



Ahead of your needs

Flour Fortification

Dr. Max Blum, Roche Vitamins Europe Ltd.

P.O. Box 3255

4002 Basel / Switzerland

max.blum@roche.com

Bread: A staple food



Bread and cereals

The fundament of a healthy diet

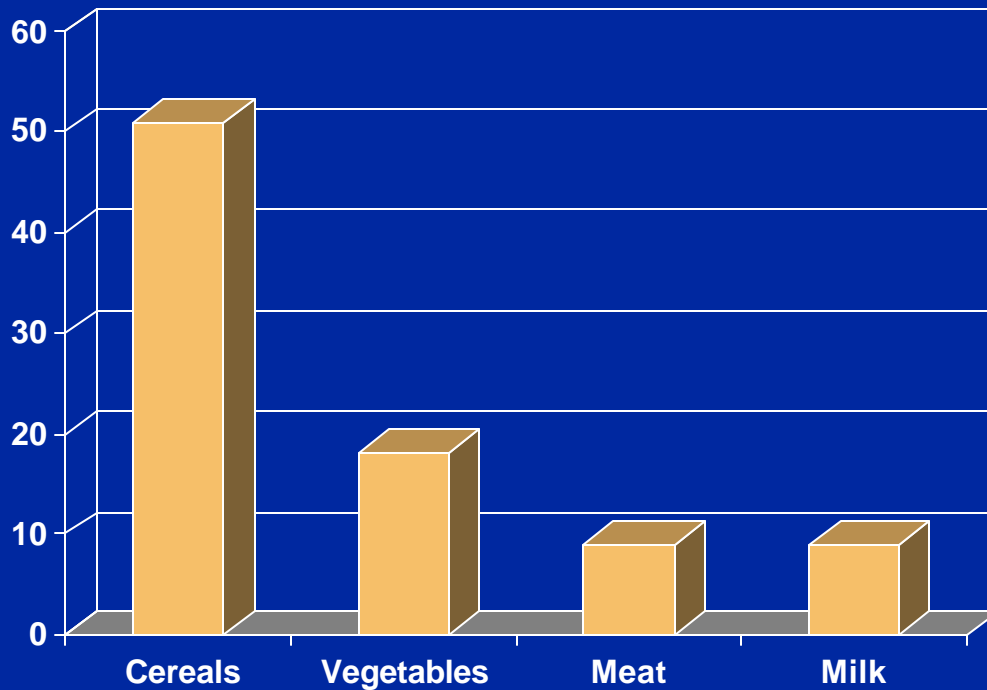


Thiamine sources in the diet

Bailey A, et al, Br J Nutr 72:111-25, 1994



Percent contribution to thiamine intake





The wheat grain

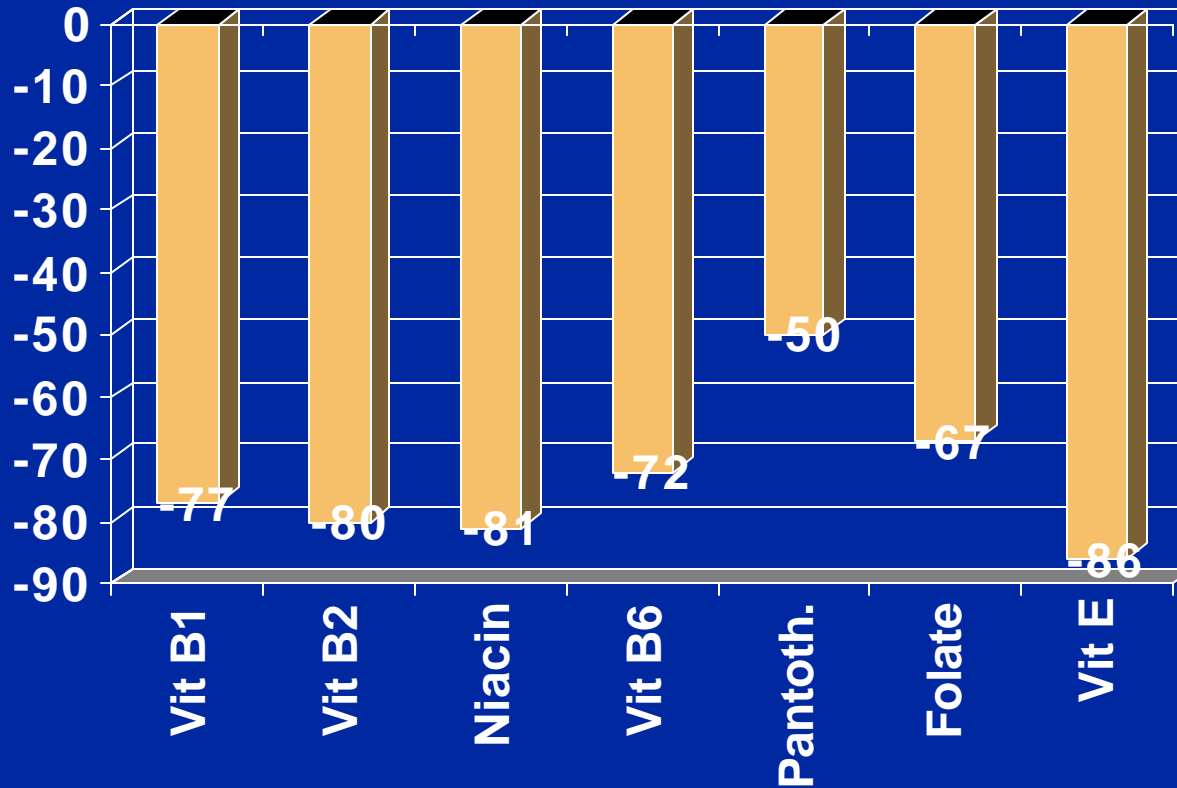
Nutrients lost during milling



- ***Nutrients lost during milling:***
 - Thiamine
 - Riboflavin
 - Niacin
 - Folic acid
 - Iron
 - Zinc

Vitamin losses during milling of wheat flour

Percent losses





Principles of food fortification

Codex Alimentarius

Nutrients shall be added to foods for the purpose of:

- **Restoration** of nutrients lost during food processing and milling
- **Nutritional equivalence** for food substitutes
- **Fortification** for prevention of low intake and micronutrients deficiencies
- To foods for **special nutritional purposes**.



Food fortification: Examples of highly successful interventions

Micronutrient	Food vehicle	Country
Iodine	Table salt	Switzerland 1923
Vitamin D	Milk	UK, USA 1933
Vitamin A	Margarine	Denmark 1930
Vitamin B1,B2, niacin, folic acid	Flour, corn meal, cereals	USA, UK 1941 Folate: 1998
Vitamin A	Sugar	Guatemala 1974

..



