Food Fortification
A complementary strategy to tackle micronutrient deficiencies

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Senior Advisor Nutrition, TATA Trusts

NAMS-NFI Symposium
MDGs Lessons learnt and way forward to SDGs
November 27th, 2015, New Delhi, India
Global Nutrition Challenge

Micronutrient Deficiencies are major public health problem

Vitamin and mineral deficiencies affect nearly 2 billion people worldwide and contribute substantially to Global Burden of Disease.

Food fortification is a cost effective and complementary strategy that has helped virtually eliminate many nutrition disorders from the more industrialized countries in the world, but is grossly under-utilized strategy in developing countries.
Micronutrients

- Zinc
- Iodine
- Vitamin B₆
- Manganese
- Folate
- Vitamin A
- Vitamin C
- Thiamin
- Riboflavin
- Niacin
- Iron
- Selenium
- Vitamin B₁₂
- Cobalamin
- Phosphorus
- Vitamin K
- Cobalt
- Magnesium
- Vitamin D
- Vitamin E
- Vitamin B₁₂
Micronutrient deficiencies: A silent emergency in India

IDA prevalence

Prevalence of zinc deficiency

Households consuming adequately iodized salt

Children 6-59 months receiving two doses of Vitamin A during calendar year

Micronutrient deficiencies: A silent emergency in India

**IDA prevalence**

<table>
<thead>
<tr>
<th>Non pregnant women NFHS 3</th>
<th>Pregnant women NFHS 3</th>
<th>Preschool age children NFHS 3</th>
<th>Children &lt; 2 years NFHS 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>59</td>
<td>70</td>
<td>82</td>
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</table>

**Prevalence of zinc deficiency**

<table>
<thead>
<tr>
<th>Orissa</th>
<th>Uttar Pradesh</th>
<th>Gujarat</th>
<th>Madhya Pradesh</th>
<th>Karnataka</th>
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<tbody>
<tr>
<td>51.3</td>
<td>48.1</td>
<td>44.2</td>
<td>38.8</td>
<td>38.2</td>
</tr>
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</table>

**Households consuming adequately iodized salt**

<table>
<thead>
<tr>
<th>Adequately iodized salt</th>
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<tbody>
<tr>
<td>49</td>
</tr>
<tr>
<td>51</td>
</tr>
<tr>
<td>71</td>
</tr>
<tr>
<td>78</td>
</tr>
</tbody>
</table>

**Children 6-59 months receiving two doses of Vitamin A during calendar year**

<table>
<thead>
<tr>
<th>Year</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>50</td>
</tr>
<tr>
<td>2003</td>
<td>60</td>
</tr>
<tr>
<td>2004</td>
<td>70</td>
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<tr>
<td>2005</td>
<td>80</td>
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<tr>
<td>2006</td>
<td>90</td>
</tr>
<tr>
<td>2007</td>
<td>50</td>
</tr>
<tr>
<td>2008</td>
<td>40</td>
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</table>

Vitamin A and Vitamin D Deficiency is Widespread in India

- A study published in American Society for Clinical Nutrition, 2005, found 84% of Indian women testing deficient for Vitamin D - having 25 (OH)D levels below 22.5 ng/L
- 59% of the population is deficient in Vitamin D, 25% have very low levels of Vitamin D (Journal of Clinical Endocrinology and Metabolism, March 2010)
- The prevalence of Bitot’s spot, the objective sign of clinical VAD (0.8%) higher than WHO cut off for public health significance (0.5%) – NNMB Technical report 22, 2003
- Blood Vitamin A deficiency 61% - ‘severe public health problem’ as per WHO (20%)
- Proportion of Severe blood VAD 21% - again qualifies as ‘severe public health problem as per WHO (5%)
NTD in India

- NTD is the commonest congenital malformation in Indian population
- The incidence varies - 0.5 - 8 / 1000 births
- Significant regional variation in its incidence

Incidence of neural tube defects in the least-developed area of India: a population-based study

