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SUMMARY

Report of a Study by the
Berkeley Project on Education and Nutrition

Analysis of Longitudinal Data Collected in
an Experimental Nutritional Supplementation Program:

An examination of the INCAP four-village study to investigate relationships between nutrition, health, family background, children's activities and school attendance and performance

Concise Title:

EDUCATION & NUTRITION: PERFORMANCE AND POLICY

Charles S. Benson, Co-Principal Investigator
Sheldon Margen, Co-Principal Investigator
Judith B. Balderston, Project Director
Maria E. Freire
Mari S. Simonen
Alan B. Wilson

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INTRODUCTION

The work that is described in this report represents the results of a search, for policy purposes, on the relationships between nutrition and education and the out-of-school performance of young people. The study was undertaken (1) to test hypotheses regarding the relationships between education, health, and nutrition, particularly with respect to the effect of nutrition on school performance and activities of children, and (2) to analyze how choice to use nutritional supplementation, health care, contraception, and education are related to family income, parental literacy, and education. At the time the study was proposed and funded, it was suggested that it would "be useful in predicting the effects of early malnutrition on later stages in the life cycle and how early growth and development are related to success in school and in the performance of economic activities."

To carry out such an investigation requires the collection of data embracing a wide variety of areas -- physiological, nutritional, socio-economic, psychological, and a natural setting environment where the interaction among areas would take place and be observed. It was therefore extremely fortunate that the ambitious and costly longitudinal study by INCAP funded by the National Institute of Child Health and Development for data collected between 1969 and 1978, and by Rand, funded by the Rockefeller Foundation, for data collected in 1974 and 1975, had already occurred in the four villages in Eastern Guatemala. Out of these projects, a large and varied data base had been amassed, and it was therefore possible to make the connections between children's individual growth and development, their families' economic and social conditions, and the environment of the village economies and schools. It was hoped that the results obtained through the use of appropriate analytical models would be useful for the formulation of policies in international agencies, mainly by stressing the importance of inter-sectoral planning in less developed countries.

At the time of the proposal, it was recognized that, although much was already know about effects of severe malnutrition, the result of chronic malnutrition on human functioning deserved much more investigation. Nutritional science, well-developed in the laboratory, had not yet been able to translate known chemical and biological relationships into functional outcomes. The purpose of the ambitious study begun by INCAP in 1969 was to relate some of the nutritional and health inputs into growth and development outcomes. The objective of the Berkeley study was to enable educational and other planners to see how nutritional change might affect educational outcomes.

Integrating the plans made by organizations in separate fields, such as nutrition, public health, rural development, and education would potentially improve the cost-effectiveness of their programs. To do such integration requires knowledge of relationships between the separate sectors, and it was suggested that data from the INCAP and Rand studies in the four villages in Guatemala were capable of providing many important research results.

This report represents the findings of the Berkeley Project on Education and Nutrition, financed by USAID under contract #DSPE-C-0021 during the period October 1, 1978 to January 1, 1980. It is hoped that these findings will be of interest and importance to those with responsibility for making plans in a variety of sectors. The data base is so rich that we have necessarily only been able to tap a small part of it for our purposes. We expect and hope that others will follow in utilizing the information from INCAP and Rand as well as in undertaking related studies in other places. We do not expect that there will be such an ambitious collection of data made again, but that, instead, the lessons learned from the strengths and weaknesses of the INCAP and Berkeley efforts will assist those who would follow. We believe that some results of our investigation are clear and could indicate definite policy steps, while others will need to be further clarified.

The Scope of the Study

The pervasiveness of malnutrition and its relationships through both causes and effects to so many other sectors can be seen in the range of disciplines that are employed to study it. Research findings in many areas are recognized as essential to both the understanding of the problem and to the formulation and implementation of adequate policies.

This study is an example of such an interdisciplinary approach. While we began with a detailed examination of the links between early nutrition, growth, development, and school performance which was the primary concern of the study, we also moved into other related areas which must be addressed for the proper formulation of development policy.

Economists tend to see the lack of food available to the household and/or the individual in a malnourished population as a problem of insufficient production and distribution of food. Those trained in other disciplines point to diverse reasons for nutritional deficiency -- poor health, excessive and poorly spaced numbers of children per family, and poor distribution of food within the household. Educational policy makers are concerned with whether nutritional deficiency impairs school performance. Development planners attempt to measure how nutritional status affects work productivity. Nutritional planners search for adequate measures of expressing nutritional status in functional terms. Besides short and medium range policy problems, policy makers are concerned with the longer range pay-offs of nutritional policies such as how the outcomes of current nutritional policies will themselves be reflected in the future supply of food and the well being of children and families.

The current study addresses some of these problems and interrelationships. Using data from the malnourished rural population in Eastern Guatemala which was the subject of the INCAP/Rand investigation, we

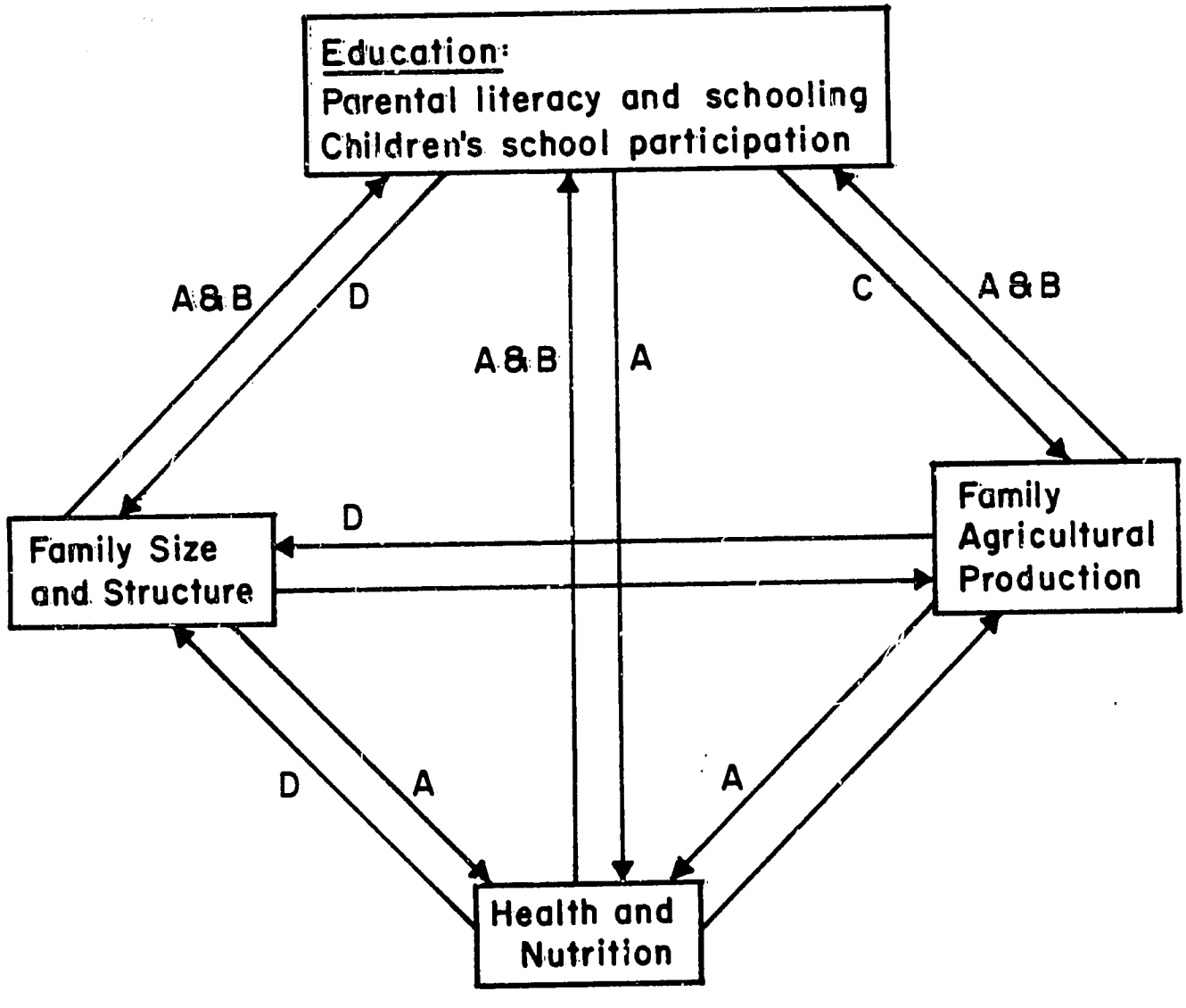
analyze the links between early childhood nutritional intake, health, growth, and school attendance and performance. Additional links between children's schooling, family work, family size, parental literacy, and agricultural efficiency are also investigated.

Figure 1 depicts, in simplified terms, the principal sectoral links that are addressed in analyses in this report. Each arrow is labeled with a letter indicating the section in Part II in the text which relates to the specific relationship depicted.

In each of the following sections, we will present research results and, wherever possible, the policy significance of these conclusions. In some cases, research findings are strong and clear enough to lead directly to policy conclusions while, in other cases, more research is needed. At the conclusion in Part III, we shall present a more complex version of Figure 1 from the perspective of the child which reflects more properly the results of our study.

Figure 1

Nutrition, Education, Agricultural Production, and Fertility: Interactions Among Sectors



Note: A, B, C, D refer to the section in Part II of this report that investigates the linkages.

Structure of the Report

This report is organized into three major parts. Part I-A describes the experiment carried out by INCAP (Institute for Nutrition in Central America and Panama) and summarizes INCAP's findings. Part I-B describes the villages where the experiment took place.

Part II presents the methods of analysis and findings. Alan Wilson's contribution in Section II-A describes a series of longitudinal models which relate the influence of early nutrition to growth, verbal development, school attendance, and school performance. The models, using information for children studied from birth, include how nutritional intake (calories and proteins, as well as home and supplementation) affects physical growth, how nutritional intake and physical growth then enter models of verbal development, school enrollment, and achievement.

Sections II-B, C, and D describe three cross-sectional analyses carried out with data from Rand-Rockefeller surveys and some elements from the longitudinal study. Although their populations vary in composition, their features are similar enough to allow their integration in the final summary of findings. In II-B, Judith Balderston analyzes how household decisions to send children to school and/or work (including both paid work and help to the family) appear to be determined by nutrition, health, and family economic factors. Utilizing Alan Wilson's findings relating height, nutritional intake, and health, Maria Freire's economic groupings (shown in II-C), and Mari Simonen's measures of perceived child economic utility (shown in II-D), the models presented in II-B focus on the significance of family and village economic conditions upon children's school attendance. In this part, older children's work activities are also examined in relation to family and village economic factors.

Sections II-C and D address the pay-offs of nutritional policies. In II-C, Maria Freire investigates the links between education and agriculture production for 500 farmers using data collected in the Rand-Rockefeller project. The relation of formal education and literacy to farm production and profits is analyzed, as well as a search for the main factors which affect farm production and, ultimately, food availability. Findings from this study can be used (1) to speculate on the intergenerational effect of nutritional policies since, with results from II-A and B, we can see how nutrition affects education which affects food production (with a generational lag) and, consequently, nutritional status; (2) to complement II-B and analyze children's economic contribution, and (3) to detect the constraints that may impinge upon the availability of food for the household as a whole.

In II-D, Mari Simonen analyzes relationships between education, fertility, and family size. Her findings are important in several ways: (1) differential behavior is observed between rural and urban populations (using data for two additional "semi-urban" villages not included in the longitudinal study); (2) family size and fertility are explained in terms of economic and social variables which contribute to inter-sectoral planning; (3) it complements II-B and II-C by explaining fertility and family size in terms of parents' perceptions of the economic utility of children.

In Part III, the main findings of each section are summarized. Then, viewing the analytical results as interrelated from the research policy standpoints, the report concludes with a discussion of the policy implications of various interventions.

PART I

Summary of INCAP's Experiment and Findings
by Sheldon Margen and Maria Freire

The review of the published material from INCAP is rather difficult to summarize. Since much of the data was analyzed before all the studies were complete and since different samples were the basis for different papers, contradictions do appear. It is difficult at present to reconcile these differences since the final papers, based on the entire experiment, have not yet been published by INCAP. In addition, there are two important points which we wish to make. First, most of the INCAP analyses were based solely upon the amount of supplement consumed and ignored home diet. To do this requires the assumption that the supplement acted as a true incremental increase in the dietary intake of the individual and that, therefore, the amount of supplement consumed can serve as a proxy measure of total intake. However, close analyses of the data shows that there is an unknown degree of error in the home diet, and that the degree, direction, and variability of the bias in reporting home diet is unknown but important for interpretation of the experiment. It certainly appears that at least a portion of the supplement consumed is actually replacement of home diet; therefore, the amount of supplement cannot serve as a measure of the increase in diet. Second, in view of the attempts to analyze the data, primarily in terms of the supplement intake, the problem of differentiating between protein and caloric effects has been a very difficult one using INCAP's method of analysis. This is a problem which the Berkeley group recognized from the onset and that must be kept in mind when examining the published work to date.

The experiments which were carried out by INCAP and described in their published papers which we have summarized suggest the following interpretations:

1.) Birth weight is determined mainly by the physical characteristics of the mother at the time of conception, particularly height and weight. Since these two characteristics are strongly dependent on social class and the early nutritional status of the mother (when she was between the ages of one and seven), the problem of low birth weight is likely to continue for generations unless specific measures are considered. In particular, interventions that are directed specifically to shorter and thinner mothers may correct this condition. INCAP's experiments suggest that, for pregnant women, supplementation of 20,000 additional calories during pregnancy increases appreciably the weight of the newborn baby. The effect of an additional caloric supplement of 10,000 calories increases the newborn's weight another 25-80 grams. There appear to be sex differences; the effect of increased calories during pregnancy is greater for female newborns than for males. The Guatemalan group believes that their results show that growth effects can be explained entirely on calories and that protein played no role.

2.) Birth weight appears to influence mental development during the first fifteen months of life. Mental performance also seems to be associated with certain physical characteristics of the mother, such as head circumference.

3.) Physical growth is often used by INCAP as a proxy of the child's nutritional status. Not only height, weight, and head circumference have been studied, but other anthropometric measurements such as bone growth and ossification, tooth eruption, and various types of arm measurements are used by INCAP to reflect the nutritional status of the child. Important

conclusions can be derived from the INCAP data which show that physical growth is mainly dependent on environmental conditions, such as nutrition and health conditions, and independent of genetic factors. For developing countries, the most important health factor explaining delayed physical growth appears to be diarrheal disease, supposedly responsible for 10-15% of the growth retardation in younger children. Nutrition (including nutrition of pregnant women) seems to be the other important factor explaining the physical growth retardation. Results of the Guatemalan experiment show that low supplemented children are three to seven times more likely to be physically retarded than children who are receiving high supplements. It is estimated that adequate supplemental feeding programs would reduce the differences of growth between Guatemalan and U.S. children by 50%.

4.) The causes of poor or lower mental performances have not been uniquely determined. Certain measures of physical growth seem to have some predictive power for specific mental tests, but results vary by age and sex and reflect the powerful influence of socio-economic factors such as infant rearing practices, economic status, etc. Analysis of mental development between the ages of five and seven years "shows that prior test results are the best predictors of seven year old's performance." One might infer that the mental characteristics of the child, therefore, are settled at five years and no subsequent changes can result from an alteration in environmental conditions. Whether this is a correct interpretation of the results of the Guatemalan experiment or whether this conclusion will hold up in the final analysis is obviously open to serious question.

5.) Final Conclusions. Many studies report the influence of birth weight on mental performance during the life of the human being. These results have been accepted at this time virtually as "universal truth."

If this is true, then, the main policy implications of the Guatemalan data would suggest that one of the principal methods for avoiding mental performance impairment would be to begin intervention primarily at the pre-school level, concentrating on girls to avoid their physical retardation, lower weight new-borns, and high-risk mothers. Finally, one might assume from the INCAP experiments that nutritional factors are strongly associated with physical growth but that their influence on mental tests of performance is not yet well determined over the long-run. For policy formulation, the short-run effects measured by psychological tests will need to be translated into measures of school performance and social competency. This is the question that will be considered in analyses that were examined by the Berkeley group and that are described in the present report.

PART II

ANALYTICAL RESULTS FROM THE BERKELEY STUDY

Introduction

In the introduction to this report, we recommended that the effects of malnutrition on child growth and development and school performance need to be investigated. It was recognized that, if links could be shown between childhood nutrition, health, and educational performance, then not only the efficiency of educational investments would benefit from the improvement of nutritional and health conditions, but, also, the allocation of total resources could be made more efficiently.

In Part II, we shall present the results of four sets of analyses using INCAP and Rand data collected in the four study communities in Eastern Guatemala. In II-A, a series of models is used to find out how prenatal and early childhood nutrition, in combination with other socio-environmental factors of family and village, determine children's growth, health, verbal development, and school performance. From these longitudinal models, it appears that children's height is affected by nutritional intake and the incidence of diarrheal infection, and that the child's size at school age is a good measure of the child's nutritional and health history. These are strong and significant results and imply that the improved health and nutritional status of children can affect in important ways the children's future opportunities. It will be seen that children who have grown taller are also more likely to be further advanced in verbal development and are more likely to attend school at an earlier age.

For development planning purposes, these results are important. They enable planners to trace the effects of continuing food intake, in combination with family and environmental factors, to children's functioning at school and work in the villages. Moreover, if the intergenerational effects of

education can be measured by the impact of adult literacy on economic productivity, then school attainment can be related to economic productivity benefits. With such results, development planning can take into account benefits which derive from one sector and affect another; these are known as positive externalities of programs by economists. Better nutrition for children, leading to improved growth, stamina, verbal development, school attainment, work performance, and, utlimately, adult efficiency, combined with appropriate levels of land accessibility and school quality would enhance lives beyond the gains expected by the change in nutrition alone.