Health benefits of vitamins added to flour and bread



General health benefits of food fortification

- Reduces child mortality
- Enhances child growth and development
- Enhances physical and intellectual performance of children
- Reduces maternal mortality
- Eliminates nutritional blindness, goiter and cretinism
- Reduces the risk for chronic disease in later life.

Health benefits of B-Vitamin fortification

Vitamin B1, B2, B6, niacin, folic acid, B12

- For neurological & psychomotor development
- To improve learning and cognitive functions
- For prevention of anemia
- For prevention of birth defects (e.g. spina bifida)
- For prevention of cardiovascular disease & cancer
- To enhance immunity.

Health benefits fortification

Iron



- To reduce iron deficiency anemia in children and women
- To reduce anemia related fatigue and lethargy
- To enhance brain development and cognitive functions
- To reduce maternal mortality at birth
- To enhance immunity.



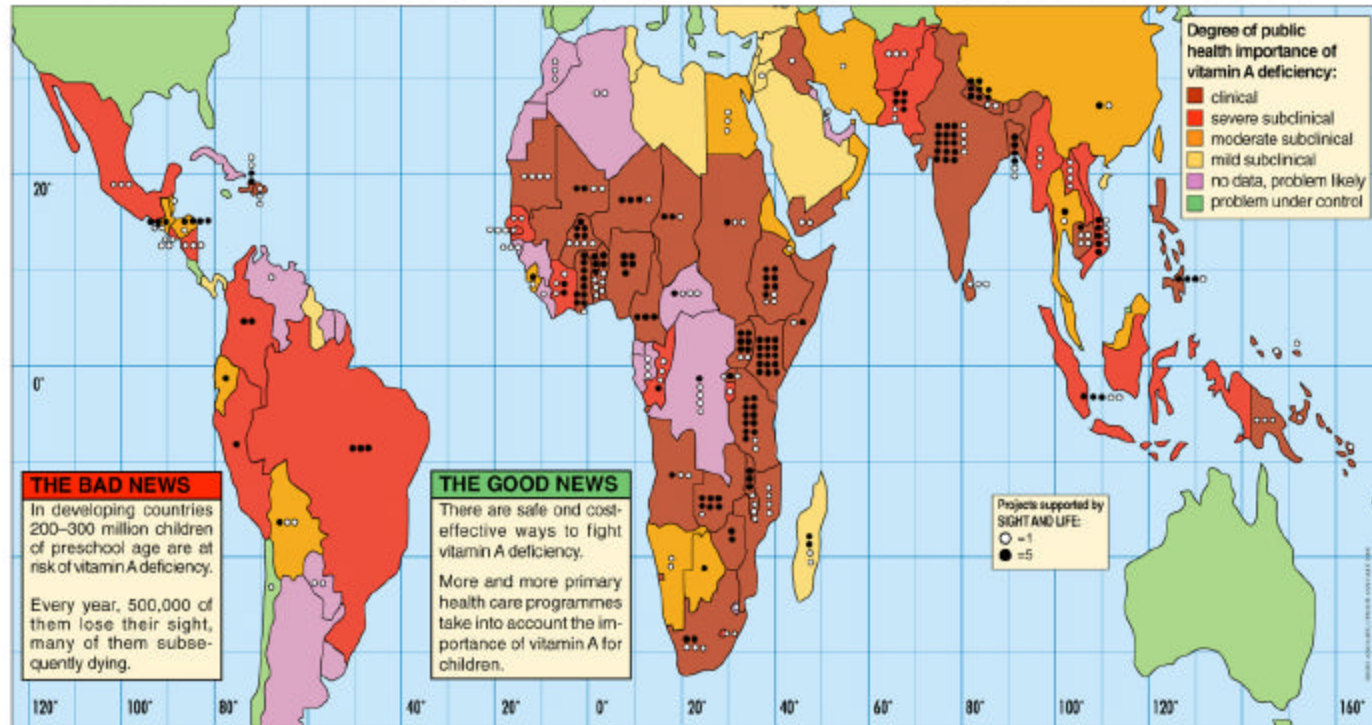
Health benefits

Vitamin A

- Prevention of nutritional blindness
- Reduction of child mortality
- Reduces maternal mortality
- For normal growth and development
- For enhancement of immunity and mucosal integrity
- Reduces severity of diarrhoea
- Reduces anemia
- Reduces fatality rate in measles



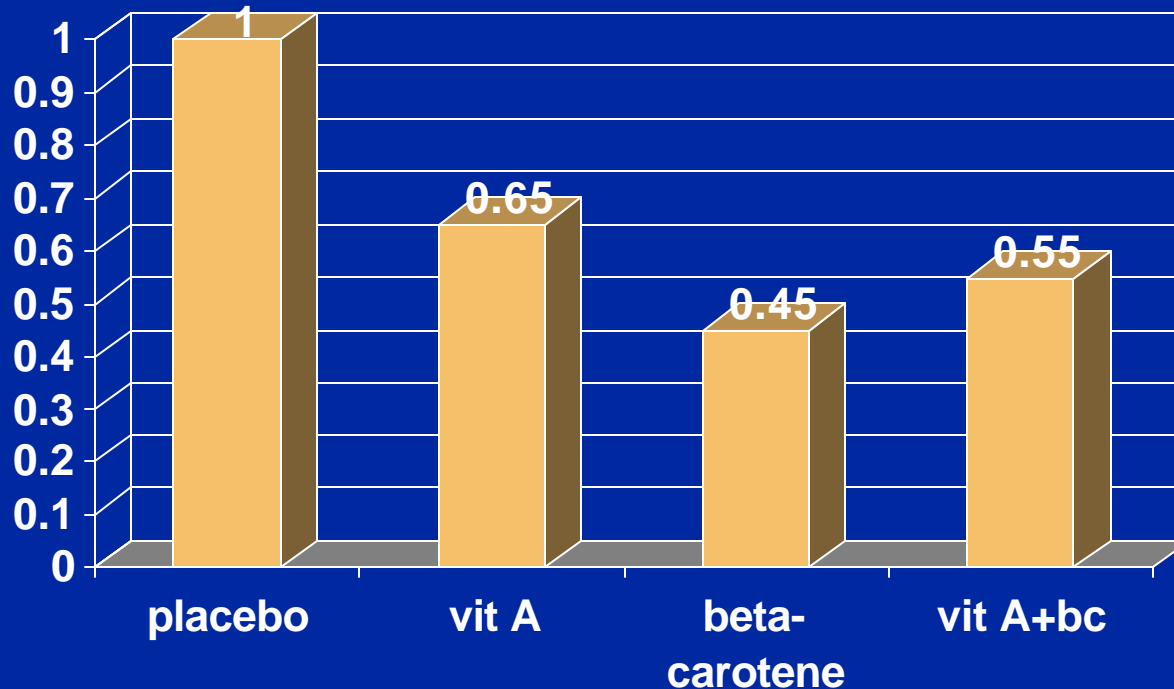
WHAT CAN BE MORE IMPORTANT THAN SIGHT AND LIFE?





