# 微量营养素营养与健康



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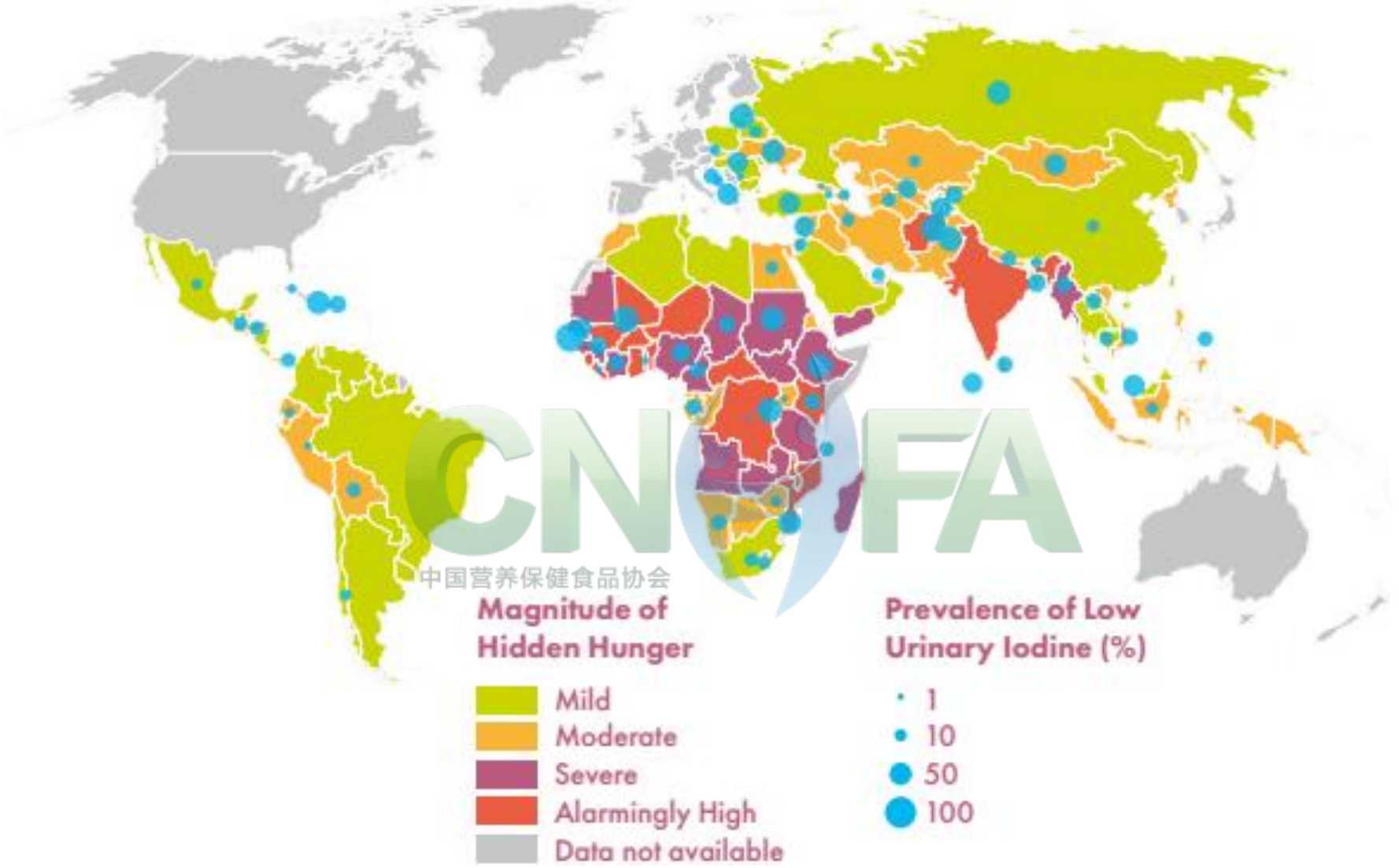
2018年11月1日，北京

营养：人体从外界环境摄取食物，经过消化、吸收和代谢，利用其有益物质，供给能量，构成和更新身体组织，以及调节生理功能的全过程。

1. 营养不足
2. 微量营养素缺乏
3. 超重和肥胖

- 碳水化合物：淀粉、多糖、低聚糖、三糖、双糖和单糖。
- 蛋白质：肽、氨基酸（其中成人8中必需氨基酸，赖氨酸、色氨酸、苯丙氨酸、蛋氨酸、苏氨酸、异亮氨酸、亮氨酸、缬氨酸；组氨酸-儿童）。
- 脂肪：甘油三酯，蜡、甾醇、磷脂、脂肪酸（饱和、单不饱和以及多不饱和脂肪酸：亚油酸、亚麻酸、DHA、EPA）。
- 维生素：脂溶性维生素（A、D、E和K）、水溶性维生素（B1、B2、B6、B12、泛酸、叶酸、尼克酸、胆碱、生物素、VC）。
- 矿物质：常量元素（钙、磷、钾、钠、镁和氯）、微量元素（铁、碘、锌、铜、硒、氟、铬、锰、钼）。
- 功能成分：纤维素、植物甾醇、番茄红素、叶黄素、原花青素、大豆异黄酮、花色苷、氨基葡萄糖、姜黄素等。
- 生物活性物质：免疫球蛋白、乳铁蛋白、金属硫蛋白、SOD、POD等。
- 益生菌：乳酸菌、双歧杆菌等。

