



**NAMS – NFI Symposium on  
Food Fortification for Improving Micronutrient Intakes**

**Food Fortification – Global Scenario**

Dr R Sankar, MD, MNAMS, FICP  
*New Delhi, 29<sup>th</sup> November 2017*

# Micronutrient Deficiencies

## Major public health problem



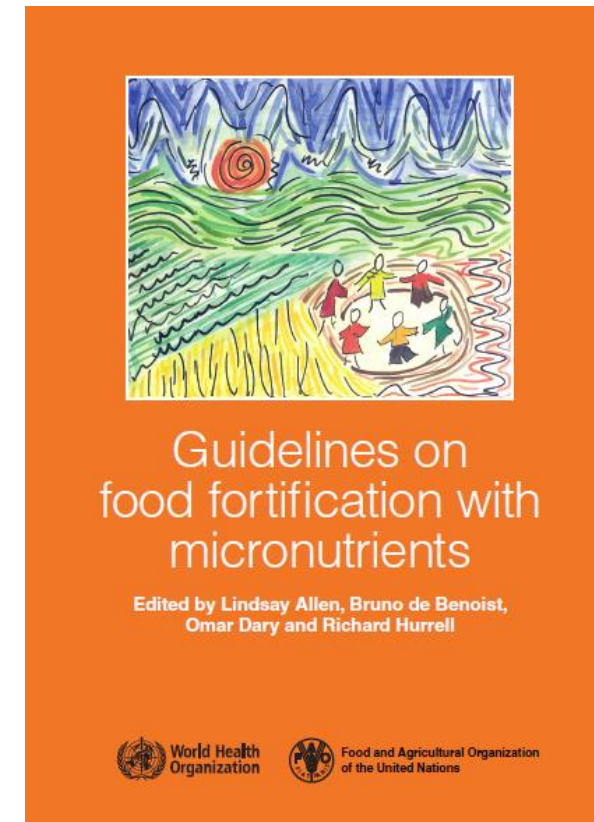
Vitamin and mineral deficiencies affect nearly 2 billion people worldwide and contribute substantially to Global Burden of Disease

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

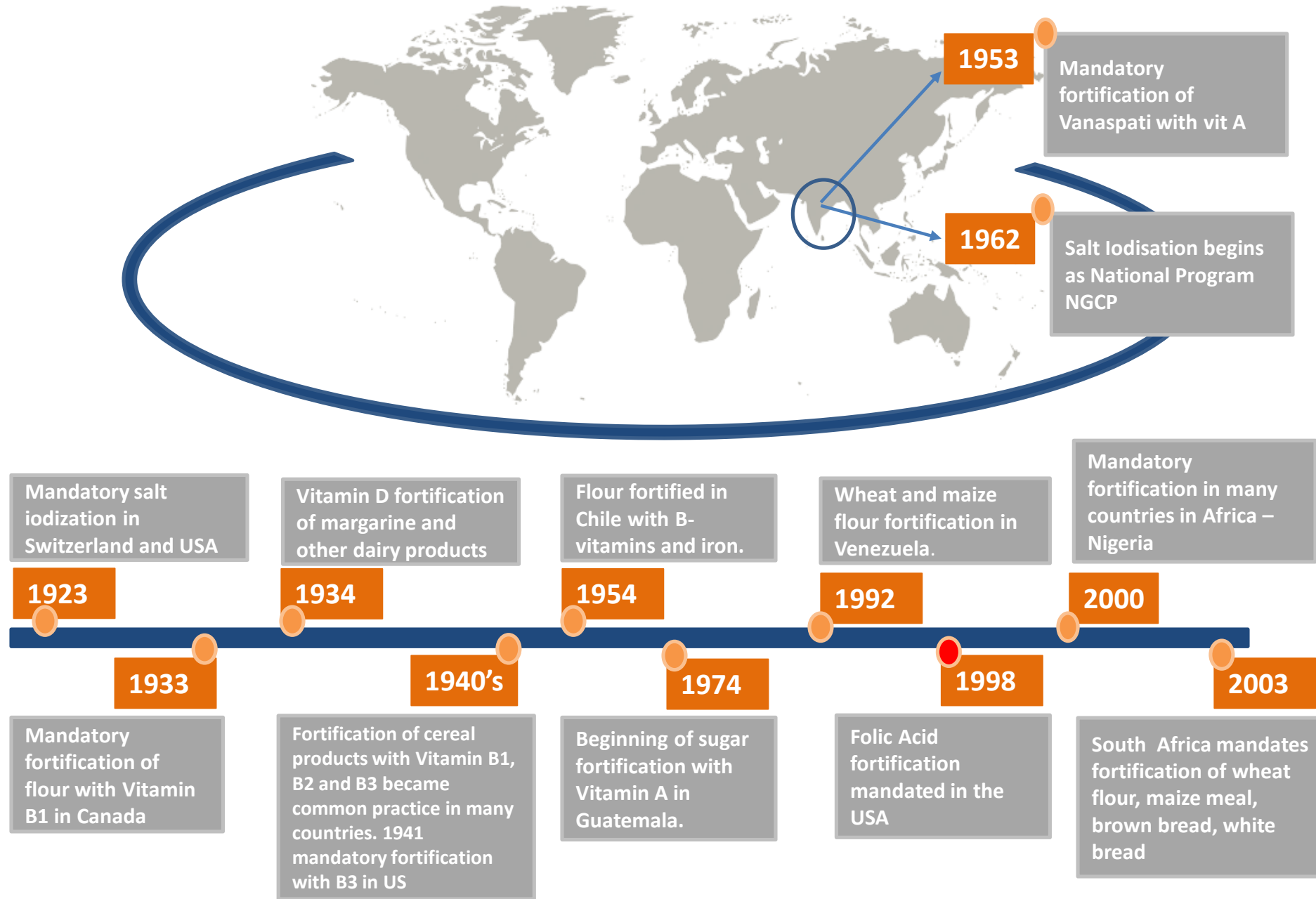
# Types of Fortification

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

<b>Mass fortification</b>	<ol style="list-style-type: none"><li>1. <b>Salt</b></li><li>2. <b>Fats and oils</b></li><li>3. <b>Milk</b></li><li>4. <b>Wheat flour</b></li><li>5. <b>Rice</b></li></ol>
<b>Targeted fortification</b>	<ol style="list-style-type: none"><li>1. <b>MNP – children, women</b></li><li>2. <b>RTE supplementary food</b></li></ol>
Market driven	<ol style="list-style-type: none"><li>1. Wheat products</li><li>2. Beverages</li><li>3. Others</li></ol>
Other types of fortification	<ol style="list-style-type: none"><li>1. <b>Point of use fortification</b></li><li>2. Fortified dal analogue</li></ol>



