The Philippine Review of Business and Economics Vol. XII No. 2 December 1975

NUTRITION PLANNING: AN APPLICATION OF BENEFIT-COST ANALYSIS IN CEBU

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Abstract

The economic effects of eliminating one of the four major nutrition problems in the world, vitamin A deficiency, are studied. A conceptual framework is developed for both private and social benefits. For the individual child, the expected value of his economic benefits come from the effects of preventing this deficiency on both those with and without the problem. Costs come from a variety of programs developed to prevent this deficiency. Under the most stringent assumptions, all programs are shown to produce a net gain for society.

Introduction

More frequently, problems of malnutrition and disease are entering the development literature. Hypotheses relating the impact of malnutrition to physical and mental performance, morbidity and mortality abound (e.g. Berg; Belli; Mirrless; Popkin 1972). Despite the number of articles and books purporting to delineate these relationships, we have few controlled studies conducted on the effects of either changes in nutritional status or of malnutrition on human productivity. In the few careful studies, it has been difficult to establish clear positive relationships between improved nutrition and measures of economic performance.

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Probably the best example of the problems that arise with the indiscriminate use of the nutrition-physical productivity relationship was found in a study conducted in a coal mine in India (Satyanarayana). The effect of a 500 calorie food supplement (about 20% of the normal intake) on the working efficiency of men who shoveled coal into cars was studied over a six-month period. At the end, this carefully controlled study produced no impact on productivity because a basic operational constraint — the number of coal tubs they were given to fill — was unchanged. Absenteeism did not change but the weight of those fed the caloric supplement did change. A study among sugar cane workers in several plantations in Jamaica produced similar results (Heywood). More positive results on productivity associated with anemia among civil construction workers have been found in Indonesia.[1]

Knowledge about nutrition and mental performance is just as inconclusive. Many economists and nutritionists have discussed the possibility that pre-school child malnutrition would lead to permanent retardation (e.g. Belli). More recently, nutritionists, psychologists, and others have realized that this relationship may not be true. Now it is generally accepted that no investigation has completely shown the relative importance of malnutrition versus social and environmental deprivation factors in cognitive development nor that this development retardation cannot be reversed with stimulation at a later stage of the child's life.[2] Furthermore, no carefully-controlled studies have established the positive effects of improved nutrition on school performance or absenteeism.

Without really concrete results on the impact of improved nutritional status on measures of economic performance, economists are forced to utilize the best information gathered by nutritionists on the effects of malnutrition (e.g. Selowsky). This paper reports the results of a benefit-cost analysis of alternate nutrition programs in the Philippines based partially on the information of nutritionists and also on some research being conducted as part of this study. The programs were designed to eliminate and prevent a nutritional disease, xerophthalmia. Caused by vitamin A deficiency alone or in combination with a variety of interacting factors, xerophthalmia is

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[1] See Basta and Karyadi for reports on that study. These results are being followed up with a larger IBRD-supported study conducted by the Nutrition Research Institute in Bogor, Indonesia.

[2] The article by Latham summarizes most of the findings in this area.

one of the four leading nutritional problems in the world, affects millions of children, and blinds or kills tens of thousands. Utilizing a very conservative definition of xerophthalmia, about 40% of the 1800 Filipino children aged 1-16 in the sample population were affected.[3]

The endemic nature of this disease in many developing areas requires us to develop analytic techniques which can deal with many nonmarginal changes which can affect a society. Unfortunately general equilibrium theory has little operational value as of yet.[4] A second problem related to the endemic nature of a disease is the need to consider preventive programs whose benefits and costs cover the entire population of a given age cohort. Within a framework which will deal with this issue, an attempt is also made to encompass the external benefits of eliminating this disease. The first section of the paper presents the conceptual framework of benefit-cost analysis. The second section reports the results of the benefit-cost analysis based primarily on a large survey in the island of Cebu, Philippines. The results of this project have been utilized in selecting programs to be ran on a pilot-project basis over a two-year period. This analysis is based on the projected benefits, costs and effectiveness of these programs.

II. The Conceptual Framework

It may be argued that the primary objective of any health or nutrition project is to increase society's welfare. A the same time, the prevention and elimination of xerophthalmia produces significant "real" or monetary effects. Xerophthalmia (X) affects both the future productive time and the productivity of children of ages 1-16. A higher mortality and total blindness rate from X lower the productive time and increased morbidity, and partial blindness lower the

[3] Xerophthalmia is normally defined as the clinical syndrome associated with Vitamin A deficiency. However, these clinical signs can remain after the Vitamin A deficiency has cleared up. Consequently, use of biochemical levels which indicate the vitamin A nutritional status of the child can eliminate some of these problems. For this study, a combination of both clinical and biochemical definitions of xerophthalmia were required for the child to be included as having xerophthalmia (Popkin, 1974).

[4] Barlow's pathbreaking study on the effects of malaria eradication is one of the few attempts to use even macroeconomic growth models to capture the effects of health changes on economic output. Also, see Weisbrod (1973) for comments on this.

productivity.[5] Associated with these direct benefits are the reduced costs of treatment for the children who would have had X and the external effects of lowering X. Decreasing X, in turn, lowers the effects of other contagious diseases such as tuberculosis and broncho-pneumonia on the target population as well as other age groups. There are a variety of more subtle effects of X, especially of the less understood subclinical deficiency on economic behavior.

It is meaningful to analyze the economic benefits or returns to the individual as well as to society. These individual or private returns will be discussed first.

Private Returns

We may define private returns accruing to the person benefiting from the X program as

$$R_p = R_{pl} + R_{p2} \tag{1}$$

where R_p = total returns, R_{pl} = monetary returns, and R_{p2} = the nonmonetary component of R_p.

