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The Structure and Models Used in PROFILES 2.0 with Application to Bangladesh

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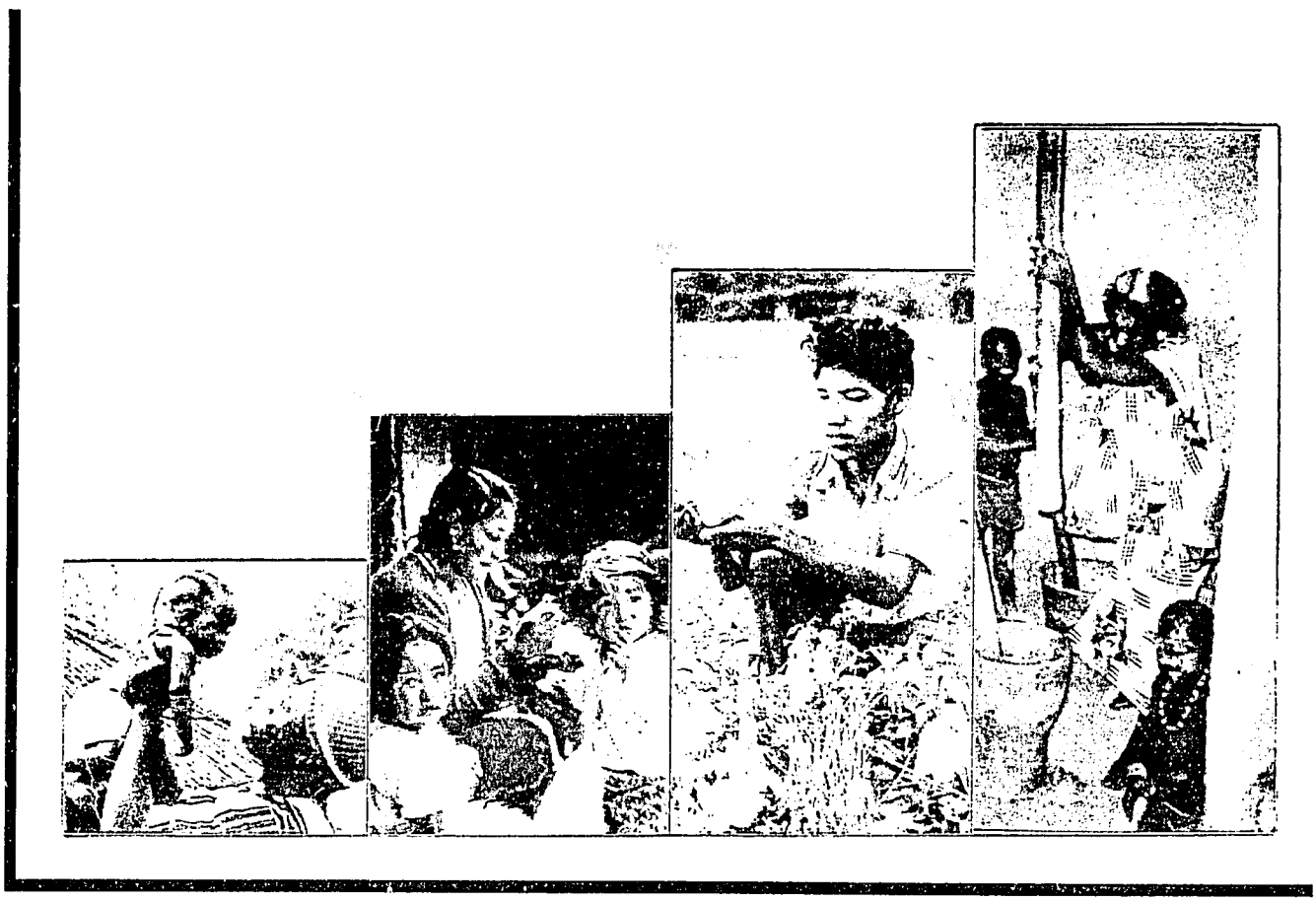
May 26, 1994



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CONTRIBUTORS

The original development of Profiles 1 and 2.0 was envisioned and sustained by Richard Seifman, Eunyong Chung and their colleagues in the Office of Nutrition, U.S. Agency for International Development. Many individuals made important contributions to the work described in this paper or significantly influenced our thinking about the paper, including Akhter Ahmed, David Alnwick, K.M.A. Aziz, Radhesyam Bairagi, M. Baquer, Martin Bloem, William Bender, Joanne Capper, Rolf Carriere, John Dunn, Susan Eastman, Omar Faruque, Jack Fiedler, Claudia Fishman, Stuart Gillespie, Steven Hansch, Nazmul Hassan, M. Mujibul Huq, Sandra Huffman, M.D. Jahangir, Urban Jonsson, A.F.M. Iqbal Kabir, Lynnda Kiess, Eileen Kennedy, Thomas Krift, Miriam Labbok, Betsy Lozoff, M.G.V. Mannar, Francisco Mardones, Yameen Mazumder, Judith McGuire, Roy Miller, Jose Mora, John Novak, Philip O'Brien, C.S. Pandav, James Pines, Habib Rahman, S.K. Roy, Zak Sabry and his colleagues at the University of California in Berkeley, Sharad Sapra, Jerald Schoudt, Donald Shepard, Rebecca Stoltzfus, Michael Strong, MG-K Talkuder, R.A. Ward and Alfred Zerfas. Certain individuals contributed in specific and substantial ways to the development of particular models; these include William Bender and Sharad Sapra to the program description model, Rebecca Stoltzfus to the influence of vitamin A in the mortality model, John Dunn and C.S. Pandav to the influence of iodine deficiency in the mortality, intelligence and livestock productivity models, and Joanne Capper to the school repeater model.

Finally, the work reported here relies heavily on the publications of many authors noted in the References.

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* These models are not included in the 2.0 version of PROFILES, but will be included in version 2.1.

A. Overview

PROFILES 2.0 is a computer program written in Turbo-Pascual for a WINDOWS operating system. It graphically portrays many important consequences of nutritional problems and improvements. Its intended purpose is to stimulate policy makers to give higher priority to nutritional problems and investments that will resolve those problems.

PROFILES 2.0 builds on an earlier version of the program, PROFILES 1, that operates in DOS. The operation of and models underlying PROFILES 1 are described in two separate documents (Abel, 1992; Burkhalter, 1993a) The development of PROFILES has been supported by the Office of Nutrition, U.S. Agency for International Development through its Nutrition Communication Project by the Academy for Educational Davelopment and The Futures Group. The initial application of PROFILES was implemented in Bangladesh in behalf of and supported by UNICEF. Although the structure and models in PROFILES 2.0 are general and can be applied in any country or area, this document presents many of the default values used in Bangladesh in order to illustrate with a real application.

PROFILES 2.0 contains four types of information, as shown in Figure 1. (1) First is information about nutritional programs (sometimes called "interventions") and combinations of programs (called "packages"). It is called "program" information. (2) Second is "demographic" information, some of which is computed by a population growth model contained in PROFILES 2.0 that estimates the population of a country or region by age and gender for 30 years into the future. (3) Third is information about various nutritional conditions, most frequently defined in terms of the prevalence of various nutritional indicators in different age and population groups, and referred to as "prevalence" information. (4) Last is information about different consequences of the nutritional conditions, and is referred to as "consequence" information. These four types of information are organized into two types of functions – prevalence functions that use program and demographic information to compute prevalence information, and consequence functions that use prevalence and demographic information to compute consequence information.

The concept of a scenario is central to PROFILES 2.0. A scenario is a particular set of program, demographic, prevalence and consequence data. It is also possible to have a scenario that ignores program data and includes only demographic, prevalence and consequence data, but this requires that the user specify the prevalence data rather than having PROFILES 2.0 compute it using the prevalence functions. PROFILES 2.0 can display information about a particular scenario, or it can compare the differences between two (or more) scenarios.

PROFILES 2.0 builds directly on the models used by PROFILES 1. PROFILES 1 includes the demographic, prevalence and consequence components, but not the program component of PROFILES 2.0. Both PROFILES 1 and 2.0 include the same six nutritional conditions, namely, (1) PEM in children under 5 years, (2) maternal malnutrition and low birth weight, (3) breastfeeding practices, (4) vitamin A status, (5) iodine status, and (6) iron status. Each condition is defined by one or more indicators, and most of the indicators have two or more severity levels.

In PROFILES 1, each indicator of a nutritional condition (and its associated prevalences) is related to one or several consequences, such as listed in Figure 1. These relationships are called consequence functions. In PROFILES 1 a separate consequence function is defined for each pair of indicators and consequences where scientific evidence exists indicating a reasonable chance of a causal relationship between the two. In other words, the consequence functions in PROFILES 1 contain one independent variable (an indicator of a

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FIGURE 1
Conceptual Framework for PROFILES 2.0

PROGRAMS	PREVALENCES	CONSEQUENCES
Nutrition programs and combination of programs • Costs • Coverage • Effectiveness	Prevalence of nutrition conditions by severity level • Protein-energy malnutr. . Underweight (U5) . Stunted (2 yrs) • Maternal malnutrition & Birth weight • Breastfeeding practice • Vitamin A • Iodine and goiter • Iron and anemia	• Mortality (U5) • Days sick (U5) . Diarrhea . ARI • Fertility • Intelligence • Blindness • School performance • Health service costs • School costs • Worker productivity • Livestock productivity • Discounted lost wages

DEMOGRAPHIC (GROWTH MODEL)
- Population by age and sex
- Fertility and Births
- Mortality and Deaths
- Migration

nutritional condition) and one dependent variable (a consequence). In PROFILES 2.0, there is only one consequence function for each type of consequence; all of the different prevalence indicators are combined into that one consequence function. In other words, the consequence functions in PROFILES 2.0 contain several independent variables and one dependent variables. This avoids double counting and allows PROFILES 2.0 to show the effects of several programs and several different types of nutritional deficiencies on a single consequence. PROFILES 2.0 has added some consequences not available in PROFILES 1, such as school performance. See Annex A for more information.

PROFILES 1 and 2.0 both include the population growth model. This allows PROFILES to translate prevalences into actual numbers of people. By knowing the size of the population in future years, PROFILES can estimate the future effect of policy changes in terms of the number of people that will continue to suffer some consequence. For example, compare the future difference in number of child deaths under assumptions of high versus low prevalence of underweight children. However, PROFILES 2.0 differs from PROFILES 1 in that program effects on mortality and fertility are fed back into the population growth model and future births and deaths modified accordingly. This is not the case in PROFILES 1 where effects on mortality and fertility are displayed but not fed back into the population growth model.

PROFILES 2.0 includes an option (not available in PROFILES 1) that allows the user to define one or more nutrition programs. The definition requires specifying program costs over time, program coverage over

time, the predicted effectiveness of the programs in improving nutritional conditions in the population that is covered, and some information on how multiple programs interact. The information describing the programs is incorporated into prevalence functions that connect the costs, coverage and effectiveness of the programs to the prevalence variables.

The models in PROFILES 2.0 are substantially more complex than the models in PROFILES 1, and therefore the organization of this document is more complex than the corresponding document for PROFILES 1 (Burkhalter, 1993a). Section B provides a description of the variables and notation used in this document. It includes detailed descriptions of the prevalence variables and subscript notation, and summary descriptions of the notation used for other types of variables. It then moves to descriptions of the population growth model (in section C), the programs and prevalence functions in which programs and program combinations are defined (in section D), and finally to the consequence functions (in section E). The assumptions and scientific evidence underlying the models are presented along with algebraic formulas that define the functions precisely.

PROFILES 2.0 runs on most WINDOWS based micro-computers. Operating instructions are available in another document (Abel and Schoudt, 1993). More detailed descriptions of the models and some alternatives proposed during the design process are available in a series of working notes (Burkhalter, 1993b).

B. Variables, Notation and Data Entry

B.1. Types of variables.

The variables used in PROFILES 2.0 can be grouped into seven types: demographic, program, prevalence, consequence, relational, temporary and subscripts. The demographic variables are used in the population growth model; the program variables are used to describe the nutrition programs; the prevalence variables to describe the prevalence of the different indicators of nutritional conditions; the consequence variables describe the various consequences; the relational variables include a host of other variables and parameters found primarily in the consequence functions; the temporary variables are few in number and are used in some of the derivations to simplify the explanation; and subscript variables (which sometimes take the form of superscripts as well as subscripts) specify certain subcategories of key variables such as severity of a nutritional condition, age group, or year. Some variables fit in more than one category. For example, fertility is both a demographic variable and a consequence variable.

Standard notation is used throughout the document to refer to these different types of indicators, as described below. See the complete list of alphabetized variables at the back of this document.

B.2. Subscripts. The following subscript notation is used.

A = age. ("A" is often used to refer to a particular population group such as pregnant women.)

A@ = primary population group of a particular program.

b = disease type (b="d" for diarrhea, b="r" for respiratory infection, b="n" for malnutrition). This particular variable is used as a leading superscript. (Lower case "b" is also used for the coefficients in the formula that estimates cretin prevalence.)

C = type of cost (C="1" for startup, C="2" for annual maintenance per beneficiary, C="3" for expansion per new beneficiary).
F = funding source (F="1" for gov't/donor total, F="2" for gov't/donor additional, F="3" for foreign currency, F="4" for commercial, F="5" for family cash self-pay, F="6" for family in-kind.
J = particular program.
j = particular program; used with "k" in program packages.
k = particular program; used with "j" in program packages.
L = location of residence (L="r" for rural, L="u" for urban).
Q = indicator of nutritional condition or deficiency (not always used as a subscript).
Q@ = primary nutrition indicator for a particular program.
S = sex (male or female).
T = time (calendar year).
V = severity category (related to indicators of nutritional conditions; V="1" for the healthy or sufficient condition and V="2","3",... for deficient conditions).

Subscripts are always attached to another variable, most frequently the prevalence variables. Unlike the other subscript variables, "b" is a leading superscript and is attached to prevalence variables in the morbidity consequence function. "C", "J" and "Q" are used as subscripts only in connection with certain program variables, and "j" and "k" are used to denote the programs in a package. The remaining subscript variables are frequently used as a group following the prevalence variables ("VALT") and are always written in the same order: "V" first, "A" second, "L" third, and "T" fourth. Not all subscripts are used with all variables.

The "T" subscript has slightly different meanings depending on which variable it modifies. In the program itself, the year always refers to a particular calendar year (such as 1995). In this document, "T" can refer to a particular calendar year but frequently refers to the number of years since the base year (where the base year is "0"). For some variables, "T" represents their integration across a particular year. Examples include program setup costs, births, deaths and prevalence variables that are really incidences such as low birth weights or newborns initiating breastfeeding. For other variables, "T" reflects an average value during the year which is sometimes approximated by a mid-year value. Examples include all true prevalence variables and rates such as mortality and morbidity.

The subscripts V and A take on different values in different contexts. For example, in reference to <u>underweight</u> children, V=2 means mildly underweight children (70-80% of the reference weight-for-age median), whereas in reference to <u>stunting</u>, V=2 means mildly stunted children (1-1.99 Z-scores below the reference height-for-age median). Age categories are defined differently in different situations, so that in one place A=1 may refer to children aged 0-5 months, and in another place A=1 may refer to children aged 0-2 months. The definitions of the values of these subscripts is made clear in each case as it arises.

There are two special values that apply to subscripts. First is the base year, which is always denoted by T=0. Second is when all of the subcategories are intended. This is denoted in one of two ways. Either the value "all" is used, such as in V=all or A=all, or the subscript is left off entirely. Thus, when a subscript is missing, it means the entire set of possibilities is included.

B.3. Prevalence variables.

Prevalence variables denote the prevalence of various nutritional conditions at a point in time. Each condition is defined by an indicator and a severity level of the indicator. (All indicators are divided into two or more severity levels.) Most prevalence variables start with the letter "P" followed by one or more capital letters denoting a nutritional condition and indicator. Four following subscripts are attached to the prevalence variables, denoting severity level, age or population group, location of residence, and time. (As noted above, the letters V, A, L and T are used in that order to refer to these subscripts.) The lower case letter "b" is sometimes used as a leading superscript to denote a particular disease in the morbidity consequence function. A few "prevalence" variables are not really prevalences, but rather are frequencies or incidences, as described in the specific definitions below.

B.3.1. Prevalence of PEM.

Protein-energy malnutrition (PEM) in children is commonly measured with indicators of physical growth. Numerous such indicators of PEM and its severity are in common use. PROFILES 2.0 uses two indicators of PEM: weight-for-age ("underweight") and height-for-age ("stunting"). Both indicators use four severity categories (normal, mild, moderate and severe), although the category boundaries are different for underweight than for stunting. In addition to these two anthropometric measurements, PROFILES 2.0 includes a variable that denotes the proportion of children receiving PEM programs who also receive tutoring and stimulation programs. This variable is used to estimate intellectual development, and is treated in the model as if it were a prevalence variable, even though it is not.

Weight-for-age (underweight) indicators. Weight-for-age is used as an indicator of PEM in children under five years of age by PROFILES 2.0. The following notation is used to denote the prevalence of normal, mild, moderate, and severe underweight.

PU_{VALT} = Prevalence of children in age group "A" and location "L" who are in underweight severity category "V" at time "T".

Where: V = 1 for normal wt/age children (80%+ of reference median), V = 2 for mild PEM wt/age child (70-80% of reference median), V = 3 for moderate PEM wt/age child (60-70% of reference median), V = 4 for severe PEM wt/age child (below 60% of reference median).

Height-for-age (stunting) indicators. Height-for-age is used as an indicator of PEM in children at their second birthday, and during their primary school years (age 6-10) in PROFILES 2.0. In practice height-for-age at the second birthday is usually estimated by taking the average during the third year of life. The notation used to denote the prevalence of normal, mild, moderate, and severe stunting parallels that used for underweight prevalence, as defined below.

PS_{VALT} = Prevalence of children at age "A" in location "L" who are in stunting severity category "V" at time "T".

Where: V = 1 for normal ht/age children (not less than 1 Z-score below reference median), V = 2 for mild PEM ht/age child (1-1.99 Z-scores from reference median), V = 3 for moderate PEM ht/age child (2-2.99 Z-scores from reference median), V = 4 for severe PEM ht/age child (3 or more Z-scores from reference median).

Intellectual stimulation indicator. This variable tells the proportion of children who are receiving an intellectual stimulation program, such as special tutoring. It is used in combination with programs aimed at reducing PEM in order to estimate intellectual development and school performance. This variable is called $PQ_{A,T}$ as defined below.

$PQ_{A,T}$ = Proportion of participants in a PEM program that are in age group "A" who are also in an intellectual stimulation or tutoring program in time "T."

B.3.2. Frequency of low birth weight.

Birth weight is an indicator of maternal health and nutritional status during pregnancy, as well as an important consideration in its own right. A low birth weight is defined as a live birth of less than 2500 grams. Low birth weight is one of the few indicators in PROFILES 2.0 that is an incidence rather than a prevalence. The notation used to denote the frequency of normal and low birth weights is defined below.

$PW_{V,L,T}$ = Frequency of live births in location "L" falling into severity category "V" at time "T."

Where: V = 1 for birth weights of 2500 or more grams (normal). V = 2 for birth weights below 2500 grams (low).

B.3.3. Breastfeeding Prevalence.

Infant feeding, including breastfeeding, is a complex phenomena with many dimensions. PROFILES 2.0 follows WHO guidelines in establishing categories of feeding behavior by age. PROFILES 2.0 uses three indicators of infant feeding – the WHO definitions of breastfeeding behaviors by age (full, partial, none), whether or not breastfeeding was initiated, and the average duration of breastfeeding.

Feeding behavior by age group. PROFILES 2.0 uses three modes of feeding behavior (full, partial and no breastfeeding), four age groups (0-5, 6-11, 12-23, and 24-35 months), plus urban and rural. The prevalence of each feeding mode by age group and residence (urban or rural) is denoted by the variable $PF_{V,A,L,T}$.

$PF_{V,A,L,T}$ = Prevalence[1] of feeding mode "V" in age group "A" residing in region "L" at time "T".

Where: V = Feeding mode (1 = full breastfeeding, 2 = partial breastfeeding, 3 = no breastfeeding). A = Age group (1 = 0-5 mths, 2 = 6-11 mths, 3 = 12-23 mths, 4 = 24-35 mths). L = Residence (u = urban, r = rural).

Unlike other nutrition indicators where the sufficient and deficient categories are clear and unchanging with age, the recommended mode of feeding changes with age; full breastfeeding is the recommended (i.e., "sufficient ") mode during 0-5 months of age, whereas partial breastfeeding is recommended thereafter. Typically, rates of mortality and morbidity are lowest in fully breastfed infants during 0-5 months, but lowest in partially breastfed children in older age groups. (For this reason, the relative mortality and morbidity variables for breastfeeding used by PROFILES 2.0, which have mortality and morbidity of fully breastfed children as the denominator, are often less than one for partially breastfed children over 6 months.)

Initiation of breastfeeding. Initiation of breastfeeding is an incidence, denoted by the variable $PB_{V,L,T}$.

$PB_{V,L,T}$ = Proportion of newborns residing in location "L" that initiate (when V=1) or do not initiate (when V=2) breastfeeding in time "T."

Average duration of breastfeeding. The average duration of any breastfeeding in months is denoted by the variable $PD_{L,T}$.

$PD_{L,T}$ = Average duration in months of any breastfeeding among children residing in location "L" at time "T."

B.3.4. Prevalence of vitamin A deficiency.

PROFILES 2.0 defines five levels of vitamin A status, listed here in order of increasing "severity": (1) no vitamin A deficiency; serum retinol 20 micrograms per deciliter or more and no evidence of nightblindness or Bitot's spots, (2) serum retinol below 20 micrograms per deciliter, (3) serum retinol below 10 micrograms per deciliter, (4) nightblind, and (5) presence of Bitot's spots. The four deficiency levels are not mutually exclusive, nor necessarily cumulative. The prevalence of the five vitamin A severity categories is denoted by the variable $PA_{V,A,L,T}$, as shown below.

$PA_{V,A,L,T}$ = Prevalence of vitamin A severity level "V" in age group "A" residing in location "L" at time "T." Definitions of V are given in Table B-1.

In most countries, systematic data is not available to estimate default values for all five PA variables. In lieu of better information, the model assumes that the ratios among the PA four vitamin A deficient variables equals the ratios among the minimum prevalences at which vitamin A deficiency is considered a public health problem (West and Sommer, 1984)[2].

TABLE B-1: Severity Levels and Default Values for Vitamin A Deficiency

Severity Level (V)	Prevalence Variable (6-59 mths)	WHO Class	Definition	Minimum Prev. for Public Health Problem
1	PA_1	--	No evidence of deficiency	--
2	PA_2	--	Serum Retinol < 20 ug/dl	10%
3	PA_3	--	Serum Retinol < 10 microgr/dl	5%
4	PA_4	XN	Nightblind	1%
5	PA_5	X1B	Bitot's spots	0.5%

B.3.5. Prevalence of iodine deficiency.

PROFILES 2.0 uses two indicators to reflect the prevalence of iodine deficiency in the population – goiter and cretinism, and one indicator of iodine deficiency in livestock.

Goiter prevalence. Goiter prevalence is denoted by the variable $PG_{V,L,T}$, and refers to the prevalence of any goiter, visible or palpable. Although the variable applies to the total population (no A subscript), the models in PROFILES 2.0 are only concerned with iodine deficiency in pregnant women and newborns, which is assumed to be equal to iodine deficiency in the total population.

$PG_{V,L,T}$ = Prevalence of no goiter (when V=1) or goiter (when V=2) in the population residing in location "L" at time "T."

Cretin prevalence. The prevalence of cretins in the population is denoted by the variable $PC_{L,T}$. The prevalence of cretins is more difficult to measure than goiter prevalence, and is generally not available for developing countries. PROFILES 2.0 estimates cretin prevalence from goiter prevalences in previous years. The prevalence of non-cretins is not used and therefore V is omitted.

$PC_{L,T}$ = Prevalence of cretins residing in location "L" at time "T."

Prevalence of iodine deficiency in livestock. The prevalence of iodine deficiency in livestock is denoted by the variable $PIL_{V,T}$.

$PIL_{V,T}$ = Prevalence of iodine sufficient (V=1) and iodine deficient (V=2) livestock at time "T."

TABLE B-7: Definition of Population Groups for Iron Deficiency Prevalence Variables

Population Group (A)	Variable	Description	Minimum Acceptable Hgb
1	$PIR_{V,1,L,T}$	Prevalence of iron deficiency in children under 5 years	11
2	$PIR_{V,2,L,T}$	Prevalence of iron deficiency in school children	12
3	$PIR_{V,3,L,T}$	Prevalence of iron deficiency in non-pregnant women aged 15-49 years	12
4	$PIR_{V,4,L,T}$	Prevalence of iron deficiency in pregnant women	11
5	$PIR_{V,5,L,T}$	Prevalence of iron deficiency in men aged 15-49 years	13

Source: Minimum acceptable Hgb levels for PIR_1 through PIR_5 obtained, respectively, from tables 8.3, 8.4, 8.8, 8.8 and 8.6 in Ahmad and Hassan, 1982.

B.3.6. Prevalence of iron deficiency.

Blood hemoglobin concentration (Hgb) is one indicator of iron status. In PROFILES 2.0, the severity level of iron deficiency is based on the amount of hemoglobin in the blood. The minimum acceptable value for Hgb varies by age and gender, as specified in Table B-2. The prevalence of iron is denoted by the variable $PIR_{V,A,L,T}$.

$PIR_{V,A,L,T}$ = Prevalence of iron sufficiency (V = 1) or iron deficiency (V = 2) as measured by Hgb in population group "A" residing in location "L" at time "T."

B.4. Relational variables.

Nearly all relational variables start with the letter "K" and are followed by a number from 1 to 116. (In addition, there are five relational variables (K201-K205) used in models in this paper and anticipated for inclusion in PROFILES 2.1 but not included in PROFILES 2.0.) The relational variables are arranged in eight groups: one group for each of the six conditions plus "crossover and interactions" and "global." These eight groups follow the arrangement in the PROFILES 2.0 computer program. The variables in the six "condition" groups are used uniquely in relation to those conditions. The "crossover and others" group includes variables which characterize interactions between the prevalences of conditions or biological effectiveness of different interventions. The "global" group includes miscellaneous relational variables, many of which can change over time. Although the default values for the global relational variables are usually constant, PROFILES 2.0 allows the user to establish different values over time for many of the global relational variables.

See the list of variables at the back of this report for a definition of all relational variables, and default values used in Bangladesh.

B.4.1. Relative rate variables.

Relative rate variables are a special type of relational variable used to estimate mortality and morbidity. They are defined with respect to a particular severity level and indicator The relative rate variable for mortality ("relative risk of death") expresses the ratio between the mortality rate in a deficient severity level to the mortality rate in the healthy severity level for some particular indicator. For example, the ralative risk of neonatal death associated with low birth weight is the neonatal mortality rate of low birth weight newborns divided by the neonatal mortality rate of normal birth weight newborns. Similarly, the relative rate variable for morbidity ("relative morbidity") expresses the ratio between the morbidity rate in a deficient severity level to the morbidity rate in the healthy severity level for a particular indicator.

PROFILES 2.0 assumes that relative rate variables are constant over time and, in most instances, across countries. Relative rate variables are used to estimate mortality and morbidity rates by severity level in a country. In addition to relative rate variables, the estimation procedure also uses data from the base year, including the prevalences by severity level, the overall mortality or morbidity, and the population. Basically, it is a process of allocating the overall base year mortality or morbidity to the various severity levels, weighted according to their prevalence and relative rates.[3]

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B.5. Demographic, program, consequence and temporary variables.

The notation for these types of variables is not standardized. They are defined in the respective sections, and summarized in the list of variables at the back of this report.

B.6. Generalizing values across countries and time.

The values of some variables vary by country and year; other variables vary by country but are assumed to be constant through time; while others are assumed to be constant for all countries and years. Variables that vary through time are subscripted with "T." Variables that are assumed to be constant, either across countries or through time, are assigned a default value by PROFILES that the user can modify. The assigned default value is usually based on research results reported in the literature. In many cases, the "constant" variables and their assigned default values reflect a biological phenomena that is thought to be relatively invariant across geography, cultures and time.

All of the prevalence variables are assumed to vary across countries and through time. Similarly, most of the demographic variables are assumed to vary across countries and time. (The male-to-female birth ratio is an exception. It is assumed to be constant over time for a given country, and although it is allowed to vary from one country to another, the global average of 1.05 is an adequate default figure for many countries.)