Data collected by INCAP and Rand indeed did permit the investigation of relationships between children's school and work activities, parental economic productivity and literacy, and parental literacy and perceptions about desirable family size. We were able to examine the following questions: (1) how immediate needs for work affect family decisions about the desirability of school attendance and the attainment of literacy; (2) the effects on adult economic productivity of literacy attained; (3) the effect of parental literacy on the perceptions of children's economic utility.

These three sets of important relationships are explored in Sections II-B,C,D. Using cross-sectional data as well as the findings of II-A, in II-B parental decisions on sending children to school are examined as well as how nutritional status, parental literacy, family size and structure, and family economic conditions affect educational enrollment and achievement. Using the findings of II-A in II-B, attained height at school age is used as the proxy measure of children's past nutritional and health status. Relationships between prior nutrition and health and school achievement are seen to vary by village and by type of economic activity of the family, indicating that, while the opportunity to attend school may be available to

all, children actually attend school if their parents can spare their work or value the long-run benefits of schooling in relation to the short-run costs. Moreover, controlling for family economic and attitudinal factors, it appears that height at school age does appear to explain school enrollment and achievement. Among families of comparable levels of affluence, in three of the villages, bigger, healthier children do participate in school more often than smaller children.

In Section II-C, family agricultural production is related to land holdings, type of production, and farmer's literacy. Education enabled farmers to choose the best combination of production factors, to introduce modern crops and chemical inputs, and to obtain, in the overall, higher levels of land and labor productivity. The estimation of a production function for different groups of farmers, according to their level of market integration, provides information of the influence of literacy and of an additional year of schooling on increased agricultural production.

In Section II-D, individual fertility behavior and desires are related to perceived economic need for children, family economic activity, and literacy of the heads of the household. These results allow us to see how increasing years of schooling and literacy may affect attitudes toward family size and actual fertility.

SECTION II.A
LONGITUDINAL ANALYSIS OF NUTRITION, GROWTH, VERBAL DEVELOPMENT, AND SCHOOL ACHIEVEMENT

by Alan B. Wilson

I.A.1. Introduction

This part of the report deals with 824 children who were born between January 1969, when data collection was initiated by INCAP in the four study villages, and March 1972, the last cohort to have attained age six when data collection was discontinued and who had lived in the village at any time during their first six years. Many of these children were in the village for only brief periods of time, and this sample includes children who died in infancy or who left the village while still very young. Most of the analyses are based upon that subset of 512 children who were born in one of the four villages and continued to live in the village of birth at least until age three, thus excluding the transient population. The effective sample size for the various tabulations which follow is often further reduced by unavailability of data for the set of variables over the age ranges included in the particular analysis. There is a discussion of the sources and extent of missing data in Appendix A.11.d.

The overall concern of this study is to estimate the effects of nutrition at various ages upon verbal development and school performance. This large topic is broken down into several discrete questions. (1) What are the effects of variations in diet and morbidity upon growth in stature and weight during early childhood? (2) Does a child's cumulative health at age three have short- or long-term effects upon verbal development from age three through age seven? (3) Does concurrent nutrition substantially modify verbal development during childhood? (4) Do verbal development, diet, and health affect school enrollment? (5) Among those who do attend school, do verbal development, diet, and health affect teachers' assessments of performance. This sequence of questions is depicted diagramatically in Figure A.1 in this section.

Variations in children's growth are determined by genetic factors, variations in nutrition at the cellular level, morbidity, and energy expenditure. None of these factors is measured directly, completely, or accurately in the present study. Parental anthropometry, which in turn has been affected by the parents' environments, is available as a proxy for genetic potential for growth; boys and girls are either analyzed separately or sex is included as a control variable to allow for average sex differences in growth; and, the inclusion of lagged values of children's anthropometric measures, for example, height the preceding year, presumably partly controls for prior predisposition. While the residual unexplained individual variance in growth (ranging from 10% to 30% in subsequent analyses) may be due to unmeasured genetic factors, inadequately measured morbidity, and unmeasured patterns of energy expenditure, we assume that the systematic differences between groups of children are largely due to variations in diet and morbidity -- in particular to the effects of the nutritional intervention.

Contrasts between the four villages are reviewed in Section II.A.2. While there are a number of significant demographic differences among the villages, the comparisons which are most germane to our present questions have to do with the pre-intervention nutritional status of the children in the villages. Anthropometric surveys of children conducted in 1968, before the beginning of the nutritional intervention (and before the birth of the first of the cohorts included in the sample studied here), show that there were no large or systematic differences in the average growth patterns of children in the Atole and Fresco villages.

After the initiation of the project, there are substantial differences in growth between children in the Atole and Fresco villages, beginning by age three months and increasing through age thirty-six months. At age

thirty-six months, in the Atole villages, the girls were 11.4% heavier and boys 7.3% heavier than their counterparts in the Fresco villages. These patterns of growth in weight and stature by sex, age, and treatment group are described in Section II.A.4.

While there is evidence that prior to the project the home diets of the children must have been comparable, after the introduction of the supplementation, children in the Atole villages ate considerably less at home. They more than compensated for this reduced home diet, however, by the consumption of supplementation. This suggests a substantial gross replacement of home diet by supplementation in the Atole villages. One clear impact of this replacement in the Atole villages has been to raise the proportion of their total dietary intake arising from protein sources from about 11% (the proportion in the home diets in both Atole and Fresco villages) to well over 13%.

The treatment -- the provision of a high-protein dietary supplement -- had an apparent impact on the growth of children during infancy. While the total caloric intake of the children in the Atole villages was higher than in the Fresco villages until they were about five years old, the effect of the supplementation on the amount of protein consumed was much more pronounced than its effect on total caloric intake. These dietary contrasts are detailed in Section II.A.3. During the second year of life, total caloric intake is estimated to be 17% higher in the Atole villages, and the available protein is over 46% higher.

This initial descriptive contrast raises an additional question as to whether, despite substantial replacement, the differences in total available calories in the diet accounts for the differential growth rates or whether the very large average advantage in available protein in the Atole villages

due to supplementation led to the differences. This question has been explored in two different ways.

First it was reasoned that if the limiting factor for growth in the villages was the deficiency of calories in the diet while protein available from home diet was sufficient, (a) calories from home diet and calories from supplementation should have very similar effects upon growth, and (b) supplementation in the Atole villages, while rich in available protein, and supplementation in the Fresco villages, which contained no proteins, should have similar effects on growth. The contrasts between the effects of supplementation and home diet, and between the effects of supplementation in the two treatment groups, are described in Section II.A.5.

In Section II.A.6, a more direct approach is used. The estimated available protein in the home diets of each child in kcal units is deducted from the total caloric value of the home diets. In the Atole villages, each child's supplementation intake is divided into two portions: 27% of the total being the kcal value of the protein content, the remaining 73% being calories net of protein. For each child, two new variables are reaggregated: dietary protein in kcal units, and calories net of protein, each including both home diet and supplementary sources. The effects of these two variables -- "straight" proteins and calories -- upon growth in stature and weight are estimated at several age levels.

Turning to the linkage between early physical growth and subsequent verbal development, to be discussed in Section II.A.7, there may be important interactions between biological and social factors (cf., Ricciuti, 1977). Early malnutrition and ill health, resulting in poor physical growth, may have direct effects on learning ability and energy available to explore and interact with the environment. These same factors adversely affect

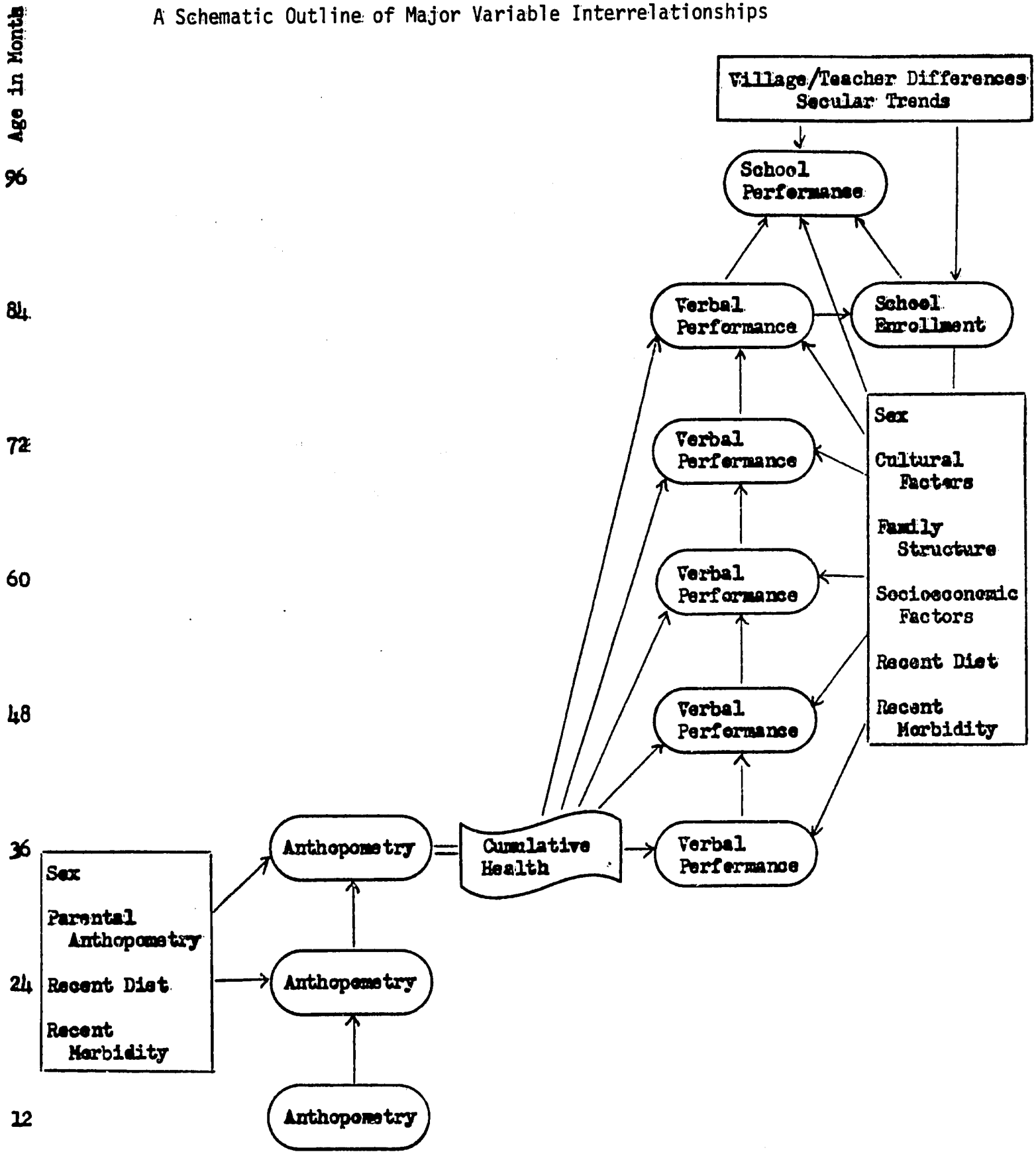
the social responses of others to the child. Similarly, the complex of poverty and illiteracy leads to poorer health care as well as minimal stimulation of learning. In the analysis undertaken here, however, we leave these interactions between biological and social sources of cognitive development as unanalyzed correlations and estimate the direct independent effects of each upon verbal development. In this analysis, we construe stature at a given age as a proxy for cumulated prior nutrition and health.

In Section II.A.8, the effects of verbal development, height, and a large number of social and economic characteristics of the family upon enrollment in school by age seven is estimated for the small group of 114 children in the sample who had reached age seven by January of 1977. Here it is plausible that health, size, and performance may have different effects for different families. For some families, the robust child may be deemed too valuable for the family enterprise to permit school enrollment; for others, the less developed child may be judged incapable of benefitting from schooling. Further analysis of factors affecting parental evaluation of the utility of child labor is undertaken in other portions of this report. In the present section, while we note large differences between villages in rates of school enrollment, we estimate the average effects, across villages and families, of a large number of characteristics.

Finally, for those children who were enrolled in school for at least one year, we examine the effects of both pre-school health and concurrent diet and morbidity during the first year of schooling, upon the teachers' assessment of performance in language and mathematics.

Figure A.1

A Schematic Outline of Major Variable Interrelationships



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II.A.2. Summary of Findings

Rather than a discursive reiteration of the already brief text of the preceding sections, this summary consists of a series of substantive propositions which are organized into three groups: (1) findings reported with a high degree of confidence, (2) findings reported with a lesser confidence, and (3) anomalous findings.

The classification here is based not only on levels of statistical significance of individual regression coefficients but also on a combination of apparent robustness, evidenced by internal consistency across models, interpretability, and, to a lesser extent, congruence with findings in other research.

A few statistically significant coefficients which appear in various tables in this part of the report are not discussed in either the text or the summary. These are primarily coefficients of social and economic indicators which were included as controls but were not themselves of central interest. Because they were included eclectically and, to some extent, redundantly, the magnitudes of the partial regression coefficients vary from table to table and hence fail on the criterion of robustness. As indicated in various places in this report, however, the focus of this section is primarily on the biological rather than social backgrounds of achievement.

I. Findings in Section A reported with high confidence:

1) The availability of free high-protein supplementation in the Atole villages led to considerable replacement of home diet by supplementation and a consequent increase in the proportion of protein in the diets of children in those villages.

2) While children's anthropometry by age before the project were similar, after the introduction of supplementation, growth in weight and stature was greater in the Atole villages.

3) Differences between Atole and Fresco villages in the growth of children in both weight and stature was greater for girls than for boys.

4) Within the Atole villages, children who consumed more supplement before age 36 months gained more in both weight and stature; this was not true in the Fresco villages.

5) Incidence of diarrhea has a consistently negative effect upon physical growth -- particularly stature.

6) Children are more likely to consume supplement if their mothers attend the supplementation centers.

7) Children from more affluent homes (CONSUMP scale) are less likely to consume supplementation.

8) Boys eat more at home than girls, even allowing for initial weight differences.

9) Parental literacy is associated with the provision of better home diets.

10) Taller children perform better on verbal performance tests.

11) Children from more affluent homes (CONSUMP scale) perform better on verbal tests.

12) Girls perform better than boys on verbal tests.

13) Children with high verbal proficiency are more likely to enroll in school.

14) Children with high verbal proficiency are more likely to perform better in school.

15) Verbal performance, stature, weight, home diet, and supplementation show high stability over time. They show "simplex" patterns of intercorrelations.

16) Concurrent nutritional intakes affect the school performance of children of similar stature.

II. Findings reported with somewhat less confidence:

17) The sex-treatment interaction noted in 3, above, is due to the relatively more ample home diets of girls, at early ages, in the Atole villages, which they enjoy because of the presence of a free nutritional supplement which, in turn, reduces competition for food at home.

18) The effect of the Atole supplement upon physical growth and lack of effect of Fresco supplement upon physical growth, noted in 4, above, is due to the high protein content of the Atole.

19) Parental literacy, particularly maternal literacy, favorably affects verbal development.

20) Verbal performance is enhanced by the presence of more elder persons in the family; it is depressed by the presence of younger siblings in the family.

21) The incidence of morbidity (other than diarrhea) depresses verbal performance.

22) Families in which children have died provide a poorer home diet to surviving children.

III. Anomalous finding:

23) The negative coefficients of the regressions of growth in weight and stature upon caloric consumption, holding protein constant, do not have any clear biological interpretation. There are several possible misspecifications of the models in Section II.A.6 where these results were found. There, the lack of information on intake of nursing infants, including their home diet, may have been the cause of this anomalous result. This unexplained coefficient reduces confidence in the estimate of the independent effect of protein, reported as 17, above.

Tables summarizing the major empirical findings follow.