For the individual, the appropriate measure of R_{pl} is the additional income he/she is able to earn over his/her lifetime. Those persons who either have X or will suffer from it will be benefited by changes in productivity from lower death, blindness and morbidity rates. Those who do not have X will have higher productivity from lower morbidity rate resulting from less communicable disease existing after X is eliminated. Benefits calculated here will be those resulting from effects which are assumed to be permanent.

Most children will benefit from the reduction in the incidence of X either directly or indirectly. The children are divided into four mutually exclusive groups each with different returns.

Group a: have xerophthalmia, but do not die or go blind as a result of it

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[5] The morbidity effects come through lowered cognitive development and school performance. Lower productivity within the same occupation and poorer occupation are the results. For a broader discussion of the effects of nutrition on human capital see Berg or Popkin (1972).

Group b: have X and become totally or partially blind as a result of X

Group d: have x and dies as a result of X

Group nox: do not have X but suffer from a higher incidence of communicable diseases as a result of other children having X

Clearly, there are children with X (Group a) who experience no medical or other effects as there are children without X (Group no.) who are not affected. Since we are dealing with the expected effects of X, such cases are included. Figure 1 delineates these four groups before the prevalence of X is reduced.[6]

Since a child may fall in groups a, b, d, or no., private monetary returns are viewed as the expected value to the potential recipient ($E(R_{pl})$). The expected value of each person's potential monetary returns in annual terms for year i are defined as follows:

$$mE(R_{pli}) = mp_a np_i (W_i - (W_{ai} + T_{ai})) \quad (2a)$$

$$+ mp_b p_i (W_i - (W_{bi} + T_{bi})) \quad (2b)$$

$$+ mp_d p_i (W_i - T_{axi}) \quad (2c)$$

$$+ mp_{nox} p_i (W_i - (W_{noxi} + T_{noxi}) \quad (2d)$$

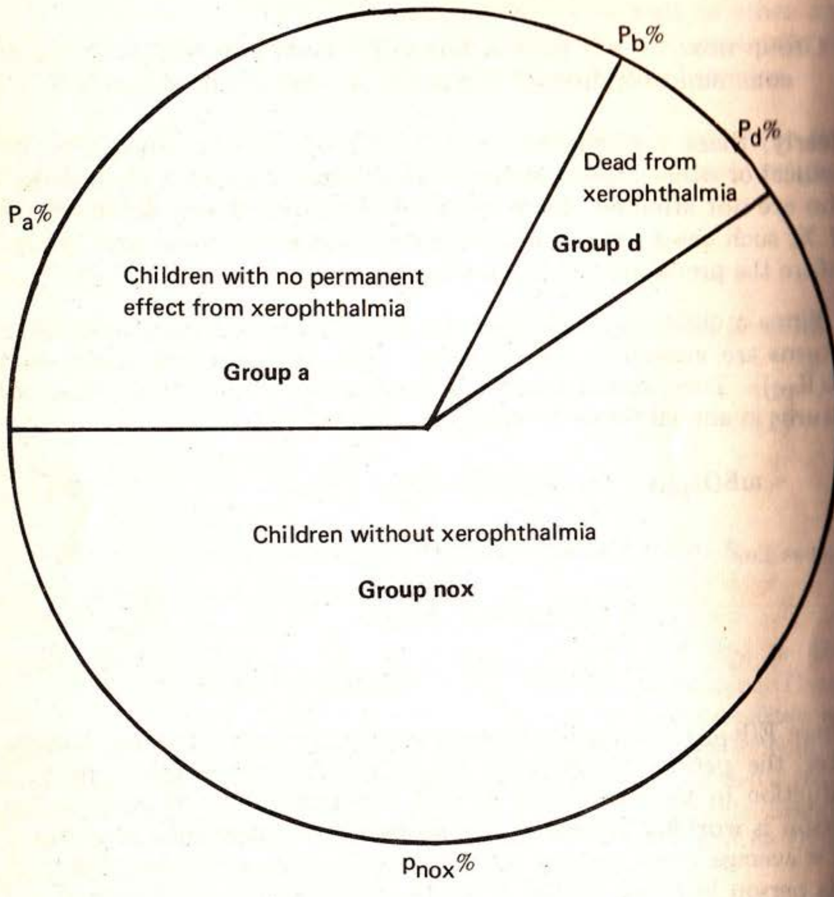
where $E(R_{pli})$ = expected monetary returns in year i from a program after the person has entered the productive labor force; m = % reduction in the prevalence of X;[7] p_i = probability of survival, the person is working in year i; p_a = probability of belonging to group a; w_i = average gross earning for the healthy socio-economic cohort of this person in group a after X has been eliminated; $\mathbf{w}_{ai}$ = average net

[6] Knowledge of the incidence rate or percent of X over the period of a year was not available. Only the prevalence rate at a given point in time was known. This prevalence rate used for calculating p_a, p_b, and p_d will produce an unknown but possibly significant downward bias in the estimate of the returns.

[7] It is assumed that each program affects the various benefit categories in a proportional manner. Thus each program will reduce the effects of 2a-2d by m. $E(R_{pli})$ assumes 100% or complete benefits and m is a figure between 0 and 100%. A pure model would have a differential m for each category and these differential effects would vary for different programs. Similarly, the probability of survival could be different for each subgroup.

Figure 1

Distribution of Children Aged 1-16 According to Xerophthalmia Prevalence



earnings for group a before X has been eliminated; T_{ai} = marginal income tax on $(W_i - W_{ai})$; p_b = probability of belonging to group b; W_{bi} = average net earnings for individual blinded by X in year i; T_{bi} = tax on difference $(W_i - W_{bi})$ in year i; p_d = probability of dying from X (i.e., belonging to group d) before X has been eliminated; T_{axi} = total taxes on W_i; p_{nox} = probability of belonging to group nox with no xerophthalmia before X has been eliminated; W_{noxi} = net earnings of group nox; and T_{noxi} = tax on the difference $(W_i - W_{noxi})$.