Many of the relational variables are based on research which suggests that they are approximately true for all countries and in all years, or at least in a wide range of conditions. The relative rate variables (see section B.4.1) are such variables. They are combined with base year data from a country to obtain severity-specific mortality (or morbidity) rates for the country. The severity-specific rates are assumed to vary by country but not by year, and thus, once estimated for a country, can be used to calculate overall mortality (or morbidity) in subsequent years. Note that overall mortality (or morbidity) does vary by year, based on the fluctuations in the prevalences of the severity levels.

B.7. Data Input.

During the application of PROFILES 2.0, it is convenient to think of data input as occurring at two distinct times – (1) country setup and (2) program description. (In fact, the program is organized somewhat differently, as explained in the Operations Manual (Abel and Schoudt, 1993).) However, this simplified view allows us to group the information about the variables and their relationships into four categories, as noted below.

1. Invariant relationships that cannot be modified.
2. Country data entered during country setup.
3. Program data entered during program description.
4. Results computed by PROFILES 2.0.

The variables falling in each category are summarized in Table B-3. Note that the prevalence variables in future years can be computed from the prevalence functions, or in the case that no programs are defined, can be entered directly in order to see the effects of different nutritional conditions on the consequence variables. Annex B contains a program description data entry form.

TABLE B-3: How Variable Values Are Obtained

Invariant	Equations. Variable definitions.
Country Setup	Demographic: Base year population by age & sex in 5 year age intervals. Total fertility rate each year for 30 years. Life expectancy at birth each year for 30 years. Base year prevalences, by severity level. Relational variables in consequence functions. (Many relational variables have global default values that can be used, especially relative rate variables.) Base year mortality and cause-specific morbidity.
Program Description	Each program: Duration of program in years. Coverage by year. Effectiveness in primary group and indicator by year. Maximum impact by group and nutritional indicator. Costs by type: Setup, transition, maintenance. Source (gov't, family, etc) Combinations of programs (scenarios): Relational variables in prevalence functions.
Computed	Future prevalences of nutritional indicators. (These can also be entered directly in order to see effect on consequences without programs.) Consequence variables in future years.

C. Population Estimates

PROFILES 2.0 rests on a population projection model that uses a single year, single age survival approach to estimate future values of the demographic variables. Historical data about a country's population are used to estimate the current (base year) population by age and sex. Future estimates of life expectancy, fertility, migration and urban-to-rural ratio are exogenously specified, and used to project future population by sex and age at one-year intervals over the projection period. Individuals over 80 are placed in a single group (80+). Frequently the historical data come from UN population projections (UN, 1991).

Total population. In brief, the total population in a year equals the total population in the previous year plus births minus deaths that occur during the previous year. The net number of migrants moving into or out of the country during the previous year are then added to, or subtracted from, the result.

Age-specific population. The population of any age over one equals the population of that age in the previous year minus deaths that occur during the previous year. The net number of migrants of that age are

then factored into the result to reflect inward or outward migration. The under one population in a year equals the number of births that occur during the year minus infant deaths. Migrating infants are then factored in as with the over one cohorts.

Urban/rural split. PROFILES 2.0 contains two methods for allocating the population to urban and rural areas. The first, and most straightforward method, is to specify the proportion of the population that lives in urban areas for the base year and each year during the population projection. Figures for the total population, age-specific population and sex-specific population are multiplied by the urban proportions to obtain the corresponding urban population in any year. The rural population is the residual. The second method treats the urban and rural areas as two totally separate populations, with separate fertility and mortality rates. Migration includes net rural-to-urban migration as well as net migration in and out of the country to each area.

Required data. PROFILES 2.0 requires the user to input information on the base year population, the urban/rural split, the fertility patterns, and the mortality patterns for a country. The base year population must be specified by gender and five year categories (0-4, 5-9,...80+). Estimates of the fraction of the population that is urban must be entered for all future years starting with the base year.

Births are calculated using total fertility rate (TFR) and age-specific fertility rates (ASFR). The TFR must be directly entered into PROFILES 2.0 for the base year and each year of the projection period (usually 30 years). The ASFRs (the proportion of TFR that occurs at each 5 year age interval) can be obtained in one of two ways: (1) directly enter estimates of the ASFRs for each 5-year group of women of reproductive age for different TFRs, or (2) enter an appropriate age-specific model fertility table for the country. In the second alternative, PROFILES 2.0 contains three standard model fertility tables – UN Sub-Sahara, UN Arab, and UN Asia.[4] In both alternatives, the user must enter an estimate of the male/female birth ratio (SR for sex ratio) for the country. This ratio is assumed to be constant over time and its usual default value is 1.05 (used in the Bangladesh application).

Deaths are calculated using the sex-specific life expectancy at birth (LE) and age-specific survival rates (ASSR). The LE is entered directly into PROFILES 2.0 for the base year and each year of the population projection. The ASSRs (the probability that a person of age "n" will live to be "n+1") are derived from model life tables available in PROFILES 2.0. There are currently nine standard model life tables available – UN Chile, UN Latin America, UN East Asia, UN South Asia, UN General, Coale-Demeny West, Coale-Demeny East, Coale-Demeny North and Coale-Demeny South. One of these nine must be selected. (See endnote 4.)

Breakout during first year of life. Population and mortality during the first year of life is further allocated by month so that estimates can be made for neonates, for infants under six months of age, and for infants aged 6-11 months. Monthly survival rates have been calculated for each of the nine model life tables, and are used to estimate the number of infants that survive from month to month. The calculation procedure for estimating monthly survival rates is described in a separate document (Dworak, 1993).

Feedback of nutrition program effects to population model. In PROFILES 2.0, both the fertility and mortality rates are influenced by nutrition programs and changes in nutrition prevalences over time. Thus, in any given future year, the total fertility rate equals the TFR originally estimated for that year adjusted according to the results of the fertility consequence function for that year. Similarly, the age and gender specific mortality rates originally estimated for a given year (by combining the estimated life expectancy for the year with the chosen model life table) are adjusted according to the results of the mortality functions for various age groups in that year.

The trends in fertility and mortality built in to most population models (such as the UN projections) are usually downward for both fertility and mortality, and may already incorporate assumptions that nutritional deficiencies will decrease. (These assumptions are generally not made explicit in the population models because the downward trends are usually based on extrapolation of historical data rather than on explicit events.) To the extent these assumptions are true, PROFILES 2.0 double-counts the decreases and thus underestimates the true mortality and fertility. However nutritional improvements are only one of many factors influencing the historical trends, thus lessening their relative importance in the trends.

Population model equations. The key equations used by the model are presented below to give precise definition to the above statements and to clarify the meaning of the variables that are used in subsequent sections. Note that special equations are required for the infants and the 80+ year olds.

For A = 0:

[C-1] $POP_{0,S,T} = B_T - D_{0,S,T} + MIG_{0,S,T}$.

For A = 1 thru 79:

[C-2] $POP_{A,S,T} = POP_{A-1,S,T-1} - D_{A-1,S,T-1} + MIG_{A-1,S,T-1}$.

For A = 80+:

[C-3] $POP_{80+,S,T} = POP_{79,S,T-1} - D_{79,S,T-1} + MIG_{79,S,T-1} + POP_{80+,S,T-1} - D_{80+,S,T-1} + MIG_{80+,S,T-1}$.

Where:

[C-4] $D_{A,S,T} = POP_{A,S,T} * MR_{A,S,T}$.

[C-5] $B_T = \text{SUM of } (FR_{A,T} * POP_{A,fem,T})$, for A = 15, ..., 49.

[C-6] $B_{fem,T} = B_T / (1 + SR)$.

And: A = Subscript denoting age group (0,...,79,80+). B_T = Number of births during year T. $B_{fem,T}$ = Number of female births during year T. $D_{A,S,T}$ = Deaths in a cohort of sex "S" of age "A" years during year T. $FR_{A,T}$ = Fertility rate of women in age group "A" during in year T after adjusting for nutrition effects. $MIG_{A,S,T}$ = Number of surviving net migrants of sex "S" entering age group "A" during year T. $MR_{A,S,T}$ = Mortality rate after adjusting for nutrition effects for cohort of sex "S" of age "A" years during year T. $POP_{A,S,T}$ = Population in age group "A" of sex "S" during year T. SR = Ratio of male to female births.

Breakout by urban and rural. The value of all of the demographic values in urban and rural areas can be obtained using the UR_T variable. For example, the value for the urban population of sex "S" and age "A" in year T is given in equation [C-8], and the corresponding rural population is given in equation [C-9].

[C-8] $POP_{A,S,U,T} = UR_T * POP_{A,S,T}$.

[C-9] $POP_{A,R,R,T} = (1 - UR_T) * POP_{A,R,T}$.

Where: $POP_{A,R,L,T}$ = Population of age group "A" of sex "S" residing in location "L" in year T. UR_T = Proportion of total population that lives in urban areas in year T.

D. Programs and Prevalence Functions

PROFILES 2.0 allows users to define one or several nutritional programs which influence the future values of the nutritional prevalence indicators. The relationships linking the program variables (coverage, effectiveness, maximum impact) to the prevalence indicators are called the "prevalence functions." Program definitions also include duration and costs. The variables that describe a program or combination of programs can be grouped in three categories – variables that enable PROFILES to compute the effect of the program(s) on the prevalence indicators, variables that describe the costs of the program, and variables that enable PROFILES to sort out interactive effects of two or more programs operating simultaneously.

D.1. Effective coverage.

PROFILES 2.0 uses two factors to estimate the impact of a program on the prevalence variables. First is the coverage of the program, and second is the effect of the program on those covered. Combined, they produce effective coverage. Both the coverage and effect can vary among programs and, within a given program, over time. Thus, PROFILES 2.0 recognizes that some programs may achieve wide coverage but relatively low impact on those covered, whereas other programs may not reach that many people but have a high impact on those they do. It also allows programs to learn in the sense that they can increase their effectiveness over time.

However, the calculation of effective coverage is complicated by the fact that many programs impact several nutritional indicators and several population groups, but the size of the effect is not the same in the different indicators and population groups. In order to calculate the impact of the program on all nutrition indicators and population groups, PROFILES 2.0 uses the following definitions.

(1) Primary group. A "primary" population group is specified for each program at the time the program is described to PROFILES. "A@" refers to the primary group.

(2) Primary indicator. A "primary" nutrition indicator is specified for each program at the time the program is described to PROFILES. "Q@" refers to the primary indicator.

(3) Coverage. Coverage – denoted by $COV_{J,T}$ – is defined with respect to the primary group of a particular program (J). It is the fraction of the primary group covered by the program in a given year (T).

$COV_{J,T}$ = Coverage of program J in its primary population group in year T, where coverage is the fraction of the total primary group reached by program.

Coverage is specified for each year after the base year at the time the program is described to PROFILES. Typically coverage is zero in the base year and grows gradually through the program lifetime to some maximum value.

(4) Maximum impact. Maximum impact – denoted by $MIMP_{J,Q,A}$ – is defined with respect to a particular program, and within that program with respect to every population group and every nutritional indicator. However, it applies only to severity levels reflecting a deficient status. It is the maximum reduction that the program will ever have on the prevalence in the deficient severity category of an indicator of nutritional condition. Maximum impact does not change over time.

$MIMP_{J,Q,A}$ = Maximum impact that program J will ever have on reducing the deficiency prevalence of indicator Q in population group A (a number from 0 to 1 representing the proportional reduction in the base year prevalence).

The definition of $MIMP_{J,Q,A}$ is clear for indicators with only two severity levels – sufficient and deficient, such as the birth weight indicator. However, the definition given above is unclear when indicators have more than two severity levels, such as stunting with its four severity levels (normal, mild, moderate and severe). One way of dealing with this is to assume that all of the reduction occurs in one of the deficient severity levels (such as severe stunting) and the other deficient severity levels (mild, moderate) remain the same and the sufficient level (normal) picks up the slack. Another alternative is to assume that the reduction in prevalence occurs proportionally across all the deficient levels, based on the base year prevalences, and the slack is picked up by the sufficient level. PROFILES 2.0 assumes the later alternative – proportional distribution of prevalence reductions among all the deficient severity levels – as a default unless specified otherwise.

Although the maximum impact of the program in the primary group and primary indicator is usually greater than the maximum impact associated with other groups and indicators, there are several reasons why a program might have an effect on groups and indicators other than the primary ones. There are carry-over effects in which children who benefit from a program in an earlier year sometimes continue to benefit from the program in future years even though they are no longer targeted by the program. There are spill-over effects in which siblings, neighbors or others may benefit from programs aimed at other children. In addition, many programs include several target groups and indicators other than the primary ones.

Note that ratios can be formed between the maximum impact in the primary group and indicator and all the other maximum impacts. These ratios remain constant over time, so that if the impact of the program on the primary group and indicator is known in some year, the impact of the program on all other groups and indicators can be calculated for that year.

Maximum impact is specified for every group and indicator at the time the program is described. (See section 4 in Annex A.)

(5) Correctable deficiency. The "correctable deficiency" is the difference between the base year prevalence in the deficient category and the residual prevalence if maximum impact is achieved. Specifically, the correctable deficiency associated with a particular indicator and group equals (P_0*MIMP), where P_0 is the base year prevalence and MIMP is the maximum impact for that indicator and group.

(6) Effectiveness. Effectiveness – denoted by $EFF_{J,T}$ – is defined with respect to a particular program, and within that program with respect to the primary population group and primary nutritional indicator. Note that it applies only to severity levels reflecting a deficient status of the indicator. It is the fraction of covered, deficient persons in the primary group who are correctable and who become sufficient in a given year as a result of the program.

$EFF_{J,T}$ = Effectiveness of program J in reducing the correctable deficiency of its primary nutritional indicator in the primary population group in year T, where effectiveness is a number between 0 and 1 representing the fractional reduction in correctable deficiency.

Effectiveness is specified for each year after the base year at the time the program is described to PROFILES. Typically effectiveness is zero in the base year and grows through the program lifetime, possibly to 100%.

The impact of a program on prevalence is always calculated for the deficient severity level(s) of a particular indicator and population group. The reduction in the base year prevalence of indicator Q in group A caused by program J in year T equals the prevalence in the base year times the coverage in year T ($COV_{J,T}$) times the effectiveness in year T ($EFF_{J,T}$) and times the maximum impact on the indicator ($MIMP_{J,Q,A}$). The prevalence function which computes the prevalences in future years from program characteristics (coverage, effectiveness, maximum impact) equals the base year prevalence minus the reduction caused by the program.

The prevalence after program impact in year T on indicators with only one deficiency severity category is given in equation [D-1].

[D-1] $$P_{Q,V,A,T} = P_{Q,V,A,0} - P_{Q,V,A,0} \cdot COV_{J,T} \cdot EFF_{J,T} \cdot MIMP_{J,Q,A}$$

Where: $P_{Q,V,A,T}$ = Prevalence of nutritional indicator Q, severity level V (where V=2, a deficient severity category) in population group A in year T (T=0 in base year). $COV_{J,T}$ = Coverage of program J in year T. $EFF_{J,T}$ = Effectiveness of program J in year T. $MIMP_{J,Q,A}$ = Maximum impact of program J on indicator Q and group A (always defined with respect to a deficient severity category).

To calculate the prevalence of indicators with multiple deficient severity categories (such as stunting) and assuming proportional impact on all the deficient categories, use equation D-1 to calculate the impact on the sum of the prevalences in all the deficient categories, and then allocate the resulting reduction among the several deficient severity categories according to their base year prevalences. The prevalence of the sufficient (healthy) severity category is always calculated as the residual by subtracting the deficient prevalences from one.

D.2. Program costs.

PROFILES 2.0 organizes program costs along two separate dimensions. One dimension includes setup-maintenance-expansion costs and the second dimension portrays the source of the funds (donor, government, family, commercial).

The first dimension defines three kinds of costs (setup, maintenance, and expansion), each of which is related to a different aspect of the program. All three are specified to PROFILES at the time the program is described.

(1) Setup costs refer to fixed costs which do not depend on the number of persons covered by the program. Setup costs can be specified on a year-by-year basis, and therefore the setup cost variable ($C1_T$) is subscripted with "T."

(2) Maintenance costs refer to the costs required to maintain the coverage of the program for one year to one beneficiary once it has been established and are denoted by C2. These costs are sometimes referred to as annual recurring costs. Because maintenance costs are defined "per beneficiary covered," the total maintenance cost of the program in a year equals the maintenance cost (C2) times the number of beneficiaries covered by the program in that year ($POP_{A@,T}*COV_T$). PROFILES 2.0 allows the user to specify maintenance cost per beneficiary as a function of the coverage. Thus it is possible to reflect situations with increasing marginal maintenance costs, such as might be found in locations where households are the most expensive to serve and the last to be reached, or to reflect situations with decreasing marginal costs where economies of scale exist.

(3) Expansion costs refer to the cost of expanding the coverage of the program to one additional beneficiary and are denoted by C3. The total expansion costs of the program in any given year equal the number of newly covered beneficiaries in that year ($POP_{A@,T}*(COV_T-COV_{T-1})$) times the expansion cost per new beneficiary (C3). As with maintenance costs, PROFILES 2.0 allows the user to specify expansion cost per new beneficiary as a function of coverage.

The total costs in any year equals the sum of the setup costs, maintenance costs and expansion costs in that year, as given in equation D-2. Note that if coverage shrinks rather than expands, C3 goes to zero. In some programs, efficient screening may allow the segment of the population that was healthy (in the sufficient severity category) in the base year to be excluded from the primary target population group.

[D-2] $$C0_{J,T} = C1_{J,T} + C2_J*POP_{A@,T}*COV_{J,T} + C3_J+POP_{A@,T}*(COV_{J,T}-COV_{J,T-1})$$

Where: $C0_{J,T}$ = Total costs of program J in year T. $C1_{J,T}$ = Setup cost of program J in year T. $C2_J$ = Annual maintenance cost per beneficiary covered, program J. $C3_J$ = Expansion cost per new beneficiary added to program J (equals zero if program shrinks in year T). $COV_{J,T}$ = Coverage of program J in year T. A@ = The primary population group.

The total cumulative costs of a program from its start through any year T ($CC_{J,T}$) is the sum of the total costs in all the individual years up through year T, as given in equation D-3.

[D-3] $$CC_{J,T} = C0_{J,0}+C0_{J,1}+...+C0_{J,T}$$

Where: $CC_{J,T}$ = Cumulative costs of program J through year T. $C0_{J,x}$ = Total cost of program J in year x, as calculated in equation [D-2].

PROFILES 2.0 does not require that all three types of costs be used. For example, an annual program budget could be defined using a setup cost in each year that is independent of the program coverage by setting C2 and C3 equal to zero. Another simple approach is to estimate an annual average cost per beneficiary (C2), set C1 and C3 equal to zero, and calculate the total cost in any year from the number of

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people covered in that year. Having the three types of costs available allows users to take advantage of additional information about program costs when it is available.

The second dimension for categorizing costs used by PROFILES 2.0 is the source of the funds that pay the costs. The *six* types of sources available are: (1) government\donor total, (2) government\donor "additional," (3) foreign (hard) currency, (4) commercial, (5) family cash self-pay, (6) family in-kind. Note that government\donor "additional," which refers to expenditures that would not have been made if the program did not exist, is a subset of total government\donor expenditures. Foreign (hard) currency is also a subset of other categories, usually of government\donor additional.

Information on source of funds can be specified for each type of cost (setup, maintenance or expansion) by year at the time the program is described to PROFILES. Thus, define six variables (called $SOURCE_1,...SOURCE_6$) that reflect the proportion of total costs, by type, that are covered by the six sources of funds in a given year.

$SOURCE_{J,C,F,T}$ = Proportion of all costs of type C in program J that are paid by funding source F in year T.

Where: F = Source of funds (1 = government/donor total, 2 = government/donor additional, 3 = foreign (hard) currency, 4 = commercial, 5 = family cash self-pay, and 6 = family in-kind). C = Type of cost (1 = setup costs, 2 = maintenance costs, and 3 = expansion costs).

For a given program, year and type of cost (setup, maintenance or expansion), the six SOURCE variables must always sum to one, that is, for all values of J, C, and T,

$$SOURCE_{J,C,1,T} + ... + SOURCE_{J,C,6,T} = 1.$$

To calculate the amount of funds from a particular source, it is necessary to multiply the appropriate SOURCE variable by the costs in that year because the SOURCE variables are proportions, that is, for all F, J and T,

$SOURCE_{J,1,F,T} \cdot C1_T$ = Setup costs in program J in year T from source F.

$SOURCE_{J,2,F,T} \cdot C2 \cdot POP_{A\Theta,T} \cdot COV_T$ = Maintenance costs in program J in year T from source F.

$SOURCE_{J,3,F,T} \cdot C3 \cdot POP_{A\Theta,T} \cdot (COV_T - COV_{T-1})$ = Expansion costs in program J in year T from source F.

D.3. Multiple programs.

It is possible to define and run several programs simultaneously in PROFILES 2.0. Such combinations of programs are sometimes called "packages" in this document. The costs of individual programs are always summed in packages. Thus there is no interactive effect with respect to costs. However, this is not the case with either coverage or effectiveness. Interaction is permitted with respect to both coverage and effectiveness. For example, to what extent do two different programs cover the same persons? When two programs do reach the same individual, how do the separate effects of the two programs combine together to reduce the prevalences of different nutritional deficiencies? PROFILES 2.0 permits users to define these

interactions for combinations of two programs, but for combinations of three or more programs it uses built-in default assumptions.

First, some definitions. With respect to coverage, two programs are said to "overlap" if they cover (that is, reach or provide service to) the same individuals. Two programs are said to "totally overlap" if all the individuals that are covered by the program with the smaller coverage are also covered by the program with the larger coverage. Two programs are said to "partially overlap" when some individuals are covered by both programs, some by one only and some by the other only. Define a variable (e_{jk}) that captures the degree to which the coverage of two programs (j and k) overlap. Specifically, e_{jk} is defined as:

e_{jk} = the proportion of the coverage of the smaller-coverage program that is not also covered by the larger-coverage program.

Thus, e_{jk} = 0 for totally overlapping programs, and e_{jk} = 1.0 for non-overlapping programs. "Coverage combination" refers to all individuals covered by a particular combination of programs. When a package of two programs (say programs "j" and "k") is partially overlapping, there are four coverage combinations – covered by both, covered by program "j" only, covered by program "k" only, and covered by neither. The coverages in these four coverage combinations are denoted by COV_{jk}, COV_{jo}, COV_{ok}, and COV_{oo} respectively, but COV_{oo} always is zero.

With respect to effectiveness, two programs (say programs "j" and "k") are said to have an "additive effect" if the effectiveness values of the two programs add together for double-covered individuals, in other words, $EFF_{jk} = EFF_j + EFF_k$. Two programs are said to have a "non-additive effect" when the effectiveness value of double-covered individuals equals the largest of the two individual program effectiveness values. In other words, $EFF_{jk} = MAX(EFF_j, EFF_k)$, where $MAX(x_1, x_2, \ldots x_n)$ equals the largest value among x_1 through x_n. Define a variable (f_{jk}) that captures the degree to which the effectiveness of two programs (j and k) both impact on an individual covered by both programs. Specifically, f_{jk} is defined as:

f_{jk} = a number that is multiplied by the sum of EFF_j and EFF_k to give the effectiveness of the overlapping portion of programs "j" and "k".

Thus, the effectiveness of the overlapping portion is $f_{jk} * (EFF_j + EFF_k)$. When $f_{jk} = 1.0$ the effect is additive, and when $f_{jk} > 1.0$ the effect is greater than additive. Similar to coverage, the effectiveness in the four different coverage combinations in a two-program package are denoted by EFF_{jk}, EFF_{jo}, EFF_{ok} and EFF_{oo}.

PROFILES 2.0 gives the user three options for describing the coverage and effectiveness interactions in a two-program package. The options are summarized in Table D-1. Note that the first option is the default; it is the option used by PROFILES 2.0 if the user does not specify an option. Option 1 is very conservative, in the sense that it causes a relatively small reduction in prevalence. Option 2 is the opposite; it assumes that the coverages do not overlap, thereby causing a relatively large reduction in prevalence. The third option is flexible because it allows the user to specify the value of e_{jk} and f_{jk}.

The impact of a program or package of programs on any prevalence variable is defined as the reduction in the prevalence of the deficient severity category from the base year prevalence, and is denoted by "RP" (for reduction in prevalence). In PROFILES 2.0, the reduction in prevalence of a program in any year is calculated by multiplying together the coverage, the effectiveness and the maximum impact in that year.

TABLE D-1: User Options to Estimate Interaction Between Two Programs

Option	Description	Comment
1	Total coverage overlap ($e=0$); Non-additive effect ($f=MAX\{EFF_j, EFF_k\}$).	Default option; Conservative; relative small prevalence reduction.
2	No coverage overlap ($e=1$). f not relevant when $e=1$.	Not conservative; relatively large prevalence reduction.
3	User specifies e and f.	Flexible option.

Similarly, the reduction in prevalence attributable to the individual coverage combinations can be obtained by multiplying the coverage, the effectiveness and the maximum impact for that coverage combination.[5] The RP for any of the three options is the sum of the RPs in the three coverage combinations for that option, as expressed in equation [D-4].

[D-4] $$RP = RP \text{ in } COV_{jo} + RP \text{ in } COV_{jk} + RP \text{ in } COV_{ok}.$$

The formulas for calculating the reduction in prevalence (RP) for standard options 1 and 2[6] are given in equations [D-5] and [D-6] respectively.

[D-5] $$RP(\text{option } 1) = (COV_j - COV_k)*EFF_j*MIMP_j + COV_k*(MAX\{EFF_j, EFF_k\}*MIMP_k.$$

[D-6] $$RP(\text{Option } 2) = COV_j*EFF_j*MIMP_j + COV_k*EFF_k*MIMP_k.$$

The formula for option 3 depends on whether the expression $(f_{jk}*EFF_j + f_{jk}*EFF_k)$ is greater than or less than one, as shown in equations [D-7] and [D-8].

<u>For $f_{jk}*(EFF_j + EFF_k) < 1.0$</u>

[D-7] $$RP(\text{option } 3) = (COV_j - [1-e_{jk}]*COV_k)*EFF_j*MIMP_j + (e_{jk}*COV_k)*EFF_k*MIMP_k + ([1-e_{jk}]*COV_k)*(f_{jk}*[EFF_j + EFF_k])*(MAX\{MIMP_j, MIMP_k\}).$$

<u>For $f_{jk}*(EFF_j + EFF_k) =$ or > 1.0</u>

[D-8] $$RP(\text{option } 3) = (COV_j - [1-e_{jk}]*COV_k)*EFF_j*MIMP_j + ([1-e_{jk}]*COV_k)*(MAX\{MIMP_j, MIMP_k\}) + (e_{jk}*COV_k)*EFF_k*MIMP_k.$$

E. The Consequence Functions

E.1. Mortality

E.1.1. General approach to deriving mortality function.

PROFILES 2.0 estimates stillbirths and deaths in under five year old children as a function of many of the prevalence variables. The mortality consequence function is really three separate functions: one for stillbirths, one for neonatal deaths, and one for deaths of children aged 1-59 months. Different prevalence variables are used in the three functions, as shown below.

Stillbirths	Neonatal Deaths	Deaths 1-59 Months
Iodine status (PG)	Iodine status (PG)	Weight-for-age (PU)
Iron status during pregnancy (PIR_4)	Iron status during pregnancy (PIR_4)	Feeding mode (PF)
Birth weight (PW)	Birth weight (PW)	Vitamin A status (PA)
	Initiate breastfeeding (PB)	

The formulas for the three functions are obtained in similar fashion. First divide the relevant population into subgroups, where each subgroup contains all the people with a unique combination of severity categories for the indicators that influence the mortality in that population group. (These subgroups are called "coverage combinations.") Second, estimate the population of each subgroup. Third, estimate the mortality rate and number of deaths in each subgroup. And finally, sum the deaths in all the subgroups.[7]

In order to complete the second step, namely, estimating the population in each subgroup, PROFILES 2.0 assumes that the nutritional indicators are independent. That is, being deficient in one condition neither increases nor decreases the odds of being deficient in another condition. However, there are some exceptions to the assumption of independence which PROFILES 2.0 takes into account, namely, iron deficiency during pregnancy is associated with low birth weight (Murphy, *et al*, 1986) (see variable K83), breastfeeding decreases the likelihood of vitamin A deficiency especially in infants (Newman, 1993) (see variables K77 and K78), and low weight-for-age and vitamin A deficiency tend to occur together (see variables K80 and K81).

