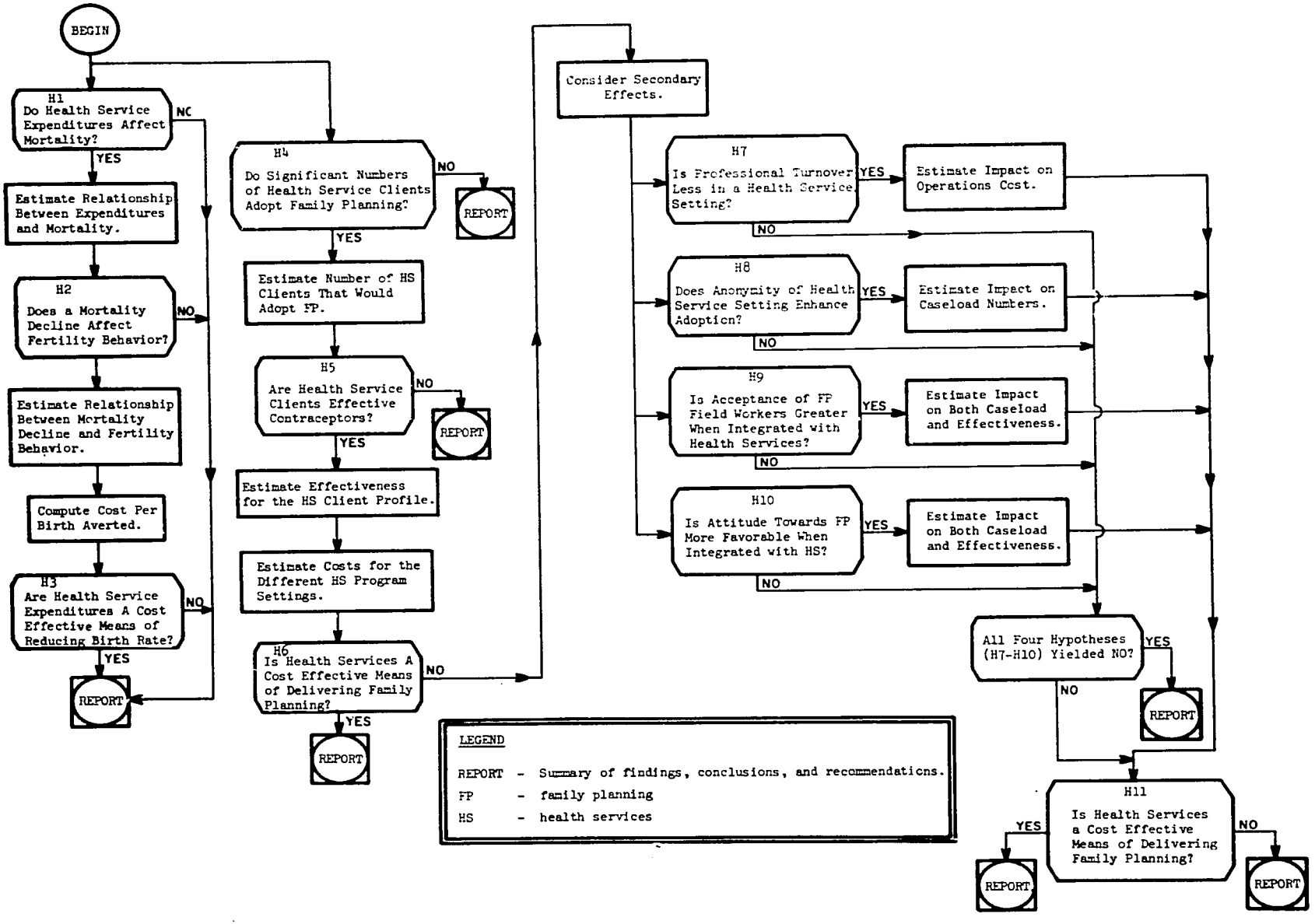

Fig. 1. Basic Hypotheses for Analyzing Health Services as a Means of Promoting Family Planning

health services is a competitive means of promoting family planning practices. The test of the hypothesis is based on quantitative results of H4 and H5 plus associated costs for using health services as a means of delivery.

H7: Professional personnel morale is higher and turnover reduced in a health service setting. This is the first of four secondary effects that may require investigation before health services can be proved a relatively effective means for promoting family planning. The effects of reduced turnover will lower both the training and operations costs as the program matures. Thus, an initially unfavorable evaluation of cost-effectiveness based on early personnel costs may become favorable when reduced costs become evident.

H8: The anonymity provided by a health services program enhances the adoption of a contraceptive technique. It is thought that certain individuals would go to a clinic where many services are provided to obtain advice on family planning but not to a "family planning only" clinic. This anonymity aspect would increase the total population reached.

H9: The incorporation of family planning with health services aids the field worker in dispensing FP information and in acceptance of the information. Having a larger selection of services should promote both entrance into the home and communication with the potential client.

H10: Favorable attitudes toward family planning result from its inclusion in a health services program. Health services tend to be viewed as a program that gives something; family planning sometimes has the stigma of taking something away--a stigma which might be alleviated by integration. Further, there is a logical basis for family planning as a component in a preventive health program.

H11: Considering all effects, health services is a cost-effective means of delivering family planning. This is H6 re-evaluated with the results of H7-H10.

The investigation implied by this hypothesis structure proceeds by first determining if the hypothesis is true or false and, if true, then estimating the impact upon a cost-effectiveness criteria. Any one hypothesis may have many sub-hypotheses that may require verification and quantification. For example, to determine if health expenditures affect mortality may require investigating several sub elements of health expenditures to determine cause-effect relationships, e.g., do expenditures in sanitation reduce mortality? This research project has verified some of these hypotheses and estimated some of their impacts. The primary purpose, however, was limited to providing the structure needed for a subsequent, more thorough, sequential investigation.

I.3 Improved Health as a Means of Reducing Fertility

Many of the reasons given for incorporating family planning in a program of health services are short-term, e.g., accessibility to client or increased effectiveness of education. One basic reason, that according to many is far more significant and alone justifies the incorporation, is that until mortality declines fertility will remain at a high level. The adoption of family planning requires a motivation to change and a reason for such a change must exist. As pointedly stated by Notestein, et al.:

> "Before any of the under-developed countries can effectively spread the practice of family limitation, they must have reasonably well-developed services in maternal and child health, health education, and community development. . . . Occasionally, one hears the objection that such efforts only complicate the problem of population growth by reducing the death rate. In the narrow sense, it is true, but it is basically false. No efforts of social-economic development can be successful in a disease-ridden population, nor will a desire for small families be likely to emerge. Better health and improved chances for survival of the individual child lie at the root of the motivational change we are seeking. . . . The failure of birth rates to fall in other parts of the world clearly turns less on lack of effective means than on the absence of strong motivation" [Ref. 8].

Fredericksen has studied the general question of whether fertility trends are conditioned by the economic rather than the demographic aspects of economic and demographic transition [Ref. 9,10]. Based upon a review of case histories from six countries, both developed and developing, and upon a cross-national study of 21 countries, he

concludes that mortality varies inversely with economic indicators of the level of living, with a balancing movement of fertility toward approximate equilibrium with mortality, i.e., toward a net reproduction rate above the replacement level but near unity.

Further, Fredericksen feels that a deliberate reduction in fertility is a sequel to a reduction in mortality. The reduction in mortality develops individual and collective motivation necessary for a restraint of fertility.

Among Fredericksen's findings for 21 nations are these, that "The coefficient of correlation between logarithmic transformations of the per capita products at constant prices and the mortality rates for the age group 1-4 years was -0.86 in the cross-sectional comparison and -0.72 in the longitudinal comparison" [Ref. 11]. The correlation between number of physicians and mortality rates for the same age group was -0.54 for the same point in time and -0.21 for the same period. These findings indicate that in certain developing countries the beneficial effects of health services are achieved in synergism with other improvements in the levels of living. By studying the rank correlations of personal income and ratios of physicians to population for 50 United States indicates, however, that after a certain point, the development of health services may become more important in the reduction of infant mortality than is increasing the economic levels.

The investigation of correlations between birth rates and changes in economic variables revealed either weak or no association, e.g., correlation between an index of the change in birth rate, 1951-1961, and product per capita at constant prices was only -0.23. Nor was there a high correlation between birth rates and marriage rates (0.37). The significant correlation (-0.73) appeared between the logarithms of the decennial index of relative change in birth rates, 1951-1961, and the logarithms of the rate of national increase (excess of birth rate over death rate in 1950) [Ref. 12]. Various effects are eliminated or held constant and the partial correlations studied. In each case, the coefficient remains highly negative, ranging

from -0.73 to -0.80. Fredericksen, after this thorough analysis, concludes that:

> "Thus 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. Moreover, the extension of health services provides facilities for the extension of family planning" [Ref. 13].

The Fredericksen indications are found at the macro level by investigating economic and demographic statistics and corroborate investigations by Carlsson and Schultz [Ref. 14, 15].

Hassan has found that childhood mortality raises both actual and desired family size [Ref. 16]. Since a large portion of these deaths occur within the first three birth orders or early in the marriage, the women tend to postpone contraception until high parity is achieved. Hassan concludes that early deaths among low parity children provides a stimulus to compensate rapidly while the couple is still fertile. The difference in actual and desired family size may be on the average as much as one additional child. The converse causal relationship, i.e., that lower mortality reduces actual family size, has not been demonstrated; this relationship is vital to the health effects argument. A complete discussion of these forces (as seen by Hassan and others) operating at the individual level has been documented by Rulison [Ref. 17].

I.4 Health Services As a Delivery Medium

Maternal and child health programs (MCH) are generally considered, by the advocates of service integration, to be the programs "of choice" in which to include family planning. As stated by the World Health Organization,

> ". . . care for girls and women of child bearing age should be provided at several stages--preconceptional, antepartum, postpartum, and interconceptional. Family planning is related to every phase of maternity care, in both service and educational aspects. If it is separated from the rest of maternity care, its potential availability and effectiveness are reduced" [Ref. 18].

The reason generally given for family planning inclusion in MCH is that it provides a means of child spacing. This in turn promotes maternal and child health by preventing maternal depletion, decreasing fetal wastage, and increasing the general well being of the child at birth. An MCH program with family planning incorporated thus provides a delivery mechanism and fosters improved health, realizing both the long- and short-term effects. This is in contrast to the postpartum program which, when not integrated with MCH, is solely a means of delivering family planning information and services.

Specific reasons for the integration of services have been stated by several authors [Ref. 19, 20, 21, 22]. One major argument for inclusion in a MCH program is that the adoption of contraception in the postpartum period provides a physiological advantage since about half of the women will have conceived within three months following the first postpartum menstrual period if no contraception is used (and there is a small natural infertility). This statement is based on findings by Tietze summarized in Figure 2. The tendency to count the number of persons who simply accept contraceptive advice without regard to age, parity, or time since last pregnancy has little physiological or statistical basis. Those women who adopt contraception immediately following postpartum have proven their fertility and are at an effective point to delay future conceptions [Ref. 19]. Those women who adopt a method months or years later and have managed to avoid pregnancy in the meantime did not represent high risks at postpartum.

The earlier that contraception education occurs, the more effective it will be in terms of births averted. Optimally, contraceptive education should be provided premaritally; the next most effective point is after the delivery of the first child. Psychologically, the patient is receptive to family planning advice given by the same people who have been providing advice regarding her health and that of her child. The continuing exposure afforded by an MCH program during each pregnancy, the appropriateness of timing (in postpartum), and the more appealing basis of "child spacing" promote acceptance. The association of family planning with MCH promotes both social and political acceptance.

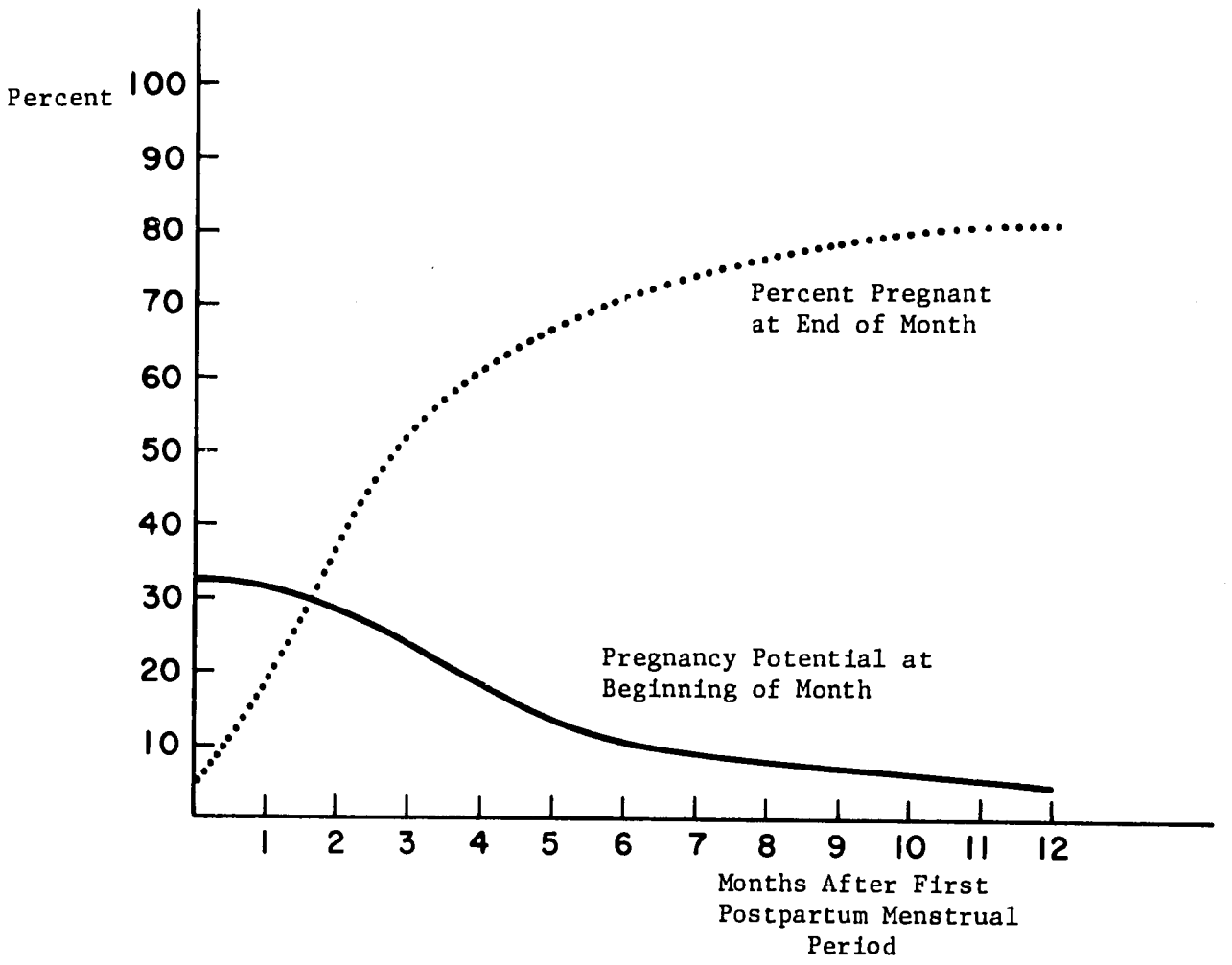

Fig. 2. Relative Effectiveness of Beginning Contraception at Various Months After First Postpartum Period.

