

MAIN: A Model for Assessing the Impact of Nutritional Interventions to Reduce Deficiencies of Vitamin A, Iron, and Zinc



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Significant sections of populations in developing countries suffer from micronutrient malnutrition, especially children, and pregnant and lactating women (WHO 2008). This type of malnutrition results from insufficient intake of vitamins and minerals such as iron, iodine, and zinc. Interventions to reduce this problem include food supplements and industrial fortification programs (Allen, 2003). More recently, biofortification—the breeding of staple food crops with higher micronutrient contents—was proposed and evaluated on a preliminary basis as a cost-effective complementary strategy for addressing micronutrient malnutrition in developing countries (Nestel et al. 2006; Qaim et al. 2007).

When analyzing the impact of the nutritional intervention it is necessary to quantify and to value “health” to be able, for instance, to compare public health improvements achieved through biofortification with those achieved through other interventions such as fortification or pharmaceutical supplementation. Moreover, quantification of “health impacts” is necessary to contrast potential health benefits of the nutritional intervention with the related research and development (R&D) costs incurred.

The major conceptual issue is how to measure health. The World Health Organization (WHO) and the World Bank have increasingly measured health—or rather its inverse, disease burden—in terms of “disability-adjusted life years” (DALYs) (Stein et al. 2005).

Calculating DALYs is tedious. Hence, it would be useful to rely on software that can easily work

them out once the required data are entered. The **MAIN (Model for Assessing the Impact of Nutritional Interventions)** is a user-friendly system for the empirical estimation of the DALYs framework. It is used to evaluate the potential benefits and costs of developing the nutritional intervention to reduce deficiencies of vitamin A, iron, and/or zinc. The model was developed in Visual Basic® for Applications (VBA), coded in Microsoft® Excel 2000. It currently relies on three worksheets and a combination of menus and submenus that allows the user to easily and simply evaluate independently the potential impact on human health of food consumption to have higher micronutrient contents, which beta-carotene (precursors of vitamin A), iron, or zinc.

The menus also have options for entering and correcting the different parameters needed, such as populations in the age groups of interest, mortality rates, prevalence, incidence rates, duration and disability weights of temporary and permanent disabilities, life expectancy, and discount rates. Other options include the definition (or elimination) of scenarios for sensitivity analysis, management of investments for developing new technology, and calculation of economic indicators such as the internal rate of return (IRR).

The concept of Disability-Adjusted Life Years (DALYs) is relatively underutilized in the economics literature as a metric for welfare. It is used to measure the potential health benefits of a nutritional intervention. The benefits can be quantified directly using DALYs saved¹, and costs per DALY saved offer a consistent way of ranking a range of alternative health interventions.

Benefits or DALYs saved are calculated by using a scenarios approach in which the health consequences of micronutrient deficiencies are quantified. This approach was developed by Murray and López (1996) and is promoted by WHO and the World Bank as a way of combining information on mortality and morbidity into one index:

$$DALY_{\text{lost}} = YLL + YLD_{\text{temp}} + YLD_{\text{perm}}$$

where,

YLL = number of years of life lost due to mortality

YLD_{temp} = number of years of life with temporary disability

YLD_{perm} = number of years of life with permanent disability

Zimmerman and Qaim (2004) adapted the general DALYs framework to evaluate the impact of vitamin-A-rich “Golden Rice”. They identified and quantified the specific health outcomes related to vitamin A deficiency in target populations. Given that their study required focusing on different groups of interest such as children, women, and men, the DALYs formula was rewritten as follows:

1. Differences between DALY values with nutritional interventions and those without.

$$DALYS_{lost} = \sum_j T_j M_j \left(\frac{1 - e^{-rL_j}}{r} \right) + \sum_i \sum_j T_j I_{ij} D_{ij} \left(\frac{1 - e^{-rd_{ij}}}{r} \right) + \sum_k \sum_j T_j I_{kj} D_{kj} \left(\frac{1 - e^{-rL_j}}{r} \right)$$

where,

- T_j = total number of persons in target group j
- M_j = mortality rate associated with micronutrient deficiency in group j
- L_j = average remaining life expectancy for group j
- I_{ij} = incidence rate of temporary illness i in group j
- D_{ij}, D_{kj} = disability weights
- d_{ij} = duration of illness i in group j
- I_{kj} = incidence rate of permanent illness k in group j
- r = discount rate for future costs

A monetary value is thus attributed to the DALYs saved, which otherwise would have been lost in a scenario without intervention. This benefit is then compared with the costs involved in developing new technology (e.g. biofortified crop, industrial fortification). By comparing this cost with the flow of benefits (monetary value of DALYs saved) we can generate economic indicators useful for evaluation such as the internal rate of return (IRR) and the benefit-cost ratio (B/C ratio).