In general, PROFILES 2.0 assumes that individuals suffering from several nutritional deficiencies have a much higher chance of dying than individuals suffering from only one. In order to complete the third step, namely, estimating the mortality rate of each subgroup, PROFILES 2.0 assumes that, with certain exceptions, the relative rate variables ("relative risk of death") associated with the severity categories in each subgroup multiply together to become the overall relative rate variable for the subgroup. This assumption generalizes the finding about the potentiating effect of undernutrition on mortality (Pelletier, *et al*, 1993) to all nutritional conditions. There are two exceptions to the simple multiplication model just described -- one is iodine deficiency and the second is the combination of severe underweight and no breastfeeding. The effect of iodine status on mortality is assumed to be independent of all other nutritional conditions, and in addition, independent of the overall mortality rate in the relevant age group. Based on results reported by Clugston, *et al* (1987), PROFILES 2.0 assumes an excess mortality model with respect to iodine in which a fixed proportion of births to iodine deficient pregnant mothers are stillborn or die neonatally over and above stillbirths and neonatal deaths to children of iodine deficient pregnant mothers due to other causes. PROFILES 2.0 gives

users the option of increasing the relative risk of death in non-breastfed infants that are severely underweight beyond that obtained in the multiplicative model described above (see variables K79 and K82).

E.1.2. Literature and default values.

Under 5 weight-for-age and mortality. Pelletier *et al* (1993) report that, in U5 children, mortality increases exponentially as weight-for-age increases in severity. Their conclusion is based on seven cross-sectional studies from four countries reported in the literature. The value of the exponentiation factor varies across the countries. PROFILES 2.0 incorporates this finding by assuming that the relative risk of death in children aged 1-59 months rises exponentially as weight-for-age goes from normal to mild to moderate to severe. The variable K8 contains the value of the exponentiation factor. (Weight-for-age is not a factor in the stillbirth and neonatal mortality functions in PROFILES 2.0; birthweight is used instead.) Four studies reported in the literature contain data on the relationship of weight-for-age and child mortality in Bangladesh.[8] One of those studies (Fauveau *et al*, 1990) found that the relative risk of death in children aged 6-36 months was eight times that of all other children. This implies an exponentiation factor of 3.63. PROFILES 2.0 uses this value (3.63) as its default value for K8 for Bangladesh.

Birthweight and mortality. McCormick (1985) reports that in the U.S. low birth weight babies (below 2500 grams) are five times more likely to die in the first year of life than normal birth weight babies (2500 grams and over), and 40 times more likely to die in the neonatal period. Data reported by Mardones (1991) on 254,000 Chilean births indicates that low birth weight babies are about ten times more likely to die in the neonatal period than normal birth weight babies. In PROFILES 2.0, K48 is the relative risk of neonatal death in low birth weight infants, and K47 is the relative risk of stillbirths in populations with low birth weight. In its Bangladesh application, PROFILES 2.0 assumes that the default values of K47 and K48 both equal 10.0, the value derived from the Mardones data for neonatal mortality.

Iodine status and mortality. In a review of all available data, Clugston *et al* (1987) propose an excess mortality model for iodine related stillbirths and neonatal deaths, and develop a model that predicts cretin prevalence in a population as a function of goiter prevalence. The latter model is approximately linear when goiter prevalence is less than 40%, where 3.43% of all live births to goitrous women are cretins.[9]

PROFILES 2.0 adopts the excess mortality model for iodine mortality proposed by Clugston *et al*, as well as the linear approximation of the Clugston *et al* model relating goiter prevalence and cretin prevalence. The variable giving the proportion of births to goitrous women that are cretins is denoted as K64, and its default value equals 0.0343. The excess stillbirth rate (the number of excess stillbirths per cretin birth) is denoted as K61 and its default value equals 0.656. The excess neonatal mortality (the number of excess neonatal deaths per cretin birth) is denoted as K62 and its default value equals 0.602.

Iron status and mortality. In a study of 54,000 pregnancies in England, Murphy *et al* (1986) found that perinatal mortality rates associated with low hemoglobin in pregnant women (Hgb<10.4) ranged from 1.077 to 1.357 higher than perinatal mortality associated with hemoglobin over 10.4. PROFILES 2.0 assumes that the relative risk of stillbirths and of neonatal mortality in iron deficient pregnant women relative to iron sufficient pregnant women equals 1.2, a rough midpoint of the range found by Murphy *et al*, and is reflected in variables K71 and K72.

Vitamin A status and mortality. Vitamin A supplements in vitamin A deficient (VAD) populations significantly reduce child mortality (Beaton *et al*, 1993; Humphrey *et al*, 1992). Based on a careful review of

all available studies, Beaton *et al* (1993) conclude that children aged 6-59 months who received vitamin A supplements were only 77% as likely to die as children not receiving supplements in high VAD populations. Although the two cited reviews (Beaton *et al*, Humphrey *et al*) do not find a relationship between prevalence of VAD and mortality in high VAD populations, Bloem *et al* (submitted) finds a strong relationship between Vitamin A capsule coverage and prevalence of nightblindness in Bangladesh and Humphrey *et al* (1992) report less effect of vitamin A supplementation on mortality in areas with low VAD than high VAD.[10]

PROFILES 2.0 assumes a direct linear relationship between the prevalence of VAD and the relative risk of death in children aged 6-59 months. For the application of PROFILES 2.0 in Bangladesh, the Beaton *et al* (1993) result was used to estimate a default value for the relative risk of death for VAD children aged 6-59 months (namely 1.82, and stored in variable K54) and to estimate mortality rates for VAD and non-VAD children aged 6-59 months (22.8 and 12.5 deaths per year per 1000 population, respectively).[11]

Breastfeeding and mortality. Numerous studies show that appropriate breastfeeding reduces infant and child mortality (e.g., Cunningham *et al*, 1991; Huffman *et al*, 1991; Victora, *et al*, 1987). Exclusive breastfeeding is recommended during months 0-5, and partial breastfeeding with appropriate complementary feeding thereafter through two years of age or more. In a study of Bangladesh children aged 6-35 months, Briend and Bari (1989) found that, in severely underweight children, the relative risk of death was six times higher in children who were not breastfeeding than children who were breastfeeding, but there was no significant difference between breast fed and not breastfed children in other underweight severity categories. Breastfeeding protects against nutrient deficiencies, especially vitamin A deficiency (Newman, 1993), although the mother's nutritional status can be an important factor in the degree of protection (Stoltzfus *et al*, 1993).

PROFILES 2.0 defines two breastfeeding indicators – "initiation" and "feeding mode." For the feeding mode indicator, two relative risk of death variables are defined for two age groups (0-5 months and 6-35 months), one is the ratio of not breastfeeding mortality to full breastfeeding mortality, and the second is the ratio of partial breastfeeding mortality to full breastfeeding mortality. These relative risk variables are denoted as K41, K42, K43 and K44. The breastfeeding initiation relative risk variable is denoted as K20. In addition, PROFILES 2.0 includes two special variables – K79 is the proportional increase in the relative risk of death in non-breast fed infants aged 0-5 months who are severely underweight compared to similar infants who are fully breastfed, and K82 is the proportional increase in the relative risk of death in non-breast fed infants aged 6-35 months who are severely underweight compared to similar infants who are partially breastfed.

For the application of PROFILES 2.0 in Bangladesh, K41 and K42, the relative risk variables in 0-5 month olds for partial breastfeeding and no breastfeeding respectively, were estimated to be 1.2 and 1.3 respectively. The corresponding relative risk variables for 6-35 month olds, K43 and K44, were estimated to be 0.9 and 1.2. These estimates are based on anecdotal undocumented evidence. The value set for K20, the relative risk of neonatal death in newborns not initiating breastfeeding compared to those that do, is 6.0, which was taken from the Briend and Bari (1989) result. The value for K79 and K82 were set at 5.0, in order bring the relative risk of death in severely underweight children who are not breastfeeding up to around 6 to reflect the Briend and Bari (1989) results.

E.1.3. Formulas for stillbirths and U5 mortality.

Stillbirths. In PROFILES 2.0, three nutrition indicators influence stillbirths – iodine status, iron status of pregnant women and birthweight. Birthweight is included because many of the same conditions that cause

low birthweight also contribute to stillbirths, especially maternal malnutrition during pregnancy, and therefore the incidence of low weight births correlates with the stillbirth rate. The number of stillbirths in any year T equals the excess stillbirths due to iodine deficiency plus the stillbirths in the four unique coverage combinations associated with iron status and birthweight. The number of stillbirths in each coverage combination is the product of four factors, namely, total births in year T, the fraction of those births associated with the coverage combination as calculated from the prevalences, a factor to adjust for the trend in the stillbirth rate inherent in the original population model projections, and a constant reflecting the stillbirth rate for that coverage combination calculated from relative rates and base year data. Because the population model does not include stillbirths, the stillbirth trend is assumed equal to the trend in neonatal mortality. The specific formula is given in the endnotes.[12]

Neonatal deaths. In PROFILES 2.0, four nutrition indicators influence neonatal deaths – iodine status, iron status of pregnant women, birthweight and initiation of breastfeeding. The number of neonatal deaths in any year T equals the excess neonatal deaths due to iodine deficiency plus the neonatal deaths in the eight unique coverage combinations associated with iron status and birthweight. As with stillbirths, the number of neonatal deaths in each coverage combination is the product of four factors, namely, total births in year T, the number of those births associated with the coverage combination as calculated from the prevalences, a factor to adjust for the trend in neonatal mortality in the original population model projections, and the mortality rate associated with that coverage combination. The specific formula is given in the endnotes.[13]

Deaths 1-59 months. In PROFILES 2.0, three nutrition indicators influence mortality in infants and children aged 1-59 months – weight-for-age, vitamin A status and feeding mode. Weight-for-age has four severity levels (normal, mild, moderate, severe), vitamin A has two (sufficient, deficient), and feeding mode has three (full, partial, no breastfeeding). Thus there are 24 unique coverage combinations (2x3x4=24). The total deaths in any year T equals the sum of the deaths in all 24 coverage combinations that year. However, PROFILES 2.0 assumes that fully breastfed infants and children are never vitamin A deficient, thereby reducing the number of coverage combinations to 20. As with stillbirths and neonatal deaths, the number of 1-59 month deaths in each coverage combination is the product of four factors, namely, total population in the age group in year T, the proportion of the population associated with the coverage combination as calculated from the prevalences, a factor to adjust for the trend in age-specific mortality in the original population model projections, and the mortality rate associated with that coverage combination.

Although the same indicators and severity levels are used throughout the 1-59 month age range, and the final formulas for computing number of deaths have exactly the same structure throughout the age range, several relational variables expressing relative risk of death are different in the 0-5 month age range than in the 6-59 month age range. Therefore, separate formulas exist for these two age groups, namely, 1-5 months, and 6-59 months. The specific formulas are given in the endnotes.[14]

E.2. Morbidity

E.2.1. General approach to deriving the morbidity functions.

Morbidity is defined as average sick days per child per year. The morbidity function in PROFILES 2.0 is organized by type of disease, by age, and by location (urban and rural). PROFILES 2.0 computes morbidity for two diseases – diarrhea and respiratory infection. (These two diseases typically account for about 50% of the mortality and morbidity in children in developing countries.) Vision impairment and malnutrition can also

be considered a type of morbidity, but are treated separately in this document. Number of annual sick days is computed separately for four age groups (neonatal, 1-5 months, 6-11 months, 12-59 months), and within in each age group, separate formulas are used for respiratory infection, rural diarrhea, and urban diarrhea. However, the rural/urban breakout is only done for the breastfeeding related indicators (PB and PF) and therefore the 12-59 month age group (where the breastfeeding indicators do not apply) includes only one diarrhea formula and one respiratory formula. Thus, there are a total of 11 separate formulas for days of sickness.

Different nutrition indicators influence the estimation of morbidity for different age groups and diseases, as shown below.

Neonatal	1-5 Months	6-11 Months	12-59 Months
Diarrhea:			
Birthweight (PW) Initiate breastfeeding (PB) Iron status during pregnancy (PIR_4)	Wt-for-Age (PU) Feeding mode (PF)	Wt-for-Age (PU) Feeding mode (PF) Vitamin A (PA)	Wt-for-Age (PU) Vitamin A (PA)
Respiratory Infection:			
Birthweight (PW) Initiate breastfeeding (PB) Iron status during pregnancy (PIR_4)	Feeding mode (PF)	Feeding mode (PF) Vitamin A (PA)	Vitamin A (PA)

The 11 formulas are obtained in similar fashion. First divide the relevant population into subgroups, where each subgroup contains all the people with a unique combination of severity categories for the indicators influencing the morbidity in that population group. (These subgroups are called "coverage combinations.") Second, obtain an expression for the population of each subgroup. Third, obtain expressions for the rural diarrhea morbidity, the urban diarrhea morbidity and the respiratory infection morbidity for each subgroup, using relative morbidity variables. Fourth, combine the population and morbidity expressions to obtain the number of days sick with diarrhea and with respiratory infection for each subgroup. And finally, sum the sick days in all the subgroups.

The second step, obtaining an expression for subgroup population, makes exactly the same assumptions of independence and non-independence among the prevalence of nutrition indicators as were made in the mortality function (section E.1.1).

The third step, obtaining expressions for morbidities, assumes an additive model rather than the multiplication model that was used in the mortality function. In other words, the relative morbidities of all the nutrition indicator severity levels influencing a particular subgroup add together (rather than multiply together) to yield the relative morbidity for the subgroup. The additive assumption for morbidity generalizes the finding of Black *et al* (1984) who reported that duration of diarrhea (and therefore days sick) increased (roughly linearly) with the severity of underweight, but incidence remained constant. There are no exceptions to the additive model for morbidity in PROFILES 2.0. Note that if a child is sick with two diseases on the same day, PROFILES 2.0 counts this as two days of sickness due to the assumption of additivity.

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E.2.2. Literature and default values.

Weight-for-age and morbidity. Black *et al* (1984) found an average diarrhea morbidity of 52.2 sick days per year per child in a sample of 125 Bangladesh children aged 0-23 months, ranging from 39 in normal weight-for-age to 56.2 in children weighing 60-75% of the reference median. Average duration of an episode was 10.2, 8.6 and 6.9 days in children weighing under 60%, 60-75%, and over 75% of the reference median, respectively. Chowdhury *et al* (1990) reported an average diarrhea morbidity of only 6.6 days per year in a sample of Bangladesh children aged 6-60 months. No publications were encountered that showed a relationship between respiratory morbidity and weight-for-age.

PROFILES 2.0 allows the user to select any values for the relative diarrhea morbidity of mild underweight, moderate underweight and severe underweight in children aged 0-59 months. In other words, there are three separate relative diarrhea morbidity variables; one each for mild (K1), moderate (K2) and severe (K3) underweight that apply over the entire 0-59 month range. Underweight status does not influence respiratory morbidity in PROFILES 2.0.

In the Bangladesh application, PROFILES 2.0 assumed an average diarrhea morbidity of 29.4 days per year, a figure halfway between the disparate results reported by Black *et al* and Chowdhury *et al*, and a linear relationship between the relative diarrhea morbidities for mild, moderate and severe underweight with a slope roughly equal to that reported in the Black *et al* study. The default values used for K1, K2 and K3 were 1.125, 1.25 and 1.375 respectively.[15]

Birthweight and neonatal morbidity. No literature was found on the relationship of birthweight and morbidity. PROFILES 2.0 assumes that birth weight can influence both diarrhea neonatal morbidity and respiratory neonatal morbidity. It includes a relative morbidity variable for low birth weight and neonatal diarrhea (K49) and a relative morbidity variable for low birth weight and neonatal respiratory infection (K50). In its Bangladesh application, PROFILES 2.0 assumes a default value for K49 of 1.25, which equals the default value for the relative diarrhea morbidity in moderate underweight children age 1-59 months. The Bangladesh default value for K50 (relative respiratory neonatal morbidity in low weight births) is 1.0.

Iron status and morbidity. Angeles *et al* (1993) found that iron supplementation of iron deficient Indonesian children aged 2-5 years reduced the incidence, but not duration, of diarrhea and respiratory infection relative to controls. The relative morbidity rates of iron deficient children compared to iron sufficient children was 3.0 for diarrhea and 2.5 for respiratory infection. No papers were found on the relation of iron status during pregnancy and morbidity of infants.

PROFILES 2.0 assumes that iron status in pregnant women can influence neonatal diarrhea morbidity and neonatal respiratory morbidity. Relative diarrhea morbidity is reflected in relational variable K75 and relative respiratory morbidity is in K76. However, PROFILES 2.0 does not make provision for iron status of children to influence child morbidity. (The Angeles *et al* results were unknown to the authors at the time the program was completed.) In the Bangladesh application, the default values of K75 and K76 were set equal to 3.0 and 2.5 respectively, reflecting the Angeles *et al* results even though they applied to a different age group.

Vitamin A status and morbidity. In general, the literature does not report a relationship between vitamin A deficiency and child morbidity in spite of the many findings of the effect of vitamin A deficiency on mortality. However, although a recent report (Ghana VAST Team, 1993) found no effect of vitamin A supplementation on total morbidity, it did find a significant effect of vitamin A supplementation on clinic and hospital attendance by children aged 6-59 months. At baseline, 57.6% of the children in the study were vitamin A deficient (SR=0.35-0.70 umol/L, or equivalently, SR<20 ugms/dL). After supplementation, clinic attendance in the vitamin A supplemented children was 88% of attendance in the unsupplemented children.

PROFILES 2.0 includes one relative morbidity variable (K51) for vitamin A deficiency in children aged 6-59 months, which is applied to both diarrhea and respiratory infection. In the Bangladesh application, the default value of K51 equals 1.263, based on the results of the Ghana VAST Team (1993).[16] This assumption is justified when computing the costs of morbidity, but less so when computing the days of sickness.

Breastfeeding and morbidity. Numerous studies report that feeding mode influences morbidity in infants. In a one year longitudinal study of 153 Peruvian infants (0-11 months) living in an underprivileged, periurban area, Brown *et al* (1989) found that both diarrhea and respiratory morbidity were influenced by feeding mode. The effect differed by age, mode (exclusive, partial, no breastfeeding) and type of complementary food when partially breastfed (food, artificial milk, other liquid). In a study of 2080 infant-mother pairs in The Philippines, Popkin *et al* (1990) found that diarrhea morbidity was influenced by age, feeding mode, type of complementary food and urban or rural location. Relative diarrhea morbidity was higher in urban than rural locations. In a review of 35 studies carried out in 14 different countries, Feachem and Koblinsky (1984) reported relative diarrhea morbidity of 3.5-4.9 in infants age 0-5 months when non-breastfed infants were compared to fully breastfed infants, but when non-breastfed were compared to fully+partially breastfed infants of different ages, the average diarrhea morbidities were 3.0 in 0-2 month olds, 2.4 in 3-5 month olds, 1.4 in 6-11 month olds and 1.0 over 12 months.[17]

As noted above, relative morbidity for feeding mode is always defined with respect to the morbidity of fully breastfed children in the age group, even though partial breastfeeding is the recommended mode for children over 6 months of age. PROFILES 2.0 defines separate relative morbidity variables for partially breastfed and non-breastfed children, by disease (diarrhea and respiratory infection) and age group (neonatal, 1-5, 6-11, 12-35). All PROFILES 2.0 relative diarrhea morbidity variables related to feeding apply to rural populations only. PROFILES 2.0 includes six different ratios of urban-to-rural diarrhea morbidity which, when multiplied by rural relative diarrhea morbidities for feeding, yield the corresponding urban relative diarrhea morbidity. The six urban/rural ratios are: 0-5 months/partial breastfeeding (K35), 0-5 months/non-breastfed (K36), 6-11 months/partial breastfeeding (K37), 6-11 months/non-breastfed (K38), 12-35 months/partial breastfeeding (K39), and 12-35 months/non-breastfed (K40). Relative neonatal morbidity for diarrhea and respiratory infection with respect to initiation of breastfeeding is in variables K21 and K28 respectively. The relative diarrhea and morbidity variables for children aged 1-5 months, 6-11 months and 12-35 months are in variables K22-K27 and K29-K34.

The default values for relative morbidities related to feeding used in the Bangladesh application are summarized in Table E-1.

E.2.3. Formulas for Days Sick.

Neonatal days sick. PROFILES 2.0 estimates the total neonatal days of sickness in a year due to diarrhea and respiratory infection. Three nutrition indicators influence neonatal diarrhea and respiratory morbidity – birthweight, initiation of breastfeeding and iron status during pregnancy. Total neonatal days sick as a result of diarrhea or respiratory infection in the population is the sum of the neonatal sick days for each

TABLE 5-1
Default Values for Breastfeeding Relative Morbidity and Urban/Rural Diarrhea Ratios Used in Bangladesh

Condition-Severity	diarrhea			respiratory infection[a]		
	0-5 m	6-11 m	12-35 m	0-5 m	6-11 m	12-35 m
Relative Morbidity:						
BF partial	2.16[b]	1.0[d]	1.0[d]	2.27[b]	1.0[d]	1.0[d]
BF none	3.91[b]	1.54[d]	1.0[d]	4.20[b]	1.78[d]	1.0[d]
Urban/Rural Ratio:						
BF partial	2.16[c]	1.00[d]	1.0[d]			
BF none	2.77[c]	1.13[d]	1.0[d]			

NOTES: [a] Includes both upper and lower respiratory infection. [b] Based on Brown *et al* (1989). [c] Partially based on Feachem and Koblinsky (1984). [d] Based on Popkin *et al* (1990). [e] No effect assumed due to lack of evidence.

disease in the eight coverage combinations. The number of diarrhea and of respiratory sick days in each coverage combination is the product of three factors, namely, the neonatal population in year T, the fraction of that population associated with the coverage combination as calculated from the prevalences, and a constant reflecting the morbidity rate for that disease in that coverage combination calculated from relative rates and base year data. The prevalences of birthweight and iron status during pregnancy are not independent, as noted above. The specific formula for total neonatal days sick is given in the endnotes.[18]

Days sick 1-5 months. As in neonatal morbidity, total sick days for the 1-5 month age group is estimated for rural diarrhea, urban diarrhea and respiratory infection. In this age group, weight-for-age and feeding mode influence diarrhea morbidity, but only feeding mode influences respiratory morbidity. These indicators produce 12 different coverage combinations. Total diarrhea and respiratory sick days in the age group is the sum of the sick days for each disease in all 12 coverage combinations. The number of sick days in each coverage combination is the product of three factors, namely, the population in the age group in year T, the fraction of that population associated with the coverage combination as calculated from the prevalences, and a constant reflecting the morbidity rate for that disease in that coverage combination calculated from relative rates and base year data. The specific formula for total days sick in the 1-5 month age group is given in the endnotes.[19]

Days sick 6-11 month olds. Morbidity in the 6-11 month age group is influenced by three nutrition indicators – weight-for-age, feeding mode and vitamin A status. These indicators produce 24 different coverage combinations. The non-independence of the prevalence of vitamin A status with weight-for-age and with feeding mode is ignored for the calculation of days sick in this age group. Days of sickness for rural diarrhea, urban diarrhea and respiratory infection in any year T are estimated for each coverage combination, and then summed to obtain the total days sick by disease and location. As in the 1-5 month age group, sick days in each coverage combination is the product of the population and morbidity rate for that coverage combination. The specific formula is given in the end notes.[20]

Days sick 12-59 month olds. Morbidity in the 12-59 month age group is influenced by two nutrition indicators – weight-for-age and vitamin A status. Vitamin A status influences diarrhea and respiratory infection while weight-for-age influences only diarrhea. These indicators produce eight different coverage combinations. The non-independence of weight-for-age and vitamin A status is included in the PROFILES 2.0 formula for days sick in this age group. Days of sickness for rural diarrhea, urban diarrhea and respiratory infection in any year T are estimated for each coverage combination, and then summed to obtain the total days sick by disease and location. As in the 1-11 month age groups, sick days in each coverage combination is the product of the population and morbidity rate for that coverage combination. The specific formula is given in the endnotes.[21]

E.3. Fertility

E.3.1. Fertility rate and breastfeeding.

In PROFILES 2.0, fertility is influenced by the duration of breastfeeding. The relationship is based on a multiplicative model by Bongaarts (1978) in which the total fertility rate (TFR) in a population is a function of four determinants – marriage, contraceptive use, induced abortion rate and lactation. The Bongaarts model takes the form:

[E-1]
$$TFR = a1 \cdot a2 \cdot a3 \cdot a4 \cdot FEC.$$

Where: FEC (total fecundity) is the maximum average number of live births that women would have in their lifetime assuming maximum in-union exposure during child-bearing years and no contraception, induced abortion or lactation, and a1, a2, a3 and a4 are parameters reflecting the level of marital exposure, contraceptive use, induced abortion and lactation in the population, respectively. The complement of each parameter (that is, one minus the parameter) is defined as the proportional reduction in fertility due to that parameter; for example, if the contraception parameter equals 0.7, then the effect of contraception would be to reduce TFR by 30%.

Bongaarts(1978) has shown that the lactation parameter (a4) in equation [E-1] can be estimated as a function of the average duration of lactation ($a4 = 20/(20+0.56 \cdot PD)$), where "PD" is the average duration of lactation in months, and therefore equation [E-1] can be written as shown in equation [E-2].

[E-2]
$$TFR = FEC \cdot a1 \cdot a2 \cdot a3 \cdot 20 / (20+0.56 \cdot PD).$$

PROFILES 2.0 assumes that the values for FEC, a1, a2 and a3 are constants for a particular country. Thus, the numerator in equation [E-2] can be written as a single constant (K116) and equation [E-2] becomes equation [E-3] for a particular country and year.

[E-3] $$TFR_T = (K116) / (20+0.56*PD_T).$$

The value of the relational variable "K116" can be estimated in one of two ways. (1) Base year values for TFR and PD can be obtained and plugged into [E-6] to obtain the estimate. (2) Use estimates of FEC, a1, a2 and a3 to calculate the value of K116 directly. Bongaarts (1978) and Cleland *et al* (1984) provide separate estimates of FEC, a1, a2, a3 and a4 for various countries, with the Cleland *et al* estimates based on World Fertility Survey data. Cleland *et al* also provide estimates of the effect of location (rural, towns, metropolitan) on a1 through a4 in different regions of the world.

As with mortality rates, the fertility estimates entered into the population growth model in PROFILES generally decrease slowly over time. In order to accommodate this decrease, PROFILES 2.0 multiplies the estimate of TFR_T given in [E-3] by the ratio of the model TFR in year T to the model TFR in the base year, as shown in [E-4].

[E-4] $$TFR_T = ({}^{MOD}TFR_T/{}^{MOD}TFR_0)*(K116) / (20+0.56*PD_T).$$

Where: TFR_T = Total fertility rate in year T. ${}^{MOD}TFR_T$ = Total fertility rate in year T given in the selected model fertility table before adjusting for the extra effect of change in duration of breastfeeding. PD_T = Duration of breastfeeding in year T in months. K116 = Relational variable giving effect of factors other than breastfeeding on fertility.

In the Bangladesh application of PROFILES 2.0, K116 was estimated directly from FEC, a1, a2 and a3 using and updating the estimates by Bongaarts (1978) and Cleland *et al* (1984). The estimates were FEC = 16.1, a1 = 0.86, a2 = 0.613 and a3 = 1.0, yielding K116 = 169.75.[22]

E.3.2. Replacement cost of fertility effects of breastfeeding (Not programmed in version 2.0; planned for version 2.1.)

The replacement cost of the fertility effects of breastfeeding is estimated as the cost to achieve those same effects with other family planning programs. PROFILES 2.0 uses a simplified approach in which a fixed dollar amount (K203) is assumed to be the cost of reducing fertility by one. Thus the cost of reducing fertility from 7 to 6 children is the same as the cost of reducing it from 4.5 to 3.5 children. This rate is expressed in the variable K203. Since total fertility rate (TFR) in PROFILES 2.0 is a function of the average duration of breastfeeding (PD), the monetary value of the fertility effects of increasing the average duration of breastfeeding can be estimated, as given in equation [E-5].

[E-5] $$SAV2_{L,T} = K203 * (TFR(PD_{L,T}) - TFR(PD_{L,0})).$$

Where: $SAV2_{L,T}$ = Monetary value in $ U.S. of fertility effects of increased breastfeeding in year T over the base year. $PD_{L,T}$ = Average duration of breastfeeding in months in year T. $TFR(PD_{L,T})$ = Total fertility rate as a function of average duration of breastfeeding in year T. K203 = Cost of family planning programs in $ U.S. that decrease TFR by one.

E.4. Vision

Vitamin A status is the only nutrition indicator that influences vision in PROFILES 2.0. Four vision related consequences are estimated -- new cases of total blindness and of partial blindness, and prevalence of total blindness and of partial blindness.