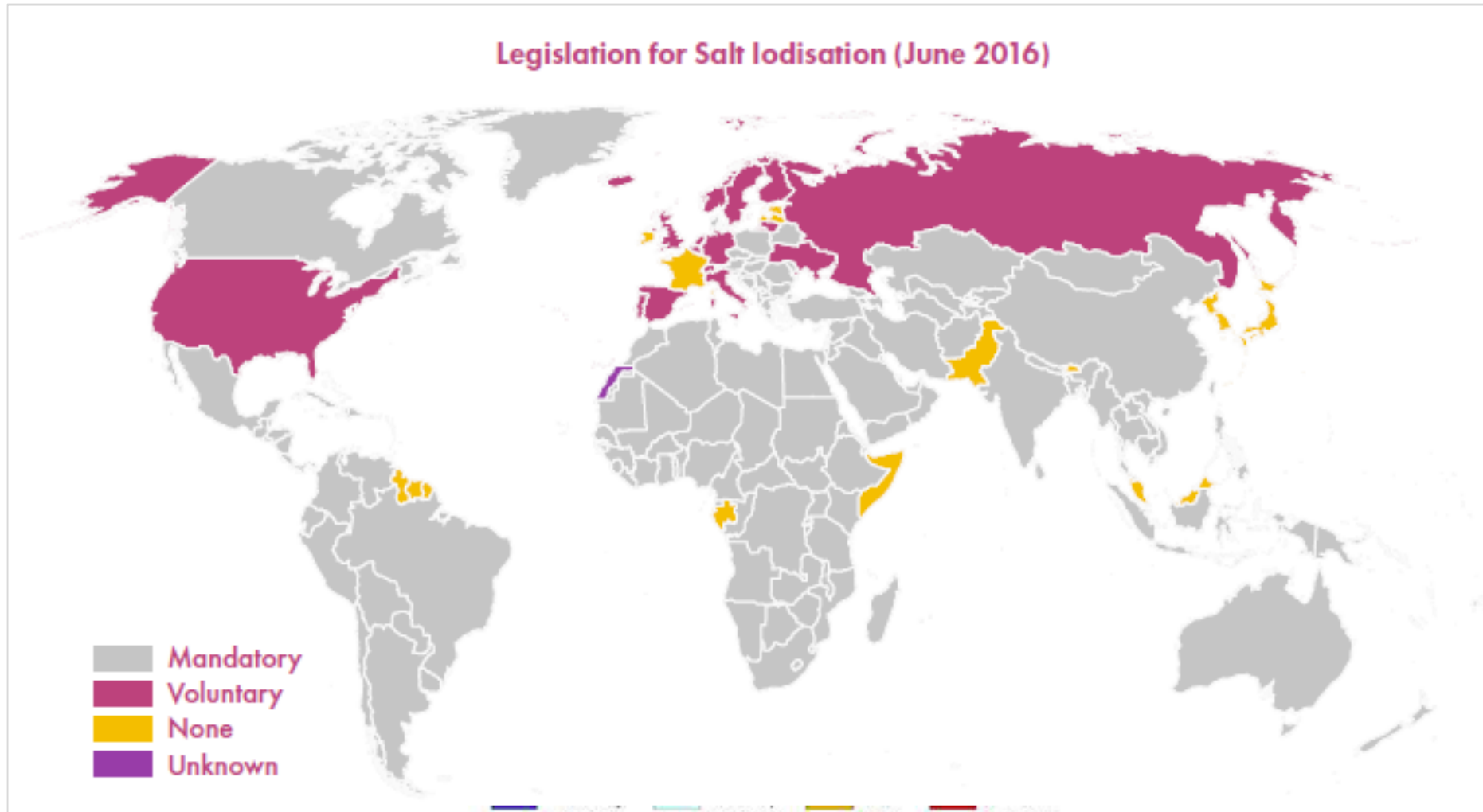
# Food fortification: Global timeline





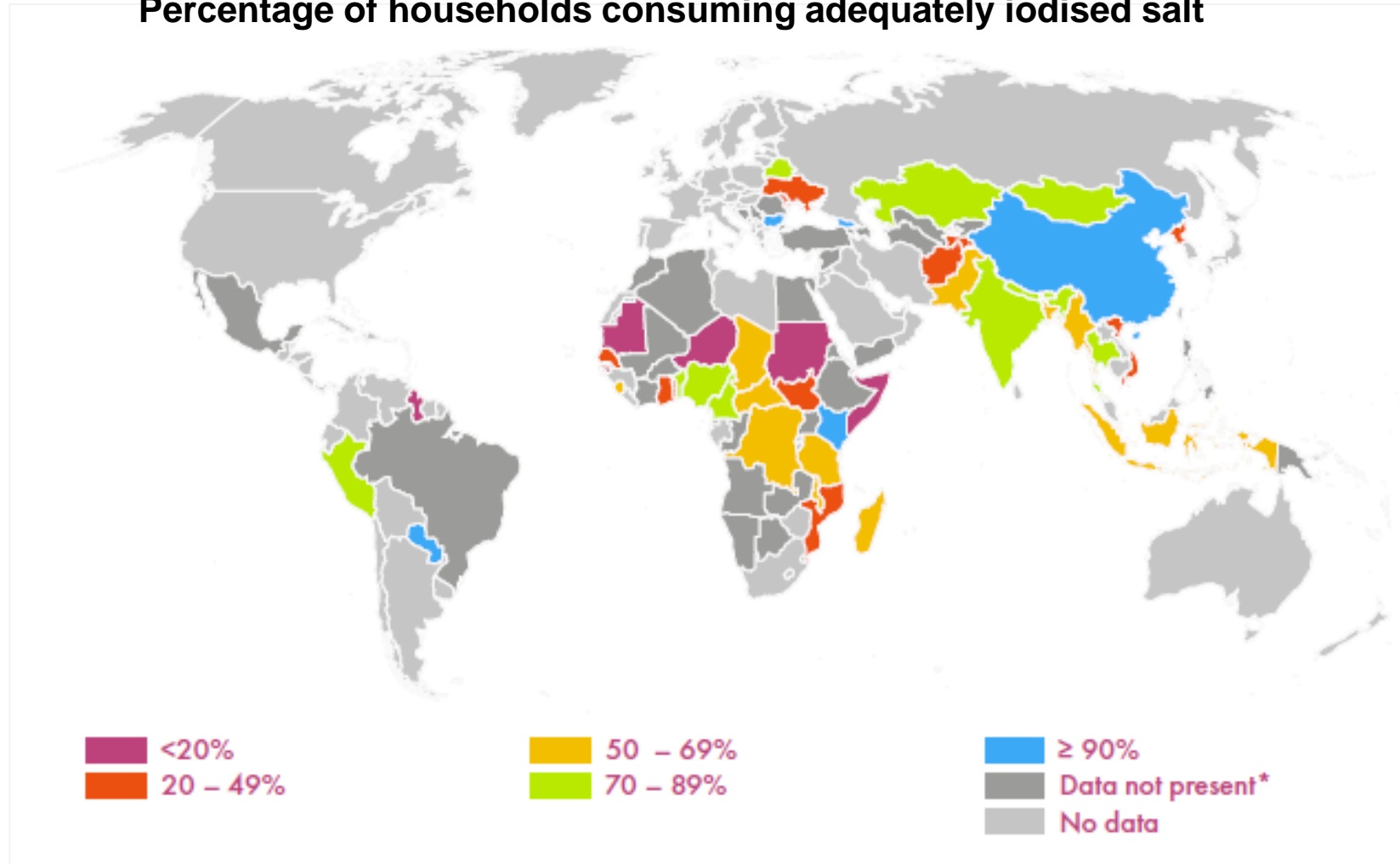
**Staple food fortification**

# Universal Salt Iodisation



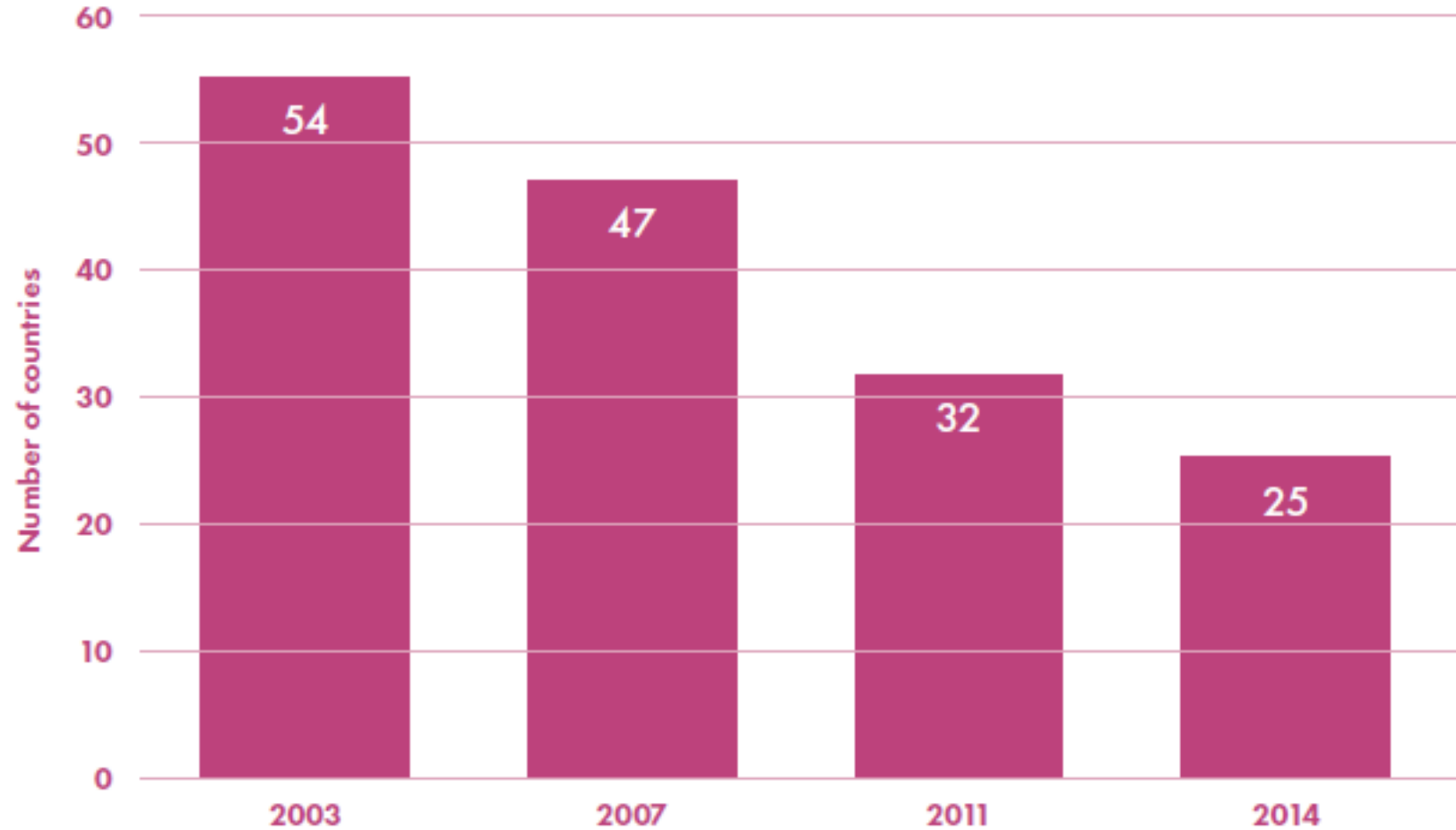
# Universal Salt Iodisation

Percentage of households consuming adequately iodised salt



# Universal Salt Iodisation

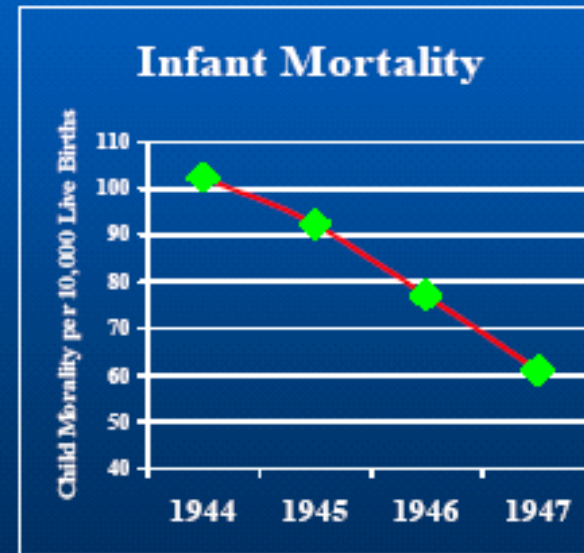
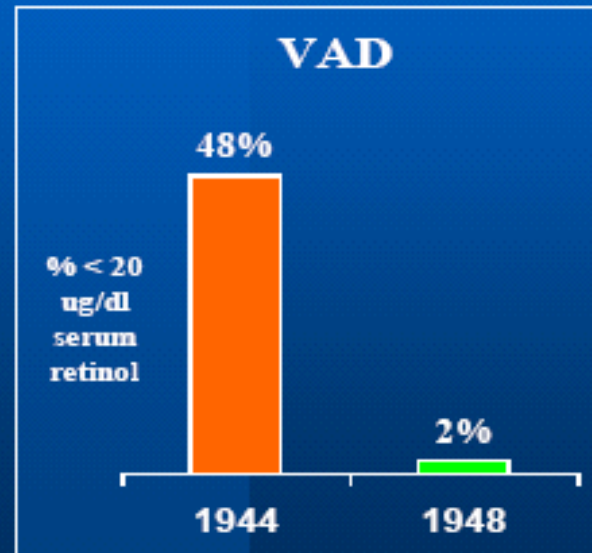
Number of iodine deficient countries in 2003, 2007, 2011 and 2014