Vitamin A and beta-carotene supplementation reduces mortality in pregnant women (NNIPPS-2 Study Nepal)

Relative risk



Dose: 7000 RE once per week

Folic acid

Health benefits

- Reduction of birth defects by 30 to 40 percent
- Lowering of plasma homocysteine - a new risk factor for cardiovascular disease and stroke
- Reduction of total mortality (Hordaland County Study Norway):
 - Lower mortality in persons with low homocysteine levels (< 9.0 micro moles per liter)
 - Each increment of 5 micro mol homocysteine is associated with a 49 % increase in mortality.

Neural tube defect

Spina bifida

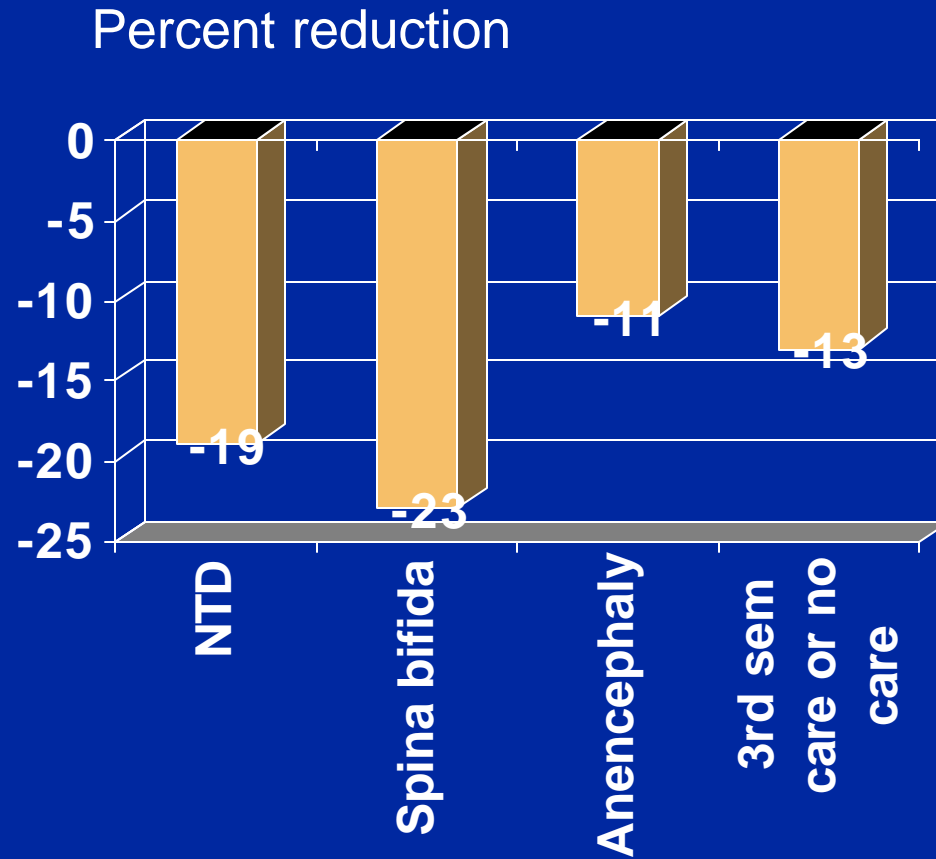




Folic acid addition level to flour, bread and cereals

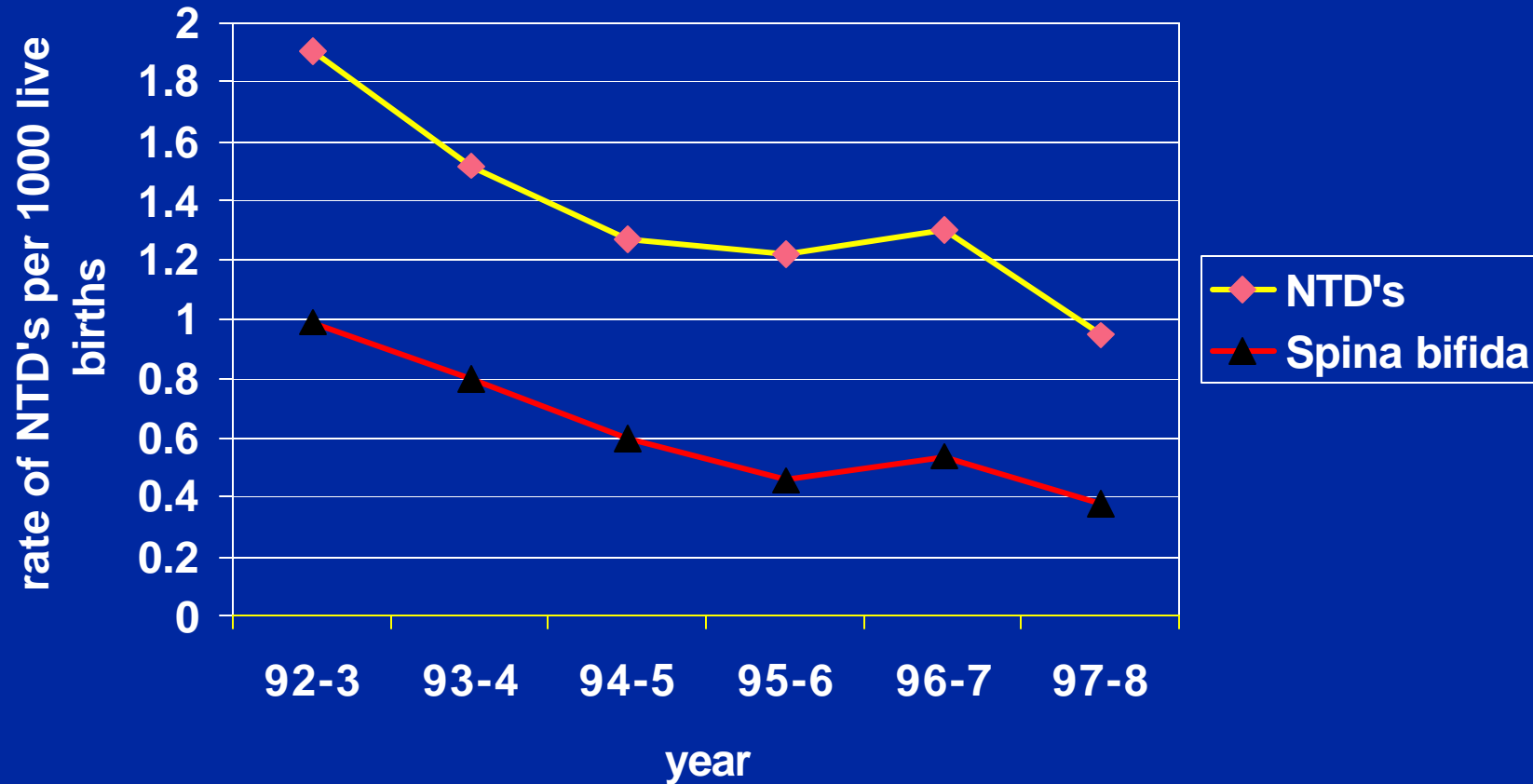
Cereals, flour, bread	Folic acid mcg / 100 g
Bread, bakery products	95
Flour	154
Corn meal	154 - 220
Rice	154 - 308
Pasta	198 - 264