A monetary value is attributed to the DALYs saved, DALYs that otherwise should be lost in a scenario without intervention in population with micronutrient-deficient diets. This benefit is then compared with the costs involved in developing new technology. The comparison of this cost with the flow of benefits (DALYs saved) allow us to generate

The model incorporates other methodological concepts. These are “adoption rate” and “disadoption”.

Adoption Rate

On release, a new technology is first adopted slowly, becoming progressively accepted by potential users until a point of maximum adoption is reached. The logistic function was used to simulate this process.

Assuming the rate of adoption of the new technology is A , and that its adoption obeys a logistic function of the type:

$$A_t = \frac{C}{1 + e^{\alpha + \beta t}}$$

where

- A_t = adoption rate over period t
- C = rate of coverage of the technology (asymptote)
- α and β = parameters
- t = time

To estimate the value of the adoption rate in every period t , using the previous logistic function, we must know:

- a. How much the new technology will be used by farmers and to what extent it will be available in the markets of consumers. This value constitutes the asymptote of the function and represents the rate of coverage or the maximum possible value of adoption.
- b. The percentage of the adoption rates A_1 and A_2 corresponding to periods t_1 and t_2 located in any place on the curve.

With this information, parameters a and β of the logistic function can be estimated according to the following formulas:

$$\beta = \frac{\text{logit}(A_2) - \text{logit}(A_1)}{t_2 - t_1}$$

$$\alpha = \text{logit} (A_1) - \beta$$

$$\text{logit} (A_1) = \ln \left[\frac{(A_1)/100}{1 - (A_1)/100} \right]$$

On knowing the values for C, α , and β , the logistic function is fully defined.

Disadoption

Taking into account that, in addition to a new technology being adopted by consumers, it can likewise be abandoned or replaced with other new technologies that enter the market. Such elimination behavior constitutes disadoption.

Figure 1 outlines a hypothetical process that lasts 20 years, and comprises different stages: research and development, adoption, stabilization, and disadoption.

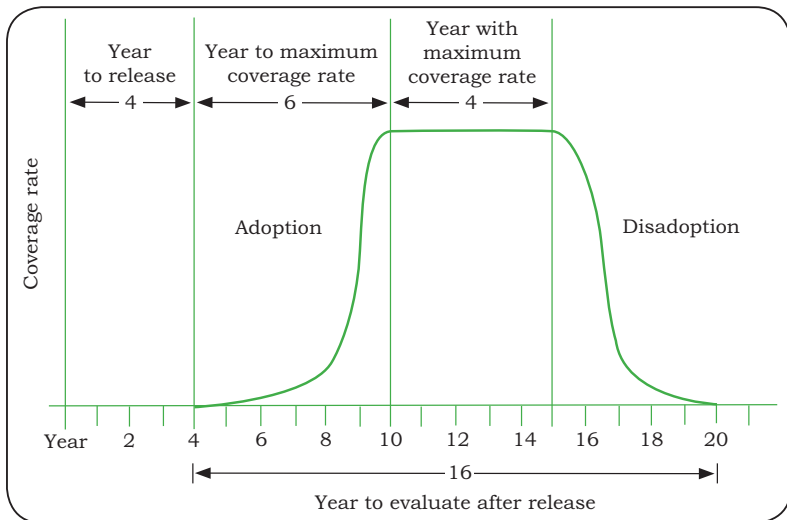


Figure 1. Schematic presentation of a new technology's adoption process.

For easy operation, the model has an interface of menus available to users. To guarantee correct operation, users first need to perform the following:

- a. To ensure that the security level selected in Excel is at **Medium**, the user selects the menu option **Tools**, and then **Macro** and **Security...** In the displayed window, the user selects the tab **Security Level** to verify that the option **Medium** is selected.
- b. On file Excel opening the user will see a message box in which three available options are presented (Figure 2). The option **Enable Macros** is then selected.



Figure 2. Ensuring security by using macros.

- c. Once the message box with the respective credits (Figure 3) is displayed, the user enters the model by selecting the option **OK**.