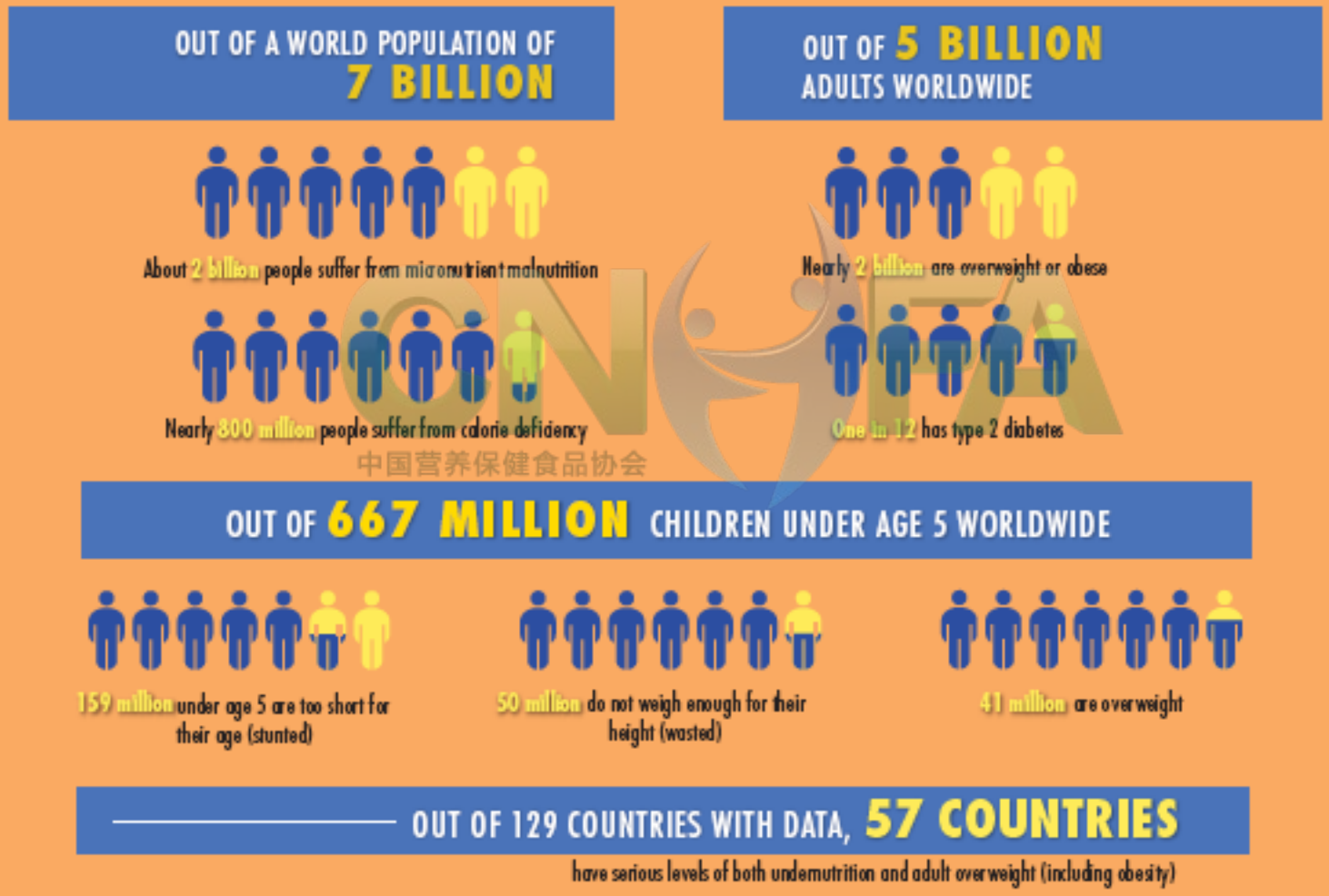





Data source: Food fortification map study 2016. GAIN.
Hidden hunger: zinc, iron and VA deficiencies.

# PANEL 1.1 THE SCALE OF MALNUTRITION IN 2016

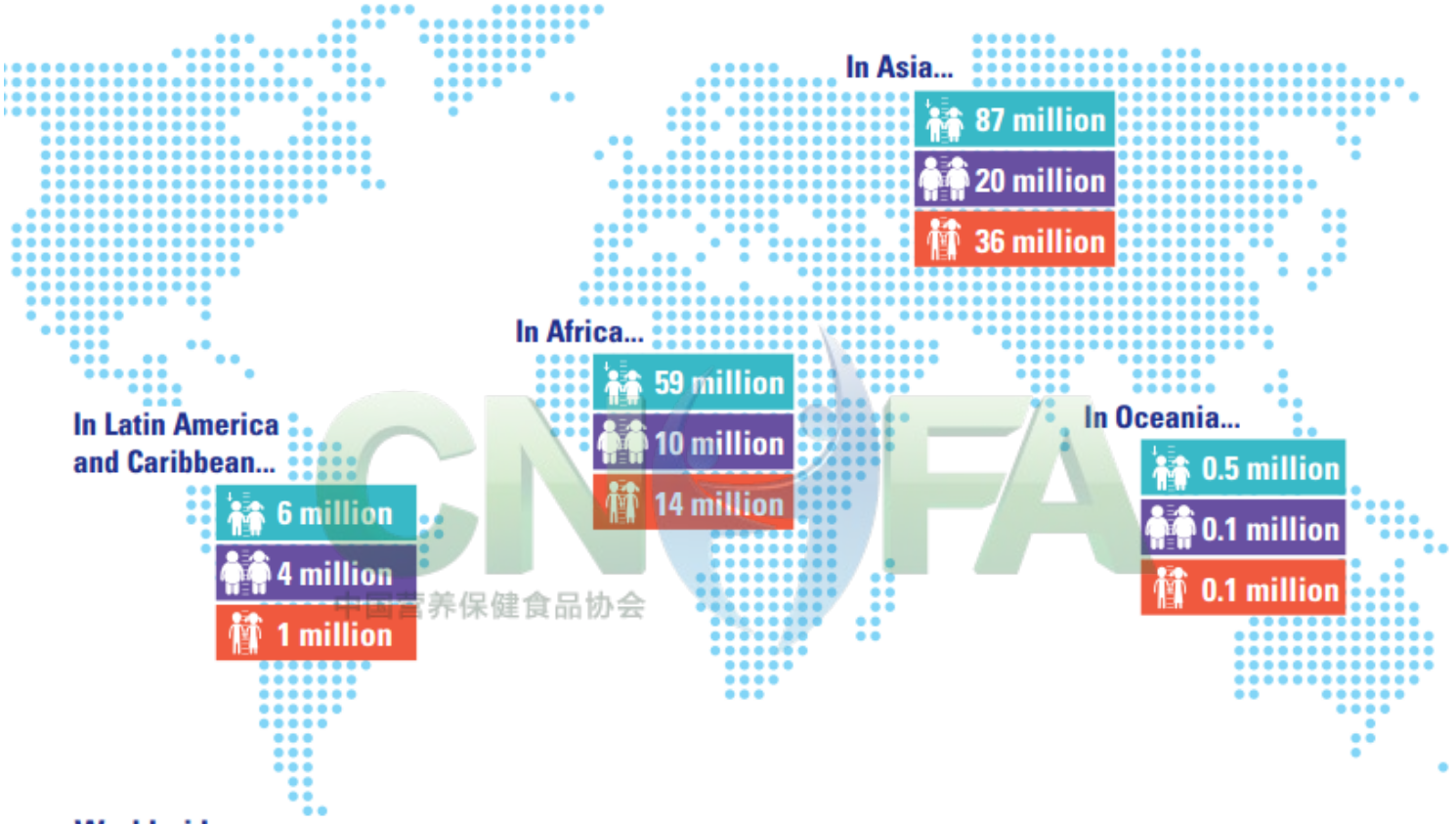
Although the numbers of people affected by different types of malnutrition cannot simply be summed (because a person can suffer from more than one type), the scale of malnutrition is staggering.




Sources: Micronutrient malnutrition: WHO (2009); overweight and obesity: WHO (2016j); child stunting, wasting, and overweight: UNICEF, WHO, and World Bank (2015); calorie deficiency: FAO (2015b); diabetes: WHO (2016c). Multiple burdens: The cutoffs for placing countries in each indicator category are as follows: under-age-5 stunting ≥ 20 percent, women of reproductive age anemia ≥ 20 percent, and adult overweight and obesity (BMI > 25) ≥ 35 percent. Full results appear in Appendix Table A1.1.

# UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates

## Key findings of the 2017 edition






### Worldwide...

**155 million**
**STUNTED**

Stunting affected an estimated 22.9 per cent or 154.8 million children under 5 globally in 2016.

**41 million**
**OVERWEIGHT**

An estimated 6.0 per cent or 40.6 million children under age 5 around the world were overweight in 2016.