Social Returns

The social returns in year i, R_{si}, generated by each X program could be treated as the sum of the expected private returns plus additional returns accruing to society (R_{ei}):

$$R_{si} = m \sum_{j=1}^{p} E(R_{ij}) + R_{ei}$$

where $E(R_{pi})$ is summed over j = 1, 2, . . . p, the p persons benefited by the prevention program. The total social returns, R_{si} can be split into the monetary (R_{sli}) and nonmonetary (R_{s2i}) components:

$$R_{si} = R_{sli} + R_{s2i} \qquad (4)$$

These are the total benefits of a nutrition program independent of who receives the benefits.

Social Monetary Returns

Basically, the nutrition programs preventing X increase the supply, raise the productivity and lower the financial dependency of people of working age. The social money return (R_{sl}) is the sum of the present value of individual money returns ($E(R_{pi})$), plus the additional benefits (R_{ei}) occurring to society. One big aspect of R_e is taxes. In private returns income taxes are excluded; however, they certainly are returns to society. Also, indirect excise and sales taxes are raised by the additional production of this population (Paul).

These tax increases form one component of R_e, the reduced costs of treatment form a second. While a reduction in treatment costs may not increase GNP, the economic welfare of society undoubtedly increases due to the reallocation of scarce medical resources (Weisbrod). A third component is the reduction in welfare payments as cash, in-kind, or institutional services to the blind. The transfer payments reduction also represents an increase in societal welfare. Most of these are social services. The fourth component is the more difficult one to quantify effects of a better educated and more healthy populace on technological change and economic growth.

Gross production is considered the relevant benefit to society. If the societal perspective is from the view of nonprogram recipients, it would be logical to view their potential benefits as the recipients loss of net production (income minus consumption expenditures.)[8] When

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[8] See Weisbrod (1971).

all of society is included, certainly the perspective of the program recipients must be included and their consumption is viewed as a component of R_i.

An additional consideration is potential change in income due to labor force changes. In one year the labor force increase from preventing X will be about 1-6%. This may affect the wage rate. Over a ten-year period a labor force increase of 10% would produce price effects. It is assumed these labor supply increases will not affect the supply of labor in non-cohort (middle and upper class) occupations. Thus, the supply increase would be reflected in the same group's occupations. The effects on wage rates depend on numerous factors outside the purview of this analysis. These effects only indicate a transfer between the various sectors of society. They may lead to an overestimation of the private benefits but will not effect the social benefits. The private benefits will be overestimated if the net transfer leads to gains for owners of fixed factors and a loss for workers. The latter are most affected by X.

Total social monetary returns, R_{sl}, are the present value in year 1 of the private returns (r_{pj}) and the additional returns to society, R_e. This is expressed as:

$$R_{sl} = \sum_{j=1}^{p} \sum_{i=1}^{p} \frac{(E(R_{pijk}) + T_{ijk} + C_{tijk} + W_{ijk} + \Delta\, Tech_k)}{(1 + r_s)^i} \quad (8)$$

where $E(R_{pij})$ = private returns for individual j in year i from program k; T_{ijk} = the tax payments with program k minus the tax payments without program k; C_{tijk} = the treatment costs which are not needed for individuals from program k; W_{ijk} = the welfare payments which previously went to individual j in year i for program k; $\Delta\, Tech_k$ = the economic and technological change resulting from the increase in the health and education of these persons from program k; and r_s = the social discount rate or any other societal time preference factor.

Each X prevention program will have a different success rate. The reduction in X, m, is the percent of cases prevented by a program. It relates to the total percentage of persons in the relevant cohort protected from X.

Nonmonetary Returns

To the individual, good health is of the greatest importance. It is fair to say most people want to feel healthy, be able to see, and avoid dependency on others. It is felt that good health is an end in itself.

Possibly the most important effect of nutritional or any other health change is summarized by Fein: "The relationship between health and education may be even more explicit than has yet been suggested. It is not just that better health makes education possible, it is that better health . . . [is] part of the educational process, part of the process of increasing wants and at the same time demonstrating that 'it can be done', part of the process of breaking away from the past, from tradition, part of the process of creating hope, a desire for change."

Program Costs

Three different programs are being considered. They are: (1) the provision of a vitamin A capsule providing adequate protection for a 6-month period and requiring foreign exchange and unskilled people to distribute them; (2) a nutrition education and public health plus home gardening approach providing nutrition and home garden education and public health intervention (PHI); and (3) the fortification with vitamin A of a product consumed universally by a target population. Cost components for the different elements of each of these programs are discussed.

Private Costs

The per capita investment costs for a family (I) consist of a direct and an indirect outlay. The direct outlay (Id) purchases the materials required by a given program such as seeds, fertilizer, medical supplies or food (for fortification and some nutrition education programs). The direct outlay excludes the subsidized portions of each item. One critical question is the proportion of costs, if any, which should be attributed to food purchases. In fortification programs, consumption patterns are not affected, rather the program operates in an invisible manner and no Id will be included. In some nutrition education programs, however, additional expenditures for food are called for. Since the person is asked to make these expenditures for the purpose of eliminating X, all marginal food costs must be included. In this case, additional benefits from this food must be analyzed.

The indirect outlay (If) consists of the earnings foregone during the period of investment. These represent the opportunity costs of the time devoted to home gardening, nutrition education, or public health education programs. The quantity of If can be developed only by imputation as earnings are not generated during the investment pericd. It is possible that this will be costless if the opportunity cost of the labor is zero.

The present value of I for each family is:

$$PV(I) = \sum_{t=1}^{16} \frac{(Id + If)}{(1 + r)^t} \qquad (6)$$

where time begins at age one and covers the first 16 years of the person's life;[9] Id = direct private outlays; If = indirect (opportunity cost) outlays; and r = the opportunity cost of capital for the family.