Anil Cherian, Sijy Srerna, Robyn K Bullock, Alok C Antony

Hospital-based records from major cities of India, where roughly a quarter of the population resides, identified the frequency of neural tube defects (NTDs) as ranging from 3.9 to 8.8 per 1000 births, but the incidence in rural areas is unknown. We did a population-based door-to-door survey of mothers living in remote clusters of villages in Balmuirp District in Uttar Pradesh, a region ranked as the least-developed area in India. The data showed that the incidence of NTDs was 6.57-8.21 per 1000 livebirths, which is among the highest worldwide. India's Ministry of Health needs to produce a strategy to reduce the incidence of such defects.
Neural Tube Defects per 10000 births

Source: "India Strategy" : Flour Fortification Initiative
Zinc Deficiency

Zinc in the national food supply, as % weighted mean per capita requirement (adjusting for estimated zinc absorption from food supply)
Solution pathway

Malnutrition
  - Undernutrition
    - Stunting
    - Underweight
    - Wasting
  - Micronutrient Deficiencies
  - Obesity
  - NCDs

Undernutrition
  - Supplements
  - Micronutrient Powders
  - Fortification
  - Bio-fortification

Overnutrition
  - Dietary Diversification
  - Salt
  - Wheat Flour
  - Rice
  - Oils
  - Condiments
  - Milk

NCDs: Non-communicable diseases
Micronutrient deficiencies

**Dietary diversification**

- Median intakes of all the nutrients, except for thiamine were below the recommended dietary allowances (RDA) for Indians.

- Proportion of HHs not meeting even 50% of RDA was 50-81% for riboflavin and vitamin A.

- Proportion of pre-school children not meeting even 50% of RDA for calcium, vitamin A, riboflavin and vitamin C was about 51-82%.

- Proportion of adolescents not meeting even 50% of RDA for calcium, vitamin A, riboflavin and vitamin C was about 52-85%.
Micronutrient deficiencies

Supplementation

➢ IFA coverage – received/purchased > 100 tablets 31.2%

➢ IFA coverage – consumed 100 or more tab in pregnancy 23.6%

➢ IFA coverage in children 6-59 months 13.8%

➢ Vitamin A supplementation 6-59 months 46.2%

➢ ORS and Zinc in children with diarrhoea 12.6%
Types of Fortification

- Mass fortification – Universal
- Targeted fortification
- Market-driven fortification
- Other types of fortification

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Targeted fortification</td>
<td>1. MNP - children, women</td>
<td>2. RTE supplementary food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other types of fortification</td>
<td>1. Point of use fortification</td>
<td>2. Fortified dal analogue</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Food fortification: Global timeline

- 1923: Mandatory salt iodization in Switzerland and USA
- 1933: Mandatory fortification of flour with Vitamin B1 in Canada
- 1934: Vitamin D fortification of margarine and other dairy products
- 1934: Flour fortified in Chile with B-vitamins and iron.
- 1940: Beginning of sugar fortification with Vitamin A in Guatemala.
- 1941: Mandatory fortification with B3 in US
- 1943: Fortification of cereal products with Vitamin B1, B2 and B3 became common practice in many countries. 1941 mandatory fortification with B3 in US
- 1954: Fortification of cereal products with Vitamin B1, B2 and B3 became common practice in many countries.
- 1958: Folic Acid fortification mandated in the USA
- 1961: Mandatory fortification of Vanaspati with vit A
- 1962: Salt Iodisation begins as National Program NGCP
- 1974: Mandatory fortification in many countries in Africa – Nigeria
- 1998: Folic Acid fortification mandated in the USA
- 2000: South Africa mandates fortification of wheat flour, maize meal, brown bread, white bread
- 2000: Mandatory fortification in many countries in Africa – Nigeria
Flour

DEATHS BY PELLAGRA IN USA
EFFECT OF CEREAL ENRICHMENT

Source: D. Miller, 1955
Food Fortification – Does it work

Flour

Developing Country Impact
Venezuela Flour Fortification

Iron Deficiency
- 15% in 1992
- 9% in 1994

Anemia
- 37% in 1992
- 19% in 1994
Flour fortification – Iron deficiency Effectiveness Studies

Pre-fortification
Post-fortification
Wheat Flour

[Graph showing the prevalence of ID Iron, ID control, IDA Iron, and IDA Control over time (months)].