**52 million**
**WASTED**

In 2016, wasting continued to threaten the lives of an estimated 7.7 per cent or nearly 52 million children under 5 globally.

**These new estimates supersede former analyses and results published by UNICEF, WHO and the World Bank Group.**

# 微量营养素食物摄入状况

- 居民膳食维生素A、维生素B1、维生素B2和维生素C存在摄入不足风险的比例均较高，分别有77.0%、77.8%、90.2%和67.7%的人群摄入量低于EAR。与2002年相比，摄入量均呈现下降趋势。
- 我国有96.6%的人群膳食钙摄入量低于EAR，显示绝大多数人群都存在着膳食钙摄入不足的风险；约有35.6%的人群锌的摄入量低于EAR，达到或超过RNI水平的人群占46.5%。与2002年相比，为见明显改善。

中国居民营养与健康监测报告，人民卫生出版社，2015

中国居民主要营养素摄入量的分布（%）

| | | 合计 |
|---|---|---|
| 钙 | <EAR | 96.6 |
| | EAR~RNI | 2.0 |
| | ≥RNI | 1.4 |
| 锌 | <EAR | 35.6 |
| | EAR~RNI | 18.0 |
| | ≥RNI | 46.5 |
| 铁 | <EAR | 11.5 |
| | EAR~RNI | 16.5 |
| | ≥RNI | 72.0 |
| 维生素A | <EAR | 77.0 |
| | EAR~RNI | 11.0 |
| | ≥RNI | 12.0 |
| 维生素$B_1$ | <EAR | 77.8 |
| | EAR~RNI | 10.0 |
| | ≥RNI | 12.2 |
| 维生素$B_2$ | <EAR | 90.2 |
| | EAR~RNI | 5.1 |
| | ≥RNI | 4.8 |
| 维生素C | <EAR | 67.7 |
| | EAR~RNI | 9.2 |
| | ≥RNI | 23.1 |

Nutrient intakes data in past decades in China from national survey ( /person.day)

| | 1959* | 1982* | 1992# | 2002# | 2012 |
|---|---|---|---|---|---|
| Energy, kcal | 2621.8 | 2484.7 | 2328.3±735 | 2250.5 | 2172.1 |
| Protein, g | 57 | 66.8 | 68.0±24.9 | 65.9 | 64.5 |
| Fat, g | -- | 10.8 | 58.3±41.8 | 76 | 79.9 |
| Carbohydrates, g | -- | -- | 378.4±128.8 | 321.2 | 300.8 |
| Fiber, g | -- | -- | 13.3±9.9 | 12.0 | 10.8 |
| VA, mcg | -- | 76.5 | 156.5±737.7 | 151.1 | 141.1 |
| Ret EQ, mcg | -- | 656.5 | 476.0±829.5 | 469.2 | 443.5 |
| VB1, mg | 1.86 | 2.33 | 1.2±0.5 | 1.0 | 0.9 |
| VB2, mg | 0.72 | 0.77 | 0.8±0.4 | 0.8 | 0.8 |
| Niacin, mg | 15.8 | 17.8 | 15.7±6.4 | 14.7 | 14.3 |
| Ascorbic acid, mg | 63.8 | 121.8 | 100.2±82.9 | 88.4 | 80.4 |
| Calcium, mg | 354.9 | 540.2 | 405.4±322.4 | 388.8 | 366.1 |
| Iron, mg | -- | 43.1 | 23.4±14.4 | 23.2 | 21.5 |
| Zinc, mg | -- | -- | 12.0±5.0 | 11.3 | 10.7 |

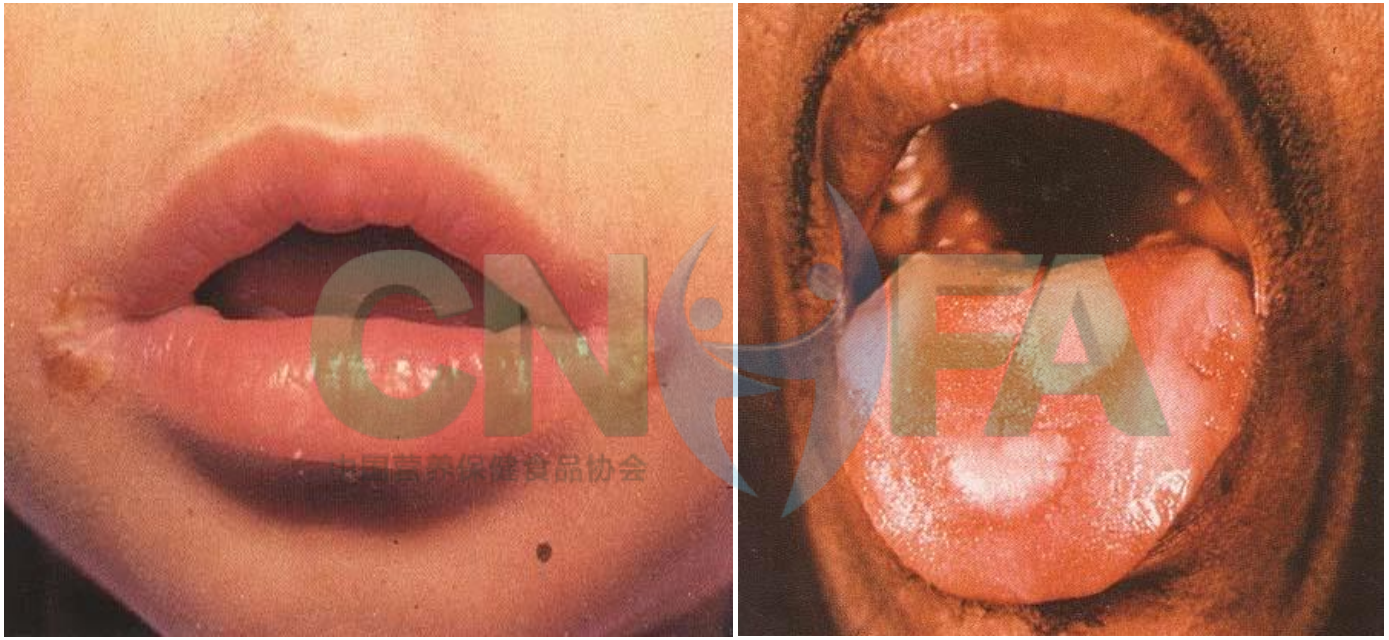
*: national average of different adult groups. #: reference man

