MINIMOD: TOOLS FOR IDENTIFYING EFFECTIVE AND COST-EFFECTIVE MICRONUTRIENT INTERVENTIONS

USAID Advancing Nutrition Webinar
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Steve Vosti and the MINIMOD team
MOTIVATION FOR DEVELOPMENT OF MINIMOD TOOLS

Substantial contribution of micronutrient deficiencies to global burden of disease and excess mortality across LMICs
- Detrimental impacts on health, cognitive development, human capital acquisition, work capacity, productivity → high private and social costs, hindering economic growth

Long-term solution
- Adequate diets for all – this will take time and investments

What to do in the short-term?
- Many options exist -- Fortification of staple foods and condiments, biofortification, supplementation, etc.
- We cannot do everything, everywhere, forever
- So, what to choose (and what not to choose) – When, where, how and how long to intervene?

What we need to know
- The nature and severity of MN deficiencies
- How effective the alternative intervention programs will be
- How costly these alternative intervention programs will be
- Hence, how cost-effective alternative intervention programs will be
- The most cost-effective national and sub-national portfolio of MN intervention programs
MINIMOD OBJECTIVES AND FRAMEWORK

Primary objective
- Develop and use tools to help design and manage a more cost-effective set of national and sub-national micronutrient intervention programs in LMICs

Framework: 3-part model
- Nutritional needs and intervention program benefits model
- Intervention program cost model
- Economic optimization model

Spatially and temporally explicit
**Cost Model**

- Planning, establishment, and operational costs for all combinations of candidate interventions estimated using "activity-based costing"
- Spatially and temporally explicit

**Nutrition Needs and Benefits Model with Link to LiST**

- Usual dietary intakes and dietary inadequacy estimated from primary or secondary data sources
- Predicts effects of all combinations of candidate interventions on number of individuals with low intake and with intake above the UL
- Lives Saved Tool (LiST) used to predict functional outcomes (lives saved, anemia averted)
- Spatially and temporally explicit

**MINIMOD TOOL FRAMEWORK**

1. **Dietary Intake Data**
   - Nutrition Needs and Benefits Model with Link to LiST
     - Usual dietary intakes and dietary inadequacy estimated from primary or secondary data sources
     - Predicts effects of all combinations of candidate interventions on number of individuals with low intake and with intake above the UL
     - Lives Saved Tool (LiST) used to predict functional outcomes (lives saved, anemia averted)
     - Spatially and temporally explicit
   
2. **Program Cost Data**
   - Cost Model
     - Planning, establishment, and operational costs for all combinations of candidate interventions estimated using "activity-based costing"
     - Spatially and temporally explicit

3. **Relative Cost-effectiveness of Alternative MN Intervention Programs**

4. **Economic Optimization Model**

- Finds the most cost-effective set of intervention programs
- Reports summary measures of nutritional benefits
- Reports costs and cost savings vis-à-vis alternative sets of intervention programs
NUTRITIONAL NEEDS AND INTERVENTION BENEFITS MODEL
MEASURES OF SUCCESS/NUTRITION BENEFITS

**Reach**: number (%) of individuals who receive an intervention

**Effective Coverage**: number (%) of individuals who are both at risk of deficiency due to inadequate intake and also receive sufficient additional intake from an intervention or multiple interventions to be classified as having sufficient intake

**Minimum additional intake** (iron and zinc): number (%) of individuals who receive more than a specified amount of additional micronutrient intake from an intervention(s)

**Functional outcomes**: Lives saved; cases of anemia averted

**Excessive intake**: number (%) of individuals whose intake would exceed the tolerable upper intake level (UL) due to the intervention(s)
CALCULATING EFFECTIVE COVERAGE: BASIC APPROACH

1. Estimate distribution of usual* nutrient intakes at baseline
   
   Estimate % < EAR and % > UL

2. Simulate distribution of usual* nutrient intakes under new program scenario(s)
   
   Re-assess % EAR and % > UL

3. Effective Coverage =

   % inadequate before – % inadequate after

   50% inadequate before – 20% inadequate after

   = 30% effective coverage

Shape of the new distribution of intakes will depend on:
> Baseline nutrient intakes,
> program reach, and
> amount of nutrient delivered,
all of which can vary spatially

*Usual intake distributions estimated using National Cancer Institute (NCI) method. See: http://riskfactor.cancer.gov/diet/usualintakes/
MODEL IS USEFUL IN ESTIMATING THE EFFECTS OF CURRENT AND HYPOTHETICAL PROGRAMS, AND COMBINATIONS OF THEM
PROGRAM BENEFITS DEPEND ON THE DEFINITION OF SUCCESS:
PREDICTED EFFECTS OF FORTIFICATION WITH VITAMIN B-12 AMONG CHILDREN IN CAMEROON

Unpublished results: not for circulation or citation
PREDICTED NUMBER OF ANEMIA CASES AVERTED AMONG WOMEN BY STRENGTHENING WHEAT FLOUR FORTIFICATION WITH IRON IN CAMEROON