J Nutr Sep 26, 2012
WFF has picked up momentum in India. Gujarat has been doing it for few years now. Several other state govts are introducing it in PDS and are using it in Mid Day Meal.
Food Fortification – Does it work

Flour

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Reduction in Neural-Tube Defects after Folic Acid Fortification in Canada

Philippe De Wals, Ph.D., Fassiatou Tairou, M.Sc., Margot I. Van Allen, M.D.,

CONCLUSIONS

Food fortification with folic acid was associated with a significant reduction in the rate of neural-tube defects in Canada. The decrease was greatest in areas in which the baseline rate was high.
The Centers for Disease Control and Prevention reported that neural tube defects has decreased by 19 percent following folic acid fortification in the U.S. food supply.
Food Fortification – Does it work

NTD rates before and after fortification

![Graph showing NTD rates before and after fortification in different countries.](image-url)
Wheat Flour Fortification Legislation - mandated in 81 countries

Source: Food Fortification Initiative, 2014. Note: All countries fortify flour with at least iron and folic acid except Australia which does not include iron, and Venezuela, the United Kingdom, and the Philippines which do not include folic acid.
# Bulk of the Research has focused on Iron fortification

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Country</th>
<th>Source/Study Type</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>India</td>
<td>American Journal of Clinical Nutrition, 2006</td>
<td>Extruded rice fortified with micronized ground ferric pyrophosphate reduces iron deficiency in Indian schoolchildren: A double-blind randomized controlled trial</td>
</tr>
<tr>
<td>Rice</td>
<td>Mexico</td>
<td>Food and Nutrition Bulletin, 2008</td>
<td>Efficacy of iron-fortified Ultra Rice in improving the iron status of women in Mexico</td>
</tr>
<tr>
<td>Rice</td>
<td>The Philippines</td>
<td>Journal of Nutrition, 2005</td>
<td>Iron-biofortified rice improves the iron stores of nonanemic Filipino women</td>
</tr>
<tr>
<td>Rice*</td>
<td>Brazil</td>
<td>Journal of Nutrition, 2009</td>
<td>Iron-fortified rice is as efficacious as supplemental iron drops in infants and young children</td>
</tr>
<tr>
<td>Rice</td>
<td>India</td>
<td>National Institute of Nutrition; Department of Biotechnology, Government of India, 2009</td>
<td>Evaluation of bio-effect of Ultra Rice on iron status of beneficiaries of Mid Day Meal Programme: a study in a primary school of Ranga Reddy district of Andhra Pradesh</td>
</tr>
<tr>
<td>Rice</td>
<td>Thailand/Bangladesh</td>
<td>Journal of the Science of Food and Agriculture, 2009</td>
<td>Iron fortification and parboiled rice quality: appearance, cooking quality and sensory attributes</td>
</tr>
<tr>
<td>Rice</td>
<td>N/A</td>
<td>International Journal of Food Science and Technology, 2008</td>
<td>Effect of Iron Compounds on the Storage Stability of Multiple Fortified Ultra Rice</td>
</tr>
</tbody>
</table>
Potential for wheat flour fortification

- Widely and regularly consumed
- Technology is simple
- Extensive experience - > 70 years
- Cost effective and proven efficacy and effectiveness
- PDS offtake under NFSA – 60 MMT
Wheat flour fortification in India