Flour and bread fortification with folic acid reduces birth defects

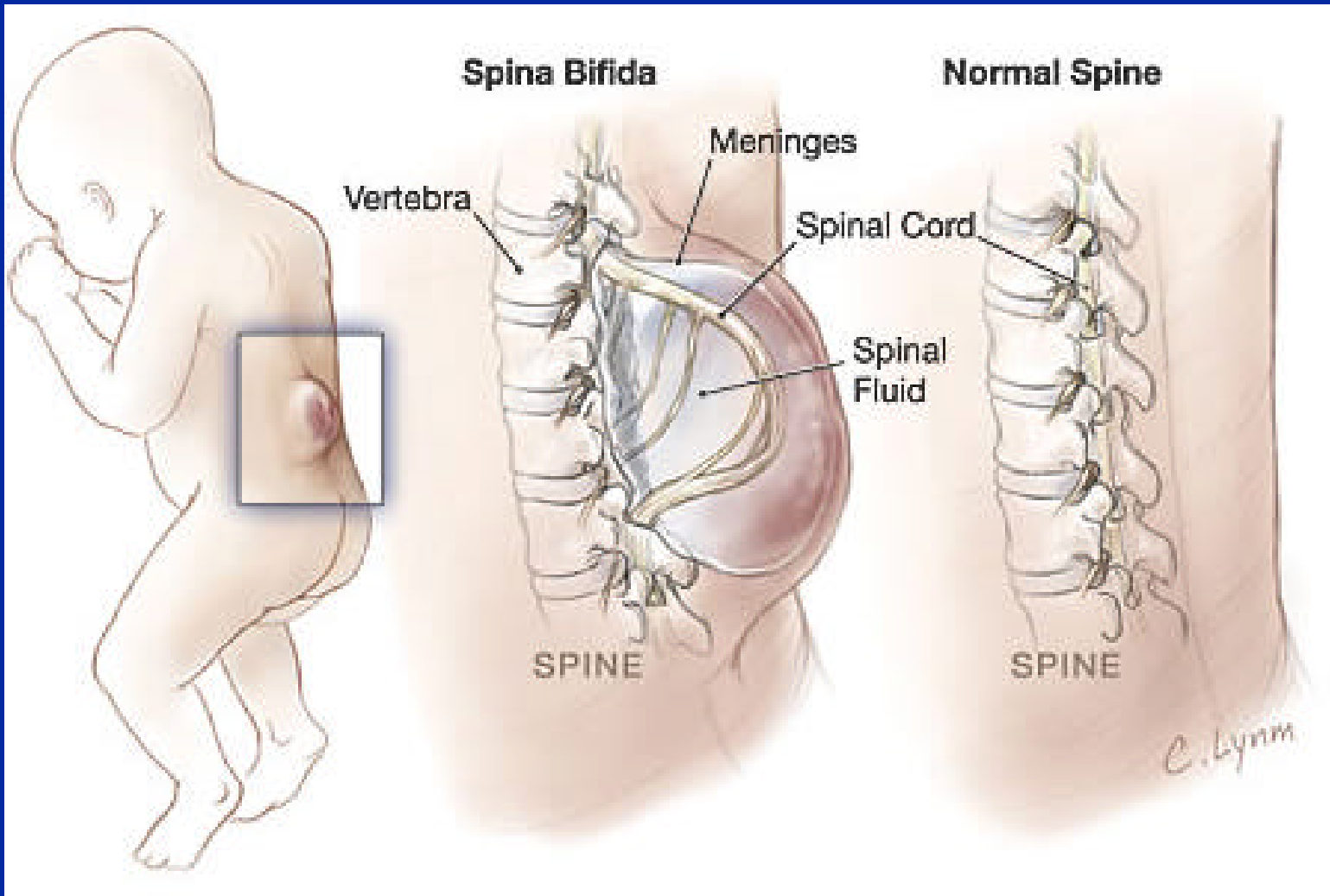




Declining rates of NTD's in South Carolina 1992-1998 following the introduction of folic acid supplementation



Stevenson, R E et al, Pediatrics 2000, 106: 677-683



http://www.cdc.gov/ncbddd/folicacid/



The screenshot shows a Netscape browser window displaying the CDC Folic Acid Campaign website. The browser's address bar shows the URL <http://www.cdc.gov/ncbddd/folicacid/>. The website features the CDC logo with the tagline "SAFER • HEALTHIER • PEOPLE" and the text "National Center on Birth Defects and Developmental Disabilities". The main heading is "Folic Acid Now" with a sub-heading "Learn More About Folic Acid". Below this, there are links for "Overview", "FAQs", "Quiz", and "Order Materials". The main section is titled "Why Folic Acid is So Important" and contains the following text: "Folic acid, also known as folate, is a B-vitamin that can be found in some enriched foods and vitamin pills. If women have enough of it in their bodies before pregnancy, this vitamin can decrease the risk for neural tube defects (NTDs), which are birth defects of the baby's brain (anencephaly) or spine (spina bifida)." Below the text is a photograph of three women sitting around a table, engaged in a discussion. At the bottom of the page, there is a paragraph: "For many women, an easy way to be sure you're getting enough folic acid is to take a vitamin with folic acid in it. The U.S. Public Health Service recommends that all women who could possibly" (the text is cut off). The browser's taskbar at the bottom shows several open applications: "Start", "Inbox - Microsoft Outlook", "Folic Acid Campaign, ...", and "Microsoft PowerPoint - [Du...". The system tray on the right shows the time as 11:37.

