THE ECONOMIC COSTS AND BENEFITS OF AN IMMUNIZATION PROGRAM IN INDONESIA

by

Howard N. Barnum*

CENTER FOR RESEARCH ON ECONOMIC DEVELOPMENT
The University of Michigan
Ann Arbor, Michigan 48108

Discussion Paper No. 89

January 1981

THE ECONOMIC COSTS AND BENEFITS OF AN IMMUNIZATION PROGRAM IN INDONESIA

by

Howard N. Barnum*

* * * * * * * *

*This study was conducted with the support of the United States Agency for International Development. The author is grateful for the advice and cooperation of Daniel Tarantola and I. Setiady.

THE ECONOMIC COSTS AND BENEFITS OF AN IMMUNIZATION PROGRAM IN INDONESIA

by Howard N. Barnum

TABLE OF CONTENTS

ABSTRACT

This analysis illustrates that, in addition to the humanitarian benefits of reduced mortality and morbidity, an immunization program for diptheria, pertussis, tetanus and tuberculosis can be expected to yield tangible economic benefits that exceed the program costs. A separate examination was made of the DPT-TT and BCG components in the program. This examination reveals that, although the expected benefits of the BCG program may not be sufficient to cover costs when operated independently, the BCG program is strongly justifiable on economic grounds (assuming a vaccine efficacy of .5) when included as part of a larger innoculation program. The analysis provides an example of a program where the delivery of multiple vaccines makes it possible to include component vaccinations which, given individually, may not be economically justifiable.

RESUME

Cette analyse montre qu'en surcroit des bénéfices de type humanitaire qu'impliquent une mortalité et morbidité réduites, un programme de vaccination contre la diphtérie, la coqueluche, le tétanos et la tuberculose peut produire une série annuelle de bénéfices tangibles excédant la série annuelle des côuts du programme. Les éléments DPT-TT et BCG du programme ont été éxaminés séparement. Cet examen révèle qu'alors que les bénéfices attendus du programme BCG puissent n'être pas suffisants pour en couvrir les frais quand ce programme est mis en oeuvre indépendemment, le même programme est trés justifiable du point de vue économique (en partant de l'hypothèse d'un taux d'éfficacité de vaccination de 0,5), lorsqu'il est inclus dans un programme de vaccination plus élargi. Cette analyse fournit un exemple d'un programme ou l'administration de vaccins multiples rend possible l'inclusion d'éléments d'immunisation qui, d'eux-mêmes, pourraient ne pas être économiquement viables.

LIST OF TABLES

Introduction

This paper gives an assessment, through an application of cost-benefit analysis, of the economic merits of an Expanded Immunization Program in Indonesia.[1] The first in a series of immunization programs against childhood diseases in developing countries, this program is to be carried out by the World Health Organization in conjunction with host countries and bilateral donor agencies. Its objective is to reduce infant and child morbidity and mortality, by expanding the present national BCG immunication program to cover a larger proportion of the population and to include immunization for diptheria, whooping cough and tetanus. The program entails the delivery of BCG[2] (tuberculosis) and DPT (diptheria, pertussis, tetanus) vaccinations in two visits during the first year of life, and TFT (tetanus) vaccinations of pregnant women. In addition, BCG vaccinations are to be given to children entering and leaving school.[3]

A five-year period, beginning with the fiscal year 1979-1980, is anticipated for the planning and analysis of the project. The estimates of the morbidity and mortality impact are, therefore, conservative because, if the program is continued longer than five years, DT boosters for children entering school would give extended immunity that is not included in these calculations. In addition, the estimates include only the direct effects of immunization and omit the effects of extended community protection as a result of reduced transmission.

The estimates are also conservative because, in order to simplify our calculations, we have omitted the impact of the BCG immunization of children completing school and the effect of TFT on maternal morbidity and mortality. The effects of these omissions are probably negligible, since the incidence of tetanus in women of childbearing age is low[4] and the number of children completing school is also small.

1/ The analysis was conducted with the support of the United States Agency for International Development. However, the content of the paper remains the sole responsibility of the author.

2/ Referred to as BCG I.

3/ Referred to as BCG II.

4/ Although post-partum tetanus, particularly in induced abortions, may be significant.

Given the paucity of available data, a number of assumptions have been made to facilitate the analysis. In some cases, we have extrapolated from data, available for specific regions on Java, to the entire country. Other information such as health service participation rates is highly subjective and derived from consultation with hospital and health ministry officials. Finally, hospital record surveys have been used in combination with other information in an attempt to reconstruct incidence and fatality rates. The difficulties in conducting this analysis with the available data are likely to be common in most developing countries, and demonstrate the strong need for a careful surveillance system to be incorporated into the early stages of an immunization project.

The paper provides an illustration in the use of investment analysis for a health care program. An important aspect of this illustration is the use of marginal cost-benefit analysis to examine the economic desirability of a component part in the total program. Often, health projects are comprised of an integrated set of sub-projects--any one of which may or may not be economically viable. The economic desirability of a given sub-program can be examined by considering the addition to benefits and costs attributable to individual sub-programs. Applied in this way, cost-benefit analysis can be an important tool in determining program composition.

The cost-benefit analysis is carried out by estimating whether, at the levels of disease incidence in Indonesia, the present value of the economic benefits from an immunization program will exceed the present value of the costs.[1] Because the vaccine efficacy and disease incidences

---

1/ Three alternative procedures are available for the analysis. First, we can calculate the net present value of the project as,

$$NPV = \sum_{t=o}^{T} \frac{B_t - C_t}{(1 + i)^t}$$

where B_t and C_t represent the benefits and costs attributable to the program at time t, and i represents the rate at which future benefits and costs are discounted. If the NPV is positive, the project is viable. Alternatively we can calculate the present value of the benefits and costs separately. If the ratio of benefits divided by costs is greater than one, the project is viable. As a third alternative, we can search for the value of i, called the internal rate of return (IRR), that produces a NPV of zero. If the IRR is greater than the prevailing interest rate, the project is viable. For a discussion of cost-benefit analysis, see Lyn Squire and H. Van der Tak, Economic Analysis of Projects, (Baltimore, Johns Hopkins Press), 1977.

differ considerably for BCG and DPT,[1] we examine the costs and benefits of the BCG and DPT components in the program separately, as well as looking at the total program's costs and benefits. This is done by considering the programs as if they were to be operated separately. Therefore, we consider the costs and benefits of the BCG program as if there were no DPT program. Likewise, we consider the costs and benefits of a DPT program carried out in the absence of a BCG program.