E.4.1. Total blindness.

According to International Ophthalmology (1990), approximately 5% of children who develop xerophthalmia eventually become totally blind. PROFILES 2.0 assumes that the prevalence of xerophthalmia equals PA_3, the prevalence of nightblindness.

Incidence of new cases. In order to estimate the incidence of new cases of total blindness, PROFILES 2.0 assumes that the conversion from xerophthalmia to total blindness all occurs in the same year that the xerophthalmia first occurs. This assumption is appropriate in a steady state situation but overestimates total blindness when vitamin A deficiency, and therefore xerophthalmia, is decreasing. Thus, in PROFILES 2.0. the new cases of blindness in a year is proportional to the new cases of xerophthalmia in that year. The new cases of xerophthalmia in children under 5 years in any year equals new cases in a one year cohort (which PROFILES 2.0 assumes to be the survivors at age 5) plus an adjustment when there is an increase in the xerophthalmia rate, as shown in equation [E-6].

[E-6] $$ITB_{U5,T} = K57 \cdot PA_{3,U5,T} \cdot POP_{A=5,T} + K57 \cdot [(PA_{3,U5,T} \cdot POP_{6\text{-}59,T}) - (PA_{3,U5,T-1}) \cdot POP_{6\text{-}59,T-1})].$$

Where: $ITB_{U5,T}$ = Incidence of new cases of total blindness in children under 5 years in year T; $PA_{0,U5,T}$ = Prevalence of nightblindness in children under 5 years in year T; $POP_{A=5,T}$ = Population of children aged 5 years in year T; $POP_{6\text{-}59,T}$ = Population of children aged 6-59 months in year T; K57 = Proportion of nightblind children who go totally blind.

PROFILES 2.0 assumes that new cases of total blindness occur in school age children (ITB_{SCL}) only when there is an increase in the xerophthalmia rate in school aged children, as shown in equation [E-7].[23]

[E-7] $$ITB_{SCL,T} = K57 \cdot [(PA_{3,SCL,T} \cdot POP_{SCL,T}) - (PA_{3,SCL,T-1}) \cdot POP_{SCL,T-1})].$$

Prevalence. Mortality is much higher in blind children than in seeing children. Therefore, the prevalence of total blindness is lower than would be obtained from the incidence of new cases. Levin *et al* (1993) estimate that 50-80% of young children who go blind die within one year. PROFILES 2.0 assumes that the prevalence of total blindness equals the prevalence of xerophthalmia (as denoted by PA_3) multiplied by the xerophthalmia-to-blindness conversion rate (K57 or K58) and the one year survival rate of children who become totally blind (K52), as shown in equation [E-8].

[E-8] $$PTB_{A,T} = K52 \cdot K57 \cdot PA_{3,A,T}, \text{ for A = U5 and SCL.}$$

Where: $PTB_{A,T}$ = Prevalence of total blindness in age group "A" in year "T;" $PA_{0,A,T}$ = Prevalence of nightblindness in age group "A" in year "T;" K52 = Proportion of U5 children who survive at least one year after going totally blind (K52 = 1.0 for children over 5 years); K57 = Proportion of nightblind children who go totally blind.

The Bangladesh default value for K52, the one year survival rate of totally blind U5 children, is 0.50, which is the lower bound of the estimate by Levin *et al* (1993). The default value for K57, the xerophthalmia-to-total blindness conversion rate children, is 0.05, which is the figure estimated by International Ophthalmology (1990).

E.4.2. Partial blindness.

Partial blindness refers to long-lasting vision impairment, such as permanent scars or one blind eye. The formulas for estimating the incidence and prevalence of partial blindness are similar to those for total blindness with the following exceptions: (1) partial blindness is assumed not to cause excess mortality and so the K52 variable is omitted, and (2) conversion rates from xerophthalmia may be different in school age children than in U5 children and so a different relational variable, K58, is used in place of K57. The formulas for incidence of new cases of partial blindness ($IPB_{A,T}$) and prevalence of partial blindness ($PPB_{A,T}$) are given in the endnotes.[24]

No information was found on the xerophthalmia-to-partial blindness conversion rate in the literature, and therefore the default value for K58 is set equal to 0.05, the value for K57.

E.5. Intelligence

Iodine status, as measured by goiter prevalence, is the only nutrition indicator that influences intelligence in PROFILES 2.0. The consequence of iodine status on intelligence is described in two different ways. First is the number of cretins and other mentally impaired persons resulting from iodine deficiency. Second is the total deficit in IQ points in the population as a result of iodine deficiency.

E.5.1. Cretins and other mentally impaired persons.

Iodine deficiency in pregnant women and newborns can hinder the proper development of the nervous system, resulting in lower intelligence and in motor and sensory handicaps. A limited number of the iodine deficient newborns can be successfully treated. PROFILES 2.0 defines three mutually exclusive groups that are mentally impaired as a result of iodine deficiency: cretins, permanently mentally impaired (PMI) and correctable mentally impaired (CMI). The degree of mental impairment is more severe in cretins than in PMIs and CMIs, although some cretins are deaf-mutes with normal native intelligence.

Cretin births and population. PROFILES 2.0 assumes a linear relationship between goiter prevalence and the birth rate of cretins.[25] This relationship is also discussed in section E.1.2 above and in Endnote 9. Based on this relationship, PROFILES 2.0 computes the number of cretins who are born and survive the early stages of life in any year T using equation [E-9].

[E-9]
$$BC_T = K64 \cdot PG_{2,T} \cdot B_T .$$

Where: BC_T = Births of surviving cretins in year "T;" PG_2 = Prevalence of goiter in the population; B_T = Live births in year "T;" and K64 = Proportion of live births to goitrous women that are cretins who survive the early stages of life.

PROFILES 2.0 estimates that the number of cretins alive in any year, T, equals the cretins born in all past years less the deaths of those cretins according to standard life tables. Equation [E-10] gives the number of cretins alive in year T ($CRET_T$) as a function of the cretin population ($CRET_{T-1}$), cretin births (BC_{T-1}) and deaths (DC_{T-1})in year T-1.

[E-10] $$CRET_T = CRET_{T-1} + BC_{T-1} - DC_{T-1}.$$

Other mentally impaired due to iodine deficiency. Based on their review of the available studies, Clugston *et al* (1987) conclude that iodine deficiency produces about three mentally impaired persons for every cretin. Therefore, PROFILES 2.0 assumes a linear relationship between the number of cretin births and the number of (PMI+CMI) births, and a linear relationship between the prevalence of cretins and the prevalence of PMIs. The prevalence of CMIs is assumed to be proportional to the goiter prevalence because it is correctable. The formulas that PROFILES 2.0 uses to compute values for PMI and CMI are given in equations [E-11] through [E-13].

[E-11] $$BPMI_T = BC_T * K63 * (1-K65).$$

[E-12] $$PMI_T = CRET_T * K63 * (1-K65).$$

[E-13] $$CMI_T = K63*K64*K65*PG_T*POP_T.$$

Where: $BPMI_T$ = Births of PMIs in year T; BC_T = Cretin births in year T; CMI_T = Number of CMIs alive in year T; $CRET_T$ = Number of cretins alive in year T; PG_T = Goiter prevalence in year T; PMI_T = Number of PMIs alive in year T; K63 = The ratio of mentally impaired persons due to iodine deficiency (PMI+CMI) to cretins; K64 = Cretin birth rate in goitrous women; and K65 = CMI/(PMI+CMI).

The total number of mentally impaired persons due to iodine deficiency is the sum of cretins, PMIs and CMIs. The rate of mentally impaired births to goitrous women is equal to K63*K64, and is stored independently as relational variable K66.

The Bangladesh default value for K63 is the estimate reported by Clugston *et al* (1987), namely K63 = 3.0. The estimate for K64 was noted above (section E.1.2) as 0.343. No information was found on the ratio of CMIs to PMIs, and the default value for Bangladesh is arbitrarily set equal to 0.10. K66, the rate of all mentally impaired births to goitrous women, equals K63*K64, or about 13%.

E.5.2. Lost IQ Points (Not programmed in version 2.0; planned for version 2.1.)

Some studies, notably Boyages *et al* (1989), have found a systematically lower IQ distribution in populations living in iodine deficient areas of China than comparable populations living in iodine sufficient areas. However, Bleichrodt *et al* (1980) found no such effect in Indonesia. Goiter prevalence in the deficient areas in the Boyages *et al* study was 60%, and in the Bleichrodt *et al* study was 68%. Boyages *et al* found the average IQ was 12.0 points lower in the deficient children (84.4 vs. 72.4) and 10.5 IQ points lower in the deficient adults (75.6 vs. 65.1).

PROFILES 2.0 estimates the total number of lost IQ points due to iodine deficiency in two age groups – newborns and the total population. Lost IQ points in newborns in any year T is proportional to the number of live births and the goiter prevalence in year T. Lost IQ points in the total population depends of the goiter

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prevalence in all past years and therefore is proportional to cretin prevalence. Formulas for computing lost IQ points in newborns and in the total population are given in equations [E-14] and [E-15].

[E-14] $LIQ_{B,T} = K201 \cdot B_T \cdot PG_T$.

[E-15] $LIQ_{POP,T} = K201 \cdot CRET_T / K64$.

Where: B_T = Live births in year T; $CRET_T$ = Cretins alive in year T, as computed in [E-10]; $LIQ_{B,T}$ = Lost IQ points due to iodine deficiency in infants born in year "T;" $LIQ_{POP,T}$ = Lost IQ points due to iodine deficiency in entire population in year "T;" K64 = Proportion of births to iodine deficient women that are cretins; K201 = Average deficit per person in IQ points due to iodine deficiency during pregnancy compared to persons with iodine sufficient mothers.

In manual applications of this model to Bangladesh, the value of K201, the average IQ deficit due to iodine deficiency, was set equal to 10.0, just less than the lowest of the two IQ deficits reported by Boyages *et al* (1989).

E.6. School Repeaters

The school repeat rate is defined as the proportion of students enrolled in a particular grade (or grades) that have been enrolled in that same grade in any previous year. Repeat rates are an indicator of learning and school performance and are also related to school costs.

In PROFILES 2.0 iodine status and stunting influence school repeat rates. Fierro-Benitez *et al* (1986) reported that first grade repeat rates dropped significantly in an Ecuadorean village after iodine deficiency in the village was eliminated, compared to a control village, but that little or no effect was observed in repeat rates in grades 2-6. The first grade repeat rate was 1.77 times higher in the control. In a comprehensive review, Pollitt (1990) presents evidence that reduced stunting has improved school performance when accompanied by mental stimulation such as tutoring. Therefore, PROFILES 2.0 assumes that stunting reduction programs must be accompanied by mental stimulation programs in order to influence school repeat rates.

The number of primary school repeaters in any year is a function of the school age population and enrollment rate in that year. PROFILES estimates the number of repeaters in the first grade separately from the repeaters in grades 2-6 because a large proportion of all repeats occur in the first grade, and because of the evidence that the relative repeat rate associated with iodine deficiency is markedly different in the first grade than in grades 2-6. In this model, the estimate of first grade repeaters is based on the 6 year old cohort and the estimate for grades 2-6 is based on the 7-11 year old cohort.

With respect to iodine deficiency, PROFILES 2.0 assumes that cretins do not enroll and that the number of repeaters is proportional to the prevalence of CMIs + PMIs in the 6 year and 7-11 year age cohorts. With respect to stunting, all three severity levels (mild, moderate and severe) are grouped into a single category. As noted above, PROFILES 2.0 assumes that a drop in the stunting prevalence reduces the repeat rate to the extent that the stunting reduction is accompanied by a mental stimulation program. PROFILES 2.0 uses a prevalence-like variable called PQ_T to indicate the proportion of children involved in stunting reduction that have also participated in mental stimulation programs such as tutoring.

Relative rate variables, specifically relative school repeat rates, are used to derive the default values of the indicator specific repeat rates, similar to the approach used in the mortality and morbidity functions. Four relative repeat rate variables are defined – the relative repeat rate for CMIs+PMIs in grade 1 (K67) and in grades 2-6 (K68), and the relative repeat rate for stunted children in grade 1 (K10) and in grades 2-6 (K11). In addition relational variables are defined for the base year first grade repeat rate (K84), the base year repeat rate for grades 2-6 (K85), the base year enrollment rates for first grade (K100) and grades 2-6 (K101). The formulas for calculating the number of repeaters by grade level are given in the endnotes.[30]

Default values for Bangladesh. Default values for relative repeat rates for children of iodine deficient mothers are taken from the Fierro-Benitez *et al* (1986) study in Ecuador, with the first grade relative rate (K67) equal to 1.77 and the repeat rate for grades 2-6 (K68) set at 1.0. No direct data was found on relative repeat rates for stunted children, but based on Pollitt's work, a 5% effect was assumed for all grades. Thus the default values of K10 and K11 were set at 1.05. The base year repeat rates and enrollment rates were set equal to the overall repeat rate and overall enrollment rate in primary schools in 1990 as reported by the Bangladesh Ministry of Education, namely K84 = 5%, K85 = 5%, K100 = 89% and K101 = 89%.

E.7. Government Expenditures

PROFILES 2.0 estimates the potential effect of nutritional improvements (as measured by changes in the nutrition indicators) on government health and school expenditures. These estimates should not be construed as predictions of actual increases or decreases in government budgets or expenditures. Rather, they are estimates of what it costs the government to accomplish certain work which no longer needs to be done because of nutritional improvement.

E.7.1. Government health expenditures.

Government health expenditures are determined by morbidity, vision impairment, mortality and births (including stillbirths). Morbidity related expenditures are estimated for three childhood diseases – respiratory infection, diarrhea and malnutrition, which in turn are related to weight-for-age, feeding mode, birthweight (for neonates), iron status and vitamin A status. Vision impairment is related to vitamin A status. Mortality is related to all six nutrition conditions. Number of births is influenced by feeding mode; and stillbirths by iron status, iodine status and birthweight. The expenditures associated with morbidity, vision impairment, mortality and births are summed to obtain total expenditures.

Morbidity. Morbidity-related expenditures are proportional to the number of clinic visits, which in turn are proportional to the prevalence of respiratory infection, diarrhea and underweight (moderate and severe only). Specifically, PROFILES 2.0 defines three relational variables, K94, K95 and K96, that give the average number of days a child is sick with respiratory infection, diarrhea or underweight (moderate or severe), respectively, to generate one clinic visit. The formula for estimating morbidity-related expenditures is given in equation [E-16].

[E-16] $$EX1_T = K104 \cdot ({}^{r}S_{U5,T}/K94 + {}^{d}S_{U5,T}/K95 + 365 \cdot POP_{U5,T} \cdot (PU_{3,U5,T} + PU_{4,U5,T})/K96.$$

Where: $EX1_T$ = morbidity-related government health expenditures in year T. ${}^{b}S_{U5,T}$ = total days of sickness with disease type "b" in children under 5 years in year T. $PU_{V,U5,T}$ = Prevalence of underweight of severity level "V" (V=3 for moderate, V=4 for severe) in children under 5 years in year T. K94 = Average

days sick with respiratory infection to generate one clinic visit. K95 = Average days sick with diarrhea to generate one clinic visit. K96 = Days in a state of moderate or severe underweight to generate one clinic visit for malnutrition.

Morbidity cost default values. In a study of diarrhea costs in Indonesia, Lerman *et al* (1985) found that 37% of all diarrhea episodes in children generated a clinic visit, and that the marginal cost (medicines, tests, supplies, but not personnel or facilities) was $0.85 (U.S.) per visit. For Bangladesh, PROFILES arbitrarily assumes that 15% of all diarrhea episodes generate a clinic visit, which yields a figure for K95 of 53.3 days of diarrhea to generate one clinic visit assuming an average annual diarrhea prevalence of 29.4 days and an average duration of 8 days per diarrhea episode. In lieu of other data, K94 (respiratory sick days to generate one clinic visit), is set equal to K95, namely 53.3 days.

A study of 19 health clinics in Bangladesh found that 11% of all the visits were for "malnutrition" and 23% were for "diarrhea" (Stanton and Clemens, 1989). The default value for K96, the days of malnutrition (moderate plus severe underweight) required to generate one clinic visit, is estimated to be 509.1 days using base year data and assuming the same ratio of malnutrition to diarrhea clinic visits as found by Stanton and Clemens.[27]

Vision impairment. Vision related costs are proportional to the prevalence of blindness and partial blindness in preschool and school-aged children. The marginal average annual government health expenditures associated with one totally blind child (K59) and one partially blind child (K60), over the expenditures for a normal child, form the basis of the estimate, as given in equation [E-17].

[E-17] $EX2_T = K59*(PTB_{U5,T}*POP_{U5,T} + PTB_{5\text{-}14,T}*POP_{5\text{-}14,T}) + K60*((PPB_{U5,T}*POP_{U5,T} + PPB_{5\text{-}14,T}*POP_{5\text{-}14,T}).$

Where: $EX2_T$ = Vision-related government health expenditures in year T. $PPB_{A,T}$ = Prevalence of partial blindness in children in age group "A" in year T. $PTB_{A,T}$ = Prevalence of total blindness in children of age "A" in year T. K59 = Average annual government health expenditures to care for a totally blind child over and above the costs of caring for a normal child. K60 = Average annual government health expenditures to care for a partially blind child over and above the costs of caring for a normal child.

Vision cost default values. No information was found on the additional cost to the government of caring for visually impaired children. Therefore, for the Bangladesh application, K59 and K60 were both set equal to 0.

Mortality. Mortality-related government health expenditures are of two types -- those directly related to the death such as funeral or record-keeping costs, and those related to the replacement of the dead child with another pregnancy and birth. The direct costs are estimated by multiplying the number of under 5 deaths (plus stillbirths) by the average direct cost of a death (K105). Costs associated with replacement of children who die are proportional to the number of child deaths, the replacement rate (K109) and the average government health expenditures to raise a replacement child to the age of the replaced child's death (average age of death in U5 children (K107) times the average annual government health expenditure per person (K108)). PROFILES 2.0 assumes these expenditures occur in the year that the replaced child dies. The formula for estimating the direct costs related to mortality is given in equation [E-18] and the formula for expenditures related to replaced child deaths is in equation [E-19].

[E-18] $EX3_T = K105*(POP_{U5,T}* X_{U5,T} + B_T* SB_T).$

[E-19] $$EX4_T = K107 \cdot K108 \cdot K109 \cdot (POP_{U5,T} \cdot X_{U5,T}).$$

Where: $EX3_T$ = Total government expenditures in year T associated with direct costs of child deaths. $EX4_T$ = Total government expenditures in year T associated with replacement of under five deaths. B_T = Live births in year T. SB_T = Stillbirth rate per live birth in year T. $X_{U5,T}$ = Mortality rate of children under 5 years in year T. K105 = Average direct cost associated with a child death. K107 = Average age at which U5 deaths occur. K108 = Average annual cost to government of providing health services to one U5 child. K109 = Average replacement rate of children who die with another pregnancy and birth that would not have occurred if the first child had not died.

Mortality cost default values. Based on a comprehensive review by the United Nations Office of Population (UN Secretariat, 1988), PROFILES 2.0 estimates the value of K109, the child mortality replacement rate for Bangladesh, to be 20%. A study of health costs in Matlab, Bangladesh (Horton and Claquin, 1983) reported that in 1979 the marginal annual costs per capita for health services was $1.80 (U.S.). This translates into $4.61 in 1990 assuming a 9% inflation rate, which is the default value for K108. The average age of U5 deaths (K107) is estimated to be 2.0 years. No information was found on the average direct cost of child mortality, and the default value for K105 was arbitrarily set equal to $0.10.

Deliveries. Each birth and stillbirth is assumed to generate a government expenditure that includes prenatal and delivery care, and which is denoted by K106. Total delivery related costs in a year are simply the product of this average cost and the total number of live births and stillbirths in that year, as given in equation [E-20].

[E-20] $$EX5_T = K106 \cdot (B_T + SB_T).$$

Where: $EX5_T$ = Total government expenditures in year T associated with deliveries, including prenatal and delivery care costs. B_T = Live births in year T. SB_T = Stillbirth rate per live birth in year T. K106 = Average government expenditures associated with one birth.

Total. Total government health expenditures in any year related to child morbidity, vision impairment, mortality, mortality replacement and births is the sum of the individual components, as given in equation [E-21].

[E-21] $$EX6_T = EX1_T + EX2_T + EX3_T + EX4_T + EX5_T .$$

Birthing cost default values. No information was found on the average cost associated with prenatal and delivery care for one birth. The Bangladesh default value for K106 was arbitrarily set at $2.00.

E.7.2. Government school expenditures.

PROFILES 2.0 estimates government costs associated with primary school repeaters, not all school costs. The estimate is the number of repeaters in a year times the average cost of educating a primary school student for one year (K102). The formula for estimating this amount is given in equation [E-22].

[E-22] $$EX7_T = K102 \cdot (REP_{1,T} + REP_{2+,T}).$$

Where: $EX7_T$ = Government expenditures in year T associated with primary school repeaters (grades 1-6). $REP_{G,T}$ = Number of repeaters in grade "G" (where G=1 for first grade and G=2+ for grades 2-6) in year T. K102 = Average cost to government to educate one primary school student for one year.

The default value of K102 for Bangladesh is set equal to 400 Taka, based on Ministry of Education data.

E.8. Production and Value of Breastmilk

E.8.1. Quantity of breastmilk

The amount of breastmilk produced by a lactating woman depends on the mode of feeding (full or partial breastfeeding) and the age of the child. Production is higher with younger children and full breastfeeding. Using the methodologies given by Alim (1993) and Levine and Huffman (1990), PROFILES estimates the average maximum potential amount of breastmilk a mother produces at different child ages, and the losses that occur at these ages due to non-breastfeeding and non-optimal partial breastfeeding, thereby arriving at the estimated actual production by age and feeding mode. Equations [E-23] through [E-26] compute, respectively, the potential national production, national loss due to non-breastfeeding, national loss due to non-optimal partial breastfeeding, and actual national production, all in liters. Note that potential daily production (K12-K15) is given in milliliters, and therefore must be divided by 1000 to transform the answer to liters.

[E-23] $QTY1_{L,T} = (POP_{0\text{-}5m,L,T} \cdot K12 + POP_{6\text{-}11m,L,T} \cdot K13 + POP_{12\text{-}23m,L,T} \cdot K14 + POP_{24\text{-}35m,L,T} \cdot K15) \cdot 365/1000.$

[E-24] $QTY2_{L,T} = (PF_{2,0\text{-}5m,L,T} \cdot POP_{0\text{-}5m,L,T} \cdot K12 + PF_{2,6\text{-}11m,L,T} \cdot POP_{6\text{-}11m,L,T} \cdot K13 + PF_{2,12\text{-}23m,L,T} \cdot POP_{12\text{-}23m,L,T} \cdot K14 + PF_{2,24\text{-}35m,L,T} \cdot POP_{24\text{-}35m,L,T} \cdot K15) \cdot 365/1000.$

[E-25] $QTY3_{L,T} = (PF_{2,0\text{-}5m,L,T} \cdot POP_{0\text{-}5m,L,T} \cdot K12 \cdot K16 + PF_{2,6\text{-}11m,L,T} \cdot POP_{6\text{-}11m,L,T} \cdot K13 \cdot K17 + PF_{2,12\text{-}23m,L,T} \cdot POP_{12\text{-}23m,L,T} \cdot K14 \cdot K18 + PF_{2,24\text{-}35m,L,T} \cdot POP_{24\text{-}35m,L,T} \cdot K15 \cdot K19) \cdot 365/1000.$

[E-26] $QTY4_{L,T} = QTY1_{L,T} - QTY2_{L,T} - QTY3_{L,T}.$

Where: $QTY1_{L,T}$ = Total potential production of breastmilk in region "L" in liters during year T. $QTY2_{L,T}$ = Loss of potential production of breastmilk in liters in region "L" during year T due to prevalence of no breastfeeding. $QTY3_{L,T}$ = Loss of potential production of breastmilk in liters in region "L" during year T due to prevalence of non-optimal partial breastfeeding. $QTY4_{L,T}$ = Estimated actual annual production of breastmilk in liters in region "L" during year T. $PF_{2,A,L,T}$ = Prevalence of partial breastfeeding in age group "A" in location "L" in year T. $PF_{3,A,L,T}$ = Prevalence of no breastfeeding in age group "A" in location "L" in year T. K12-K15 = Average maximum potential daily breastmilk production per mother in milliliters with child in age groups 0-5m, 6-11m, 12-23m and 24-35m, respectively. K16-K19 = Average percentage loss in breastmilk production due non-optimal partial breastfeeding with child in age groups 0-5m, 6-11m, 12-23m and 24-35m, respectively.

Default values. The default values for the potential daily maximum production at different ages (K12-K15) is based on estimates by Rhode (quoted in Alim, 1993) and Brown *et al*, 1982 (quoted in Huffman and Huque, 1983). Default values for the loss rates due to non-breastfeeding and non-optimal partial breastfeeding

are assumed to increase as the nursing child ages, and are based in part on "top-losses" estimated Alim (1993). Table E-2 presents default values for K12-K15 and K16-K19 and national estimates of the maximum potential production, loss rates and estimated actual production for Bangladesh in 1990.

TABLE E-2: Estimated Breastmilk Production in Bangladesh by Child's Age in 1990[a]

Item	Age Group (months)				Total
	0-5	6-11	12-23	24-35	
1. Average potential daily production of breastmilk in ml (K12-K15)	850	810	530	360	–
2. National potential production of breastmilk in million liters (Y40)	712	423	890	591	2,616
3. National loss due to non-breastfeeding in million liters (Y41)	7	9	72	252	340
4. Average loss rate due to non-optimal partial breastfeeding (K16-K19)	20%	30%	40%	50%	–
5. National loss due to non-optimal partial breastfeeding in million liters (Y42)	32	88	315	174	609
6. Estimated national production of breastmilk in 1990 in million liters (Y43)	673	326	503	165	1,667

E.8.2. Market value of breastmilk.

In order to estimate the market value of all breastmilk produced in a year, PROFILES 2.0 estimates the total liters of breastmilk produced by rural mothers and urban mothers separately, and then multiplies these volumes by a market price per liter. The market price in rural areas (K45) can differ from the market price in urban areas (K46).

The estimated market value (in $ U.S.) of the breastmilk produced (MVB_T) in the entire country is the sum of the value in rural areas plus urban areas, as given in equation [E-27].

[E-27]
$$MVB_T = (K45 * QTY4_{R,T} + K46 * QTY4_{U,T}) / K97.$$

Where: MVB_T = Market value (in $ U.S.) of all breastmilk produced in year T. $QTY4_{L,T}$ = Total liters of breastmilk produced by mothers in location "L" in year T. K97 = Exchange rate – local currency per one U.S. dollar. K45 = Market value of one liter of breastmilk substitute in rural areas in local currency. K46 = Market value of one liter of breastmilk substitute in urban areas in local currency.

In Bangladesh, cows milk valued at 10 Taka per liter was used as the rural substitute for breastmilk, and powdered milk valued at 40 Taka per liter was used as the urban substitute for breastmilk, following the suggestions of Alim (1993).

E.8.3. Net cost of breastmilk substitutes (Net savings not programmed in version 2.0; planned for version 2.1.).

In addition to health advantages, breastmilk is less expensive than breastmilk substitutes. PROFILES 2.0 assumes that, from the family's viewpoint, the monetary value of breastfeeding equals the savings from not buying breastmilk substitutes minus the additional cost of feeding the lactating mother (over and above the cost of feeding her if she were not breastfeeding). For the entire country, the savings from breastfeeding equals the market value of breastmilk produced (QTY4) less a fraction of that amount for additional food for the mother (K202). Equation [E-28] estimates the savings.

[E-28]

$$SAV1_T = (1-K202) \cdot MVB_T .$$

Where: $SAV1_T$ = National savings in $ U.S. associated with breastfeeding over substitutes in year T. MVB_T = Estimated market value of breastmilk produced nationally in year T. K202 = Fractional part of the market value of breastmilk devoted to marginal food for lactating mothers and other marginal costs associated with breastfeeding.

E.9. Current Worker Productivity - Iron Related.

Levin *et al* (1993) report that workers with iron deficiency anemia are less productive at physical labor than non-anemic workers, producing 1.5% less output for every 1.0% their Hgb is below standard.[29] PROFILES 2.0 uses this result to estimate the effect of iron status on the productivity of agricultural workers. In order to apply this model, the average iron deficit of workers in the country must be obtained so that the relative productivity of anemic and non-anemic workers can be estimated.