Source: [Ref. 19]

Integration of the two services tends to insure a systematic coverage of each woman in the community. A pregnancy or the birth of a child is a highly visible event, and provides a logical and easy point of introduction both of health services and family planning. The existing health organizational structures in certain countries can be effectively used to promote family planning; in those countries without such established health services, their development generally has a high priority. These organizations and the health worker can provide a means of care detection and effective servicing.

Descriptions of typical MCH programs have been provided by several writers [Refs. 20, 21, 23, 24, 25]. Minimum functions for maternity and family planning as stated by Taylor, Berelson, Helbig, and Chen are --

a) A trained attendant at delivery;

b) Two antepartum and one postpartum visits preferably in a regional clinic or village subcenter;

c) Accessible facilities for the hospitalization of the complications of pregnancy and labor; and

d) A system of records of maternal deaths, perinatal mortality, and contraceptive acceptance [Ref. 20],

To realize these goals in an urban setting, these authors assume--

a) Hospitalization for delivery,

b) Supervision by a full-time obstetrician-gynecologist, and

c) Two-thousand annual births.

In a rural setting the assumptions are--

a) A maternity-family planning unit per 100,000 people,

b) One physician with training or experience in OB-GYN,

c) Facilities for antepartum and postpartum care and family planning,

d) A 20-bed unit for complications and surgery, and

e) Substations for each 4,000 people.

The requirements for these programs are given in Table 1.

One example of the actual delivery of health care that incorporates a MCH program is that embodied in the health center concept practiced in India. The resulting program operations, particularly in the area of MCH include--

Table 1

REQUIREMENTS FOR MODEL INTERNATIONAL MCH PROGRAM

	Urban	Rural
	Maternity Hospital for 2,000 Annual Deliveries	Health Center for Each 100,000 People (Approximately 4,000 Deliveries)
Maternity Beds	20	20
Staff		
Physicians in OB-GYN	1	1
Supervising Nurse or Chief Midwife	1	
Midwife Supervisors or Health Workers		5
Auxiliary Nurse Midwives	3	
Other	7	6
		Substations for each 4,000 persons
Auxiliary Nurse Midwife		1

Source: [Ref. 20].

a) The service population is designed to be 60,000 to 80,000 persons per center. Actually, the realized service population is approximately 20,000 persons living within a radius of 5 miles [Ref. 26, 27, 28, 29].

b) Maternal and child health occupies close to full-time of the health visitor and of four midwives that form half of the usual health center's staff [Ref. 26].

c) Estimates of the extent of prenatal care provided in terms of expectant mothers within the effective service area that were seen ranged from 10 to 50 percent with a mean of 29 percent [Ref. 30].

d) Estimates of the participation of center staff in child delivery indicated that 20 percent of those mothers who received prenatal care were assisted by staff during delivery [Ref. 30].

e) According to 31 center doctors, patients are seen on the average for 5 minutes or less; one third of these doctors felt the average to be one minute or less [Ref. 31].

f) Of a sample of center doctors, 84 percent felt MCH to be a basic center service but only 39 percent felt family planning to be so [Ref. 32].

g) From the same sample, 17 percent listed MCH as the service which should have the highest priority in center operations and 9 percent listed family planning. (Other choices included curative work, preventive work and health education) [Ref. 33].

The MCH/FP program as described above is largely a rural based program with an emphasis on health improvement. One program for the delivery of family planning in health services has been conducted within the International Postpartum Program, the basic premise of which is that the postpartum period represents an extremely favorable time to begin a contraceptive program since:

a) The subject is "captive" and time is available in which to do a thorough educational program,

b) The subject is psychologically receptive to advice about child spacing, etc., and

c) The necessary medical expertise is available for certain methods as IUD's and sterilization.

One further assumption inherent in this program is that the subject is delivered in a hospital and/or the subject will return for a postpartum checkup shortly (5 to 7 weeks) after delivery. Usually, the program is hospital-based, with emphasis placed upon accepting a particular method before the patient is discharged, i.e., on the short-term, delivery of service aspect. If the acceptance does not occur then, the postpartum checkup provides a second chance to achieve acceptance.

The International Postpartum Program organized by the Population Council began in 1966 and within the first 15 months of operation included 25 hospitals in the program. Each delivery or each abortion patient on its public service is informed of the significant aspects

of family planning. Methods utilized to inform the patients include both individual and group talks by social workers or other qualified personnel, visual aids, and even public address systems.

Significant results from this program for the first 15 months include these [Ref. 34, 35].

a) An average of 388 acceptors per hospital month, with a 315 average for the first month of the program and 500 for the fifteenth month.

b) The mean percentage of acceptance among hospitalized population is 22 percent; 45 percent in U. S. hospitals and 19 percent in non-U.S. hospitals.

c) Methods and percentages are--

	% Non-U. S.	% U. S.
IUD	52.0	30.3
Orals	22.7	53.7
Tubal Ligation	9.4	8.8
Others	15.9	7.2

d) The average preprogram postpartum return rate was 24 percent. Program experience has exceeded 40 percent.

e) Better than 50 percent of those who returned for postpartum care accepted family planning.

f) After 6 months an average of 88 percent were still using the original method.

g) Cost per acceptor ranged from an average of $16 for U. S. hospitals to $3.34 for non-U. S. hospitals.

Two major considerations in the postpartum program result from the method used. If the IUD is selected and if insertion takes place before the patient is discharged, a maximum of time between parturition and insertion should be observed. Retention rates as a function of this time period are illustrated in Figure 3. In some cases, it may be necessary to delay discharge of the mother in order to insure a higher probability of IUD retention. The associated cost trade-off must be considered. Reinsertion rates for IUD's experienced to date in the

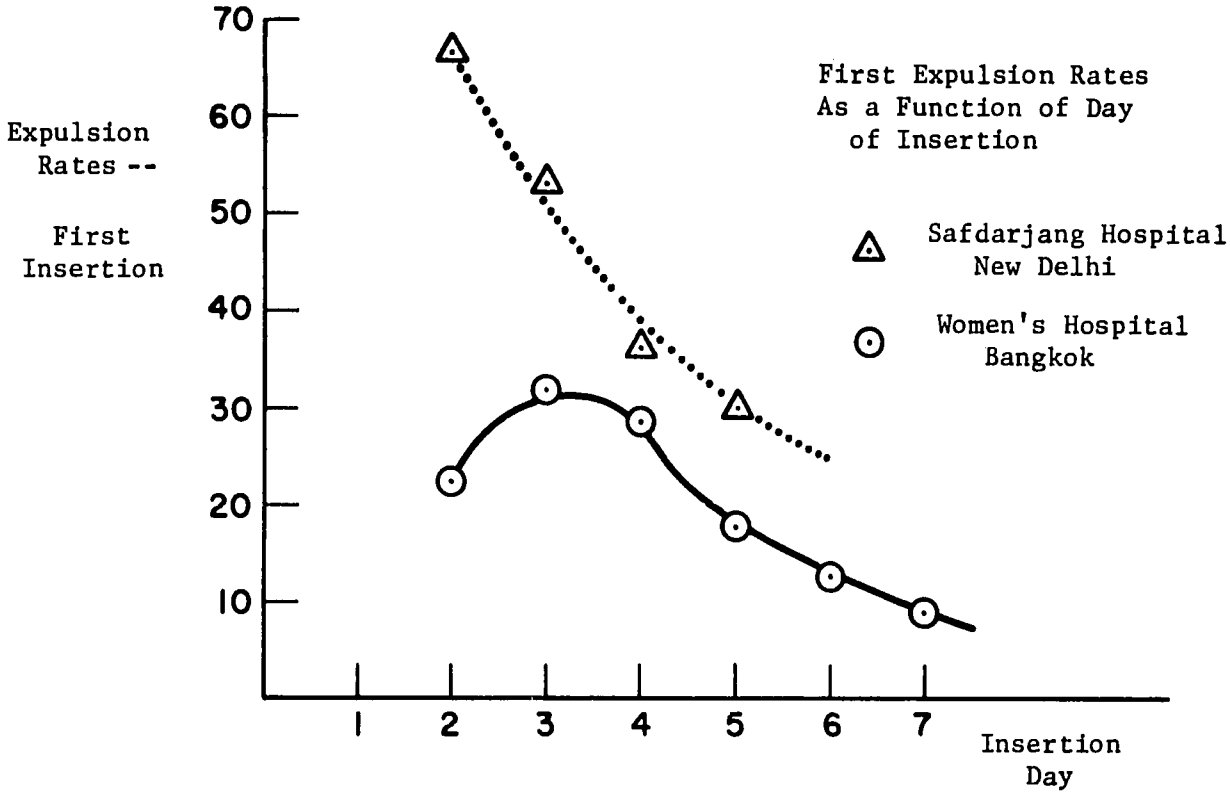

Fig. 3. First Expulsion Rates as a Function of Day of Insertion Following Parturition.

Source: [Ref. 34.]

program population has been high (60 to 95 percent) yielding overall results equivalent to retention rates in nonpuerperal women.

Secondly, if the mother is to breast feed and if oral contraceptives have been chosen, then this method should not be undertaken until lactation has been established [Ref. 36]. In certain cases of malnourished women, orals should not be given at all during lactation. This latter restriction implies a follow-up program to insure that those patients who adopt orals will be tracked, will have the necessary medical supervision to determine if orals are indicated, and, if so, will be provided the necessary supply. Further, any oral program implies that the user must be resupplied or be provided with access to supply points.

I.5 Concluding Remark

This chapter has discussed the general problem, provided a structure of hypotheses for investigation, and described the two general health service programs that usually are considered a means for promoting family planning. The next chapter provides three general models for analyzing aspects of this problem. The third chapter provides first an initial quantification of the mortality-fertility hypotheses, then reviews data available for estimating the models.

Chapter 2

MODELS

II.1 General

Three models, derived from descriptions found in the literature and from professional experience, needed to analyze the family planning/health services problem, are presented in this chapter. First, an aggregate model of the mortality-fertility behavior hypothesis is developed. This is followed by an elementary model that attempts to define the essential aspects in the delivery of family planning within health services. The final model of the sequential decision process performed by family planning decisionmakers has the potential of determining an optimal mix of family planning and health service programs. Following these model descriptions, their use in investigating the hypotheses of Chapter 1 is discussed. The presentations of these models in this chapter has purposefully been kept to a minimum; additional details of basic model structure are contained in Appendix B.

Three models were required because of different levels of aggregation and different time frames. The first model is a macro model that addresses the broad aspects of the health services--mortality decline--reduced fertility behavior phenomena. The second model is operative at a micro level within the delivery systems for a single time period. The final model is operative also at the micro level but for several time periods.

II.2 The Health Effects Model

The basic relationship between child mortality and fertility behavior are abbreviated in the following equations. First, child mortality is assumed to be a function of health expenditures, resources, and other socioeconomic variables. In functional notation,

$$CM = f(EHS, HSR, SE)$$

where

CM - child mortality

EHS - total expenditures on health services

HSR - health services resources

SE - other socioeconomic considerations

Assuming that fertility behavior is reflected in average family size and further assuming that each couple member is a rational decisionmaker* making maximum use of available information, then

$$AFS = f(DFS, ECD, ACD)$$

where

AFS - actual family size

DFS - desired family size at some future time; e.g., when father is 65 years old

ECD - expectations of the number of children that will die

ACD - actual number that die; i.e., ACD = f(CM)

Further:

$$DFS = f(ES, CF, RD, OSE)$$

where

ES - economic structure, e.g., industrial or agricultural economy

CF - cultural folkways

RD - religious dogma

OSE - other socioeconomic considerations (differs from SE above)

And:

$$ECD = f(ECM, CP, CH)$$

where

ECM - childhood mortality in earlier periods

CP - communication patterns within the community; determines how quickly information concerning improved conditions spreads and how this information is accepted

CH - couple's history of infant deaths

If the general form of the AFS equation is given by

$$AFS = a_1 DFS + a_2 ECD - a_3 ACD$$

$$a_1, a_2, a_3 > 0$$

then reduction in infant mortality either may increase or decrease the actual family size. The initial effect is to reduce the actual number that die thereby increasing the population. The reduction in infant

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* A rational decisionmaker is one whose decisions are consistent with his model of reality, the information available to him and his set of values that determine the utility to him of each possible outcome.

mortality then may induce a lowering in expected children deaths (ECD), first, as a result of reducing the "commonly accepted" number of excess children to bear necessary to compensate for infant mortality and, secondly, as a result of fewer couples experiencing early infant deaths with the resulting tendency to over-react by conceiving at every possible opportunity (the tendency reported by Hassan, described earlier [Ref. 16]). The direction of change in actual family size is determined by the initial level of excess births (the difference between ECD and ACD) and the degree to which this difference is dependent upon over-reaction by parents upon an early loss of a child. The reduction of ECD arising from decreasing mortality is only compensating in nature, generally lags the actual decrease, and thus would rarely exceed the population gains produced by decreasing mortality. (Note: Over-reaction upon the loss of an early child could be considered a non-rational act, a contradiction to a previous assumption. The assumption, however, allowed the couple to decide on "available information", which in their case means based on actual experience. Given their set of values concerning children and their specific statistics concerning infant loss, their acts are very rational.)

The above explanation was based on the assumption that desired family size* is not a function of childhood mortality. If the reduction in mortality is accompanied by a reduction in morbidity, then the average family may decide they need fewer children to participate in the work of the home. However, change in desired family size probably is far more sensitive to shifts in the economic and social structures which can occur in a shorter time span.than to the realization that fewer healthier children are needed for work.