In addition, since most of the capital expenditures (cold chain and transportation) and a large part of the immunization delivery system are used in common by both program components, the sum in the costs of operating both programs separately is greater than the cost of the proposed joint program. It is, therefore, of interest to compare the costs and benefits of the component programs considered as marginal. That is, we ask the question "Given an operating DPT program, would the added benefits, derived from the additional cases and deaths prevented, exceed the costs of adding a BCG program?" The question is of interest, since an immunization program that is not economically viable in itself, may become viable when considered as an additional or marginal component to an existing program.

To review, there will be a total of four cost-benefit analyses, (1) the total program, (2) DPT only, (3) BCG only, and (4) BCG marginal. Other analyses are possible; for example, one could look at the cost effectiveness of TFT or DPT as separate and marginal programs. However, the four analyses chosen are sufficient to provide an example of the marginal cost-benefit approach to program evaluation.

To conduct the analyses, information is needed on program impacts in cases and deaths prevented for each disease, the costs of the program and the economic benefits of disease reduction.

1/ DPT refers here and in the following analyses to both the DPT and TFT immunizations.

A. Cases and Deaths Prevented by the Immunization Program

Estimates of the program's impact in meeting the objective of reducing child mortality and morbidity are given in Table I. These estimates[1] indicate that a total of 254,200 deaths would be prevented by the five-year program. Epidemiological refinements are omitted and it is assumed that the trends of disease are constant. The analysis, therefore, includes only the direct effect of the immunizations and omits any epidemiological protection which might be extended to non-immunized persons. The estimates are obtained by tracking immunized cohorts over the life of the vaccine under consideration and accounting for survival, as well as the number of cases and deaths that would have occurred in the absence of immunization. Since present disease surveillance is insufficient to provide accurate estimates of initial disease incidence (attack rates) and case fatality rates, the table is based on a variety of sources and assumptions--including the use of rates observed in other tropical countries with similar population densities. An effort has been made to choose assumptions which will provide conservative estimates on the impact of the immunization program. Table II summarizes the assumptions underlying the analysis.

B. Program Costs

The economic costs are the incremental project expenditures minus the value of capital remaining at the end of the fifth project year. The costs of operating the BCG and DPT programs independently were obtained by estimating the portion of total expenditures, in various categories of the financial projections for the EPI project made by the Indonesian Ministry of Health, that would be necessary to operate the programs separately. Thus, for instance, the total cost of the cold chain and transport categories is included in both programs but vaccine costs, vaccine production development, syringes and other equipment are broken into components directly

---

1/ The calculations underlying Table I were carried out with D. Tarantola (WHO, Indonesia) and I. Setiady (Ministry of Health, Indonesia). Details of the calculations are presented in an appendix available from the author. The procedure for the computation of cases and deaths prevented follows R. Barlow, "Application of Health Planning Model in Morocco," International Journal of Health Services, Volume 6, Number 1, 1976, pp. 103-122.

Table I

Potential Number of Cases and Deaths Prevented
by the Immunization Program.

	DPT & TFT		BCG		Total	
Year	Cases	Deaths	Cases	Deaths	Cases	Deaths
1979-80	119,640	14,446	1,670	376	121,310	14,822
80-81	252,682	23,012	3,439	773	256,121	23,785
81-82	421,161	36,736	5,358	1,205	426,519	37,942
82-83	596,744	47,439	7,442	1,675	604,186	49,114
83-84	774,107	57,756	9,549	2,150	783,656	59,906
84-85	506,235	16,449	11,368	2,556	517,603	19,005
85-86	319,990	11,428	13,742	3,093	333,742	14,521
86-87	222,622	7,110	16,371	3,682	238,993	10,792
87-88	119,367	3,980	19,269	4,336	138,636	8,316
88-89			22,312	5,019	22,312	5,019
89-90			18,896	4,252	18,896	4,252
90-91			14,688	3,305	14,688	3,305
91-92			10,102	2,272	10,102	2,272
92-93			5,109	1,149	5,109	1,149
Total	3,332,908	218,356	159,315	35,844	3,492,223	254,200

Table II

Summary of Assumptions Underlying the Calculation of Cases and Deaths Prevented

I. Assumptions Related to Year of Program

Year	Number of Children Born[1]	Program Coverage in Total Population[2]			Program Effectiveness[3]					
		DPT-TFT	BCG I	BCG II	Diptheria	Pertussis[4] Age 0-1	Pertussis[4] Age 1-5	Tetanus	BCG I	BCG II
1979-80	5,800,000	.20	.59	.47	.190	.050	.10	.190	.295	.235
80-81	5,920,000	.28	.62	.50	.266	.070	.14	.266	.310	.250
81-82	6,040,000	.42	.67	.54	.399	.050	.21	.399	.335	.270
82-83	6,160,000	.50	.73	.58	.473	.125	.25	.475	.365	.290
83-84	6,280,000	.57	.73	.59	.542	.143	.29	.542	.365	.295

See following page for continuation of Table II.

Table II - Continued

II. Assumptions Related to Age[5]

Age	Probability of Surviving One Year	Attack Rates				Case Fatality Rates			
		Diptheria	Pertussis	Tetanus	Tuberculosis	Diptheria	Pertussis	Tetanus	Tuberculosis
0	.860	.0006	.40	.0175	.00055	.222	.0275	.6	.225
1	.968	.0021	.16	.0029	.00055	.204	.019	.2	.225
2	.968	.0009	.08	.0051	.00055	.176	.019	.2	.225
3	.968	.0010	.08	.0022	.00055	.143	.019	.2	.225
4	.968	.0011	.08	.0032	.00055	.093	.019	.2	.225

[1]Assumes a 2.5% population growth rate.

[2]As planned by program administrators, Indonesian Ministry of Health.

[3]Program effectiveness equals vaccine efficacy times program coverage. Vaccine efficacy is assumed to be .95 for diptheria, .8 for pertussis, .95 for tetanus and .5 for BCG.

[4]It is assumed that only .5 of all newborn children will be protected by the age of six months. The program effectiveness for the first year is therefore one half of the effectiveness in the 1 - 5 age group.

[5]The table is truncated at five years to save space. Actual table used was extended to age fifteen for tuberculosis. Rates are based on hospital records, morbidity surveys and judgment. The attack rate for tuberculosis increased for age groups above 5 from .00085 at age 5 to .0029 at age 15.

attributable to the separate programs. Estimated program costs for the separate and total programs are given in Table III.