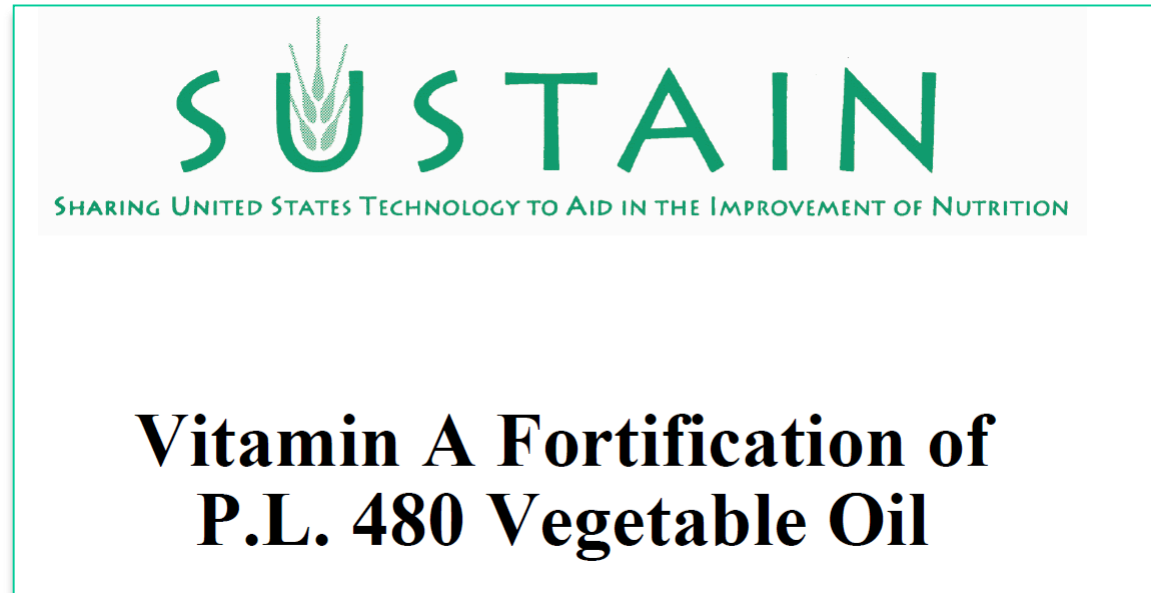
# Fats and oil

## Industrial Country Impact: Canada Margarine Fortification



Fortification Begins 1944

## Fats and oil



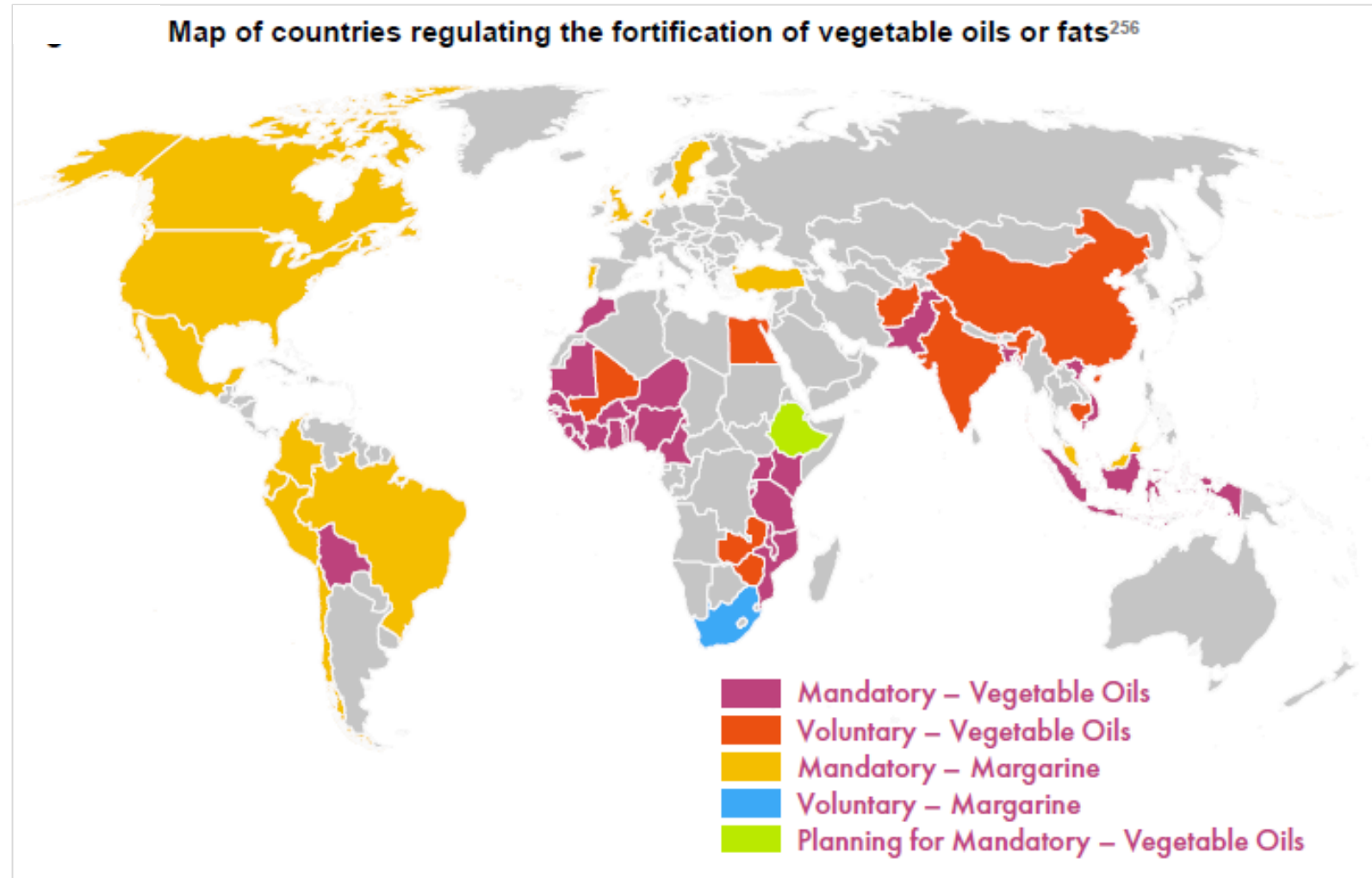
The stability of vitamin A in oil is greater than other currently used food vehicles such as flour, sugar or corn soy blends. Losses are estimated at 5% during shipping and 10% during open storage in the field. Cooking losses will range from 5% for boiling or simmering to 20% when the food is fried. 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.

## Fats and oil

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

Number of frying	% Vitamin A retained	
	33.3 IU/G	66.6 IU/g
1	90.5	93.5
2	87.0	86.5
3	77.5	82.0
4	72.5	76.5
5	68.0	70.5

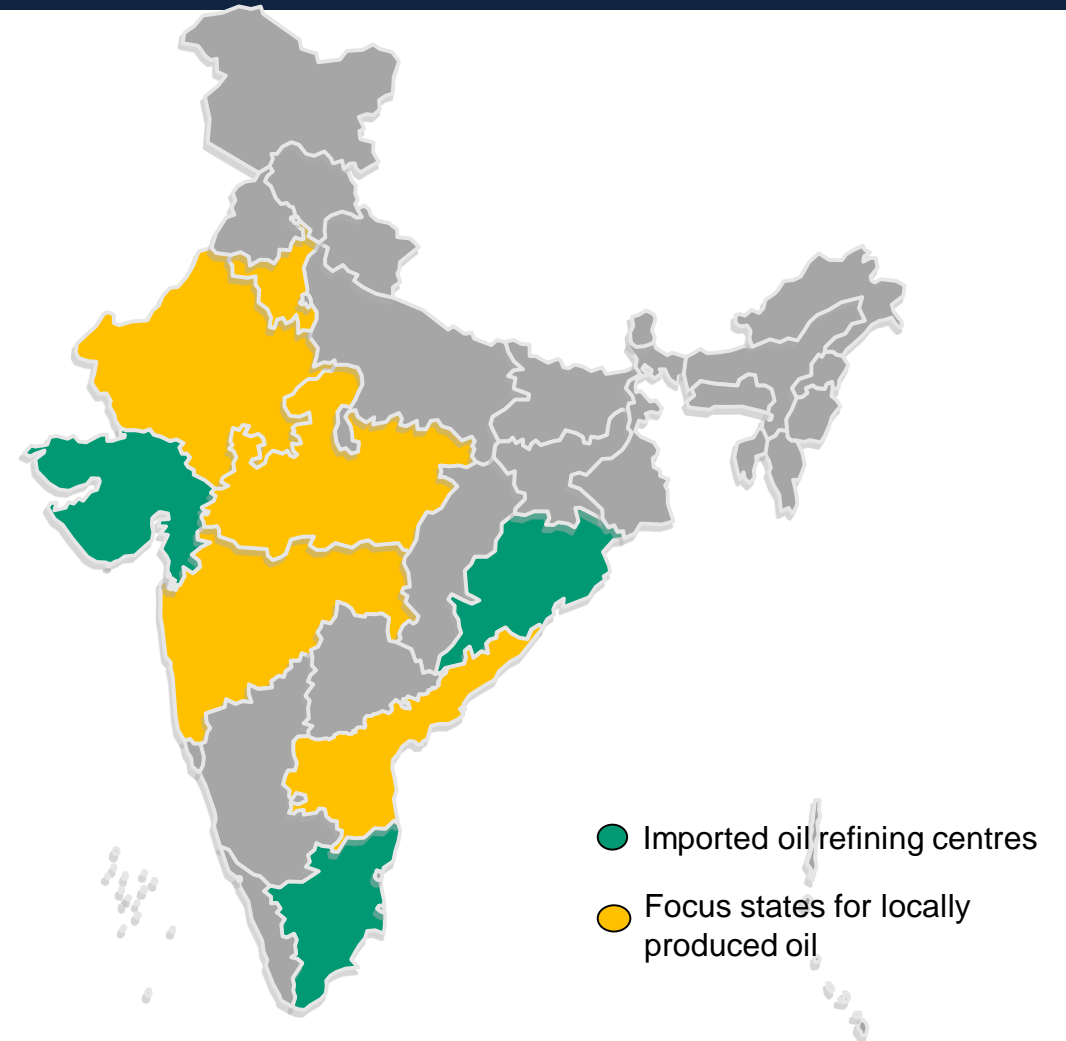
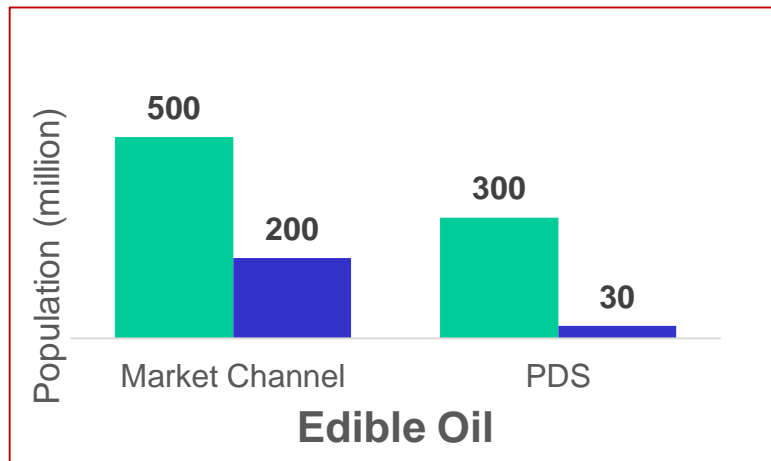
# Fats and oil



# Potential for Edible Oil Fortification in India

- Vanaspati fortification mandatory in India since 1953
- Edible oil has high penetration - all population sections use oil
- Significant consolidation occurring with organized sector's share steadily increasing. Currently at 55%
- TT has supported National Alliance for edible oil fortification at CII
- Top ten players have started fortification
- TT has completed a situation analysis and on that basis will be working in few states
- Currently >100 mio people are reached with fortified oil. All of Dhara oil is fortified.
- Potentially fortifiable oil can reach 500 million people – our target in 2 years

Potential Reach – Fortified Edible Oil



# Milk

## Nutrients commonly added to milk

### Liquid milk

- Vitamin A & D
- Vitamin C
- Vitamin E
- Calcium
- Iron

### Dried milk powder

- Vitamin A & D
- Vitamin C, E
- Iron, zinc, copper,
- PUFA

Vitamin	Suggested Level (IU/L)	Natural Content (IU/L)		Quantity to add (IU/L)
		Whole Milk	Skim Milk	
A	5,000	1,300	trace	4,000-5,000
D	500	40	trace	500

- Fat soluble vitamins are best added in oily form
- Care must be taken to minimize aeration – A & D are sensitive to oxidation
- Iron – pasteurization at 81degree Celsius is recommended
- Calcium addition includes stabilizers and emulsifiers to maintain calcium in suspension

# Milk

## Efficacy of food fortification on serum 25-hydroxyvitamin D concentrations: systematic review<sup>1-4</sup>

*Siobhan O'Donnell, Ann Cranney, Tanya Horsley, Hope A Weiler, Stephanie A Atkinson, David A Hanley, Daylily S Ooi, Leanne Ward, Nick Barrowman, Manchun Fang, Margaret Sampson, Alexander Tsertsvadze, and Fatemeh Yazdi*

## Vitamin D fortification in the United States and Canada: current status and data needs<sup>1-4</sup>

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

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

## Milk fortification - Effective public health strategy

Efficacy of food fortification on serum 25-hydroxyvitamin D concentrations: systematic review<sup>1-4</sup>

*Siobhan O'Donnell, Ann Cranney, Tanya Horsley, Hope A Weiler, Stephanie A Atkinson, David A Hanley, Daylily S Ooi, Leanne Ward, Nick Barrowman, Manchun Fang, Margaret Sampson, Alexander Tsertsvadze, and Fatemeh Yazdi*

*Am J Clin Nutr* 2008;88:1528-34.