Xerophthalmia: vitamin A deficiency

Beriberi: vitamin B1 deficiency

Goiter; Cretinism: Iodine deficiency

Scurvy: vitamin C deficiency

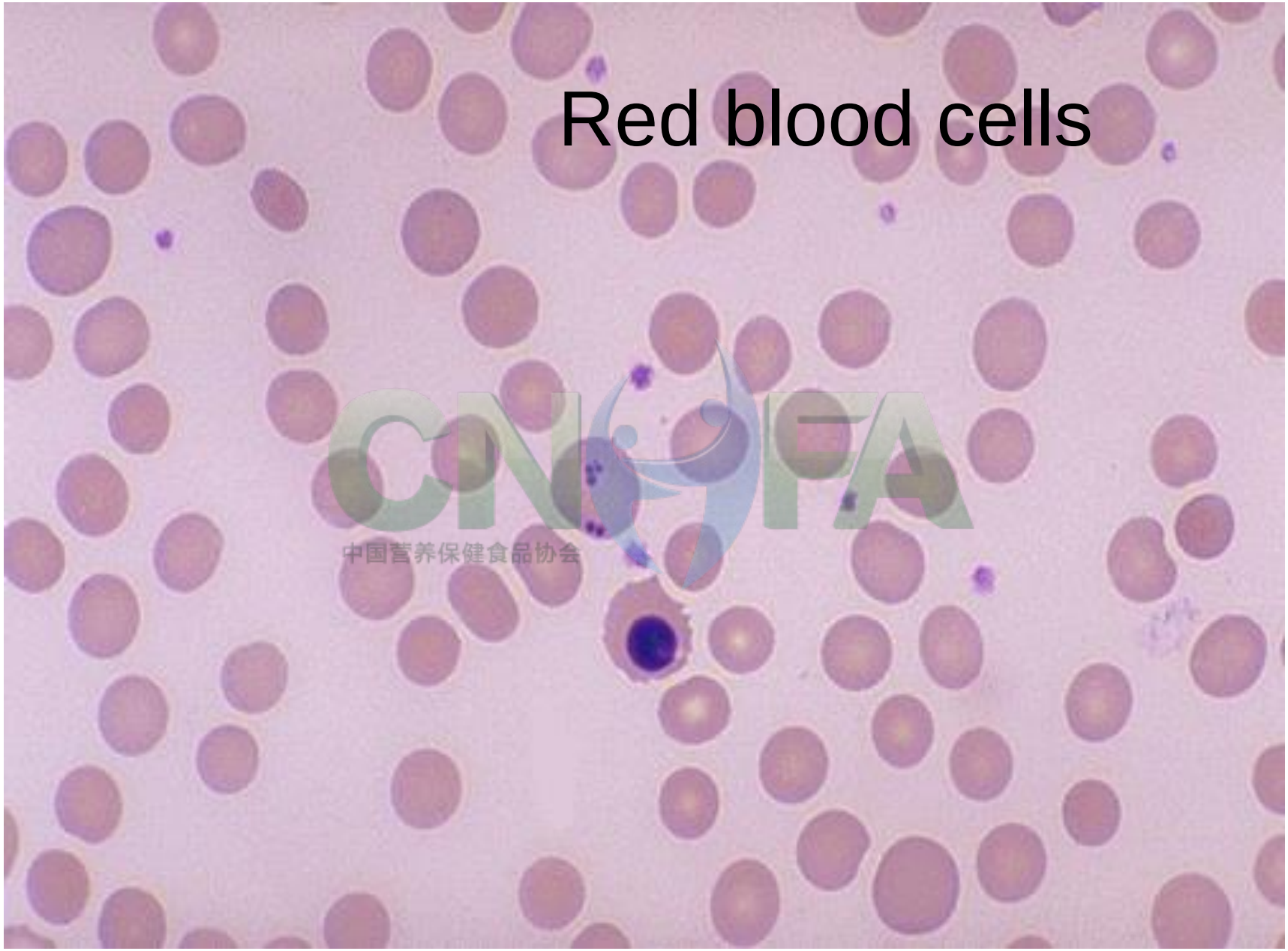


Angular stomatitis; geographic glossitis: vitamin B2 deficiency


Pellagra: niacin deficiency

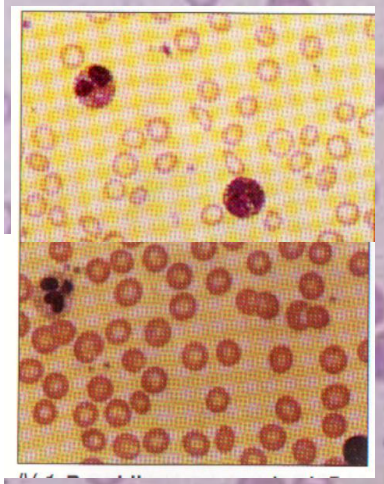

Neural tube defect (NTD): folic acid deficiency

# Red blood cells



# Red blood cells of anemic





微量营养素缺乏

- 已成为公共健康问题。
- 造成免疫机能低下，成为各类疾病的重要基础性原因。
- 造成巨大社会经济负担。
- 影响智力和身体发育，导致学习能力和工作能力低下，影响人口素质及社会和经济发展。

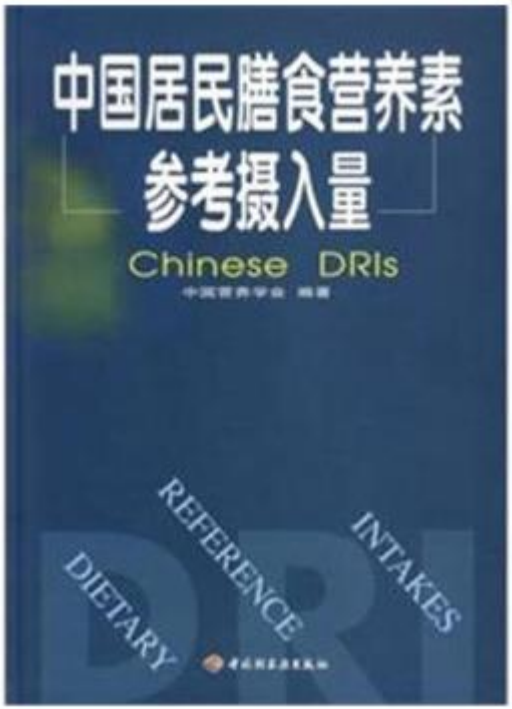



表 30 中国 18-49 岁成年居民膳食营养素参考摄入量

| 能量或营养素 | RNI 男 | RNI 女 | AMDR | 营养素 | RNI 男 | RNI 女 | PI | UL | 营养素 | RNI 男 | RNI 女 | PI | UL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 能量[a]（MJ/d） | | | | 钙（mg/d） | 800 | | | 2000 | 维生素 A(μgRAE/d)[e] | 800 | 700 | | 3000 |
| PAL(I) | 9.41[a] | 7.53[a] | — | 磷（mg/d） | 720 | | | 3500 | 维生素 D（μg/d） | 10 | | | 50 |
| PAL(II) | 10.88[a] | 8.79[a] | — | 钾（mg/d） | 2000 | | 3600 | | 维生素 E(mg α—TE/d)[f] | 14 | | | 700 |
| PAL(III) | 12.55[a] | 10.04[a] | — | 钠（mg/d） | 1500 | | 2000 | | 维生素 K（μg/d） | 80 | | | |
| 蛋白质(g/d) | 65 | 55 | — | 镁（mg/d） | 330 | | | | 维生素 $B_1$（mg/d） | 1.4 | 1.2 | | |
| 总碳水化合物（%E[c]） | — | | 50~65 | 氯（mg/d） | 2300 | | | | 维生素 $B_2$（mg/d） | 1.4 | 1.2 | | |
| —添加糖（%E） | — | | <10 | 铁（mg/d） | 12 | 20 | | 42 | 维生素 $B_6$（mg/d） | 1.4 | | | 60 |
| 总脂肪（%E） | — | | 20~30 | 碘（μg/d） | 120 | | | 600 | 维生素 $B_{12}$（μg/d） | 2.4 | | | |
| —饱和脂肪酸（%E） | — | | <10 | 锌（mg/d） | 12.5 | 7.5 | | 40 | 泛酸（mg/d） | 5.0 | | | |
| —n-6 多不饱和脂肪酸(%E) | — | | 2.5~9.0 | 硒（μg/d） | 60 | | | 400 | 叶酸（μgDFE/d）[g] | 400 | | | 1000[h] |
| —亚油酸（%E） | 4.0 | | — | 铜（mg/d） | 0.8 | | | 8 | 烟酸（mg NE/d）[i] | 15 | 12 | | 35/310[i] |
| —n-3 多不饱和脂肪酸(%E) | — | | 0.5~2.0 | 氟（mg/d） | 1.5 | | | 3.5 | 胆碱（mg/d） | 500 | 400 | | 3000 |
| —α-亚麻酸（%E） | 0.60(AI | | | 铬（μg/d） | 30 | | | | 生物素（μg/d） | 40 | | | |
| —DHA+EPA(g/d) | — | | 0.25~2.0 | 锰（mg/d） | 4.5 | | | 11 | 维生素 C（mg/d） | 100 | | 200 | 2000 |
| | | | | 钼（μg/d） | 100 | | | 900 | | | | | |