Social Costs

The direct social costs (Sd) consist of the fixed investment in training and other facilities, and the operating and maintenance costs for the various programs. In addition, the net costs of any food or other subsidy are included. The largest fixed outlays will be for the fortification equipment and the training facilities.

The present value of the social costs of the X program is:

$$PV(Sd) = \sum_{t=1}^{16} \frac{O_t + K_t + Id + If}{(1 + r_s)^t} \qquad (7)$$

where O_t = operating costs in year t; K_t = outlays for facilities and equipment in year t; Id and If are the private direct and foregone costs; and r_s = the social discount rate. These costs are the aggregate ones for reaching a specific population group.

Research costs, which can be viewed as joint costs with the application costs analyzed here, are excluded (Weisbrod). Numerous technological breakthroughs instrumental in the development of

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[9] Recurring costs to prevent X after the age of 16 are very small. For this study, they are assumed to equal zero.

these programs have preceded this project.[10] These can be viewed as a fixed cost which should not affect the present investment decision. Also, Weisbrod showed that research costs were nominal relative to the application costs for the polio vaccine and this should be similar for X.

Other Considerations

A key factor affecting the time horizon is the economic life of each program. The programs will be analyzed for their effects over a 25-year span. This is done to capture the differential economic lives of each program. For the fortification program new equipment is required every 12.5 years while the PHI has training costs every fifth year which are large relative to the program's variable costs. A 25-year time horizon would not affect differentially the relative attractiveness of each program.

One question ignored in the discussion of costs and benefits has been the joint production of costs which can be attributed to other programs. Home gardening is part of a national Philippine "green revolution" efforts. Thus, it could be argued that part of the home gardening costs should be attributed to this development effort. In this case, only the marginal expense of the X programs to the government would be included. The cost valuations utilized here include the total costs for these components; consequently, the incremental social costs of the PHI will be less than those determined here.

III. The Empirical Analysis

In this section the benefits and costs of each program are determined in a three-step process. First, the private and social costs and potential effectiveness of each program are specified, giving PV(I) and PV(Sd) and m for each of the three programs. Second, the private and social benefits which assume that the xerophthalmia is eliminated completely are derived. This provides the present expected value of the private benefits $PV(R_{pl})$ and the social benefits

[10] Three examples are: (1) Professor George Wald's Nobel Prize-winning research on the role of vitamin A (retinol) in the development of rhodopsin for the eye; (2) the work of scientists at Hoffman-LaRoche and elsewhere in the development of inexpensive mass-produced synthetic vitamin A; and (3) agricultural breeding and selection work to increase the vitamin A content of vegetables and fruits.

R_c. The third step is the combination of the first two steps into private and social benefit-cost ratios. These ratios are calculated for each age-sex-education-zone grouping (cohort).

The private benefit-cost ratio is:

$$\frac{PV(R_{plk})}{PV(I)_k} \qquad (k = 1, 2, 3) \qquad (8)$$

where $PV(r_l)$ is the private benefits for eliminating X completely for program k; and $PV(I)_k$ are the private costs for program k.

The social benefit-cost ratio is:

$$\frac{R_{sk}}{PV(Sd)_k} \qquad (k = 1, 2, 3) \qquad (9)$$

where R_s is the total societal benefit for the 25-year period under which the program k will function; $PV(Sd)_k$ are the total societal costs for the program k over that same period. These benefits are a weighted average of the program for the 1-6 and 7-16 age groups for each sex-zone cohort.

Four ecological zones — urban squatter areas, urban fringe barrios, rural coastal barrios, and hinterland barrios — have been studied. In each zone, three separate areas or barrios were sampled to obtain data on 1800 children and 660 families. Data from this study were used to determine the benefits and costs reported next. In addition, the effectiveness parameter m is based on these data.

Private Benefits[11]

The age-income profile for "healthy" persons from the relevant education-sex-zone cohorts, the incomes' profiles for those affected by X (2a, 2b, 2d), the probabilities of belonging to the four groups, and the marginal tax rates, are needed to determine the expected

[11] The fortification and capsule programs only provide benefits through the provision of vitamin A with the subsequent elimination of X. On the other hand, the PHI program provides additional benefits such as better sanitation, consumption of additional protein and calories, etc. We did not attempt to quantify these additional PHI benefits. These will be discussed in a qualitative manner only.

value of benefits for each child if X is eliminated completely. The effects are analyzed for each age-sex-education-zone cohort.

The "healthy" persons were the adults in the zones who were not blinded by X or any other factor. The sample excluded the higher income quartile of the Cebu income strata by design. It was felt this group, which resides in poblacions and urban residential areas would not have problems with X. The peak annual income for males was found among the college educated residents of the coastal barrios and for females among urban barrio college educated persons. These figures were $656 and $369, respectively. Income functions were used to determine these profiles. The income functions are shown in table 1.[12] The unusual dip in the income for males between the ages of 35-44 could not be explained so it was not revised.

The average income of the sample working women drops significantly during their peak child-bearing years. Most likely this dip reflects the decline in hours worked by women aged 30-34 during this peak child-bearing period. Simultaneously, the proportion of working women declined during this age group. Data were unavailable to back up this assumption but arbitrary adjustments were made to allow women aged 30-34 to earn the simple average of earnings of the 25-29 and 35-39 age cohorts. The adjustment changed the regression coefficient for age (30-34) to 25.

There is a downward bias in the "healthy" income profiles (W_i) because some of these children may enter the upper income quartile and also the "healthy" person's productivity will have been affected by X similar to the effects signified by equations 2a and 2d.

In equation (2), marginal tax rates were used to determine the net after tax benefits going to each cohort. In a study of the marginal tax rates for low income Filipinos, it was found that such adjustments were unnecessary. The total tax incidence for direct plus indirect taxes did not vary greatly for the relevant lower income groups.[13] A weighted average of the tax burden for each income

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[12] The age, education and zone dummy variable groupings were significant at .05 level. For males and females there were 643 and 250 degrees of freedom, respectively. R^2's of .20 — .25 are normal for earnings functions based on ungrouped cross-sectional data.