TABLE A.1

Calories, Protein, and Growth
Ages 12-48 Months
All Villages Combined

x^2=401.35; d.f.=393; x^2/d.f.=1.02; p=.37
N=256

Home Diet Error at 23%

		WEIGHT			HEIGHT		
		24	36	48	24	36	48
y_i	Mean	9.70	11.88	13.62	77.36	85.80	93.10
	Standard deviation	1.15	1.30	1.41	3.64	3.88	4.03
$-\beta_{ij}$	Lagged values		.98*	1.01*		.90*	.98*
	Calories	-.0005	0	0	-.0022*	0	.0005
	Protein	.0081*	0	0	.0232*	.0070	0
γ_{ik}	SEX	.11	0	0	-.31	0	-.27
	MAHT				.05*	.03*	0
	PAHT				.05*	.03*	0
	DIARRHEA	-.49	0	0	-2.20	-2.67	-3.12
	MORBIDITY	0	0	-.16	0	0	0
	WT6 (12 months)	.82*					
	HT6 (12 months)				.97*		
	$R^2 = 1 - \psi^*$	.64	.79	.88	.70	.82	.89
	$F_{k, N-k-1}$	72.39	158.12	293.72	71.09	141.32	255.27
	p <	.001	.001	.001	.001	.001	.001

TABLE A.2

CALORIES, PROTEIN, DIARRHEA, AND GROWTH -- REDUCED FORM

Ages 12-48 Months

All Villages Combined

N=256

		WEIGHT			HEIGHT		
		24	36	48	24	36	48
Calories	18 mo.	-.0005	-.0005	-.0005	-.0022	-.0020	-.0020
	30 mo.	0	.0003	.0003	0	.0005	.0005
	42 mo.	0	0	-.0001	0	0	.0005
Protein	18 mo.	.0081	.0080	.0081	.0232	.0210	.0206
	30 mo.	0	-.0002	-.0002	0	.0070	.0068
	42 mo.	0	0	.0011	0	0	.0009
Diarrhea	12-24 mo.	-.4924	-.4847	-.4905	-2.2006	-1.9868	-1.9480
	24-36 mo.	0	-.4296	-.4346	0	-2.6694	-2.6172
	36-48 mo.	0	0	.1323	0	0	-3.1169

TABLE A.3

Verbal Development, Ages 36 to 84 Months, Standardized Coefficients
All Villages Combined
x^2=42.78; df=166; x^2/df=.26; p=1.00
N=105 (minimum)

		36	48	60	72	84
y_i	Standard Deviations	3.41	4.22	4.61	4.30	3.91
$-\beta_{ij}$	Lagged Values	--	.80*	.83*	.87*	.85*
γ_{ik}	HTi2	.35*	.14	.08	0	.13*
	SEX	-.18	0	0	-.09	0
	FMSZO	0	0	0	0	.15*
	YOUNG3	0	0	-.13	.07	0
	CONSUMP	.24*	0	0	0	.06
	ZMAOCC	0	0	0	0	-.05
	PASTAT	-.12	0	0	0	-.10*
	MODVOC	0	0	0	0	0
	ZMARD	0	.09	0	0	.05
	ZPARD	0	0	0	0	.11*
	COHORT	0	0	0	0	0
	DIED3	0	0	-.10	0	.17*
	STRUC3	0	-.11	0	-.14*	-.16*
	$R^2=1-\Psi^*$	.25	.74	.82	.88	1.00
	F_k, N-k-1	2.31	18.34	27.45	48.00	--
	p <	.05	.001	.001	.001	.001

TABLE A.4

TEACHER ASSESSMENTS IN LANGUAGE AND MATHEMATICS

at End of First Completed Year of Schooling.

All Villages Combined.

χ^2=361.72; df=328; χ^2/df=1.10; P=.10

N=83

		S22 Language	S21 Mathematics	Composite Factor
y_i	Mean	57.51	55.89	
	Standard Deviation	20.72	19.87	19.83
$-\beta_{ij}$	Protein 2			.21
	Calories 3			.02
γ_{ik}	Verbal factor 5			1.87*
	CHDIAR15			0
	MORBOTH4			11.93
	HTC15			0
	FMSZ6			-3.34*
	YOUNG6			0
	DIED6			0
	DSTRUC6			8.00
	SEX			-4.97
	ZMARD			-2.91
	ZPARD			0
	MODVOC			-5.20*
	CONSUMP			3.76
	PASTAT			5.75*
	ZMAOCC			0
	EDASP			2.00
	ATTAGE			.35
	D6 Atole-Large			-21.56*
	D8 Fresco-Small			0
	D14 Atole-Small			-21.83*
	$R^2 = 1 - \psi^*$			.59
	$F_{20, 62}$			4.38
	$p <$			.001
λ	Relative factor weights	1.00	.97	
ε	Unique variance	57.68	47.05	
ε/s_i^2	Proportion of variance unique	.13	.12	

SECTION II-B

Determinants of School Enrollment and Achievement: Summary of a Study on the Effects of Nutrition, Health, and the Need for Children's Work*

by Judith B. Balderston

The object of this analysis was to test for the effects of nutrition, health, and parental occupation, education, and affluence upon children's school enrollment and achievement.

The central question of the Berkeley project was whether school enrollment and achievement depend on children's nutrition and health. Results of Alan Wilson's analysis reported in the previous section show that there were nutritional and health effects on children's verbal scores and on school achievement. In the present section, we assume that prior nutritional intake and health have affected height by age seven and that present nutritional intake and morbidity measures during the child's eighth year can be used as indicators of current health and diet. Variables describing family work and the need for children's help are included in the analysis.

It was hypothesized that several factors would contribute to the family's decisions with respect to the child's schooling. First, the economic need of the family for the child's work would be determined by family occupation and land holdings, family size and composition, family income and wealth. Second, in addition to these measureable economic factors, attitudinal factors such as parental attitudes and aspirations for the child would affect family decisions on the allocations of children's time. Third, the effects of children's past nutritional intake and health, physical development, and verbal ability would influence the child's enrollment performance in school.

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*This is a brief version of the results obtained in a longer report, "School Enrollment and Achievement: Effects of Nutrition, Health, and Need for Children's Work," by the same author, included in the full report of the Berkeley Project on Education and Nutrition, April 1980.

The direction of these effects is difficult to assess a priori. Alan Wilson's findings indicate that taller children also achieve higher verbal development and appear to be more successful in school. But, healthier, more robust children might be more valuable for helping in the household or on the family plot, so their school participation may be limited by the need for thier work. In this study, the relationships between children's nutrition and schooling and parental decisions to enroll children were both addressed.

From the longitudinal study carried out by INCAP, it was possible to identify determinants of height, verbal development, and school enrollment for children born between 1969 and 1971. Because of the presence of the supplementation program, it was possible to separate out the effects of family economic status from the child's food intake, since children at low economic levels had the opportunity to obtain improved nutrition than they would otherwise have had. The INCAP experiment and data collection, therefore, permitted us to analyze how attained size at age seven, as a proxy measure of prior nutritional intake and morbidity, along with current measures of health, affected school enrollment and performance. The availability of information on family work, income, wealth, parental literacy, and perceptions of the economic utility of children, collected by Rand (with Rockefeller Foundation support) in 1974-75, permitted us to analyze the relationships between family economic conditions, children's work activities, and school attendance for children born before 1967. Data colelcted by INCAP (with NSF support) for children born between 1962 and 1968 included information on children's school attendance and achievement (from the Guatemalan Ministry of Education) and children's work for pay. Unfortunately, these three sets of data were for different subjects and did not provide a full set of variables to analyze one model completely.

We therefore had to make use of available data by carrying out analysis in stages.

Using the data from the Rand and INCAP studies for children born between 1962 and 1968, we matched variables by child and merged data files. We could then look at the child's work and school activities by family economic groups*, income, parental literacy, and perceptions of the mother on the economic utility of children.** For these chidren, measures of height, health, nutritional intake, and verbal performance were unfortunately not available.

In Table B-1, we see the results of regressions analysis*** performed to explain the variation in children's activites (from the R09 files) when we divide these activities into four mutually exclusive categories -- school only, work only, school and work, neither school nor work. We see that about 50% of the children work only, about 9% go to school only, about 28% do both, and about 14% did neither. This table shows the results for all villages and occupations combined and explains only a small proportion of the variation in behavior.

It was then hypothesized that work and school activities would be better explained by disaggregating into groups by occupation of parents. Table B-2 permits comparisons by parents' economic groups.

Similar analyses were also done using schooling data from 1972 to 1978 obtained by INCAP for children born before 1969. This analysis includes

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*For a description of economic groupings, see Section II-C by Maria Freire.

**For a description of "perceived economic utility," see Section II-D by Mari Simonen.

***Interpretation of the results of these regressions requires caution since the regression technique is suitable for dichotomous dependent variables when the occurrence of an event is close to one half. In this case, the work only variable is the best indicator for our purposes.

TABLE B-1

REGRESSION OF WORK/SCHOOL CHOICES FROM RØ9.
N=515
All Villages and Occupations

VARIABLE	Mean	S.D.	School Only		Work Only		School & Work		No School, No Work	
			Coeff.	T-Stat.	Coeff.	T-Stat.	Coeff.	T-Stat.	Coeff.	T-Stat.
School	.0893	.2855								
Work	.4951	.5005								
School & Work	.2777	.4483								
No School	.1379	.3451								
PLB1	.5308	.3247	.0211	.5201	.1144	1.6442	-.0733	-1.1120	-.0623	-1.2263
PLB2	.0000	.0001	-149.3545	-.9694	-64.6865	-.2461	322.0873	1.2905	-107.8644	-.5606
COM2	.2350	.4244	.0155	.4825	.0117	.2128	-.0345	-.6652	.0674	.1853
COM3	.3476	.4767	.0287	.9692	-.0912	-1.8019	.1205*	2.5448	-.0580	-1.5700
PERUTIL	2.5010	1.7537	-.0012	-.1711	.0217	1.7428	-.0298**	-2.5349	.0094	1.0379
HSTYPE	2.7320	.6096	.0099	.4367	-.0596	-1.5320	.0168	.4563	.0328	1.1570
SEX (m=1, f=2)	1.4913	.5004	-.0617*	-2.5660	.1366***	3.3237	.0026	.0068	-.0776**	-2.5848
Y63	.1049	.3067	.0186	.4469	-.1721*	-2.4194	.2671***	3.9638	-.1135*	-2.1856
Y64	.1223	.3280	.1407***	3.5987	-.2337***	-3.4937	.2079***	3.2819	-.1149*	-2.3533
Y65	.1243	.3302	.0568	1.4627	-.1977**	-2.9771	.1969**	3.1315	-.0560	-1.1553
Y66	.1437	.3511	.1179**	3.1898	-.0796	-1.2584	.0666	1.1128	-.1050*	-2.2741
Y67	.1359	.3450	.0224	.5934	-.1611*	-2.4976	.1455*	2.3811	-.0067	-.1426
V2	.2796	.4492	-.0289	-.8994	.1266*	2.2991	-.0938	-1.7997	-.0038	-.0945
V3	.1961	.3974	.0089	.2306	.0442	.6720	-.0124	-.1990	-.0407	-.8471
V4	.2175	.4129	.2045***	5.9718	-.3391***	-5.7887	.0081	.1462	1.765**	2.9577
FAMSZ	7.4893	1.6984	.0154*	2.1536	.0024	.1958	-.0058	-.5067	-.0119	-1.3356
			R2 = .155		R^2 = .195		R^2 = .101		R^2 = .100	

*$p \leq .05$

**$p \leq .01$

***$p \leq .001$

Source: Rand File R09

TABLE B-2

COMPARISON OF MEANS AND STANDARD DEVIATIONS OF VARIABLES USED IN REGRESSIONS OF SCHOOL AND WORK ON FAMILY BACKGROUND AND ECONOMIC VARIABLES, OLDER COHORTS, FOUR VILLAGES

Variable	Children of Non-Farmers N=60		Children of Subsistence Farmers N=178		Children of Semi-Subsistence Farmers N=121		Children of Commercial Farmers N=179	
	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.
School only	.0167	.1291	.1067	.3907	.1074	.3110	.0782	.2693
Work only	.3667	.4860	.4944	.5014	.5455	.5000	.4804	.5010
School and work	.3833	.4903	.2528	.4358	.1818	.3873	.3631	.4823
No school, no work	.2333	.4265	.1461	.3542	.1653	.3730	.0782	.2693
PLB1	.1438	.3033	.6325	.3277	.6206	.2920	.4614	.2497
PLB2	.0000	.0000	.0000	.0001	.0000	.0000	.0000	.0001
ACTGY	136.1567	294.3516	59.4579	162.0781	68.0934	220.0047	123.2872	227.1168
SALESA	35.0000	66.7802	0	0	63.5207	54.9921	335.6704	417.9128
PERUTIL	2.1833	1.7611	2.1461	1.6945	3.1157	1.5011	2.5642	1.8360
HSTYPE	2.9667	.6630	2.6348	.5276	2.5950	.5565	2.8547	.6370
SEX (m=1, f=2)	1.5667	.4997	1.4888	.5013	1.4545	.5000	1.4972	.5014
Y63	.0667	.2515	.0843	.2786	.1240	.3309	.1173	.3227
Y64	.1667	.3758	.1236	.3300	.1322	.3402	.1117	.3159
Y65	.1000	.3025	.1404	.3484	.0992	.3001	.1341	.3417
Y66	.1167	.3237	.1292	.3364	.1570	.3653	.1620	.3695
Y67	.1333	.3428	.1517	.3597	.1240	.3309	.1229	.3292
V2	.1333	.3428	.2528	.4358	.2810	.4514	.3464	.4771
V3	.2833	.4544	.1292	.3364	.0744	.2635	.3240	.4693
V4	.1833	.3902	.3483	.4778	.2562	.4383	.0782	.2693
FAMSZ	6.0833	1.6395	7.3483	1.3909	7.8264	1.8105	7.6983	1.7477

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

Source: R09 Files

information on children's work for pay and therefore differs from the analysis using the Rand data. Tables B-3 and B-4 present results.

So far, we have included information on health, height, or verbal development, for this was not available for children born before 1969. Thus, insofar as family economic factors affect diet and health positively and need for children's work negatively, these models tend to overstate the positive effects of the family's economic level and the need for children's work on children's school participation.

Next, using information on school enrollment and achievement for children born before 1969 as background, we analyzed school participation and performance of the group of subjects born between 1969 and 1971. For this group, we had a large range of anthropometric, morbidity, nutritional, psychological, and socio-economic variables but did not have data on children's work activities. Thus, it was necessary to use the information from prior analysis to infer that work activities of the children would be the result of family occupation and need for the children's work. This was done by introducing parental economic groups into the set of variables that was used to explain children's school participation. Tables B-3 and B-4 show the results of this analysis.

We see that villages differ in the amount of variance explained and in the statistical significance of the variables. Because of collinearities in variables, statistical significance was not obtained on some variables that might have occurred using a smaller set. However, it is interesting to note the signs and sizes of coefficients.

Table B-5 shows the results of a stepwise regression. Here we see from a series of related models which involve an increasing number of explanatory variables how economic factors, then parental literacy, and, finally, measures of child development appear to affect enrollment. These

TABLE B-3

OLS COEFFICIENTS FOR REGRESSION OF YEARS OF SCHOOL ENROLLMENT AND PAID WORK ACTIVITIES OF CHILDREN BORN 1962-1968
From Schooling Study

Variable Name	Mean	Stan. Dev.	School Only N=277		Paid Work Only		Paid Work and School		No School and No Paid Work	
			Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
School only	.5379	.4995								
Paid work only	.0469	.2119								
School and paid work	.3646	.4822								
No school, no paid work	.0505	.2195								
PLB1	.5011	.3332	-.0739	-.7103	.0908*	2.0003	-.0190	-.1841	.0021	.0427
PLB2	.0000	.0001	-50.2894	-.1602	1.0458	.0076	115.7854	.3726	-66.5418	-.4529
COM2	.2202	.4151	-.1937*	-2.4040	-.0235	-.6677	.1887*	2.3656	.0284	.7522
COM3	.3430	.4756	-.1515*	-2.0921	-.0201	-.6374	.1483*	2.0673	.0234	.6888
PERUTIL	2.4585	1.7721	-.0122	-.6933	-.0033	-.4346	.0158	.9018	-.0002	-.0221
SALALL	289.0903	451.3604	.0001	.7655	.0000	.0112	-.0001	-.7561	-.000001	-.0457
ACTGY	108.4152	261.0222	-.0001	-.4965	-.00001	-.2918	-.00002	-.1838	.0001	1.7213
HSTYPE	2.7329	.6145	-.0528	-.8858	-.0133	-.5123	.0514	.8693	.0148	.5301
SEX (m=1, f=2)	1.4910	.5008	.1090	1.8186	-.0051	-.1939	-.1336*	-2.2492	.0296	1.0549
Y63	.1264	.3328	-.3176**	-3.0435	.0635	1.3944	.2732**	2.6433	.0191	-.3909
Y64	.1444	.3521	-.2069*	-2.1027	.0750	1.7484	.1557	1.5981	-.0239	-.5188
Y65	.1444	.3521	-.1889	-1.9457	.0901*	2.1279	.1213	1.2606	-.0225	-.4940
Y66	.1841	.3883	-.0719	-.7840	.0310	.7738	.0632	.6959	-.0227	-.5185
Y67	.2202	.4151	ne		ne		ne		ne	
Y68	.1805	.3853	.0321	.3436	.0047	.1162	-.0882	-.9523	.0514	1.1726
V2	.1552	.3628	-.1539	-1.6973	.1154**	2.9163	.0767	.8532	-.0381	-.8972
V3	.2852	.4523	-.0834	-1.0011	.0084	.2318	.0826	1.0001	-.0076	-.1949
V4	.1697	.3760	.1250	1.3819	-.0632	-1.5772	-.0055	-.0605	-.0564	-1.3112
Family Size	7.3502	1.7867	.0203	1.2004	-.0061	-.8887	-.0198	-1.1861	.0057	.7177
RMMA	.2527	.4364	.0911	1.2565	-.0392	-1.2387	-.0247	-.3445	-.0272	-.8007
Expected Grades	5.1480	1.8096	.0647**	2.9861	-.0041	-.4287	-.0448*	-2.0852	-.0158	-1.5542
RWPA	.2862	.5697	.0201	.3487	-.0343	-1.3499	.0133	.1966	.0028	.1036
			R^2 = .172		R^2 = .124		R^2 = .128		R^2 = .060	

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

ne = not entered in equation

Source: ESGOL and ESCLIS Files

TABLE B-4

COMPARISONS OF MEANS AND STANDARD DEVIATIONS OF VARIABLES USED IN REGRESSIONS OF SCHOOL AND PAID WORK
From Schooling Study by Occupation of Father