注：EAR=Estimated Average Requirement,平均需要量；RNI=Recommended Nutrients Intakes，参考摄入量；AI= Adequate Intake，适宜摄入量；UL= Tolerable Upper Intake Level，可耐受最高摄入量，有些营养素未制定 UL，主要是因为研究资料不充分，并不表示过量摄入没有健康风险；AMDR=Acceptable Macronutrient Distribution Range，宏量营养素可接受范围; PI=Proposed Intakes for Preventing Non-communicable Chronic Disease,预防非传染性慢性病的建议摄入量；PAL=Physical Activity Level，身体活动水平;I=1.5（轻）,II=1.75（中）,III=2.0（重）。

a. 能量需要量,EER. Estimated Engergy Requirement；1000kcal=4.184MJ, 1MJ=239kcal;

b. 未制定参考值者用“—”表示;

c. %E 为占能量的百分比;

d.单位为 g/d

e. 维生素 A 的单位为视黄醇活性当量(RAE)，1μgRAE = 膳食或补充剂来源全反式视黄醇(μg) + 1/2 补充剂纯品全反式 β-胡萝卜素(μg) + 1/12 膳食全反式 β-胡萝卜素(μg) + 1/24 其他膳食维生素 A 类胡萝卜素(μg)； 维生素 A 的 UL 不包括维生素 A 原类胡萝卜素 RAE；

f. α-生育酚当量(α—TE),膳食中总-α-TE 当量（mg）= 1×α-生育酚(mg) + 0.5×β-生育酚(mg) + 0.1×γ-生育酚(mg) + 0.02×δ-生育酚(mg)+ 0.3×α-三烯生育酚(mg)；