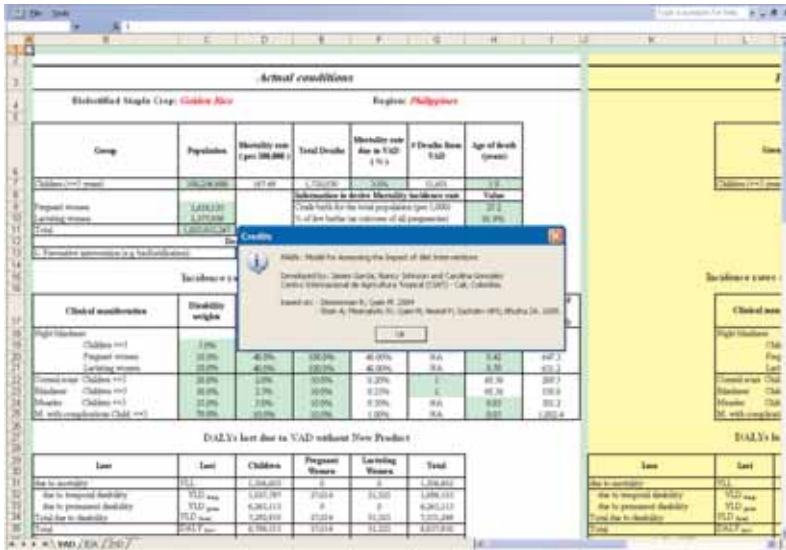


Figure 3. Credits.

On entering the model, the user will see three worksheets, each containing a spreadsheet, entitled as follows: **VAD**, for the analysis of interventions with vitamin A; **IDA** for the analysis of interventions with iron; and **ZnD** for the analysis of interventions with zinc (bottom red box in Figure 4). (The acronyms themselves refer to vitamin A deficiency [VAD], iron-deficiency anemia [IDA], and zinc deficiency [ZnD]).

Likewise, the model displays, in its left upper corner, the main menu made up of four options: **VAD Menu**, **IDA Menu**, **Zinc Menu**, and **End** (top red box in Figure 4). Each option gives access to another menu of options, which is described in the next section.

Each spreadsheet lists the diseases or clinical manifestations that can be attributed to the existence of deficiency of the micronutrient being analyzed. Likewise, vulnerable population groups within the

Actual conditions

Biofortified Staple Crop: Golden Rice **Region: Philippines**

Group	Population	Mortality rate (per 100,000)	Total Deaths	Mortality rate due to VAD (%)	# Deaths from VAD	Age of death (years)
Children (<=6 years)	106,126,680	187.40	1,700,000	3.0%	51,000	1.0
Pregnant women	5,811,151					
Lactating women	5,872,238					
Total	1,027,111,247					

Intervention to decrease Mortality incidence

Value	
Crude birth for the total population (per 1,000)	27.2
% of live births (as outcome of all pregnancies)	94.9%
Mortality rate Children(<=6) (per 1,000 live births)	327.0

Deaths preventable through

1. Immediate intervention (e.g. biofortification)	2.0%	2. Treatment intervention (e.g. supplementation)	1.0%
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Incidence rates and number of people affected by VAD

Class of manifestation	Disability weights	Overall Incidence rate (%)	% due to VAD	Incidence rate due to VAD (%)	Age of onset	Duration of disease (years)	Number of affected (thousands)
Blind blindness							
Children <=6	5.0%	20.0%	100.0%	20.00%	NA	1.00	20,047.3
Pregnant women	10.0%	40.0%	100.0%	40.00%	NA	0.42	647.3
Lactating women	10.0%	40.0%	100.0%	40.00%	NA	0.50	631.2
Concealed vision							
Children <=6	20.0%	2.0%	10.0%	0.20%	1	08.56	200.5
Blindness							
Children <=6	50.0%	2.5%	10.0%	0.37%	1	08.56	350.0
Deafness							
Children <=6	37.0%	1.0%	10.0%	0.36%	NA	0.03	561.2

Figure 4. Independent spreadsheets for analyzing biofortification with vitamin A, iron, and zinc.

population are identified according to age and sex. The three micronutrient deficiency menus present similar options. These are **Parameters**, **Supply**, **Efficacy**, **Scenarios**, and **IRR** (i.e., internal rate of return.)

The “VAD Menu”

This menu presents options to facilitate the analysis corresponding to biofortification with vitamin A (Figure 5).

Parameters

This submenu gives access to 12 options that define the different values needed for the model’s calculations; in other words, this is the information that the user must compile and enter into the program. These are:

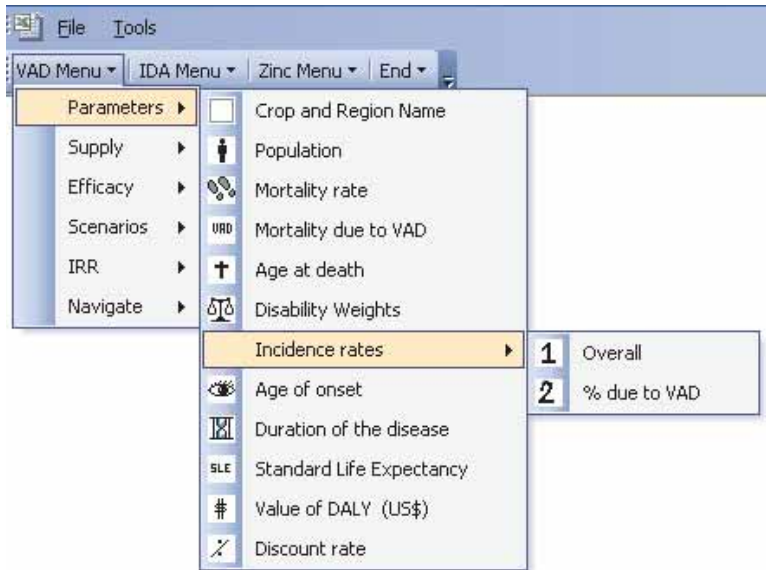


Figure 5. The “VAD Menu”.