In the Bangladesh application, the distribution of iron levels in rural adults was obtained from the Bangladesh 1989/90 National Nutrition Survey (BBS, 1991), with the result that anemic workers are estimated to be 80.5% as productive as non-anemic workers in Bangladesh.[30]

In order to estimate the value of this lost productivity in the agricultural sector, the Gross Domestic Agricultural Product for 1989/90 is attributed to anemic and non-anemic agricultural workers according to their prevalence and relative productivity. The average anemic agricultural worker in Bangladesh contributed $261 (U.S.) in the base year and the average non-anemic agricultural worker contributed $324 (U.S.).[31]

The model assumes that in the future, anemic and non-anemic agricultural workers will continue to contribute $261 and $324 per year respectively to the Gross Domestic product (GDP), and that the agricultural work force will stay at the same percentage of the total work force as in the base year. It also assumes that the agricultural sector will absorb increased productivity due to reduced prevalence of anemia as well as the natural growth in population. The formula used by the model to estimate the Gross Domestic Agricultural Product as a function of the prevalence of iron deficiency is given in equation [E-29].

[E-29] $GDAP_{G,T} = GDAP_{anemic,T} + GDAP_{non\text{-}anemic,T}$

$= [(K74 \cdot PIR_{3/4/5,T}) + K73 \cdot K74 \cdot (1-PIR_{3/4/5,T})] \cdot (K98 \cdot K99 \cdot POP_{15\text{-}64,R,T})$.

Where: $GDAP_{G,T}$ = Contribution (in base year $ U.S.) of group "G" to the gross domestic agricultural product in year T. $PIR_{3/4/5,T}$ = Prevalence of iron deficiency in year T in adults (population categories 3, 4 and 5). K73 = Productivity of an average anemic worker as a fraction of the productivity of an average non-anemic worker. K74 = Average annual productivity per anemic agricultural worker in base year in $ U.S. K98 = Rural labor force participation rate. K99 = Fraction of employed rural persons in agriculture.

The default values for K73, K74, K98 and K99 in Bangladesh are, respectively, 0.805, $261, 0.84 and 0.70.[32]

E.10. Lost future wages.

E.10.1. General approach.

Nutritional events that occur during childhood, such as going blind or becoming stunted, can influence the future productivity and wages earned as an adult. PROFILES 2.0 estimates the value of future lost wages due to three long-lasting, nutrition related disabilities that occur prior to birth or in childhood – vision impairment due to vitamin A deficiency, mental impairment due to iodine deficiency and stunting. PROFILES 2.0 also estimates the value of future lost wages due to childhood mortality. These events are termed "disabling nutritional events."

Each of these disabling nutritional events generates a lifetime of reduced wages. In order to estimate the value of the lost wages, PROFILES 2.0 defines a disability factor for each type of event which quantifies the proportional reduction in productivity (K7,K55,K56,K69,K70). The annual wage in any future year is assumed to equal the current average annual wage (K112) adjusted for the disability factor and for the current employment rate (K111). These adjusted annual wages are summed for all productive years after discounting them back to the year when the disabling nutritional event occurred. The discounting is accomplished by means of a Lifetime Discounting Factor (g(a)) which is a function of the ages of entry to and exit from the labor force (K114, K115), an annual discount rate reflecting the time value of resources (K113), the age, a, at which the disabling nutritional event occurs, and the probability of surviving from age "a" to each future wage earning year.[33] When the lifetime discounting factor is combined with the current average annual wage, the employment rate, the disability factor and the number of children who suffered the disabling event in year T, the result is the discounted lost future wages for year T.

Computed this way, lost future wages are an indication of future productivity that is potentially lost due to current nutritional deficiencies. PROFILES 2.0 does not address the issue of whether jobs will be available, although the employment rate variable (K111) can be altered to reflect whatever assumption the user wishes to make in this regard.

In the Bangladesh application, the default value for the employment rate (K111) was 75%, and the default values for the ages of entry (K114) and exit (K115) to and from the labor force were set at 10 and 64 years. The annual discount rate (K113) was set at 3%, based on the recommendation of the World Bank (1993).

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E.10.2. Lost future wages due to vision impairment.

In PROFILES 2.0 vision is influenced by vitamin A status. Total or partial blindness is a long-term disability that influences future wages. In the Bangladesh application, the default values for total blindness disability (K55) and partial blindness disability (K56) were 50% and 20% respectively.

For purposes of estimating lost future wages, PROFILES 2.0 assumes that all new cases on total and partial blindness in preschool children (0-4 years) occur at 3 years of age, and in school age children (5-14 years) occur at 9 years of age. The formula for computing lost future wages due to total and partial contains four components, namely, lost future wages associated with total blindness in preschoolers, total blindness in school age children, partial blindness in preschoolers, and partial blindness in school age children, as given in equation [E-30].

$$\text{[E-30]}\quad WAGE1_T = POP_{0\text{-}4,T} \cdot (ITB_{0\text{-}4,T} \cdot K55 + IPB_{0\text{-}4,T} \cdot K56) + K111 \cdot K112 \cdot g(3) + POP_{5\text{-}14,T} \cdot (ITB_{5\text{-}14,T} \cdot K55\ IPB_{5\text{-}14,T} \cdot K56) + K111 \cdot K112 \cdot g(9).$$

Where: $WAGE1_T$ = Total discounted lost future wages due to new cases of total and partial blindness occurring in year T. $ITB_{A,T}$ = Incidence of new cases of total blindness in age group "A" in year T. K55 = Productivity disability from total blindness. K56 = Productivity disability from partial blindness. K111 = Employment rate. K112 = Average annual wage. g(a) = Lifetime discounting factor for people of age "a" years, as defined in endnote 33.

E.10.3. Lost future wages due to mental impairment.

Although several types of nutritional deficiencies can influence learning performance, only iodine status is assumed to influence lost future wages due to mental impairment. Specifically, in the Bangladesh application, cretins are assumed to be totally disabled (K69 = 100%), and PMIs and CMIs are assumed to be 25% disabled (K70 = 25%). All new cases of cretinism, PMI and CMI are assumed to occur at birth. (Therefore future lost wages will be slightly overstated in years when goiter prevalence is dropping because the decrease in CMIs will not be reflected.) The formula for discounted lost future wages due to iodine-related mental impairment (WAGE2) is given in equation [E-31].

$$\text{[E-31]}\quad WAGE2_T = B_T \cdot PG_T \cdot K64 \cdot (K69 + K63 \cdot K70) \cdot K111 \cdot K112 \cdot g(0).$$

Where: $WAGE2_T$ = Discounted lost future wages due to iodine-related mental impairment first occurring in year T. B_T = Live births in year T. PG_T = Prevalence of goiter in year T. K63 = Ratio of PMI+CMI births to cretin births. K64 = Proportion of all births to goitrous women that are cretins. K69 = Productivity disability factor for cretins. K70 = Productivity disability factor for PMIs and CMIs. K111 = Employment rate. K112 = Average annual wage. g(0) = Lifetime discounting factor for people at birth, as defined in endnote 33.

E.10.4. Lost future wages due to stunting.

Reviews by Behrman (1992) and Burger *et al* (1990) indicate that several methodologically sound studies have found a significant relationship between stature and labor productivity in adults. One of these studies (Haddad and Bouis, 1991) found that the productivity of agricultural workers increased 1.38% for every 1% increment in height.

Another study (Martorell *et al*, 1991) found that stunting at 22 months of age was maintained into adulthood. Therefore, PROFILES 2.0 assumes that stunting is a disabling nutritional event occurring at the age of two years.

In order to estimate the stunting disability factors for mild, moderate and severe stunting, PROFILES 2.0 defines three relational variables (K4, K5 and K6) that give the adult height deficit (as a percent of normal adult height) for persons who were mildly, moderately and severely stunted at two years of age. These percentage height deficits are multiplied by the elasticity of productivity with respect to stature (K7) to obtain the respective disability factors.

Discounted lost future wages due to stunting is obtained by combining the prevalence and disability at each severity level in the two year old population, the employment rate, the average annual wage and the lifetime discounting factor, as shown in equation [E-32].

[E-32] $$WAGE3_T = POP_{2,T} \cdot (PS_{2,2,T} \cdot K4 + PS_{3,2,T} \cdot K5 + PS_{4,2,T} \cdot K6) \cdot K7 \cdot K111 \cdot K112 \cdot g(2).$$

Where: $WAGE3_T$ = Discounted lost future wages due to stunting at age 2 in year T. $PS_{V,2,T}$ = Prevalence of stunting of severity level "V" at age 2 in year T. K4 = Adult height deficit as proportion of normal adult height in adults who were mildly stunted at two years of age. K5 = Adult height deficit as proportion of normal adult height in adults who were moderately stunted at two years of age. K6 = Adult height deficit as proportion of normal adult height in adults who were severely stunted at two years of age. K7 = Elasticity of productivity in relation to adult height deficit. K111 = Employment rate. K112 = Average annual wage. g(2) = Lifetime discounting factor for people at 2 years of age, as defined in endnote 33.

In the Bangladesh application, PROFILES 2.0 assumed that the elasticity of productivity with respect to stature (K7) equaled 1.38, based on the Haddad and Bouis (1991) study.[34] Data in Burger *et al* (1990) indicates that the approximate height deficits of mildly, moderately and severely stunted two year olds was 5 cm, 7 cm and 10 cm. This translates into percentage adult height deficits of 3.125% (K4), 4.375% (K5) and 6.25% (K6), and given the base year stunting prevalences in Bangladesh, an average productivity deficit of 5.85%.

E.10.5. Lost future wages due to child mortality.

Lost future wages due to child mortality is qualitatively different from lost future wages due to vision impairment, mental impairment or stunting in the sense that the dead child does not consume resources in future years. The present value of lost future wages due to child (U5) mortality in any year depends on the number of U5 deaths in that year ($X_{U5,T}$) less the replaced deaths (K109), the employment rate, the average annual wage, and the lifetime discounting factor (g(a)) at the average age of U5 deaths. Productivity disability is 100%. The formula for computing lost future wages due to child mortality is given in equation [E-33].

[E-33] $$WAGE4_T = POP_{U5,T} \cdot X_{U5,T} \cdot (1-K109) \cdot K111 \cdot K112 \cdot g(a).$$

Where: $WAGE4_T$ = Discounted future lost wages due to U5 child mortality. $X_{u5,T}$ = U5 mortality rate in year T. K109 = Proportion of U5 deaths replaced by another birth. K111 = Employment rate. K112 = Average annual wage. g(a) = Lifetime discounting factor assuming that the average age of U5 deaths is "a," as defined in endnote 33.

E.11. Livestock production (Not programmed in version 2.0; planned for version 2.1.)

There is evidence, albeit limited, that iodine deficiency in livestock reduces livestock productivity, for example in reduced production of eggs, milk and offspring, and furthermore, that efforts to decrease iodine deficiency in humans can also decrease it in livestock. Dunn and Van der Haar (1990, page 10) report that in one study site in China, farm production increased almost tenfold in the eight years following iodine deficiency control.

The value of total livestock production in any year T ($VAL1_T$) given in equation [E-34] is the sum of the production from iodine sufficient and iodine deficient animals. PROFILES 2.0 defines a separate variable for the prevalence of iodine deficiency in livestock (PIL_T) which is the average across all types of livestock weighted by the monetary value of the production of one animal (one unit). A relative rate variable (K204) reflecting the relative productivity of iodine deficient livestock to iodine sufficient is used in the estimation. PROFILES 2.0 assumes that livestock production grows at a constant annual rate (K205) due to increases in both the number of producing units and productivity per unit.

[E-34]
$$VAL1_T = (1 - PIL_T + K204 * PIL_T) * (Y34 * (1 + K205)^T).$$

Where: $VAL1_T$ = Monetary value of all livestock production in year T. PIL_T = Prevalence of iodine deficiency in livestock in year T. K204 = Relative productivity of iodine deficient to iodine sufficient livestock. K205 = Annual growth rate of livestock production.

And:
$$Y34 = VAL1_0 / (1 - PIL_0 + K204 * PIL_0).$$

Default values. Total value of meat, milk, eggs and hides from cows, buffalos, goats, sheep, hens and ducks in Bangladesh in 1992/3 was $1.6 million ($VAL_0$), and the annual growth rate in this production was estimated to be 2.7% (K205), according to the Ministry of Agriculture (Burkhalter, 1993b, Working Note 14). In lieu of objective data, PIL_0 was set equal to 50% of PG_0 roughly reflecting that the iodine status of livestock on small farms probably resembles that of the human population but livestock from large producers probably are less deficient. In lieu of objective data, the relative productivity (K204) of iodine deficient animals was set equal to 50% of iodine sufficient animals, which is the increase found in a study by the Bangladesh Ministry of Agriculture that improved the diet of farm animals (although iodine was not included in the improved diet).

E.12. Summary of consequences assigned monetary values.

Many of the consequences have been assigned a value in monetary terms. Thus, even though these various monetary values have different meanings, it is possible to sum them, and in some situations this may be appropriate. These consequences are summarized below.

Description	Variable	Section
1. Replacement of fertility effect of breastfeeding	SAV2	E.3.2
2. Government health expenditures due to morbidity	EX1	E.7.1
3. Government health expenditures due to vision impairment	EX2	E.7.1
4. Direct government health expenditures due to mortality	EX3	E.7.1
5. Government expenditures due to mortality replacement	EX4	E.7.1
6. Government health expenditures due to births	EX5	E.7.1
7. Government expenditures due to school repeaters	EX7	E.7.2
8. Net cost of breastmilk substitutes	SAV1	E.8.3
9. Lost productivity due to iron deficiency	GDAP	E.9
10. Discounted lost future wages due to vision impairment	WAGE1	E.10.2
11. Discounted lost future wages due to mental impairment	WAGE2	E.10.3
12. Discounted lost future wages due to stunting	WAGE3	E.10.4
13. Discounted lost future wages due to child mortality	WAGE4	E.10.5
14. Livestock production	VAL1	E.11

LIST OF VARIABLES

(Default values used in Bangladesh are given in brackets.)

a1..a4	These four variables (a1,a2,a3,a4) are the proportional reduction in total fecundity due to nuptuality, contraception, induced abortion and lactation respectively. (Temporary variables used in the explanation of the fertility consequence function.)
$b_0..b_2$	Coefficients used in formula estimating cretin prevalence (temporary variables). (Lower case "b" also used a leading superscript to prevalence variables denoting type of disease.)
$B_{L,T}$	Number of births in location "L" in year "T (demographic variable).
BC_T	Number of cretins born in year "T" that survive early stages of life (consequence variable).
$BPMI_T$	Number of permanently mentally impaired (due to iodine deficiency) births in year "T" (consequence variable).
$CO_{J,T}$	Total costs of program J in year T (program variable).
$C1_{J,T}$	Setup cost of program J in year T (program variable).
$C2_J$	Annual maintenance cost of program J per beneficiary covered. Can be specified as a function of program coverage. (program variable.)
$C3_J$	Expansion cost per new beneficiary added to program J (equals zero if program shrinks in year T). Can be specified as a function of program coverage. (Program variable.)
CMI_T	Number of correctable mentally impaired (due to iodine deficiency) persons alive in year "T" (consequence variable). Used in intelligence consequence function.
$CC_{J,T}$	Cumulative costs of program J from its start through year T (program variable).
$COV_{J,T}$	Coverage of program J in its primary population group in year T, where coverage is the fraction of the total primary group reached by program (program variable).
$CRET_T$	Number of cretins alive in year "T" (consequence variable).
$D_{A,S,L,T}$	Number of deaths in age group "A" of sex "S" residing in location "L" in year T (both a consequence and a demographic variable).
e_{jk}	The degree to which the coverage of two programs (j and k) overlap, specifically, the proportion of the coverage of the smaller-coverage program that is not also covered by the larger-coverage program.
$EFF_{J,T}$	Effectiveness of program J in reducing the correctable deficiency of its primary nutritional indicator (in the severity categories representing deficiencies) in the primary population group in year T, where effectiveness is a number between 0 and 1 representing the fractional reduction in the correctable deficiency, and correctable deficiency is the difference between the base year prevalence and the residual prevalence if the maximum impact is achieved (program variable).
$EX1_T..EX5_T$	Annual total government health expenditures in year T associated with U5 morbidity, U14 vision impairment, direct U5 mortality, U5 mortality replacement and birthing, respectively (consequence variables).
$EX6_T$	Annual total government health expenditures related to nutritional factors in year T, namely the sum of $EX1_T$ through $EX5_T$ (consequence variable).
$EX7_T$	Government expenditures in year T associated with primary school repeaters (consequence variable).

f_{jk} The degree to which the effectiveness of two programs (j and k) both impact on an individual covered by both programs, specifically, a number that is multiplied by the sum of EFF_j and EFF_k to give the effectiveness of the overlapping portion of programs "j" and "k".

FEC Total fecundity; maximum average number of live births women would have in their lifetime assuming maximum exposure during child-bearing years and no contraception, induced abortion or lactation. (Temporary variable used in explanation of fertility consequence function.)

$FR_{A,T}$ Fertility rate of women in age group "A" during year "T" after adjusting for nutrition effects (demographic variable).

g(a) Lifetime discounting factor for disabling nutritional events occurring at age "a," as defined in endnote 33.

$G1_n$ Present worth of $1.00 generated "n" years in the future, assuming an annual discount rate of K113 (used in definition of g(a)).

$G2_{x/a}$ A function that computes the probability that a person who is "a" years old will survive to "x" years of age (used in definition of g(a)).

$GDAP_{A,T}$ Contribution (in base year $ U.S.) of population group "A" to the gross domestic agricultural product in year T (consequence variable).

$IPB_{A,T}$ Incidence of new cases of partial blindness in age group "A" in year "T" (consequence variable).

$ITB_{A,T}$ Incidence of new cases of total blindness in age group "A" in year "T" (consequence variable).

Relational - PEM

K1 Relative diarrhea morbidity in days sick per year with diarrhea of mildly underweight children aged 1-5 months compared to normal weight children of the same age. (1.125)

K2 Relative diarrhea morbidity in days sick per year with diarrhea of moderately underweight children aged 1-5 months compared to normal weight children of the same age. (1.250)

K3 Relative diarrhea morbidity in days sick per year with diarrhea of severely underweight children aged 1-5 months compared to normal weight children of the same age. (1.250)

K4 Average adult height deficit as a percent of normal adult height of children who are mildly stunted at 2 years of age. (3.125)

K5 Average adult height deficit as a percent of normal adult height of children who are moderately stunted at 2 years of age. (4.375)

K6 Average adult height deficit as a percent of normal adult height of children who are severely stunted at 2 years of age. (6.250)

K7 Percent productivity decrease (or increase) in adults per one percent decrement (or overage) below normal height. (1.30)

K8 Exponentiation factor in the relationship between severity of underweight and relative risk of death in infants aged 0-5 months. (3.63)

K9 Exponentiation factor in the relationship between severity of underweight and relative risk of death in children aged 6-59 months. (3.63)

K10 Relative risk of repeating first grade by stunted children compared to non-stunted children. (1.0)

K11 Relative risk of repeating a year in grades 2-6 by stunted children compared to non-stunted children. (1.05)

Relational - Breastfeeding

K12 Average potential daily production of breastmilk in milliliters by rural mothers with infants aged 0-5 months. (650)

K13 Average potential daily production of breastmilk in milliliters by rural mothers with infants aged 6-11 months. (610)

K14 Average potential daily production of breastmilk in milliliters by rural mothers with children aged 12-23 months. (530)

K15 Average potential daily production of breastmilk in milliliters by rural mothers with children aged 24-35 months. (360)

K16 Proportion of potential production of breastmilk lost on average due to suboptimal breastfeeding practices in women with infants aged 0-5 months. (0.2)

K17 Proportion of potential production of breastmilk lost on average due to suboptimal breastfeeding practices in women with infants aged 6-11 months. (0.3)

K18 Proportion of potential production of breastmilk lost on average due to suboptimal breastfeeding practices in women with children aged 12-23 months. (0.4)

K19 Proportion of potential production of breastmilk lost on average due to suboptimal breastfeeding practices in women with children aged 24-35 months. (0.5)

K20 Relative risk of neonatal death in infants who do not initiate breastfeeding compared to those who do. (6.0)

K21 Relative diarrhea morbidity during neonatal period in days sick per year with diarrhea of rural infants who initiate breastfeeding compared to those who don't. (3.91)

K22 Relative diarrhea morbidity in days sick per year with diarrhea of rural infants aged 1-5 months who partially breastfeed during this age compared to those who exclusively breastfeed during the same age. (2.16)

K23 Relative diarrhea morbidity in days sick per year with diarrhea of rural infants aged 1-5 months who do not breastfeed during this age compared to those who exclusively breastfeed during the same age. (3.91)

K24 Relative diarrhea morbidity in days sick per year with diarrhea of rural infants aged 6-11 months who partially breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.00)

K25 Relative diarrhea morbidity in days sick per year with diarrhea of rural infants aged 6-11 months who do not breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.54)

K26 Relative diarrhea morbidity in days sick per year with diarrhea of rural children aged 12-35 months who partially breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.00)

K27 Relative diarrhea morbidity in days sick per year with diarrhea of rural children aged 12-35 months who do not breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.00)

K28 Relative respiratory infection morbidity during neonatal period in days sick per year with respiratory infection of all infants who initiate breastfeeding compared to those who don't. (4.20)

K29 Relative respiratory infection morbidity in days sick per year with respiratory infection of all infants aged 1-5 months who partially breastfeed during this age compared to those who exclusively breastfeed during the same age. (2.27)

K30 Relative respiratory infection morbidity in days sick per year with respiratory infection of all infants aged 1-5 months who do not breastfeed during this age compared to those who exclusively breastfeed during the same age. (4.20)

K31 Relative respiratory infection morbidity in days sick per year with respiratory infection of all infants aged 6-11 months who partially breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.00)

K32 Relative respiratory infection morbidity in days sick per year with respiratory infection of all infants aged 6-11 months who do not breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.78)

K33 Relative respiratory infection morbidity in days sick per year with respiratory of all children aged 12-35 months who partially breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.00)

K34 Relative respiratory infection morbidity in days sick per year with respiratory infection of all children aged 12-35 months who do not breastfeed during this age compared to those who exclusively breastfeed during the same age. (1.00)

K35 Ratio of relative diarrhea morbidity in urban infants aged 0-5 months who partially breastfeed compared to those who exclusively breastfeed (K21, K22) to rural infants of the same age. (2.16)

K36 Ratio of relative diarrhea morbidity in urban infants aged 0-5 months who do not breastfeed compared to those who exclusively breastfeed (K23) to rural infants of the same age. (2.77)

K37 Ratio of relative diarrhea morbidity in urban infants aged 6-11 months who partially breastfeed compared to those who exclusively breastfeed (K24) to rural infants of the same age. (1.0)

K38 Ratio of relative diarrhea morbidity in urban infants aged 6-11 months who do not breastfeed compared to those who exclusively breastfeed (K25) to rural infants of the same age. (1.13)

K39 Ratio of relative diarrhea morbidity in urban infants aged 12-35 months who partially breastfeed compared to those who exclusively breastfeed (K24) to rural infants of the same age. (1.0)

K40 Ratio of relative diarrhea morbidity in urban infants aged 12-35 months who do not breastfeed compared to those who exclusively breastfeed (K25) to rural infants of the same age. (1.0)

K41 Relative risk of death in infants aged 0-5 months who are partially breastfeeding compared to those who are exclusively breastfeeding of the same age. (1.2)

K42 Relative risk of death in infants aged 0-5 months who are not breastfeeding compared to those who are exclusively breastfeeding of the same age. (1.3)

K43 Relative risk of death in infants aged 6-35 months who are partially breastfeeding compared to those who are exclusively breastfeeding of the same age. (0.9)

K44 Relative risk of death in infants aged 6-35 months who are not breastfeeding compared to those who are exclusively breastfeeding of the same age. (1.2)

K45 Value in Taka of one liter of breastmilk in rural area. (10)

K46 Value in Taka of one liter of breastmilk in urban area. (30)

Relational - Birth weight

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K47	Relative risk of stillbirth to malnourished mother, as indicated low birthweight (below 2500 grams), compared to well nourished mother as indicated by normal (2500 grams or more) birthweight. (10.0)
K48	Relative risk of neonatal death to infant with low birthweight (below 2500 grams) compared to that of infants with normal birthweight. (10.0)
K49	Relative diarrhea morbidity in days sick per year with diarrhea in neonates with low birthweight (below 2500 grams) compared to those with normal birthweight. (1.25)
K50	Relative respiratory infection morbidity in days sick per year with respiratory infection in neonates with low birthweight (below 2500 grams) compared to those with normal birthweight. (1.00)

Relational - Vitamin A

K51	Relative morbidity in days sick per year in children aged 6-59 months who are vitamin A deficient as indicated by serum retinol below 20 ug/dl compared to children who are not vitamin A deficient of the same age. (1.263)
K52	Proportion of U5 children who survive at least one year after going totally blind (K52 = 1.0 for children over 5 years). (0.5)
K53	Relative risk of death in children aged 0-5 months who are vitamin A deficient as indicated by serum retinol below 20 ug/dl compared to children who are not vitamin A deficient of the same age. (1.82)
K54	Relative risk of death in children aged 6-59 months who are vitamin A deficient as indicated by serum retinol below 20 ug/dl compared to children who are not vitamin A deficient of the same age. (1.82)
K55	Reduction in productivity due to total blindness. (0.50)
K56	Reduction in productivity due to partial blindness. (0.20)
K57	Proportion of nightblind children that go totally blind. (0.05)
K58	Proportion of nightblind children that go partially blind. (0.05)
K59	Annual average government expenditures to care for one totally blind child over the expenditures for a normal child in Taka. (20)
K60	Annual average government expenditures to care for one partially blind child over the expenditures for a normal child in Taka. (10)

Relational - Iodine

K61	Excess stillbirths per cretin born. (0.656)
K62	Excess neonatal deaths per cretin born. (0.602)
K63	Ratio of mentally impaired persons (MI) to cretins. (3.0)
K64	Proportion of births to iodine deficient women (as indicated by goiter) that are cretins who survive the early stages of life. (0.0343)
K65	Proportion of all persons who are mentally impaired due to iodine deficiency (except cretins) whose mental impairment can be corrected with iodine. (0.10)
K66	Proportion of births to goitrous women that are mentally impaired (including cretins) due to iodine deficiency in the mother during pregnancy. (0.13)
K67	Relative risk of repeating first grade by children born to iodine deficient mothers compared to iodine sufficient mothers. (1.77)
K68	Relative risk of repeating a year in grades 2-6 by children born to iodine deficient mothers compared to iodine sufficient mothers. (1.0)

K69 Reduction in productivity due to cretinism. (1.00)

K70 Reduction in productivity due to mental impairment from iodine deficiency in pregnant mother. (0.25)

Relational - Iron

K71 Relative risk of stillbirth for women who are iron deficient during pregnancy compared to woman who are iron sufficient. (0.012)

K72 Relative risk of neonatal death in newborns of mothers who are iron deficient during pregnancy compared to mothers who are iron sufficient during pregnancy. (0.012)

K73 The ratio of the productivity of an iron deficient manual laborer compared to the productivity of an iron sufficient manual laborer. (0.805)

K74 Annual contribution to GDP of one iron deficient agricultural laborer in U.S. dollars. ($261)

K75 Relative diarrhea morbidity in days sick per year with diarrhea in neonates whose mothers were iron deficient in pregnancy compared to those whose mothers were not iron deficient. (1.0)

K76 Relative respiratory infection morbidity in days sick per year with respiratory infection in neonates whose mothers were iron deficient during pregnancy compared to those whose mothers were not iron deficient. (1.0)

Relational - Crossovers and Interactions

K77 Proportion of infants aged 0-5 months of age who are both vitamin A deficient and normal weight-for-age, expressed as a fraction of what would be expected if these two conditions were independent. (0.25)

K78 Proportion of infants aged 0-5 months who are both vitamin A deficient and exclusively or partially breastfeeding, expressed as a fraction of what would be expected if these two conditions were independent. (0.10)

K79 Increased relative risk of death in infants aged 0-5 months who are severely underweight and who do not breastfeed, expressed as a multiple of the relative risk of death of all severely underweight children of this age. (5.0)

K80 Proportion of children aged 6-71 months of age who are both vitamin A deficient and normal weight-for-age, expressed as a fraction of what would be expected if these two conditions were independent. (0.25)

K81 Proportion of children aged 6-59 months who are both vitamin A deficient and partially breastfeeding, expressed as a fraction of what would be expected if these two conditions were independent. (0.30)

K82 Increased relative risk of death in children aged 6-59 months who are severely underweight and who do not breastfeed, expressed as a multiple of the relative risk of death of all severely underweight children of this age. (5.0)

K83 Increase in proportion of pregnant women who are iron deficient and produce low birth weight babies, relative to what would be expected if these two conditions were independent. (0.30)

Relational - Global

K84 Proportion of children repeating first grade in base year. (0.05)

K85 Proportion of children repeating in grades 2-6 in base year. (0.05)

K86	Average number of days per year neonates were sick with diarrhea in the base year. (52.2)
K87	Average number of days per year infants aged 1-5 months were sick with diarrhea in the base year. (52.2)
K88	Average number of days per year infants aged 6-11 months were sick with diarrhea in the base year. (52.2)
K89	Average number of days per year children aged 12-59 months were sick with diarrhea in the base year. (15.7)
K90	Average number of days per year neonates were sick with respiratory infection in the base year. (25.6)
K91	Average number of days per year infants aged 1-5 months were sick with respiratory infection in the base year. (25.6)
K92	Average number of days per year infants aged 6-11 months were sick with respiratory infection in the base year. (100.7)
K93	Average number of days per year children aged 12-59 months were sick with respiratory infection in the base year. (0)
K94	Average days sick with respiratory infection to generate one clinic visit. (0)
K95	Average days sick with diarrhea to generate one clinic visit. (53.3)
K96	Average days with malnutrition to generate one clinic visit. (509.1)
K97	Exchange rate in local currency per U.S. dollar, which is taka per dollar in Bangladesh. (39.4)
K98	Rural labor force participation rate; proportion of all rural persons aged 15-64 years participating in labor force. (0.84)
K99	Proportion of entire rural labor force working in agricultural sector. (0.70)
K100	Proportion of 6 year olds that were enrolled in school in base year. (0.89)
K101	Proportion of 7-10 year olds that were enrolled in school in base year. (0.89)
K102	Annual government expenditures per primary school student in Taka in base year. (400)
K103	Stillbirths per 1000 live births in base year. (35.7)
K104	Average cost to government per clinic visit in Taka. (30)
K105	Government expenditures associated with one child death in Taka. (4)
K106	Government expenditures associated with one birth in taka. (80)
K107	Average age in years of child deaths in children under 5 years. (2.0)
K108	Annual average government expenditures associated with providing health services to one child under age 5 years in Taka. (184.4)
K109	Proportion of all under 5 deaths replaced eventually by another birth that would not have occurred if the first death had not occurred. (0.20)
K110	Gross domestic product (GDP) in the agricultural sector in millions of U.S. dollars in the base year (1990). ($8,466)
K111	Employment rate among persons aged 15-64 years. (0.75)
K112	Average annual wage in base year in U.S. dollars. ($387)
K113	Annual discount rate. (0.03)
K114	Average age to enter labor force. (10)
K115	Average age to exit from the labor force. (64)
K116	A composite reflecting the effect of all factors except lactation (especially marriage, contraception and induced abortion) on total fertility rate. (169.75)
K201	Average IQ deficit in individuals whose mothers were iodine deficient during pregnancy relative to those with iodine sufficient mothers.