A further consideration to be included in this model is the maternal health effects. A comprehensive health program will produce decreases both in childhood and maternal mortality. In addition, the fecund period will be increased. These positive additions to the population will be compensated in part by an increase in postpartum amenorrhea. Notationally this can be expressed:

$$PCM = f(MM, IF, IA)$$

---

* Note that this is the desired family size of couples that have not experienced early child loss.

where

PCM - population changes arising from improving maternal health

MM - decreasing maternal mortality

IF - increased fecundity

IA - increased amenorrhea

To summarize the previous general equations into a more explicit form, consider just the changes that might result from improved health:

$$\Delta TP = \Delta PB + \Delta AB + \Delta M$$

where at any time

ΔTP - change in the total population

ΔPB - changes in "planned" births, those considered conceptions

ΔAB - changes in accidental births, those conceptions not planned

ΔM - changes in surviving mothers

or, when expanded

$$\Delta TP = 1 + \Delta TC \{[\Delta ACD - \Delta ECD] + CR[\Delta FP - \Delta IA]\} + \Delta MP \Delta MM$$

where

ΔTC - changes in the number of conceiving couples

ΔACD - changes in the actual childhood deaths, a result of changes in childhood mortality rates

ΔECD - changes in expected childhood deaths

CR - rate of "accidental" conception

ΔFP - change in the average total fecund period

ΔIA - change in the average total period spent in postpartum amenorrhea

ΔMP - change in maternal population at risk

ΔMM - change in maternal mortality

This equation can be converted to the more general form

$$TPC = \int_{o}^{T} TC(t) \{ACD(t) - ECD(t) + CR[FP(t) - IA(t)]\} + MP(t)MM(t)dt$$

where

TPC - total population change in period T

TC(t), ACD(t) etc. are the time function equivalents of ΔTC, ΔACD, etc.

Whether there is a positive or negative change in population depends upon the actual values of the above terms, some estimates of which are included in Chapter 3.

II.3 The Delivery System Model

The delivery system model can be generally structured as a maximazation problem given certain budget, manpower, and client constraints. The objective of the delivery system is to maximize some program performance measure, e.g., births averted. To realize this requires the maximization of contraceptive acceptors weighted according to the effectiveness of the accepted technique. The constraints imposed upon this maximization are defined by the funds available for operations, including the dissemination of information, the necessary personnel and actual population that are potential acceptors. The following model attempts to relate the necessary aspects that are sufficient to explain the majority of delivery system aspects.

Beginning with the constraint imposed by program operations $[PM_i]$, this can be defined by

$$[PM_i]_t = \min[PMB_i, PMM_i]_t$$

where in time period t

$[PM_i]_t$ - the maximum number of acceptors that can be supplied/ serviced by government programs; defined as the minimum of two maximums

$[PMB_i]_t$ - the maximum number as determined by operational budgets

$[PMM_i]_t$ - the maximum number as determined by available trained manpower.

Defining further,

$$[PC_i]\cdot[PMB_i]_t \leq [BPO_i]_t$$

where PC_i is the unit cost for technique i; e.g., the cost to supply and insert an IUD, and BPO is the available operational budget. Similarly,

$$[MR_i]\cdot[PMM_i]_t \leq [MPO_i]_t$$

where

MR_i - the required units of manpower adequately trained to provide the service required by technique i and MPO is the available manpower.*

---

*An assumption is made here that the required unit of manpower is an optimum unit, i.e., a mix of manpower types has been optimized to provide a maximum output given the constraints of available manpower.

Available manpower in any period is a function of decisions regarding training made in previous periods. Certain of these decisions rest with the decisionmaker especially in areas of support personnel; however, the supply of trained physicians is more dependent upon the decision process of the individual physician many years previously. Since the short term effects in this instance are relatively constant, it will be considered to be an exogenous variable. The inducement of physicians into program services, especially on a fee-for-service basis, will be reflected in the unit cost figure. Thus available manpower other than physicians is given by

$$[TCS_i]\cdot[MPO_i]_t \leq [BPT_i]_{t-1}$$

where

TCS - cost to train support personnel.

It is assumed that only one time period is required to train personnel; further, it is assumed that the basic time period is one year. The exogenous physician supply (denoted by MPP) now is separated from the previous PMM equation; thus, PMM must satisfy both

$$[MR_i]\cdot[PMM_i]_t \leq [MPO_i]_t$$

and

$$[PP_i]\cdot[PMM_i]_t \leq [MPP_i]_t$$

where

$[PP_i]_t$ - physician unit required to perform the service required by technique i.

(NOTE: the assumption is made that costs and manpower requirements are time independent.)

Reduction of the attitudinal aspects is similar, considering first those couples beginning to use technique i who have reached their desired family size [IFS]:

$$[IFS_i]_t = [IIFS_i]_t\cdot[NDFS_i]_t$$

where in any period t

$[NDFS_i]_t$ - an exogenous variable representing the fraction of eligible population that has reached desired family size

and the fraction of [NDFS] that has been sufficiently informed [IIFS] is given by

$$[CIF_i]\cdot[IIFS_i]_t \leq [BPI_i]_t$$

$$[MIR_i]\cdot[IIFS_i]_t \leq [MI_i]_t-[MFT_i]_t$$

$$[IIFS_i]_t \leq PEF$$

where

CIF - cost to inform

MIR - manpower required to inform

BPI - budget allocated in this period to inform

MI - manpower available for information

MFT - manpower turnover (losses)

PEF - a maximum defined by external conditions, e.g., in a clinic setting where information is provided only in the clinic, PEF would be the number of clinic patients.

The assumptions are made that the individual cost figure includes the cumulative effect of information/education activities performed in previous periods and that the cost to inform for those who have attained desired family size is less than that necessary to change attitudes, etc., implied in practicing birth spacing. As the program matures many of those who practice contraception for birth spacing will continue for family size reasons. Thus the assumption that costs for "family size" informing are less is doubly reasonable--both attitudinally and from a return on previous investment consideration.

Manpower available is again a function of previous budget decisions:

$$[TCI_i]\cdot[MI_i]_t \leq [BTI_i]_{t-1}$$

where

TCI - cost to train information activity personnel

BTI - budget for training personnel in previous time period.

It is assumed that there is a very large pool of trainable personnel; the costs to train reflect difficulties in realizing this assumption.

Those practicing contraception for birth spacing reasons [IBS] also are a function of [NDFS] and information spread:

$$[IBS_i]_t = (1-[NDFS_i]_t)\cdot[IIBS_i]_t$$

where

IIBS - the fraction of couples eligible for birth spacing practice that have been adequately informed.

The fraction [IIBS] was stated to be a function of many complex, culturally-based variables. To simplify this relationship, an index of message effectiveness is used that reflects the combined results over time of such factors as perceived infant mortality, changing cultural folkways, modernization, decreasing mortality, etc. (NOTE: this factor includes the effects described by the first model.) Notationally,

$$[IIBS_i]_t = [ME]_t\cdot[EEP_i]_t$$

where

$[ME]_t$ - the index of message effectiveness assumed technique independent; an exogenous variable

$[EEP_i]_t$ - the eligible population that is exposed to a message.

The exposed eligible population is given by the maximum [EEP] that satisfies:

$$[CIB_i]\cdot[EEP_i]_t \leq [BIB_i]_t$$

$$[MIB_i]\cdot[EEP_i]_t \leq [MAB_i]_t-[MBT_i]_t$$

$$[EEP_i]_t \leq (1-[NDFS_i]_t)$$

$$[EEP_i]_t \leq [PEP]_t$$

where for time period t

$[CIB_i]_t$ - cost to inform for birth spacing reasons

$[BIB_i]_t$ - budget allocated for informing those eligible for birth spacing

$[MAB_i]t$ - manpower available to inform--birth spacing

$[MIB_i]_t$ - manpower required to inform one individual

$[MBT_i]_t$ - manpower turnover (losses)

$[PEP]_t$ - a maximum defined by external conditions, e.g., in clinic patients.

Manpower available again is a function of previous training:

$$[TCB_i] \cdot [MAB_i]_t \leq [BBT_i]_{t-1}$$

where

TCB - cost to train

BBT - budget allocated in previous period

The fraction of the eligible population that is sufficiently motivated thus becomes the sum of the [IFS] and [IBS], i.e.,

$$[AT_i]_t = [IFS_i]_t + [IBS_i]_t.$$

The remaining factor for consideration is the eligible population. During the previous discussions the terms individuals and couples were used interchangeably; it is assumed that one individual per couple is affected by the technique used but that the couple practice contraception. The eligible population thus becomes the collection of couples who qualified for the given technique.

A further attribute could be attached to these populations in order to apply the proper birth rate probabilities; this attribute is the age of the female member. Thus when a population, age 25-29, is discussed, it implies that the female member of the couple is in that age bracket.

In general, the eligible population is increased by individuals growing older and entering the population while it is decreased by departures to other populations or by death. Eligibility definitions may also alter the size. Assuming a constant set of eligiblity definitions,

$$[EP_i]_t = [EP_i]_{t-1} + [AD_i]_t - [DE_i]_t$$

where for any time period t,

$[EP_i]_t$ - the eligible population

$[AD_i]_t$ - additions to that population

$[DE_i]_t$ - deletions to that population.

Finally, assuming that the contributions from the private sector are zero, ($[PR_i]_t = 0$) the acceptors $[A_i]$ of a given technique can be stated to be

$$[A_i]_t = [EP_i]_t \cdot [AT_i]_t \leq [PM_i]_t.$$

The user defined in the structural model has become translated into an acceptor for this reduced model. This simplification was made since computation of users in any period would require knowing previous program performance in each contraceptive category. This additional information is not deemed that significant, especially when aspects that will arise in the development of a sequential decision model are considered. This aspect will be discussed again during the decision model development.

Further, no age categories have been incorporated in the above model (although this could be done and was indicated at one point). This sacrifice was made for ease of computation; for this initial model it is considered adequate that a weighted average based on population characteristics be used for birth rate probabilities which will then be converted into a weighted average of births averted for the objective function. The objective function for this model becomes

$$[BA]_t = \sum_i [E_i][A_i]_t[E(BA)_i]$$

where for period t

BA - total births averted

E - effectiveness of technique i

A - acceptors of technique i.

$E(BA)_i$ - expected value of births averted per couple accepting (using) technique i

Finally, the various techniques and programs implied by the subscript i must be defined. One possible set is given in Table 2. Additional technique-program elements can be added with an accompanying increase in data requirements.

The model, its parameters and variables are summarized in Tables 3 and 4.

II.4 A Decision Model

The initial delivery system model--given the appropriate data--can be used to investigate the hypotheses listed in Chapter 1 (a discussion of the investigation feasibility as determined by data constraints is included in the next chapter). The basic decision process from which

Table 2

TECHNIQUE-PROGRAM DEFINITION

Subscript Value i	Technique	Setting
1	Sterilizations	Free Standing FP Program
2	IUD	Free Standing FP Program
3	Other	Free Standing FP Program
4	Sterlizations	Health Services - Urban
5	IUD	Health Services - Urban
6	Other	Health Services - Urban
7	Sterlizations	Health Services - Rural
8	IUD	Health Services - Rural
9	Other	Health Services - Rural

Table 3

SUMMARY OF THE REDUCED MODEL

Objective Function: $\max \{[BA]_t = \sum_i [E_i][A_i]_t[E(BA)_i]\}$

Subject to:

1. $[A_i]_t = [EP_i]_t \cdot [AT_i]_t \leq [PM_i]_t$
2. $[EP_i]_t = [EP_i]_{t-1} + [AD_i]_t - [DE_i]_t$
3. $[AT_i]_t = [IFS_i]_t + [IBS_i]_t$
4. $[IFS_i]_t = [IIFS_i]_t \cdot [NDFS_i]_t$
5. $\max [IIFS_i]_t$,
   such that $[CIF_i] \cdot [IIFS_i]_t \leq [BPI_i]_t$
   $[MIR_i] \cdot [IIFS_i]_t \leq [MI_i]_t - [MFT_i]_t$
   $[IIFS_i]_t \leq PEF$
6. $[TCI_i] \cdot [MI_i]_t \leq [BTI_i]_{t-1}$
7. $[IBS_i]_t = (1-[NDFS_i]_t) \cdot [IIBS_i]_t$
8. $[IIBS_i]_t = [ME]_t \cdot [EEP_i]_t$
9. $\max [EEP_i]_t$
   such that $[CIB_i] \cdot [EEP_i]_t \leq [BIB_i]_t$
   $[MIB_i] \cdot [EEP_i]_t \leq [MAB_i]_t - [MBT_i]_t$
   $[EEP_i]_t \leq (1-[NDFS_i]_t)$
   $[EEP_i]_t \leq [PEP]_t$
10. $[TCB_i] \cdot [MAB_i]_t \leq [BBT_i]_{t-1}$
11. $[PM_i]_t = \min [PMB_i, PMM_i]_t$
12. $[PC_i] \cdot [PMB_i]_t \leq [BPO_i]_t$
13. $\max [PMM_i]_t$
    such that $[MR_i] \cdot [PMM_i]_t \leq [MPO_i]_t$
    $[PP_i] \cdot [PMM_i]_t \leq [MPP_i]_t$
14. $[TCS_i] \cdot [MPO_i]_t \leq [BPT_i]_{t-1}$

Table 4

VARIABLES AND PARAMETERS USED IN THE DELIVERY SYSTEM MODEL

Variables			Parameter	Description
Exogenous		Endogenous		
Decision	Non-Decision			
BPO				Budget allocated for operations
	MPP			Available physicians
		MPO		Available personnel for operations
		PMM		Limitation due to manpower
		PMB		Limitation due to budget
			MR	Manpower required per service
			PC	Cost per service
			TCS	Cost to train support personnel
BPT				Budget for training service manpower
			PP	Physicians time required per service
		PM		Program limitation
BPI				Information Budget
		IIFS		Informed fraction of those who have desired family size
	NDFS			Fraction having desired family size
			CIF	Cost to inform for birth prevention
			MIR	Manpower required to inform
		MI		Manpower available to inform--birth prevention

(continued)

Table 4

VARIABLES AND PARAMETERS USED IN THE DELIVERY SYSTEM MODEL (cont.)