1. **Intervention and region names:** Requests the names of the diet intervention (e.g. biofortified crop, food fortification, others) and the target region where the effects of this intervention are to be evaluated.
2. **Population:** Requests information on the number of persons in each target group at risk:
 - Children aged ≤ 5 years
 - Pregnant women
 - Lactating women
 - Total target population in the study
3. **Mortality rate:** This parameter is calculated internally by the model when the following information is provided:

- Crude birth for the total population per 1000
 - Percentage of live births as an outcome of all pregnancies
 - Mortality rate for children aged ≤ 5 years per 1000 live births.
4. **Mortality from VAD²:** This option requests values for the following parameters
 - Mortality rate (%) from VAD for children aged ≤ 5 years
 - Deaths preventable (%) through preventive intervention
 - Deaths preventable (%) through treatment intervention
 5. **Age at death:** Average age at death in children aged ≤ 5 years
 6. **Disability weights³:** Requests information on the weighted value (%) assigned to the disability caused by vitamin A deficiency (VAD) for each clinical manifestation in the different groups at risk, namely, where 0 (zero) implies no disability and 1 (one) implies total and permanent disability or death:
 - Night blindness for children aged ≤ 5 years (%)
 - Night blindness for pregnant women (%)
 - Night blindness for lactating women (%)
 - Corneal scars for children aged ≤ 5 years (%)

-
2. If values are unavailable, then used those described in Stein et al. 2005.
 3. This type of data can be found on the World Health Organization's (WHO) Web page, specifically in Health statistics and health information systems at <http://www.who.int/healthinfo/bod/en/index.html>.

- Blindness for children aged ≤5 years (%)
- Measles for children aged ≤5 years (%)
- Measles with complications for children aged ≤5 years (%)

7. **Incidence rates:** Incidence is defined as the number of new cases of a disease that develop in a population over a given period (Tapia G 1994). The incidence rate or incidence density is calculated by dividing the incidence value by the sum of individual observation times.

Because this type of information can be very difficult to obtain, if prevalence data are available, they can be used to approximate incidence rates using the formula:

$$DI = \frac{P}{D}$$

where,

P = prevalence

DI = density or incidence rate

D = average time of duration of the disease.

Prevalence quantifies the proportion of individuals of a population who suffer from a disease at a given time or over a given period (Tapia G 1995).

The model requests the global incidence rate and the part attributable to vitamin A deficiency for each clinical manifestation in the different groups at risk (*see the corresponding list under Disability weights*).

- **Overall:** This option requests information on incidence rates for each clinical manifestation in each group at risk, independent of the cause.
- **% due to VAD:** Requests information on what part of the incidence of each clinical manifestation for each group at risk is attributable to vitamin A deficiency.

8. **Age of onset:** This information defines the average age at which the disease or its clinical manifestation is presented:
 - Corneal scars for children aged ≤ 5 years
 - Blindness for children aged ≤ 5 years
9. **Duration of disease:** Average duration of the disease or clinical manifestation presented in each group at risk.
 - Night blindness for children aged ≤ 5 years
 - Night blindness for pregnant women
 - Night blindness for lactating women
 - Measles for children aged ≤ 5 years
 - Measles with complications for children aged ≤ 5 years.
10. **Standard life expectancy (SLE):** Standard life expectancy for children aged ≤ 5 years. Information on the average remaining life expectancy for different gender and age groups is available from standard life tables (e.g., WHO).
11. **DALY value:** To calculate different economic indicators, a value must be assigned, indicating the quantity of money attributable to one disability-adjusted life year (DALY). The gross domestic product (GDP) per capita of the country or region to which the study corresponds can be used. But if the study involves several countries or regions with independent economies, a value that facilitates or permits comparisons is recommended.
12. **Discount rate:** Requests the annual discount rate, which will be used to calculate the present value of future flows. From the economic viewpoint, the **discount rate** is the process of reducing the interest rate of a given capital to find

the current value of that capital when it is payable in the future. This same concept is used here to give current value to the DALYs generated through time.