[13] Professor Agustin Kintanar, Jr. is thanked for his assistance in providing this tax data.

TABLE 1

Earnings Functions For The Mother And Father*

Income, Fathers = 86 + 16 Zone 2 + 53 Zone 3** − 13 Zone 4 − 11 Ed (1-2) + 5 Ed (3-4) + 61 Ed (5-7)
(39) (39) (40) (69) (58) (55)

+ 56 Ed (8-9) + 121 Ed (10-11)## + 301 Ed (Coll)# + 162 Age (25-29)# + 216 Age (30-34)#
(61) (62) (66) (58) (56)

+ 198 Age (39-39)## + 171 Age (40-44)# + 212 Age (45-49)# + 142 Age (50+)# (R^2 = .21)
(55) (59) (75) (71)

Income, Mothers = 37 + 31 Zone 1# + 118 Zone 2# + 42 Zone 3 + 29 Ed (1-2) + 60 Ed (3-4) + 38 Ed (5-7)
(44) (41) (38) (71) (53) (53)

+ 49 Ed (8-9) + 162 Ed (10-11)# + 173 Ed (Coll)# + 41 Age (25-29) − 46 Age (30-34)[a]
(68) (70) (69) (48) (46)

+ 8 Age (35-39) − 3 Age (40-44) − 39 Age (45+) (R^2 = .23)
(50) (54) (62)

*Each variable is a (0-1) dummy variable. Standard deviations of the coefficients in parentheses.
**Significant at .10% level.
#Significant at .01% level.
##Significant at .05% level.
[a] Adjusted in later analysis to +25 age (30-34).

quartile was used to determine the average and marginal tax rate of 16.85% for this population. (Philippines, Table 13) Consequently the tax rate, ti, is substituted for the tax amount Ti in the following derivations.

The most difficult benefits to determine were those accorded to persons who would be blind without the project. A substudy of blind persons from the 4,450 persons in the sample was used to estimate the age-earnings profiles of blind persons (W_{bi}) and the age-specific incidence of blindness (p_b) associated with X. Fifty-five blind persons or their parents were interviewed. Only 4% of the males and 24% of the females were inactive. Because of the significantly different earnings patterns for males and females, separate W_{bi} were estimated. The earnings functions are:

$$\text{(1)}\quad \text{Female income} = -4 + 5\ \text{blind}(1\ \text{eye} = 1) + \underset{(6)}{10\ \text{Age}\ (17\text{-}30)^{xxx}} + \underset{(8)}{4\ \text{Age}\ (31\text{-}40)} + \underset{(6)}{26\ \text{Age}\ (41\text{-}50)^{xxx}} + \underset{(6)}{4\ \text{Age}\ (51+)} \qquad (R^2 = .587)$$

$$\text{(2)}\quad \text{Male income} = -28 + \underset{(94)}{102\ \text{blind}\ (1\ \text{eye} = 1)} + \underset{(118)}{63\ \text{Age}\ (17\text{-}30)} + \underset{(137)}{69\ \text{Age}\ (31\text{-}40)} + \underset{(193)}{13\ \text{Age}\ (41\text{-}50)} + \underset{(109)}{57\ \text{Age}\ (51+)} \qquad (R^2 = .137)$$

xxx Significant at .10 level. Standard deviation in parentheses.

The small sample size did not allow differentiation of the incomes by zone. As contrasted with the earnings before the age of 16 for blind males, surprisingly few "healthy" males earned an income before that age.[14]

[14] This may be due to the small percentage of farm and other forms of income generation in which it is easier for children to participate. Even in the most isolated hinterland (and mountainous) barrios, 81% of the income was from business or wage sources. In-kind and cash income from home production (gardening, etc.), farming and fishing constituted only 12% of their income. The rest was from credit or contributions from other household members.

The probability of blindness associated with X was estimated at .001514 (1 of every 661 children) aged 1-6 and .000462 for the ages of 7-16. The other probabilities were based on the survey and other scientific studies. The average prevalence of X was 40%. Of these, it was assumed 15% (p_d) would die. Most medical researchers estimate a mortality rate from X of 25 of 50% but these studies have not been very careful. The remainder of those with X ($\%X - (p_b + p_d)$ are in the p_a group.

The economic effect of the behavioral changes from the non-permanent X (p_a and p_{nox}) has not been established. We are forced to make an assumption about these effects. The productivity of each person with X in this p_a category will be assumed to be 5% less than that of the average healthy person (W_i).[15] This 5% figure results from a sequence of effects. They include the partial effect of xerophthalmia on school performance, the resultant effect of changes in school performance on mental productivity, and the combined effect of schooling and mental productivity (as measured by a factor such as IQ) on earnings.[16]

A variety of diseases whose incidence or severity may be increased by X are communicable. These include tuberculosis, upper respiratory infections, and pneumonia. The reduction of X should lead, in turn, to an overall reduction in these diseases among the population without X. All students of epidemiology and public health discuss this general relationship although little quantifiable documentation exists to identify the linkages in human populations.

These external effects are tangible in the case of reduction in X lowering the morbidity of the nonX population. They also are intangible when the effects are not quantifiable. One example of this is a reduction in the number of "blind beggars in the street." Of course, all of these effects do not have to be positive. Some people may suffer as a result of the increased health of another person. Most clearly this is seen when the reduction in thymortality rate leads to a

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[15] Although it is impossible to justify a figure such as this 5%, the author feels it is reasonable based on the wide range of behavioral effects of X. The various effects of X on morbidity and mental performance are felt to be important by most nutritional and medical researchers. A longitudinal study is being conducted now in an attempt to understand some of these morbidity-xerophthalmia relationships.