Variables			Parameter	Description
Exogenous		Endogenous		
Decision	Non-Decision			
		IFS		Fraction practicing birth prevention
BPI				Budget for program information--birth prevention
			TCI	Costs to train information personnel
		IBS		Fraction practicing birth spacing
		IIBS		Fraction of eligibles informed
	ME			Message effectiveness
		EEP		Exposed eligible population
			CIB	Cost to inform for birth spacing
BIB				Budget for program information--birth spacing
			MIB	Manpower required to inform
		MAB		Manpower available to inform --birth spacing
	PEB			Maximum exposed population --birth spacing
	PEF			Maximum exposed population --birth prevention
	MBT			Turnover in manpower-- birth spacing
	MFT			Turnover in manpower-- birth prevention
			TCB	Cost for training information manpower--birth spacing

(continued)

Table 4

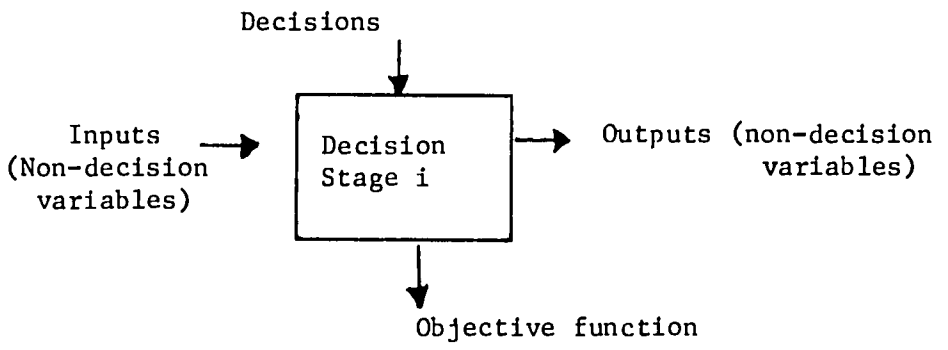
VARIABLES AND PARAMETERS USED IN THE DELIVERY SYSTEM MODEL (cont.)

Variables			Parameter	Description
Exogenous		Endogenous		
Decision	Non-Decision			
BBT				Budget allocated for training information manpower--birth spacing
		IBS		Fraction of eligible population that practices birth spacing
		AT		Fraction practicing family planning
		EP		Eligible population
			AD	Additions to the eligible population
			DE	Deletions to the eligible population
		A		Acceptors of a contraceptive technique
			E	Effectiveness of a given technique
			E(BA)	Expected value of births averted per couple
		BA		Total births averted

this model was derived is a sequential allocation of budgets to various activities. In order to evalute decision strategies, this sequential nature over long periods of time must be considered. The determination of an optimal policy could be undertaken using simulation techniques and the appropriate modification of the model formulated above. Such an approach would require searching many combinations of the decision variables to select a best combination. Such a search does not insure an optimal solution since all solutions are not searched.

Another approach particularly suited for optimization of sequential optimizations is provided by dynamic programming. The technique of dynamic programming can be described briefly by:

a) Consider any stage i in a sequential decision process; the non-decision variables have been given values, the decision-maker decides upon values for the decision variables, and the values of the non-decision variables are altered according to the basic relationships between variables. The new values for the variables yield a new value for the objective function used by the decisionmaker. Schematically:



b) The decisionmaker normally attempts to optimize his objective function for each stage. But, since the stages are interdependent (output from one stage is the input for the next stage), stage-wise optimization is not necessarily the optimal procedure for the total sequence of stages.

c) Dynamic programming begins with the last stage in the decision sequence and computes the optimal solution (values for objective function, and decision variables) and the resulting output values for each combination of input variable values. The results of this computation are stored. The same procedure is then used for the preceding stage, only now the output values are used to enter the stored results from the last stage computations to determine the associated optimal value of the objective function which is added to the value of the next-to-last stage objective function. The optimal value of these sums is determined. The associated decision values are recorded thus yielding an optimal decision policy and objective function value for each input combination.

d) This is repeated stage-by-stage for all preceding stages. Once the actual values of inputs to the first stage have been determined, the optimal decisions and the resulting value of the total objective function can be determined [Ref. 37].

Utilization of dynamic programming is limited by the number of variables--both input and decision--that define the model. A further simplification of the initial model is necessary before attempting a dynamic program solution. The model is given by:

Objective function:

$$\max \{BA=\sum_t \sum_i [E_i][A_i]_t[E(BA)_i]\}$$

Subject to the constraints for each stage t given by:

$$\sum_i C_i A_i \leq B \qquad i=1, 2, \ldots 9$$

$$\sum_j M_j A_j \leq MU \qquad j=1, 2, 3$$

$$\sum_k M_k A_k \leq MR \qquad k=4, 5, 6$$

$$\sum_\ell M_\ell A_\ell \leq MF \qquad \ell=7, 8, 9$$

$$A_i \leq P_i \qquad i=1, 2, \ldots 9$$

$$A_i \geq 0$$

$$A_m \geq OL_m \qquad m=3, 6, 9$$

where:

- BA - total births averted
- E_i - effectiveness of technique i
- A_i - acceptors of technique i
- $E(BA)_i$ - expected births averted per couple accepting technique i
- C_i - unit cost per acceptor of technique i
- B - budget for operations
- M - manpower required to service a given technique
  - j - manpower required in an urban health service setting
  - k - manpower required in a rural health service setting
  - ℓ - manpower required in a family planning program
- MU - maximum manpower available in an urban health services program
- MR - maximum manpower available in a rural health services program
- MF - maximum manpower available in family planning programs
- P - eligible populations that have been adequately informed
- OL_m - lower limits on conventional contraceptives distributed

A total budget is given for each decision stage which is then allocated among operations, training, and information. The training budget determines the fraction of the eligible population that is sufficiently informed to accept a given technique. The eligible population is determined by basic demographic characteristics and previous program success in eliciting acceptors. Notationally, for stage n

$$BT = B + BM + BI$$

$$BM = BMU + BMR + BMF$$

$$BI = \sum_i BI_i$$

$$P_i = [FI_i]_n [EP_i]_n$$

$$[FI_i]_n = [IK_i][BI_i]_n$$

$$[EP_i]_n = [EP_i]_{n-1} - [A_i]_{n-1} + [PI_i]_n$$

$$[IK_i] = f([\sum_n A_i]/EP_i)$$

$$MU = LU[BMU]_{n-1} + [MU]_{n-1} - [TMU]_{n-1}$$

$$MR = LR[BMR]_{n-1} + [MR]_{n-1} - [TMR]_{n-1}$$

$$MF = LF[BMF]_{n-1} + [MF]_{n-1} - [TMF]_{n-1}$$

$$E(BA)_i = f(\sum_a R_a P_a)_i$$

where

BT - total budget

B - operations budget, including equipment cost, etc.

BM - budget for training

BI - budget for information

BMU - budget for urban health services manpower

BMR - budget for rural health services manpower

BMF - budget for family planning manpower

BI_i - budget for informing about technique i

P_i - eligible population that has been informed about technique i

FI_i - fraction of eligible population informed about technique i

EP_i - total eligible population

IK_i - factor that converts budget dollars into fraction of individuals informed. This factor is a function of the ratio of acceptors (A_i) to total eligible population (EP_i)

PI_i - increase in population eligible for technique i during the period

MU, MR, MF, BMU, BMR, BMF - as defined above

TMU, TMR, TMF - turnover in the appropriate manpower categories

LU - factor that converts budget dollars into trained manpower for health services - urban

LR - factor that converts budget dollars into trained manpower for health services - rural

LF - factor that converts budget dollars into trained manpower for family planning

(NOTE: these factors include considerations of buildings, equipment, etc.)

$E(BA)_i$ - expected value of births averted for technique i; a function of age specific fertility rate factors (R_a) and number of females by age category (a) in population (P_a) eligible for technique i.

Using the further simplified model in a dynamic programming algorithm should yield an optimal allocation of resources between the two health service programs and family planning. Given the boundary conditions in a particular country, such a solution would indicate the best strategy to be followed by a decisionmaker.

II.5 Comments on the Models and Their Use

The previous three models provide a means of estimating, given the appropriate data, the impact of the subject hypotheses. Certain comments regarding these models and their use are required before ending this chapter. These comments are of two types: first, there are certain observations regarding the models as models; secondly, an explanation of how specific country situations affect model use is needed.

The general health effects model is an aggregate, macro model. It requires certain simplifying assumptions (e.g., reductions in infant mortality affects the expected childhood deaths, not desired family size) and provides results based on expected values of certain parameters. The estimation of these parameters and the further modeling of relationships underlying the basic population change equation (ΔTP) may prove both conceptually and procedurally difficult.

Further, only the explicit form of the effectiveness equation (change in population) was provided. The explicit cost equation would relate mortality to health expenditures and would probably be of the form:

$$M = k_1 e^{-(a_1 EHS + a_2 HSR + a_3 SE)}$$

where

M - mortality

k_1, a_1, a_2, and a_3 - positive constants

EHS - health expenditures

HSR - health resources

SE - other socioeconomic indicators

The actual equation form would have to be determined from an investigation of a health service system to insure that the effects directly attributable to health programs were the only ones included in the equation. The effects on child and maternal mortality would then have to be computed. Given these results, appropriate cost-effectiveness ratios for various levels of health expenditures could be determined.

The initial delivery system model is stated in a linear programming format. The assumption of linear relationships may be untenable, especially for certain of the costs given a wide range in the associated variable. Similar reservations must be stated for the sequential decision model.

The country specific situational characteristics enter the models by altering the values of certain parameters. The significant differences in the countries include--

- Extent of health infrastructure
- Maturity of health programs
- Number of different health programs
- Rural-urban population mix
- Economic status
- Sociopolitical structure
- Belief syndromes
- Extent of family planning infrastructure; previous family planning policies and programs
- Degree of health services and family planning integration

The effects of differences in these are summarized in Table 5.

Table 5

EFFECTS OF CONSIDERING COUNTRY-TYPE SITUATIONS ON THE THREE MODELS

Description of Type Situation	General Effect	Model Effects		
		Health Effects Model	Delivery System Model	Decision Model
• Extent of health infrastructure	Extensive infrastructure promotes spread of information, has potential for large clientele, reduces cost of delivering FP	Reduces cost to achieve reduction in mortality. The constant a_1 in the equation above.	Reduces unit costs (PC) Increases eligible population (EP). Reduces cost to inform (CIF, CIB). Increases available manpower (MAB,MI).	Reduces cost (C) Increases manpower available (MU,MR) Increases eligible populations (EP)
• Maturity of health programs	Similar to those for extent of infrastructure except where a mature program may have made gains in reduction of mortality to the degree that further reductions are dependent on non-health factors or require increasing levels of expenditures.	Similar to above, except for the possible diminishing returns on health expenditures which would yield a different value of a_1.	Similar to above except for those diminishing returns on fixed levels of health expenditures.	Similar to above except for those diminishing returns on health expenditures.
• Number of different health programs	Greater number of programs increases potential population, and should enhance acceptance.	Decreases the cost for a given reduction in mortality. Increases the total couple population (ΔTC).	Increases eligible population (EP).	Increases eligible population (EP).

(continued)

Table 5

EFFECTS OF CONSIDERING COUNTRY-TYPE SITUATIONS ON THE THREE MODELS (cont.)

• Rural-urban population mix	Determines the target population for the various programs.	Depending upon the relative effectiveness of the rural-urban health programs, determines the overall effectiveness of health programs on mortality. Enters via the term SE in the explicit cost equation.	Determines the maximum eligible population for each program (EP)	Determines the eligible population (EP)
• Economic Status of Country	Determines funds available for programs. Also, by working through per capita income, affects those aspects of acceptance and continuance that are income dependent.	Determines the value of health expenditures (EHS). Affects the values of constant a_3 and the socio-economic term (SE).	Determines values of the budget variables (BPO, BPT, etc). Affects the value of technique effectiveness (E), expected number of births averted (F(BA)) and, message effectiveness (ME).	Determines budget variables (BT, B, BM, BI). Affects the value technique effectiveness (E), expected number of births averted (F(BA)) and conversion factor for dollars into informed individuals (IK).
• Socio-political structure	Increasingly modern, industrial culture generally desires smaller families, is more futuristic oriented and is less fatalistic. May also determine the relative share of GNP that health/family planning receives.	Determines desired family size, speed with which information concerning mortality spreads and enhances mortality reduction arising from health expenditures. (Variables DFS, CP, and constant a_1).	Affects the acceptance of messages (ME), and the fraction having desired size family (NDFS). Also affects the expected number of births averted (E(BA)).	Affects the informed population (FI) and the cost to inform (IK). Affects the number of expected births averted (E(BA)).

(continued)

Table 5

EFFECTS OF CONSIDERING COUNTRY-TYPE SITUATIONS ON THE THREE MODELS (cont.)

• Belief Syndromes	Positive attitudes towards family planning and feelings of self-determination enhance acceptance. Religious beliefs, etc., concerning surviving son would tend to promote fertility.	Affects desired family size (DFS).	Affects message effectiveness (ME), technique effectiveness (E) and expected births averted (E(BA)).	Affects the number informed (FI), technique effectiveness (E), and the expected births averted (E(BA)).
• Extent of family planning infrastructure, programs and policies.	Extensive FP infrastructure provides increased clientele, and reduced costs per acceptor.	No effect.	Reduces unit cost (PC). Increases population eligible for the family planning programs (EP). Increases manpower available (MAB, MI).	Reduces cost(C). Increases manpower available (MF). Increases the family planning program population (EP).
• Degree of health service/family planning integration	Affects the costs, populations and results of both health service and family planning operations.	In general would increase cost to reduce mortality.	To be studied by model.	To be studied by model.

Chapter 3

DATA

III.1 General

Several investigations of available data were performed in order to answer two general questions:

a) Did the data verify or refute the basic contention of each hypothesis?;

b) Was sufficient data available with which to estimate the impact of each true hypothesis?

The following sections summarize the findings in several areas. The first three treat aspects of the health effects model. The final two relate to aspects of the delivery system and decision models.

In no way was this data review intended to be a complete information search; rather, the intent here was to determine what was feasible as a next step.

III.2 An Initial Estimate of the Relative Effects of a Decline in Child Mortality

The basic equation relating changes in population to declining child mortality was given by:

$$\Delta TP = (1 + \Delta TC)\ \{[\Delta ACD - \Delta ECD] - CR[\Delta FP - \Delta IA] + \Delta MS\}.$$

Maternal mortality in developing countries ranges from 1.6 to 3.6 per thousand births [Ref. 38]; assume a nominal value of 2.5 per thousand live births. Given a total born per couple figure of approximately six for those same countries, the probability of maternal survival is $[1-.0025]^6$ or .9851. Assume a reduction of 50 percent in the rate; probability of survival becomes $[1-.00125]^6$ or .9925. The change in maternal survival (ΔMS) is .0074.