- *Discount rate for DALYs:* Given that a lost DALY will have less value to the extent that it is distant from current time, we need a value that assigns a weight to DALYs lost at different ages. In the literature, it seems reasonable to use a value of 3%—which signifies a year (12 months) of healthy life today—is considered to be equivalent, in the future, to 6 months at 23.5 years and 3 months at 47 years

$$\text{equivalent_months} = \frac{12 \text{ months}}{(1+3\%)^{\text{future_age}}}$$

However, a zero discount rate can be used in the sensitivity analysis as other possible scenario.

- *Discount rate for flow of economic values (\$):* The interest value through which the current value of the future cash flows is calculated.

Supply

1. **Food intake:** Requests the estimated daily average amount consumed (g/day) of the food being studied by one individual from each group at risk.
2. **Current VA supply:** Requests the estimated average quantity of vitamin A (µg/day) in retinol equivalents provided by the food (diet intervention as biofortified crop, fortified food, etc.) currently ingested by one person from each group at risk.

3. **RDA:** This refers to the recommended dietary allowance⁴ and requests the amount of vitamin A ($\mu\text{g}/\text{day}$) required or recommended for the human body's good functioning for individuals from each group at risk. Although the Food and Nutrition Board of the U.S. National Academy of Sciences has established other indicators such as dietary reference intakes (DRIs) to serve as reference for nutrient needs, the RDA is one of four DRI indicators that aim to establish the minimum intake needed to prevent diseases caused by deficiency. The other three types of DRI values are: EAR⁵ (Estimated Average Requirement), AI (Adequate Intake), and UL (Tolerable Upper Intake Level). Any of those intake measures could be used in MAIN.

Efficacy

Because this is an unknown parameter, different scenarios (Optimistic, Pessimistic, and others) can be proposed. This information is provided for calculating

4. This type of data can be obtained from the home pages of, for example, the International Food Information Council Foundation at <http://ific.org/publications/otherdriupdateom.cfm?renderforprint=1> and the Food and Nutrition Information Center at http://fnic.nal.usda.gov/nal_display/index.php?info_center=4&tax_level=1.
5. "The EAR is at the midpoint, where 50 percent of the population would meet the end-point criterion. The RDA, calculated as two standard deviations above the EAR, is the intake level at which, theoretically, 97.5 percent of the population would meet that end-point criterion. AIs are set when data are insufficient to establish an EAR. The AI for a nutrient is a recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people and is assumed to be adequate." http://www.nal.usda.gov/fnic/DRI/DRI_Research_Synthesis/Ch1_5-14.pdf?debugMode=false

the degree of effectiveness with which the diet intervention will reduce vitamin A deficiency. In other words, efficacy refers to the proportion of the current total deficiency that is eliminated by the extra quantity of vitamin A obtained from the diet intervention (e.g. biofortified crop, fortified product, etc.).

1. Pessimistic
2. Optimistic

As for any other possibility, the information required for both of these scenarios is the following:

- The additional amount of beta-carotene ($\mu\text{g/g}$) that is expected to be incorporated into the new diet intervention
- The conversion factor beta-carotene to vitamin A, that is, the number of units of beta-carotene that the human body must absorb to produce one unit of retinol.
- Estimated percentage of losses in beta-carotene content generated between elaboration (or harvest for crops) and consumption of the food from factors such as postharvest handling, storage, exposure to temperature changes, and cooking
- Technology coverage rate: Estimated percentage of actual crop production that is expected to be substituted by the use of the new technology (e.g. food fortified, biofortified crop). It is equivalent to the maximum possible value of adoption..

Scenarios

1. **New scenario:** This function creates up to a maximum of 7 new scenarios, requesting, for each, information needed to calculate efficacy, as mentioned above.

2. **Delete scenario:** This function deletes the scenario that is not of interest. Hence, it requests the scenario's number to be deleted. This number should be more than 2, inasmuch as the numbers 1 and 2 are already assigned to the scenarios Optimistic and Pessimistic, respectively.

IRR (Internal rate of return)

This option permits analysis of economic benefits through indicators such as the IRR and the benefit-cost ratio (B/C ratio).