- Chakki level fortification in 200 villages - a successful pilot
- All packaged atta sold through commercial market is fortified
  - 120,000 MT per year
  - Reaches 2 million
  - Raj Atta through PDS reached 11 million
- All packaged atta is fortified
  - 250,000 - 300,000 MT is sold through commercial market channels
  - Reaches 4.5 million people
- Voluntary fortification by industry
  - 1,000,000 MT per year
  - Reaches 15 million

Fortified atta reaches 20-25 million persons in India

TINI - A Nutrition Initiative of TATA Trusts
Universal Salt Iodisation

Progress towards universal salt iodization

- Out of 128 countries with data:
  - 37 countries coverage is ≥90% of households
  - 39 countries coverage is <50%
  - 70% households worldwide have access to well iodized salt

UNICEF, SOWC 2012
Summary Findings

- Progress achieved during the last decade is remarkable
- The results of the survey constitute an unprecedented success
- This optimism however need to be tempered
DFS – Iodine and Iron fortified salt


Fats and oil

**Industrial Country Impact: Canada Margarine Fortification**

- **VAD**
  - 48% in 1944
  - 2% in 1948
  - % < 20 μg/dl serum retinol

- **Infant Mortality**
  - Fortification Begins 1944
  - Child Mortality per 10,000 Live Births
    - 110 in 1944
    - Decrease to 40 in 1947

*Food Fortification – Does it work*
Oil Fortification

Vitamin A Fortification of P.L. 480 Vegetable Oil

The stability of vitamin A in oil is greater than other currently used food vehicles such as flour, sugar or corn soy blends. Losses are estimated at 5% during shipping and 10% during open storage in the field. Cooking losses will range from 5% for boiling or simmering to 20% when the food is fried. Higher losses, over 50%, would occur with very high temperature and/or repeated frying, but this type of application is not believed to be common with PL 480 vegetable oil.
### Stability of Vitamin A in fortified oil after repeated frying of potatoes at 180°C
(Average of 2 replicates)

<table>
<thead>
<tr>
<th>Number of frying</th>
<th>% Vitamin A retained</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>33.3 IU/G</td>
</tr>
<tr>
<td>1</td>
<td>90.5</td>
</tr>
<tr>
<td>2</td>
<td>87.0</td>
</tr>
<tr>
<td>3</td>
<td>77.5</td>
</tr>
<tr>
<td>4</td>
<td>72.5</td>
</tr>
<tr>
<td>5</td>
<td>68.0</td>
</tr>
</tbody>
</table>

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Food Fortification – Does it work

Oil Fortification

Stability of Vitamin A in fortified oil after repeated frying of potatoes at 180°C
(Average of 2 replicates)

- M. RAHMANI  Institut Agronomique et Vétérinaire Hassan II  Rabat / MOROCCO
- H. AGUENAOU  Faculté des Sciences  Kénitra / MOROCCO
Potential for edible oil fortification

Domestic edible oil market: Est. at $15 billion & set to grow at 5-6% annually.

Demand for edible oils is projected to rise to 25 MMT in near future moving in tandem with the avg. per capita income growing at 4-6%.

Refined oil accounts for over third of total oil consumption with a market size of 5 MMT & is growing 15% annually.

Edible Oil consumption @ 17.55 MMT in line with population growth.

Getting turbo charged by growing per capita income.

At 14.2 kgs per capita edible oil consumption in India is much lower than global average of 20 kgs.
Edible oil fortification in India

- All packaged refined oil is fortified
- 250,000 MT per year
- Reaches 40 million

- Voluntary fortification by industry
  - 300,000 – 350,000 MT per year
  - Reaches 42-45 million

Fortified edible oil reaches 125 million persons in India
Fluid milk is the only food that is routinely fortified with vitamin D. In the United States and Canada, fortified milk and ready to eat cereals are the predominant food sources of vitamin D.
This systematic reviewed showed that fortification of foods with vitamin D was associated with statistically significant improvements in serum 25(OH)D concentrations that have important implications for the maintenance of vitamin D status in the population.
**Milk fortification - Effective public health strategy**