The additional time added to the fecund period by good health results both from an earlier age of menarche and a later onset of menopause. The earlier age of menarche should have little effect because of the small chance of conception; however, the added years arising from a later onset of menopause enhance the chances of additional births. Assume three additional years results from improved health. Assume two months addition

to postpartum amenorrhea (a 25 percent increase [Ref. 39]) or for six births, an extra year (a conservative estimate since one of these births will die on the average before the end of amenorrhea). The net gain ($\Delta FP-\Delta IA$) equals 2 years; assume CR equals .018 [Ref. 40]. The additional births per couple due to net gain in the fecund period are .036.

The change in conceiving couples (ΔTC) is a result of mothers surviving childbirth or a fractional change of .0074 per couple (as computed above). Thus the term ($1 + \Delta TC$) is sufficiently approximated by 1.

Recall that the change in expected childhood deaths arises from perception of actual childhood mortality in previous periods and the history of individual couples in child loss. Divide the total couple population into two groups: Group A does not experience early child loss; group B does experience an early loss (before four years of marriage); further assume group A has 60 percent of the couple population and group B the remaining 40 percent (this division based on Hassan's study [Ref. 16]). If childhood mortality is declining by 4 percent per year,then in two years time group A's expectation should decrease to .921 of its previous level. Stated symbolically: for group A

$$\Delta ECD_A = .921\Delta ACD.$$

Based upon Hassan's study, slightly more than one child everborn is added for each child death up to two deaths; after two deaths the figure drops to less than one per death. Using the value of one and making the assumption that this effect works equally well in the converse, then for group B

$$\Delta ECD_B = + 1.0\Delta ACD.$$

Weighing these two according to population,

$$ECD = (.6)(.92)\Delta ACD + (.4)(1)\Delta ACD$$

and for the difference

$$\Delta ACD - \Delta ECD = \Delta ACD - .55\Delta ACD - .4\Delta ACD.$$

Thus on a per couple basis

$$\Delta TP = (1)\{.05\Delta ACD + .036 + .0074\}.$$

These computations have indicated the relative magnitude of the components of the model. The most sensitive assumptions are those concerning percent yearly decrease in childhood mortality (4 percent) and

the increase in children everborn for each death. If, on the average, for each death more than one child is added to those everborn, this could change the total effect from an increase to a decrease in total population.

III.3 Mortality-Fertility Interactions

The results of estimating the population change equation (in the previous section) indicate that both positive and negative results on total population of various childhood mortality rates and various fertility patterns may occur. No assumption of causality between mortality and fertility behavior was made. This investigation was performed using a simple computer demographic simulation model in which initial cohorts by single years of age were processed through time.

The death rates for each year of age were based on 5-year age group rates with the exception of the ages 0-4 in which single year rates were estimated in order to approximate the total distribution of deaths that have been reported elsewhere [Ref. 41]. The initial cohorts and vital rates used in the model were based on India 1961 data.

Three parameters were varied during the different simulations: the mortality reduction of ages 0-5, the fertility pattern, and the years of lag between decline in mortality and decline in fertility. The significant result sought from each simulation was the year in which a net reduction in population would be realized resulting from the model with changes over the basic model with no changes. The effects of these parameters are summarized in Figure 4.

Six levels of reduced mortality were used, ranging from .9 to .6 of the initial values; the initial values are given in Table 6, "Initial Death Rates--Age 0-4." Four values for the lag parameter were used; 2, 5, 7 and 10 years. Three fertility profiles were used; these are summarized in Table 7, "Fertility Profiles Used in Simulation Experiments." The basic rates are those of India 1961. The rates in curve B are for Chile 1964 with curves A and C above and below B respectively. The results of these experiments are given in Figure 5, "Results of Simulation Experiments Illustrating Effect of Reduced Mortality, Different Lag Times and Reduced Fertility on Total Population."

These results afford some indication of when net reductions in total population will be realized if a given fertility behavior is achieved

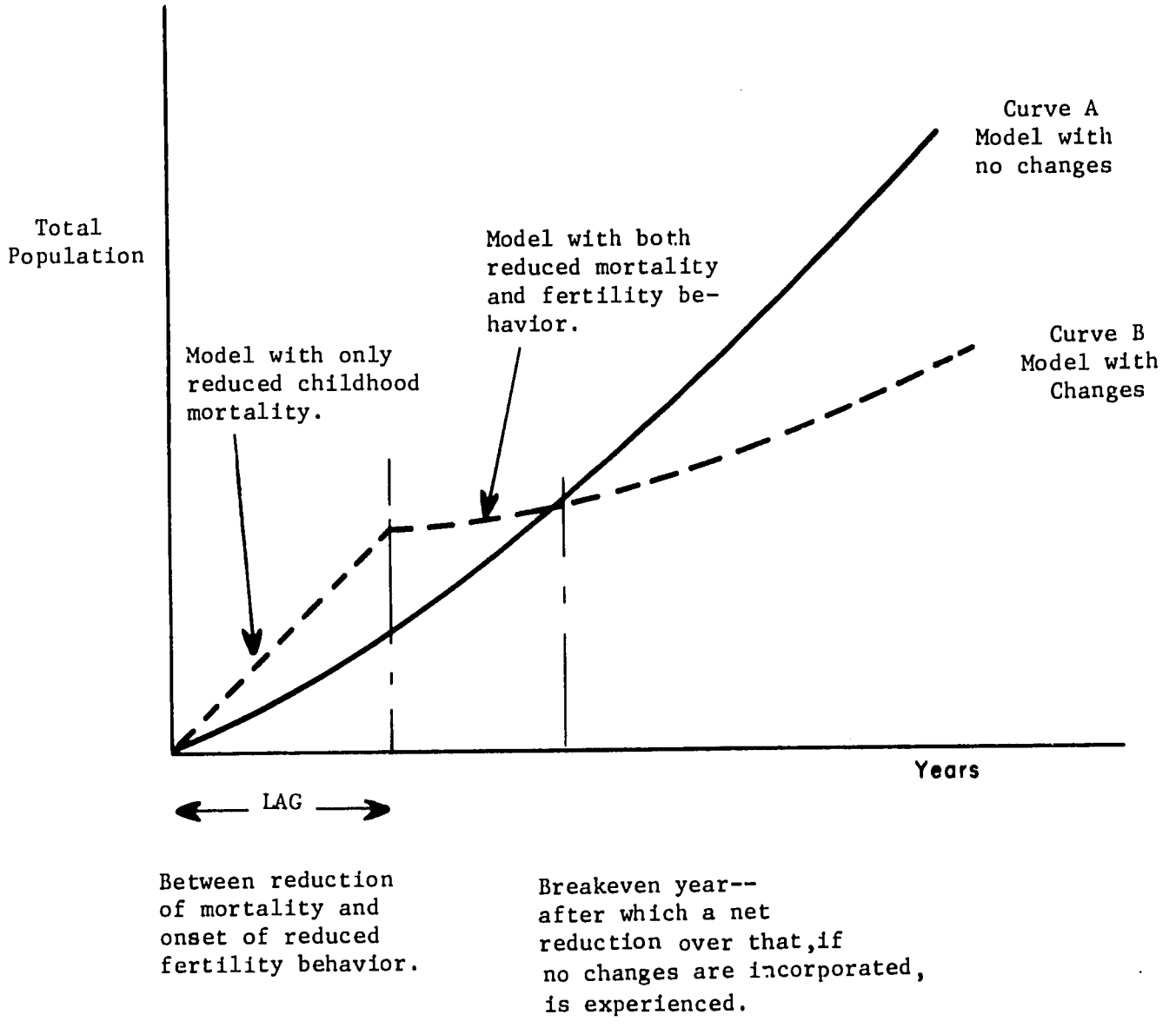


Fig. 4. Intereffects of Mortality-Lag-Fertility.

Table 6

INITIAL DEATH RATES--AGES 0-4

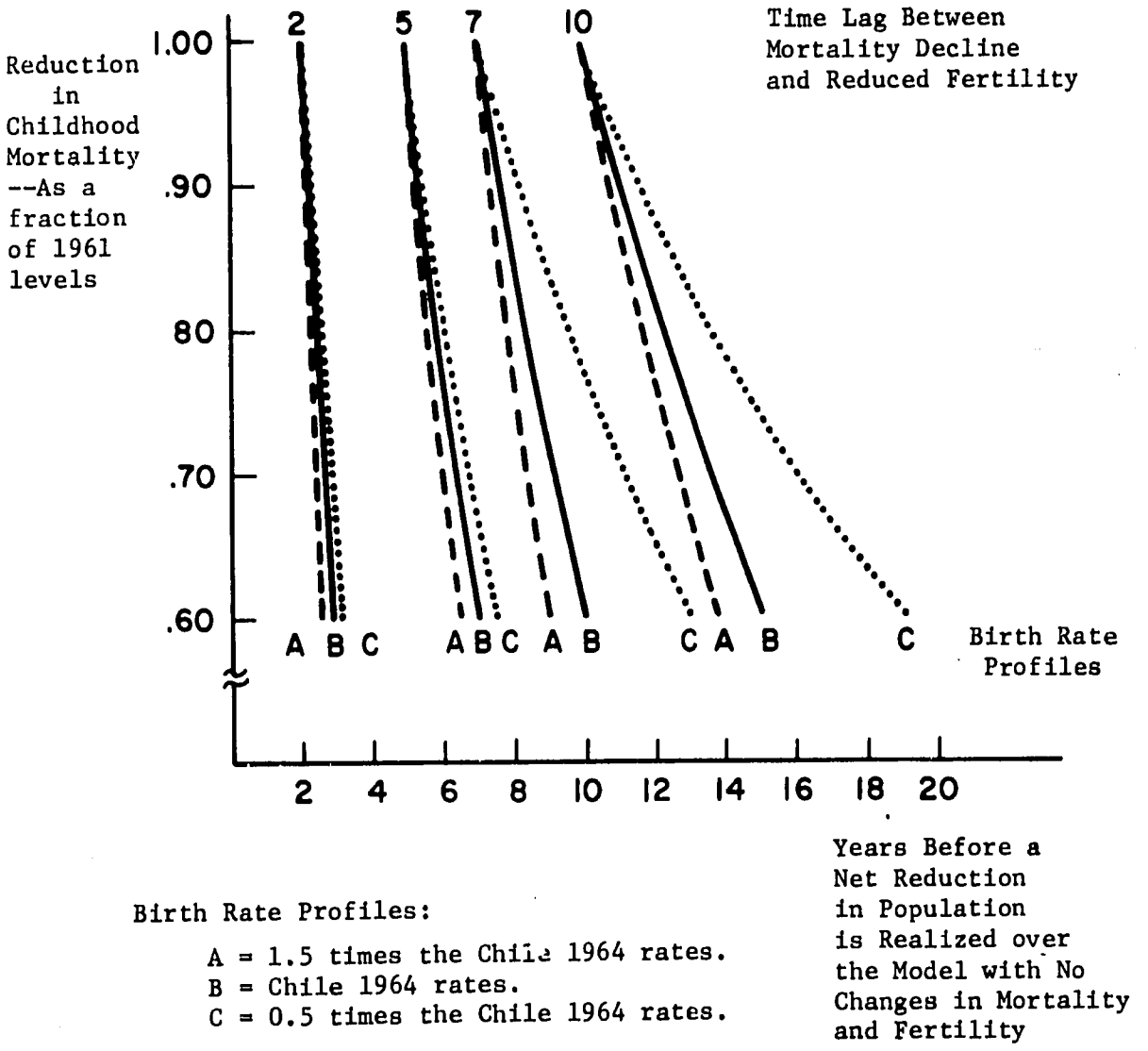
Age	Male	Female
0-1	.14611	.15206
1-2	.06079	.07821
2-3	.01127	.01369
3-4	.00382	.00601
4-5	.00364	.00573

Table 7

FERTILITY PROFILES USED IN SIMULATION EXPERIMENTS

Age	Basic	A	B	C
10-14	.00107	.000642	.000428	.000214
15-19	.15385	.10308	.07692	.0507705
20-24	.28183	.22546	.19728	.169098
25-29	.26119	.22462	.20895	.193281
30-34	.20133	.187237	.181197	.175157
35-39	.13675	.12717	.123075	.118972
40-44	.05303	.045605	.042424	.039242
45-49	.01882	.012609	.009410	.006210
50-54	.00246	.001	.0005	.0002

NOTE: Curves A and C for ages 10-14 are approximately 1.5 and .5 times Curve B, thus the caption on the graph. The differences in the middle years (20-44) are far less than that of 10-14.



Birth Rate Profiles:

A = 1.5 times the Chile 1964 rates.
B = Chile 1964 rates.
C = 0.5 times the Chile 1964 rates.

Fig. 5. Results of Simulation Experiments Illustrating Effect of Reduced Mortality, Different Lag Times and Reduced Fertility on Total Population.

following a lag period after a reduction in childhood mortality has been realized. No assumptions of causality between mortality reduction and fertility behavior have been made in these experiments; rather the purpose has been to demonstrate what is necessary if population reduction is desired.

III.4 Estimate of a Mortality-Expenditures Function

A linear regression analysis was performed using data from the WHO Third Report on the World Health Situation 1961-1969 [Ref. 42]. Inspection of the data indicated that a logarithmic transformation of infant mortality was appropriate and transformed values for 21 countries* were used as the dependent variable. The independent variables included were--

- Government health expenditures on a per capita basis
- Hospital beds per thousand population
- Physicians per thousand population
- Gross national product per capita.

The resulting estimating equation was found to be:

$$IM = 71.6e^{-.0072HSE-.017HB-.17MD-.00014GNPC}$$

where

IM - infant mortality

HSE - government health service expenditures per capita in U.S. dollars

HB - hospital beds per 1000 population

MD - physicians per 1000 population

GNPC - gross national product per capita in U. S. dollars.

The results of the analysis yielded a correlation coefficient of +.83 and a standard error of approximately 10 percent.