Fortification concepts for flour, bread and cereals



- 5 B-Vitamins: B1, B2, B6, Niacin, Folate
- 5 B-Vitamins plus iron
- 5 B-Vitamins, plus Vitamin A & iron

Fortification concepts for flour, bread and pasta

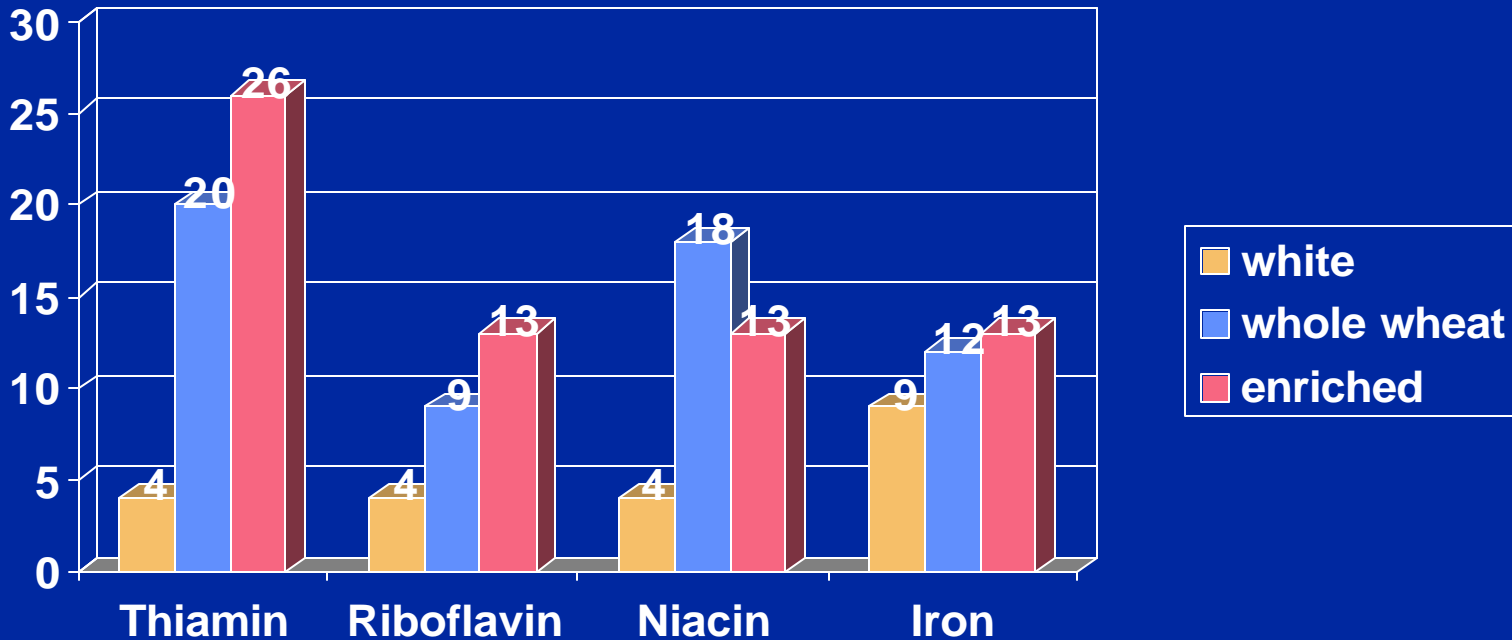


Vitamins & minerals	Flour	Bread	Pasta
B-Vitamins	X	X	X
Iron	X	X	X
Vitamin A	In countries with low intake	In countries with low intake	
Calcium	optional	optional	optional
Zinc	optional	optional	optional

Nutritive value of enriched bread vs. white or whole wheat bread



% RDA per 100 gram bread (3 slices)





Vitamin premix addition to flour

- Vitamin premixes for flour enrichment
- Dosage
- Vitamin stability

ROVIFARIN F

Premix: 4 B-Vitamins plus iron



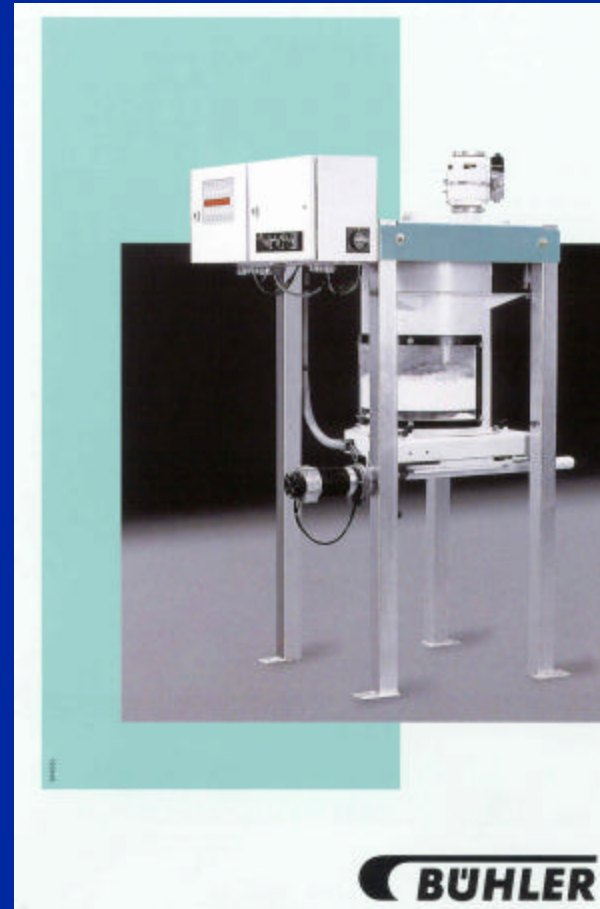
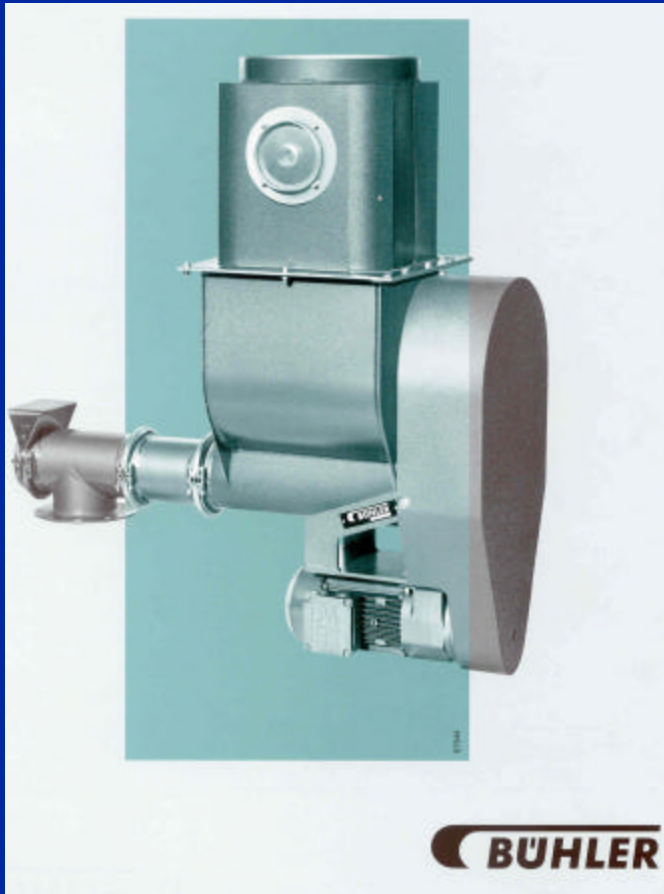
Ingredients	Gram per kg premix	Label claim per 100 g flour *	Percent of RDA Per 100 g flour
Thiamine	49.528	0.28 mg	20
Riboflavin	36.200	0.25 mg	15
Folic acid	18.100	90 mcg	45
Niacin	481.350	3.37 mg	18
Iron	393.323	2.75 mg	20