Variable Name	Non-Farmers N=43		Subsistence Farmers N=99		Semi-Subsistence Farmers N=61		Commercial Farmer N=95	
	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.	Mean	Stan. Dev.
School only	.5814	.4992	.6364	.4835	.4590	.5025	.4737	.5020
Paid work only	.0698	.2578	.0606	.2398	.0328	.1796	.0316	.1758
School and paid work	.3023	.4647	.2727	.4476	.4426	.5008	.4316	.4979
No school; no paid work	.0465	.2131	.0303	.1723	.0656	.2496	.0632	.2445
PLB1	.2001	.3060	.5956	.3478	.5980	.3128	.4238	.2509
PLB2	.0000	.0000	.0000	.0001	.0000	.0001	.0000	.0001
PERUTIL	2.1628	1.7173	2.3131	1.8386	3.0984	1.5460	2.2947	1.7617
SALALL	453.8605	557.6657	334.0404	494.7766	159.8033	267.1866	330.7579	504.0498
ACTGY	189.4302	418.4296	62.6273	168.8538	81.3459	241.4953	123.8368	229.8465
HSTYPE	2.7442	.6580	2.6869	.5277	2.6230	.5821	2.8526	.6518
SEX (m=1; f=2)	1.4419	.5025	1.5051	.5025	1.4918	.5041	1.4842	.5024
Y63	.0698	.2578	.1111	.3159	.1967	.4008	.0947	.2944
Y64	.2791	.4539	.1313	.3359	.1311	.3404	.1474	.3564
Y65	.0930	.2939	.1717	.3791	.0820	.2766	.1579	.3666
Y66	.1628	.3735	.1818	.3877	.1475	.3576	.2105	.4098
Y67	.2093	.4116	.2121	.4109	.1967	.4008	.2421	.4306
Y68	.1860	.3937	.1919	.3958	.2459	.4342	.1474	.3564
V2	.0930	.2939	.1717	.3791	.1475	.3576	.1579	.3666
V3	.4186	.4992	.1717	.3791	.1148	.3214	.4632	.5013
V4	.1163	.3244	.2828	.4527	.2131	.4219	.0421	.2019
Family Size	5.5581	1.9062	7.3838	1.3455	7.7705	2.0363	7.4632	1.7370
RWMA	.3721	.4891	.1919	.3958	.2623	.4435	.2947	.4583
Educational Asperations	5.4884	1.4699	4.8182	1.6682	5.2623	1.3404	5.2842	1.3889
RWPA	.1163	.9053	.1717	.3791	.2787	.5811	.4632	.5614

Source: ESCOL and ESCLIS Files

TABLE B-5

OLS Coefficients for Stepwise Regressions for Enroll

N=184

Levels of Significance in ( )

Variable	Mean	S.D.	Step 1		Step 2		Step 3		Step 4	
Enroll	.6467	.4793								
Sex	.5217	.5009	.1508**	(.014)	.1497***	(.013)	.1562**	(.009)	.1513**	(.011)
Y69	.4837	.5011	.4478**	(.000)	.4527***	(.000)	.4494***	(.000)	.4460***	(.000)
Y70	.4347	.4971	.3890***	(.001)	.3696***	(.001)	.3738***	(.001)	.3718***	(.001)
V2	.2880	.4541	-.2893***	(.001)	-.2780**	(.002)	-.3047***	(.001)	-.3665***	(.000)
V3	.2337	.4243	.2038*	(.036)	.1811	(.059)	.1764	(.062)	.1112	(.248)
V4	.2120	.4098	-.0163	(.857)	.0174	(.847)	-.0012	(.989)	-.0334	(.706)
VGRAS	347.1641	623.4997	-.00002	(.966)	-.00002	(.977)	-.0001	(.817)	-.00001	(.880)
ORDR6	.5973	.1576	-.5311*	(.026)	-.5537*	(.019)	-.5260*	(.024)	-.4907*	(.032)
FMSZ6	6.9402	1.7561	.0155	(.454)	.0230	(.268)	.0212	(.299)	.0282	(.168)
SALALL	196.6141	299.8552	.0002	(.147)	.0002	(.103)	.0002	(.104)	-.0002	(.106)
ACTGY	67.1647	174.7513	.00001	(.958)	.00002	(.882)	-.00001	(.974)	-.0001	(.755)
PLB1	.6179	.3380	.0442	(.668)	.0717	(.487)	.0566	(.577)	.0356	(.724)
PERUTIL	2.4022	1.7806	-.0324	(.069)	-.0342	(.052)*	-.0344*	(.047)	-.0317	(.064)
CONSUMP	.0343	.9991	.1663***	(.000)	.1510***	(.000)	.1298***	(.001)	.0963*	(.018)
RWMA	.2391	.4277			.0567	(.448)	.0399	(.588)	.0388	(.594)
RWPA	.4022	.4917			.1438*	(.029)	.1450*	(.025)	.1325*	(.038)
RECOG4	33.7609	4.0065					.0195**	(.011)	.0154*	(.048)
HTC16	104.8109	4.3869							.0150*	(.043)
CHHLTH6	.6685	.3234							.1728	(.077)
			R^2=.359		R^2=.384		R^2=.407		R^2=.431	

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

results provide strong evidence that, controlling for economic factors and other characteristics of the family, the child's height, verbal development at age seven, and health appear to affect school participation significantly.

Table B-6 shows the results of regressions done by village. Since village 6 has consistently shown low school participation and high involvement of children in the work force, our breakdown was done by village 6 compared to villages 3, 8, and 14 combined. Different patterns emerge as explainers of school enrollment. In village 6, we see that affluence has a significant positive effect on school attendance while the proportion of older siblings and amount of economic activity are negatively and significantly related to enrollment. In villages 3, 8, and 14, on the other hand, boys, older children, more verbal children, and taller children are more likely to be in school.

Table B-7 gives means and standard deviations for variables used in the regressions of school enrollment divided by father's occupational groups. Here we see differences in the proportion of children participating in school by family occupation. Non-farming families in the longitudinal sample had to be excluded because of low sample size, but, for others, in Table B-8, given the results of regressions, we see that patterns differ by level of economic activity and land holdings. Again, we see that village 6 is a significant negative influence on school enrollment and village 14 a positive influence. Among semi-subsistence farmers, the child with fewer older siblings is more likely to go to school, the taller, more verbal child is also more likely to go to school. More affluent families also tend to have increased positive effect on school enrollment.

A final table, 3-9, shows the results of regression school achievement measures on the same set of variables as before. School achievement was

TABLE B-6

OLS COEFFICIENTS FOR REGRESSION OF ENROLL WITH VILLAGE 6 AND VILLAGES 3, 8, 14

Variable	Village 6 (N=53)				Villages 3, 8, 14 (N=131)			
	Mean	S.D.	Coeff.	Level of Signif.	Mean	S.D.	Coeff.	Level of Signif.
ENROLL	.3396	.4781	---	---	.7710	.4218	----	---
SEX	.5660	.5004	.1107	(.412)	.5038	.5019	.1835**	(.005)
Y69	.4906	.5047	.4681	(.068)	.4809	.5016	.4648***	(.000)
Y70	.4151	.4975	.2515	(.330)	.4427	.4986	.4292**	(.001)
RWMA	.2075	.4094	.2248	(.195)	.2519	.4358	.0435	(.610)
RWPA	.3396	.4781	.2164	(.151)	.4275	.4966	.1590*	(.035)
VGRA$	541.3140	990.9916	-.00001	(.933)	268.6149	364.4617	.0001	(.585)
ORDR6	.6136	.1627	-.6454	(.161)	.5907	.1556	-.3280	(.232)
FMSZ6	7.0377	1.7316	.0209	(.650)	6.9008	1.7709	.0351	(.136)
SALALL	246.7358	326.7757	-.00004	(.848)	176.3359	287.0863	.0001	(.264)
ACTGY	52.4981	176.3489	-.0007	(.082)	73.0985	174.4287	.0002	(.238)
PLB1	.6409	.3246	-.2990	(.264)	.6086	.3441	.1523	(.180)
PERUTIL	3.0566	1.4730	.0007	(.990)	2.1374	1.8304	-.0315	(.086)
HTC16	106.3189	4.0927	-.0078	(.634)	104.2008	4.3691	.0255**	(.002)
CHHLTH6	.6052	.3567	.2025	(.321)	.6941	.3066	.0435	(.706)
RECOG4	34.2830	3.5701	.0004	(.985)	33.5496	4.1643	.0167*	(.049)
CONSUMP	-.2025	1.0398	.1730*	(.041)	.1301	.9698	-.0062	(.880)

$R^2 = .493$ $R^2 = .360$

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

TABLE B-7

COMPARISONS OF MEANS AND STANDARD DEVIATIONS OF VARIABLES USED IN REGRESSIONS OF CHILDREN'S SCHOOL ENROLLMENT ON SIZE, HEALTH, FAMILY ECONOMIC VARIABLES
Children Born 1969-1971

Variable	Non-farmers		Subsistence Farmer		Semi-Subsistence		Commercial	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
	N=12		N=65		N=47		N=65	
ENROLL	.8333	.3892	.5385	.5024	.6596	.4790	.7231	.4510
SEX	.3333	.4924	.5385	.5024	.5745	.4998	.5231	.5034
Y69	.5000	.5224	.4308	.4990	.5745	.4998	.4615	.5224
Y70	.2500	.4523	.4923	.5038	.3404	.4790	.4615	.5024
V2	.1667	.3892	.2462	.4341	.3191	.4712	.3385	.4769
V3	.2500	.4523	.1846	.3910	.0851	.2821	.3846	.4903
V4	.1667	.3892	.3538	.4819	.2128	.4137	.0769	.2685
RWMA	.6667	.4924	.1692	.3779	.2766	.4522	.2462	.4341
RWPA	.5833	.5149	.2308	.4246	.4468	.5025	.5231	.5034
VGRA$	208.9806	229.5051	91.4631	75.3192	196.5499	113.1571	746.2240	916.8300
ORDR6	.7017	.1563	.5800	.1476	.5808	.1503	.6120	.1706
FMSZ6	6.5833	1.3790	6.8308	1.6160	6.8723	1.9849	7.1231	1.7545
SALALL	603.8333	507.0945	196.0769	299.1494	142.8085	176.5176	213.3692	348.3545
ACTGY	55.2000	172.0033	53.7846	157.4257	62.6723	183.2678	80.8354	182.3494
PLB1	.6063	.4482	.9608	.1519	1.0000	0	.5894	.2949
PERUTIL	1.7500	1.7645	2.1077	1.8466	2.9149	1.5719	2.4154	1.7931
HTC16	106.4417	3.4516	104.1092	4.8542	104.9362	4.4806	105.2877	3.8158
CHHLTH6	.5903	.3292	.6652	.3321	.6622	.3095	.6792	.3334
NAMING4	23.7500	3.8168	19.5538	5.0468	22.7447	4.4841	21.0308	4.0349
RECOG4	35.7500	3.0488	32.6154	4.2489	34.7872	3.9379	34.0308	3.6656
CONSUMP	.9338	.9088	-.2221	.9392	-.0150	.9772	.2394	.9913

TABLE B-8

OLS COEFFICIENTS FOR REGRESSION OF CHILDREN'S SCHOOL ENROLLMENT ON FAMILY ECONOMIC AND BACKGROUND VARIABLE AND SIZE AND HEALTH BY FAMILY OCCUPATION
Cohorts Born 1969-1971

Variable	Subsistence Farmers		Semi-Subsistence Farmers		Commercial Farmers	
	Coeff.	Level of Signif.	Coeff.	Level of Signif.	Coeff.	Level of Signif.
ENROLL	---	---	---	---	---	---
SEX(1)	.1861	(.180)	.3482**	(.010)	.1879	(.129)
Y69	.4447	(.063)	.1541	(.455)	.7118***	(.001)
Y70	.3659	(.120)	.1273	(.582)	.6152**	(.005)
V2	-.4043	(.077)	-.2714	(.118)	-.3719*	(.033)
V3	.2271	(.313)	1.1003**	(.003)	-.1084	(.544)
V4	.1233	(.487)	-.1977	(.237)	.0672	(.794)
RWMA	-.1189	(.503)	.1380	(.318)	.0057	(.964)
RWPA	.1328	(.416)	.1499	(.242)	.1498	(.196)
VGRA$	.0001	(.559)	.0001	(.831)	-.00004	(.417)
ORDR6	-.1215	(.821)	-1.3199**	(.009)	-.5306	(.279)
FMSZ6	.0347	(.463)	.0537	(.151)	.0441	(.299)
SALALL	.0003	(.198)	-.0001	(.849)	.0001	(.475)
ACTGY	.0001	(.881)	-.0003	(.429)	-.0004	(.191)
PLB1	-.5468	(.200)	not entered		-.2426	(.291)
PERUTIL	-.0560	(.099)	-.0045	(.922)	.0102	(.766)
HTC16	.0813	(.561)	.0287*	(.050)	.0065	(.717)
CHHLTH6	.2031	(.306)	-.1774	(.373)	.2100	(.236)
RECOG4	.0109	(.501)	.0401	(.026)	.0243	(.149)
CONSUMP	.0943	(.355)	.2391**	(.013)	.0323	(.638)
	R^2 = .497		R^2 = .741		R^2 = .482	

(1) Male = 1
Female = 0

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

TABLE B-9

REGRESSION RESULTS FOR ACHIEVEMENT ASSUMING ENROLL=1
N=119

Variable	PROMOTION RATE				AV. MATH SCORE		AV. LANG. SCORE	
	Mean	S.D.	Coeff.	T-Stat.	Coeff.	T-stat.	Coeff.	T-stat.
PROMOTION RATE	.5421	.4249	---	---	---	---	---	---
AVERAGE MATH	60.1244	17.6321	---	---	---	---	---	---
AVERAGE LANG.	60.7008	18.5801	---	---	---	---	---	---
SEX	.5630	.4981	-.1251	-1.6182	-4.0895	-1.2956	-4.8213	-1.4949
Y69	.5042	.5021	.0584	.2670	2.6058	.2925	-1.0851	-.1192
Y70	.4622	.5007	.0692	.3194	.2157	.0244	-1.3326	-.1474
V2	.1513	.3598	-.3336*	-2.5595	-12.3837*	-2.3267	-18.0132***	-3.3122
V3	.2857	.4537	-.1693	-1.3893	-5.0128	-1.0072	-5.7285	-1.1265
V4	.2353	.4260	-.2660*	-2.4660	-14.4254***	-3.2748	-8.9604*	-1.9915
RWMA	.2857	.4537	-.0603	-.6668	4.9890	1.3513	4.0111	1.0633
RWPA	.4790	.5017	-.0378	-.4507	-2.4349	-.7101	-2.6753	-.7636
VGRA$	330.31[illegible]	439.9829	.0002	1.8330	.0075	1.7974	.0091*	2.1344
ORDR6	.5838	.1630	.0539	.1666	4.4937	.3399	2.5477	.1886
FMSZ6	6.9076	1.8226	-.0461	-1.5540	-1.6038	-1.3233	-2.0784	-1.6783
SALALL	211.7563	336.6810	-.0001	-.7978	-.0020	-.3734	-.0028	-.5072
ACTGY	77.4840	181.3413	.0000	.1538	.0076	.8309	.0068	.7266
PLB1	.6063	.3499	-.0973	-.7660	3.9463	.7610	1.5253	.2879
PERUTIL	2.1597	1.8411	-.0154	-.7099	-.1231	.1390	-.0642	-.0710
HTC16	105.3008	3.9990	.0112	1.0704	.5745	1.3455	.2084	.4776
OLDSIB	.5966	.8667	-.0030	-.0466	-.6231	-.2337	1.1628	.4268
CHHCTH6	.7198	.2972	.0138	.1010	-4.1278	-.7375	-5.4443	-.9520
RECOG4	34.2941	3.8628	.0268**	2.6413	1.1018**	2.6546	1.4947***	3.5246
CONSUMP	.2412	.9452	.0588	1.0148	3.1250	1.3217	3.8264	1.5839

R^2 = .280 R^2 = .303 R^2 = .344

measured in terms of school promotion rates and scores in language and mathematics which were assigned by teachers at the completion of the school year. Few significant explainers appear here. The factors that explained participation in school did not appear to determine school performance once the child attended. Only verbal development appears to be of positive significance in determining achievement. These results are consistent with those obtained by Alan Wilson in Part II-A of this report.

Summary of Results

We see that school enrollment appears to be affected strongly by the economic conditions of the family. When we control for economic factors by separating the subjects by family occupation or by village, thereby controlling for economic differences, we find that children's health, size, and verbal development influence significantly and positively their school participation.

We also find that school participation differs by village which apparently reflects work opportunities for children and attitudes about the value of schooling by parents. In the village where work is readily available, school participation is far lower than in the other villages.

We find that there are differences in school participation by sex, schooling for girls is less frequent than for boys, and their work in the household apparently more valued. The perceived value of literacy for girls is apparently lower than for boys.

We see that size and health of children, when all other economic and family background factors are kept constant, are significant determinants of children's school attendance and performance. Thus, prior nutrition appears to make a difference in height, and height along with present health

and verbal development makes a difference in school attendance and achievement. The sign of effects of nutritional status on school participation appears to be positive, even with the competing needs for the children's work.

SECTION II-C

FARMER'S EDUCATION AND AGRICULTURAL EFFICIENCY[1]

Maria E. Freire

1. The objective of the study whose main findings are reported in this section was to test the hypothesis, using data from the four rural villages, that education improves agricultural productivity and farm efficiency by means of enhancing farmer's managerial skills.[2]

The analysis began with the observation of significant differences in production indices between literate and illiterate farmers. In terms of land units (corrected for quality differences), literate farmers obtained 17 percent more yield, used 35 percent more cash inputs, grew 44 percent more cash crops (tomato and chili), and, consequently, less food crops (corn, beans, and maicillo). Moreover, literate farmers used, for the same unit of land, 18 percent less labor (in man days) than their illiterate neighbors. Educated farmers appeared to substitute chemical inputs for labor, and when an efficient measure for total productivity, yield/total costs, was applied, literate farmers were 56 percent ahead of the illiterate ones.