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<sup>1</sup>](#), [Marwaha RK](#), [Garg MK](#), [Ramot R](#), [Oberoi AK](#), [Sreenivas V](#), [Gahlot M](#), [Mehan N](#), [Mathur P](#), [Gupta N](#)

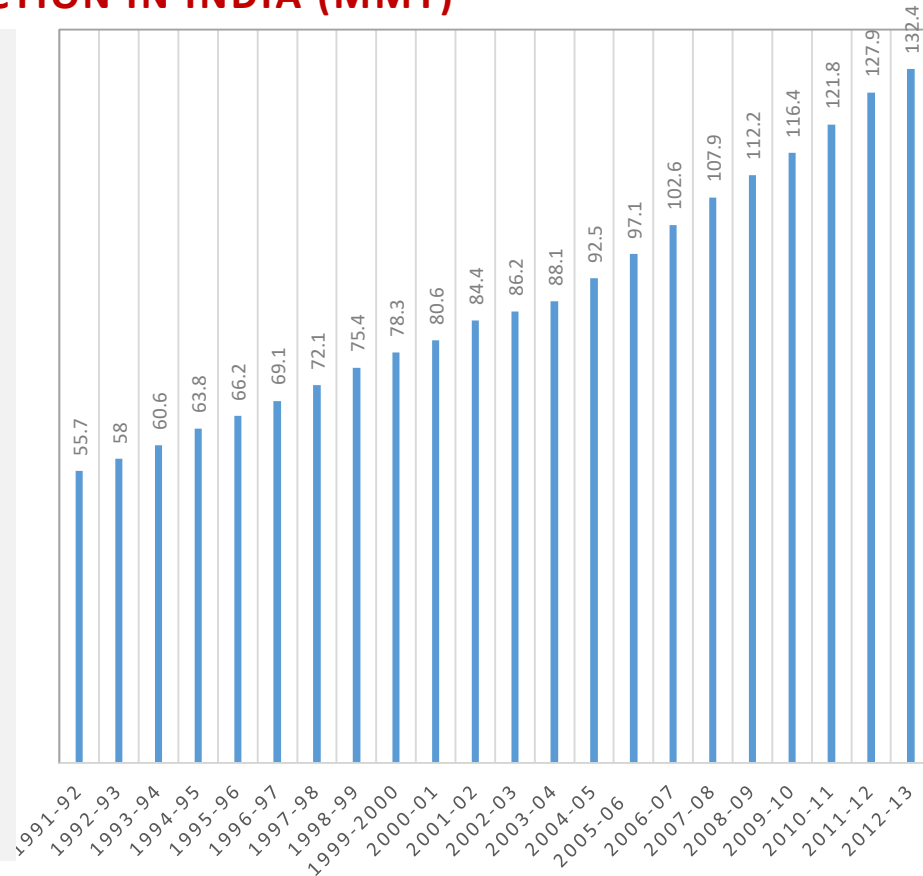
**Effects of fortified milk on morbidity in young children in north India: community based, randomised, double masked placebo controlled trial**

Sunil Sazawal<sup>1</sup>, Usha Dhingra<sup>1</sup>, Girish Hiremath<sup>1</sup>, Jitendra Kumar<sup>2</sup>, Pratibha Dhingra<sup>2</sup>, Archana Sarkar<sup>2</sup>, Venugopal P Menon<sup>2</sup>, Robert E Black<sup>1</sup>

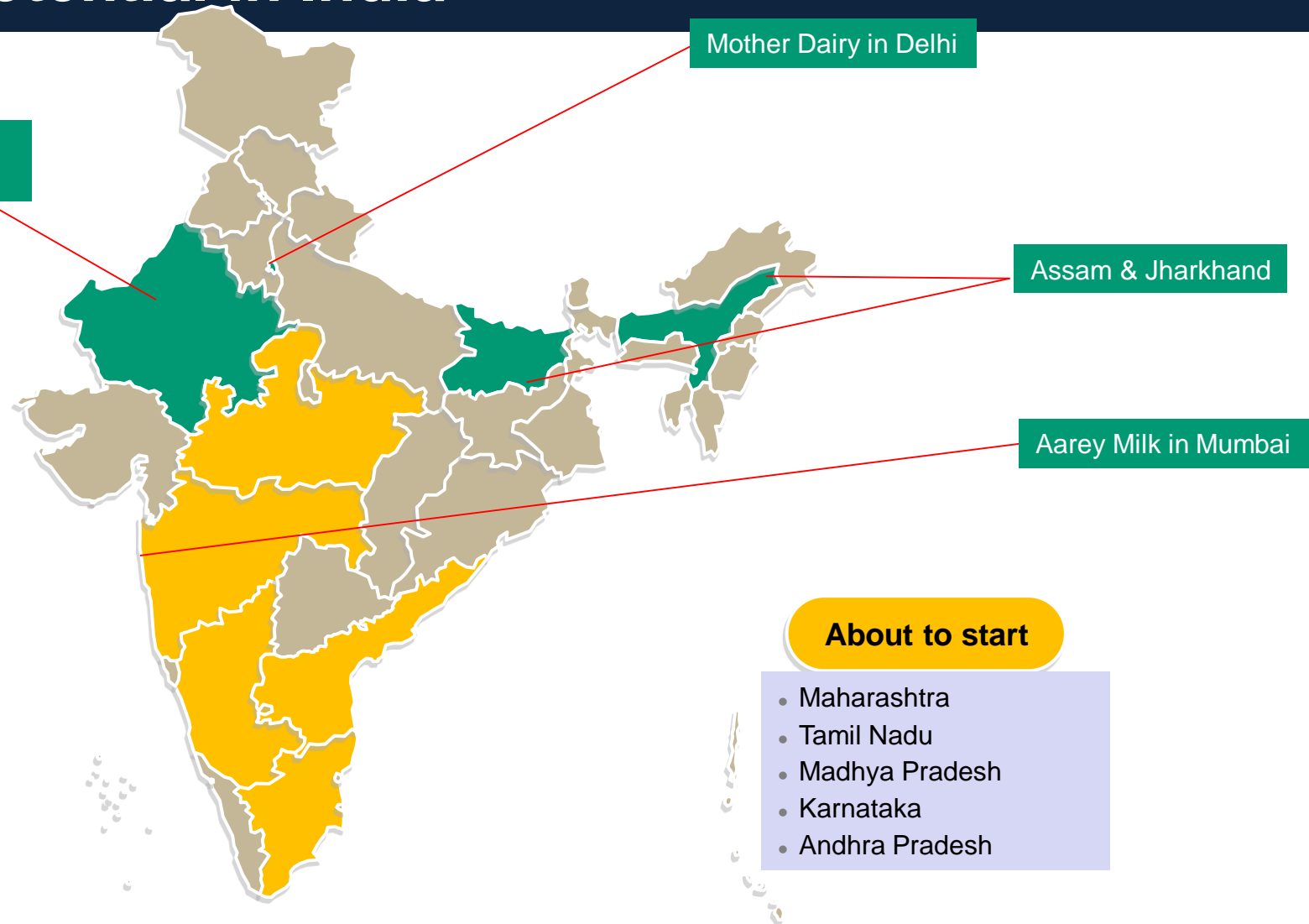
# Potential for milk fortification in India

## MILK PRODUCTION IN INDIA (MMT)

- 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. About 25 % of this goes through organized sector and lends itself for fortification
- In the organized sector 65% is cooperatives and the rest with private sector
- 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