* Addition rate: 70 grams premix per 1000 kg flour (1 MT)

Modern high throughput milling facility



Vitamin dosage equipment for small to medium size mills



Quality control of fortified flour


Sampling device





Content uniformity of fortificant in final product

- Flowability of premix
- Particle size and shape
- Mixing equipment and mixing procedure
 - Addition rate
 - Pre-dilution of premix
- ***Quality control procedure***
 - sample size and frequency
 - analytical variability

 **Content uniformity will improve with time and experience**



Shelf life of flour

Factors affecting shelf life

- Flour extraction rate, lipid content
- Flour moisture (water content)
- Quality of premix
 - iron, zinc compound desiccated, no crystal water
 - selection of ingredients e.g. carrier
- Storage conditions (temperature, humidity)



Vitamin stability in fortified flour

Vitamin	Initial	Storage 6 mts, RT	Storage 4 w, 45 d C
Vitamin A (IU)	8200	7950	7500
Vitamin E (IU)	15.9	15.9	15.9
Vitamin B6 (mg)	2.3	2.2	2.2
Folic acid (mcg)	370	300	300

Source: Roche Vitamins



Vitamin stability in bread made of fortified flour

Vitamin	Label claim	Content after baking	Content 5 days storage at RT
Vitamin A (IU)	7500	8280	8300
Vitamin E (IU)	15	16	16
Vitamin B6 (mg)	2	2.4	2.5
Folic acid (mcg)	300	340	360

Source: Roche Vitamins



Iron

Iron salts suitable for flour fortification

- Elemental iron, reduced (fine particle size)
- Iron pyrophosphate
- Iron fumarate (for biscuits, rusks & crackers)

Relative bioavailability of iron compounds used in food fortification

Iron compound	Relative bioavailability	Relative cost
Ferrous sulphate	100	1.0
Ferrous gluconate	89	5.1
Ferric orthophosphate	25-32	4.1
Ferric pyrophosphate	21-74	2.3
Elemental iron	75	
Ferrous succinate	92	4.1
Ferrous fumarate	100	1.3
Ferric saccharate	74	5.2

Adapted from Hurrell R; Nutr Rev 60:7, S7-S15, 2002

Iron

Dietary factors affecting iron absorption

- ***Enhancers of iron absorption:***
 - Meat (heme iron)
 - Vitamin C
 - Fruits and vegetables rich in Vitamin C
- ***Inhibitors of iron absorption:***
 - Cereals with a high content of phytic acid (whole wheat, corn, millet)
 - Soybeans high in phytic acid
 - Tea rich in tannins and polyphenols.



Iron overload

- ***Net iron requirement per day:***
 - 2 mg for women,
 - 1 mg for men
- ***RDA for iron***
 - 10 mg for men
 - 15 mg for women
- Low absorption of non-heme iron
- Absorption increases in iron deficient individuals

Contribution of fortified foods to daily vitamin and iron intake



Vitamin / iron	Percentage
Vitamin A	13
Vitamin C	8
Vitamin B1	24
Vitamin B2	20
Niacin	18
Vitamin B6	6
Folic acid	6
Vitamin B12	4
Iron	24



BB BAKERIES BREAD



CONCEPT: MICRONUTRIENT ENRICHED BREAD

MICRONUTRIENT CONTENT:

(per 200g)			% RDA*
	Vitamin A	188RE	18
	Vitamin B ₁	0,32mg	22
	Vitamin B ₂	0,32mg	20
	Niacin	6,17mg	34
	Vitamin B ₆	0,5mg	26
	Folic Acid	44mcg	22
	Iron	3,0mg	22

* South African RDA for persons 10 years and older

HEALTH CLAIMS: Added vitamins and minerals

MANUFACTURER: BB Bakeries
341 Sydney Road,
Durban, South Africa



Fortification Basics

Wheat Flour

Rationale

Wheat is the most widely produced cereal in the world, most of which is destined for human consumption; thus, its contribution to energy intake is significant, particularly in the Americas and the Middle East (Table 1).

The processing of whole wheat to wheat flour is generally concentrated in a few large mills. The resulting flour is used to make bread, biscuits, pasta, and other products. Because of its widespread geographic distribution, acceptance, stability, and versatility, wheat flour is a suitable vehicle for delivering micronutrients to mankind.

Micronutrient Content of Wheat and Wheat Flour

In its natural state, wheat is a good source of vitamins B1 (thiamine), B2 (riboflavin), niacin, B6 (pyridoxine), E, as well as iron, and zinc.

Nevertheless, because most of these nutrients are concentrated in the outer layers of the wheat grain (Figure 1), a significant proportion is lost during the milling process. For lower extraction rates of flour (i.e. more refined flour), the loss of vitamins and minerals is greater (Figure 2).

Nutrients Generally Added to Wheat Flour

In developed countries, wheat flour is generally fortified with vitamins B1, B2, niacin, and iron. In some countries calcium and folate are also added. Vitamins A and D can also be added to flour.

The levels of vitamin B1, niacin, and iron added to wheat flour is often equivalent to the amount lost in milling, i.e. these micronutrients are restored and the flour is enriched. For other micronutrients such as vitamin B2, the amount added is over and above that lost in milling, i.e. the flour is fortified.

Fortification rather than enrichment is done when the overall diet is deficient in particular micronutrients and restoring the micronutrients lost in milling will not make good this deficit.