2012: Yaoundé/Douala 76% of fortification target

2016: National, 12 sites 50% of flour fortification target

Unpublished results: not for circulation or citation
# Micronutrients and Delivery Platforms

<table>
<thead>
<tr>
<th>Delivery Platforms</th>
<th>Micronutrients</th>
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<tbody>
<tr>
<td>Periodic high-dose supplements*</td>
<td>Vitamin A</td>
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<tr>
<td>Daily supplementation*</td>
<td>Zinc</td>
</tr>
<tr>
<td>Industrial fortification (edible oils, wheat flour, salt, sugar, bouillon cubes)</td>
<td>Vitamin A, Zinc, Iron, Folate, Vitamin B12, Iodine</td>
</tr>
<tr>
<td>Biofortification (orange-flesh sweet potatoes, beans {iron}, maize {VA})</td>
<td>Vitamin A</td>
</tr>
<tr>
<td>Agronomic Fortification (enriched fertilizers)</td>
<td>Zinc, selenium</td>
</tr>
<tr>
<td>Other intervention strategies (LNS, MMP, other)*</td>
<td>Vitamin A, Zinc, Folate, Vitamin B12, Iodine</td>
</tr>
</tbody>
</table>

*Delivery platforms: Child Health Days, Health Centers (primary care), Community Distribution

**All Delivery Models Require Investments and M&E!!**

**Benefits and Cost-effectiveness Depend on Delivery Model Performance!!**
MINIMOD INTERVENTION PROGRAM COST MODEL
COMPONENTS OF THE COST MODEL

Start-up Costs
- Planning, legislation change, advocacy, etc.; initial staffing, training, infrastructure, vehicles, etc.

Operational Costs
- Fixed costs -- Overhead costs, management, etc.
- Variable costs -- costs that increase with the scale of the program

Costs Faced by all Stakeholders
- Public sector costs
- Private Sector costs
- Caregiver/household costs

Marginal/Incremental Costs
- Costs of adding MN intervention programs to existing platforms
- Costs of designing/implementing completely new programs

Calculates Costs for All Intervention Programs and Combinations of Them
### MEETING VA NEEDS OF YOUNG CHILDREN IN CAMEROON: A CLOSER LOOK AND BENEFITS, COSTS AND COST-EFFECTIVENESS

<table>
<thead>
<tr>
<th>Program</th>
<th>Reach, 000s of child-years</th>
<th>Effective Coverage, 000s of child-years</th>
<th>Child Deaths Averted, # of children</th>
<th>Total Cost, 000s US$</th>
<th>Cost per Child Reached, US$</th>
<th>Cost per Child-Year Effectively Covered, US$</th>
<th>Cost per Child Death Averted, US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA-Fortified Edible Oils (44% target)</td>
<td>National 17,188</td>
<td>5,075</td>
<td>9,724</td>
<td>$2,657</td>
<td>$0.15</td>
<td>$0.52</td>
<td>$273</td>
</tr>
<tr>
<td>VA-Fortified Edible Oils (44% to 100% target)</td>
<td>National 17,188</td>
<td>8,055</td>
<td>15,527</td>
<td>$4,851</td>
<td>$0.28</td>
<td>$0.60</td>
<td>$312</td>
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<tr>
<td>VA-Fortified Bouillon Cubes</td>
<td>National 29,039</td>
<td>7,731</td>
<td>16,098</td>
<td>$2,932</td>
<td>$0.10</td>
<td>$0.38</td>
<td>$182</td>
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<tr>
<td>VA-Biofortified Maize</td>
<td>National 13,435</td>
<td>2,512</td>
<td>5,720</td>
<td>$1,398</td>
<td>$0.10</td>
<td>$0.56</td>
<td>$244</td>
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<tr>
<td>VA Supplementation via Child Health Days</td>
<td>National 23,649</td>
<td>8,586</td>
<td>19,267</td>
<td>$26,923</td>
<td>$1.14</td>
<td>$3.14</td>
<td>$1,397</td>
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<tr>
<td></td>
<td>North 11,340</td>
<td>5,201</td>
<td>13,630</td>
<td>$8,766</td>
<td>$0.77</td>
<td>$1.69</td>
<td>$643</td>
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<tr>
<td></td>
<td>South 8,918</td>
<td>2,131</td>
<td>3,889</td>
<td>$12,963</td>
<td>$1.45</td>
<td>$6.08</td>
<td>$3,333</td>
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<td></td>
<td>Cities 3,391</td>
<td>1,253</td>
<td>1,748</td>
<td>$5,194</td>
<td>$1.53</td>
<td>$4.15</td>
<td>$2,972</td>
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Vosti et al., 2019
MINIMOD ECONOMIC OPTIMIZATION MODEL
WHAT THE OPTIMIZATION MODEL DOES

**Combines** the Results of the Nutrition Benefits and Cost Models
- Nutrition model predicts impacts of specific MN intervention programs, and combinations of them
- Cost model predicts the costs of specific MN intervention programs, and combinations of them

**Uses** Linear Programming Techniques
- Mixed integer programming (General Algebraic Modeling System – GAMS)

**Seeks** Economically Optimal Combinations to MN Intervention Programs (over space & time)
- Minimum cost of meeting specific program objectives
- Maximum contribution to objectives given funding or other constraints
**BUSINESS AS USUAL* IN CAMEROON: VAS FOR CHILDREN**

(* Implies the replication over 10 years of programs administered over the past few years.)