C. Economic Benefits

It is widely recognized that cost-benefit analysis is difficult to apply to health projects because, although the costs are usually concrete, a substantial proportion, often a preponderance, of the benefits are intangible. For the present study, the intangible benefits include the incalculable value of life, the value of reduced suffering to the child whole illness is prevented, and the avoidance of the suffering, bereavement and anxiety of friends and family. Nevertheless, an analysis based only on the tangible and quantifiable benefits is useful since it forces the recognition of a substantial class of benefits - the economic benefits - which might otherwise be overlooked and that may be sufficient to cover tangible program costs. For the present study, these benefits include the avoidance of lost income through premature death, and the value of housewives time saved in the care of the sick.

1. Avoided treatment costs

The treatment costs include the costs of treatment by traditional means (jamu medicine), as well as medical care received through outpatient clinics or hospitalization. These costs represent an allocation of resources that would be unnecessary in the absence of the diseases considered. A 1976 study of the marketing and consumption of jamu medicine indicated that approximately 75% of all respondents would use jamu for medication in response to illness,[1] irrespective of whether or not modern medical care is also received. This indicates an expenditure in addition to jamu purchased for other purposes and that the additional expenditure would be 75 Rupiah (hereafter abbreviated Rp.) per symptom week (two weeks) for diptheria, pertussis and tetanus and 50 Rp. per symptom week (thirty weeks) for tuberculosis. The total traditional costs avoided are then obtained by multiplying 112.50 (= .75 x 75 Rp. x 2) times the number of DPT cases prevented, and 1125 (= .75 x 50 Rp. x 30) times the number of tuberculosis cases prevented.

1/ O. Roesnadi, W. Tahar, Y. Anwar, Report on the Marketing and Consumption of Jamu, P. T. Inscore, Indonesia, 1977, pp. 16-17.

The proportion of households using modern medical care was estimated[1] at 7%. The total modern medical costs avoided are obtained by the product of .07 times the number of cases prevented, times the cost of treatment. Modern treatment costs represent the costs of inpatient care for tetanus and diptheria, and outpatient care for tuberculosis and pertussis. The cost of inpatient care was obtained by multiplying the average length of stay[2] for tetanus and diptheria by the average daily cost[3] of pediatric hospital care for sick children. These costs include drugs, food, nursing, lab tests and doctors' salaries. The costs of outpatient care were obtained by the pricing of specific treatment regimes for pertussis and tuberculosis.[4] The resulting estimates are 45,000 Rp./case for diptheria, 6,000 Rp./case for pertussis, 55,000 Rp./case for tetanus and 49,000 Rp./case for tuberculosis.

2. Value of mothers time spent in home care

The inclusion of this benefit recognizes the economic role of women in the agricultural household. Accounts of the use of time over a calendar year indicate that the marginal product of both male and female labor may remain positive and substantial throughout the busy season during which planting or harvesting occurs. In the slack season, off-farm employment opportunities may exist for men but are often limited for women, as a consequence, the marginal value of female labor time falls severely. In the calculations used to derive the value of mothers time spent in home care,

---

1/ This figure was taken after discussions with health officials at the Indonesian Ministry of Health.

2/ An average length of stay is 13.2 days for tetanus and 10.7 days for diptheria.

3/ An initial estimate was obtained for the cost per patient day of operating sick child pediatric wards in Class A and two Class B hospitals. Since the majority of hospitals are of Class C and D and have substantially lower costs, the estimates were revised downwards by thirty percent. The final estimate of the average daily pediatric costs for all classes of hospitals is 5,600 Rp. The author is indebted to J. Lopez and G. Frester of the Indonesian Ministry of Health for the estimates of pediatric costs.

4/ The regimes and prices were outlined by Dr. Gunowiseso, Indonesian Ministry of Health. The costs reflect total real costs of the care rather than the subsidized cost to patients.

we have assumed that, given the two crop cycles in Indonesia, the busy season comprises approximately one-fourth of the calendar year.

Based on the results of a labor force participation survey, we have evaluated the mothers time at a shadow wage of one-half of the average wage during the busy season and one-fourth of the average wage during the slack season.[1] Assuming that the disease occurs randomly over the calendar year, the value of mothers time spent in care is:

$$(1/2 \quad 1/4 + 1/4 \quad 3/4)\ W \quad DL \quad C = .3215\ W\ DL\ C$$

where W is the average wage rate, DL is the average number of days lost in care per illness and C is the number of prevented cases. It is assumed that the total time spent in care is seven working days per case for tuberculosis and three working days per case for diptheria, pertussis and tetanus.

3. <u>Value of income derived from prevented mortality</u>

The discounted value of the expected lifetime earnings gives an estimate in the present value of the output lost through the premature death of an individual.[2] Since the early years of life, up to entrance in the labor force (assumed to occur at 12 years in Indonesia), are accompanied by outlays for the costs of child-rearing, it is possible that evaluated on the basis of monetary flows alone, the present value of the lifetime earnings would be small. However, if we assume that children are the result of a rational action on the part of the parents, then it can be argued that the value of children to the parents at least offsets the costs of child-rearing. There is, in fact, a strong argument that besides the consumption value of status and emotional attachment, children provide non-market household and farm labor, and security for old age. In Indonesia, which is primarily agricultural and where most of the population is not covered by any form of social security, these are important, rational reasons for

---

1/ The activity rates for females between 25 and 35 years of age are approximately .5 during the busy season and .3 during the slack season. See H. Redmana, H. Mori; and Daliyo, <u>Labor Force and Labor Force Utilization in Selected Areas in Java</u> Vol. 1, National Institute of Economic and Social Research, Indonesia, 1977, p. 77. The source for the wage rates is <u>Annual Labor Report 1977</u>, American Embassy, Jakarta. The projected wage rates assume a growth in the real wage of 2% per annum.

2/ Details of the calculation of the present income value derived from prevented mortality are discussed in the appendix to the paper cited in footnote 1.

parents to perceive the benefits of children as more than offsetting the costs of childhood. By omitting the costs in the early childhood years before entrance into the labor force, we in effect partially quantify an important quasi-tangible benefit and move it into the economic benefit category.

Accepting the argument above, the expected present value of lifetime earnings derived from prevented deaths attributable to the immunization program can be calculated. The calculations are based on an age-earnings profile which assumes that the average child enters the labor market at the age of twelve and receives an entering income of approximately one-fourth the national average. His expected income then increases with maturity and gains in productivity up to the national average at age 20. Assuming a horizon of age 55, his income will continue to increase and gain in productivity (assumed to be .04 per year) from age 20 to 55.[1] A discount rate of .15 has been used and a correction has been made for the probability of survival from the early years of childhood to entrance in the labor force.