Technology

The technology for fortifying flour is simple. First, a premix

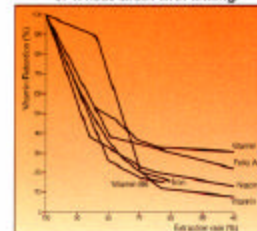
Table 1
Per Capita Wheat Consumption
in Selected Countries

Country	Consumption (g/person/day)	% of Daily Energy Intake
Pakistan	318	45
Turkey	454	44
Syria	490	44
Chile	372	42
Egypt	397	35
Greece	371	29
Argentina	344	28
Uruguay	269	26
Bolivia	159	20
South Africa	191	18
Peru	136	17

Figure 1
Schematic Diagram of the Wheat Grain



Figure 2
Changes in Micronutrient Content
of Wheat Grain with Milling



Adapted from FAO, 1975. *Wheat in Human Nutrition* and Thomas, E. 1966. *Nutritional - physiological views in processing cereal products*. *Vegetables*: 15, 360.





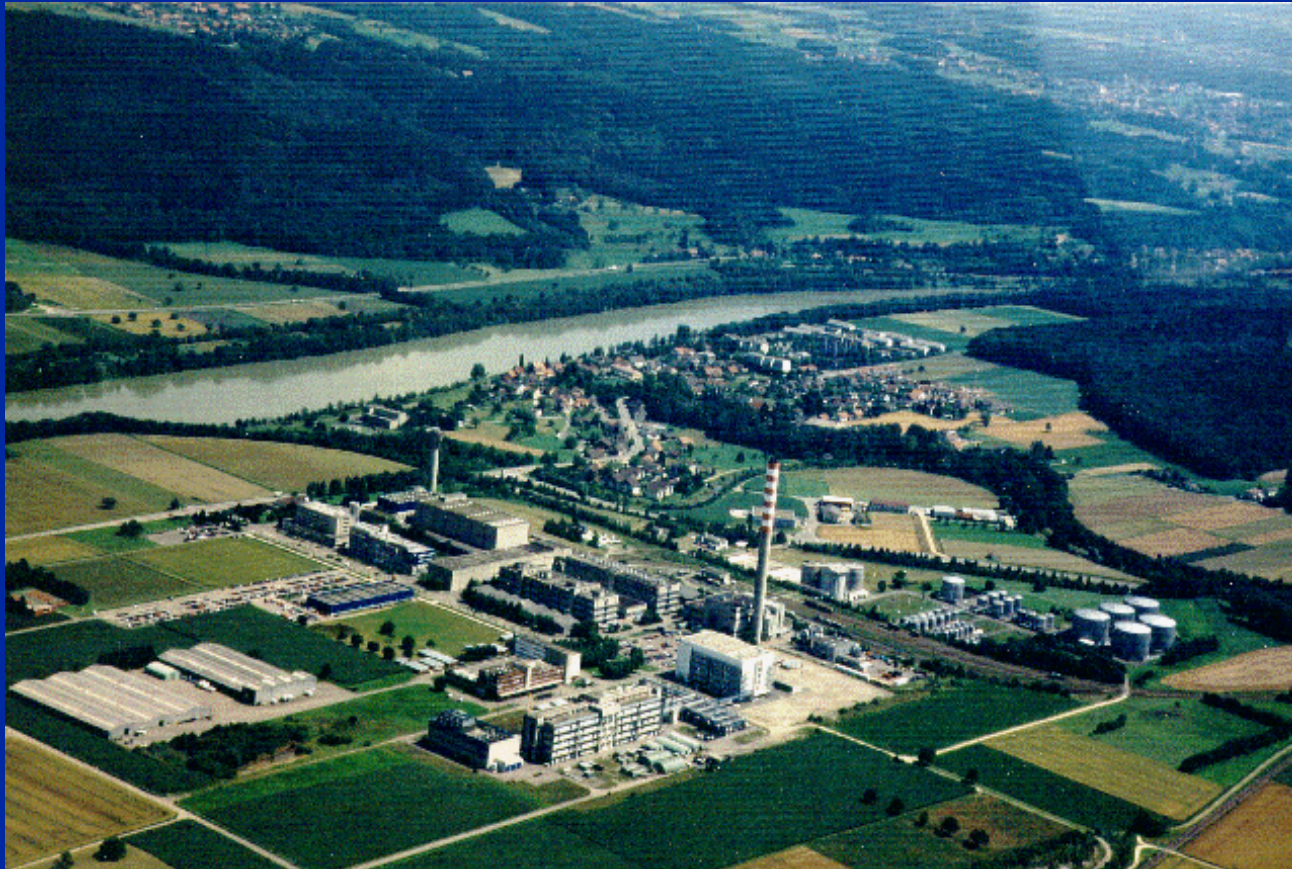
Internet

Useful addresses

- ***American Association of Cereal Chemists:***
- www.aaccnet.org/
- ***The American Institute of Baking:***
- www.aibonline.org/
- ***Buhler Milling:***
- www.buhlergroup.com/
- ***Roche Vitamins Inc.***
- www.roche-vitamins.com/

Roche Vitamin Factory

Sisseln / Switzerland



Thank you!



Back-up slides





Strategies to eliminate micronutrient malnutrition

- Dietary diversification
- Nutrition education
- Food fortification
- Dietary supplementation



Micronutrient deficiencies

“The Hidden Hunger Problem”

- Vitamin A
- Iron
- Iodine
- B-vitamins: B1, B2, B6, Niacin, Folic acid, B12
- Zinc
- Calcium

Measuring the global burden of disease

Definition of disability adjusted life years (DALY)