[16] Marcelo Selowsky and Lance Taylor estimated some of these linkages.

large increase in unemployment. Some of these unemployed persons could have been in the nonX population.

For this study, only the positive effects are considered. As with the morbidity effects, the benefits will be calculated as a percentage increase productivity. They are calculated only for children although adults would also benefit from a reduction in the incidence of communicable diseases among the X population. In this case, the effect will be a 1% increase in lifetime productivity for the children aged 1-16. These effects are very small. The four-year old male and female child who will have 5-7 years of education will receive an additional present value of \$7 and \$6 if they live in the squatter area.

To attain the expected value or average private benefits for each child, the sum of the probability of each benefit times this benefit is calculated for the four benefit categories. An example is given in table 2. For the morbidity category, the expected value of the morbidity benefit $(W_i - W_{ai})$ $(1 - t_i)$ was \$37. The probability of belonging to this category was .3295. The sum of \$60 represents the expected value for this cohort, urban squatter children age 1-6 who would expect to receive 5-7 years of education after the X was eliminated completely.

If one person from this cohort were to be benefited each year over the next 25 years, a total benefit of \$641 would be received by these 25 children for an average annual benefit of \$26. Since the programs are analyzed as if they will operate for 25 years, these 25-year totals were calculated. The total and average figures represent present values over a 25-year period.

Social Benefits

Economic benefits were estimated for three categories of social benefits for 600 children in each cohort. The 600 figure was based on the fact that each program will operate in four barrios (one/zone) and reach a total of 150 children per barrio. The first group of benefits in the aggregate social benefits for the 600 children is the private benefits for the cohort times 600.

The treatment benefits are the amount of savings coming from the reduced treatment for the children, both in rural and urban health centers (out-patient care) and hospital or other in-patient centers. It was estimated that only 4% of the children with X would be treated

TABLE 2

Economic Benefits From The Elimination of Xerophthalmia

Private Person	Cohort: Males — Ages 1-6 P.V. Benefit	Urban Squatter Education 5-7 years Probability
Expected value of the Present Value of Sum of:		
A. $p_a\, p_i\, (W_i - W_{ai})(1 - t_i)$ Morbidity =	(37)	.3295 = $12
B. $p_b\, p_i\, (W_i - W_{bi})(1 - t_i)$ Blind =	(324)	.0015 = $ 0
C. $p_d\, p_i\, W_i\, (1 - t_i)$ Death =	(738)	.059 = $44
D. $p_{nox}\, p_i\, (W_i - W_{noxi})(1 - t_i)$ External =	(7)	.61 = $ 4
	Expected value one year	= $60

(i = year 1, 2, . . . 60)
(nP_i = probability of survival year 1 to 1 + N)

by outpatient clinics. The total cost for four visits was estimated conservatively at \$.50. Only a 0.25% of the children with X will be placed in a hospital at an average cost of \$60 based on a stay of 12 days, at \$5/day. Thus the average cost per child for the urban squatter cohort of males aged 1-6 is \$.0078 for out-patient care and \$.0585 for in-patient care. Of this cohort (600), 39% have X at a total treatment cost of \$40 for one year.

The tax figure was calculated directly from the private expected value of the cohort's benefits since this sum represented the after tax benefits.

For the population in Cebu, minimal welfare programs for the blind and disabled existed. It was felt improper to estimate the benefits from reduced welfare payments because such a very small proportion of children would go to the one school for the blind, etc.

The residual effect of better health (Δ tech) is the variety of more intangible effects on the attitude and overall productivity of the society caused by the combination of all the health and nutritional benefits. No estimate of this category was made.

The benefits for eliminating X completely in one year of the program were based on two assumptions. First, there would be equal benefits from each year of treatment for a child in a given cohort. In other words, there does not exist any carry-over in the vitamin A storage or other treatments from one year to the next. While this assumption is not exactly correct, it would be very difficult to estimate the relative benefits of a program which treated a child for 1, 2, 3, . . . or 16 years. Second, it was assumed that there was an equal and constant age distribution over time among the children aged 1-16 in the sample. This will lead to a slight overestimation of the benefits.[17] The overestimation results from the younger age group with its smaller benefits being slightly undervalued relative to the older age group.

Each year basically 1/16th of the sample is assumed to be benefited by the elimination of X. Since the age distribution was assumed to be constant over time, the same amount of benefits would come each year. Since the benefits occur over a 25-year period, the present value of these benefits was calculated. The 25-year benefits for the urban squatter males discussed above are $78,995.

Effectiveness Parameter M

Here we determine the percentage of the X which will be both eliminated now and prevented in the future. This percentage or level of effectiveness is the variable m. If m = .95, this would mean that 95% of the X is eliminated now and prevented in the future. Thus,

[17] Based on the 1970 census and a few estimates, roughly 580,000 Cebuano children are aged 1-14. About 38% of them are aged 1-5. This gives a ratio for each of the ages 1-5 of 1:13 of the total age group 1-14 and of 1:14.5 for the age group 6-14. The ratio 1:16 was used for both the 1-6 and 7-16 age cohorts to facilitate the aggregation process.

95% of the benefits from the complete elimination of X would be received by the population if the benefits at each level of m were independent of benefits at other levels. The program effectiveness will be assumed to be equal among all the population for which X is eliminated or presented. Consequently if 80% of the population were completely cured of X while the remaining 20% were only 50% cured, m would equal 90%. m was estimated for each age-sex-zone cohort.

Program Costs

Two assumptions are basic in the development of the program costs. The first is that meaningful economies of scale exist in the delivery of health care, especially in the training of health para-professionals. For one example, three nutrition educators were trained to carry out most of the barrio work for this project. For their work, they would need one month of training but it was assumed 20 educators could be trained together. Consequently, the costs of each trainer would be 3/20 of one month(s) salary.