By using the national average income, an adjustment is implicitly made for the possibility of unemployment or underemployment. The assumption is that infections are approximately random and a child whose death is prevented may grow up to be unemployed, underemployed or a highly productive member of society with probabilities that are exactly reflected by the present distribution of income.

D. Results of the cost-benefit analysis

The four cost-benefit analyses are summarized in Table III. Analysis #1 provides a comparison between the costs and benefits of the total five year program. At a discount rate of 15%,[2] the present value of the planned expenditures for the five year program is 9,309 ($\times 10^6$) Rp. while the present

---

1/ The four percent gain in productivity has been used in other recent projections of Indonesian wages. To the extent that this is over optimistic, the economic benefit of prevented deaths will be overestimated.

2/ A discount rate of 15-18% has been used in other recent cost-benefit studies in Indonesia. This range appears to approximate the present opportunity cost of capital in Indonesia. Because the choice of discount rate is, to some extent, arbitrary, the results of using discount rates of 15% and 20% are also given in the tables. It can be seen that the conclusions are relatively insensitive to the rates chosen.

Table III
Cost-Benefit Analysis of Indonesian Immunization Program
(Rp. x 10^6)

	Total Immunization Program (DPT-TFT & BCG)		DPT-TFT Program only		BCG Program only		BCG as an added Program	
Year	Costs	Benefits[1]	Costs[2]	Benefits[1]	Costs[2]	Benefits[1]	Costs[3]	Benefits[1]
1979-80	2541	1400	2268	1328	1388	72	273	72
80-81	2654	2486	2384	2319	1457	167	270	167
81-82	2943	4228	2641	3936	1531	291	302	291
82-83	3379	6378	3052	5927	1785	450	327	450
83-84	3623	7795	3267	7148	1817	646	356	646
84-85	-1332[4]	3716	-1311[4]	2649	-1217[4]	1067	-21[4]	1067
85-86		4183		2555		1628		1628
86-87		4092		1836		2256		2256
87-88		4098		1144		2954		2954
88-89		3104				3104		3104
89-90		3305				3305		3305
90-91		2667				2667		2667
91-92		1901				1901		1901
92-93		997				997		997
Net Present Value								
at 10%	17089		9326		3615		7761	
15%	12196		7156		1322		5040	
20%	8903		5555		0		3347	
Benefit-Cost Ratio								
at 10%	2.8		2.0		1.7		7.9	
15%	2.3		1.9		1.3		6.1	
20%	2.1		1.8		1.0		4.8	
Internal Rate of Return	100%		108%		20%		79%	

1/ This is the undiscounted value of total benefits accruing to the program in the column heading.

2/ This represents the cost of operating a BCG program without a DPT program (or conversely for column three). The costs of operating the two programs separately do not add up to the costs of the total program since much of the total costs are for shared expenditures.

3/ This represents the added cost if a BCG program is considered as additional to a DPT program.

4/ Value of capital remaining at the end of five years.

value of benefits is 21,505 (x10^6) Rp. This gives a benefit/cost ratio of 2.3 and a net present value of 12,196 (x10^6) Rp. ($27.6 million). The internal rate of return (IRR) is 100%. Even when costs are increased by 25% and benefits decreased by 33%, the ratio of benefits to costs remains greater than one and the net present value is positive. Clearly, the total project is economically viable and desirable; the economic returns to the immunization program are more than sufficient to offset the program costs.

Looking at the separate immunization components of the total program, we see with analysis #2 that the benefit-cost ratio for DPT-TFT immunization operated as a separate program is 1.9 with an internal rate of return of 108%. The DPT-TFT program is, therefore, economically sound when operated separately.

The same is not true, however, of BCG immunization as a separate program. Analysis #3 indicates that if the BCG program was operated independently, the benefit-cost ratio (again using a 15% discount rate) would be 1.3, and the IRR of return would be 20%. This result will not withstand a sensitivity test. With a 25% increase in costs and 33% decrease in benefits, the cost-benefit ratio is substantially less than one, and the IRR is less than 15%.

The BCG program is, however, capable of generating economic benefits that exceed the costs of adding BCG immunization to an ongoing DPT-TFT program. When BCG is viewed as an added or marginal program, the ratio of incremental benefits to incremental costs is 6.1 and the IRR is 79%. Thus, it is found that a program which is not economically viable by itself becomes viable when added as one component of a larger immunization program. This result suggests that once the expenditures for cold chain and delivery system have been made, the addition of other immunization programs, such as polio and measles, that may not be economically justifiable when operated separately, may be warranted on the basis of cost-benefit analysis.

APPENDIX

Page

NOTE TO TABLES A - E

THE ESTIMATION OF CASES AND DEATHS PREVENTED

The number of cases in each age cohort for each year is found by multiplying the number of children in the cohort at the time of immunization, by program effectiveness, times the appropriate attack rate and then, by the probability of survival from the initial age of immunization to the year under consideration. The number of deaths is found by multiplying the number of cases by the appropriate case fatality rate. The estimates include only the direct effect of immunization and are not based on an epidemiological model. The estimates, therefore, assume that the trends of disease are constant. This may introduce errors for diptheria, where the relationship between faucial and skin diptheria and environmental factors may be quite complicated. It is considered of less importance for pertussis and tetanus. No adjustment has been made in any of the tables for the possibility of a decrease in vaccine efficacy due to malnutrition.

TABLE A-1 DIPHTHERIA

Number of cases and deaths of faucial Diphtheria
prevented (by year of prevented occurence)

	AGES 0 - 1		1 - 2		2 - 3		3 - 4		4 - 5		0 - 5	
YEARS	C	D	C	D	C	D	C	D	C	D	C	D
1979-80	595	132									595	132
80-81	850	189	1,805	368							2,656	557
81-82	1,302	289	2,580	526	825	145					4,706	960
82-83	1,580	351	3,948	805	1,179	207	877	125			7,584	1,489
83-84	1,837	408	4,794	978	1,804	318	1,273	179	980	91	10,668	1,974
84-85			5,571	1,137	2,190	386	1,917	274	1,401	130	11,080	1,927
85-86					2,546	448	2,328	333	2,144	199	7,018	980
86-87							2,706	387	2,603	242	5,308	629
87-88									3,025	281	3,025	281
TOTAL	6,164	1,328	18,699	3,815	8,544	1,504	9,081	1,299	10,152	944	52,640	8,929

NOTE: This is an estimate of the number of cases (and deaths) prevented during the first five years of life. The estimate omits the benefits of additional protection beyond five years of age. The table therefore underestimates the benefits provided by the program. The underestimation is small, however, since the attack rate for ages greater than five is negligible.