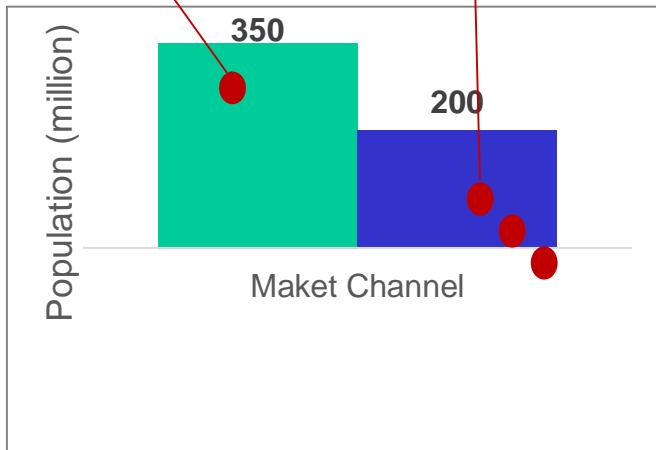


# Milk Fortification potential in India



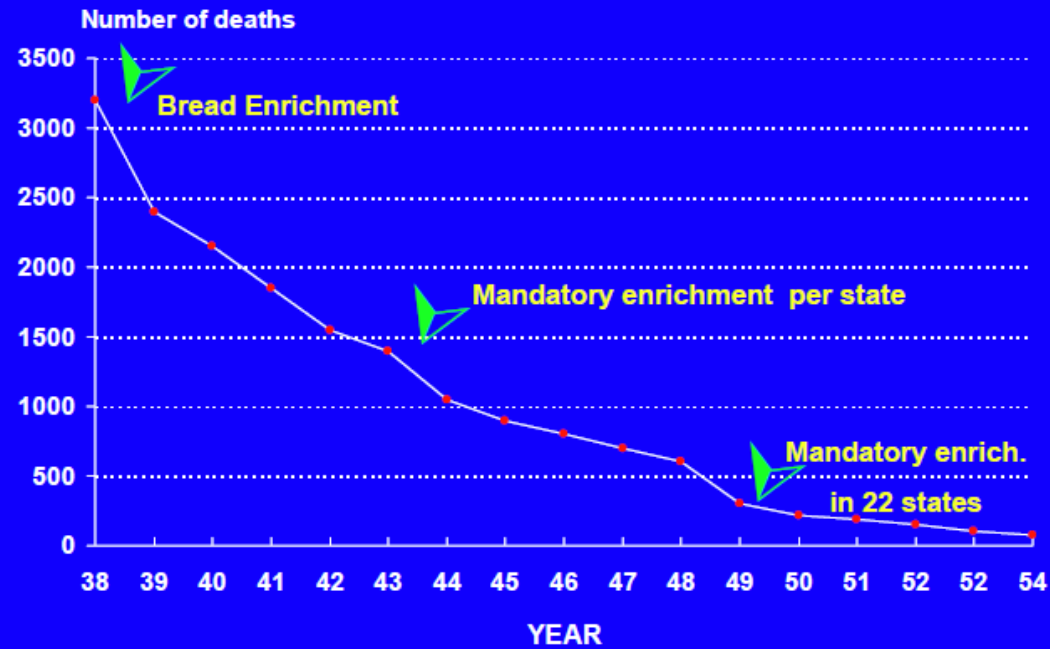
Potential Reach of Fortifiable milk

Target Reach in 2 years



# Flour

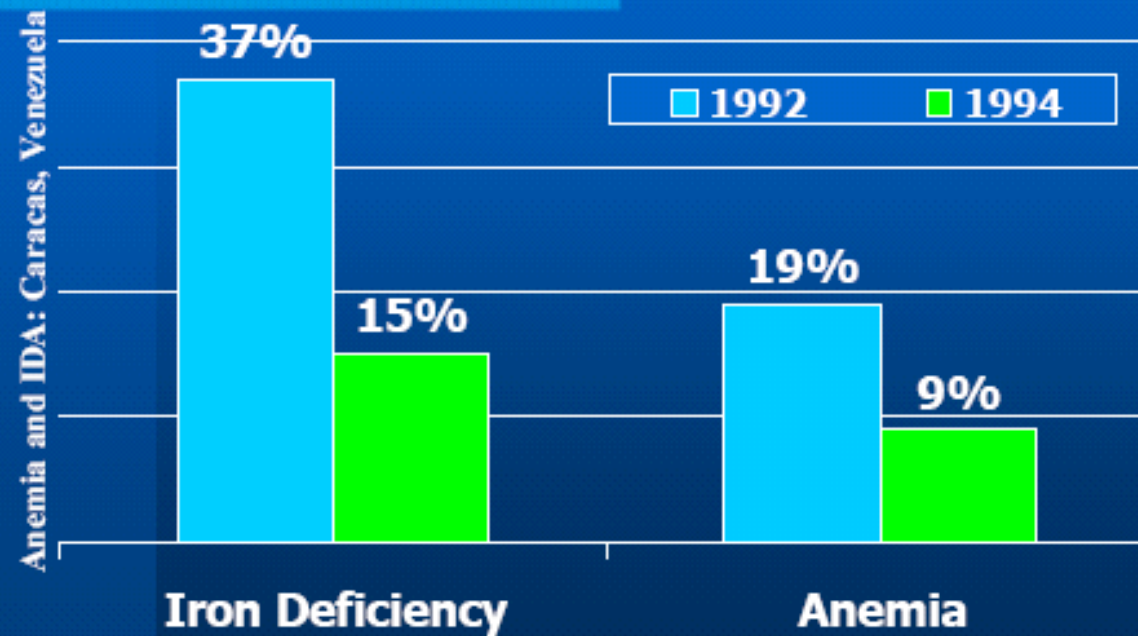
## DEATHS BY PELLAGRA IN USA EFFECT OF CEREAL ENRICHMENT



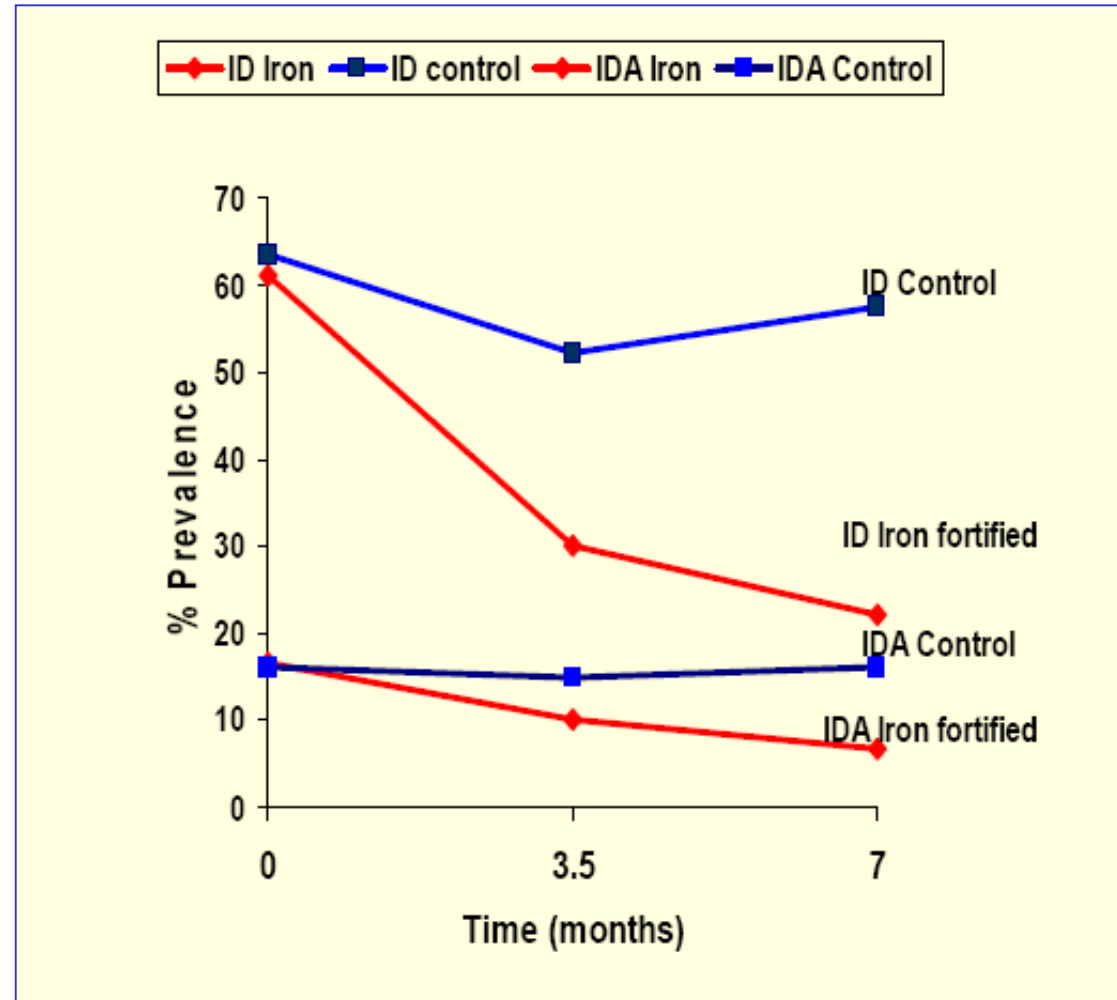
Source: D. Miller, 1955

# Flour

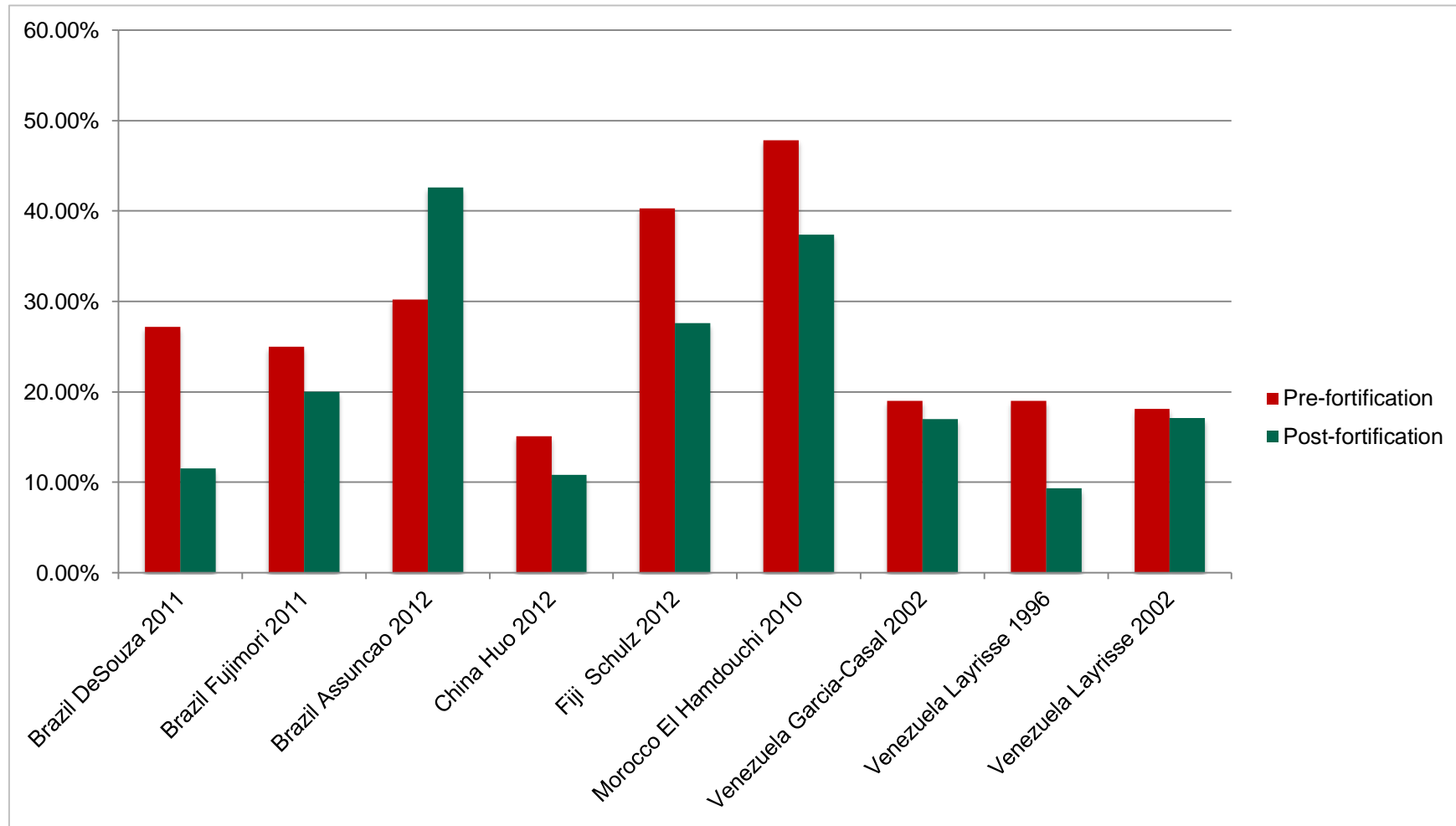
## Developing Country Impact Venezuela Flour Fortification



# Wheat Flour



## Flour fortification – Iron deficiency Effectiveness Studies



# 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

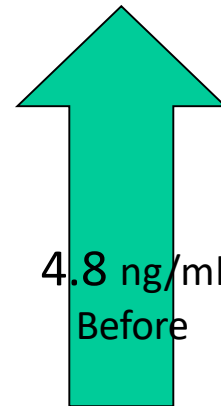
Food fortification with folic acid was associated with a significant reduction in the rate of neural-tube defects in Canada. The decrease was greatest in areas in which the baseline rate was high.



## Flour

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.