A second assumption relates to the indirect outlay, If, or opportunity costs of the time family members spend caring for a home garden or attending nutrition education meetings. These costs, If, are treated as zero. The largest cost would be the time spent in gardening. In this sample, about 60% of the population or 95% of those people who can garden do this already. Little additional time would be required by the home gardening component of the PHI. Rather more efficient techniques, improved seeds and cuttings, fertilizer and spray would be used. Minimal time will be required for the education programs.

The costs of these programs consist of only the direct costs since the indirect costs (opportunity costs or earnings foregone) are assumed to be zero. The direct costs are either social or private. Private costs (I) include the \$.10 each child must pay for two vitamin A capsules per year, no costs for fortification of MSG, and costs for seeds, sprays, chlorine for sanitizing the water supply and toilet construction. Most social costs (Sd) would be provided by the government; in fact most are supposed to be included in the services of the extensive City and Rural Health Units of the government. The combinations of inputs and delivery of them, however, are quite different for the PHI.

IV. Program Analysis

Benefit-cost ratios are one of the chief criteria considered for our analysis of many development projects. This criteria presents an incomplete picture in cases in which complex benefits and costs, many of which are intangible, exist. Moreover, most of these analyses limit the scope of their benefits and do not examine many of the secondary effects of their projects. After the benefit-cost ratios are determined, systematic variations in the discount rate are examined over a realistic range. Also the role of the parameter m and the relative weight given some of the parameters is discussed. Finally some of these broader considerations are brought to bear on the analysis.

Benefit-Cost Analysis

The private and social benefit-cost ratios are quite large. Using a discount rate of 8%, these ratios indicate a large benefit to both child and society. The private benefits are meaningful for determining if it would be rational for each child to be involved in these programs. Of course, the private costs accrue to the family while the private benefits will accrue 1-19 years in the future. Thus, the parent must be assumed to desire the maximization of household benefits over time even though they may not accrue to him. There were assumed to be no private costs for food fortification although the very samll fortification process could be passed on to the family, especially if the demand for MSG is inelastic. The private BCR's reported in Table 3 are all very large.

The social BCR's are more important for socio-economic decision-making. They clearly indicate the superiority of the capsule program on the basis of costs and benefits related to X. Fortification of MSG is next in line. All three programs have very large BCR's, indicating economic gains to society from any of these programs. The social BCR of all the programs fluctuate widely between sexes and zones. This is due partially to the differential effectiveness rates for the fortification program, but mainly to the wide variation in private earnings of each cohort. Males in the rural coastal barrios had the highest age-earnings profile.

Sensitivity Analyses

Some of the assumptions upon which the empirical analysis was

TABLE 3

Benefit-Cost Ratios[a]

Cohort[b]	Private Benefit/Cost Ratios Capsule	Private Benefit/Cost Ratios PHI	Social Benefit/Cost Ratios Capsule	Social Benefit/Cost Ratios PHI	Social Benefit/Cost Ratios Fortification
Urban Squatter					
Males					
Age 1-6	569	157			
7-16	1005	271			
Both			696	16	83
Females					
Age 1-6	533	152			
7-16	918	258			
Both			640	15	83
Rural Coastal					
Males					
Age 1-6	978	256			
7-16	2008	554			
Both			1343	30	190
Females					
Age 1-6	358	100			
7-16	1026	280			
Both			603	14	86

[a]Discount rate = 8% for 25-year period

[b]Education will equal 5-7 years for all of these children

based are varied to understand the importance of each assumption.

The Discount Rate

Changes in the discount rate affect both the benefits and the costs although there is a bigger effect on the benefits. An increase or decrease of just 2% in the 8% can lead to significant changes.[18] In Table 4 it is shown that the social BCR for the PHI for urban squatter males drops from 26 to 10 with the increase in the discount rate from 6 to 10% (assumption 1). Similar changes occur for all the BCR. In no case does the BCR approach unity.

The Effectiveness Parameter M

It is most useful to examine the effects of the effectiveness parameter to see how small it would have to be to equate benefits and costs. For both private and social BCR's for the squatter and coastal male and female cohorts with 5-7 years of education, the largest effectiveness parameter needed to have benefits equal to costs is 7.1% for the social benefits and costs for females in the coastal zone. It is unlikely that the effectiveness of any program would be that low. Most of the effectiveness parameters would have to be 1% or less. Only the PHI required an effectiveness parameter in the 1-7% range.

Mortality Rate Changes

It is assumed that the death rate (pd) for children with X was 15%. This was felt to be a conservative estimate below the death rates of 25-60% given by other persons who have studied X. Still the economic benefits of eliminating death are so large that an overestimate of pd would lead to a much larger BCR. The death rate was reduced to 5% and the social benefits were recalculated. Then the BCR for the PHI at 6, 8, and 10% discount rates was determined. The PHI was selected as it has the lowest BCR and its BCR would be the likely candidate for a figure below one. The reductions in the BCR were dramatic; however, none went below one. In Table 4 the urban squatter and rural coastal male cohorts whose education attainment will be 5-7 years are given.

Morbidity Effect Changes

A second assumption related to the economic benefits of eliminating X concerns the effects of morbidity caused directly by X. These economic effects were calculated as an increase in lifetime productivity of 5%. A reduction of this figure to 1% leads to a slight

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[18] At present a discount rate of 15% is used by the Philippine National Economic and Development Authority.

reduction in the social BCR's for the two male cohorts. These are reported in Table 4.

TABLE 4

Social Benefit Cost Ratios: The Effect Of Assumptions About Mortality Rates And Morbidity Effects For Public Health Internvention[a]

	Urban squatter discount rate			Rural coastal discount rate		
Assumption	6%	8%	10%	6%	8%	10%
				MALES		
1. No change	26	16	10	49	30	19
2. p_d = 5% X	16	9	7	28	17	11
2. Morbidity benefits (1%)	24	14	9	44	27	17
4. Both changes	10	6	4	17	11	7
5. m parameter if BCR = 1 (for 4)	.10	.10	.27	.06	.09	.16

[a]25-year period for cohorts with 5-7 years of education.