The cross-national analysis provides an initial estimate of the impact that additions to health expenditures and resources would produce on infant mortality. It is anticipated that a similar equation would be

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* The 21 countries were: Madagascar, British Guiana, Canada, Chile, Colombia, Honduras, Peru, United States, Ceylon, Indonesia, Thailand, Czechoslovakia, Denmark, Federal Republic of Germany, Hungary, Poland, Sweden, United Kingdom, Cyprus, New Zealand, Philippines.

generated for childhood mortality. It must be realized that these results indicate the correlation between the independent and dependent variables and should not be construed as an estimate of the causal link.

III.5 Delivery System Parameters - Cost and Manpower

Various sources were investigated to determine the availability of data upon which to estimate the various costs and manpower parameters in both the delivery system and the decision model.

A summary of American experience is given in Table 8, "Clinic Staffing Patterns and Costs" derived from a similar table in Family Planning Service Programs by David R. Seidman. Estimates of cost by techniques that were found in the literature are summarized in Table 9, "Costs per User by Technique". Average costs incurred per patient by Planned Parenthood Chapters in 1964 ranged from $10 to $24.

Costs to inform have been reported and range from $.50 to $50. Various media are available including posters, letters, and home visits. The Taiwan experience indicates a cost per acceptor of (a) $1.00 for posters, (b) $1.77 for letters, (c) $6.45 for mail and home visits with the wife, and $8.17 for mail and home visits with both wife and husband [Ref. 43]. Translating this into U. S. circumstances (taking into account labor costs, etc.) yields an estimate for letters of $13 and home visits of $50 [Ref. 44].

The Chicago experience tends to confirm the per acceptor cost of letters; here the estimated cost was $12. The average cost per patient for outreach was calculated to be $48 [Ref. 45].

Studies of follow-up costs reveal marginal costs for letters ranging from $1.60 to $2.92. Marginal costs for home visits, however, was estimated to $94 [Ref. 46].

Daily and Sirey have estimated the cost for each patient initiated on a family planning method before hospital discharge to be $15.28. The cost of interviewing the patient while in the hospital setting was computed at $6.23 [Ref. 47]. Additional return and follow-up costs per year per woman remaining on family planning must be included; these costs range from $40 to $50.

Table 8

CLINIC STAFFING PATTERNS AND COSTS

Source	Physicians Hrs. Per C.H.*		Registered Nurse Hrs. Per C.H.		Practical Nurse Hrs. Per C.H.		Aides Hrs. Per C.H.		Clerks Hrs. Per C.H.		Total Man Hrs. Per Phys.Hr.	Total Cost Per C.H.	Patients Per C.H.		Cost/ Patient	
	No.	C.H.	No.	C.H.	No.	C.H.	No.	C.H.	No.	C.H.			New	Old	New	Old
Manisoff	1	1	1	2	0	0	4	8	0	0	11	$37.50	10	15	$3.75	2.50
Detroit VNA	1	1	1	2	1	2	2	2.5	1	2.75	10.25	37.00	8	16	4.63	2.31
Roberts	1	1	2	4	0	0	4	8	1	3	16	50.00	10	15	5.00	3.33
Tepper	1	1	2	4	0	0	1	2	2.5	5	12	42.00	6.5	13.5	6.46	3.11
O'Conner	1	1	1	2	0	0	1	2	0	0	5	25.50	6	11	4.25	2.32
Zatuchni	3	3	1	2	0	0	3	6	2	6	5.67	75.50	18	24	4.19	3.15

*C.H. = Clinic Hour

1. Data were obtained by personal correspondence or conversations between D. Seidman and the following:
   Mrs. Miriam Manisoff, Planned Parenthood-World Population, New York
   Detroit Visiting Nurse Association, Detroit
   Dr. Doris E. Roberts, Division of Nursing, Bureau of Helath Professionals and Manpower Training, NIH, Bethesda.
   Mrs. Sheri Tepper, Planned Parenthood of Colorado
   Dr. Ronald O'Connor, National Communicable Disease Center, Atlanta, Georgia
   Dr. Gerald Zatuchni, The Population Council, New York

2. Based on similar table in D. R. Seidman, Family Planning Service Programs;An Operational Analysis. U. S. Department of Health Education and Welfare, May 1970, p. 87.

Table 9

COSTS PER USER BY TECHNIQUE

Source	Country	IUD	Sterlization	Pills
Perkin	U.S.A.	$ 7 - $ 8		$17 - $18
Hulka	U.S.A.	$20 - $50 initial $ 5 - $10 follow-up	$400 - $500 postpartum $675 - $850 elective	$20 - $50 initial $ 5 - $10 follow-up
Ross	Taiwan	$1.30		
Agarwala	Hong Kong Korea	$ .86 $12.20		
Armada	Taiwan	$ .75		$ .25 per cycle

In addition to the clinic staffing patterns in Table 8, Perkin has provided the following "rule-of-thumb" equations for determining staff time required in a family planning clinic environment. Given the expected annual caseload x, the estimated hours required per week y are [Ref. 48]--

Physician	$y = x/500$
Clinic nurse	$y = x/100$
Nursing aide	$y = x/100$
Social worker	$y = x/250$

The manpower needs for a maternal and child health program have been estimated by Taylor, Berelson, Helbig, and Chen and were presented in Chapter 1, Table 1. Other data concerning manpower needs are contained in Refs. 44, 47, 48, 49, 50.

The best estimates of cost to train medical personnel in developing countries have been compiled by Bryant in Health and the Developing World. Comparison of these costs is summarized in Table 10, "Costs to Educate Health Personnel". Additional estimates to train physicians range from $2,800 to $33,600 [Ref. 49].

Table 10

COSTS TO EDUCATE HEALTH PERSONNEL

	Thailand	East Africa	Colombia
Physician	$6,600	$26,000	$24,600
Nurse	1,200	9,800	3,000
Auxiliary Nurse	-	840	1,000
Medical Assistant	-	1,260	-

Source: [Ref. 49, Table 27, p. 123].

III.6 Delivery System Parameters -- User Population and Technique Effectiveness Characteristics

Various articles and data sources were reviewed to determine the availability of data necessary to construct a profile of system users. In addition, data on characteristics affecting effectiveness of technique were sought. The data that were uncovered proved to be very extensive; in addition, most current American-based programs have extensive data files on their clients.

In particular, patient profile data on education, age, and occupation of the husband for various programs have been reported [Ref. 50, 51, 52, 53, 54]. Data on these characteristics are available in programs currently being conducted in North Carolina and Georgia. Additionally, those local programs record patient performance in attending clinics and follow-up sessions. Typical of the data from foreign programs is that from Taiwan contained in Table 11, "Characteristics of Patients Attending Family Planning Clinics in Taiwan."

Table 11

CHARACTERISTICS OF PATIENTS ATTENDING FAMILY PLANNING CLINICS IN TAIWAN

Age		Education		Occupation of Husband	
15-19	---	No schooling	40%	Agriculture	57%
20-24	5%	Primary school	51%	Public Servants	12%
25-29	17%	More than primary	6%	Business Owners	10%
30-34	33%	No answer	3%	Personal Service	8%
35-39	27%			Small Manufacturers	5%
40-44	16%			Miscellaneous	8%
45-49	2%				

Source: [Ref. 52].

Estimates of the number accepting family planning of those attending health clinics were noted. Hatcher in Georgia found, in a pediatric clinic setting, that of 500 mothers informed of the availability of family planning services, 48.8 percent were contracepting, 7 percent were pregnant, and 2.8 percent already knew of the service and had an appointment.

Of the remainder, 74 percent made appointments and, of those making appointments, 63 percent (or 97 women) kept the appointments [Ref. 50].

In New York City, of the women delivered within an M/C program, 43 percent accepted the offered family planning service [Ref. 51]. In another program in New York City, approximately 51 percent of the target population was reached [Ref. 55]. Perkin estimates 54 percent of those delivering on a ward will accept family planning [Ref. 48].

In a foreign family planning program setting, 7.7 percent of the married couples in Taichung accepted an IUD and 2.9 percent accepted a traditional technique [Ref. 43]. The acceptance rate in a foreign postpartum setting is reported to be 19 percent (as compared to 45 percent in the U.S.) [Ref. 54]. Green and Krotki found that the net influence of a six-year effect in one Pakistan clinic resulted in contraceptive practice by approximately one percent of all women in the reproductive age and 5 to 6 percent of the eligible couples.

Finally, the data available on technique effectiveness and on estimates of births averted is very extensive. Tietze reported estimates of the use-effectiveness of various techniques. These results are summarized in Table 12, "Use-Effectiveness of Various Contraceptive Techniques".

In order to compute effectiveness under certain programs, e.g., postpartum, factors influencing natural sterility must be estimated. Research findings on the period of lactation and postpartum amenorrhea are reported in Refs. 39, 56, 57.

Salber estimates a median duration of postpartum amenorrhea of slightly under 2 months based on 2,197 respondents in the Boston area. Of those, however, 78 percent did not breastfeed. In Taiwan, of those who did not breastfeed, the mean period of postpartum amenorrhea was 3.5 months; of those who did, the period was 10.5 months [Ref. 39].

Another means of estimating the effect of pregnancy termination on fertility is to compare the length of time before another conception following termination and the length of time before couples who discontinue contraception conceive. Stix and Notestein found the approximate

Table 12

TYPICAL USE-EFFECTIVENESS OF VARIOUS CONTRACEPTIVE TECHNIQUES

Method	Location of Study	Pregnancy Rate
Condom	North Carolina	11.1
	Puerto Rico	28.3
Diaphragm & Jelly	New York	9.2
	South Carolina	12.7
	Puerto Rico	33.6
Foam Tablets	Japan	11.9
	Puerto Rico	38.3
Jelly alone	Baltimore	11.0
	Puerto Rico	36.1
Suppositories	Denmark	7.7
	Puerto Rico	42.3
IUD		
Loop-Type A		.87
Spirals-Small		1.01
Bows-Small		.98
Double Coil		.20
Orals		
Estrogen-progesteron		0.7
Sequentials		1.4

Note: The pregnancy rate for each method is for 100 years exposure.

average length of time between pregnancies to be 12 months for "unprotected" couples but only 3 months for those discontinuing contraception [Ref. 58]. This nine months figure, resulting from reduced fertility immediately following pregnancy should enter into the computation of family planning program effectiveness.

For example, given Tietze's IUD continuation rates of 80, 65, and 60 for one, two, and three years [Ref. 59], the nine-month period of reduced fertility renders approximately 16 percent of the total women-years-of-protection unneeded and thus unproductive.

Data on continuation rates is also extensive; typical efforts in this area are reported in Refs. 59, 60, 61, 62, 63, 64, 65.

Finally, the conversion of these parameters and variables into meaningful estimates of births averted has been done by several authors. This estimation of program effectiveness is treated in more detail in Appendix B under the objective function discussion.

III.7 Conclusions

This review indicates that certain data are available, although not all from the same source nor necessarily compatible. Further investigation of data compatibility would be required if the different hypotheses are to be tested.

The data available for the macro health effects model seem more complete and appropriate than that for the second and third models. It is felt that the quantification of the macro model could be undertaken if reasonable care is taken in making explicit what data was used and assumptions necessary in its use.

Available data for the second and third models can best be used to estimate the relative effects of changes in inputs upon outputs. The data do not appear adequate to warrant any absolute conclusions to be drawn; rather, experiments to test the sensitivity of the output to variations in given inputs should be performed in order to determine what data collection tasks and associated field experiments should be undertaken.

Of the two models--delivery system and decision--the decision model should afford the best vehicle for such experimentation. This model has

fewer actual data requirements and simulates the actual decision process; experimentation using this model should provide useful insight for policy determination.

Based upon these data considerations, it is recommended:

1) That a complete information search be conducted of the health effects hypotheses using results of previous searches (e.g., the investigation of nutrition [Ref. 17]).
2) That the decision model be developed and a series of experiments be conducted to determine sensitivities to data limitations. Available data and professional estimates are to be used for this model.

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Appendix A

Work Order and Initial Problem Definition

CONTRACT AID/NESA-460

Work Order No. SU 513

PROMOTING FAMILY PLANNING THROUGH HEALTH SERVICES

1. Within the provisions of contract number AID/NESA-460 and in accordance with Article I B thereof, the contractor is hereby authorized to work on the above topical area of investigation.

2. The specific purpose of this Work Order is to structure, by means of a systematic analysis, the principal factors that are required in an evaluation of the role that health services would perform in optimally realizing family planning objectives given the significant environmental circumstances which exist in the NESA region.

3. Some preliminary work has been accomplished and the balance of work here under shall be completed not later than October 23, 1970 unless such time is otherwise extended in writing by the Contracting Officer.

4. The total cost for all work conducted under this Work Order including charges incurred during the determination of the feasibility of undertaking the Work Order shall not exceed the following limitations unless man months, line costs or total costs are otherwise increased in writing by the Contracting Officer.

Senior Analyst	3 man-months	$ 6,100
Research Assistant	1 man-month	600
Support Staff	1 man-month	500
Overhead 96%		6,900
Consultants	10 man days @ $100 a day	1,000
		$15,100

ss: John C. Ragan — 9/22/70
Research Triangle Institute, Contractor — Date
By: John C. Ragan, Head
Office of Research Contracts

ss: Russell Dilts — 9/18/70
United States of America — Date
Agency for International Development
By: Russell Dilts, Contracting Officer

Clearance: ss: Ronald Jones — 9/19/70
Ronald W. Jones — Date
Director, NESA/OPP

PROMOTING FAMILY PLANNING THROUGH HEALTH SERVICES

A. Purpose

It is the specific purpose of this analysis to structure systematically the principal factors pertinent to judging the role of health services as a means of furthering family planning objectives that is optimal under the major types of environmental circumstances extant in the NESA Region. The desired end products consequently are:

1. A minimum adequate conceptual framework for testing propositions about health services as a family planning input.
2. Classification criteria for differentiating probably significant type-situations.
3. Judgement about the feasibility of deriving from data available in the U. S. meaningful estimates of the input-output relationships likely to prove determining of strategy optimality in actual practice.

From the preceding it should be clear that in the present analysis known and believed input-output relationships for components of the sub-system here under consideration are variables to be taken into account not ends in themselves. Relevance of these variables -- hence warranty of probing their conceptual or/and empirical foundations -- consequently turns at this stage on their respective and plausibly supported contribution to understanding and/or investigating the cost/effectiveness of health service inputs for promoting the practice of contraception under specified circumstances.