**Impact of vitamin D fortified milk supplementation on vitamin D status of healthy school children aged 10-14 years.**

Khadgawat R	extsuperscript{1}, Marwaha RK, Garg MK, Ramot R, Oberoi AK, Sreenivas V, Gahlot M, Mehan N, Mathur P, Gupta N

**Vitamin D fortification in the United States and Canada: current status and data needs	extsuperscript{1-4}**

Mona S Calvo, Susan J Whiting, and Curtis N Barton

**Effects of fortified milk on morbidity in young children in north India: community based, randomised, double masked placebo controlled trial**

Sunil Sazawa	extsuperscript{1}, Usha Dholgra	extsuperscript{1}, Girish Hiremath	extsuperscript{1}, Jitendra Kumar	extsuperscript{2}, Pratibha Dholgra	extsuperscript{2}, Archana Sarkar	extsuperscript{2}, Venugopal P Menon	extsuperscript{2}, Robert E Black	extsuperscript{1}
Potential for milk fortification

- Indian dairy industry has progressed from a situation of scarcity to that of plenty
- India is now the largest milk producer in the world
- Annual production is >132 million tons
- Milk production quadrupled between 1974 and 2006 - Operation floods
- Per capita availability is 236 ml/day
- Per capita production is projected to increase to >350 ml/day by 2020
Point of use fortification - MNPs

Guideline:
Use of multiple micronutrient powders for home fortification of foods consumed by infants and children 6–23 months of age.

1. Tear open the top of the sachet.
2. Pour the entire contents of a sachet into any semi-solid cooked food at an acceptable temperature to eat (lower than 60°C).
Efficacy of MNPs established world wide
Food fortification in India

\[\text{Hb (g/dL)} \times \text{weeks of treatment}\]

- **Drops**
- **FF 12.5**
- **FF 20**
- **MFP 20**
- **FF 30**

*Indian Pediatr 2007:44;91-100*
Food fortification in India

Enhancements to Nutrition Program in Indian Integrated Child Development Services Increased Growth and Energy Intake of Children\textsuperscript{1,2}

Rasmi Avula,\textsuperscript{3} Edward A. Frongillo,\textsuperscript{3} Mandana Arabi,\textsuperscript{4} Sheel Sharma,\textsuperscript{5} and Werner Schultink\textsuperscript{4}

1. A quasi experimental longitudinal design was used
2. 15 AWCs with `enhanced’ program and 15 with normal program
3. Multilevel linear regression was used to examine changes over time
4. The enhanced program significantly increased growth in WAZ and HAZ
Prevalence Mild Anemia for NFK and FK at 0, 12, and 24 Weeks

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Mean Prevalence Mild Anemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFK 0 Weeks</td>
<td>22.6</td>
</tr>
<tr>
<td>NFK 12 Weeks</td>
<td>13.3</td>
</tr>
<tr>
<td>NFK 24 Weeks</td>
<td>19.1</td>
</tr>
<tr>
<td>FK 0 Weeks</td>
<td>9.8</td>
</tr>
<tr>
<td>FK 12 Weeks</td>
<td>20.7</td>
</tr>
<tr>
<td>FK 24 Weeks</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Prevalence Iron Deficiency Anemia for NFK and FK at 0, 12, and 24 Weeks

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Mean Prevalence Iron Deficiency Anemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFK 0 Weeks</td>
<td>9.6</td>
</tr>
<tr>
<td>NFK 12 Weeks</td>
<td>9.3</td>
</tr>
<tr>
<td>NFK 24 Weeks</td>
<td>4.9</td>
</tr>
<tr>
<td>FK 0 Weeks</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Mean Prevalence Iron Deficiency Anemia

14mg microencapsulated ferrous fumarate, 500IU’s Vitamin A (acetate 250 CW5) and 0.05mg folic acid per 25g serving