14.5 ng/ml  
Post-fortification

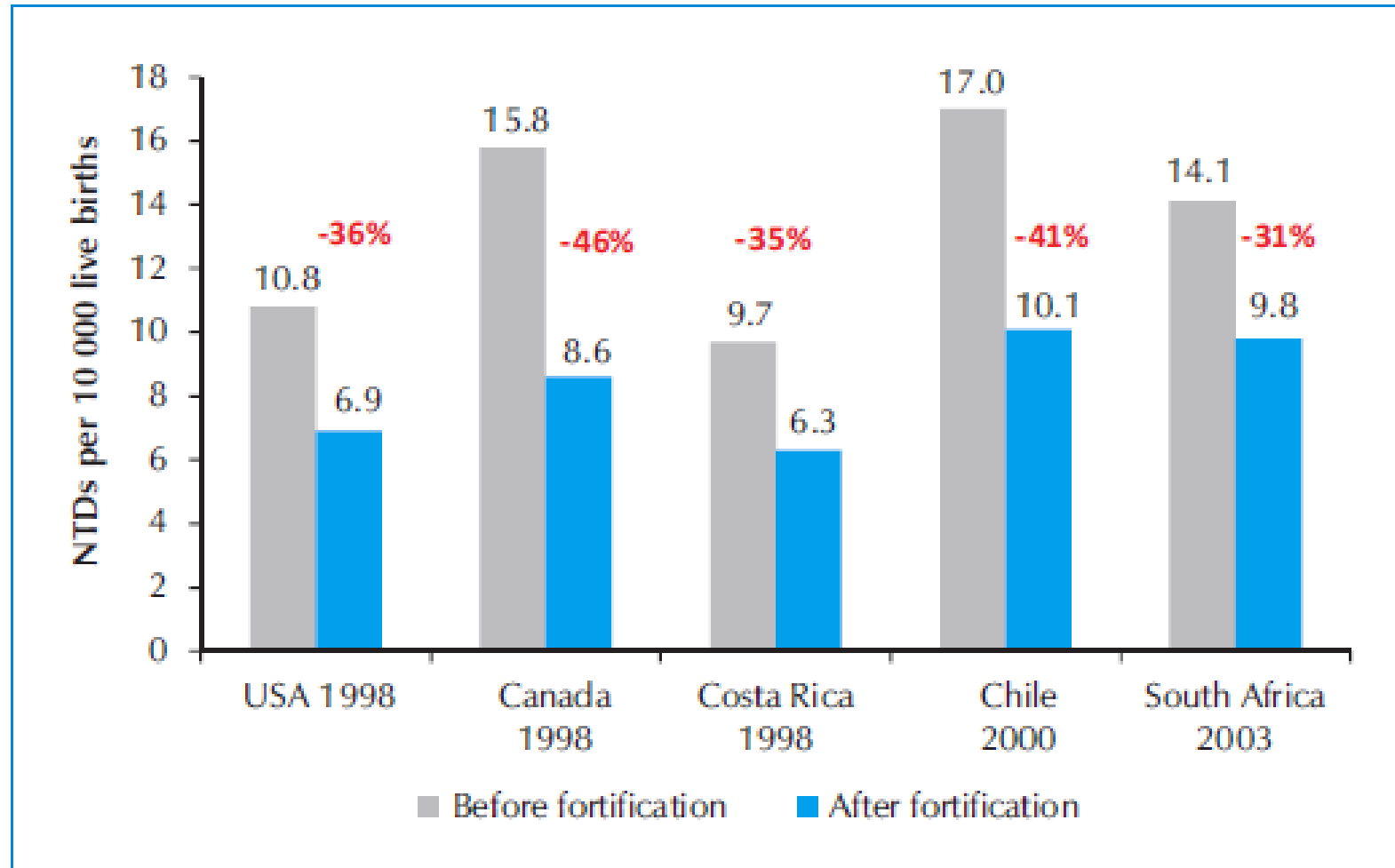


4.8 ng/ml  
Before

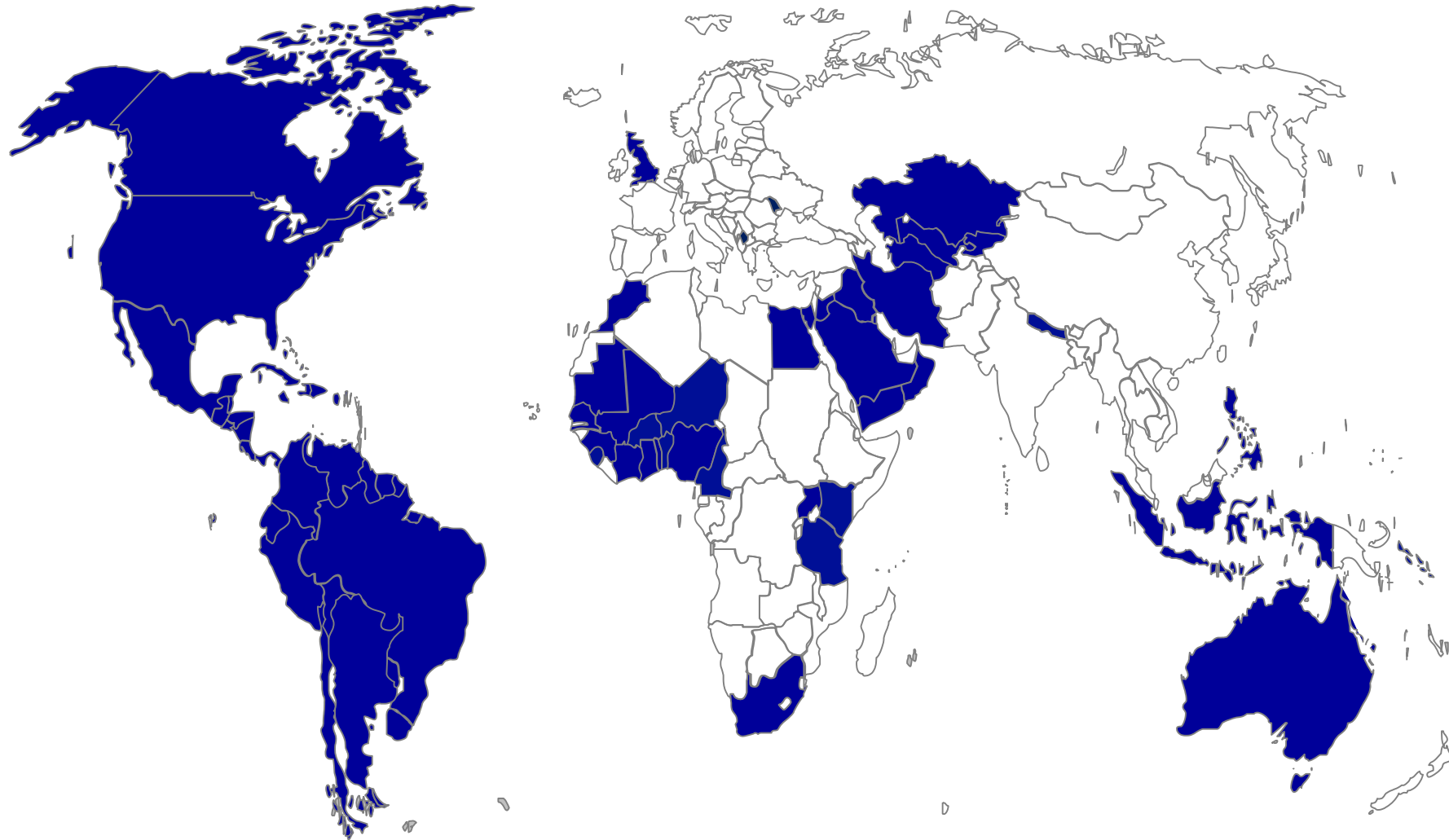


**US fortification rapidly increased the serum folate**

## NTD rates before and after fortification



# 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.

# Rice

**Bulk of the Research has focused on Iron fortification**

	Vehicle	Country	Source/Study Type	Title
Efficacy	Rice	India	American Journal of Clinical Nutrition, 2006	Extruded rice fortified with micronized ground ferric pyrophosphate reduces iron deficiency in Indian schoolchildren: A double-blind randomized controlled trial
	Rice	Mexico	Food and Nutrition Bulletin, 2008	Efficacy of iron-fortified Ultra Rice in improving the iron status of women in Mexico
	Rice	The Philippines	Journal of Nutrition, 2005	Iron-biofortified rice improves the iron stores of nonanemic Filipino women
	Rice*	Brazil	Journal of Nutrition, 2009	Iron-fortified rice is as efficacious as supplemental iron drops in infants and young children
	Rice	India	National Institute of Nutrition; Department of Biotechnology, Government of India, 2009	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
	Rice	The Philippines	International Journal for Vitamin and Nutrition Research, 2008	Efficacy of Iron-fortified rice in reducing anemia among schoolchildren in the Philippines
Acceptability	Rice	Thailand/Bangladesh	Journal of the Science of Food and Agriculture, 2009	Iron fortification and parboiled rice quality: appearance, cooking quality and sensory attributes
	Rice	N/A	International Journal of Food Science and Technology, 2008	Effect of Iron Compounds on the Storage Stability of Multiple Fortified Ultra Rice

# Point of use fortification - MNPs

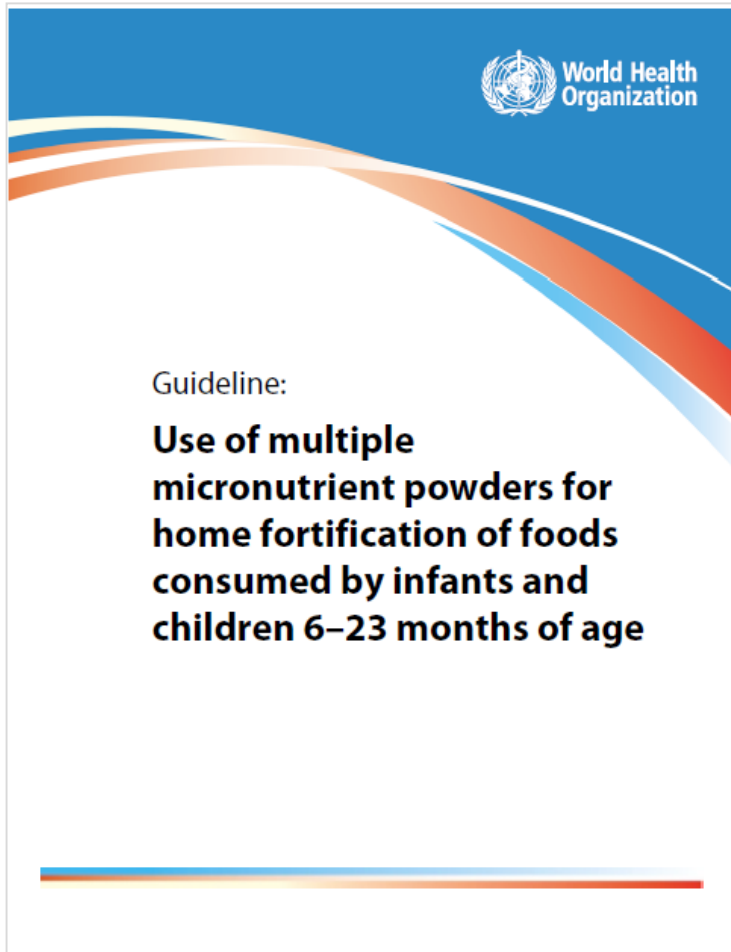


Guideline:

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




# Point of use fortification - MNPs



The image shows the cover of a World Health Organization (WHO) guideline document. The top left corner features the WHO logo and the text "World Health Organization". The background is white with a blue and orange curved graphic element. The text on the cover reads: "Guideline: Use of multiple micronutrient powders for home fortification of foods consumed by infants and children 6–23 months of age". At the bottom, there are logos for "sight and life", "WFP World Food Programme", and "HF-TAG Home Fortification Technical Advisory Group".

World Health Organization

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



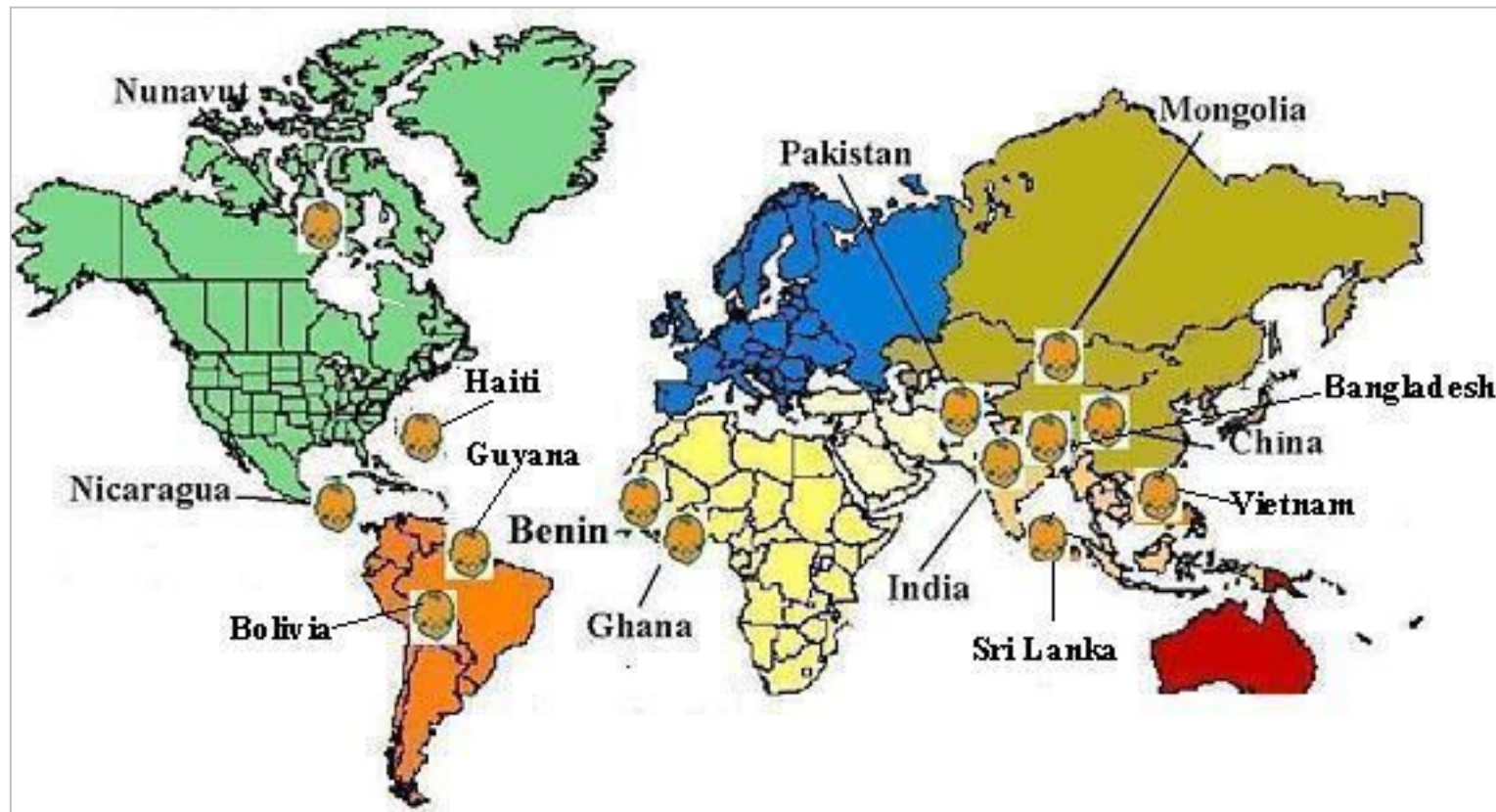
The image shows a woman in a white and pink sari feeding a young child sitting on the floor. The child is wearing a red top and blue shorts. There is a plate of food on the floor in front of the child. The background shows a simple living space with a corrugated metal wall.