TABLE A-2

ASSUMPTIONS UNDERLYING THE CALCULATION OF DIPHTHERIA
Cases and Deaths Prevented

Assumptions Related to Year of Program[1]				Assumptions Related to Age			
Year of Program	Number of Children Born	Program Coverage in Total Population	Program Effectiveness	Age	Probability of Surviving one year	Attack Rate[2]	Case Fatality rate[3]
1979-80	5.800.000	.20	.190	0	.860	.0006	.222
80-81	5.590.000	.28	.266	1	.968	.0020	.204
81-82	6.040.000	.42	.399	2	.968	.0009	.176
82-83	6.160.000	.50	.475	3	.968	.0010	.143
83-84	6.280.000	.57	.542	4	.968	.0012	.093

[1]Assumes a vaccine efficacy of .95, Program effectiveness equals vaccine efficacy times program coverage.

[2]See Table A-3 for a derivation of the attack rate for diphtheria.

[3]Hospital Record Survey 1971 - 1978, I.M.O.H.

TABLE A-3

DISTRIBUTION OF DIPTHERIA CASES

AGE GROUPS	Proportional distribution of faucial diptheria cases	Age specific Schick Test Neg. Rate	Expected Number of children in a pop. of 10,000 of the 0-4 age group	Number of diptheria infections in each age group/10.000	Number of cases of faucial diph. per 10,000 in each age-group	Age specific attack rate for faucial Diptheria
0 - 1	.13	.074	2,337	173	1,469	0.000628
1	.35	.200	2,010	402	3,955	0.001968
2	.16	-.090	1,946	175	1,808	0.000929
3	.17	.097	1,884	183	1,921	0.001020
4	.19	.108	1,823	197	2,147	0.001178
0 - 4	100%	By Age 5: 0.57	10,000	1,130	11,300	0.001130

1%

TABLE B-1 PERTUSSIS

Number of cases and deaths prevented (by year of prevented occurence)

Years	0 – 1		1 – 2		2 – 3		3 – 4		4 – 5		TOTAL	
	C	D	C	D	C	D	C	D	C	D	C	D
1979–80	99760	2743									99760	2743
1980–81	142554	3920	77254	1468							219808	5388
1981–82	218165	5999	110394	2097	37391	710					365950	5806
1982–83	264880	7284	168947	3210	53430	1015	36194	688			523451	12197
1983–84	307846	8466	205123	3897	81770	1554	51721	983	35036	666	681496	15566
1984–85			238396	4530	99280	1886	79154	1504	50066	951	466896	8871
1985–86					115383	2192	96103	1826	76621	1456	288107	5474
1986–87							111691	2122	93027	1768	204718	3890
1987–88									108117	2054	108117	2054
TOTAL	1033205	28412	800114	15202	387254	7357	374863	7123	362867	6895	2958303	64989

Note: This is an estimate of the number of cases (and deaths) prevented during the first five years of life. The estimate omits the benefits of additional protection beyond fove years of age. The table therefor underestimates the benefits provided by the programme. The underestimation is small however since the attack rate for ages greater than five is negligible.

TABLE B-2

ASSUMPTIONS UNDERLYING CALCULATION OF PERTUSSIS
Cases and Deaths Prevented

Assumptions related to year of program[1]					Assumptions related to age			
Year of Program	Number of Children born	Program Coverage	Program Effectiveness, Age 0-1	Program Effectiveness, Age 1-5	Age	Probability of surviving one year	Attack Rate[2]	Case Fatality Rate[3]
1979-80	5.800.000	.20	.05	.10	0	.860	.40	0.0275
80-81	5.920.000	.28	.07	.14	1	.968	.16	0.019
81-82	6.040.000	.42	.105	.21	2	.968	.08	0.019
82-83	6.160.000	.50	.125	.25	3	.968	.08	0.019
83-84	6.280.000	.57	.1425	.285	4	.968	.08	0.019

[1]It is assumed that only 50% of all newborn children will be protected by the age of six months. The program effectiveness for the first year is therefore one half the effectiveness in the 1 - 5 age group.
-- Vaccine efficacy: estimated 50% as the immunization schedule is based on only two consecutive shots.

[2]Indonesian Ministry of Health, Communicable Disease Center.
-- It has been assumed that children can only be affected once with pertussis during the first five years of their life.

[3]Approximated by reference to a study in Kenya by David Morley, which indicates that approximately 60% of all pertussis mortality occurs in the first year, and by reference to a Hospital Record Survey, Indonesian Ministry of Health, 1976.

TABLE C-1 TETANUS[1]

Number of cases and deaths prevented (by year of prevented occurence[2])

	0 - 1		1 - 2		2 - 3		3 - 4		4 - 5		0 - 5	
	C[3]	D	C	D	C	D	C	D	C	D	C	D
1979-80	19.285	11.571									19.285	11.571
80 - 81	27.558	16.535	2.660	532							30.218	17.067
81 - 82	42.174	25.304	3.802	760	4.529	906					50.505	26.970
82 - 83	51.205	30.917	5.818	1.164	6.472	1.294	1.891	378			65.709	33.753
83 - 84	59.566	35.740	7.108	1.422	9.904	1.981	2.702	540	2.663	533	81.943	40.216
84 - 85			8.217	1.643	12.101	2.420	4.136	827	3.805	761	28.259	5.651
85 - 86					13.989	2.798	5.053	1.011	5.823	1.165	24.865	4.974
86 - 87							5.841	1.163	7.115	1.423	12.956	2.591
87 - 88									8.225	1.645	8.225	1.645
T O T A L	200.111	120.067	27.605	5.521	46.995	9.399	19.623	3.924	27.631	5.527	321.965	144.438

Note: See attached notes on table B-1

TABLE C-1
continued

[1]This is an estimate of the number of the cases (and deaths) prevented during the first five years of life. The estimate omits the benefits of additional protection beyond five years of age. An estimate of the number of the cases and deaths prevented in a woman of a fertile age is also omitted. The table therefore underestimates the benefits provided by the program.

[2]In the case of Tetanus neonatorum, prevention is achieved through immunization of pregnant women, while prevention of non-neonatal infant tetanus (29 days - 1 year) is achieved through immunization of infants. The programme coverage rate used in the calculation is that of the year in which the birth occured. In fact, the mother may have been immunized in the year preceeding the infant immunization, thus with a different coverage rate. To simplify the calculation, an approximation has been made in using one single coverage rate for each first year of life while, in fact, two should have been used: one corresponding to tetanus neonatorum prevention, the other to non-neonatorum infant Tetanus prevention.