2. Testing for the influence of education (formal education) on farm efficiency was carried out with three types of economic efficiency:

(1) Technical efficiency -- the ability to obtain more output out of the same amount of inputs.

(2) Allocative efficiency -- the ability to maximize profits by means of adopting the "best" combination of inputs and outputs.

(3) Market efficiency -- the ability to obtain the best prices for both inputs and outputs.

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[1]This is a selective summary of results presented elsewhere at greater length. See: M. Freire, "Assessing the Role of Education in Rural Guatemala: The Case of Farm Efficiency" (Unpublished dissertation, Department of Economics, University of California, Berkeley, 1979).

[2]For a comprehensive overview of empirical evidence linking education to farm efficiency, see: M. Lockheed, D. Jamison, and L. Lau, "Farmer Education and Farm Efficiency -- A Survey," in Economic Development and Cultural Change, forthcoming.

Data came from the Rand-Rockefeller questionnaire, 1975. Five hundred cases for which there existed elements for all relevant variables were included in the testing procedure. These variables were as follows:

Farmer's education -- measured by the number of grades passed and by literacy. Literacy (as a 0, 1 variable) was used for most cases.[3]

Farm production -- measured in several ways: value of agricultural output (evaluated both at average and sales price), value of total farm production (which includes livestock), and five major crops harvested production (corn, beans, tomato, chili, and maicillo).

Farm factors of production -- included area of land planted (in standardized quality units), labor measured in man-days, cost of purchased inputs other than hired labor (seeds, pesticides, fertilizers), and capital (both animal and farming tools).

Other farmer specific variables -- included farmer's age -- as a proxy for experience -- family average schooling grades, family average literacy status, and farmer's degree of commercialization. In this case, farmers were grouped as subsistence farmers when all farm production was consumed in the household, semi-subsistence farmers when food crops surplus was sold, and commercial farmers when cash crops were grown for sale. Profits, to test for allocative efficiency, were computed for farmers selling output and for each of the five crops described above.

3. Testing for technical efficiency (agricultural productivity) was carried out by estimating a log-linear production function (Cobb-Douglas). The variables mentioned under farm production were used as dependent variables and regressed against farm production factors, farmer's specific variables, and index variables to control for structural differences across villages.

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[3]Preliminary analysis had shown that there existed a threshold around two grades of school, the average number of grades completed by literate farmers. Literate farmers were those who reported to read and write well. They represent 37 percent of the sample of 500 cases.

Using different specifications and different measures for production did not affect the significance of education in the estimated production function (see Table 1). The results indicated that to one year of schooling corresponded an increase of 5.7 percent in agricultural production and 6.7 percent in total production. When value added was used as a dependent variable, the result was as high as 15 percent, which reflects the exclusion of chemical inputs from the independent variables and shows the high degree of correlation between literacy and use of chemical inputs.

Analysis by individual crops yielded similar results. 11.3 percent of additional beans and chili production was associated with an additional schooling year. For tomato, corn, and maicillo, one year of schooling was related to increase in production equal to 6.8 percent, 2.6 percent, and 6.7 percent, respectively. The educational coefficients estimated for these crops, however, were not statiscally significant. Once farmers were aggregated into subsistence, semi-subsistence, and commercial groups, education appeared to affect the two first groups but not the last one. Semi-subsistence farmers appeared to be those who benefitted most from an additional year of education (9 percent). For this group, literate farmers seemed to obtain 20 percent more production than those who were illiterate. For subsistence farmers, this value was 13 percent. Commercial farmers seemed unaffected by literacy; the market mechanisms were likely to level off educational differences.

Allocative efficiency was tested in two ways. The first used the estimated production function coefficients to compute the value of the marginal productivities of the production factors at their mean value. Differences between those values and factor market prices were interpreted as deviations from allocative efficiency. The second test was carried out with a simultaneous equation model with two equations.[4] The first equation tested for the influence

[4]The method corresponds to the application of a Restricted Normalized Profit Function to each individual crop. As references on the subject, see: Lau and Yotopoulos, "A Test for Relative Efficiency and Application to Indian Agriculture," in American Economic Review and D. Jamison and L. J. Lau, Farmer Education and Farm Efficiency (Baltimore: John Hopkins Univ. Press, 1971), forthcoming.

TABLE 1

FORMAL EDUCATION AND AGRICULTURE PRODUCTIVITY
Education Variable: Farmer's Literacy

FARM GROUP	Dependent Variable	Coefficient Education's Influence on Farm Output	t statistics	R^2	Increase % in Production Related With One Year of Schooling*
All, N=510	Agricult. Production	.131	2.12	.689	5.69%
	Farm Production	.153	2.55	.689	6.72%
	Value Added	.309	3.77	.489	14.7%
Subsistence Farms N=196	Farm Production	.127	1.34	.541	5.5%
Semi-subsist. N=212	Farm Production	.200	2.53	.616	9.0%
Commercial Farms, N=102	Farm Production	.016	0.135	.677	0.6%
Corn Producers N=500	Value of Harvest Av. Prices	.062	1.21	.617	2.6%
Bean Produc. N=273	Value Bean Harv. Av. Prices	.245	2.67	.623	11.3%
Tomato Producers N=91	Value of Tomato Production	.152	.80	.539	6.7%
Chili Producers N=42	Value Chili Production	.246	2.70	.669	11.3%
Maicillo Producers N=114	Value of Maicillo Produced	.150	1.00	.380	6.6%

of education on maximizing profits (normalized by crop selling price) regardless of differences in technical efficiency. The second equation tested for the influence of education in maximizing profits using the property of Cobb-Douglas functions that whenever profit maximization holds, the share of variable inputs in total costs is to be constant. Whenever the influence of education was not shown to be signficant, the parameters of this second equation were forced to be the same as the variable input coefficient in the first equation, and technical efficiency alone tested as a source of differences in profits. This second test could be used only for individual crops and for farmers selling them.

4.1. Using the production function estimates (see Table 1), marginal productivities for labor, land, and cash inputs were computed for each farm group. The results are as follows in Table 2.

TABLE 2

MARGINAL PRODUCTIVITY VALUES FOR THREE FACTORS OF PRODUCTION

	Subsistence		Semi-Subsistence		Commercial	
	Illit.	Literate	Illit.	Literate	Illit.	Literate
Labor	.18	.27	.083	.154	1.07	1.29
Land	.86	.86	1.60	2.1	.11	.14
Inputs	2.4	2.0	4.4	3.9	2.9	2.5

The differences in labor and land productivities between commercial and the other farm groups are quite striking. Since the ratio of labor to land is quite similar (4 man-days per unit of land quality), these values reflect the constraint of labor on commercial farmers and land on semi-subsistence and subsistence farmers. As an illustrative example, one computed the optimal labor input (for corresponding land size) needed to yield the actual output, optimal labor being that at which marginal productivity of

labor equals wage rate (.88 quetzales). The resulting values for the underemployed labor were:

	Subsistence Farmers	Semi-Subsistence
Illiterate	80.9%	92.2%
Literate	72.3%	89.3%

In order to remove such underemployment, land would have to increase 8.8 times for illiterate farmers on semi-subsistence farms, and 6.9 times for the literates of the same group. Such a low level of labor productivity can only be explained by the resistance of farmers to enter the local labor market or the use of labor whose opportunity cost is quite low (such as child labor for which there was no detailed information). It thus makes little sense to use the method of comparing wage rates with labor productivity to infer differences among farmer's efficiency, for either farmers are not maximizing total profit or they are using labor with an opportunity cost lower than the wage rate. In the case of commercial farmers, educated farmers appear to be less efficient: they could use more labor inputs and achieve higher levels of yield, with land and fertilizers remaining constant.

The second method to test for allocative efficiency was limited to farmers who sold output and was applied to individual crops. Educated farmers appear to be more efficient in growing and selling beans; illiterate farmers seem to be more efficient with respect to tomato production. For the other crops, no significant differences were obtained.

5. Market efficiency. The capacity to get higher prices for products sold was tested for each of the five crops. Sales prices were regressed against educational variables, farmer's age, and village indicators. The results were similar to those obtained before. Bean production and sales

show the advantage to literate farmers. The low proportion of variation explained by the regressions indicated, however, that our model was insufficient to explain the variation in output prices obtained by these farmers.

6. In short, the conclusions of this analysis were as follows:

i) Education seemed to be relevant to explain differences in agricultural productivity. Literate farmers attained higher levels of both land and labor productivity, partly because of the higher use of chemical inputs and partly because a relatively higher proportion of their total output was in cash crops. Even after controlling for those factors, education seemed to be significant in explaining variations in agricultural production among farmers. This was especially important for semi-subsistence farmers.

ii) Analysis of allocative or market efficiency did not lead to definitive results on the influence of education. Both subsistence and semi-subsistence farmers operate at very low levels of labor productivity which may reflect the fact that either they value wage income less than farm production or that they use labor whose opportunity cost is well below the market wage rate. In the first case, our basic assumption that farmers attempt to maximize does not hold, and the results of the analysis are useless as a test for market efficiency. In the second case, since information is not available on the actual work of each family member, we are also unable to reach conclusions on efficiency.

iii) The fact that educated farmers were slightly better off than their illiterate peers in terms of underemployment may indicate that they valued alternative non-farm occupations for their children or other family members or merely that, for the same input combinations, a slight edge in land quality increased the average labor productivity considerably. Only further research on this subject can shed some light on the matter.

SECTION II-D

Schooling and Fertility

by Mari Simonen

Introduction

The present section summarizes analyses of the effects of schooling and literacy on individual fertility in rural and semi-urban Guatemala.[1] The question examined is whether schooling and literacy of adults have a significant effect on fertility, and, if so, how and why they affect fertility in the context of the communities under study. In addition, other factors explaining fertility at the individual level are examined.

Fertility is defined as the number of children ever-born and as the number of desired children. Emphasis is, thus, on the "stock" aspect of fertility, although fertility desires are also analyzed from the point of view of sequential fertility decision-making.

Data used are from a series of cross-sectional household surveys administered in 1975-76 in the four rural communities where INCAP had implemented its nutrition experiment since 1969, and in two semi-urban communities nearby Guatemala City.

Theoretical Framework and Methodology

The analytical work of the fertility study is centered around estimation of a structural equation model of individual fertility determinants (see Diagram 2). The model is derived from sociological, social psychological, economic, anthropological, and family planning theories of fertility (Hill, et al. 1955, Davis 1955, Leibenstein 1957, Hoffman and Hoffman 1973, Nag 1972, Schultz 1976, Deere and deJanvry 1978). In summary, it is

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[1] This is a selective summary of results presented elsewhere at greater length. See: Simonen, M. (1979) Schooling and Fertility in Rural and Semi-Urban Guatemala. Berkeley Project on Education and Nutrition, University of California, Berkeley.

hypothesized in the model that individual female and male schooling affect fertility, together with community level schooling, family planning access, land-ownership, income, female labor force participation, family type, and child mortality, mainly through three intervening variables: (a) family planning knowledge, attitudes, and practice (KAP), (b) male/female communication, and (c) child utility.

The main analytic technique used is structural equation model estimation by means of ordinary least squares regression method (path analysis) (Duncan 1975).[1] The model is estimated for female respondents aged 14+ living in union with a male at the time of data collection. The sample consists of a total of 847 female respondents (578 rural and 269 semi-urban) aged 14+ at the time of the interview in 1975-76. The model is estimated separately by rural and semi-urban stratified samples. The major advantage of structural equation models is that they allow examination of direct and indirect effects of several variables on the main endogenous variables while holding constant the effects of other variables in the model.

Before turning to the results, a brief description of the three intervening variables used is in order. Family planning knowledge, attitudes, and practice (KAP) is measured as a simple additive scale of three items: (a) whether the respondent thinks women should have all children that come, or do something to limit the number; (b) knowledge of a specific way to limit the number of children,[2] and (c) whether one practices a method or not.

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[1] In addition, multiple classification analysis and logit analysis (maximum likelihood estimation of qualitiative choice models) are used (Andrews 1973, Nerlove and Press 1973).

[2] Coded as [0] no knowledge, [1] knowledge of a 'traditional' method (herbs, rhythm, lactation, . . .), and [2] knowledge of a 'modern' method (pill, condom, diaphragm, . . .).

Male/female communication is measured as an additive scale of four items: two are the female respondent's report on whether she has talked and agreed with spouse about the number of children desired, and the other two are comparisons of male and female respondents' answers to a question about how many additional children they want. And last, perceived child utility measures the number of times the respondent mentions children during the interview. The assumption is that respondents who mention children to be useful in several different contexts (questionnaire items) perceive greater "utility" from children than respondents who mention children fewer times.

Results

(1) Prior to the models presented here, analyses were undertaken to assess the effect of grades of schooling completed by female and male on fertility. They showed that the only statistically significant effect of grades of schooling completed by female on children ever-born is its indirect effect -- through perceived child utility -- in the semi-urban area. The effect of male grades of schooling completed on fertility were not found to be statistically significant in either rural or semi-urban areas.

(2) Of the effects of grades of schooling completed on desired parity, that of female schooling in the semi-urban area was found to be statistically significant.

(3) Points 3 through 8 summarize findings in Tables 4 and 5 and illustrated in Diagrams 2A and B. Female literacy has a significant direct (negative) effect on children ever-born in the rural sample, and an indirect (through child utility) (negative) in the semi-urban sample. The effects of male literacy on children ever-born are not statistically significant.

(4) The effects of female and male literacy on desired parity are not significant in either sample.

(5) The effects of land-ownership on children ever-born and desired parity are statistically significant in the rural but not in the semi-urban sample. Land-ownership has a curvilinear direct effect (first positive and after a threshold level, negative) on fertility (actual and desired) in the rural sample. Its indirect effect (through perceived child utility) is negative and significant in the case of children ever-born, rural sample.

(6) Income per capita has a statistically significant negative indirect effect (through child utility) on children ever-born and desired parity in the rural sample.

(7) Community characteristics have significant positive indirect effects (through child utility) on fertility (both actual and desired) in the rural sample. That is, residence in rural community #2 and #3 increases perceived child utility significantly which, in turn, has a positive effect on fertility.

(8) Age effects are strong and significant, as expected, in both samples, using both measures of fertility.

(9) In addition, we have found that type of economic production of family[1] has a statistically significant effect (indirectly through child utility) on fertility in the rural sample (i.e., semi-commercial farmers

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[1] Type of economic production of family is coded in four categories: (1) wage-laborer: no reported agricultural production, (2) subsistence farmer: does not sell produce nor hire labor, (3) semi-commercial farmer: sells produce but does not hire labor, (4) commercial farmer: both sells produce and hires labor.

perceive significantly more child utility than respondents in other categories of economic production).

(10) Estimation of the fertility model separately by groups of economic production shows that the previously observed indirect effect of literacy on fertility (negative effect through perceived child utility) in the semi-urban sample is upheld among wage laborers but not among farmers in that area.

(11) A non-linear maximum likelihood analysis of sequential fertility desires shows that perceived child utility remains consistently the strongest predictor of desire to have/not have another child at a given parity level. Also, family planning KAP becomes statistically significant at 7+ parity level, while it is non-significant at earlier parity levels (see Table 12).