1. **Investments:** Requests data on costs incurred for research, development, dissemination, and maintenance of the new technology (biofortified crop, food fortified, etc). When this option is used, the model requests the following data:
 - Number of years of research and development that the new technology needed (Figure 1)
 - Number of years after release that the new technology needed to reach the maximum rate of coverage or adoption expected
 - Number of total years needed for economic evaluation (the evaluation period begins at zero and includes the years needed for research, development, and maintenance)
 - An indicator that signals when the analysis becomes a process of release of a new technology with a disadoption phase or stage (1 = indicates process with disadoption; 0 = indicates process without disadoption)
 - Number of years of consolidation of use of the technology during which a maximum rate of coverage (or adoption) is maintained before the phase of disadoption starts

- Value of the costs incurred in each period (year) for research, testing, development, dissemination, maintenance, and monitoring of the new technology (nutritional intervention as biofortified crop or food fortified)
- 2. **IRR calculate:** This option calculates the IRR and B/C ratio for all proposed scenarios, with results displayed in a summary table entitled, “Impact of parameter variations on results”.
- 3. **Technology depreciation:** Refers to the speed, from one year to the next, at which the magnitude of benefits from biofortification diminishes as a consequence of dilution or genetic loss of the improved trait. In practice, this situation should be corrected by incorporating fresh new material to the seed market. If the technology refers to a type of food other than a biofortified crop, the value may be considered as “zero” for this parameter. Or, a value can be used to represent the rejection that the product may be exposed to on the market where it comes into competition with substitute products.

The “IDA Menu”

This menu presents options to facilitate the analysis corresponding to biofortification with iron (Figure 6).

Parameters

This submenu gives access to 9 options that define the different values needed for the model’s calculations:

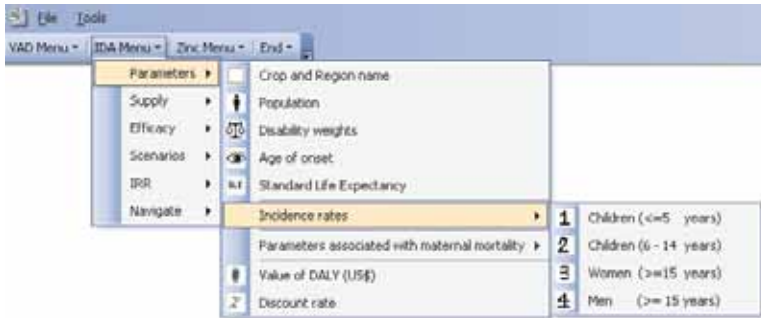


Figure 6. The “IDA Menu”

1. **Crop and region names:** Requests the names of the biofortified crop and the region where the effects of biofortified crop are to be evaluated.
2. **Population:** Requests information on the population in each group at risk:
 - Children aged ≤ 5 years
 - Children aged 6–14 years
 - Women aged ≥ 15 years
 - Men aged ≥ 15 years.
3. **Disability weights:** Requests information on the weighted value (%) assigned to the disability caused by iron-deficiency anemia (IDA) for each clinical manifestation in the different groups at risk, where 0 (zero) implies no disability and 1 (one) implies total and permanent disability or death:
 - Impaired physical activity (moderate, severe) for children
 - Impaired mental development (moderate, severe) for children
 - Impaired physical activity (moderate, severe) for adults.

4. **Age of onset:** Defines the average age at which the disease or its clinical manifestation is present in each group at risk:
 - Impaired physical activity (moderate, severe) for children aged ≤ 5 years
 - Impaired physical activity (moderate, severe) for children aged 6–14 years
 - Impaired mental development (moderate, severe) for children aged ≤ 5 years
 - Impaired physical activity (moderate, severe) for adults.

5. **Standard life expectancy (SLE):** Standard life expectancy at age of onset for:
 - Impaired mental development (moderate, severe) for children aged ≤ 5 years
 - Impaired physical activity (moderate, severe) for women
 - Impaired physical activity (moderate, severe) for men

6. **Incidence rates:** Requests the incidence rate for each clinical manifestation in the different groups at risk:
 - Children aged ≤ 5 years:
 - Impaired physical activity (moderate, severe)
 - Impaired mental development (moderate, severe)
 - Children aged 6–14 years:
 - Impaired physical activity (moderate, severe)
 - Adult women aged ≤ 15 years:
 - Impaired physical activity (moderate, severe)

- Adult men aged ≤ 15 years:
 - Impaired physical activity (moderate, severe).

7. **Parameters associated with maternal mortality:** This function presents the following options:

- *Rates:* Requests values for the following parameters:
 - Number of births per 1000 of total population
 - Percentage of live births as outcome of all pregnancies
 - Maternal deaths per 100,000 live births
 - Percentage of maternal deaths attributable to IDA
 - Stillbirth rate as percentage of maternal mortality from IDA (percent of the pregnancies of women who died during childbirth due to iron deficiency)
 - Child mortality rate per 1000 children aged 0–5 years
 - Prevention of ≤ 5 years deaths by breastfeeding (%)
 - Percentage of ≤ 4 -month-old babies who are exclusively breastfed.