g. 膳食叶酸当量（DFE,μg）=天然食物来源叶酸(μg)+1. 7×合成叶酸(μg)；

h. 指合成叶酸摄入量上限，不包括天然食物来源叶酸，单位为 μg/d；

i. 烟酸当量（NE, mg）=烟酸（mg）+1/60 色氨酸（mg）；

j. 烟酰胺，单位为 mg/d。

# 中国居民平衡膳食宝塔（2016）

油25-30克
盐6克
糖50克

奶制品类300克
豆类及坚果25克以上

畜禽类40-75克
鱼虾类40-75克
蛋类40-50克

日均饮用水
1500-1700毫升

蔬菜类300-500克
水果类200-350克

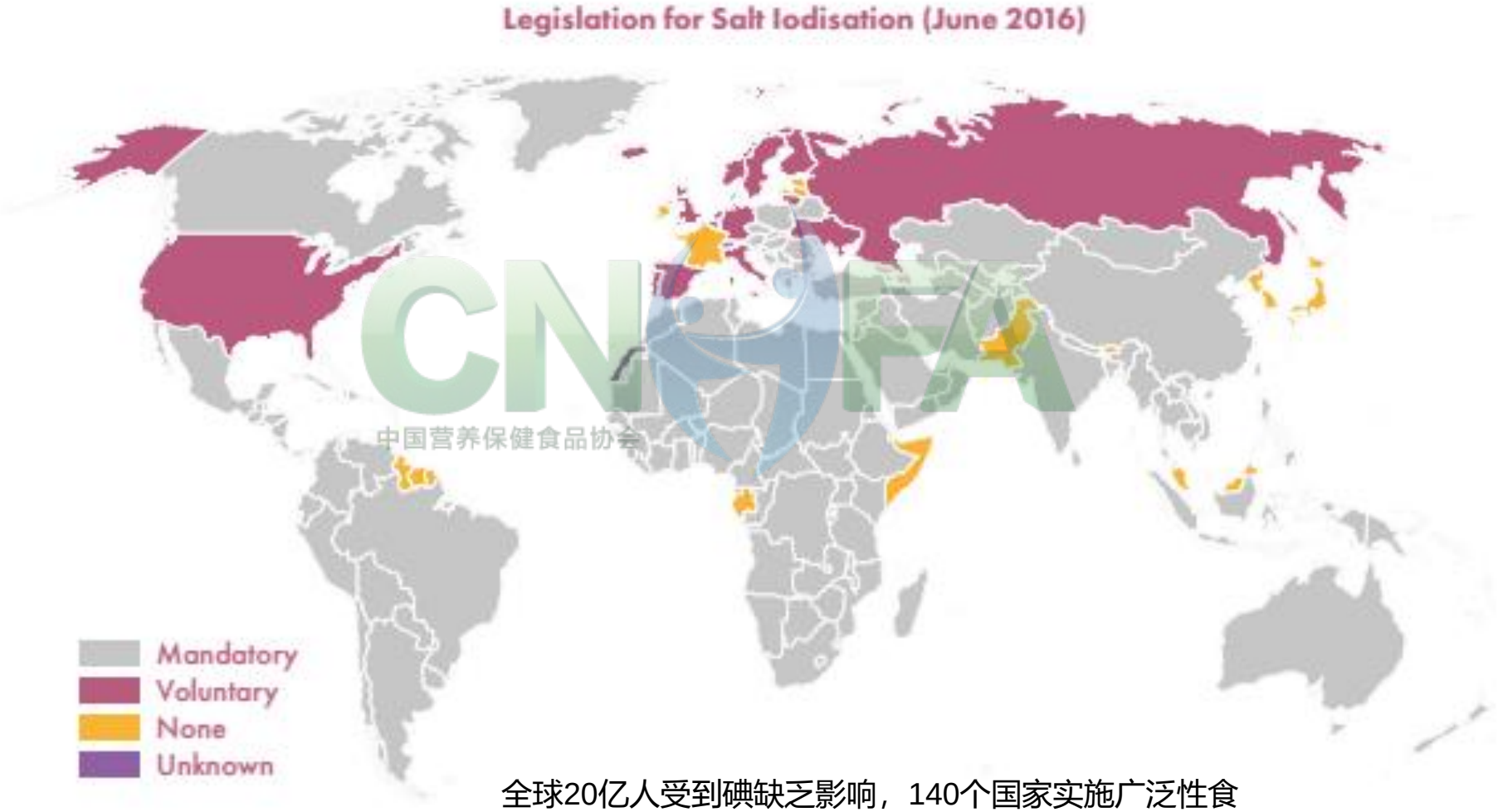
谷薯类及杂豆
250-400克

每天活动
6000步

一日三餐怎么吃

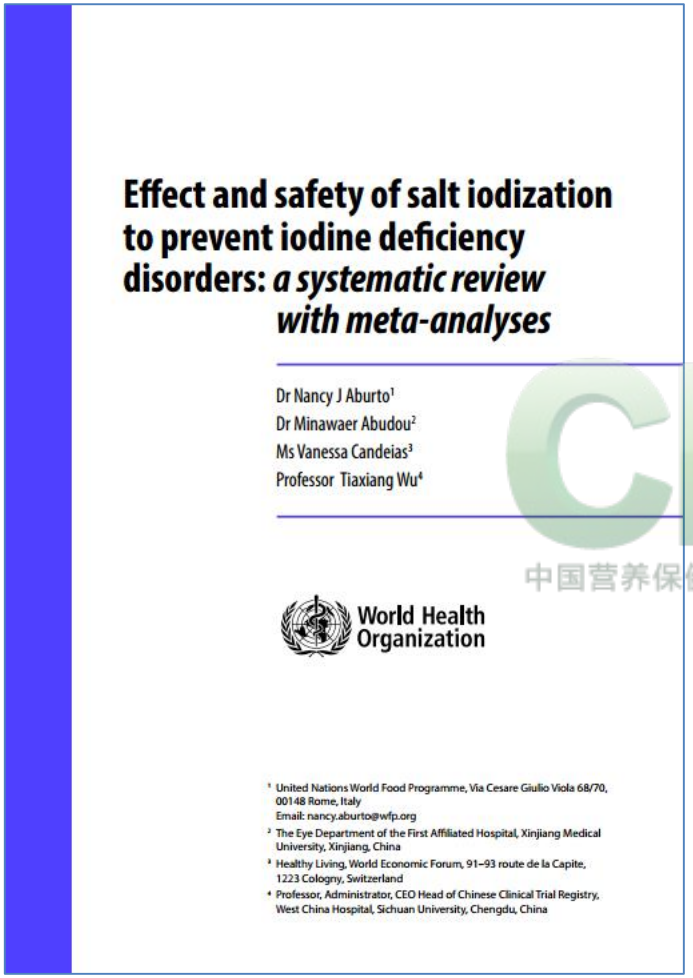
# 食盐加碘

## Countries with legislation for salt iodisation






全球20亿人受到碘缺乏影响，140个国家实施广泛性食盐加碘，碘盐已覆盖75%的发展中国家家庭。



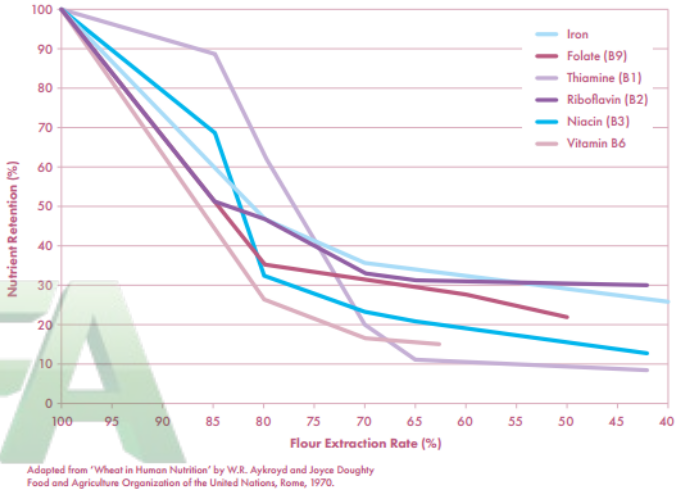

结论：
该综述显示碘盐对减少甲状腺肿、克汀病、低认知功能及碘缺乏具有显著的作用。
——————

**Conclusions**: This review showed that iodized salt has a large effect on reducing the risk of goitre, cretinism, low cognitive function and iodine deficiency. Robust monitoring of salt iodization programmes is important, to ensure safe and effective levels of iodine consumption, especially as countries implement programmes to reduce population salt intake.

# 谷物营养强化

| FLOUR AND CEREAL | |
|---|---|
| **Vehicle focus** | Wheat flour, maize flour and rice |
| | Unique characteristics: Fortification levels vary based on per capita consumption and extraction rate for wheat and maize flour; three different technologies available for rice fortification depending on local preparation/cooking practices |
| **MND focus** | Iron, zinc, folate, vitamin B12, other B-vitamins, (and vitamin A) |
| **Current status globally** | Legislation: 85, 16 and 6 countries mandate wheat flour, maize flour and rice fortification, respectively |
| | Coverage: Percentages fortified globally: 28% of wheat flour, 58% of maize flour and 0.8% of rice |
| | Micronutrient status: Reductions in prevalence of anaemia and neural tube defects have been documented |

**Figure 18: Graphic example of nutrient losses due to milling of wheat**




Adapted from 'Wheat in Human Nutrition' by W.R. Aykroyd and Joyce Doughty
Food and Agriculture Organization of the United Nations, Rome, 1970.