B. Scope

Substantive scope of this analysis is reflected in the above statement of its purpose and proximate objectives. Given the variety of beliefs about the interdependencies between health services and family planning and that of the environmental circumstances found in NESA countries, determination of that scope of inquiry necessary to acceptable confidence in the prescriptive conclusions drawn can only flow out of the inquiry itself. Responsiblity for rigorous attention

to relevance in the interest of economizing resources consequently rests with RTI.

Knowledge of the kinds of decisions being considered by host country program managers and/or being pressed upon them by various outside interests together with that of the differing types of environments confronting such decision makers, commends priority consideration to the factors listed below. It is emphasized, however, that the items indicated are illustrative of factors various individuals think are important. The validity of such beliefs is by no means proven -- particularly with respect to specific combinations of circumstances. And it goes without saying that this listing is not all-inclusive. At the same time RTI report of findings and recommendations is expected to cover each of the items indicated in such a manner as they deem appropriate.

1. Types of health services: MCH, post partum, general health services.
2. Contraceptive techniques: sterilization (male and female respectively), IUD, orals, conventionals (especially condom but also such treatment of female vs. male types as prevailing usage and related circumstances warrant).
3. Status of health services: Type-situation differences such as those represented by Afghanistan with little health infrastructure, Ceylon where 80% of deliveries are in hospitals, areas of India which fall at different points on that spectrum.

   Some central questions are: Where health facilities do not exist is establishing some level of health services the most cost/effective way of promoting family planning? Is there some minimum level of health services below which family planning efforts consistently produce low returns?
4. Integration of health and family planning: Type-situation differences in existing practice such as India where family planning ostensibly is fully integrated with health services in rural areas and Pakistan where they are essentially separate. A distinction probably needs to be made between common use of facilities and that of personnel.

5. Family planning program stage: Type-situations differing in maturity of family planning program, e.g. government/public acceptance of and commitment to fertility control as public policy.

   Intra-country differences need to be considered in this same light, e.g., is the role of health services in starting a family planning program in an Indian or Pakistani district not presently served different or the same as in Turkey where there is little national support for population control.

6. Urbanization: At the minimum distinction must be made between big cities and rural areas. How far it is meaningful to go in differentiating type-situations reflecting intermediate degrees of urbanization is unclear. The question, however, would seem to deserve some consideration.

7. Belief syndromes: Characteristic types of beliefs about the ways in which health services contribute to increasing the practice of contraception.

   At bottom prescriptive propositions about health services as a family planning input rest on the same two broad premises as do those about nutrition: (1) the surviving son syndrome and (2) access to clients. On both counts, however, the arguments are far more involved and interwoven in the case of health services than in that of nutrition. They also appear to be overlain with value judgements about the importance of sustained confidence of a public in both the quality and purpose of services rendered, of anonimity for the client, of population control in the public interest vs. family limitation as a human right, etc., etc. There also is more than a little indication that many advocates of integrated health and family planning services actually are mainly interested in capitalizing on the current popularity of family planning as a means of getting funds for improving general health services. These various motivations not infrequently are cloaked in comparative cost terms. Seldom

are the assumptions supporting a given position made explicit nor are adaptations made of generalized relationships to varying local conditions.

In the present study, widely held beliefs about the health-family planning interface are among the key propositions which the analytic structure to be designed must accomodate. Categorizing and elucidating such major syndromes would seem to be a necessary and highly important aspect of the overall structuring process.

C. Priorities

As in all other elements of the Information Search project, importance priority centers upon India and Pakistan and major internal differences in type-situations in those two countries. This, however, speaks to broad level consideration. Turkey, Afghanistan, Nepal, Ceylon and Iran all face critical and immediate decisions about strategy for mounting a family planning effort in which the place of health services is of paramount concern. Consequently, to the extent choice must be made, preference runs with broad consideration of the major types of situations represented by the several countries named as contrasted to differentiation of comparatively minor ones in India and/or Pakistan. That type of further refinement can better be undertaken by means other than the present analysis.

As for priorities in substance, RTI will be guided by the policies reflected in Sections A and B above. Few of the topics to be explored in the entire Information Search endeavor afford greater opportunity for over-extension and getting lost in details than does the one at hand. The essentiality of rigorous attention to relevance on the part of all concerning consequently cannot be over emphasized.

R. W. Jones
June 5, 1970

Appendix B

A Structural Model and Objective Function

Appendix B

A Structural Model and Objective Function

B.1 Purpose

There are certain common elements in all decision situations; these are:

a) Sets of variables and parameters. These include:
   1) Decision variables--those variables which can be altered by the decisionmaker.
   2) Exogenous variables--those variables outside of the control of the decisionmaker.
   3) Parameters--whose values are also not controllable and are taken to be completely determined by a "given state of nature."

b) A model--a set of relationships among the parameters and variables.

c) An objective function--a function whose value is determined by the values of certain variables and parameters in the model. This function is used by the decisionmaker to rank as to their desirability the various outcomes resulting from different values of the decision variables.

d) Computation methods by which the outcome can be systematically evaluated [Ref. 1].

The purpose of this appendix is to define a general structural model of the family planning/health services (FP/HS) problem derived from descriptions found in the literature and from professional experience. This model definition is followed by a review of possible objective functions which a family planning decisionmaker might use and selects a suitable one for this research. This material is provided as a basis for the delivery systems and decision models and the objective function described in the second chapter.

B.2 The General Structural Model

The number of effective users of a given contraceptive technique is a function of (1) the total population eligible to use the technique, (2) the fraction of that population that have a sufficient positive attitude and motivation to perform the actions required for contraception, and (3) the constraint placed upon the previous two by the availability of both supplies and knowledge. The eligible population is defined both by physical characteristics (e.g., being female in order to use an IUD) and by policy (e.g., only individuals having more than two sons will be sterilized). These three variables are further defined below. Functionally, we can then relate the number of users by:

$$[U_i]_t = f([AT_i]_t, [EP_i]_t, [PM_i]_t, [PR_i]_t)$$

where

- $[U_i]_t$ - the number of users of technique i in period t
- $[AT_i]_t$ - the fraction of the eligible population that are sufficiently motivated and knowledgeable to properly use the technique during the period t
- $[EP_i]_t$ - the number of individuals with the proper characteristics to use the technique at the beginning of period t
- $[PM_i]_t$ - the maximum number of users that will be supplied as determined by governmental budget or manpower limitation
- $[PR_i]_t$ - the maximum number of users as determined by private capital or manpower limitation.

The eligible population in a given time period is a function of the eligible population in the previous period and the net change to that population. Additions and deletions to the population are a function of natural processes as aging and death and arbitrary processes as policy definitions. Functionally this becomes:

$$[EP_i]_t = f([EP_i]_{t-1}, [\Delta EP]_{t-1})$$

where for any time period

$[\Delta EP_i] = f([NAD_i], [NDE_i], [GAD_i], [GDE_i])$

$[\Delta EP_i]$ - change in eligible population for technique i

$[NAD_i]$ - natural additions arising from birth, aging, and immigration

$[NDE_i]$ - natural deletions arising from aging, death, and emigration

$[GAD_i]$ - additions to eligible population arising from changes in policy defining eligibility

$[GDE_i]$ - deletions arising from policy changes.

The fraction of the total population sufficiently motivated to effectively use technique i can be considered to comprise two groups. The first group are those couples who have their desired number of living children and thus do not desire any further children. To be sufficiently motivated and belong to this group requires, then, the attainment of some number of living children, adequate knowledge of the technique, of the means of obtaining the required supplies and of their use plus finally, taking the required action. Notationally,

$[IFS_i]_t = f([NDFS_i]_t, [IIFS_i]_t)$

where for period t:

$[IFS_i]_t$ - the fraction of couples having a desired sized family that use technique i

$[NDFS_i]_t$ - the fraction of those eligible couples for technique i that have reached their desired family size

$[IIFS_i]_t$ - the fraction of $[NDFS_i]_t$ that have been sufficiently informed to make them effective users.

Desired family size might be termed a cultural variable; it is sensitive to various religious teachings, folkways and mores of the society, plus factors as infant mortality and those implied by the term "modernization."

The Fredericksen studies and Hassan's work indicate the interdependence of mortality and fertility behavior [Ref. 2, 3, 4]. The

effects of modernization have been investigated by Pareek and Kothandapani and indicate that there is an increasing disposition towards family planning with increasing industrialization and increasing education [Ref. 5]. As they hypothesized based on their data:

> "One plausible explanation is that family-sized preference is a widely shared norm generated by the larger community in which a person lives and that the change in such a deeply ingrained norm comes about when a person has a new reference group (an institution, like a factory) and also has exposure to the wider world (through education). . . . Attitude toward birth control may be more a function of more knowledge about it, and this is provided either by exposure to formal education (and, therefore, possibility of reading), or by exposure to informal sources of information (in an institution like a factory)" [Ref. 6].

The impact of religion upon fertility behavior has been summarized by Berelson [Ref. 7]. Among Catholics, the controversy between doctrine and desired practice appears to be a non-relevant discussion in that the practice among Catholic women is not significantly different from that of other women [Ref. 8, 9, 10]. Liberalization of Catholic doctrine would directly affect government sponsorship of family planning but have less effect upon the conscience and practice of the laity.

Within the Moslem religious community, Berelson feels that fertility is less a function of theological doctrine than the traditional subordination of women in their culture. Among the Hindus within India, any inhibition towards family planning is more a result of their philosophical fatalism than religious doctrine. In short, according to Berelson:

> ". . . it seems clear that formal religious considerations are of greater importance to the elite than to the masses; and that the broad social trends that everywhere affect the conditions of life--like industrialization, urbanization, population education, and mortality rates--have more impact on fertility behavior" [Ref. 11].

The effects of social forces within the immediate setting of the individual have been illustrated by the communication experiments conducted in Taiwan and Korea [Ref. 12, 13, 14]. Group meetings were

held in neighborhoods as a part of these programs to disseminate information. Results indicate the peer group acceptance of the idea arising from such a meeting is effective, as illustrated in Table A.

The term [NDFS] can be related functionally to these factors by:

NDFS = f(IM, MOD, CFM, RD)

where:

IM - level of infant mortality or possibly, the probability of child at birth reaching some mature age

MOD - an index of country's modernization as per capita income

CFM - cultural folkways and mores

RD - religious dogma (considered a less significant variable).

Table A

ACCEPTANCE RATES PER 100 MARRIED WOMEN AGED 20-39 IN TAICHUNG UP TO APRIL 1964 BY TYPE OF METHOD, BY COMMUNICATION TREATMENT, AND BY WHETHER A GROUP MEETING WAS HELD AND WAS EFFECTIVE OR NOT

Communication Treatment	Method		
	All	IUD	Others
Everything*, with:			
Effective meeting	21	13	8
Somewhat effective meeting	17	11	6
Ineffective meeting	14	7	7
No meeting	14	8	6
Mail	8	7	1
Nothing	7	7	1

* Everything was the experimental treatment in which posters, mass meetings, letters, small group meetings, and home visits were employed.

Source: [Ref. 15].

Informing those couples represented by [NDFS] is limited in the initial periods of interest by the available capital and manpower necessary to spread the information. The spread of information from

users to potential users by informal channels reduces the effective resource cost necessary to inform. Evidence of the residual effects of previous communication efforts have been reported both in the Taiwan program and in the postpartum program [Ref. 16, 17]. In the latter case, indirect acceptors--women from the community at large who heard about the program and sought out the hospital's service--numbered approximately 80 percent of the level of direct acceptors--those who were obstetrical or abortion cases. In the Chicago studies, 65 percent of a sample drawn from a population who had been subjected to a family planning information program passed on the pamphlet used in the program to at least one person and more than 90 percent had discussed the subject with another person [Ref. 18]. The net effect of this phenomena is to make the capital and manpower necessary a function of time or a function of total individuals informed. Eventually, however, information concerning technique, use, and availability becomes part of the cultural folklore. For the initial periods,

$$IIFS = f(CIF, MIR, BI, MI, NDFS)$$

where

CIF - the cost to inform one individual

MIR - manpower required to inform

BI - the budget available for information activities

MI - manpower available for information activities

NDFS - interpreted here as the number needed to be informed.

The second group sufficiently motivated are those who use technique i for birth spacing. This group differs from the first group in that the motivation is based on far more subtle logic and in most countries where family planning is being initiated, this logic orginates from external sources thereby representing attitudinal change for the practicing individual. The alteration of attitudes by external persuasion is normally successful only in thos areas where there is little emotional involvement. As stated by Klapper, based upon a review of several studies:

> "Communications research strongly indicates that persuasive mass communication is in general more likely to reinforce the existing opinions of its audience than it is to change such opinions" [Ref. 19].

Later he notes,

> "Mass communication is widely believed to be quite efficient in creating opinions among people who were not previously inclined one way or another on the issue in question" [Ref. 20].

The persuasion of a couple to alter their behavior so as to delay the birth of their children may be viewed by them as an encroachment of the most vital function of their union. The relative effectiveness of the message carrying information concerning technique, use, and availability is directly related to the effectiveness of previous messages concerning the reasons for such practice [Ref. 21]. The possible functional relationships describing this attitude-motivation complex are many as a large variety of variables may prove significant. One possible formulation similar to that for [IFS] is given by:

$$[IBS_i]_t = f([1\text{-}NDFS_i]_t, [IIBS_i]_t)$$

where for period t

$[IBS_i]_t$ - the fraction of couples using technique i for birth spacing

$[1\text{-}NDFS_i]_t$ - the fraction of couples eligible for technique i that would practice contraception for birth spacing reasons

$[IIBS_i]_t$ - the fraction of $[1\text{-}NDFS_i]_t$ that have been sufficiently informed to make them effective users.

Informing couples to the extent necessary for the attitude and behavior changes in practicing birth spacing is related to their concepts of the necessity to have children often (a function of perceived infant mortality), their concepts of the role of maternal health and resulting child health and family planning (a function of local folkways regarding health and childbearing and their experience with fetal wastage, etc., other folkways regarding the practice of family planning)

and the requisite knowledge of technique, use, and availability. This information/education activity is constrained by budget and manpower considerations.

Various studies into the spread of information concerning family planning have provided insights into how the acceptance arises; especially in terms of the social processes that occur. Green and Krotki investigated certain geographic aspects of clinic utilization in Pakistan but their findings required explanations in terms of sociological phenomena [Ref. 22]. They observed that a large proportion of the people who utilized the clinic services came from outside the immediate area of the clinic [Ref. 23]. Further analysis indicated that proximity alone was not sufficient to explain utilization, rather, it was as if the clinic was bounded by several neighborhoods each with its distinct attitude and behavior. When income considerations were included it was discovered that neighborhoods having high client rates also had higher incomes; the inference drawn here is: if people having higher incomes lead the way in attending the clinic then the others will follow and if low income persons lead, then others will be discouraged.