Am J Clin Nutr 2007:85;1127-33
### Food fortification in India Opportunities

#### Staple food fortification

<table>
<thead>
<tr>
<th>Edible oil</th>
<th>350-400 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour - commercial</td>
<td>200 million</td>
</tr>
<tr>
<td>PDS</td>
<td>300 million</td>
</tr>
<tr>
<td>Milk</td>
<td>300 million</td>
</tr>
</tbody>
</table>

#### Through government programs

1. PDS – potential reach is 800 million
2. MDM – potential reach is 150 million
3. ICDS – potential reach is 90 million

#### Through commercial market

1. Increasing market share in the urban and peri urban areas
2. Progressively increasing rural market share
3. More women in workforce and higher disposable income are other drivers
Denmark, Sweden, Finland – 10 -20 % of iron intake was from fortified foods


German children 2-13 yrs – 60% of iron intake in 1987 was from fortified foods and increased to 78% in 1995.


Nationally representative data in USA – in women of reproductive age, 40% of total iron intake was from fortified ready-to-eat cereals

*Ramakrishnan U, et al. FASEB J 2001;15:748.8*

Fortified foods are major contributors to nutrient intakes in Diets of US Children and Adolescents

*Academy of Nutrition and Dietetics 2014*
Impact at national level

**The impact of voluntary fortification of foods on micronutrient intakes in Irish adults**

Evelyn M. Hannon*, Mairead Kiely and Albert Flynn

*Irish Universities Nutrition Alliance, Department of Food and Nutritional Sciences, University College Cork, Cork, Republic of Ireland*

*(Received 27 July 2006 – Revised 29 November 2006 – Accepted 4 December 2006)*

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**Invited Commentary**

Further evidence that food fortification improves micronutrient status
Food Fortification

Cost-effectiveness
Cost-effectiveness

Cost-effectiveness of selected interventions affecting children

<table>
<thead>
<tr>
<th>Intervention</th>
<th>$DALY saved</th>
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<tbody>
<tr>
<td>Iron fortification</td>
<td>10</td>
</tr>
<tr>
<td>Vitamin A/Zinc fortification</td>
<td>50</td>
</tr>
<tr>
<td>Oral rehydration</td>
<td>200</td>
</tr>
<tr>
<td>Pneumonia management</td>
<td>50</td>
</tr>
<tr>
<td>Disinfection of water supply</td>
<td>250</td>
</tr>
</tbody>
</table>
Food Fortification as a Strategy for Nutrition Delivery

Critical Factors for Success
Critical success factors

Choosing a vehicle

Food Industry and market related

Food laws and regulation

Building PPP and alliances
Critical success factors

Choosing a vehicle

- Food consumption data for potential food vehicle(s)
- Marketing and distribution data for the food vehicles(s)
- Determining the technical and economic feasibility
Critical success factors

• Food Industry and market analysis
  ➢ Industry capacity & concentration
  ➢ Public – private share and role
  ➢ Investment climate for food fortification
Critical success factors

• Food laws and regulation
  ➢ Voluntary fortification
  ➢ Mandatory fortification
  ➢ Monitoring and enforcement
  ➢ Role of Govt & Food Industry
Critical success factors

Barriers - Consumers

- Nutrition Low Purchase Priority
- Price Sensitivity
- No Perceived Need. Hidden Hunger
- Prevention & Future Benefits

*The most at risk choose the least expensive product*
Food Fortification

Critical success factors

• Barriers - Producers

  ➢ Little Price or Volume Increase
  ➢ Competition and Price Pressure
  ➢ Low Profit Margins
  ➢ Low Capacity Utilization

*It is not the Cost*
*It is the Competition*
**Food Fortification**

**complementary strategy**

1. **Targeted interventions**
   - Needed to reach few physiological groups and during critical periods
2. Convergence with other impactful interventions and sectors is absolutely necessary
3. Agenda setting and advocacy to ensure nutrition being adequately addressed is also critical for success

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**Integrated approaches needed to ensure most vulnerable populations are reached**