[3]The number of Tetanus cases prevented in first year of life has been calculated using the number of live births as the denominator disregarding whether tetanus neonatorum or non-neonatorum infant tetanus was considered. However, survival rates have been applied as of the 2nd year of life. The denominator used for 1 - 2 year old children is:

Number of live births x .86 x .986 = Survivors 2nd year of life.

TABLE C-2

ASSUMPTIONS UNDERLYING THE CALCULATION OF CASES AND DEATHS PREVENTED

Assumption Related to Year of Program				Assumption Related to Age			
Year of Program	Number of Children born[1]	Program Coverage[2]	Program Effectiveness[3]	Age	Probability of Surviving one year[4]	Attack Rate[5]	Case Fatality Rate[6]
1979-80	5.800.000	.20	.190	0	.860	.0175	.6
80-81	5.920.000	.28	.266	1	.968	.0029	.2
81-82	6.040.000	.42	.399	2	.968	.0051	.2
82-83	6.160.000	.50	.475	3	.968	.0022	.2
83-84	6.280.000	.57	.542	4	.968	.0032	.2

[1]Assumes a 2.0% growth rate.

[2]Programme coverage as a proportion of total children born.

[3]Programme efficiancy = coverage x vaccine efficacy; vaccine efficacy is .95

[4]Infant mortality rate is 140/1000; Probability of surviving for other ages is approximated from U.S. Department of Commerce, Levels and Trends of Mortality in Indonesia 1961 to 1977, International Research Document No. 2, October 1975, p. 9.

[5]see Table C-3 for derivation of the age specific attack rates.

[6]Based on Hospital records, Communicable Diseases Center, Indonesian Ministry of Health, 1976.

TABLE C-3

CALCULATIONS TO ESTIMATE ATTACK RATE FOR TETANUS FROM AVAILABLE DATE[1]

Age Group	Proportion of total tetanus cases in each age group[2]	Population in age group/ 100.000[3]	Number of cases/ 100.000	Age Specific Attack Rate
0 - 1	.21	4.000	70	0.0175
1 - 2	.03	3.440	10	0.0029
2 - 3	.05	3.330	17	0.0051
3 - 4	.02	3.223	7	0.0022
4 - 5	.03	3.120	10	0.0032
> 5	.66	82.887	219	0.0026
Total	1.00	100.000	333	

[1]The birth rate is estimated to be approximately 4000/100.000 total population. Given an estimate[4] of neonatal tetanus of 15/1000, the number of cases of neonatal tetanus per 100.000 population will be 60 (=.015 x 4.000). Neonatal tetanus is estimated to be .18 of all tetanus, therefore the total number of cases of tetanus per 100.000 population is 333 (= 60: .18).

The number of cases per 100.000 total population (column 4) is estimated by multiplying the proportion of total tetanus cases in each age group (column 2) by 333.

[2]Hospital Record Survey, reported in unpublished Indonesian Government document, 1976. The use of a hospital survey may imply an underestimate of neonatal tetanus.

[3]Model Life Table.

[4]Indonesian Communicable Diseases Center, From a survey of Central Java, 1972.

Table D-1 TUBERCULOSIS, BCG I

Number of Cases and Deaths Prevented – Tuberculosis, BCG I
(by year of prevented occurance)

ear	Age 0 – 1		Age 1 – 2		Age 2 – 3		Age 3 – 4		Age 4 – 5		Age 5 – 6		Age 6 – 7		Age 7 – 8		Age 8 – 9		Age 9 – 10		TOTAL	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
9-80	809	182																			809	182
0-81	868	195	783	176																	1.651	371
1-82	957	215	840	189	758	171															2.555	575
2-83	1.063	239	926	208	813	183	734	165													3.536	795
3-84	1.084	244	1.029	232	897	202	787	177	711	160											4.508	1.015
4-85			1.050	236	996	224	868	195	762	171	704	158									4.380	984
5-86					1.016	229	965	217	840	189	755	170	1.078	243							4.654	1.048
6-87							983	221	934	210	833	187	1.157	260	1.069	241					4.976	1.119
7-88									952	214	925	208	1.275	287	1.146	258	1.059	238			5.357	1.205
8-89											943	212	1.417	319	1.264	284	1.136	256	1.050	236	5.810	1.307
9-90													1.445	325	1.404	316	1.253	282	1.126	253	5.228	1.176
0-91															1.432	322	1.392	313	1.241	279	4.065	914
1-92																	1.419	319	1.379	310	2.798	629
2-93																			1.406	316	1.406	316
	4.781	1.075	4.628	1.041	4.480	1.009	4.337	975	4.199	944	4.160	935	6.372	1.434	6.315	1.421	6.259	1.408	6.282	1.394	51.733	11.636

TABLE D-2

ASSUMPTIONS UNDERLYING ESTIMATES OF THE NUMBER OF CASES AND DEATHS PREVENTED

Assumptions Related to year of program[1]				Assumptions Related to Age			
Year of Program	Number of Children born	Program Coverage	Program Effectiveness	Age	Probability of Surviving one year[2]	Effective-Attack Rate[3]	Case Fatality Rate[4]
1979-80	5.800.000	.59	.295	0	.860	.00055	.225
80-81	5.920.000	.62	.310	1	.968	.00055	.225
81-82	6.040.000	.67	.335	2	.968	.00055	.225
82-83	6.160.000	.73	.365	3	.968	.00055	.225
83-84	6.280.000	.73	.365	4	.968	.00055	.225
				5	.991	.00055	.225
				6	.991	.00085	.225
				7	.991	.00085	.225
				8	.991	.00085	.225
				9	.991	.00085	.225

[1]Vaccine efficacy is assumed = .5.

[2]Levels and Trends of Mortality in Indonesia 1961 to 1971, International Research Document No. 2, October 1975, p. 9.

[3]The effective attack rate = the infection rate x the percentage of infected cases that develop tuberculosis. For the 0 - 5 age group the infection rate is .011; for the 6 - 10 age group the infection rate is .017; for the 11 - 15 age group the infection rate is .058. The percentage of infections developing the disease is .05 for all age groups. Source: Indonesian Ministry of Health, Communicable Diseases Center.

[4]Indonesian Ministry of Health, Communicable Disease Center.