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Diagram 2A

RURAL

Children Ever-Born Model
N=308

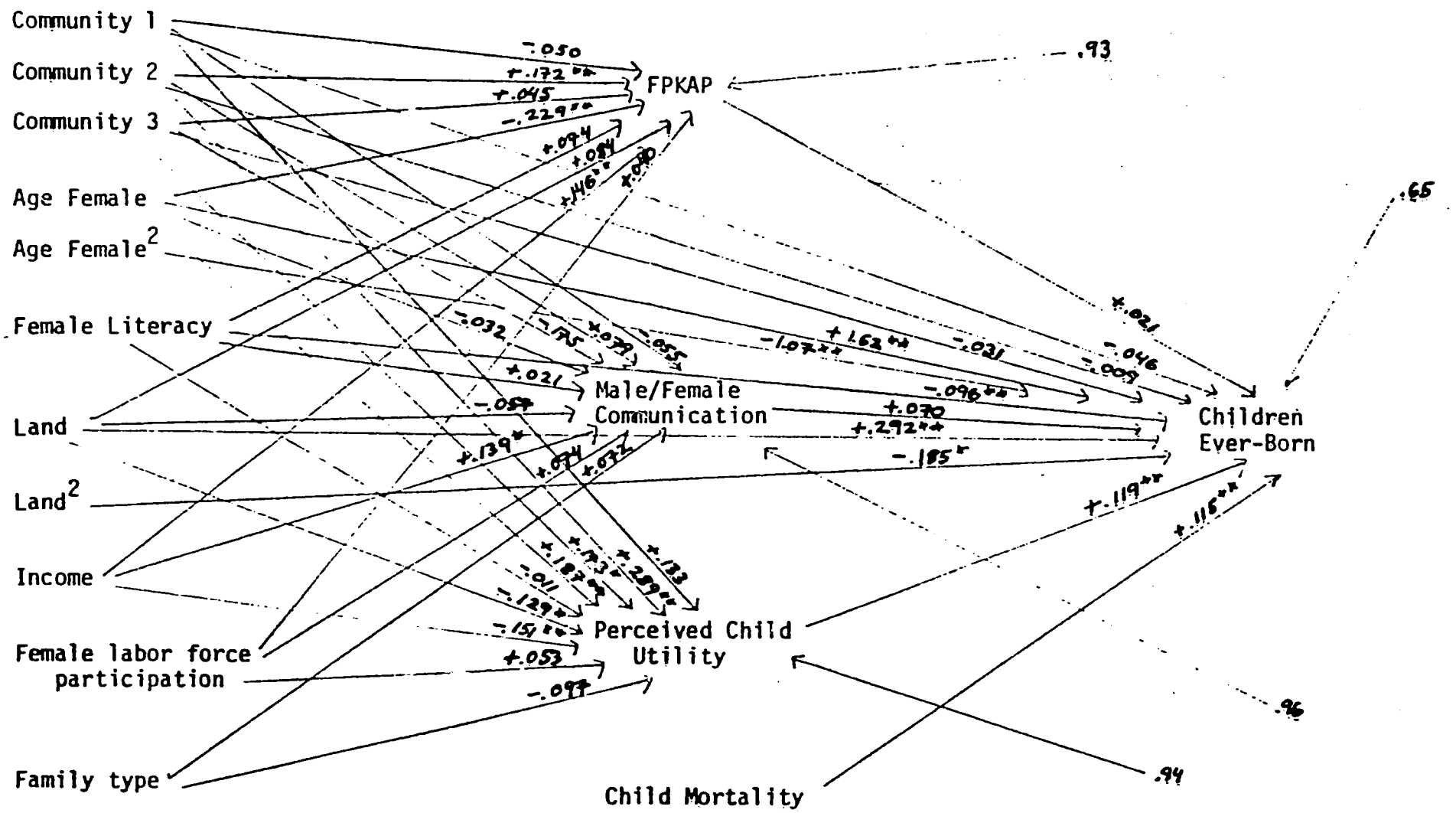

Diagram 2B

SEMI-URBAN

Children Ever-Born Model
N=91

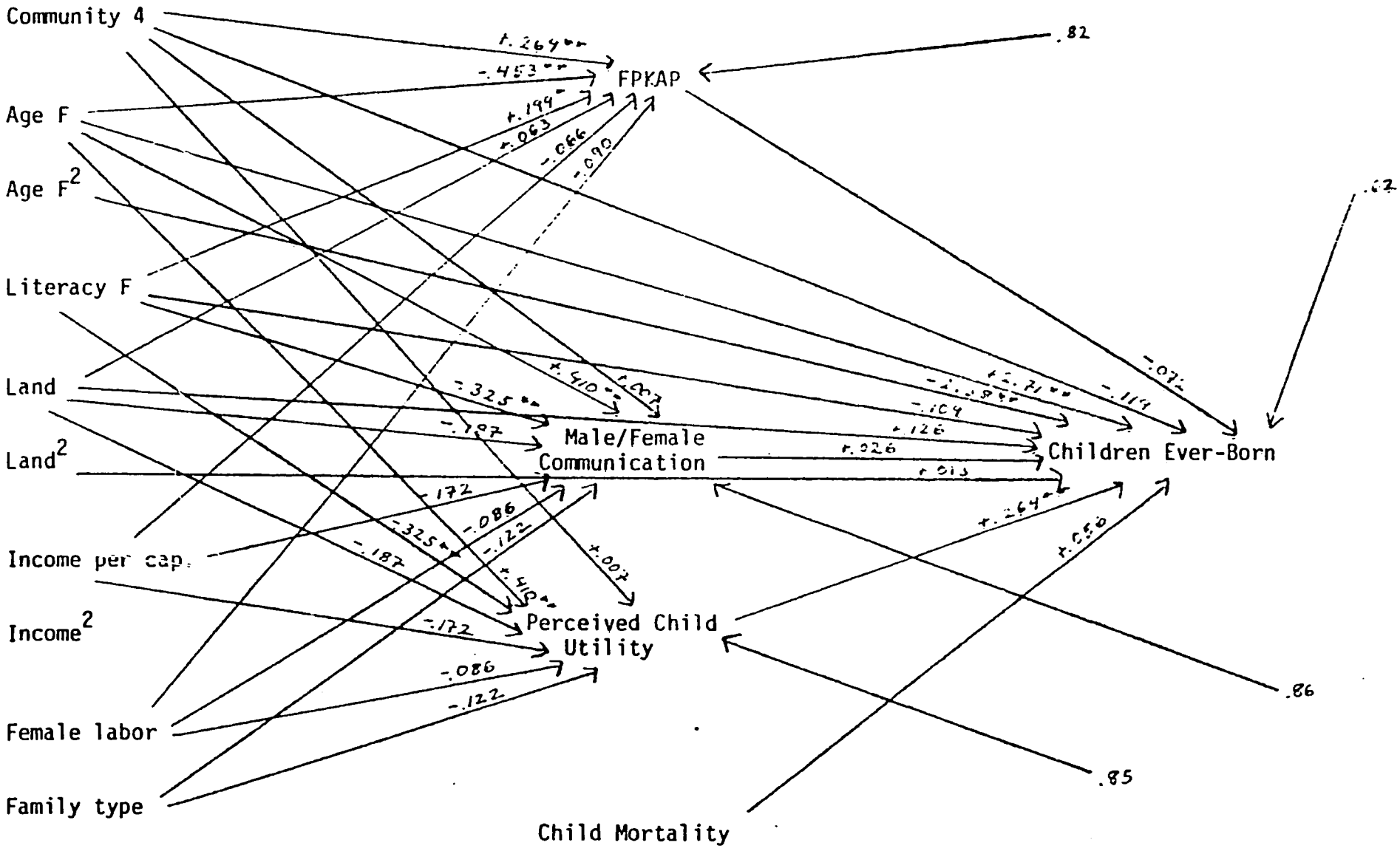

TABLE 4

MEAN AND STANDARD DEVIATION OF VARIABLES IN OLS ESTIMATION OF THE FERTILTIY MODEL:

	Desired Parity Model				Children Ever-Born Model			
	Rural N=214		Semi-Urban N=85		Rural N=308		Semi-Urban N=91	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Age female	34	10	35	13	34	10	35	13
Literacy female	.26	.44	.61	.49	.25	.43	.58	.49
Income per capita	126	155	240	188	115	140	237	183
Land ownership	50	106	2.49	9	50	100	2	9
Female paid labor hours	592	1055	616	1190	535	1025	612	1192
Family type	1.31	.55	1.35	.67	1.29	.53	1.33	.65
Parity	---	---	---	---	5.90	3.35	4.92	2.56
Desired parity	4.98	3.24	3.76	1.68	---	---	---	---
Family planning KAP	1.68	1.40	2.89	1.29	1.43	1.36	2.80	1.33
Male/female communication	1.95	1.17	2.59	1.16	1.88	1.13	2.49	1.20
Perceived child utility	3.27	2.19	3.01	2.09	3.35	2.21	3.13	2.13
Child mortality	1.30	1.75	.89	1.20	1.31	1.71	.89	1.19
Village Dummy 1	.28	.45	---	---	.26	.44		
Village Dummy 2	.32	.47	---	---	.32	.47		
Village Dummy 3	.22	.41	---	---	.19	.39		
Village Dummy 4	---	---	.40	.49	---	---	.38	.49

Table 5

OLS ESTIMATION RESULTS. T-STATISTICS IN PARENTHESES.

Dependent Variable: Desired Parity(1)

	#1				#2				#3				Dependent Variable: Children Ever-Born			
	Rural N=214		Semi-Urban N=85		Rural N=214		Semi-Urban N=85		Rural N=214		Semi-Urban N=85		Rural N=308		Semi-Urban N=91	
	β	Beta	β	Beta	β	Beta	β	Beta	β	Beta	β	Beta	β	Beta	β	Beta
Age female	.002 (.06)	.005	.003 (.16)	.024	.012 (.48)	.035	.005 (.31)	.044	-.007 (.28)	.022	.008 (.47)	.068	.561** (7.30)	1.62	.522** (5.84)	2.71
Age female^2	---	---	---	---	---	---	---	---	---	---	---	---	-.005** (4.70)	-1.07	-.005** (4.91)	-2.38
Literacy F	.032 (.07)	.004	-.564 (1.45)	-.164	-.015 (.03)	-.002	-.618 (1.65)	-.180	.006 (.02)	.000	-.510 (1.32)	-.149	-.740** (2.52)	-.096	-.566 (1.39)	-.109
Land	.010* (2.83)	.323	-.122 (1.21)	-.656	.009* (2.22)	.299	-.119 (1.20)	-.640	.011* (2.20)	.003	-.127 (1.27)	-.686	.009** (3.22)	.262	.039 (.36)	.126
Land^2	-.000* (2.28)	-.298	.003 (1.37)	.718	-.000* (2.15)	-.279	.003 (1.34)	.700	-.000 (2.10)	-.258	.003 (1.39)	.733	-.000* (2.38)	-.185	.000 (.04)	.013
Income per capita	-.003 (.86)	-.138	.003 (1.04)	.359	-.003 (.86)	-.137	.003 (1.06)	.361	-.005 (.90)	-.239	.004 (1.24)	.421	---	---	---	---
Income^2	.000 (.42)	.066	-.000 (1.21)	-.403	-.000 (.35)	.055	-.000 (1.22)	-.404	.000 (.55)	.068	-.000 (1.42)	-.467	---	---	---	---
FPKAP	-.211 (1.26)	-.092	-.097 (.55)	-.075	---	---	---	---	-.410** (2.57)	-.177	-.187 (1.18)	-.144	.052 (.50)	.021	-.139 (.75)	-.072
M/F Communication	-.540** (2.80)	-.195	-.216 (1.19)	-.149	-.626** (3.46)	-.226	-.259 (1.59)	-.179	---	---	---	---	-.209 (1.70)	.070	.057 (.30)	.026
Child utility	.495** (5.08)	.335	.083 (.90)	.104	.482** (4.96)	.326	.078 (.86)	.097	.512** (5.16)	.346	.081 (.88)	.101	.180** (2.94)	.119	.318** (3.28)	.264
Child mortality	-.003 (.28)	-.020	.022* (2.35)	.257	-.005 (.40)	-.028	.023* (2.46)	.265	.002 (.19)	.001	.022* (2.31)	.254	.026* (3.74)	.155	.007 (.76)	.056
Village d1	-1.191 (1.87)	-.166	---	---	-1.13 (1.78)	-.158	---	---	-1.15 (1.61)	-.159	---	---	-.351 (.93)	-.046	---	---
Village d2	-.995 (1.56)	-.143	---	---	-1.06 (1.66)	-.153	---	---	-1.24* (1.96)	-.179	---	---	-.069 (.19)	-.009	---	---
Village d3	-1.959** (2.86)	-.251	---	---	-1.99** (2.90)	-.255	---	---	-1.70** (2.54)	-.215	---	---	-.262 (.63)	-.031	---	---
Village d4	---	---	-.362 (.96)	-.106	---	---	-.418 (1.16)	-.122	---	---	-.348 (.93)	-.102	---	---	-.587 (1.48)	-.119
Constant	5.80** (5.33)	---	4.01** (3.58)	---	5.41** (5.18)	---	3.80** (3.62)	---	4.78** (4.56)	---	3.41** (3.39)	---	-7.50** (5.66)	---	-6.47** (3.55)	---
R^2	.24		.27		.24		.27		.20		.26		.58		.61	
R^2 adj.	.19		.16		.19		.17		.17		.16		.57		.56	
SSE	1697		173		1711		174		1756		176		1433		229	
D.F.	200		73		201		74		201		74		295		80	

(1) Desired parity equation is estimated in three ways:
- #1 - equation includes both family planning KAP and male/female communication variables.
- #2 - equation excludes family planning KAP variable.
- #3 - equation excludes male/female communication variable.

Table 5 (cont'd.)

Dependent Variable = Perceived Child Utility

Variables	Desired Parity				Children Ever-Born			
	Rural N=214		S-U N=85		Rural N=308		S-U N=91	
		Beta		Beta		Beta		Beta
Age female	.042**	.186	.062**	.406	.043**	.187	.065**	.410
	(2.67)		(3.40)		(3.26)		(3.74)	
Literacy female	-.027	-.005	-1.17*	-.274	-.056	-.011	-1.40**	-.325
	(.08)		(2.46)		(.20)		(3.16)	
Per capita income	-.002**	-.171	-.002	-.185	-.003**	-.151	-.002	-.172
	(2.46)		(1.66)		(2.65)		(1.66)	
Land-owned	-.003	-.132	-.041	-.179	-.003*	-.129	-.045	-.187
	(1.92)		(1.45)		(2.29)		(1.65)	
F labor force participation	.000	.107	-.000	.081	.000	.053	-.000	-.086
	(1.48)		(.75)		(.88)		(.86)	
Family type	-.306	-.076	-.335	.107	-.405	-.097	-.401	-.122
	(1.12)		(.99)		(1.77)		(1.23)	
Village D1	.213	.044			.666	.133		
	(.47)				(1.91)			
Village D2	1.29**	.276			1.36**	.289		
	(2.93)				(4.08)			
Village D3	.801	.151			.978*	.173		
	(1.60)				(2.41)			
Village D4			.063	.015			.029	.007
			(.14)				(.07)	
Constant	1.92**	---	2.65**	---	2.01**	---	2.84**	---
	(2.35)		(2.98)		(3.28)		(3.32)	
R^2	.13		.23		.12		.28	
R^2 adj.	.09		.16		.09		.22	
SSE	896		283		1316		294	
D.F.	204		77		298		93	

next page

TABLE 5 (cont'd.)

DEPENDENT VARIABLE: MALE/FEMALE COMBINATION

	Desired Parity				Children Ever-Born			
	Rural		S-U		Rural		S-U	
Age female	-.006	-.052	-.044**	-.515	-.004	-.032	-.045**	-.501
	(.74)		(4.23)		(.55)		(4.33)	
Literacy female	.104	.039	.105	.045	.055	.021	.272	.113
	(.57)		(.40)		(.37)		(1.06)	
Per capita income	.001*	.157	-.004	-.592	.002*	.139	-.004*	-.638
	(2.21)		(1.80)		(2.38)		(2.04)	
Income^2			.000	.566			.000*	.605
			(1.76)				(1.98)	
Land owned	-.001	-.066	.016	.128	-.001	-.057	.019	.139
	(.94)		(1.03)		(.98)		(1.17)	
F labor force participation	.000	.056	.000	.196	.000	.074	.001	.192
	(.90)		(1.84)		(1.19)		(1.87)	
Family type	.169	.079	.176	.101	.153	.072	.235	.128
	(1.14)		(.95)		(1.27)		(1.25)	
Village D1	-.118	-.045	---	---	-.140	-.055	---	---
	(.48)				(.78)			
Village D2	.197	.079	---	---	.190	.079	---	---
	(.81)				(1.08)			
Village D3	-.406	-.144	---	---	-.503*	-.175	---	---
	(1.49)				(2.37)			
Village D4	---	---	.191	.082	---	---	.234	.096
			(.79)				(.96)	
Village D5	---	---	---	---	---	---	---	---
Constant	1.81**	---	4.12**	---	1.72**	---	3.97**	---
	(4.06)		(6.99)		(5.39)		(6.65)	
R^2	.08		.26		.08		.26	
R^2 adj.	.04		.18		.05		.18	
SSE	268		84		360		96	
D.F.	204		76		298		82	

Table continued on next page

Table 5 (cont'd.)

DEPENDENT VARIABLE: FAMILY PLANNING KAP[1]

	Desired Parity		Children Ever-Born	
	Rural	S-U	Rural	S-U
Age female	-.040** -.277 (4.16)	-.042** -.443 (3.95)	-.032** -.229 (4.04)	-.045** -.453 (4.31)
Literacy female	.287 .089 (1.38)	.385 .146 (1.40)	.233 .074 (1.36)	.538* .199 (2.02)
Per capita income	-.001* .139 (2.07)	-.000 -.050 (.49)	.001** .146 (2.58)	-.000 -.066 (.67)
Land owned	.001 .043 (.65)	.004 .032 (.27)	.001 .083 (1.45)	.001 .063 (.59)
Female labor force participation	.000 .082 (1.17)	-.000 -.090 (.90)	.000 .040 (.68)	-.000 -.090 (.93)
Access	.369 .123 (1.39)		(a)	
Village D1	-.409 -.131 (1.49)		-.156 -.050 (.73)	
Village D2	a		.503** .172 (2.45)	
Village D3	-.122 -.036 (.39)		.157 .045 (.63)	
Village D4		.712** .272 (2.78)		.737** .269 (2.89)
Village D5				
Constant	2.73** --- (6.40)	3.98** --- (9.36)	2.06** --- (6.45)	3.96** --- (9.29)
R^2	.17	.31	.13	.33
R^2 adj.	.14	.25	.10	.28
SSE	348	97	498	108
D.F.	205	78	299	84

a = not forced into equation due to insufficient tolerance.

(1) KAP=knowledge, attitudes and practice

Table 12

CONDITIONAL LOGIT MODEL OF FERTILITY CHOICE.
DEPENDENT VARIABLE EQUALS THE LOG ODD OF CHOICE TO HAVE AT LEAST ANOTHER CHILD. BINARY LOGIT MAXIMUM LIKELIHOOD ESTIMATES, T-STATISTICS IN PARENTHESES. RURAL SAMPLE.