K202	Fractional part of the market value of breastfeeding devoted to marginal food for lactating mothers.
K203	Cost of family planning programs in $ U.S. that decrease TFR by one.
K204	Relative productivity of iodine deficient to iodine sufficient livestock (average across all types of livestock weighted by the financial value of their production per unit). (0.2; RAG)
K205	Annual real growth rate of livestock production (due to increased in units produced and in productivity per unit). (0.027; g)
$LIQ_{A,T}$	Lost IQ points due to iodine deficiency in age group "A" (A="B" for newborns; A="POP" for entire population) in year "T" (consequence variable).
$MAX(a_1..a_n)$	Function whose output is the largest of the input values $(a_1..a_n)$.
$MIG_{A,S,T}$	Number of net migrants of sex "S" entering age group "A" during year T (demographic variable).
$MIMP_{J,Q,A}$	Maximum impact that program J will ever have on reducing the prevalence of the deficient severity category of nutritional condition indicator Q in population group A (a number from 0 to 1 representing the proportional reduction in the base year prevalence).
$MR_{A,T}$	Mortality rate in age/population group "A" in year "T" across all severity levels (demographic variable). (X_v is used to denote mortality by severity level.)
$^{MOD}MR_{A,T}$	Mortality rate given in the selected model life table for group "A" in year T across all severity levels (demographic variable).
MVB_T	Estimated market value in $ U.S. of breastmilk produced in year T (consequence variable).
$ND_{L,T}$	Number of neonatal deaths in location "L" in year T.
$NMR_{A,L,T}$	Neonatal mortality rate in population group "A" residing in location "L" in year "T" (both a consequence and a demographic variable).
$P_{Q,V,A,T}$	Prevalence of severity level "V" of nutrition indicator "Q" in age group "A" in year T. (Temporary variable used in endnote on severity level mortality.)
$PA_{V,A,L,T}$	Prevalence of vitamin A status "V" for age group "A" residing in location "L" in year "T" (nutrition indicator).
$PB_{L,T}$	Proportion of newborns that initiate breastfeeding residing in location "L" in year "T" (nutrition indicator).
$PC_{A,L,T}$	Prevalence of cretins in age group "A" residing in location "L" in year T (a consequence variable).
$PD_{L,T}$	Average duration of breastfeeding in months in location "L" in year "T" (nutrition indicator).
$PF_{V,A,L,T}$	Prevalence of feeding mode "V" for age group "A" residing in region "L" in year "T" (nutrition indicator).
$PG_{V,L,T}$	Prevalence of iodine status "V" (as measured by goiter) in total population residing in location "L" in year "T" (nutrition indicator).
PIL_T	Prevalence of iodine deficiency in livestock in year T (prevalence variable).
$PIR_{V,A,L,T}$	Prevalence of iron status "V" in population group "A" (A=1 for U5 children, A=2 for school children, A=3 for non-pregnant women aged 15-49, A=4 for pregnant women, A=5 for men aged 15-49) residing in location "L" in year "T" (nutrition indicator).
$PPB_{A,T}$	Prevalence of partial blindness in age group "A" in year "T" (a consequence variable, not a nutrition indicator).
PMI_T	Number of permanently mentally impaired (due to iodine deficiency) persons alive in year "T" (consequence variable). Used in intelligence consequence function.

$POP_{A,S,T}$	Population in age/population group "A" of sex "S" in year "T" (demographic variable).
PQ_T	Proportion of children in stunting reduction programs who receive mental stimulation such as tutoring (treated as if it were a prevalence variable).
$PS_{V,L,T}$	Prevalence of children at 2nd birthday who are in stunting severity category "V" residing in location "L" in year "T" (nutrition indicator).
$PTB_{A,T}$	Prevalence of total blindness in age group "A" in year "T" (a consequence variable, not a nutrition indicator).
$PU_{V,A,L,T}$	Prevalence of children in population group "A" residing in location "L" who are in underweight severity category "V" in year "T" (nutrition indicator). In section E, it is the prevalence of underweight U5 children before adjusting for the effect of LBW.
$\underline{PU}_{V,A,L,T}$	Prevalence of children in population group "A" residing in location "L" who are in underweight severity category "V" in year "T" after adjusting for effect of LBW (nutrition indicator).
$PW_{V,L,T}$	Proportion of all live births in location "L" during year "T" that are in birthweight severity category "V" (nutrition indicator).
$QTY1_{L,T}$	Total potential production of breastmilk in region "L" in liters during year T (consequence variable).
$QTY2_{L,T}$	Loss of potential production of breastmilk in liters in region "L" during year T due to prevalence of no breastfeeding (consequence variable).
$QTY3_{L,T}$	Loss of potential production of breastmilk in liters in region "L" during year T due to prevalence of non-optimal partial breastfeeding (consequence variable).
$QTY4_{L,T}$	Estimated actual annual production of breastmilk in liters in region "L" during year T (consequence variable).
$REP_{G,T}$	Number of children who are repeating grade "G" in year "T," where G = "1" for first grade and G + "2 +" for grades 2-6 (consequence variable).
RP	Reduction in prevalence in the deficient severity category of any nutritional indicator due to a particular program or package of programs, as a proportion of the base year prevalence. Subscripts denoting program (J), nutritional indicator (Q) and time (T) are implied but not usually written in this variable. (Temporary variable used in program section.)
$S_{A,L,T}$	Number of days sick with diarrhea or respiratory infection during year "T" for all individuals in age group "A" residing in location "L" (consequence variable).
$^bS_{A,L,T}$	Number of days sick with disease "b" (diarrhea = "d" and upper or lower respiratory infection = "r") during year "T" for all individuals in age group "A" residing in location "L" (consequence variable).
$SAV1_T$	National savings in $ U.S. associated with breastfeeding over substitutes in year T (consequence variable).
$SAV2_{L,T}$	Monetary value in $ U.S. of fertility effects of increased breastfeeding in year T over the base year.
$SB_{L,T}$	Number of stillbirths in location "L" during year "T" (Consequence variable; not used in population model).
$SOURCE_{J,C,F,T}$	Proportion of all costs of type C (startup, maintenance or expansion) in program J that are paid by source F in year T, where: F = "1" for government/donor total, "2" for government/donor additional, "3" for foreign (hard) currency, "4" for commercial, "5" for family cash self-pay, and "6" for family in-kind.
SR	Sex ratio; the ratio of male births to female births (demographic variable). (1.05)

TFR_T	Total fertility rate in year "T" after adjusting for extra nutrition effects (both a consequence and a demographic variable).
$^{MOD}TFR_T$	Total fertility rate in year "T" as given in the selected model fertility table (demographic variable).
U1	Average proportion of married women using contraception. Used in explanation of fertility consequence function.
U2	Average effectiveness of contraception. Used in explanation of fertility consequence function.
UR_T	Proportion of total population living in urban areas in year T (demographic variable).
$VAL1_T$	Monetary value of all livestock production in year T.
$WAGE1_T$	Discounted lost future wages due to new cases of total and partial blindness occurring in year T (consequence variable).
$WAGE2_T$	Discounted lost future wages due to new cases of mental impairment due to iodine deficiency occurring in year T (consequence variable).
$WAGE3_T$	Discounted lost future wages due to stunting at 2 years of age in year T (consequence variable).
$WAGE4_T$	Discounted lost future wages due to child (U5) mortality in year T (consequence variable).
X_v	Mortality rate for persons in severity level "V" of a particular indicator; invariant over time. Temporary variable used in derivation of mortality rates from relative risk of death variables.

Temporary Variables

$Y1_T$	The rate of additional low weight births to iron deficient pregnant women over that expected assuming independence between iron deficiency and incidence of low weight births at time "T."
Y2	A constant calculated from base year data and relational variables and used in computing stillbirths.
$Y3_{X,T}$	The proportion of the population in coverage combination "X" in year "T." Used in the formula for estimating neonatal deaths.
$Y4_{X,T}$	The relative risk of neonatal death in coverage combination "X" in year "T." Used in the formula for estimating neonatal deaths.
Y5	A constant calculated from base year data and relational variables and used in computing neonatal deaths.
$Y6_{X,T}$	The proportion of the population in coverage combination "X" in year "T." Used in the formula for estimating deaths in children aged 1-59 months.
$Y7_{X,T}$	The relative risk of neonatal death in coverage combination "X" in year "T." Used in the formula for estimating deaths in children aged 1-59 months.
$Y8_T$	The reduction in the joint prevalence of vitamin A deficiency, normal weight-for-age and partial breastfeeding due to non-independence of vitamin A deficiency and normal weight-for age, in year "T."
$Y9_T$	The reduction in the joint prevalence of vitamin A deficiency, normal weight-for-age and no breastfeeding due to non-independence of vitamin A deficiency and normal weight-for-age, in year "T."

$Y10_T$	The reduction in the joint prevalence of vitamin A deficiency, full or partial breastfeeding and normal weight-for-age due to non-independence of vitamin A deficiency and breastfeeding, in year "T."
$Y11_T$	The reduction in the joint prevalence of vitamin A deficiency, full or partial breastfeeding and mild underweight-for-age due to non-independence of vitamin A deficiency and breastfeeding, in year "T."
$Y12_T$	The reduction in the joint prevalence of vitamin A deficiency, full or partial breastfeeding and moderate underweight-for-age due to non-independence of vitamin A deficiency and breastfeeding, in year "T."
$Y13_T$	The reduction in the joint prevalence of vitamin A deficiency, full or partial breastfeeding and severe underweight-for-age due to non-independence of vitamin A deficiency and breastfeeding, in year "T."
Y14..Y16	Constants calculated from base year prevalence data used in the 1-59 month mortality function.
Y17	For 1-59 month olds, ratio of base year mortality to the sum across all coverage combinations of the prevalence times the relative risk of death of each coverage combination in the base year. Used as a constant in the mortality function.
$^bY18_L$	A constant calculated from base year data and relational variables and used in computing neonatal morbidity due to disease "b" in location "L."
$^bY19_L$	A constant calculated from base year data and relational variables and used in computing morbidity due to disease "b" in the 1-5 month age group in location "L."
$^bY20_L$	A constant calculated from base year data and relational variables and used in computing morbidity due to disease "b" in the 6-11 month age group in location "L."
$^bY21_L$	A constant calculated from base year data and relational variables and used in computing morbidity due to disease "b" in the 12-59 month age group in location "L."
Y30..Y31	Constants calculated from base year data and relative school repeat rates for first grade and grades 2-6. Used in school repeater function.
$Y32_{A,T}$	Prevalence of CMIs + PMIs of age "A" in year "T." Can be approximated by $Y32_{A,T} = K63 * PC_{A,T}$. Used in school repeater function.
$Y33_{A,T}$	Decrease in prevalence of stunted children of age "A" from base year to year "T." Used in school repeater function.
Y34	Parameter reflecting theoretical maximum production of livestock in base year if there were no iodine deficiency.

ENDNOTES

1. Feeding prevalence as point prevalence. The prevalence of a particular mode of feeding is a point prevalence, that is, the proportion of all children in group "A" being fed by a particular mode on the day of a survey, which is different from the proportion of children being fed by that mode on their last day in that age group or throughout the time they were in that age group.

2. Vitamin A prevalences. The prevalences at which the four Vitamin A severity levels (PA_1,PA_2,PA_3,PA_4) constitute a public health problem are in the ratio of 20, 10, 2 and 1. West and Sommer (1984) provide public health problem prevalences for PA_2, PA_3 and PA_4, while Humphrey *et al* (1992) note that PA_1 is about ten times PA_3 in high VAD countries. However, Bloem *et al* (submitted) note that in some countries where nightblindness (PA_3) is in the 1-3% range, more than 50% of the children were vitamin A deficient (PA_2). Data presented at the poster sessions of the IVACG meeting in Arusha, Tanzania, March, 1993 indicate that a large variance among the prevalence ratios is common, as summarized in End-Table 2.1 below.

END-TABLE 2.1
Prevalence of Vitamin A Deficiency Reported in Country Surveys at IVACG

Country	Sponsor/Author	Age	Prevalence of VAD by Severity Level			
			PA_1	PA_2	PA_3	PA_4
Bolivia	VITAL/USAID	12-59 m	11.2%	0.1%		
Cameroon(N)	VITAL/USAID		21%			0.5%
Dom.Rep.	VITAL/USAID	1-5 yr	15.4%	4.2%		
Panama	VITAL/USAID	12-72 m	5.9%	0.2%		
Solomon Is.	VITAL/USAID				0.5%	1.42%
India	Coimbatore				0.5%	2.0%
Indonesia	Muhilal	Lactating	30.1%			
		Non-lact	9.6%			
S. Africa			44%	5%		

3. Derivation of severity level mortality rates. PROFILES 2.0 derives age-specific and year-specific mortality rates for each severity level of all indicators that influence mortality in that age group at the time of country setup. The derivation uses four kinds of information: (1) relative risk of death by severity level, (2) base year mortality rate in the age group overall and by severity level, (3) mortality rate in the age group by year as predicted by the population growth model and (4) population in the age group by year. Similar information is required for the derivation of morbidity rates. The simplest situation is when there is only one indicator influencing mortality and that indicator has only two severity levels, such as birthweight. The derivation proceeds as follows in this situation. (Assume the derivation applies to a particular age group, and all variables are subscripted for that age group.) First solve equations [1], [2] and [3] below for $X_{1,0}$, the mortality rate of healthy individuals in the base year. Then substitute the result into equation [2] and solve for $X_{2,0}$, the base year mortality rate of unhealthy (deficient) individuals.

[1] $$MR_0 \cdot POP_0 = P_{1,0} \cdot POP_0 \cdot X_{1,0} + P_{2,0} \cdot POP_0 \cdot X_{2,0} .$$

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[2] $$R_2 = X_{2,0} / X_{1,0}.$$

[3] $$P_{1,0} + P_{2,0} = 1.$$

where MR_0 = base year mortality rate of all individuals in the age group given by the population growth model, $X_{1,0}$ = base year mortality rate of healthy individuals, $X_{2,0}$ = base year mortality rate of unhealthy (deficient) individuals, POP_0 = base year population of age group, $P_{1,0}$ = base year prevalence of healthy individuals, $P_{2,0}$ = base year prevalence of unhealthy individuals, and R_2 = relative risk of death in unhealthy individuals. The solution is:

[4] $$X_{1,0} = MR_0 / (P_{1,0}+R_2+P_{1,0}{}^{\circ}R_2).$$

[5] $$X_{2,0} = R_2{}^{\circ}MR_0 / (P_{1,0}+R_2+P_{1,0}{}^{\circ}R_2).$$

A severity level mortality rate in any future year, T, is in the same proportion to its corresponding base year mortality rate as the overall mortality rate in year T (MR_T) is to the overall mortality rate in the base year (MR_0). Thus, $X_{1,T}$ and $X_{2,T}$ are calculated according to equations [6] and [7] below.

[6] $$X_{1,T} = MR_T / (P_{1,T}+R_2+P_{1,T}{}^{\circ}R_2).$$

[7] $$X_{2,T} = R_2{}^{\circ}MR_T / (P_{1,T}+R_2+P_{1,T}{}^{\circ}R_2).$$

A similar procedure can be used in situations with more than two severity levels, such as weight-for-age, which has four severity levels (normal, mild, moderate, severe). In this case, the procedure is to solve equations [8], [9] and [10] below.

[8] $$MR_0{}^{\circ}POP_0 = P_{1,0}{}^{\circ}POP_0{}^{\circ}X_{1,0} + \ldots + P_{4,0}{}^{\circ}POP_0{}^{\circ}X_{4,0}.$$

[9] $$R_2 = X_{2,0} / X_{1,0}\,;\; R_3 = X_{3,0} / X_{1,0}\,;\; R_4 = X_{4,0} / X_{1,0}.$$

[10] $$P_{1,0} + \ldots + P_{4,0} = 1.$$

4. Standard fertility and life tables. Each of the three standard model fertility tables gives the age-specific fertility rates (ASFR) by 5 year increments for different total fertility rates (TFR). Each of the nine standard model life tables gives one year survival probabilities for each year of life (ASSR) for different life expectancies-at-birth (LE). As the projection period advances and TFRs and LEs change, PROFILES 2.0 uses the correct ASFRs and ASSRs selected from the model tables.

5. Formulas for combining two programs. The formulas for calculating the components of prevalence reduction in options 1 and 2 are given in End-Table 5.1.

END-TABLE 5.1: Expressions for Coverage, Effectiveness and Maximum Impact

Coverage Combination	COV_p	COV_p	COV_m	Total
Cover: Total Overlap	$COV_i - COV_k$	COV_k	0	COV_i
Cover: No Overlap	COV_i	0	COV_k	$COV_i + COV_k$
Effect: Not Additive	EFF_i	$MAX(EFF_i, EFF_k)$	EFF_k	ns
Effect: Additive	EFF_i	$EFF_i + EFF_k$	EFF_k	ns
Maximum Impact	$MIMP_i$	$MAX(MIMP_i, MIMP_k)$	$MIMP_k$	ns

NOTES: (1) $COV_i > COV_k$. (2) MAX(a, b,..., n) equals the largest number among a,b...n.

6. Standard option 2 for integrating two programs. Standard option 2 (No coverage overlap and/or additive effectiveness) really consists of three options, namely, (1) Total Overlap and Additive Effectiveness, (2) No Overlap and Not Additive, and (3) No Overlap and Additive Effectiveness. However, the two "No Overlap" options always produce exactly the same reduction in prevalence, namely $(COV_j \cdot EFF_j \cdot {}_j + COV_k \cdot EFF_k \cdot MIMP_k)$. The "Total Overlap/Additive Effectiveness" option yields $([COV_j - COV_k] \cdot EFF_j \cdot MIMP_j + COV_k \cdot [EFF_j + EFF_k] \cdot MAX(MIMP_j, MIMP_k))$, which reduces to the RP(reduction in prevalence) yielded by the No Overlap options when $MIMP_j > MIMP_k$. In most cases when $MIMP_j > MIMP_k$, the marginal effect on RP is likely to be small. Therefore, in order to simplify user decisions (especially in default and standard mode), they are combined into a single option.

7. Derivation of formula for deaths. The derivation of the formula for the number of deaths in a particular population group (such as stillbirths or neonatal deaths) uses the following steps. (1) Identify the influencing conditions and their indicators. (For stillbirths, the indicators are iodine status in pregnant women, iron status in pregnant women, and birthweight, as an indicator of maternal malnutrition.) (2) Separate the conditions that use an excess mortality model from those using a relative risk model. (Only iodine deficiency uses an excess mortality model; all other conditions use a relative risk model.) (3) Derive the formula for additional deaths for conditions based on an excess mortality model. (4) Define all subgroups for the remaining indicators, where each subgroup is a unique combination of severity categories for the indicators in the relative risk model. (For example, for stillbirths iodine status uses an excess mortality model and the remaining two indicators form four subgroups – sufficient iron/normal birthweight, sufficient iron/low birthweight, deficient iron/normal birthweight, and deficient iron/low birthweight.) (5) Express algebraically the prevalences of the subgroups under the assumption that the occurrence of the various severity categories of the different indicators is independent. (For stillbirths, this produces the following four prevalences: $PIR_1 \cdot PW_1$, $PIR_1 \cdot PW_2$, $PIR_2 \cdot PW_1$, $PIR_2 \cdot PW_2$.) (6) Adjust these prevalences for non-independence by adding or subtracting a proportional amount where appropriate. (For stillbirths, a fractional amount was added to the first and last subgroup prevalences and the same amount subtracted from the second and third subgroup prevalences to reflect the higher than random likelihood of iron deficiency and low birthweight occurring together, thus, $PIR_1 \cdot PW_1 + e$, $PIR_1 \cdot PW_2 - e$, $PIR_2 \cdot PW_1 - e$, $PIR_2 \cdot PW_2 + e$, where "e" is the fractional amount.) (7) Express algebraically the relative risk of death for each subgroup under the assumption that the relative risks of the individual indicators and severity categories involved in the subgroup all multiply together to produce the subgroup relative risk. (For stillbirths, this produces the following four subgroup relative risks – 1.0, K47, K71, K47•K71.) (8) Adjust these relative risks when the multiplication assumption does not hold. (For stillbirths, no adjustments are necessary. The only interaction in PROFILES 2.0 which permits an adjustment is the combination of severe underweight and no breastfeeding, in which the unadjusted product is multiplied by K79 or K82 depending on the age.) (9) Estimate mortality rates for each subgroup using base year estimates of prevalence and mortality for the entire age group according to the procedure for estimating mortality rates from relative risks described above. (10) Calculate the number of deaths in each subgroup as the product of the mortality rate and population for the subgroup. (11) Calculate the total number of deaths in the age group by summing across all subgroups.

8. (1) Alam *et al* (1989), (2) Bairagi *et al* (1985), (3) Cogill (1982), (3) Fauveau *et al* (1990).

9. Relation of goiter prevalence and cretin prevalence. Based on an analysis of the limited existing data, Clugston *et al* (1987) found a non-linear relationship between the goiter prevalence and the cretin prevalence in a population, which they approximated by the formula in equation [1] below.

$$[1] \qquad CP = \exp(b_0 + b_1 PG + b_2 (PG)^2) / [1 + \exp(b_0 + b_1 PG + b_2 (PG)^2)].$$

Where: CP = cretin prevalence; PG = prevalence of goiter; b_0 = -9.394; b_1 = 15.796; b_2 = -8.803; and "exp(x)" means "e" (2.718...) raised to the x power. This relationship and the data used in deriving it is approximately linear for goiter prevalence (PG) in the range 0-40%, namely CP = 0.0343•PG. For values of PG>40%, the linear approximation underestimates the value given by the non-linear formula. Presumably, these relationships assume that PG is fairly stable; otherwise, recent changes in PG would produce proportional changes in CP as well as in births of cretins. (See Burkhalter, 1993b for additional information.)

10. Relation of vitamin A prevalence and reduction of child mortality. Humphrey *et al* (1992) estimate that 30-55% of all deaths of children aged 12-59 months and 10-25% of all deaths of children aged 6-11 months can be eliminated through effective vitamin A supplementation in high VAD areas, compared to a 10-15% reduction in 12-59 month olds and 3-6% in 6-11 month olds in low VAD areas.

11. Estimation of vitamin A relative risk of death. The following procedure was used to estimate the relative risk of death in vitamin A deficient (VAD) children aged 6-59 months in Bangladesh, compared to non-VAD children of the same age, and to estimate mortality rates for VAD and non-VAD children aged 6-59 months in Bangladesh. The 23% of the deaths that Beaton *et al* (1993) claim can be prevented by vitamin A supplementation are all attributed to VAD children. The remaining 77% are attributed to VAD and non-VAD children in proportion to their relative populations as reflected in the prevalence variables. Thus, if $D_{0,6\text{-}59,0}$ represents all base year deaths to children aged 6-59 months, and $PA_{2,0}$ represents base year prevalence of VAD children aged 6-59 months, then base year deaths of VAD children = $(0.23)*D_{0,6\text{-}59} + (0.77)*PA_2*D_{0,6\text{-}59}$, and base year deaths to healthy (non-VAD) children = $(0.77)*(1-PA_2)*D_{0,6\text{-}59}$. Mortality rates and the relative risk of death are easily calculated from the number of deaths.

12. Formula for estimating stillbirths. The formula for estimating the number of stillbirths in any year T (SB_T) is given below. The derivation procedure is described in sections E.1.1 and E.1.3, and in Burkhalter (1993b).

$$
\begin{aligned}
SB_T = \; & B_T*K61*K64*PG_T + B_T*(NMR_T/NMR_0) * [Y2*(PW_{1,T}*PIR_{1,4,T} + Y1_T) \\
& + Y2*K71*(PW_{1,T}*PIR_{2,4,T} - Y1_T) \\
& + Y2*K47*(PW_{2,T}*PIR_{1,4,T} - Y1_T) \\
& + Y2*(K47+K71)*(PW_{2,T}*PIR_{2,4,T} + Y1_T)].
\end{aligned}
$$

Where: SB_T = Number of stillbirths in year T. B_T = Number of live births in year T. NMR_T = Neonatal mortality rate in year T according to the original population model estimates. PG_T = Prevalence of goiter in the general population in year T. $PIR_{V,4,T}$ = Prevalence of pregnant women in year T that are iron sufficient (V = 1) or iron deficient (V = 2). $PW_{V,T}$ = Proportion of all live births in year T that are normal (V = 1) or low (V = 2). K47 = Relative risk of stillbirth to malnourished women, as indicated by low birthweight, relative to well nourished women, as indicated by normal birthweight. K61 = Excess stillbirths per cretin born. K64 = Proportion of live births to iodine deficient women that are cretins. K71 = Relative risk of stillbirth to women who are iron deficient during pregnancy, relative to iron sufficient pregnant women. K83 = Increase in proportion of pregnant women who are iron deficient and produce low birth weight babies relative to that expected if the two conditions were independent. T = 0 signifies base year.

And:

$$Y1_T = K83*PW_{2,T}*PIR_{2,4,T}.$$

$$
\begin{aligned}
Y2 = \; & (SB_0/B_0 - K61*K64*PG_0) \,/\, [(PW_{1,0}*PIR_{1,4,0}) + K71*(PW_{1,0}*PIR_{2,4,0}) \\
& + K47*(PW_{2,0}*PIR_{1,4,0}) + (K47+K71)*(PW_{2,0}+PIR_{2,4,0}) + Y1].
\end{aligned}
$$

Where: Y2 is a temporary variable that is a function of base year data and relational variables. Y1 is a temporary variable expressing the rate of additional low weight births to iron deficient pregnant women over that expected assuming independence during year T.