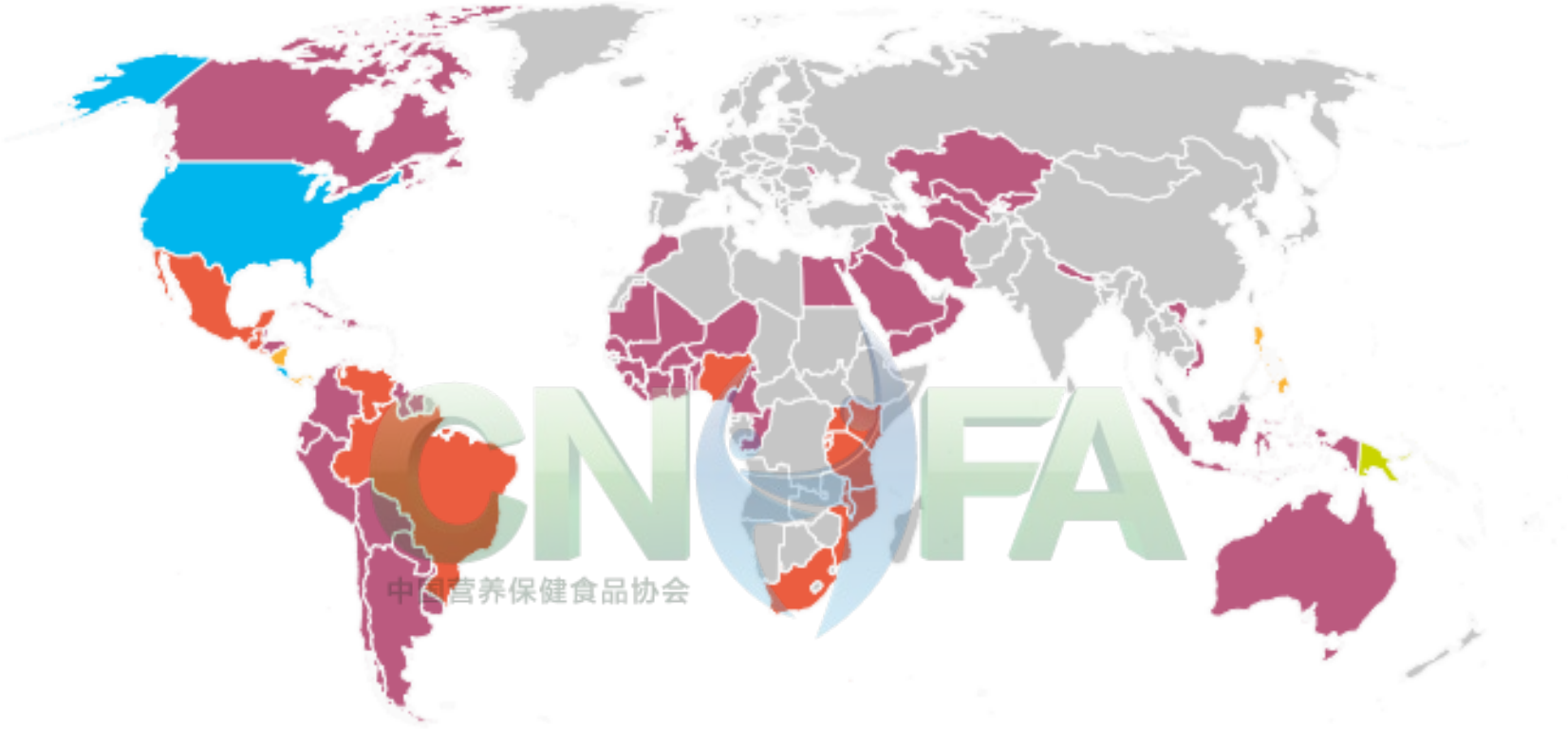


**Table Global progress on fortification of industrially produced wheat and maize flours and rice**

| Progress indictor | 2014 | 2015 |
|---|---|---|
| Proportion of industrially milled wheat flour worldwide that is fortified | 29.9% | 28.1% |
| Proportion of industrially milled maize flour worldwide that is fortified | 47.7% | 58.0% |
| Proportion of industrially milled rice worldwide that is fortified | 0.8% | 0.8% |

Source: FFI (2016). 2015 Year in Review. Atlanta, USA,
http://www.ffinetwork.org/about/stay_informed/releases/2015Review.html (accessed 14 July 2016).

## Global status of industrially milled flour and rice fortification legislation – May 2016



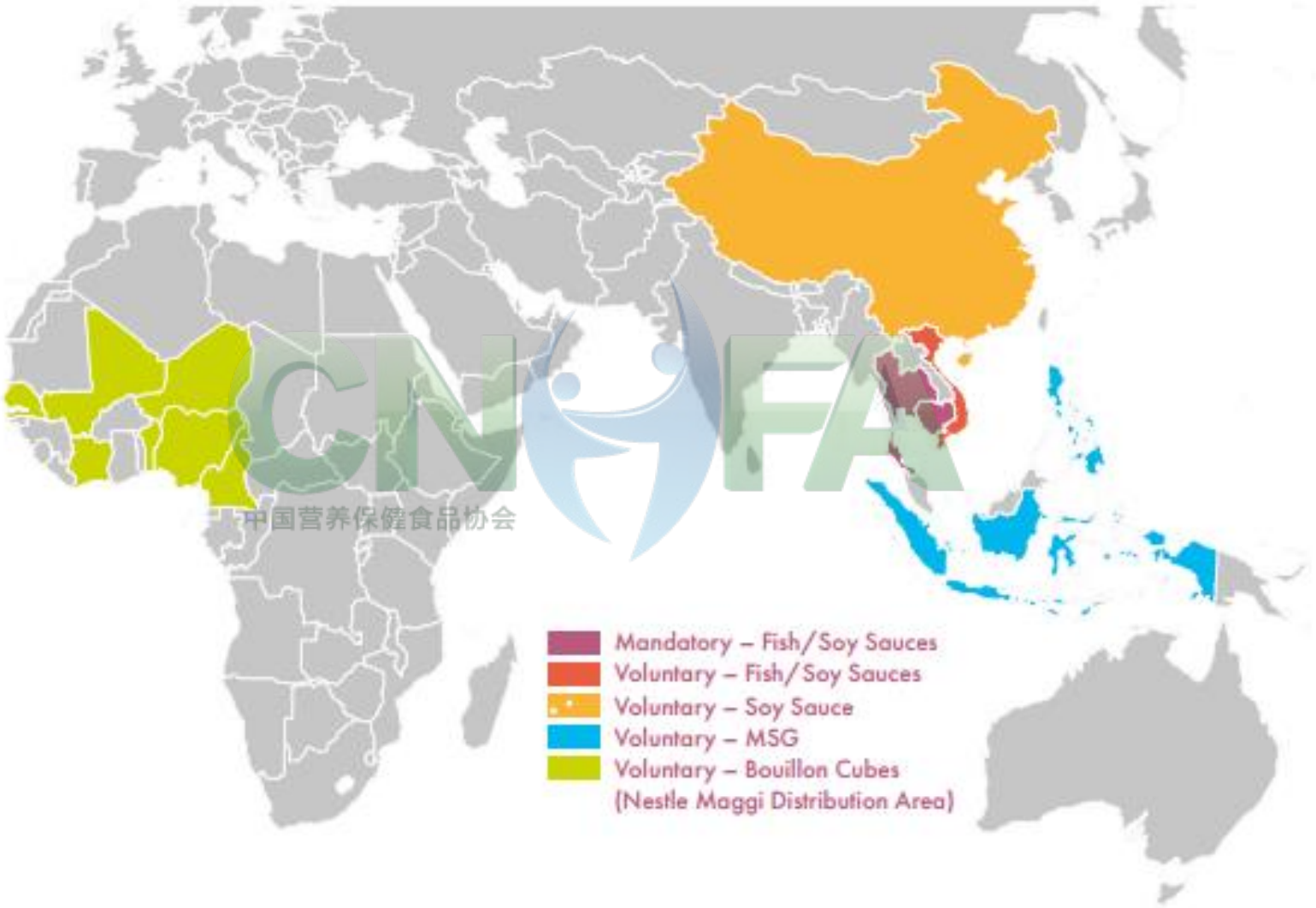
- Wheat flour – 66 countries
- Rice – 1 country (Papau New Guinea)
- Wheat flour and maize flour – 14 countries
- Wheat flour and rice – 3 countries (Nicaragua, Panama, Philippines)
- Wheat flour, maize flour and rice – 2 countries (Costa Rica and the United States)
- No grain fortification legislation

* Legislation has effect of mandating grain fortification with at least iron or folic acid.
Legislation status from the Food Fortification Initiative (www.FFInetwork.org) May 2016