The previous values are needed for the model to calculate the following parameters:

- Maternal mortality rate attributable to IDA
 - Percentage of “surviving infants at risk of death”, stillbirths, and deaths of children aged 0–5 years.
- Age at death:
 - Average age of women at childbirth
 - Average number of stillbirths (for

- stillbirths, the average age of death for the child is 0 years)
- Average age at death of children (aged 0–5 years)
- *Remaining life expectancy (RLE)*: The average remaining life expectancy can be calculated, given the average age of death from each cause for a particular target group.
 - RLE for women at childbirth (assumption: SLE of women at childbirth)
 - RLE for stillbirth (*assumption*: SLE of born alive).
 - RLE for children (aged 0–5 years, *assumption*: SLE of born alive).

Note: For the menu options listed below, see the descriptions given in the “VAD Menu”.

8. DALY value
9. Discount rate

Supply

1. Food intake
2. Current iron supply
3. RDA

Efficacy

1. Pessimistic
2. Optimistic

Scenarios

1. New scenario
2. Delete scenario

IRR (Internal rate of return)

The “Zinc Menu”

This menu presents options to facilitate the analysis corresponding to biofortification with zinc (Figure 7).



Figure 7. The “Zinc Menu”.

Parameters

This submenu gives access to 10 options that define the different values needed for the model’s calculations:

1. **Crop and region names:** Requests the names of the biofortified crop and the region where the effects of the biofortified crop are to be evaluated.
2. **Population:** Requests information on the total population in the study region and each group at risk:
 - Infants (aged 0–12 months)
 - Children aged 1–5 years.

3. **Disability weights:** Requests information on the weighted value (%) assigned to the disability caused by zinc deficiency for each clinical manifestation in the different groups at risk, where 0 (zero) implies no disability and 1 (one) implies total and permanent disability or death.
 - Infants (aged 0–12 months)
 - Diarrhea
 - Pneumonia
 - Stunting
 - Children aged 1–5 years
 - Diarrhea
 - Pneumonia.
4. **Incidence rates:** The model requests the incidence rate for each clinical manifestation in the different groups at risk:
 - Infants (aged 0–12 months):
 - Diarrhea—average number of episodes per infant/year
 - Diarrhea—percentage of all cases attributable to zinc deficiency
 - Pneumonia—average number of episodes per infant/year
 - Pneumonia—percentage of all cases attributable to zinc deficiency
 - Incidence rate of stunting for infants
 - Children aged 1–5 year:
 - Diarrhea—average number of episodes per child/year
 - Diarrhea—percentage of all cases attributable to zinc deficiency
 - Pneumonia—average number of episodes per child/year
 - Pneumonia—percentage of all cases attributable to zinc deficiency.

5. *Duration of the disease*: Defines the average duration of episodes of disease:
 - Infants (aged 0–12 months):
 - Diarrhea (days)
 - Pneumonia (days)
 - Children aged 1–5 years:
 - Diarrhea (days)
 - Pneumonia (days).
 6. *Average age of onset of stunting*: Requests age, in number of months, at which disease is suffered.
 7. *Standard life expectancy (SLE)*: Standard life expectancy at age of onset for:
 - Infants (aged 0–12 months)
 - Children aged 1–5 years.
 8. *Data on mortality rate*: This option requests the following information:
 - Crude births per 1000
 - Percentage of all live births (as output of all pregnancies)
 - Percentage of all deaths attributable to zinc deficiency (infant and child mortality)
 - Mortality rate for infants per 1000 live births
 - Mortality rate for children aged 1–5 years per 1000 live births.
- Note:** For the menu options listed below, see the descriptions given in the “VAD Menu”.
9. DALY value
 10. Discount rate

Supply

1. Food intake
2. Current zinc supply
3. RDA

Efficacy

1. Pessimistic
2. Optimistic

Scenarios

1. New scenario
2. Delete scenario

IRR (Internal rate of return)

The “End” menu

To finish the task, this menu presents two options

Save as ...

Permits saving the file. The user selects the directory where it is to be saved and assigns a name to the file

Exit

It permits leaving Excel without saving file changes.

According to the parameters supplied, MAIN will automatically conduct a great variety of calculations, including those listed below

1. DALYs that are being lost in the current situation because of deficiency of the micronutrient of interest (no counteracting dietary or nutritional intervention) (Figure 8)

DALYs lost due to VAD without New Product

Loss	Lost	Children	Pregnant Women	Lactating Women	Total
due to mortality	YLL	1,506,603	0	0	1,506,603
due to temporal disability	YLD _{temp}	1,027,797	27,014	31,323	1,086,135
due to permanent disability	YLD _{perma}	6,265,113	0	0	6,265,113
Total due to disability	YLD _{total}	7,292,910	27,014	31,323	7,351,248
Total	DALY _{lost}	8,799,513	27,014	31,323	8,857,850
In monetary terms (million US\$)		9,063.5	27.8	32.3	9,123.6

Figure 8. Current DALYs lost to micronutrient deficiency

2. New rates of incidence and the number of people who continue to be affected by micronutrient deficiency, even after intervention (Figure 9).