Other considerations from this study, indicate that for those attending the clinic from the immediate proximity, friends and relatives were the major sources of referrals. As Fosters states, in most societies, ". . . a small social group. . . provides, through concentrated public opinion, the means for discouraging the innovator. . . ." [Ref. 24]. The individual will look to those in his immediate surroundings to determine their reaction towards his intended acts and possible rejection [Ref. 25, 26]. Thus, acceptance of the clinic and of family planning becomes a function of the attitude both of the individual and of the community towards the clinic.

Dubey and Cholden studied the adoption of the IUD using the diffusion framework of Katz, Hamilton, and Levin [Ref. 27]. Diffusion is the process of

"(1) acceptance, (2) over time, (3) of some specific item--an idea or practice, (4) by individuals, groups or other adopting units, linked (5) to specific channels of communication, (6) to a social structure, and (7) to a given system of values or culture" [Ref. 28].

Dubey and Choldin found that different communications media and informal communications networks come into the diffusion and adoption processes at different stages. In the early awareness stages messages originating within the family planning activity and carried by newspapers and clinic staff have greatest impact. At the later stages of interest and evaluation, local sources gain importance. Both husbands and wives are involved in the information gathering process; husbands tend to use mass media for initial information followed by confirming conversations with friends and co-workers. Wives tend to use clinic staff or other housewives for their sources; in addition, they use other users as a prime source. Following initial exposure to cosmopolitan sources (sources with a larger geographic or cultural emphasis) both parties shift their focus to local persons for additional information, for discussion, and for social approval.

Palmore has studied the adoption process for specific contraceptives in the Taiwan program. He found that

"1. Viewing the adoption of family planning in stages is instructive.
2. Specific contraceptives do have differential rates of acceptance, and women who become aware of specific methods do have differential rates of continuation from one stage in the adoption process to that next.
3. The probability that women will enter and complete the adoption process is correlated with where they first hear about a contraceptive method.
4. There is evidence that a particular combination of one type of contraceptive with one type of awareness source has different effects on adoption than those the same method with another source or the same source with a different method" [Ref. 29].

Additionally, Palmore notes that, prior to any family planning programs, medical or quasi-medical personnel played a small role in bringing family planning information to the awareness of women. Usually, the woman is occupied with other problems when in contact with medical personnel; thus, family planning is not a likely topic for the medical personnel as contrasted to suitable topics for friends, relatives, etc. However, if the particular woman heard of a method from a medical source, the chances were greatest that she would continue to gather information on use. Notationally,

IIBS = f(PIM, CFH, CIB, BIB, MIB, 1-NDFS)

where

PIM - perceived infant mortality

CFH - cultural folkways regarding maternal health, etc.; includes the effects of programs to educate re: maternal-child care

CIB - cost to inform one individual re: birth spacing, etc.

BIB - budget available for this activity

MIB - manpower available

1-NDFS - maximum number to be informed about birth spacing.

The total fraction of the eligible population that are sufficiently motivated can be expressed as a function of IFS and IBS:

$$[AT_i]_t = f([IFS_i]_t, [IBS_i]_t).$$

Finally, in determining the number of users of any given technique in any period, the limitations imposed by the available budget to satisfy user demand and by available trained manpower must be included. For example, once a couple decides to use the IUD as a contraceptive device, both the IUD and someone to perform the insertion are required. For the public sector:

$$[PM_i]_t = f([BPO_i]_t, [MPO_i])$$

where for the time period t

$[BPO_i]_t$ - the budget available for program operations for technique i

$[MPO_i]_t$ - the trained manpower available for program operations for technique i.

A similar relationship exists for the private sector $[PR_i]_t$.

The previous functional relationships represent one elementary way to define certain significant factors operative in the HS/FP decision problem. Each of the variables introduced in the equations possibly could take the form of one or more real numbers, a linear function of another variable (as time) or a complex function of one or more variables.

B.3 The Objective Function

The primary goal of family planning programs is the attainment of some population growth rate. Translating program results into growth rates presents certain theoretical difficulties. As a result, program performance measures are generally stated in terms of number of acceptances of a certain technique. The term acceptance is misleading; what is actually measured is the number of pills or condoms dispensed, IUD's inserted, sterilizations performed, etc. In the terminology of economics, these performance measures are of intermediate goods supplied by the program to the client who in turn produces the final output--births averted. For sterilizations, conversion of these intermediate services into births averted can be estimated relatively easily once age, parity, martial status, mortality expectation, etc., are known for each couple receiving the service. For IUD's or orals, this estimation is not as easy and data are required on "use-efficiency," e.g., retention rates for IUD's and dedication in taking oral pills. The estimation is least accurate for conventionals since "use-efficiency" data is most nebulous. In addition, statistics on conventionals generally do not indicate how many are placed in the hands of the user but rather indicate the extent that supplies have been distributed.

Another problem encountered arises from the "substitution" phenomena. In any country where a family program is introduced, many of the contraceptive acceptors will have been practicing some method previously. The most likely candidates for sterilization, for example, would be those couples who had been using some other method previously. This substitution tends to reduce the actual impact that a program will have in the initial short-run. The substitution problem is independent of the output measure adopted.

A generally accepted measure of intermediate output is the Couple-Year-of-Protection Index formulated by Wishik [Ref. 30]. Summarized this method allows one couple-year of protection for (1) every 12 months lived by a fecund, currently-married male or female who has been sterilized; (2) every IUD in place; (3) every total of orals or conventionals that would be enough (for a given coital frequency) to provide contraceptive protection for one calendar year. Wishik notes these limitations:

> "It is obvious that the number of couple-years did not indicate the number of different couples involved, but was merely the sum total of <u>time</u> of contraceptive practice of all couples who practiced at all, whether for shorter or longer periods. It must also be emphasized that the Couple-Year-of-Protection Index focuses on the <u>assumed period of practice</u> of contraception and in no sense carries implication concerning the use-effectiveness of the contraceptive practices or the number of births prevented by those practices. Those are matters for further derivation with the help of CYP data that will be the subject of another paper, built around the concept:
>
> $$P \cdot e \cdot F \rightarrow B$$
>
> A given amount of contraceptive practice (P), as measured in CYP's, of certain levels of use-effectiveness of the contraceptive methods used (e) among women of certain fertility expectations in the absence of contraception (F) will lead to the number of births prevented (B) by that amount of contraceptive practice" [Ref. 31].

Robinson reduces the CYP index to the following formulation [Ref. 32].

$$CYP_n = \frac{C_n}{100} + .07690_n + 7.5(V_n + TL_n) + 2.5I_n$$

where for year n

CYP_n - couple years of protection

C_n - total conventionals distributed

O_n - oral pill cycles distributed

V_n - vasectomies

TL_n - tubal ligations

I_n - IUD insertions

The assumed parameters are: a coital frequency of 100 per year; average number of years an IUD is retained by a married, fecund female (allowing for reinsertions) is 2.5; the average number of fecund years remaining to a woman before she dies, is widowed, or reaches menopause following a sterilization (vasectomy or tubal ligation), is 7.5; 13 cycles (.0769 = 1/13) of orals are required per calendar year. (Note: This formulation assumes a use-effectiveness of 100 percent for orals, conventionals, and IUD's).

This formulation measures current achievement in terms of this and future year results; thus, it does not measure current prevalence of contraceptive practice since in the case of sterilizations and IUD's there would be substantial carry-over from year to year.

Advantages to this index are its relative simplicity of computation and the ease of intra-program comparisons. Certain assumptions must be reconsidered, however, when inter-program comparisons are considered. The parameters associated with IUD's and sterilizations result from the average retention period and the average period the woman will remain alive, married and fecund, respectively. These may vary from one population to another either as a result of program charateristics (e.g., educational activities, screening, etc.) or as a result of demographic characteristics. In the first case, these differences should be considered in judging program efficiencies; the second set of circumstances should not be considered but, rather, are exogenous to the program.

Inter-program comparisons that transcend national boundaries usually encounter the currency exchange problems. Thus, a given output for a given resource input measured in some common term may be difficult to obtain since market-clearing rates of exchange vary from day to day and are difficult to know. Further relative factor costs will differ among countries as will productivity differences. These wage-productivity differentials will affect costs regardless of exchange rate considerations.

Finally, the CYP index obscures program mix which may preclude the recognition that different mixes requiring different technologies may have different cost-output relationships. Program mix may be an important intervening variable that needs to be considered in a inter-program comparison.

A relatively more sophisticated CYP index based on the Pakistan Program (1960) is described by Bean and Seltzer [Ref. 33]. Differences include a more comprehensive treatment of conventionals, a constantly decreasing (by 15 percent per year) number of protected couples for any given years sterilization efforts, and an IUD component of the form:

$$CYP_{my} = .75(\sum_{k=1}^{m} I_{ky}) + .5(I_y-1) + .35(I_y-2)$$

where for the month m of year y of the program

I_{ky} - IUD insertions in month k of program year y

I_y-1 - aggregate IUD insertions in program year y-1

I_y-2 - aggregate IUD insertions in program year y-2.

Further, they discuss the decay curve estimate of IUD retention and resulting protection developed by Mauldin, Stephen, and Nortman [Ref. 34] of the form:

$$Y = C(\frac{a}{r})(1-e^{-rT})$$

where

Y - cumulative protection (CYP equivalent)

C - size of cohort

a - constant allowing for immediate dropouts

r - constant rate of decline

T - time period between dates of acceptance and estimation.

Comparison of these two means of estimating CYP provided by IUD's indicated differences ranging from 10 percent below to 24 percent above the program measure.

Attempts to measure final output (births averted) have been undertaken by Bean and Seltzer; Potter; Mauldin; and Lee and Isbister [Ref. 33, 34, 35, 36]. These studies were done for the IUD but the approach is suitable for any contraceptive. For example, Potter estimates the prolongation of stay in the fecundable state arising from the use of a contraceptive and converts this into births averted by dividing the stay time by the average marriage duration per birth that would have been experienced by a non-contracepting couple. In equation form:

$$I = F(R-A-PW)$$

where

I - average duration that childbearing is interrupted, i.e, mean prolongation of stay in the fecundable state

F - proportion of couples fertile at time of contraception

R - mean time contraception is practiced with considerations given to mortality, divorce, and sterility among couples fertile at time of beginning contraception

A - allowance for amenorrhea

P - proportion becoming accidently pregnant while practicing contraception

W - penalty per accidental pregnancy; proportional to the mean fecundable period that would have been required per pregnancy among still fertile acceptors if they had not practiced contraception.

and

$$B = I/D$$

where

B - births averted

D - average duration per birth that might have been required under non-contraception.

Using data available for five age categories from the Taiwan IUD Program, estimates for the above were derived by Potter and are summarized in Table B. (General discussion of the estimation is contained in [Ref. 35]; details are contained in [Ref. 37]).

The choice of an objective function becomes one of choosing from among increasingly complex forms having data requirements difficult to satisfy but which yield better indication of actual program impact. In addition, when births averted are estimated, considerations of the conversion process from program services to final output are required; these considerations include many exogenous factors both physiological and psychological that vary from individual to individual and country to country.

The intended use of the objective function in this study is within a decision model for intra-program evaluations. The problems of population variation, exchange rates, etc. associated with inter-program comparisons do not arise. The objective function should provide a consistent estimate of program impact, not necessarily an accurate one, where consistency implies that the impact of interest remains undistorted for those variations in exogenous and decision variables anticipated in the analysis, i.e., the relative impact as indicated is correct ordinally not necessarily accurate cardinally.

One inherent limitation of the CYP index decides against its use in the current analysis. No consideration is made for the variations in the distribution by age, and thus by potential fertility, for the acceptors in a given program. Assuming a model of program performance that tends to attract different age distributions as a function of time, a CYP index in year n equal to a CYP index in year n + t would not in general translate into the same level of births averted or program impact. Since a sequential decision model is to be used in which this age distribution variation is anticipated, the births averted criteria is selected as an objective function.

Table B

INTERRUPTION OF CHILDBEARING BY IUD AND BIRTHS AVERTED BY AGE CLASS OF MOTHER

Age Class	F	R	A	P	W	PW	I=F(R-A-PW)	D	B=I/D
20-24	.9945	16.2	2.1	.11	5.9	0.6	13.4	25	.54
25-29	.9910	24.9	1.7	.18	11.0	2.0	21.0	31	.68
30-34	.9816	37.9	1.5	.23	21.2	4.9	30.9	43	.72
35-39	.9520	43.3	1.6	.12	36.1	4.0	35.9	67	.54
All ages	.9796	32.1	1.7	.15	19.3	3.2	26.5	42.2	.64

Assumptions:

a) A medium effectiveness of family planning in the absence of the IUD.
b) A medium estimate of D the duration per potential birth in the absence of the IUD.

LEGEND:

F - proportion of women fertile at insertion
R - span of useful retention
A - mean overlap with amenorrhea
P - proportion becoming accidently pregnant
W - penalty per accidental pregnancy
PW - allowance for accidental pregnancy
I - interruption of childbearing
D - duration per potential birth
B - births averted per first segment of IUD

There is one characteristic of this criteria that should be noted. As in the case of the CYP index, births averted estimates future impact and sums into a measure of current performance. At best, the first return on a contraceptive practice is nine months away and in the case of sterilizations, returns may accrue five to ten years in the future. These future events accumulated into a current measure of performance overstates the measure. Since this overstatement would be consistent across program alternatives and not limited as a program matures, use of the criteria as a relative measure in a sequential evaluation would not produce serious error. For example, as long as the limitations upon potential acceptors result from program constraints, the maximization of the criteria in each period does not effect future maximizations, i.e., the eligible population appears limitless to the decisionmaker--a situation which is consistent with the conditions in most countries of interest.

The general form of the births averted objective function is given by:

$$[BA]_t = \sum_i \sum_k [e_{ik}][U_{ik}]_t[P_k(BR)]_t$$

where for time period t

BA - total births averted

e_{ik} - effectiveness of contraceptive technique i for age category k

U_{ik} - fertile users of technique i in age category k

$P_k(BR)$ - probability of a live birth conditioned upon conception in period t by a female in age category k.

This form is modified for use in the delivery system and decision models.

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Appendix C

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Appendix C

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