Combination of Changes

Considering the economic benefits for a pd = .05 X and the morbidity benefits equal to a 1% increase in productivity lowers the BCR but the lowest BCR is about 4 for a 10% discount rate. This would mean that the effectiveness parameter m for this cohort and program would have to eliminate and prevent X among 27% of the population for the BCR to equal one. This shows that the social benefits are greater than the social costs for the PHI under the most conservative assumptions.

In Figure 2 the BCR's for each discount rate for each set of assumptions are shown. The lines between the three discount rates are only given to make the trends clearer. The effect of discount rate increases tends to reduce the BCR more in the change from 6 to 8%. From 8 to 10% the BCR is declining but at a decreasing rate. Thus, further increases in the discount rate might not lead to large changes in the BCR.

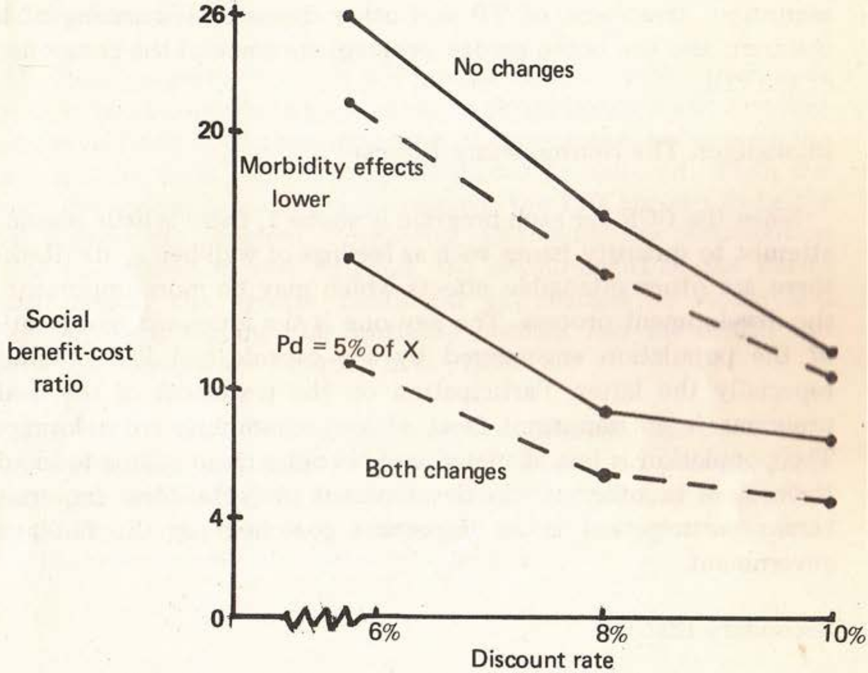

Figure 2. Sensitivity Analysis: Urban Squatter Males
Ed = 5 - 7 years

Other Considerations

Additional considerations include the benefits outside of eliminating X from each program, the intangible or nonmonetary effects, and certain general equilibrium or secondary effects.

Additional Benefits

The behavioral impact of the capsule and MSG fortification programs is limited to the increases in vitamin A intake. The capsule reaches only the target children while the fortification program will reach the entire household. Little work has been done on the impact of low vitamin A nutritional status of adults. Consequently, it is likely this will benefit them but we cannot say how. These additional benefits will be quite small in comparison to the Public Health Intervention. In the short run, this program will produce major changes in the health and nutritional status of the barrios it serves. The immunization of children, the cleaner water supply, better toilet sanitation, treatment of TB and other diseases, deworming of the children, and the home garden program are some of the components of the PHI.

Intangibles: The Nonmonetary Effects

Since the BCR for each program is above 1, there is little reason to attempt to quantify issues such as feelings of well-being, etc. Rather, there are other intangible effects which may be more important to the development process. The key one is the increased mobilization of the population engendered by the capsule and PHI programs, especially the latter. Participation on the treatment of the health programs is an important facet of any community's development. The population is less alienated and becomes more willing to involve themselves in other barrio development projects. Most important, barrio participation is an important goal held by the Philippine government.

Secondary Effects

This analysis has been based on partial equilibrium analysis. Changes in the relative prices of the various production factors have been ignored because they represent only a transfer effect.

The visibility of the PHI is important as this program is more likely to be associated with concurrent social changes. Quite possibly this will involve attitudinal changes which may lead to increased family planning. Demographers and other social scientists often argue that the low visibility and lack of social change involved with the malarial eradication and other mass public health campaigns for the past 3-5 decades did not lead to shift in social attitudes necessary for concomitant fertility declines.

V. Conclusions

The goal is the selection of the program which will be most meaningful to the Philippines. The benefit-cost ratio and the other important Filipino development priorities such as participation of local people and the development of "home gardens" have been discussed. The BCR can be viewed as a tool which converts the goal of maximization of economic benefit into a constraint that the BCR be greater than or equal to one. Then the broader developmental goals can be examined.

All three programs have BCR's greater than or equal to 4, even when the most conservative assumptions about benefits and discount rates are utilized. If the maximization of economic benefits were the sole goal, the mass capsule program should be selected. When the other developmental goals are considered, the PHI appears to be the most appropriate program. Considerations include the participation of the population in this program, the development of the Barrio Health Aides, the greater likelihood of changes in values and attitudes accompanying the mortality decline, and the health and nutritional benefits not included in the BCR.

Since the effects of xerophthalmia are so dramatic and the disease is so widespread and easy to prevent, it is easy to produce large benefit-cost ratios. For these reasons, xerophthalmia may be the first major nutritional problem eliminated in many low income nations since the reawakening of interest in nutrition.

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