Table E-1 TUBERCULOSIS, BCG II

Number of Cases and Deaths Prevented - Tuberculosis, BCG II
(by year of prevented occurence)

YEAR	Age 6 - 7		Age 7 - 8		Age 8 - 9		Age 9 - 10		Age 10 - 11		Age 11 - 12		Age 12 - 13		Age 13 - 14		Age 14 - 15		Age 15 - 16		TOTAL	
	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1979 - 1980	861	194																			861	194
1980 - 1981	935	210	853	192																	1.788	402
1981 - 1982	1.030	232	927	209	846	190															2.803	631
1982 - 1983	1.129	254	1.021	230	918	207	838	189													3.906	880
1983 - 1984	1.170	263	1.118	252	1.012	228	910	205	831	187											5.041	1.135
1984 - 1985			1.160	261	1.108	249	1.003	226	905	203	2.814	633									6.988	1.572
1985 - 1986					1.149	259	1.098	247	995	224	3.055	687	2.791	628							9.088	2.045
1986 - 1987							1.139	256	1.090	245	3.366	757	3.031	682	2.769	623					11.395	2.563
1987 - 1988									1.130	254	3.688	830	3.340	752	3.007	677	2.747	618			13.912	3.131
1988 - 1989											3.824	860	3.658	823	3.313	745	2.982	671	2.725	613	16.502	3.712
1989 - 1990													3.794	854	3.629	817	3.286	739	2.959	666	13.668	3.076
1990 - 1991															3.763	847	3.600	810	3.260	734	10.623	2.391
1991 - 1992																	3.733	840	3.571	805	7.304	1.645
1992 - 1993																			3.703	833	3.703	833
TOTAL	5.125	1.153	5.079	1.144	5.033	1.133	4.988	1.123	4.949	1.113	16.747	3.767	16.614	3.739	16.481	3.709	16.348	3.678	16.218	3.649	107.582	24.208

TABLE E-2

ASSUMPTIONS UNDERLYING ESTIMATES OF THE NUMBER OF CASES AND DEATHS PREVENTED

Assumptions Related to Year of Program				Assumption Related to Age			
Year of Program	Number of Children 6-7 years[1]	Program Coverage[2]	Program Effectiveness[3]	Age	Probability of Survival to next year	Effective Attack Rate[4]	Case Fatality Rate[5]
1979-80	4.350.000	.47	.235	6	.991	.00085	.225
80-81	4.440.000	.50	.250	7	.991	.00085	.225
81-82	4.530.000	.54	.270	8	.991	.00085	.225
82-83	4.620.000	.58	.290	9	.991	.00085	.225
83-84	4.710.000	.59	.295	10	.992	.00085	.225
				11	.992	.0029	.225
				12	.992	.0029	.225
				13	.992	.0029	.225
				14	.992	.0029	.225
				15	.992	.0029	.225

[1] 3% of Projected Population.

[2] Corrected for the fact that only .8 of all children enter school.

[3] Vaccine efficacy = .5.

[4] See footnote three on table D-2.

[5] See footnote three on table D-2.

Table F-1 BENEFITS

Value of Treatment Costs Avoided by Immunization Program (Rp. x 10^6)

Year	DPT Program			BCG Program			Total Program		
	Medical Treatment	Traditional Self Medication	Total	Medical Treatment	Traditional Self Medication	Total	Medical Treatment	Traditional Self Medication	Total
1979-80	118.0	13.5	131.5	5.7	1.9	7.6	123.7	15.3	139.0
80-81	217.0	28.4	245.4	11.8	3.9	15.7	228.8	32.3	261.1
81-82	363.0	47.4	410.4	18.4	6.0	24.4	381.4	53.4	434.8
82-83	496.7	67.1	563.8	25.5	8.4	33.9	522.2	75.5	597.7
83-84	635.3	87.1	722.4	32.8	10.7	43.5	668.1	97.8	765.9
84-85	340.0	57.0	397.0	39.0	12.8	51.8	379.0	69.7	448.7
85-86	238.8	36.0	274.8	47.1	15.5	62.6	285.9	51.5	337.4
86-87	152.6	25.0	177.6	56.2	18.4	74.6	208.8	43.5	252.3
87-88	86.6	13.4	100.0	66.1	21.7	87.8	152.7	35.1	187.8
88-89				76.5	25.1	101.6	76.5	25.1	101.6
89-90				64.8	21.3	86.1	64.8	21.3	86.1
90-91				50.4	16.5	66.9	50.4	16.5	66.9
91-92				34.6	11.4	46.0	34.6	11.4	46.0
92-93				17.5	5.7	23.2	17.5	5.7	23.2
Total	2648.0	374.9	3022.9	546.5	179.2	725.7	3194.5	554.1	3748.6

Table F-2

Projection of Daily Real Wage Rates[1]
(Rupiah/day)

Year	Real Wage[1]	Shadow Wage Rate for Female Labor[2]
1979-80	360	113
80-81	367	115
81-82	374	117
82-83	382	119
83-84	389	122
84-85	397	124
85-86	405	127
86-87	413	129
87-88	421	132
88-89	430	134
89-90	438	137
90-91	447	140
91-92	456	143
92-93	465	145

[1] The real wages are derived from a baseline estimate of 313 Rp./day in 1972 and an assumption of a 2% per year growth in the real wage. The wage estimates are derived from an urban survey. Because wages tend to be higher in urban areas these figures provide an overestimate of the average national wage. Source: Annual Labor Report, American Embassy, Jakarta, June 1977, p. 18.

[2] The shadow wage is calculated as .3125 times the real wage. See the discussion in the text for an explanation of the correction factor.

Table F-3

Value of Avoided Loss of Mothers Time Spent in Care of Sick Children (Rp. x 10^6)

Year	DPT[1]	BCG[2]	Total
1979-80	40.6	1.1	41.7
80-81	87.2	2.4	89.5
81-82	147.8	3.8	151.6
82-83	213.0	5.3	218.4
83-84	283.3	7.0	290.3
84-85	188.3	8.5	196.8
85-86	121.9	10.5	132.4
86-87	86.2	12.7	98.8
87-88	47.3	15.3	62.5
88-89		17.9	17.9
89-90		15.5	15.5
90-91		12.3	12.3
91-92		8.7	8.7
92-93		4.4	4.4
Total	1,215.5	125.4	1,340.9

[1] Assumes 3 days lost per illness.

[2] Assumes 6 days lost per illness.