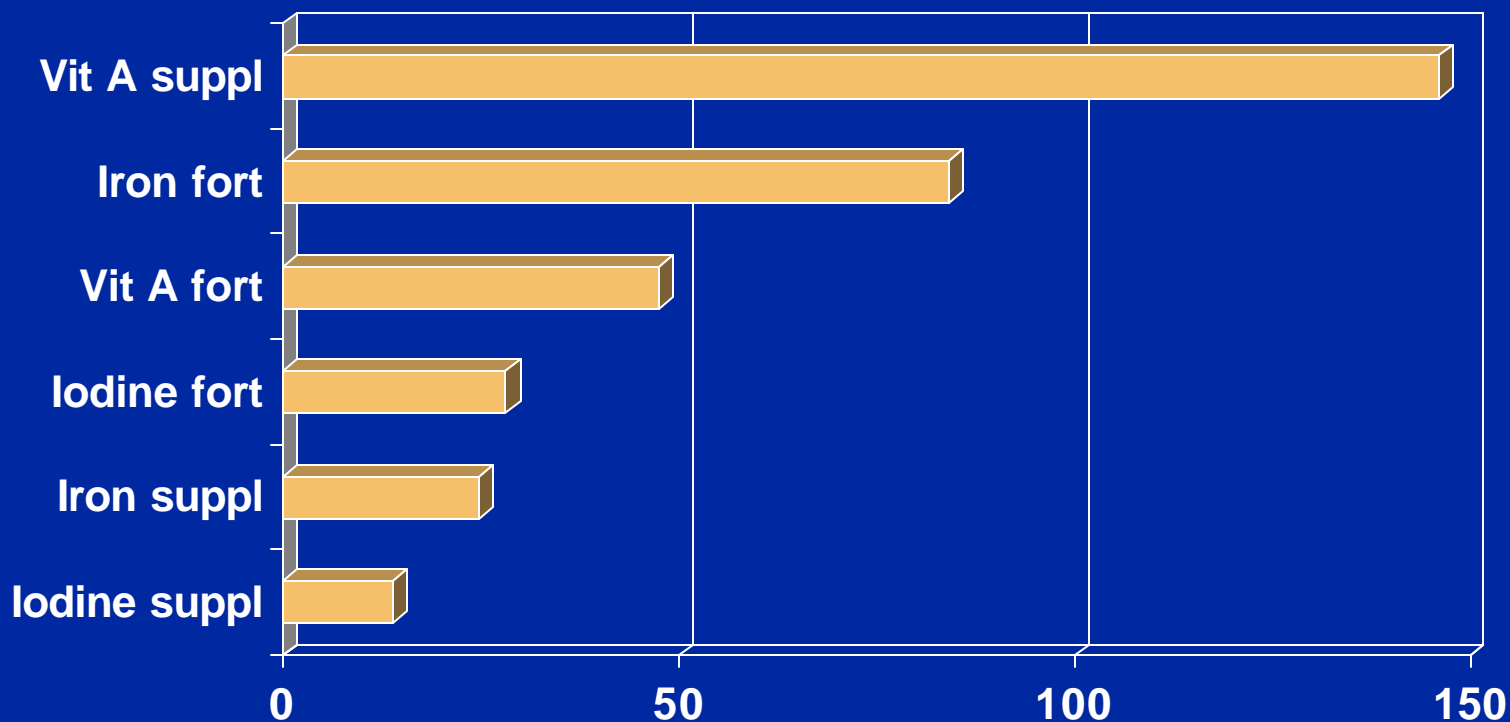
“Sum of life years lost due to premature mortality and years lived with disability adjusted for severity.”

Ten leading causes of worldwide DALY's

Rank	Disorder	DALY's x 10 ⁶
1	Lower respiratory infections	122.9
2	Diarrhoeal diseases	99.6
3	Perinatal disorders	92.3
4	Unipolar major depression	50.8
5	Ischemic heart disease	46.7
6	Cerebrovascular disease	38.5
7	Tuberculosis	38.4
8	Measles	36.5
9	Road-traffic accidents	34.3
10	Congenital anomalies	32.9



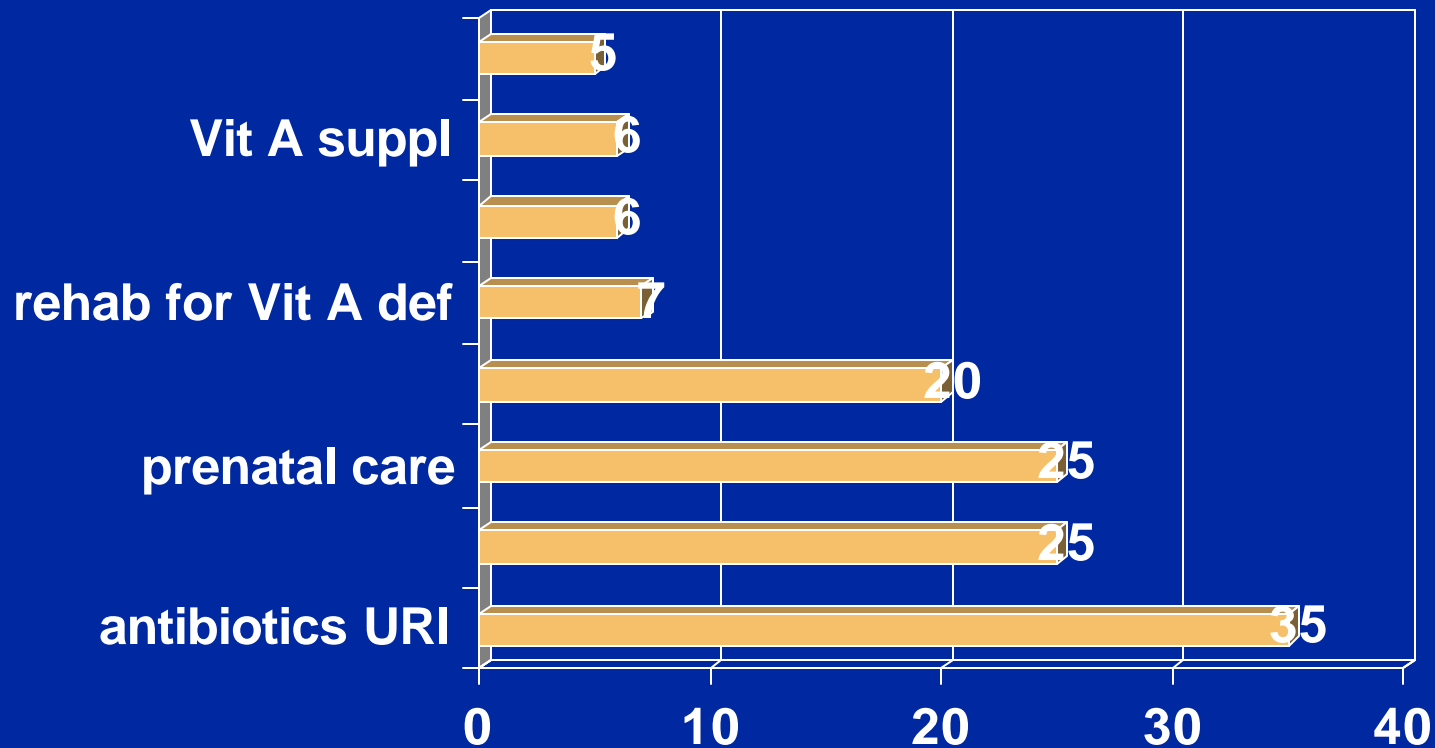
Productivity gained per program \$



Levin et al, World Bank, 1991



Costs per healthy life year gained



Jamison and Mosley, World Bank, 1990



Benefits of salt iodization

- Prevention of goiter
- prevention of hypothyroidism and lethargy
- prevention of cretinism and brain damage
- ➔ ***Improved human performance and life quality.***



Benefits of zinc fortification

- Prevention of dwarfism
- Prevention of hypogonadism and impaired sexual development
- prevention of brain damage
- for better wound healing
- for support of the immune response



Benefits of Vitamin C fortification

- To enhance the immune response
- to improve lung function & respiratory volume
- to enhance iron absorption (anemia prevention)
- for healthy gums and teeth
- for prevention of stomach cancer
- to reduce the risk of Helicobacter pylori infections