**Home Fortification with Micronutrient Powders (MNP)**

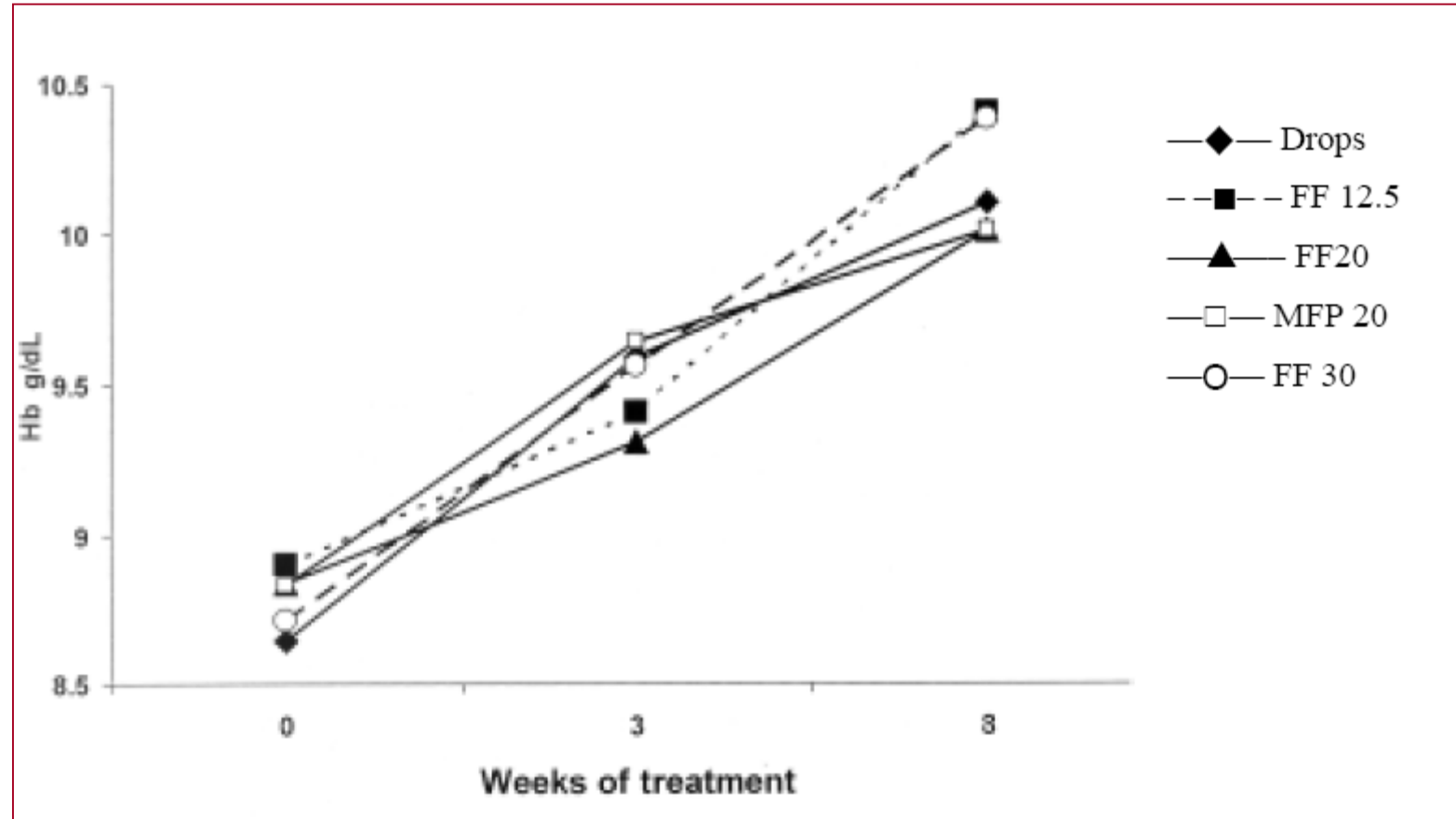
sight and life unicef WFP World Food Programme HF-TAG Home Fortification Technical Advisory Group

## Point of use fortification

Efficacy of MNPs established world wide



# Food fortification in India





## Food fortification in India

# Enhancements to Nutrition Program in Indian Integrated Child Development Services Increased Growth and Energy Intake of Children<sup>1,2</sup>

Rasmi Avula,<sup>3\*</sup> Edward A. Frongillo,<sup>3\*</sup> Mandana Arabi,<sup>4</sup> Sheel Sharma,<sup>5</sup> and Werner Schultink<sup>4</sup>  
J. Nutr. doi: 10.3945/jn.109.116954.

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

## Point of use fortification



### Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age (Review)

De-Regil LM, Suchdev PS, Vist GE, Walleser S, Peña-Rosas JP

- MNP is an effective intervention to reduce anaemia and iron deficiency in children six months to 23 months of age.
- The benefits of this strategy on child survival and developmental outcomes are unclear.
- Data on effects of malaria outcomes are lacking and needs further investigation.
- MNP containing multiple micronutrients are well accepted but adherence is variable

## Impact at national level

Denmark, Sweden, Finland – 10 -20 % of iron intake was from fortified foods

*Hallberg L, et al. Nutr Dieta 1989;44:94-105.*

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

*Sichert-Hellert W. et al. Eur J Clin Nutr 2000;54:81-86.*

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

*British Journal of Nutrition* (2007), **97**, 1177–1186  
© The Authors 2007

doi: 10.1017/S0007114507669207

### **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)*

*British Journal of Nutrition* (2007), **97**, 1051–1052  
© The Authors 2007

doi: 10.1017/S0007114507709121

### ***Invited Commentary***

### **Further evidence that food fortification improves micronutrient status**

# Impact of food fortification

Das et al. *Systematic Reviews* 2013, 2:67  
<http://www.systematicreviewsjournal.com/content/2/1/67>