Table F-4

Value of Lifetime Earnings from Deaths Prevented[1]
(Rp. x 10^6)

Year	DPT	BCG	Total
1979-80	1,155.7	63.3	1,219.0
80-81	1,986.0	149.1	2,135.1
81-82	3,378.1	263.0	3,641.1
82-83	5,150.4	411.2	5,561.6
83-84	6,142.6	595.8	6,738.4
84-85	2,604.0	1,006.5	3,610.5
85-86	2,158.3	1,554.8	3,713.1
86-87	1,571.9	2,168.7	3,740.6
87-88	996.8	2,850.5	3,847.3
88-89		2,984.5	2,984.5
89-90		3,203.2	3,203.2
90-91		2,587.3	2,587.3
91-92		1,845.8	1,845.8
92-93		969.1	969.1
Total			

[1] The values in the table represent $\sum_a V_{ax} \cdot D_{ax}$ where a is the age at which death is prevented, x is the year in which the death is prevented, V is the present value of the stream of lifetime earnings and D is the number of deaths prevented in age group a in year x.

Table F-5

Discounted Present Value of Lifetime Earnings for an average surviving child in 1979-80[1] in age groups 0 through 15

Age of Prevented Death	V_a (Rp. x 10^3)
0	80
1	109
2	129
3	154
4	183
5	216
6	251
7	291
8	338
9	392
10	455
11	531
12	609
13	595
14	573
15	550

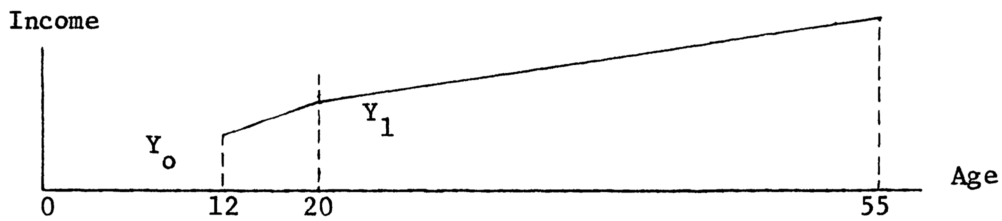
[1]The values at each age in years subsequent to 1979-80 can be corrected for increases in productivity by multiplying the values in table F-5 by $e^{.04x}$ where x is the number of years after 1979-80 in which the death is prevented. This correction was made to the entries in Table F-4.

Note to Table F-4 & F-5

Value of Income Derived From

Prevented Mortality

I. The age earnings profile used in the calculation of the present value of life-time earnings appears as:



The following assumptions have been made:

1) Costs of child rearing before age 12 are offset by the consumption benefits to parents.

2) At 12 the child enters the labor market at income Y_o

3) From age 12 to age 20 income increases at a rate of r_1 both from gains in productivity and experience up to a national norm for labor at age age 20, Y_1

4) From 20 to 55 income increases with productivity at rate r_2 (assumed= .04)

5) Y_o is assumed to be 20,000 Rp./yr[1].

6) Y_1 is assumed[1] to be (80,000 Rp./yr.) . $e^{.04(8)}$ = 110,170 Rp./yr.

(That is using the average income for 1976 of approximately 80,000 Rp./yr and assuming gains in productivity of .04 per year the national average income will be 101,700 Rp./yr. by the time the new entrant, who is presently 12, reaches full income at age 20.)

7) r_1 = .213 (growth rate implied by Y_o, Y_1)

8) i = .15

9) The probability of survival at time t between 12 and fifty five is approximated by $e^{.0008\,t}$. (More precisely $e^{.0008\,t}$ is the probability density function and .0008 is the force of mortality at time t.)[2]

II. From the point of view of a child of age 12 in 1979-80 the expected present value of lifetime earnings can be broken into two components, the first derived from the discounted stream of earnings between 12 and 20,

$$V_I = Y_o \int_0^8 e^{r_1 t} \cdot e^{-it} \cdot e^{-.0008t} \cdot dt$$

$$= 20000 \int_0^8 e^{.0622t} \cdot dt = \frac{20000}{.0622} \left[e^{.0622\,t} \right]_0^8$$

$$= 207321 \text{ Rp.}$$

and the second derived from the discounted stream of earnings between 20 and 25

$$V_{II} = Y_1 \int_8^{43} e^{r_2 t} \cdot e^{-it} \cdot e^{-.0008t} \cdot dt$$

$$= 110\ 170 \int_8^{43} e^{-.1108t} \cdot dt = \frac{110170}{-.1108} \left[e^{-.1108t} \right]_8^{43}$$

$$= 608635 \text{ Rp.}$$

The value of the stream of lifetime earnings at age 12 in 1979-80 is thus:

$$V_{12}\ (1979\text{-}80) = V_I + V_{II} = 608635 \text{ Rp.}$$

III. The value of lifetime earnings for other ages between 12 and 20 is obtained similarly to V_{12} after a suitable change of the limits of integration.

IV. The expected present value of lifetime earnings from the point of view of a child of age a, less than 12, is

$$V_a = s_a \cdot \frac{V_{12}}{(1 + i)^{(12 - a)}}$$

where s_a is the probability of survival form age a to age 12 derived from a life table.[2]

Values for V_1 through V_{12} in 1979-80 have been calculated and are given in table X b. Values at each age in subsequent years are obtained after a correction for gains in productivity.

---

[1] Source for the estimate of labor force participation at age 12: Redmana, H.; Moir, H.; Daliyo, Labor Force and Labor Utilization in Selected Areas in Java; Results of an experimental survey, Vol. 1, National Institute of Economic and Social Research, Indonesia, August 1977;

and for the estimate of average annual income (1976): AID/Indonesia, Annex to Annual Budget Submission FY 1979.

[2] Sources for survival probabilities: U.S. Department of Commerce, Levels and Trends of Mortality in Indonesia, 1961 to 1971, International Research Document No. 2, 1975.

REFERENCES

Barlow, R., "Applications of a Health Planning Model in Morocco," International Journal of Health Series, Vol. 6, No. 1 (1976).

Barnum, H., D. Tarantola and I. Setiady, "Cost Effectiveness of an Expanded Program of Immunizations in Indonesia," Bulletin of the World Health Organization (Forthcoming).

Cvjetanović, B., "Cost-benefit analysis of vaccination programs in the developing countries," Proceedings of International Conference on the Application of Vaccines against Viral, Rickettsial, and Bacterial Diseases of Man, Scientific Publication No. 226 (1971), Pan American Health Organization, Washington, D.C.

Cvjetanović, B., B. Grab, K. Uemura and B. Bytchenko., "Epidemiological model of tetanus and its use in the planning of immunization programmes," International Journal of Epidemiology, Vol. I, p.125-137.

Grab, B. and B. Cvjetanović., "Simple method for rough determination of the cost-benefit balance of immunization programmes," Bulletin of the World Health Organization, Vol. 45, p. 536-541.