Variables	PARITY		
	3, 4	5, 6	7+
Literacy female	.078	3.12	-.312
	(.13)	(1.42)	(.31)
Perceived child utility	.267*	.765	.741**
	(1.79)	(1.49)	(2.53)
Land-ownership	.002	.036	-.000
	(.45)	(.97)	(.08)
Family planning KAP	.239	1.04	-.877*
	(1.12)	(1.28)	(1.71)
Child mortality	.032	-1.34	.586*
	(.17)	(.81)	(1.81)
Age female	-.031	-.309	-.169
	(.67)	(1.25)	(1.18)
Income per cap.	.001	-.024	.001
	(.61)	(1.17)	(.20)
Village D1	-.201	.743	-2.21
	(.26)	(.27)	(1.32)
Village D2	-.592	.637	-1.91
	(.75)	(.18)	(1.43)
Village D3	-.124	2.42	-3.05
	(.12)	(.65)	(1.51)
Constant	-.017	4.23	3.40
	(.01)	(.54)	(.62)
Percent correctly classified	56	94	81
Likelihood ratio	9	22	46
D.F.	60	21	54
N	71	32	65
$\bar{y}$	.592	.375	.185

PART III

SYNTHESIS OF FINDINGS AND POLICY IMPLICATIONS
by Judith B. Balderston

Introduction

In this section, we summarize findings of the Berkeley Project on Education and Nutrition, identifying linkages between parts of the study and indicating those results which may be most important for policy purposes. Because of the wide range of data collected by INCAP and Rand on the families and individual children in the four villages, we have been able to go beyond the original questions of nutritional effects on school performance to investigate relationships connecting nutrition, schooling, work, family size, and agricultural production. Analytical results so obtained make possible the integration of findings, providing information necessary in the formulation of consistent nutritional, educational, population, or rural development policies.

In Part II of this report, we presented four related but separate studies which utilized information of the INCAP and Rand data bases collected in the four villages. The most important results of these four studies will be summarized in Section III-A. In themselves, each set of statistically significant findings is, we believe, important and robust, for both research and planning purposes.

In addition to the separate findings of each of the four studies, (the longitudinal models on child nutrition and growth, and the three cross-sectional models on schooling and work, literacy and agricultural efficiency, and literacy and fertility), we present the results of the four studies as an integrated whole. Not only are the four studies related because they are based on the same four villages, but the variables themselves measure conditions that are interrelated in the lives of the village inhabitants.

We must caution that, although we shall integrate the findings of the four studies, we could not combine variables from the four parts of the analysis into one complete and comprehensive model. Limitations imposed by available computer space and time would have precluded computation. Besides, limitations imposed by missing data would have made it impossible to construct one inter-generational model that would include a full set of economic, biological, psychological, and educational variables. We relied instead on carrying out separate studies based on sets of data that were similar in important characteristics. Following these separate analyses, we were then able to relate each set of results to the other sets.

III-A. Summary of Findings

From the series of estimations using longitudinal models carried out by Alan Wilson and presented in Section II-A, we have seen that:

1. Villages differ in farm activity and in nutritional status. Pre-intervention diet is shown to be better in the two Atole villages than in the Fresco villages. Mothers and fathers in the Atole villages have had better dietary intake before intervention, and this is confirmed by their larger head circumferences. Higher infant mortality existed in the Atole villages prior to the project.

2. The total calorie intake in home diets of children, after intervention, in the Fresco villages is consistently larger than in the Atole villages and contains almost the same proportion of protein. Because of supplementation, the aggregate proportion of protein in children's diet is substantially higher in the Atole villages.

3. At birth, the children in the four villages are at the 25th percentile for weight and the 10th percentile for height compared to American children. By 36 months, the village children are considerably below the 5th percentile of American children.

From three to seven years, children's growth follows below the 5th percentile level the slope of American children's growth patterns. The differences in growth between atole and fresco villages is especially marked for girls; girls are probably less well nourished at home than boys, but the sex disparity in home diets is less in the Atole villages.

4. There is a significant effect of supplementation, not home diet, on growth in weight and height. The most significant effect of supplementation was to increase the proportion of diet from protein sources. Protein

supplementation shows a strong positive effect on growth, especially up to 48 months. Diarrhea affects annual increments of growth negatively, as do other forms of illness, especially in the Fresco villages.

5. Combining calories and protein from both home diet and supplementation sources shows that there is a significant effect of protein on growth which appears between ages 12 and 24 months. It subsequently declines and appears again with smaller effects between 48 and 60 months. Here again is a consistent negative effect of diarrhea upon growth.

6. A highly significant positive effect of height on verbal development shows up at all ages. This is the most important result of this section: taller children do better on verbal tests, controlling for wealth (CONSUMP is a factor score of family possessions). CONSUMP itself is a significant predictor. Verbal test scores are negatively related to sex (girls do better than boys), morbidity, and family structure (children from nuclear families do worse than others) and positively to parental literacy and modernity backgrounds, and family size (with a higher proportion of older family members at the time of the subject's birth).

7. School enrollment is positively affected by verbal factor scores, by sex, by height, by the number of younger siblings at the time the subject is 6, by parental literacy and modernity, occupation of mother, but not by father's occupation.

8. Verbal factor scores and father's occupation have a highly significant positive effect on teacher assessment while mother's modernity and vocabulary, and teacher assessment of achievement influence negatively. Concurrent diet has a substantial, though not quite significant, effect upon teacher assessments.

9. Among the factors that appear most to influence growth in height, weight, and verbal development, there is a strong sequential influence of height, weight, and verbal development from one period to the next. These measures show stability from one period to another.

10. Mother's attendance at the supplementation center is a strong determinant of child's intake of supplementation, particularly in the Atole villages.

From cross-sectional analysis carried out by Judith Balderston and presented in Section II-B, it was seen that:

11. Taller, healthier children are more likely to enroll and attend a full year of school than smaller, less healthy children. School enrollment is related to the need for the child's work, but other things equal, the effect of prior nutrition on height and health determine school attendance.

12. Children from more affluent farming families work more (and also go to school more) than children from less affluent ones. This may be the result of the need for children's work because of larger land holdings, but it may also reflect the ability of more vigorous children to work more.

13. Elder siblings are more likely to attend school than younger siblings. Children in larger families are less likely to attend than children from smaller ones.

14. Parental literacy affects school attendance of children and their school achievement. Parental literacy is also related to affluence.

15. The opportunity for children to engage in paid work in commercial cash crop production is an important factor in determining high participation in the labor market and low participation in school. This is especially

evident in village 6 where over a several year period school participation is seen to be relatively low compared to the other villages.

From the analysis carried out by Maria Freire and presented in Section II-C, we saw that:

16. Farmers who are literate are more productive than those who are not. Literate farmers used more chemical inputs and raised relatively more cash crops. Even after controlling for chemical inputs and kinds of crops grown, education appeared to be a significant factor in explaining variations in output.

17. The impact of education on productivity appeared to differ among farming groups. For the middle range of farmers, literacy made the greatest difference. For commercial farmers, productivity did not appear to be affected by the farmer's education.

18. Production of traditional crops appeared to be less affected by literacy of the farmer than was the output of crops where innovation in planting and fertilizing is of importance.

From Mari Simonen's analysis presented in Section II-D, it was seen that:

19. Female literacy was found to have a significant direct negative effect on fertility (children ever-born) while male literacy was found to have no effect.

20. Land ownership (wealth) was found to have a significant direct curvilinear (first positive and after a threshold level, negative) effect on fertility (children ever-born). In addition, both land-ownership and income per capita were found to have a significant indirect (through perceived child utility) negative effect on fertility.

21. Of the three intervening variables considered in the fertility determinants' analyses, perceived child utility (i.e., the perceived benefits of children to parents in farm work, and general and old age security) showed a consistent positive effect on fertility (children ever-born), while family planning knowledge, attitudes, and practice and male/female communication showed no effect.

22. Important differences in the effects of the variables considered on fertility were found by different types of economic production of family. For example, belonging to a semi-commercial familial production unit shows a significant positive effect on fertility (children ever-born) through perceived child utility, while belonging to the other types of production units shows no effect.

III-B. Integration of Results and Policy Recommendations

Results

The strongest and most important conclusions that emerge from our analyses are as follows:

(1) Protein supplementation during early childhood has a positive effect on growth. Height, verbal development, school enrollment, and achievement are all affected positively by protein supplementation. Diarrhea has negative effects on all the same variables.

(2) Children's school enrollment and achievement are also affected by parental affluence and the need for the children's work. Village differences appear to affect patterns of work and school participation differentially. In one village, school participation is consistently low and affluence of family appears to affect school enrollment. In the other villages, enrollment is affected by child size and health. Family occupation, sex, and family size also affect child's activities and school participation.

(3) Schooling of farmers relates to agricultural production. Literate farmers accept innovation more readily and are able to bring higher returns than illiterate farmers in their farming activities.

(4) Schooling of female heads of household affects perceptions of the economic utility of children and the number of children ever-born. It is expected that because of the lower perceived utility of children, women will have fewer children as family economic conditions improve.

From these conclusions, we see from (1) that with improved nutrition and improved health conditions (medical care, potable water, improved

sanitation), children will have greater opportunity to participate and achieve better in school. With improved schooling of males (assuming that adult men continue as farming decision makers), we see from (3) that farmers will achieve higher productivity, increased affluence of the families, and less need for children's work. Improved schooling of females will lead from (4) to lowered perceptions of the need for children's help and then smaller families. Higher production and lower family size leads to higher per capita income and better nutrition for the members of the family. This leads to better school performance resulting from better health, physical and verbal development, and parental literacy.

We see that education is in a pivotal position. Literacy is one of the instruments through which farmers innovate and by which attitudes concerning the economic need for children are affected. But, educational performance is dependent on children's well-being and the family's need for their work. Children with poor health and chronic malnutrition may not realize their full physical and psychological potential. To improve their chances of school success, the early health and nutrition of children should be improved. Figure III-1 presents research results of the Berkeley project for the families in the four Guatemalan villages studied by INCAP and Rand. It portrays the interaction among interventions, conditions, and perceptions from the perspective of the child's development and is intended to show the interrelationship of family economic conditions, parental literacy, family size, health, diet, school, and work. Relationships are centered upon the child's well-being and the outcomes of well-being in terms of school and work. Arrows represent the significant and important relationships that were found in the course of the study in Berkeley.

From this diagram, which combines results from the four parts of

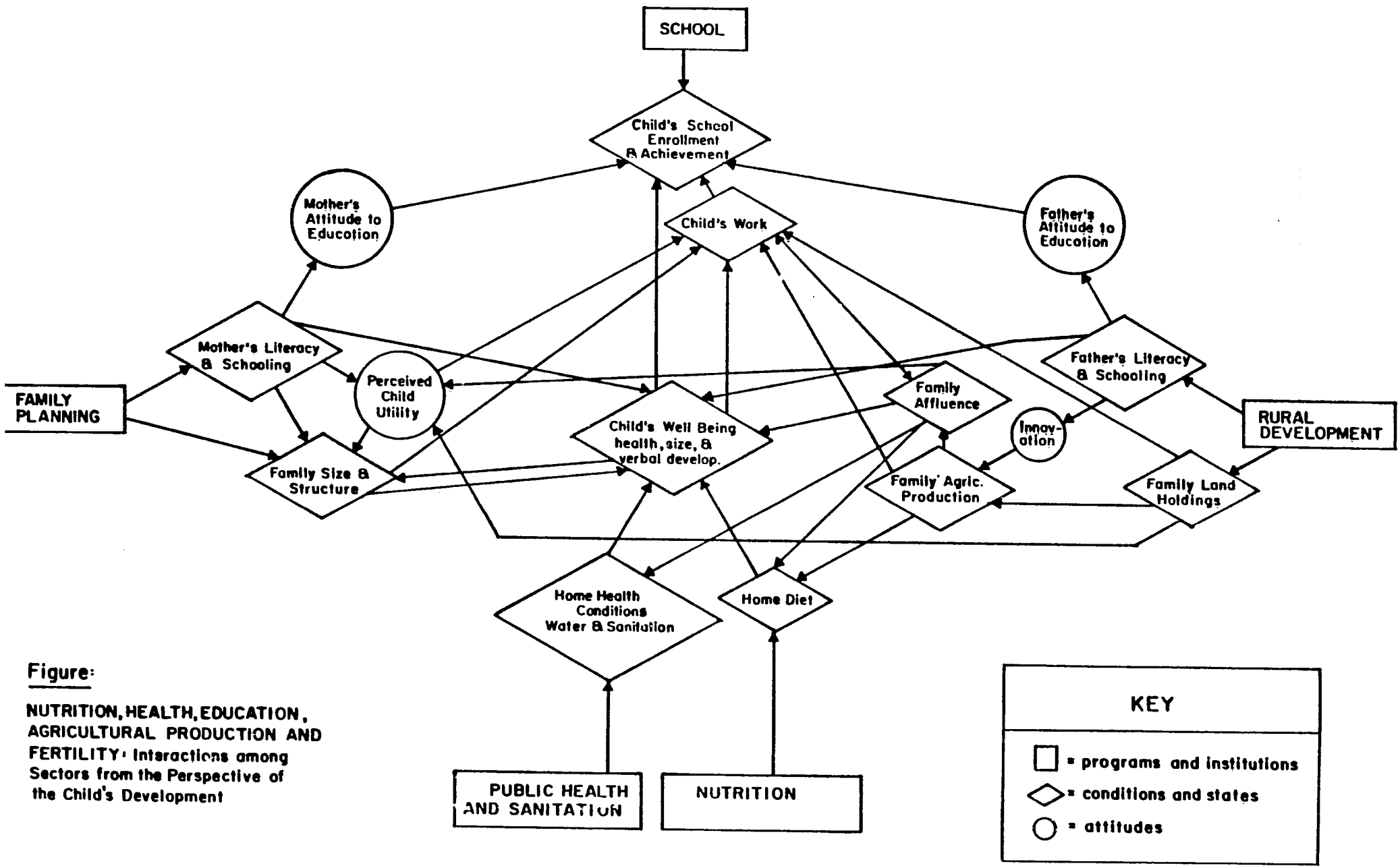

Figure:

NUTRITION, HEALTH, EDUCATION, AGRICULTURAL PRODUCTION AND FERTILITY: Interactions among Sectors from the Perspective of the Child's Development

our study, we note that the child's development is affected by family affluence and work, family size and structure, nutritional intake, quality of family diet and health conditions, and parental literacy. Improving conditions for the child at an early age has inter-generational benefits as the child reaches adulthood. At that point, the man's literacy and schooling appear to influence his productivity as a farmer, and the woman's literacy and schooling appear to influence her attitudes about desirable family size. Education, then, in combination with other development efforts, can be an effective method for increasing per capita income through its effects on increasing productivity and lowering family size.

Policy Implications

Out of these results, we shall now try to develop implications for policy planning that could improve the well-being of the child and the ultimate productivity and welfare of the adult. A great many combinations of program interventions occur (thirty possible combinations of the five interventions can be made, as shown graphically in Figure III-2), but some of these combinations of programs may be less feasible or of lower priority than others. We will suggest combinations of interventions because single interventions and poorly coordinated multiple interventions are inefficient or do not reach the poorest and neediest people. We will not offer cost-benefit estimates, as this is beyond the scope of the Berkeley Project's work. Moreover, costs are specific to countries and regions within countries; they also change over time and depend in part on the skill of policy interveners. Cost estimation would be a logical next step of analysis, along with the measurement of need for the specific context in which policy interventions are planned.

The criteria that we shall use in examining possible program interventions will be as follows: (1) we think it desirable to intervene with efficient programs, i.e., ones that are as economical as possible and that take advantage of complementarities between programs; (2) we think it desirable to intervene with programs that achieve greater equity be being directed particularly to those families in greatest need.

Since school success has been shown to depend partly on adequate prior nutritional intake and health, by intervening within these two areas (nutrition and health), children may have a better chance of achieving literacy. Thus, we recommend that educational interventions be accompanied by nutritional and public health interventions for, in terms of efficiency, the nutritional and health interventions will improve the effectiveness of the educational intervention. And, in terms of equity, the children who will be reached through improved nutrition and health will be just those children who previously would have failed to attend school.

School participation has also been found to depend on family affluence and the need for children's work. Moreover, food intake and health status of children have been found to depend partly on family affluence. Consequently, we recognize the efficiency and equity of interventions to improve incomes and family affluence that will improve children's nutrition, health status, and school success.

In order to improve nutritional intake, we do not perceive that a nutritional intervention would be necessary or advisable for the long-run. A short-term program of nutritional intervention can assist the present generation and will increase their long-run opportunities. In the long-run, an intervention of this kind would not be beneficial because of the increased dependency of families on food aid. Instead, in the long-run, measures to increase agricultural production and incomes are recommended.

Public health interventions need to be provided for the long-run, but such investments are relatively cheap and highly effective. A well, supplying potable water to a community, is not costly. Latrines are also of low cost. In both cases, the benefits of providing these services are seen to have very valuable positive externalities since the utilization of nutrients is substantially improved in the absence of infection.

Thus, it is recommended that public health interventions over the long-run and improvement of nutritional intakes both over the short-run (supplementation, family food allotments, etc.) and long-run (measures to improve family affluence) be instituted immediately. We expect that if these are undertaken, children's school performance will also improve, thereby increasing the efficiency of investments in schools.

Preconditions for the acceptance of innovation in agricultural production and more positive attitudes with respect to family planning are the literacy and grade attainment levels of adults; literate farmers tend to be more accepting of rural innovation,* and literate women tend to be more accepting of family planning information.** To increase the investment in either rural development or family planning without increasing the stock of educated and literate adults would be wasteful in the long-run since acceptance of measures would tend to be limited. Thus, the efficient and equitable approach would be to increase the education of children so that increased benefits of rural development and family planning interventions would occur as they reach adulthood. For the present generation of adults, intervention for rural development and family planning either need to be combined with adult literacy programs or should emphasize outreach to non-literate adults

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*Rural innovation also depends on the quality and quantity of land available.