RESEARCH

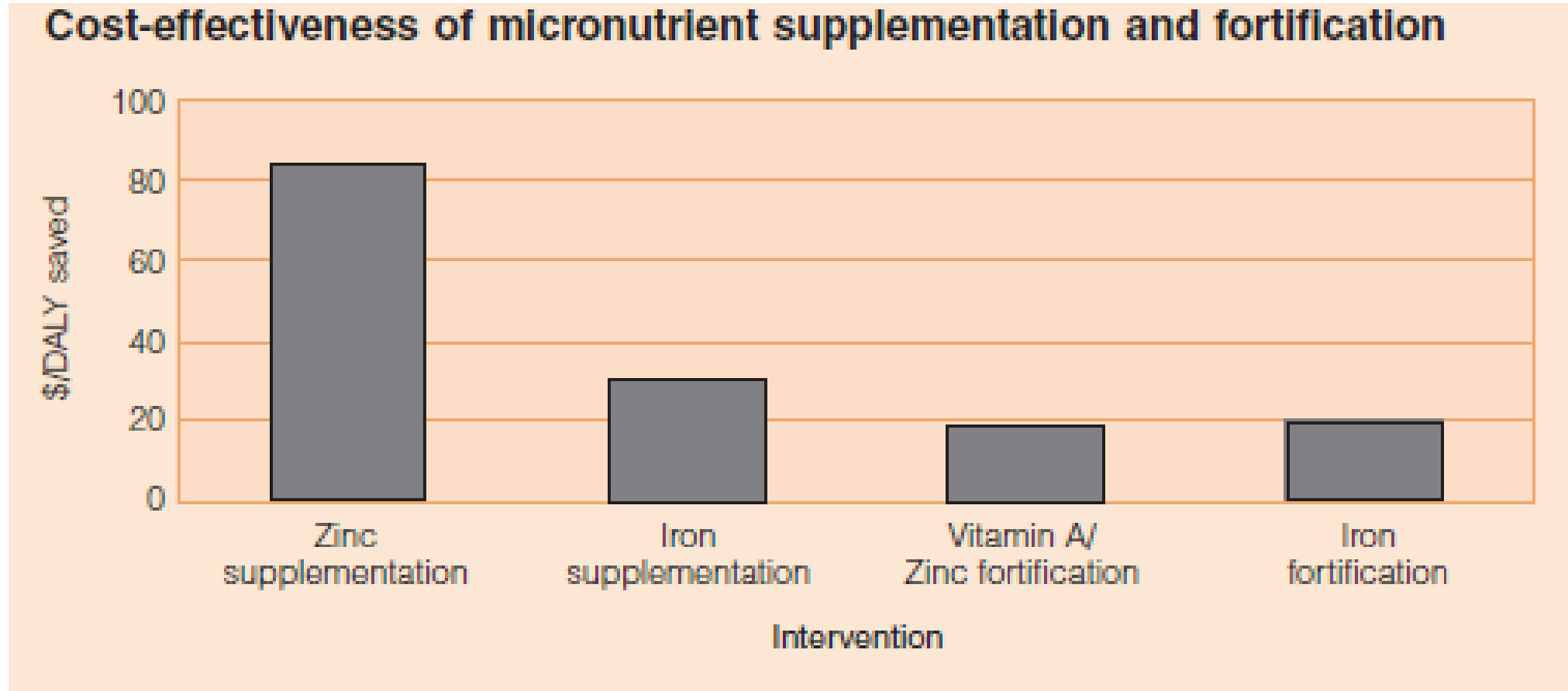
Open Access

## Micronutrient fortification of food and its impact on woman and child health: a systematic review

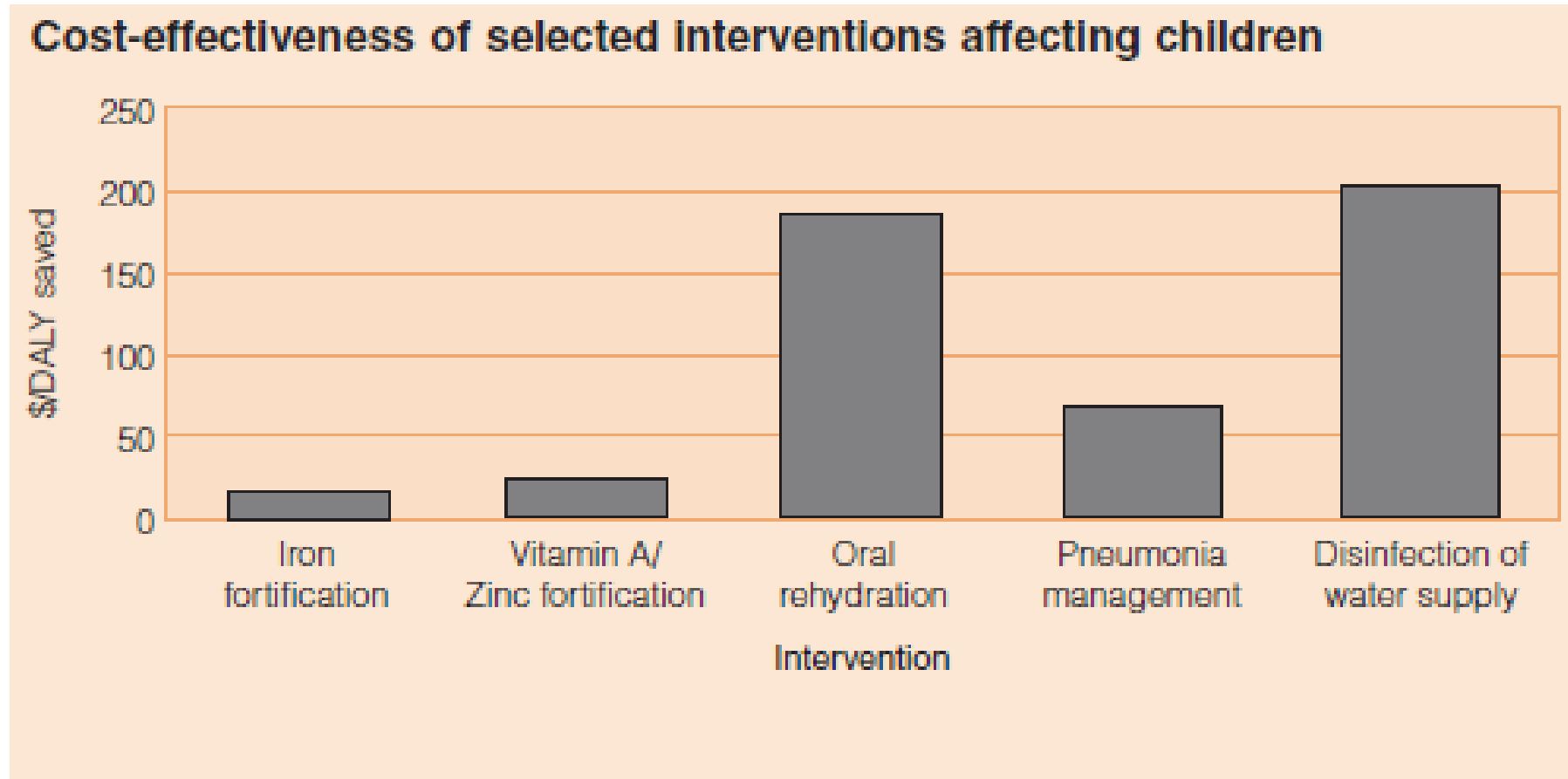
Jai K Das, Rehana A Salam, Rohail Kumar and Zulfiqar A Bhutta\*

**Conclusion:** Fortification is potentially an effective strategy but evidence from the developing world is scarce. Programs need to assess the direct impact of fortification on morbidity and mortality.

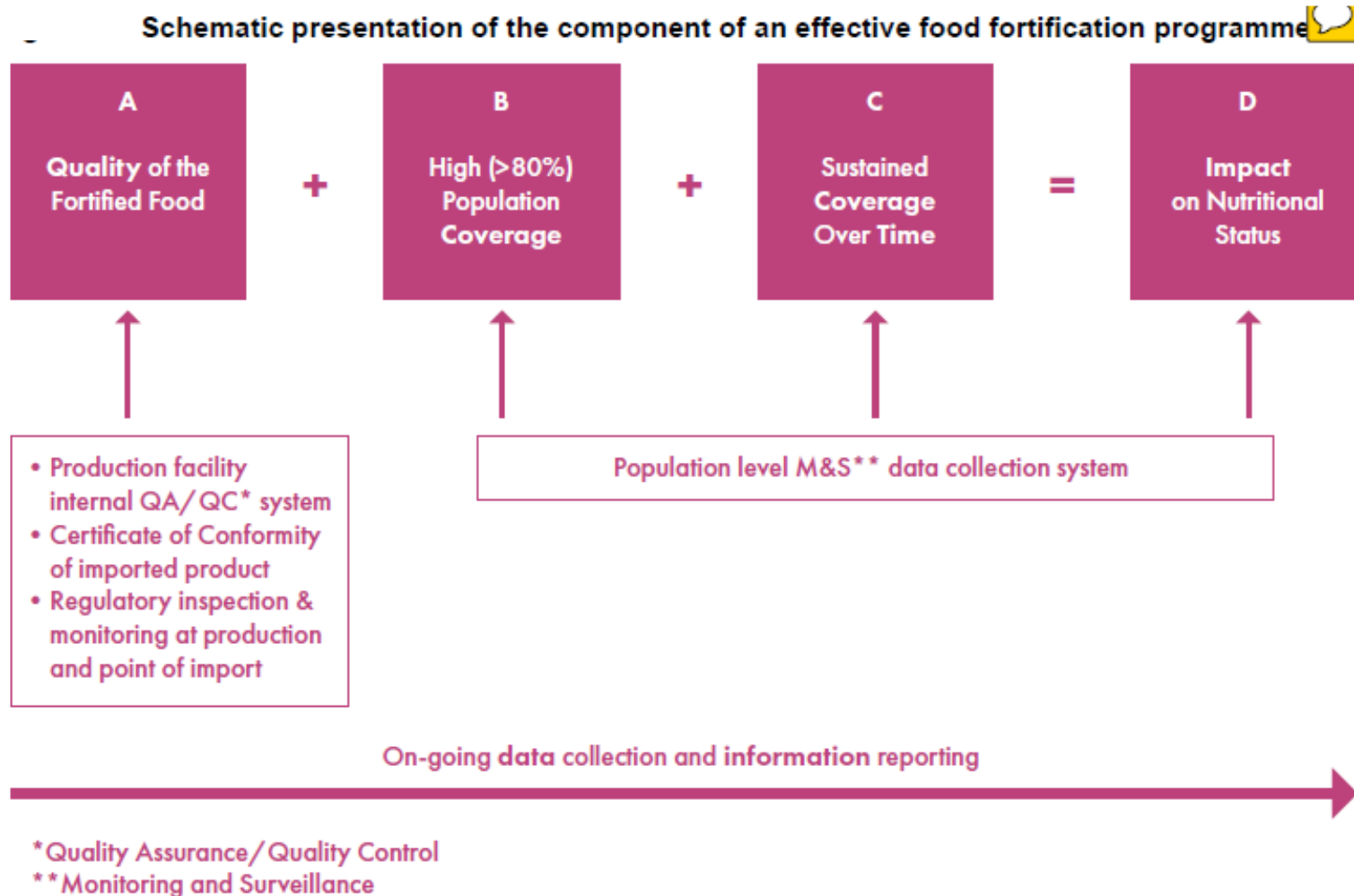
# Cost-effectiveness



# Cost-effectiveness



# Impact of food fortification

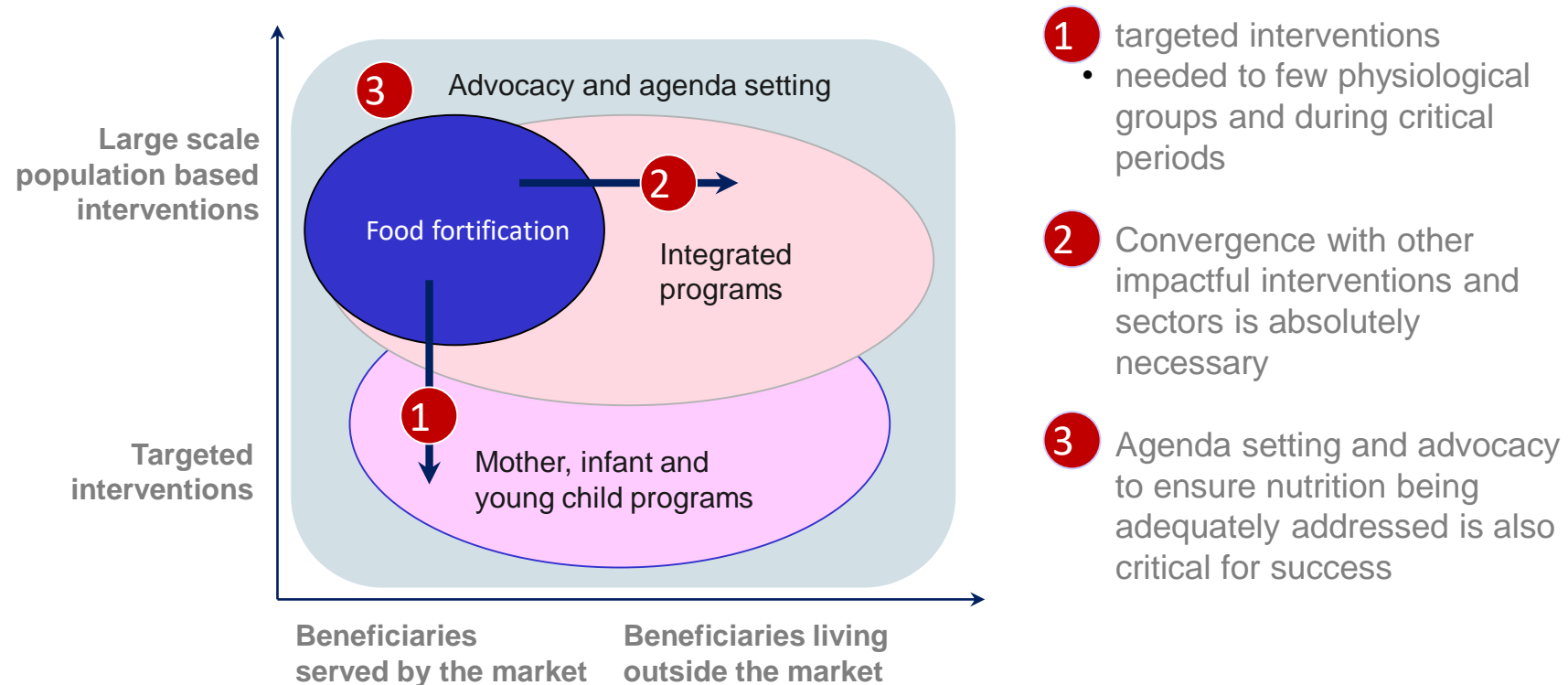




# Impact of food fortification

- if well designed and properly implemented, the various options for food fortification can make a large contribution to improving public health outcomes.
- There has been quick scaling up with over 140 countries implementing national USI programs, 85 countries mandating at least one kind of cereal grain fortification with iron and folic acid, and over 40 countries mandating the fortification of edible oils, margarine and ghee with vitamin A and/or D.
- Food fortification, however, should not be a stand-alone intervention; rather it needs to be seen as complement to long-term nutrition-specific and nutrition-sensitive strategies to strengthen food systems, increase nutritional diversity in people's diets, and address nutrient deficiencies through national systems.

# complementary strategy



Integrated approaches needed to ensure most vulnerable populations are reached