Incidence rates and number of people affected by IDA

Functional outcomes related to IDA	IDA nivel	Children (<=5 years)		Children (6-14 years)	
		New Incidence rate (%)	New Number of affected (thousand)	New Incidence rate (%)	New Number of affected (thousand)
Impaired physical activity	Moderate	4.392%	6,702.1	1.729%	3,985.7
	Severe	0.517%	788.5	0.089%	205.5
Impaired mental development	Moderate	4.788%	7,306.8		
	Severe	0.563%	859.6		
		Women (>= 15 years)		Men (>= 15 years)	
Impaired physical activity	Moderate	0.211%	651.0	0.117%	387.0
	Severe	0.027%	83.5	0.015%	48.4

Figure 9. New Incidence rates and the number of people affected by the micronutrient deficiency, even after intervention.

- DALYs that continue to be lost to micronutrient deficiency after intervention (Figure 10).

DALYs lost due to Zinc Deficiency with New Product				
Loss	Lost	Infants	Children (1-5 years)	Total
due to mortality	YLL	1,906,249	738,802	2,645,051
due to temporal disability	YLD _{temp}	28,877	80,250	109,127
due to permanent disability	YLD _{perma}	31,734	0	31,734
Total due to disability	YLD _{Total}	60,612	80,250	140,862
Total	DALY _{Lost}	1,966,860	819,052	2,785,913
In monetary terms (million US\$)		2,025.9	843.6	2,869.5

Figure 10. DALYs lost to micronutrient deficiency after intervention

- DALYs saved or potential annual benefits resulting from intervention (Figure 11).

Potential annual benefits of New Product (DALYs saved)					
Gain	Children <= 5	Children 6-14	Women >= 15	Men >= 15	Total
due to reduced mortality	2,779	0	4,356	0	7,135
due to reduced disability	75,499	28,820	9,816	5,584	119,719
Total	78,278	28,820	14,172	5,584	126,854
In monetary terms (million US\$)	80.6	29.7	14.6	5.8	130.7
resulting from reduced mortality					3.0%
resulting from reduced disability					3.2%
The health burden is reduced by	2.9%	6.2%	2.4%	2.4%	3.2%

Figure 11. Potential annual benefits from intervention (DALYs saved)

- Performance of the adoption rate, number of DALYs saved, and the gross and net values (in US\$) of the DALYs saved over the evaluation period after intervention or release of the new technology (Figure 12). Also presented are the values for the IRR and the B/C ratio for the scenario being evaluated.

Returns on project investments , B/C --->			82.6%	72.3
Year	Adoption Rate	DALYs saved	\$US Gain	\$US Net Gain
1	0.00%	0	0	-474,333
2	0.00%	0	0	-474,333
3	0.00%	0	0	-474,333
4	0.00%	2	0	-766,667
5	0.00%	13	13,066	-753,601
6	0.02%	80	82,395	-684,272
7	0.10%	503	518,133	-231,867
8	0.61%	3,108	3,201,719	2,451,719
9	3.42%	17,355	17,875,409	17,125,409
10	12.50%	63,427	65,329,680	64,579,680
11	21.58%	109,499	112,783,951	112,033,951
12	24.39%	123,745	127,457,641	126,707,641
13	24.90%	126,351	130,141,227	129,391,227
14	25.00%	126,854	130,659,360	129,909,360
15	25.00%	126,854	130,659,360	129,909,360

Figure 12. IRR, B/C relation, DALYs saved (number, US\$) and Net Gain for the evaluation period

- Table corresponding to the sensitivity analysis that summarizes, for each proposed scenario, the total value of the DALYs saved, IRR, and B/C ratio (Figure 13).

Impact of parameter variations on results			
Scenario	DALYs saved	IRR (%)	B/C
Pessimistic scenario	126,854	82.6%	72.3
Optimistic scenario	1,014,928	133.5%	578.8
New IDA Scenario 3	609,518	119.7%	347.6
New IDA Scenario 4	812,317	127.3%	463.2
New IDA Scenario 5	939,091	131.3%	535.5
New IDA Scenario 6	858,202	128.8%	489.4
New IDA Scenario 7	772,046	126.0%	440.3
New IDA Scenario 8	815,797	127.5%	465.2
New IDA Scenario 9	680,393	122.6%	388.0

Figure 13. Results of the sensitivity analysis

7. MAIN furthermore calculates other series of values such as:
 - a. Percentage contribution of the intervention towards reducing total deficiency of the micronutrient.
 - b. Efficacy or proportion of the total current deficiency of the micronutrient that is eliminated by the additional quantity of the micronutrient supplied by the intervention.
 - c. Current net value of the investment made to develop the technology.

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