13. Formula for estimating neonatal deaths. The formula for estimating the number of neonatal deaths in any year T (ND_T) is given below.

$$
\begin{aligned}
ND_T = \; & B_T*K62*K64*PG_T + B_T*({}^{M00}NMR_T/{}^{M00}NMR_0) \\
& * [(Y3_1*Y5) + (Y3_2*K72*Y5) + (Y3_3*K20*Y5) + (Y3_4*K20*K72*Y5) + (Y3_5*K48*Y5) \\
& + (Y3_6*K48*K72*Y5) + (Y3_7*K20*K48*Y5) + (Y3_8*K20*K48*K72*Y5)].
\end{aligned}
$$

Where: ND_T = Number of neonatal deaths in year T. B_T = Number of live births in year T. ${}^{MOD}NMR_T$ = Neonatal mortality rate in year T according to the selected model life table. PB_T = Proportion of newborns that initiate breastfeeding in year T. PG_T = Prevalence of goiter in the general population in year T. $PIR_{4,V,T}$ = Prevalence of pregnant women in year T that are iron sufficient (V=1) or iron deficient (V=2). $PW_{V,T}$ = Proportion of all live births in year T that are normal (V=1) or low (V=2). K20 = Relative risk of neonatal death in newborns that do not initiate breastfeeding. K48 = Relative risk of neonatal death associated with low birthweight. K62 = Excess neonatal deaths per cretin born. K64 = Proportion of live births to iodine deficient women that are cretins. K72 = Relative risk of neonatal death to women who are iron deficient during pregnancy, relative to iron sufficient pregnant women. K83 = Increase in proportion of pregnant women who are iron deficient and produce low birth weight babies relative to that expected if the two conditions were independent. T = 0 signifies base year.–

And:

$$Y3_{1,T} = PW_{1,T} \cdot PB_{1,T} \cdot PIR_{4,1,T} + Y1_T .$$
$$Y3_{2,T} = PW_{1,T} \cdot PB_{1,T} \cdot PIR_{4,2,T} - Y1_T .$$
$$Y3_{3,T} = PW_{1,T} \cdot PB_{2,T} \cdot PIR_{4,1,T} + Y1_T .$$
$$Y3_{4,T} = PW_{1,T} \cdot PB_{2,T} \cdot PIR_{4,2,T} - Y1_T .$$
$$Y3_{5,T} = PW_{2,T} \cdot PB_{1,T} PIR_{4,1,T} + Y1_T .$$
$$Y3_{6,T} = PW_{2,T} \cdot PB_{1,T} PIR_{4,2,T} - Y1_T .$$
$$Y3_{7,T} = PW_{2,T} \cdot PB_{2,T} PIR_{4,1,T} + Y1_T .$$
$$Y3_{8,T} = PW_{2,T} \cdot PB_{2,T} PIR_{4,2,T} - Y1_T .$$

$$Y1_T = K83 \cdot PIR_{4,2,T} \cdot PW_{2,T} .$$

$$Y4_1 = 1.0. \qquad Y4_5 = K48.$$
$$Y4_2 = K72. \qquad Y4_6 = K48 \cdot K72.$$
$$Y4_3 = K20. \qquad Y4_7 = K20 \cdot K48.$$
$$Y4_4 = K20 \cdot K72. \qquad Y4_8 = K20 \cdot K48 \cdot K72.$$

$$Y5 = ({}^{MOD}NMR_0 - K61 \cdot K64 \cdot PG_0) / (Y3_{1,0} \cdot Y4_1 + Y3_{2,0} \cdot Y4_2 + \ldots + Y3_{8,0} \cdot Y4_8).$$

Where: Y1, Y3, Y4 and Y5 are temporary variables. Y1 expresses the rate of extra low birth weights to iron deficient pregnant women over that expected assuming independence. The Y3 variables give the prevalences of the coverage combinations. The Y4 variables give the relative risk of neonatal death in the coverage combinations. Y5 is a constant calculated from base year data and relational variables.

14. Formula for estimating 1-59 month mortality. The formulas for estimating the number of deaths in children aged 1-5 months, 6-59 months in year T are given below. Note the formulas are similar except for certain relational variables. The index numbers for the 20 coverage combinations (used in temporary variables Y6 and Y7) are given in End-Table 14.1 below.

END-TABLE 14.1: Indices for 20 Coverage Combinations

	No VAD (PA1)			VAD (PA2)	
	Full BF (PF1)	Partial BF (PF2)	No BF (PF3)	Partial BF (PF2)	No BF (PF3)
Normal PEM (PU1)	1	2	3	4	5
Mild PEM (PU2)	6	7	8	9	10
Moderate PEM (PU3)	11	12	13	14	15
Severe PEM (PU4)	16	17	18	19	20

Formula for 1-5 month olds

$$D_{1\text{-}5,T} = POP_T \cdot {}^{MOD}MR_{1\text{-}5,T} / {}^{MOD}MR_{1\text{-}5,0} \cdot (Y6_{1,T} \cdot Y7_{1,T} + \ldots + Y6_{20,T} \cdot Y7_{20,T}).$$

Where: $D_{1\text{-}5,T}$ = Number of deaths of infants aged 1-5 months in year T. POP_T = Population of 1-5 month olds in year T. ${}^{MOD}MR_{1\text{-}5,T}$ = Mortality rate in 1-5 month olds in year T as given by the selected model life table. $PA_{V,A,T}$ = Prevalence of vitamin A status in severity level V of age group A in year T. $PF_{V,A,T}$ = Prevalence of feeding mode V in age group A in year T. $PU_{V,A,T}$ = Prevalence of weight-for-age severity level V in age group A in year T. K77 = Infants aged 0-5 months both vitamin A deficient and normal weight-for-age expressed as a fraction of expected under independence. K78 = Infants aged 0-5 months both vitamin A deficient and fully or partially breastfed expressed as a fraction of expected under independence. K79 = Increased relative risk of death in infants aged 0-5 months both severely underweight and not breastfeeding expressed as multiple of relative risk of death of all severely underweight infants of same age. K8 = the exponentiation factor for the relationship between weight-for-age and relative risk of death age 0-5 months. K53 = relative risk of death in vitamin A deficient children aged 0-5 months. K41 = Relative risk of death of partially breastfed to fully breastfed age infants 0-5 months. K42 = Relative risk of death of non-breastfed to fully breastfed infants aged 0-5 months. T = 0 in base year.

And: $Y6_1 \ldots Y6_{20}$ are temporary variables that give the prevalences of the different coverage combinations and are defined according to End-Table 14.2.

END-TABLE 14.2: Definition of Y6 Variables

	No VAD (PA1)			VAD (PA2)	
	Full BF	Partial BF	No BF	Partial BF	No BF
Normal PEM	$PU_1 \cdot PF_1 \cdot PA_1$	$PU_1 \cdot PF_2 \cdot PA_1 + Y8 + Y10$	$PU_1 \cdot PF_3 \cdot PA_1 + Y9 - Y10$	$PU_1 \cdot PF_2 \cdot PA_2 - Y8 - Y10$	$PU_1 \cdot PF_3 \cdot PA_2 - Y9 + Y10$
Mild PEM	$PU_2 \cdot PF_1 \cdot PA_1$	$PU_2 \cdot PF_2 \cdot PA_1 - Y14 \cdot Y8 + Y11$	$PU_2 \cdot PF_3 \cdot PA_1 - Y14 \cdot Y9 - Y11$	$PU_2 \cdot PF_2 \cdot PA_2 + Y14 \cdot Y8 - Y11$	$PU_2 \cdot PF_3 \cdot PA_2 + Y14 \cdot Y9 + Y11$
Moderate PEM	$PU_3 \cdot PF_1 \cdot PA_1$	$PU_3 \cdot PF_2 \cdot PA_1 - Y15 \cdot Y8 + Y12$	$PU_3 \cdot PF_3 \cdot PA_1 - Y15 \cdot Y9 - Y12$	$PU_3 \cdot PF_2 \cdot PA_2 + Y15 \cdot Y8 - Y12$	$PU_3 \cdot PF_3 \cdot PA_2 + Y15 \cdot Y9 + Y12$
Severe PEM	$PU_4 \cdot PF_1 \cdot PA_1$	$PU_4 \cdot PF_2 \cdot PA_1 - Y16 \cdot Y8 + Y13$	$PU_4 \cdot PF_3 \cdot PA_1 - Y16 \cdot Y9 - Y13$	$PU_4 \cdot PF_2 \cdot PA_2 + Y16 \cdot Y8 - Y13$	$PU_4 \cdot PF_3 \cdot PA_2 + Y16 \cdot Y9 + Y13$

NOTE: All variables should be subscripted with A = 1-5 months and T, except Y14, Y15 and Y16.

And: $Y7_1 \ldots Y7_{20}$ are temporary variables that give the mortality rates in the different coverage combinations by year and are defined according to End-Table 14.3.

END-TABLE 14.3: Definition of Y7 Variables

	No VAD (PA1)			VAD (PA2)	
	Full BF	Partial BF	No BF	Partial BF	No BF
Normal PEM	Y17	$K41 \cdot Y17$	$K42 \cdot Y17$	$K53 \cdot K41 \cdot Y17$	$K53 \cdot K42 \cdot Y17$

Mild PEM	K8*Y17	K8*K41 *Y17	K8*K42 *Y17	K8*K53 *K41*Y17	K8*K53 *K42*Y17
Moderate PEM	$K8^2$*Y17	$K8^2$*K41 *Y17	$K8^2$*K42 *Y17	$K8^2$*K53 *K41*Y17	$K8^2$*K53 *K42*Y17
Severe PEM	$K8^3$*Y17	$K8^3$*K41 *Y17	K79*$K8^3$ *K42*Y17	$K8^3$*K53 *K41*Y17	K79*$K8^3$ *K53*K42*Y17

And: $Y8_T$ and $Y9_T$ are temporary variables used in the calculation that accounts for the non-independence of vitamin A status and weight-for-age status.

$$Y8_T = (1-K77)*PU_{1,T}*PF_{2,T}*PA_{2,T}.$$
$$Y9_T = (1-K77)*PU_{1,T}*PF_{3,T}*PA_{2,T}.$$

And: $Y10_T$...$Y13_T$ are temporary variables used in the calculation that accounts for the non-independence of vitamin A status and breastfeeding.

$$Y10_T = (1-K78)*PU_{1,T}*PF_{2,T}*PA_{2,T}.$$
$$Y11_T = (1-K78)*PU_{2,T}*PF_{2,T}*PA_{2,T}.$$
$$Y12_T = (1-K78)*PU_{3,T}*PF_{2,T}*PA_{2,T}.$$
$$Y13_T = (1-K78)*PU_{4,T}*PF_{2,T}*PA_{2,T}.$$

And: Y14...Y17 are constants calculated from base year data.

$$Y14 = PU_{2,0} / (PU_{2,0}+PU_{3,0}+PU_{4,0}).$$
$$Y15 = PU_{3,0} / (PU_{2,0}+PU_{3,0}+PU_{4,0}).$$
$$Y16 = PU_{4,0} / (PU_{2,0}+PU_{3,0}+PU_{4,0}).$$
$$Y17 = {}^{MOD}MR_{1,5,0} / (Y6_{1,0}*Y7_{1,0}+\ldots+Y6_{20,0}*Y7_{20,0}).$$

Formula for 6-59 month olds

The formula for the 6-59 month olds is exactly the same as the formula for the 1-5 month old, except the following relational variables are replaced:

K77	is replaced by	K80
K78	is replaced by	K81
K79	is replaced by	K82
K8	is replaced by	K9
K53	is replaced by	K54
K41	is replaced by	K43
K42	is replaced by	K44

Each of these new variables is defined exactly the same as the variable it is replacing except that it applies to the 6-59 month age range rather than to the 0-5 month age range.

The formula for the 6-59 month age range is calculated separately for four age groups and then added. The four age groups are: 6-11 months, 12-23 months, 24-35 months and 36-59 months. The reason is that the ëdipno feeding mode prevalence variables (PF variables) are defined by these age groups rather than as a composite.

15. Bangladesh default values for morbidity and underweight. The data from the Black *et al* (1984) and Chowdhury *et al* (1990) studies and the derivation of the PROFILES 2.0 default values are the same as in PROFILES 1, as reported in Burkhalter (1993a).

16. Estimating default value for VAD relative morbidity. The Ghana VAST Team (1993) found 88% lower clinic attendance in vitamin A supplemented children (presumably non-VAD) than in controls with 57.6% VAD prevalence. The calculation of the relative morbidity (as indicated by clinic attendance) of the VAD children is: 1/[1-(1-0.88)/0.576] = 1.263.

17. Studies on relation of breastfeeding and morbidity. Results reported by Brown *et al* (1989), Popkin *et al* (1990) and Feachem and Koblinsky (1984) are summarized here in End-Table 17.1. Some of the figures in the table have been manipulated to make them roughly compatible. Further details on the results of the studies and the manipulations are given in Burkhalter (1993b, Note No. 9, Annex A).

END-TABLE 17.1: Summary of Relative Morbidity by Feeding Mode

	Popkin (1990)			Brown (1989)	Feachem (1984)
	Rural	Urban	U/R		
Diarrhea, 0-5 months					
Part/Full	4.55	9.83	2.16	2.16	2.0(a)
None/Full	5.35	14.9	2.77	3.91	3.5-4.9
Diarrhea, 6-11 months					
None/Part	1.00	1.13(b)	1.13	1.54	1.4(c)
Diarrhea, 12+ months					
None/Part	nd (d)			nd	1.0
All Respiratory Infection, 0-5 months					
Part/Full	nd			2.27	nd
None/Full	nd			4.20	nd
All Respiratory Infection, 6-11 months					
None/Part	nd			1.78	nd

NOTES: (a) If relative morbidity of None/Full = 4.0, and None/(Full+Part) = 2.7, then relative morbidity of Part/Full = about 2.0 assuming prevalence of full and part are the same. (b) Relative morbidity of (None/Full)/(Partial/None) = (None/Partial) = (1.42)/(1.26) = 1.13. (c) This figure is the relative morbidity of None/(Part+Full). (d) "nd" means no data.

18. Formula for Neonatal Sick Days. The formula for estimating the total neonatal days of sickness due to diarrhea and respiratory infection in any year "T" ($S_{A=0,T}$) is given below. The derivation procedure is described in sections E.2.1 and E.2.3 of the text.

$$S_{A=0,T} = {}^{d}S_{A=0,R,T} + {}^{d}S_{A=0,U,T} + {}^{r}S_{A=0,R+U,T} .$$

Where: $S_{A=0,L,T}$ = Total neonatal days sick in year T due to diarrhea and respiratory infection. $^bS_{A=0,L,T}$ = Total neonatal sick days due to disease "b" in location "L" in year "T." $POP_{A=0,L,T}$ = Neonatal population in location "L" in year "T." $PB_{V,L,T}$ = Proportion of all live births that initiate breastfeeding (V=1) or do not initiate breastfeeding (V=2) in location "L" in year "T." $PIR_{V,A,L,T}$ = Prevalence of pregnant women in location "L" in year "T" that are iron sufficient (V=1) or iron deficient (V=2). $PW_{V,L,T}$ = Proportion of all live births in location "L" in year "T" that are normal (V=1) or low (V=2) birth weight. K21 = Relative diarrhea morbidity in rural neonates who do not initiate breastfeeding. K28 = Relative respiratory morbidity in neonates who do not initiate breastfeeding. K36 = Urban-to-rural ratio of diarrhea morbidity in infants aged 0-5 months who do not breastfeed compared to those who fully breastfeed. K49 = Relative diarrhea morbidity in neonates of low birthweight. K50 = Relative respiratory morbidity in neonates of low birthweight. K75 = Relative diarrhea morbidity in neonates with mothers who were iron deficient during pregnancy. K76 = Relative respiratory morbidity in neonates with mothers who were iron deficient during pregnancy. K83 = Increase in proportion of pregnant women who are iron deficient and produce low birth weight babies relative to that expected if the two conditions were independent. T = 0 signifies base year.

And:

$$^dS_{A=0,R,T} = POP_{A=0,R,T} \cdot {}^dY18_R \cdot [(PW_{1,R,T} \cdot PIR_{1,A,R,T} \cdot PB_{1,R,T} + Y1_T \cdot PB_{1,R,T}) + (K49 \cdot PW_{2,R,T}) + (K75 \cdot PIR_{2,A,R,T}) + (K21 \cdot PB_{2,R,T})].$$

$$^dS_{A=0,U,T} = POP_{A=0,U,T} \cdot {}^dY18_U \cdot [(PW_{1,U,T} \cdot PIR_{1,A,U,T} \cdot PB_{1,U,T} + Y1_T \cdot PB_{1,U,T}) + (K49 \cdot PW_{2,U,T}) + (K75 \cdot PIR_{2,A,U,T}) + (K21 \cdot K36 \cdot PB_{2,U,T})].$$

$$^lS_{A=0,L,T} = POP_{A=0,L,T} \cdot {}^lY18_L \cdot [(PW_{1,L,T} \cdot PIR_{1,A,L,T} \cdot PB_{1,L,T} + Y1_T \cdot PB_{1,L,T}) + (K50 \cdot PW_{2,L,T}) + (K76 \cdot PIR_{2,A,L,T}) + (K28 \cdot PB_{2,L,T})].$$

$Y1_T$ = $K83 \cdot PW_{2,T} \cdot PIR_{2,A,T}$. (Y1 is a temporary variable expressing the rate of extra low birth weights to iron deficient pregnant women over that expected assuming independence during year T.)

$$^dY18_R = ({}^dS_{A=0,R,0}/POP_{A=0,R,0}) / [(PW_{1,R,0} \cdot PIR_{1,A,R,0} \cdot PB_{1,R,0} + Y1_0 \cdot PB_{1,R,0}) + (K49 \cdot PW_{2,R,0}) + (K75 \cdot PIR_{2,A,R,0}) + (K21 \cdot PB_{2,R,0})].$$

$$^dY18_U = ({}^dS_{A=0,U,0}/POP_{A=0,U,0}) / [(PW_{1,U,0} \cdot PIR_{1,A,U,0} \cdot PB_{1,U,0} + Y1_0 \cdot PB_{1,U,0}) + (K49 \cdot PW_{2,U,0}) + (K75 \cdot PIR_{2,A,U,0}) + (K21 \cdot K36 \cdot PB_{2,U,0})].$$

$$^lY18_L = ({}^lS_{A=0,L,0}/POP_{A=0,L,0}) / [(PW_{1,L,0} \cdot PIR_{1,A,L,0} \cdot PB_{1,L,0} + Y1_0 \cdot PB_{1,L,0}) + (K50 \cdot PW_{2,L,0})] + (K76 \cdot PIR_{2,A,L,0}) + (K28 \cdot PB_{2,L,0})].$$

Where: $^dY18_L$ and $^lY18_L$ are temporary variables that are a function of base year data and relational variables. (Some early versions of Profiles 2.0 used a single expression for $^dY18$ rather than different expressions for $^dY18_R$ and $^dY18_U$, namely, $({}^dS_{A=0,R+U,0}/POP_{A=0,R+U,0}) / [(PW_{1,0} \cdot PIR_{1,A,0} \cdot PB_{1,R+U,0} + Y1_0 \cdot PB_{1,R+U,0}) + (K49 \cdot PW_{2,0}) + (K75 \cdot PIR_{2,A,0}) + (K21 \cdot PB_{2,R,0} + K21 \cdot K36 \cdot PB_{2,U,0})]$.)

19. Formulas for Sick Days in 1-5 Month Olds. The formula for estimating the total days of sickness due to diarrhea and respiratory infection in the 1-5 month age group in any year T ($S_{1\text{-}5,T}$) is given below. The derivation procedure is described in sections E.2.1 and E.2.3 of the text.

$$S_{1\text{-}5,T} = {}^dS_{1\text{-}5,R,T} + {}^dS_{1\text{-}5,U,T} + {}^lS_{1\text{-}5,R+U,T}.$$

Where: $S_{1\text{-}5,T}$ = Total days sick in 1-5 month age group in year T due to diarrhea and respiratory infection. $^bS_{1\text{-}5,L,T}$ = Total days sick in 1-5 month age group due to disease "b" in location "L" in year "T." $POP_{1\text{-}5,L,T}$ = Population of 1-5 month age group in location "L" in year "T." $PF_{V,A,L,T}$ = Prevalence of feeding mode "V" in age group "A" in location "L" in year "T." $PU_{V,A,L,T}$ = Prevalence of weight-for-age severity level "V" in age group "A" in location "L" in year "T." K1 = Relative diarrhea morbidity of mildly underweight 0-59 month olds. K2

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= Relative diarrhea morbidity of moderately underweight 0-59 month olds. K3 = Relative diarrhea morbidity of severely underweight 0-59 month olds. K22 = Relative diarrhea morbidity in partially breastfed rural 0-5 month olds compared to fully breastfed. K23 = Relative diarrhea morbidity in non-breastfed rural 1-5 month olds compared to fully breastfed. K29 = Relative respiratory morbidity of partially breastfed 1-5 month olds compared to fully breastfed. K30 = Relative respiratory morbidity of non-breastfed 1-5 month olds compared to fully breastfed. K35 = Urban-to-rural ratio of diarrhea morbidity in infants aged 0-5 months who partially breastfeed compared to those who fully breastfeed. K36 = Urban-to-rural ratio of diarrhea morbidity in infants aged 0-5 months who don't breastfeed to those who fully breastfeed. T = 0 signifies base year.

And:

$$^{a}S_{1\text{-}a,R,T} = POP_{1\text{-}a,R,T} \cdot {}^{a}Y19_{R} \cdot [(PF_{1,1\text{-}a,R,T} \cdot PU_{1,1\text{-}a,R,T}) + (K22 \cdot PF_{2,1\text{-}a,R,T}) + (K23 \cdot PF_{3,1\text{-}a,R,T}) + (K1 \cdot PU_{2,1\text{-}a,R,T}) + (K2 \cdot PU_{3,1\text{-}a,R,T}) + (K3 \cdot PU_{4,1\text{-}a,R,T})].$$

$$^{a}S_{1\text{-}a,U,T} = POP_{1\text{-}a,U,T} \cdot {}^{a}Y19_{U} \cdot [(PF_{1,1\text{-}a,U,T} \cdot PU_{1,1\text{-}a,U,T}) + (K35 \cdot K22 \cdot PF_{2,1\text{-}a,U,T}) + (K36 \cdot K23 \cdot PF_{3,1\text{-}a,U,T}) + (K1 \cdot PU_{2,1\text{-}a,U,T}) + (K2 \cdot PU_{3,1\text{-}a,U,T}) + (K3 \cdot PU_{4,1\text{-}a,U,T})].$$

$$^{l}S_{1\text{-}a,L,T} = POP_{1\text{-}a,L,T} \cdot {}^{l}Y19_{L} \cdot [(PF_{1,1\text{-}a,L,T}) + (K29 \cdot PF_{2,1\text{-}a,L,T}) + (K30 \cdot PF_{3,1\text{-}a,L,T})].$$

$$^{a}Y19_{R} = ({}^{a}S_{1\text{-}a,R,0}/POP_{1\text{-}a,R,0}) / [(PF_{1,1\text{-}a,R,0} \cdot PU_{1,1\text{-}a,R,0}) + (K22 \cdot PF_{2,1\text{-}a,R,0}) + (K23 \cdot PF_{3,1\text{-}a,R,0}) + (K1 \cdot PU_{2,1\text{-}a,R,0}) + (K2 \cdot PU_{3,1\text{-}a,R,0}) + (K3 \cdot PU_{4,1\text{-}a,R,0})].$$

$$^{a}Y19_{U} = ({}^{a}S_{1\text{-}a,U,0}/POP_{1\text{-}a,U,0}) / [(PF_{1,1\text{-}a,U,0} \cdot PU_{1,1\text{-}a,U,0}) + (K35 \cdot K22 \cdot PF_{2,1\text{-}a,U,0}) + (K36 \cdot K23 \cdot PF_{3,1\text{-}a,U,0}) + (K1 \cdot PU_{2,1\text{-}a,U,0}) + (K2 \cdot PU_{3,1\text{-}a,U,0}) + (K3 \cdot PU_{4,1\text{-}a,U,0})].$$

$$^{l}Y19_{L} = ({}^{l}S_{1\text{-}a,L,0}/POP_{1\text{-}a,L,0}) / [(PF_{1,1\text{-}a,L,0}) + (K29 \cdot PF_{2,1\text{-}a,L,0}) + (K30 \cdot PF_{3,1\text{-}a,L,0})].$$

Where: $^{a}Y19_{L}$ and $^{l}Y19_{L}$ are temporary variables that are a function of base year data and relational variables. (Some early versions of Profiles 2.0 used a single expression for $^{a}Y19$ rather than different expressions for $^{a}Y19_{R}$ and $^{a}Y19_{U}$, namely, $({}^{a}S_{1\text{-}a,R+U,0}/POP_{1\text{-}a,R+U,0}) / [(PF_{1,1\text{-}a,R+U,0} \cdot PU_{1,1\text{-}a,R,0}) + (K22 \cdot PF_{2,1\text{-}a,R,0}) + (K23 \cdot PF_{3,1\text{-}a,R,0}) + (K35 \cdot K22 \cdot PF_{2,1\text{-}a,U,0}) + (K36 \cdot K23 \cdot PF_{3,1\text{-}a,U,0}) + (K1 \cdot PU_{2,1\text{-}a,R,0}) + (K2 \cdot PU_{3,1\text{-}a,R,0}) + (K3 \cdot PU_{4,1\text{-}a,R,0})]$.)

20. Formulas for Sick Days in 6-11 Month Olds. The formula for estimating the total days of sickness due to diarrhea and respiratory infection in the 6-11 month age group in any year T ($S_{a\text{-}11,T}$) is given below. The derivation procedure is described in sections E.2.1 and E.2.3 of the text.

$$S_{a\text{-}11,T} = {}^{a}S_{a\text{-}11,R,T} + {}^{a}S_{a\text{-}11,U,T} + {}^{l}S_{a\text{-}11,R+U,T}.$$

Where: $S_{a\text{-}11,T}$ = Total days sick in 6-11 month age group in year T due to diarrhea and respiratory infection. $^{b}S_{a\text{-}11,L,T}$ = Total days sick in 6-11 month age group due to disease "b" in location "L" in year "T." $POP_{a\text{-}11,L,T}$ = Population of 6-11 month age group in location "L" in year "T." $PA_{V,A,L,T}$ = Prevalence of vitamin A severity level "V" in age group "A" in location "L" in year "T." $PF_{V,A,L,T}$ = Prevalence of feeding mode "V" in age group "A" in location "L" in year "T." $PU_{V,A,L,T}$ = Prevalence of weight-for-age severity level "V" in age group "A" in location "L" in year "T." K1 = Relative diarrhea morbidity of mildly underweight 0-59 month olds. K2 = Relative diarrhea morbidity of moderately underweight 0-59 month olds. K3 = Relative diarrhea morbidity of severely underweight 0-59 month olds. K24 = Relative diarrhea morbidity in partially breastfed rural 6-11 month olds compared to fully breastfed. K25 = Relative diarrhea morbidity in non-breastfed rural 6-11 month olds compared to fully breastfed. K31 = Relative respiratory morbidity of partially breastfed 6-11 month olds compared to fully breastfed. K32 = Relative respiratory morbidity of non-breastfed 6-11 month olds compared to fully breastfed. K37 = Urban-to-rural ratio of diarrhea morbidity in infants aged 6-11 months who partially breastfeed compared to those who fully breastfeed. K38 = Urban-to-rural ratio of diarrhea morbidity in infants aged 6-11 months who don't breastfeed to those who fully breastfeed. K51 = Relative morbidity of vitamin A deficient 6-59 month olds. T = 0 signifies base year.