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<tbody>
<tr>
<td>VA Supplementation</td>
<td>SNC</td>
<td>SNC</td>
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<tr>
<td>Fortified Cooking Oil (44%)</td>
<td>SNC</td>
<td>SNC</td>
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<tr>
<td># of Child-Years Effectively Covered (’000s)</td>
<td>1,110</td>
<td>1,127</td>
<td>1,147</td>
<td>1,166</td>
<td>1,186</td>
<td>1,205</td>
<td>1,224</td>
<td>1,243</td>
<td>1,262</td>
<td>1,281</td>
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<tr>
<td>Total Cost (’000s USD)</td>
<td>$2,951</td>
<td>$2,957</td>
<td>$2,963</td>
<td>$2,968</td>
<td>$2,974</td>
<td>$2,979</td>
<td>$2,984</td>
<td>$2,989</td>
<td>$2,994</td>
<td>$2,999</td>
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**S = South Macro-region; N = North Macro-region; C = Cities**

| Number of Children Effectively Covered (’000s) | 11,951 |
| Total Cost (’000s $) | $29,758 |
| Cost per Child Effectively Covered ($/child) | $2.49 |

<table>
<thead>
<tr>
<th># of Children Effectively Covered (’000s)</th>
<th>National</th>
<th>North</th>
<th>South</th>
<th>Cities</th>
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<tr>
<td>11,951</td>
<td>6,554</td>
<td>3,213</td>
<td>2,183</td>
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<tr>
<th>Cost per Child Effectively Covered ($/child)</th>
<th>National</th>
<th>North</th>
<th>South</th>
<th>Cities</th>
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<tr>
<td>$2.49</td>
<td>$1.48</td>
<td>$4.35</td>
<td>$2.71</td>
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*Vosti et al., 2019*
LET’S TRY SOMETHING NEW

Add New MN Intervention Programs
- Develop VA-fortified bouillon cube (267 IU/g target) — delivered via markets; begins to generate benefits in year 4
- Biofortified maize (delivered via markets; begins to generate benefits in year 4)
- Improve efficiency of oil fortification program over three years (from 44% to 72% to 100% of 40 IU/g target)

Use the Optimization Model
- Objective: Achieve the 10-year BAU* effective coverage benefits (~11.9m children) at lowest cost

VAS Programs Assessed at 2009 Reach Levels
- CHD reach ➔ Cities=58%, North=89%, South=64%
### Economically Optimal VA Programs for Children, Effective Coverage

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<tr>
<td>VA Supplementation</td>
<td>N</td>
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<td></td>
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<tr>
<td>Fortified Cooking Oil (44%-72%-100%)</td>
<td>SNC&quot;</td>
<td>SNC&quot;</td>
<td>SNC&quot;</td>
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<tr>
<td>Fortified Bouillon Cube</td>
<td>SNC*</td>
<td>SNC*</td>
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<tr>
<td>VA Bio-Fortified Maize</td>
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**Number of Child-Years Effectively Covered ('000s)**

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<td></td>
<td>998</td>
<td>1,188</td>
<td>873</td>
<td>1,415</td>
<td>1,435</td>
<td>1,455</td>
<td>1,475</td>
<td>1,496</td>
<td>1,516</td>
<td>1,536</td>
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**Total Cost ('000s USD)**

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<td>$1,472</td>
<td>$1,478</td>
<td>$598</td>
<td>$855</td>
<td>$855</td>
<td>$855</td>
<td>$855</td>
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*S = South Macro-region; N = North Macro-region; C = Cities

*= zero benefits but some costs; #=increasing benefits thanks to investments

**Number of Children Effectively Covered ('000s)**

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<th>13,386</th>
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**Total Cost ('000s $)**

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<th>$9,537</th>
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**Cost per Child Effectively Covered ($/child)**

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<th>$0.71</th>
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Vosti et al., 2019
ONGOING AND PLANNED MINIMOD WORK

Ongoing MINIMOD Work
- Cameroon
- Ethiopia
- Haiti

New MINIMOD Work in West Africa
- Senegal
- Nigeria
- Burkina Faso

In All Sites
- MINIMOD teams are formed
- Collaborative research, including data collection/processing and modeling
- Policy engagement
- Capacity strengthening
ACKNOWLEDGMENTS

Esteemed Collaborators

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HKI – Country Offices: Cameroon, Senegal, Burkina Faso, Nigeria
Johns Hopkins University – LiST Tool
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Ministries of Agriculture – All Collaborating Countries
National Cancer Institute – USA
UNICEF – All Collaborating Countries
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THANK YOU!

For more information about MINIMOD, visit:

https://minimod.ucdavis.edu