**Attitudes favorable to family planning depend also on the economic conditions of the family.

In the long table that follows, we present the list of potential interventions, taken one at a time and in all possible combinations of the five sectors: nutrition, public health, education, rural development, and family planning. For each potential policy intervention, we discuss briefly the expected outcome in terms of feasibility, efficiency, and equity.

By "interventions," we intend the following:

1. Nutrition: Direct interventions such as improvement of intake by supplementation, family food allotments, food stamps, etc., which would be directed to specific target groups or to the whole community. Indirect interventions such as improved access to knowledge and means of production so as to increase agricultural production and family incomes.

2. Public Health: The provision of potable water, sanitation, public health clinics.

3. Education: Assuming that existing public schools continue, this intervention involves improved school facilities, classes, and materials.

4. Rural Development: Agricultural extension services, loans, and/or direct provision of irrigation equipment, fertilizer, and seed.

5. Family Planning: Provision of information and methods (possibly integrated with the health clinic services).

Since a wide range of programs can take place within each type of intervention and cost will vary with the amount of service provided, it is beyond the scope of this report to suggest the level of intervention.

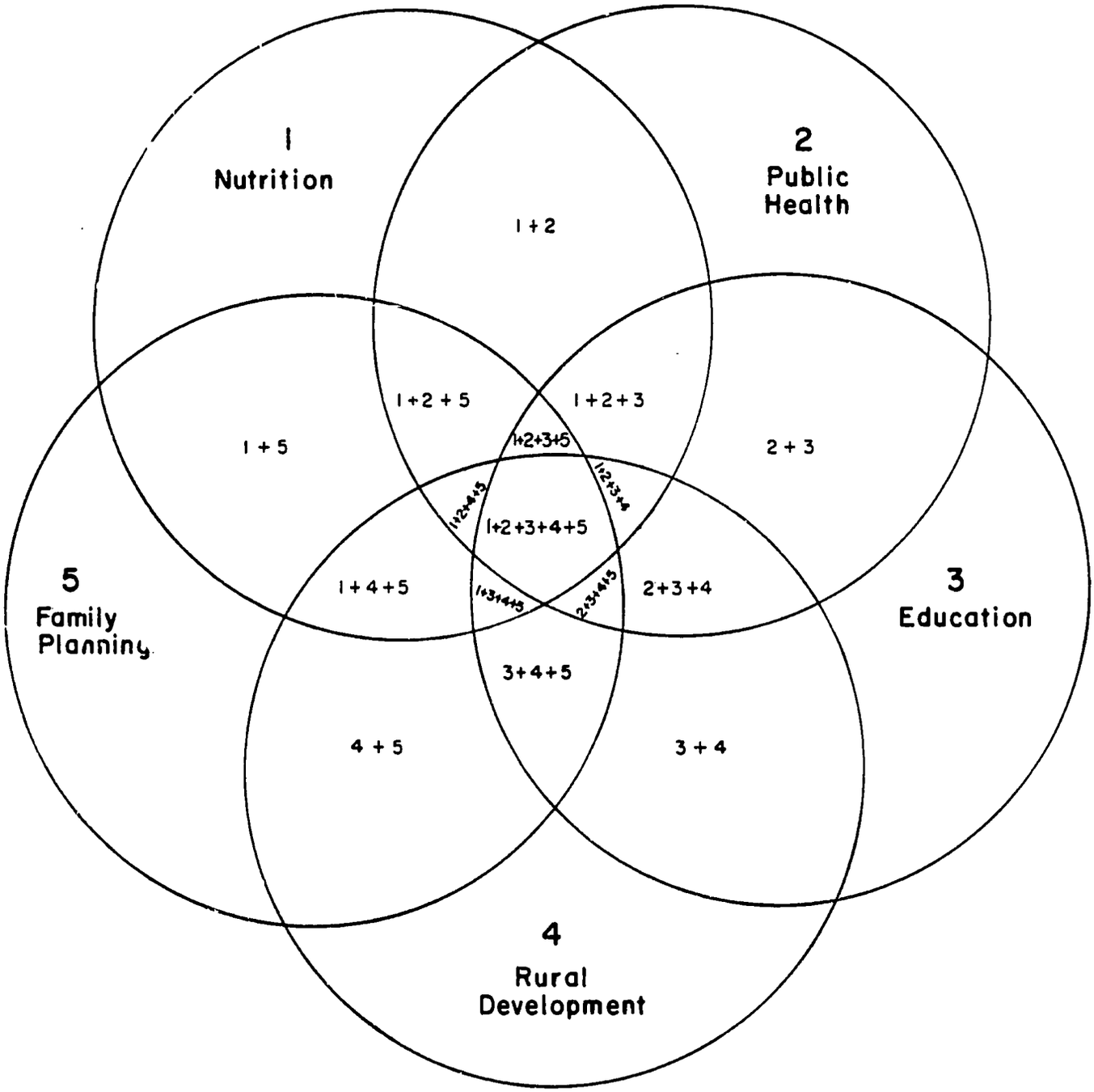
It is our intention in the remaining discussion to indicate the combinations of interventions that are relatively efficient and equitable. In the list that follows, an asterisk (*) will be found beside those interventions that, taking advantage of program complementarities, are able to save resources and meet the needs of the poorest populations.

We recognize, of course, that while our recommendations are drawn from

the results of a particular study and are, therefore, somewhat specific to that study, that in other contexts, it would be possible to conduct short cross-sectional studies that would identify needs, estimate costs, and could yield intersectoral policy results.

Figure III-2

REPRESENTATION OF ALL POSSIBLE INTERVENTIONS COMBINING SECTORS



Decision rules from the research findings:

If 1 then 2 ——— - → Improvements in nutritional intake should be accompanied by improvements in public health.

If 3 then 1 & 2 ——→ Educational investments should be accompanied by improvements in health and nutrition.

If 4 then 3 ——→ Rural development is more accepted by literate adults.

If 5 then 3 ——→ Family planning is more accepted by literate adults.

Intervention	Discussion
1 Nutrition	A nutritional intervention alone without improving public health conditions would benefit those children who are already relatively free of diarrheal disease. Our results indicate that children's growth is not affected by nutritional intake alone but depends also upon the ability of the body to utilize nutrients. This intervention would be inefficient when undertaken alone.
2 Public Health	When potable water and sanitation are provided, they reduce the incidence of diarrheal disease. This intervention would reach the poorest children and would, therefore, appear to be equitable. It would be more efficient if combined with a nutritional intervention over the short-run. Over the long-run, decreased infant mortality, leading to larger families, might have adverse effects on per capita income, unless attempts were made to increase income and decrease family size.
3 Education	Investments in education alone in the absence of improved health and nutritional intake will tend to assist the children already able to attend and profit from schooling. This is inequitable since it benefits children from relatively more affluent families. It is inefficient because children with poor health and nutrition will tend to perform poorly in school. We therefore recommend that there be investments in nutrition and health before increasing investments in education.
4 Rural Development	Programs directed at improving agricultural practice appear to be most beneficial to literate farmers, who tend to accept innovation, and those farmers with access to adequate land. To reach other farmers, increased education through adult literacy programs, plus access to better land, would increase the effectiveness of the rural development programs. In the absence of such additional interventions, rural development alone would tend to be inequitable, because it would not reach the poorest people.

Intervention	Discussion
5 Family Planning	Family planning interventions appear to influence most the attitudes of women who are literate and for whom children are perceived as having lower economic utility. To increase the acceptability of family planning methods, the need for children as a source of labor and security to parents will have to be removed. This intervention alone tends to be relatively inefficient.
1+2 Nutrition and Public Health	The combination of public health interventions with nutritional improvement would improve the utilization of food intake through the lowered incidence of diarrhea and would improve the health and physical growth of children. As a result, children's potential school performance would also benefit. It would not be desirable to continue nutritional supplementation in the long-run, however, because of its high cost and increased dependency on outside aid. We recommend that, in the short-run, nutritional intervention be given to small children in order to improve their chances of success in school and, therefore, greater productivity as adults.
1+3 Nutrition and Education	Nutritional intervention with increased investments in education are wasteful since the public health intervention, necessary to improve utilization of food, is missing. Increasing expenditures for education would tend to benefit most those already able to attend school. This combination of interventions is therefore inefficient and inequitable.
1+4 Nutrition and Rural Development	Again, improving nutritional intake without improved health is wasteful. Rural intervention alone will tend to benefit those already receptive to innovation, most likely, literate farmers. Besides, since nutritional assistance tends to increase the dependency on food relief while rural development activities are intended to increase independence, these activities appear to be incompatible.
1+5 Nutrition and Family Planning	As before, nutritional improvement without a public health intervention is inefficient. Family planning interventions are inefficient alone also because of the low level of acceptability of the information unless accompanied by change in economic conditions and female literacy. This combination is not recommended because of its inefficiency.

Intervention	Discussion
2+3 Public Health and Education	Improvements in health conditions by the provision of sanitation and potable water would improve the health and physical development of children, making it possible for them to utilize more efficiently their nutritional intake from family diet. Improved growth and health will assist children to attend and perform in school while increased investment in school may increase school participation. Therefore, this is more efficient and of lower cost than combining nutrition and education. It is inequitable, however, in that children with poorest home diets will not receive the benefits of either public health or improved quality of schooling.
2+4 Public Health and Rural Development	Rural development plus the delivery of public health services would improve the health and vigor of adults and children while assisting farmers to adopt more efficient methods. Under 4, rural development alone, it was seen that literate farmers would benefit more from information provided than would others. To improve the effectiveness of this approach, rural deveopment would be especially directed to illiterate farmers or combined with adult literacy programs.
2+5 Public Health and Family Planning	Public health and family planning can be combined in a synergistic delivery system with mutually enhancing benefits. With public health improvements, it is expected that more infants will survive, and family planning interventions are directed to discouraging the higher family size. However, it was seen that family planning information does not tend to influence the attitudes of illiterate women and those who perceive children to be useful in work and in old age security. It is therefore advisable to combine family planning with increased education for females and enhancement of family economic production over the long run.
3+4 Education and Rural Development	Increased investments in education with rural development intervention will tend to improve the productivity of families with literate members and will increase the level of performance of children already able to attend school. It is an inequitable intervention, however, because the poorest families are not reached.

Intervention	Discussion
3+5 Education and Family Planning	Education and family planning would be mutually beneficial eventually. Education of females would result in more receptivity to family planning information. However, this is inefficient as there is a delay between generations. It is also inequitable becuase the education does not tend to reach children whose health and nutritional status prevent them from attending school.
4+5 Rural Development and Family Planning	Rural development with family planning would result in some efficiency gains in agriculture and, with some decline in family size due to the acceptability of family planning information, might improve per capita income. Interventions would reach already literate adults and would, therefore, be inequitable unless focused on illiterate adults or combined with adult literacy program. If the rural development innovations would decrease reliance on family labor and increase old age security of families, then it would result in families using family planning more efficiently.
1+2+3 Nutrition with Public Health and Education	Better nourished, healthier children would benefit from better schools and eventually would lead to more productive adults. This is a recommended set of interventions since it provides assistance to children whose health and nutrition would limit their growth and development and likelihood of participating in school. In the longer run, family size would increase with improvements in diet and health. Family planning interventions would be recommended. Nutritional interventions would, in the long-run, create dependence on food assistance. This is a desirable set of interventions if the additional nutrition is offered as a short-term intervention until its long-term benefits can be realized from the higher productivity of educated adults.
1+2+4 Nutrition with Public Health and Rural Development	Increased nutritional intake for the short-run with enhanced rural assistance in the long-run will help food intake. Increased public health measures will help in the utilization of food. Higher infant survival will probably occur from introduction of public health measures which may prevent per capita income from increasing. On the other hand, increased efficiency of farmers may lead to the increased opportunity of children to attend school instead of working. In the long-run, children who are better educated will become more efficient farmers and women with lower expectations of desired family size. This appears to be an equitable and efficient combination of interventions.

Intervention	Discussion
1+2+5 Nutrition with Public Health and Family Planning	Better nourished children with better health will do better in school. More children who survive will lead to bigger families. Increased family planning interventions may help to encourage limiting births. Eventually, increased literacy and schooling will lead to more productive adults who may desire fewer children.
2+3+4 Public Health with Education and Rural Development	The combination of public health, education, and rural development interventions will tend to decrease morbidity; healthier children will be more likely to attend school and perform well. Rural development will enhance agricultural production. For farmers who are literate and innovative, this will be especially beneficial. Eventually, through increased production, diet might improve at home. Because of the absence of family planning programs, family size may increase with improved health conditions, and, thus, per capita food consumption might not improve. Lack of a nutritional intervention detracts froms its impact on the malnourished poor.
2+3+5 Public Health with Education and Family Planning	Public health with improved education and family planning will lead to higher school attendance. Family planning and public health were seen to be complementary programs. Investments in education may lead to increased school participation with beneficial effects on economic productivity. This appears to be a slow but efficient combination of programs, but inequitable because of the absence of a nutritional intervention, which would reach the malnourished poor.
3+4+5 Education with Rural Development and Family Planning	Education with rural development and family planning will benefit most those children already able to attend school because of reasonably good health and robustness and because their families are able to spare their work. Literate adults will tend to benefit from the rural development and family planning interventions. This appears to be an inefficient and inequitable combination of programs, as it tends to benefit those who already have been able to take advantage of schooling.
2+4+5 Public Health with Rural Development and Family Planning	Public health with rural development and family planning would tend to improve chances of infant survival while attempting to limit family size. However, the latter program will most benefit literate mothers with less need for the children's

Intervention	Discussion
	work. Rural development programs will assist in increasing economic productivity but will benefit most the literate farmers. This appears to be a feasible combination of programs but one that inequitably tends to reward those families with education. In the long-run, as children's school performance improves with better health, higher levels of educational attainment will enable them to participate more fully in innovation. In the long-run, this appears to be efficient, but it is slow, and effects could be felt sooner with the short-term introduction of improved nutrition for the most malnourished children.
1+2+3+4 Nutrition with Public Health, Education, and Rural Development	Increased nutritional intake with public health, education, and rural development will, in the short-run, assist children to be better nourished, healthier, bigger, and better able to perform in school. In the long-run, farmers who are able to acquire literacy will achieve higher productivity. There is the danger with this set of interventions that family size will grow larger because of decreased morbidity and that, although income and food may increase, per capita income and intake may not. It is therefore recommended that a family planning intervention be introduced to curtail such increases, with a special attempt to reach illiterate mothers. The nutritional intervention would only be needed for a short period, as eventually rural development programs would help achieve higher productivity and, therefore, improve home diets. We believe that this is a feasible combination of programs and is relatively efficient and equitable.
1+2+3+5 Nutrition with Public Health, Education, and Family Planning	This combination of improved nutrition, health, education, and family planning would be efficient and equitable in the long-run, as it would tend to assist the most needy children to achieve better health, growth, and school performance while helping to limit the growth in family size due to decreased infant mortality. We recommend this as a combination of interventions where nutritional assistance would be provided in the short-run and where family planning would be combined with special attempts to reach uneducated women.

Intervention	Discussion
1+2+4+5 Nutrition with Public Health Rural Development, and Family Planning	This set of interventions includes all sectors except additional investments in education. Nutritional improvement plus health would increase the participation and achievement of children who would probably otherwise fail to attend or to perform well. The interventions of agricultural assistance and family planning would be beneficial in the long-run especially if geared to illiterate adults in the short-run. By having nutritional improvement and health, it is likely that increased spending on schools might not be necessary, that benefits from these programs would have positive externalities for school achievement. This is a recommended set of interventions that appears efficient and equitable. Nutritional interventions would not be necessary for the for the long-run, as eventually increased productivity would assist in improving family diet.
1+3+4+5 Nutrition with Education, Rural Development, and Family Planning	This includes all sectors except public health. As a result, the nutritional intervention would be wasted since those with diarrheal infection would not be able to utilize additional nutrients effectively. The additional investment in education would inequitably tend to reach children already able to attend school. The rural development and family planning information would tend to benefit farmers already innovating, as well as literate mothers. We recommend that this set of interventions not occur, as it would be inefficient and wasteful without the introduction of potable water and sanitation.
2+3+4+5 Public Health, Education, Rural Development, and Family Planning	Since this set of interventions does not include nutrition, it is lacking in immediate assistance to the children of the poorest and most malnourished families. These children will be only partially assisted by the decreased morbidity for public health measures. The combination of education, rural development, and family planning would appear to be effective in improving economic productivity and decreasing family size in the long-run. The absence of nutritional assistance for the poorest families does detract from its advantages.
1+2+3+4+5 Nutrition, Public Health, Education, Rural Development, and Family Planning	This is the most complete, most ambitious, and therefore most expensive set of interventions. The nutritional intervention could be used only in the short-run to benefit those who need it most. In combination with improved health and decreased morbidity and infant mortality, children

Intervention	Discussion
	would function better in school, and in the long-run, educated adults would tend to be more productive and more accepting of family planning information. In the short-run, due to increased child survival, it would be important to focus family planning programs on those mothers not yet reached because of lack of education. We recommend this program if resources are available.

Report of a Study by the
Berkeley Project on Education and Nutrition

Analysis of Longitudinal Data Collected in an Experimental Nutritional Supplementation Program:

An examination of the INCAP four-village study to investigate relationships between nutrition, health, family background, children's activities and school attendance and performance

Concise Title:

EDUCATION & NUTRITION: PERFORMANCE AND POLICY

Charles S. Benson, Co-Principal Investigator
Sheldon Margen, Co-Principal Investigator
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