And: $$^{a}S_{6\text{-}11,R,T} = POP_{6\text{-}11,R,T} \cdot {}^{a}Y20_{R} \cdot [(PA_{1,6\text{-}11,R,T} \cdot PF_{1,6\text{-}11,R,T} \cdot PU_{1,6\text{-}11,R,T}) + (K51 \cdot PA_{2,6\text{-}11,R,T}) + (K24 \cdot PF_{2,6\text{-}11,R,T}) + (K25 \cdot PF_{3,6\text{-}11,R,T}) + (K1 \cdot PU_{2,6\text{-}11,R,T}) + (K2 \cdot PU_{3,6\text{-}11,R,T}) + (K3 \cdot PU_{4,6\text{-}11,R,T})].$$

$$^{a}S_{6\text{-}11,U,T} = POP_{6\text{-}11,U,T} \cdot {}^{a}Y20_{U} \cdot [(PA_{1,6\text{-}11,U,T} \cdot PF_{1,6\text{-}11,U,T} \cdot PU_{1,6\text{-}11,U,T}) + (K51 \cdot PA_{2,6\text{-}11,U,T}) + (K37 \cdot K24 \cdot PF_{2,6\text{-}11,U,T}) + (K38 \cdot K25 \cdot PF_{3,6\text{-}11,U,T}) + (K1 \cdot PU_{2,6\text{-}11,U,T}) + (K2 \cdot PU_{3,6\text{-}11,U,T}) + (K3 \cdot PU_{4,6\text{-}11,U,T})].$$

$$^{b}S_{6\text{-}11,L,T} = POP_{6\text{-}11,L,T} \cdot {}^{b}Y20_{L} \cdot [(PA_{1,6\text{-}11,L,T} \cdot PF_{1,6\text{-}11,L,T}) + (K51 \cdot PA_{2,6\text{-}11,L,T}) + (K31 \cdot PF_{2,6\text{-}11,L,T}) + (K32 \cdot PF_{3,6\text{-}11,L,T})].$$

$$^{a}Y20_{R} = ({}^{a}S_{6\text{-}11,R,0}/POP_{6\text{-}11,R,0}) / [(PA_{1,6\text{-}11,R,0} \cdot PF_{1,6\text{-}11,R,0} \cdot PU_{1,6\text{-}11,R,0}) + (K51 \cdot PA_{2,6\text{-}11,R,0}) + (K24 \cdot PF_{2,6\text{-}11,R,0}) + (K25 \cdot PF_{3,6\text{-}11,R,0}) + (K1 \cdot PU_{2,6\text{-}11,R,0}) + (K2 \cdot PU_{3,6\text{-}11,R,0}) + (K3 \cdot PU_{4,6\text{-}11,R,0})].$$

$$^{a}Y20_{U} = ({}^{a}S_{6\text{-}11,U,0}/POP_{6\text{-}11,U,0}) / [(PA_{1,6\text{-}11,U,0} \cdot PF_{1,6\text{-}11,U,0} \cdot PU_{1,6\text{-}11,U,0}) + (K51 \cdot PA_{2,6\text{-}11,U,0}) + (K37 \cdot K24 \cdot PF_{2,6\text{-}11,U,0}) + (K38 \cdot K25 \cdot PF_{3,6\text{-}11,U,0}) + (K1 \cdot PU_{2,6\text{-}11,U,0}) + (K2 \cdot PU_{3,6\text{-}11,U,0}) + (K3 \cdot PU_{4,6\text{-}11,U,0})].$$

$$^{b}Y20_{L} = ({}^{b}S_{6\text{-}11,L,0}/POP_{6\text{-}11,L,0}) / [(PA_{1,6\text{-}11,L,0} \cdot PF_{1,6\text{-}11,L,0}) + (K51 \cdot PA_{2,6\text{-}11,L,0}) + (K31 \cdot PF_{2,6\text{-}11,L,0}) + (K32 \cdot PF_{3,6\text{-}11,L,0})].$$

Where: $^{a}Y20_{L}$ and $^{b}Y20_{L}$ are temporary variables that are a function of base year data and relational variables. (Some early versions of Profiles 2.0 used a single expression for $^{a}Y20$ rather than different expressions for $^{a}Y20_{R}$ and $^{a}Y20_{U}$, namely, $({}^{a}S_{6\text{-}11,R+U,0}/POP_{6\text{-}11,R+U,0}) / [(PA_{1,6\text{-}11,0} \cdot PF_{1,6\text{-}11,R+U,0} \cdot PU_{1,6\text{-}11,0}) + (K51 \cdot PA_{2,6\text{-}11,0}) + (K24 \cdot PF_{2,6\text{-}11,R,0}) + (K25 \cdot PF_{3,6\text{-}11,R,0}) + (K37 \cdot K24 \cdot PF_{2,6\text{-}11,U,0}) + (K38 \cdot K25 \cdot PF_{3,6\text{-}11,U,0}) + (K1 \cdot PU_{2,6\text{-}11,0}) + (K2 \cdot PU_{3,6\text{-}11,0}) + (K3 \cdot PU_{4,6\text{-}11,0})]$.)

21. Formulas for Sick Days in 12-59 Month Olds. The formula for estimating the total days of sickness due to diarrhea and respiratory infection in the 12-59 month age group in any year T ($S_{12\text{-}59,T}$) is given below. The derivation procedure is described in sections E.2.1 and E.2.3 of the text.

$$S_{12\text{-}59,T} = {}^{a}S_{12\text{-}59,R,T} + {}^{a}S_{12\text{-}59,U,T} + {}^{b}S_{12\text{-}59,R+U,T}.$$

Where: $S_{12\text{-}59,T}$ = Total days sick in 12-59 month age group in year T due to diarrhea and respiratory infection. $^{b}S_{12\text{-}59,L,T}$ = Total days sick in 12-59 month age group due to disease "b" in location "L" in year "T." $POP_{12\text{-}59,L,T}$ = Population of 12-59 month age group in location "L" in year "T." $PA_{V,A,L,T}$ = Prevalence of vitamin A severity level "V" in age group "A" in location "L" in year "T." $PU_{V,A,L,T}$ = Prevalence of weight-for-age severity level "V" in age group "A" in location "L" in year "T." K1 = Relative diarrhea morbidity of mildly underweight 0-59 month olds. K2 = Relative diarrhea morbidity of moderately underweight 0-59 month olds. K3 = Relative diarrhea morbidity of severely underweight 0-59 month olds. K51 = Relative morbidity of vitamin A deficient 6-59 month olds. K80 = Fraction of 6-59 month olds both vitamin A deficient and normal weight-for-age relative to expected under independence assumption. T = 0 signifies base year.

And: $$^{a}S_{12\text{-}59,L,T} = POP_{12\text{-}59,L,T} \cdot {}^{a}Y21_{L} \cdot [(PA_{1,12\text{-}59,L,T} \cdot PU_{1,12\text{-}59,L,T} + (1\text{-}K80) \cdot PA_{2,12\text{-}59,L,T} \cdot PU_{1,12\text{-}59,L,T}) + K51 \cdot PA_{2,12\text{-}59,L,T} + K1 \cdot PU_{2,12\text{-}59,L,T} + K2 \cdot PU_{3,12\text{-}59,L,T} + K3 \cdot PU_{4,12\text{-}59,L,T}].$$

$$^{b}S_{12\text{-}59,L,T} = POP_{12\text{-}59,L,T} \cdot {}^{b}Y21_{L} \cdot (PA_{1,12\text{-}59,L,T} + K51 \cdot PA_{2,12\text{-}59,T}).$$

$$^{a}Y21_{L} = ({}^{a}S_{12\text{-}59,L,0}/POP_{12\text{-}59,L,0}) / [(PA_{1,12\text{-}59,L,0} \cdot PU_{1,12\text{-}59,L,0} + (1\text{-}K80) \cdot PA_{2,12\text{-}59,L,0} \cdot PU_{1,12\text{-}59,L,T}) + (K51 \cdot PA_{2,12\text{-}59,L,0}) + (K1 \cdot PU_{2,12\text{-}59,L,0}) + (K2 \cdot PU_{3,12\text{-}59,L,0}) + (K3 \cdot PU_{4,12\text{-}59,L,0})].$$

$$^{b}Y21_{L} = ({}^{b}S_{12\text{-}59,L,0}/POP_{12\text{-}59,L,0}) / (PA_{1,12\text{-}59,L,0} + K51 \cdot PA_{2,12\text{-}59,L,0}).$$

Where: $^{a}Y21_{L}$ and $^{b}Y21_{L}$ are temporary variables that are a function of base year data and relational variables.

22. Sources of Bangladesh default values in fertility function. FEC, total fecundity, a1 (marital parameter) and a3 (induced abortion parameter) were estimated from Figures 1 and 2 in Bongaarts (1978). a2 (contraception parameter) was estimated using a model suggested by Bongaarts (1978) and data from Cleland *et al* (1984), section 3. Bongaarts proposes a model in which a2 = 1 - 1.18*U1*U2, where U1 is the average proportion of married women using contraception and U2 is the average contraceptive effectiveness, and Cleland *et al* estimate that in Bangladesh, U1 = 0.4 and U2 = 0.82. This yields a value for a2 = 0.613.

23. Assumptions in estimating prevalence of total blindness. The formula used by PROFILES 2.0 to estimate the prevalence of total blindness is a rough approximation. K52 may overestimate the number of survivors to the extent it ignores excess deaths in subsequent years, but underestimate survivors because it assumes that all the excess deaths occur at the start of the year rather than throughout the year. K57 may overestimate total blindness to the extent that the conversion from xerophthalmia occurs over several years rather than in the same year as assumed by PROFILES 2.0.

24. Incidence and prevalence of partial blindness. The incidence of new cases of partial blindness in under five children and in school age children are given in equations [1] and [2], and the prevalence is given in [3].

[1] $IPB_{U5,T} = K58*PA_{2,U5,T}*POP_{A=5,T} + K58*[(PA_{2,U5,T}*POP_{0-5,T}) - (PA_{2,U5,T-1})*POP_{0-5,T-1})]$.

[2] $IPB_{SCL,T} = K58*[(PA_{2,SCL,T}*POP_{SCL,T}) - (PA_{2,SCL,T-1})*POP_{SCL,T-1})]$.

[3] $PTB_{A,T} = K58*PA_{2,A,T}$, for A = U5 and SCL.

Where: $IPB_{A,T}$ = Incidence of new cases of partial blindness in age group "A" in year T. $PPB_{A,T}$ = Prevalence of partial blindness in age group "A" in year T. $PA_{2,A,T}$ = Prevalence of nightblindness in age group "A" in year T. $POP_{A,T}$ = Population of age group "A" in year T. K58 = Proportion of nightblind children that go partially blind.

25. Cretin birth rate. It is widely accepted that the mortality of cretins is higher than mortality in the normal population, and especially in the early stages of life. However, no data was available to estimate cretin mortality. Therefore, the linear relationship between goiter prevalence and cretin birth rate assumed by PROFILES 2.0 should more properly be viewed as the relationship of "cretins born that survive the early stages of life" to goiter prevalence.

26. School repeater formulas. The number of children repeating the first grade and grades 2-6 in any year as a function of goiter prevalence, stunting prevalence and coverage of a mental stimulation program are given in equations [1] and [2] below.

[1] $REP_{1,T} = POP_{6,T}*K100*Y30*[(1 - PS_{2+,6,0} - Y32_{6,T} + PS_{2+,6,T}*Y32_{6,T}) + Y33_{6,T}*(PQ_T + (1-PQ_T)*K10) + K10*(PS_{2+,6,T} - PS_{2+,6,T}*Y32_{6,T}) + K67*(Y32_{6,T} - Y32_{6,T}*PS_{2+,6,T}) + (MAX(K10,K67)*PS_{2+,6,T}*Y32_{6,T})]$.

[2] $REP_{2+,T} = POP_{7+,T}*K101*Y31*[(1 - PS_{2+,7+,0} - Y32_{7+,T} + PS_{2+,7+,T}*Y32_{7+,T}) + Y33_{7+,T}*(PQ_T + (1-PQ_T)*K11) + K11*(PS_{2+,7+,T} - PS_{2+,7+,T}*Y32_{7+,T}) + K68*(Y32_{7+,T} - Y32_{7+,T}*PS_{2+,7+,T}) + (MAX(K11,K68)*PS_{2+,7+,T}*Y32_{7+,T})]$.

Where: $Y30 = K84 / [(1 - PS_{2+,6,0} - Y32_{6,0} + PS_{2+,6,0}*Y32_{6,0}) + K10*(PS_{2+,6,0} - PS_{2+,6,0}*Y32_{6,0}) + K67*(Y32_{6,0} - Y32_{6,0}*PS_{2+,6,0}) + (MAX(K10,K67)*PS_{2+,6,0}*Y32_{6,0})]$.

$$Y31 = K85 / [(1 - PS_{2+,7+,0} - Y32_{7+,0} + PS_{2+,7+,0} \cdot Y32_{7+,0}) + K11 \cdot (PS_{2+,7+,0} - PS_{2+,7+,0} \cdot Y32_{7+,0}) + K68 \cdot (Y32_{7+,0} - Y32_{7+,0} \cdot PS_{2+,7+,0}) + (MAX(K11,K68) \cdot PS_{2+,7+,0} \cdot Y32_{7+,0})].$$

$Y32_{A,T}$ = $(CMI_{A,T} + PMI_{A,T})/POP_{A,T}$. (This is the prevalence of CMIs+PMIs of age "A" in year T, and can be approximated by $Y32_{A,T} = K63 \cdot PC_{A,T}$, where $PC_{A,T}$ is cretin prevalence of age "A" in year "T.")

$Y33_{A,T}$ = $PS_{A,0} - PS_{A,T}$, or 0, whichever is greater. (This is the decrease in stunting from the base year to year T.

When G="1", A="6" and when G="2+"(2-6), A="7+"(7-11).

And: $REP_{G,T}$ = Number of children repeating grade "G" in year "T." PQ_T = Proportion of children in stunting reduction programs who receive mental stimulation such as tutoring. $PS_{2+,A,T}$ = Prevalence of stunting of any severity in age group "A" in year "T." K63 = Ratio of mentally impaired persons (CMI+PMI) to cretins. K10 = Relative first grade repeat rate by stunted children. K67 = Relative first grade repeat rate associated with iodine deficiency. K11 = Relative repeat rate in grades 2-6 associated with stunting. K68 = Relative repeat rate in grades 2-6 associated with iodine deficiency. K84 = Overall first grade repeat rate in base year and other years. K85 = Overall repeat rate in grades 2-6 in base year and in other years. K100 = Proportion of 6 year olds enrolled in school in base year and other years. K101 = Proportion of children aged 7-11 years enrolled in school in base year and other years. MAX(a,b) = Maximum of "a" or "b."

27. Estimating malnutrition days to generate one clinic visit. Based on data from Stanton and Clemens (1989), assume that the number of malnutrition clinic visits in the base year (1990) in Bangladesh equals 11/23 of the number of diarrhea clinic visits in the base year, as given in equation [1].

[1] $(11/23) \cdot {}^{d}S_{U5,0} \cdot POP_{U5,0} / K95 = {}^{m}S_{U5,0} \cdot POP_{U5,0} / K96.$

Then, $K96 = {}^{d}S_{U5,0} \cdot K95 / ({}^{m}S_{U5,0} \cdot (11/23))$
$= 29.4 \cdot 53.3 / 134.4 \cdot (11/23) = 509.1$ days.

Where: ${}^{m}S_{U5,0}$ = Average days per year per U5 child in a state of moderate or severe undernutrition in base year $= (PU_{2,U5,0} + PU_{4,U5,0}) \cdot 365 = (0.30 +).068) \cdot 365 = 134.3$ days/year/child. ${}^{d}S_{U5,0}$ = Average days per year per U5 child sick with diarrhea in base year. $PU_{2,U5,0}$ = Prevalence of moderate underweight in U5 children in base year. $PU_{4,U5,0}$ = Prevalence of severe underweight in U5 children in base year. K95 = Average days sick with diarrhea to generate one clinic visit. K96 = Average days of moderate or severe underweight to generate one clinic visit.

28. Market value of breastmilk in 1990. Table E-2 assumes 1990 populations of 3.0, 1.9, 4.6, and 4.5 million in age groups 0-5, 6-11, 12-23 and 24-36 months respectively, with 16% of the children residing in urban areas, and the prevalence of full and partial breastfeeding of urban children equal to 90% of rural children. Assuming a market value for breastmilk of 10 Taka per liter in rural areas, 30 Taka per liter in urban areas, and an exchange rate of 38.6 Taka per dollar, the market value of all breastmilk produced in Bangladesh in 1990 is estimated to be $189 million in urban areas, $374 million in rural areas, and $563 throughout the country.

29. Study of effect of anemia on productivity. The Levin *et al* (1993) conclusion appears to be based primarily on a study by Basta *et al* (1979). Although Behrman (1992) notes several methodological weaknesses in the Basta *et al* study (including, possible selective bias in dropouts, increased food intake due to higher income from participation stipend, and importance of piece-work pay), he nevertheless agrees the effect was substantial.

30. Anemic to non-anemic productivity ratio in Bangladesh. The 1989-90 National Nutrition Survey for Bangladesh (BBS, 1991) reports the following distribution of Hgb levels in men and women in Bangladesh.

END-TABLE 30.1: Distribution of Hemoglobin (Hgb) Levels in Bangladesh, 1989

Population Group	Adequate Hgb	Above 13	13-12	12-11	11-10	Below 10
Men	13	40%	20%	20%	20%	
Women non-pregnant	12	26%		30%	24%	20%

The prevalence of anemic men (Hgb < 13) equals 20% + 20% + 20% = 60%. The prevalence of anemic women equals 30% + 24% + 20% = 74%. In order to estimate the average decrement of anemic men and women below their respective standards, assume that samples in the above distributions are centered at the midpoint of each range (e.g., the 20% of the men with Hgb between 12-13 average 12.5; men with Hgb below 11 average 10.5). Then the average Hgb values are:

Anemic Men = (12.5*0.20 + 11.5*0.20 + 10.5*0.20)/(0.60) = 11.50.
Anemic Women = (11.5*.30 + 10.5*.24 + 9.5*.20)/(0.74) = 10.635.

Then using the results reported by Levin *et al* (1993), the average loss in productivity in anemic men and women in Bangladesh is:

Average Loss (Men) = (1.5)*(13-11.5)/(11.5) = 0.1945.
Average Loss (Women) = (1.5)*(12-10.635)/(10.635) = 0.1925.

The average productivity of anemic workers relative to non-anemic workers = (Anemic productivity)/(Non-anemic productivity) = (1-0.1945)/(1) = 0.804 for men, and = (1-0.1925)/(1) = 0.807 for women. Because these figures are so close and the rural anemic workforce contains slightly more anemic males than females, the default value of K73 is estimated to be 0.805.

31. Default for production of anemic and non-anemic workers. There appears to be substantial variation in the figures reported for Gross Domestic Product (GDP) and Gross Domestic Agricultural Product (GDAP) for 1989 and 1990. The 1991 World Development Report (World Bank, 1991) reports that in 1989, GDP was $20,240 million with 44% from agriculture (p 208, Table 3), resulting in GDAP for 1989 of $8,906 million. The 1992 World Development Report (World Bank, 1992) reports that in 1990, GDP was $22,280 million but the percent from agriculture was only 38%, resulting in GDAP for 1990 of $8,466 million. In its Bangladesh application, PROFILES 2.0 uses the 1990 estimate of $8,466 million as the default value for K110, the base year GDAP.

$POP_{15\text{-}64,A,1990}$ = 51,423 million according to the UN median population projections. The size of the potential agricultural labor force in 1990 is this figure times K98*K99, whose default value was based on 1990. Thus the potential agricultural labor force equals $POP_{15\text{-}64,A,1990}$*K98*K99 = (51,423 million)*(0.84)*(0.70) = 30.1 million persons. The contribution to GDP (productivity) by all agricultural workers = $8,466/30.1 = $281 per year.

To allocate this figure to anemic and non-anemic workers, first estimate the prevalence of anemic workers. Recall that 60% of the men and 74% of the non-pregnant women are anemic. In 1989, 56.76% of the rural labor force was male, and 43.24% female (BBS, 1992, p 101, Table 4.09). Thus, anemic men accounted for 56.76%*60% = 34% and anemic women 43.24%*74% = 32% of the rural labor force, with anemic persons accounting for 34% + 32% = 66% of the rural labor force in 1989. Then the average contribution to GDAP from

all workers equals the weighted (by prevalence) average contributions from anemic and non-anemic workers as follows:

$$\$281 = (0.66)*(K74) + (0.34)*(08.5)*(K74)$$

$$K74 = \$281 \text{ per year.}$$

(Note that this figure attributes the entire increase in production to labor, and assumes the same amount of unemployment as in the base year.)

32. Rural adults working in agriculture. The proportion of rural adults working in agriculture is the product of the Rural Labor Force Participation Rate (K98) and the fraction of Employed Rural Persons in Agriculture (K99). In 1989, the rural labor force participation rate for males aged 15-64 was 92.1% and for females aged 15-64 was 75.2% (BBS, 1992, p 100, Table 4.07). Assuming equal participation by males and females, K98 for all adults equals (92.1% + 75.2%)/2 = 83.65%. A default value of 0.84 is used for K98. The fraction of employed rural persons in agriculture in 1989 was 0.70 (BBS, 1992, p 101, Table 4.10), which is used as the default value for K99.

33. Computation of g(a), the lifetime discounting factor. The lifetime discounting factor (g(a)) is computed with equation [1].

[1] $$g(a) = (G1_{K114-a} * G2_{K114/a}) + (G1_{K114+1-a} * G2_{K114+1/a}) + \ldots + (G1_{K115-a} * G2_{K115/a}).$$

Where: $G1_n$ = Present worth of $1.00 generated "n" years in the future, assuming an annual discount rate of K113. $G2_{x/a}$ = Probability that a person who is "a" years old will survive to "x" years of age. a = Age of disabling nutritional event. K114 = Age at which people enter the workforce, on average. K115 = Age at which people exit from the workforce, on average.

34. Percentage adult height deficits from childhood stunting. Burger *et al* (1990) estimate that height deficits for severe and moderate stunted Indonesian children at 22 months of age are 10 cm and 7 cm respectively, and that the average Indonesian male is 160 cm in height. The default estimates for adult percentage height deficits were obtained by dividing 160 into 10, 7 and 5, producing 6.25%, 4.375% and 3.125%.

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ANNEX A
Nutritional Indicators in The Consequence Functions

Consequence Functions	Nutritional Indicators											
	A	B	C	D	E	F	G	H	I	J	K	L
Mortality												
Stillbirths	•								•		•	
Neonatal	•				•				•		•	
1-5 months		•					•	•				
6-59 months		•					•	•				
Fertility												
Total fertility rate						•						
Morbidity												
Diarrhea, neonatal	•				•						•	
Diarrhea, 1-11 mths		•					•	•				
Diarrhea, 12-59 mths		•						•				
Resp.Inf., neonatal	•				•						•	
Resp.Inf., 1-11 mths		•					•					
Resp.Inf., 12-59 mths		•										
Vision												
Blind, new cases								•				
Blind, 0-59 mths								•				
Blind, school age								•				
Intellectual												
Cretins born/alive									•			
Mentally impaired									•			
IQ points deficit									•			
School repeaters				•					•			

KEY: "A" = Birth weight. "B" = Weight-for-age (underweight). "C" = Height-for-age (stunting) at 2 years. "D" = Height-for-age (stunting) at 6-10 years. "E" = Initiate breastfeeding. "F" = Duration of breastfeeding. "G" = Feeding mode 0-35 months. "H" = Vitamin A status. "I" = Goiter in pregnant women. "J" = Iodine deficiency in livestock. "K" = Iron status in pregnant women. "L" = Iron status in adult rural labor force.

- Continued -

Nutritional Indicators in The Consequence Functions - Continued

Consequence Functions	Nutritional Indicators											
	A	B	C	D	E	F	G	H	I	J	K	L
Productivity												
Current agric. labor												•
Future lost wages			•					•	•			
Future lost workers	•	•			•		•	•	•		•	
Breastmilk lost							•					
Livestock production										•		
Lost fertility replace						•						
Government Expenditures												
Health expenses	•	•			•	•	•	•	•		•	
School expenses				•					•			

KEY: "A" = Birth weight. "B" = Weight-for-age (underweight). "C" = Height-for-age (stunting) at 2 years. "D" = Height-for-age (stunting) at 6-10 years. "E" = Initiate breastfeeding. "F" = Duration of breastfeeding. "G" = Feeding mode 0-35 months. "H" = Vitamin A status. "I" = Goiter in pregnant women. "J" = Iodine deficiency in livestock. "K" = Iron status in pregnant women. "L" = Iron status in adult rural labor force.

ANNEX B
DATA FORM - PROFILES 2.0 PROGRAM DESCRIPTION

1. **PROGRAM NAME:**

2. **PRIMARY TARGET:** *Line (a) below specifies the primary population group the program will target; line (b) specifies the primary nutritional problem and its indicator that the program will target (see list of indicators in item 4 below); and line (c) specifies the maximum improvement that the program will make in the primary indicator in the primary population group in the persons it covers. The maximum improvement is in terms of the maximum percentage reduction in the prevalence of the problem in the persons covered.*

   (a) primary group:

   (b) primary indicator:

   (c) maximum impact:

3. **COVERAGE and EFFECTIVENESS:** *The table below specifies, for each calendar year of the program, the coverage that the program is estimated to achieve during the year, and the effectiveness of the program in reducing the prevalence of the primary nutrition problem in the persons covered during the year. Coverage refers to national coverage in the primary target group. Effectiveness is defined as the percentage of the maximum impact specified in item 2(c) above. Coverage multiplied by effectiveness gives the overall reduction in the national prevalence of the primary nutritional problem in the primary target group in that year. Note that the first year is the base year and that effectiveness data is estimated beyond the life of the program funding to allow PROFILES to make projections for 30 years.*

	Base Yr									
YEAR										
Coverage										
Effectiveness										
YEAR										
Coverage										
Effectiveness										
YEAR										
Coverage										
Effectiveness										

4. **MAXIMUM REDUCTION in ALL INDICATORS.** *The table below gives the maximum reduction in all the different indicators for each relevant age group, some of which may be merged. Inapplicable cells are shaded. "Resid" means PROFILES automatically calculates the difference between 1.0 and the sum of the prevalences in the remaining severity levels and puts in this cell. The figures in this table parallel the maximum impact on the primary problem and population group specified in item #2(c) above. PROFILES assumes that the coverage and effectiveness schedules given in item #3 above are the same for each of the indicators and groups noted here; the only difference is the ratio of the maximum impact figures. (Cases where the project influences only a subset of a population group are accomodated by adjusting the maximum impact in the table below.)*

MAXIMUM REDUCTION IN PREVALENCE

Nutritional Indicator		Population Group									
		Girls	First month	1-5 mths	6-11 mths	12-23 mths	24-59 mths	School	Pregn.	Adult Women	Other
PEM											
Weight for-Age	Normal		Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid
	Mild										
	Modrate										
	Severe										
Height for-Age (Stunt -ing)	Normal		Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid
	Mild										
	Modrate										
	Severe										
Tutor PEM child	Yes										
	No		Resid	Resid	Resid	Resid	Resid	Resid			
Maternal Malnutrition/Birthweight											
Birthwt	Normal	Resid									
	Low										
Breastfeeding											
Initiate BF	Yes	Resid									
	No										
Feed Mode	Full BF		Resid	Resid							
	Partial				Resid	Resid	Resid				
	No BF										
Vitamin A deficiency											
Serum Retinol (ug/dL)	10 +	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid
	Undr 10										
Iodine deficiency											
Goiter	No	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid
	Yes										
Animal Iodine Defic.	No										
	Yes										Resid
Iron deficiency anemia											
Hemo-globin	Normal	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid	Resid
	Low										

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5. **PROJECT COSTS**: *Section (a) below specifies the one-time startup costs by year in the first few years of the program; section (b) specifies the average annual recurring cost per person covered; and section (c) specifies the expansion cost to add one additional person to the coverage. Both annual recurring cost and expansion costs are given as the average over the life of the project. The average annual recurring cost per person multiplied by the number of persons covered in a year equals the total recurring costs to operate the program that year. Expansion costs occur only once for each person added to program coverage, and the total expansion costs in a year equal the average expansion cost per person multiplied by the net increase in number of persons covered during that year. All costs are given in current U.S. dollars.*

(a) One-Time Startup Costs: *Costs begin in the first year of the project, not the base year.*

YEAR	Base Yr					
Startup Costs	0					

(b) Average Annual Recurring Cost Per Person Covered Over Life of Project: [ ]

(c) Average Expansion Cost to Add One More Person to Coverage: [ ]

(d) ALTERNATIVE Annual Recurring and Expansion Costs. *PROFILES 2.0 allows annual recurring costs per person covered and expansion cost per person added to coverage to be given as a function of the coverage, instead of an average cost over all coverage levels for the life of the program as given in items 5b and 5c above. If this section (5d) is completed, sections 5b and 5c should not be completed.*

	Program Coverage				
	0-10%	10-20%	20-30%	30-40%	40-50%
Annual Recurring Cost					
Expansion Cost					
	50-60%	60-70%	70-80%	80-90%	90-100%
Annual Recurring Cost					
Expansion Cost					