# 酱料、调味品及其他加工食品的营养强化

| SAUCES, CONDIMENTS and OTHER PROCESSED FOODS | |
|---|---|
| **Vehicle focus** | Soy and fish sauces, curry paste, sugar, bouillon cubes, flavoured salts, MSG, seasoning powders |
| **MND focus** | Primarily iron, iodine, and vitamin A; other micronutrients depending on the food vehicle |
| **Current status globally** | Legislation: 12–15 countries allow voluntary fortification of one or more condiments/sauces<br>Coverage: Global data is not available.<br>Micronutrient status: See other chapters |
| **Main players** | Donors: BMGF, USAID, Netherlands Development Cooperation<br>Implementers: National governments; producers, refiners, and importers<br>Partners: GAIN, MI, HKI, UNICEF previously involved in sugar fortification in Central America, but nothing recent |
| **Enabling environment characteristics** | Challenges in monitoring multiple food vehicles with varying levels of micronutrients<br>Advocacy and private sector engagement under voluntary fortification schemes |
| **Supply-side characteristics** | Selecting the right vehicle/micronutrient combination |
| **Demand-side characteristics** | Opportunities within a shift towards processed foods |

## Map of countries regulating the fortification of various condiments and sauces

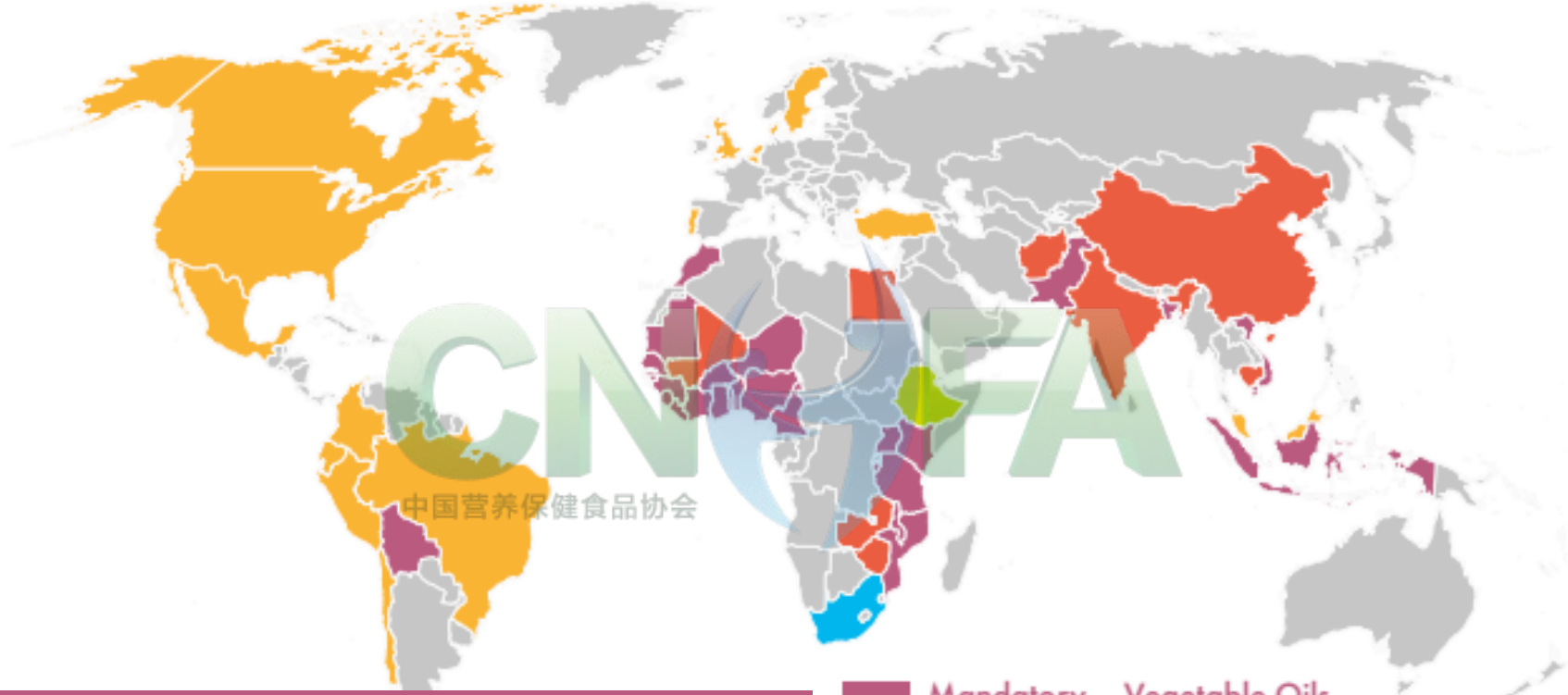


2003年中国市场化推动铁强化酱油




# 植物油强化

## Map of countries regulating the fortification of vegetable oils or fats






| VEGETABLE OILS AND FATS | |
|---|---|
| **Vehicle focus** | Vegetable oils and margarine |
| **MND focus** | Vitamin A, Vitamin D |
| **Current status globally** | Legislation: 49 countries legislate vegetable oils/fats fortification at a mandatory level. An additional ten countries allow voluntary fortification. One country is currently planning mandatory legislation<br>Coverage: Global data is not available and therefore global coverage cannot be estimated. In 12 GAIN-supported countries, 245.7 million people are currently being reached with added vitamin A intakes<br>Micronutrient status: Vitamin D deficiency data are largely non-existent. Vitamin A deficiency data is extremely dated, but most international authorities, including WHO, agree that there is poor vitamin A status in low- and middle-income countries |

# 生物强化

**HarvestPlus coverage with single fortified crops: realised end 2013 and Target 2018**

| Crop | Improved micronutrient density achieved | Country | Achievements 2013 (No. of households) | Target 2018 (No. of households) |
|---|---|---|---|---|
| **Africa** | | | | |
| **Vitamin A maize** | 0 → 152 ppm | Zambia | 10,000 | 500,000 |
| | | Nigeria | *(research phase)* | - |
| **Vitamin A cassava** | 0 → 15 ppm | Nigeria | 106,000 | > 2,000,000 |
| | | DRC | 25,000 | 750,000 |
| | | Kenya | *(research phase)* | - |
| **Orange sweet potato (vitamin A)** | 2 → 32 ppm | Uganda | 149,000 | 237,500 |
| | | Mozambique | *(research phase)* | - |
| **Iron beans** | 50 → 94 ppm | Rwanda | 714,000 | 1,200,000 |
| | | DRC | 150,000 | 1,375,000 |
| | | Uganda | *(research phase)* | - |
| **Asia** | | | | |
| **Iron pearl millet** | 30 → 71 ppm | India | 25,000 | 1,117,000 |
| **Zinc rice** | 16 → 28 ppm | Bangladesh | *(research phase)* | 500,000 |
| | | India | *(research phase)* | - |
| **Zinc wheat** | 25 → 37 ppm | Pakistan | *(research phase)* | 250,000 |
| | | India | *(research phase)* | - |
| **Latin America** | | | | |
| **Iron beans** | 50 → 94 ppm | Mexico | *(research phase)* | - |
| **Zinc wheat** | 25 → 37 ppm | Mexico | *(research phase)* | - |

# MNP和营养包

2000年，Sprinkles 或MNP产品用于家庭儿童食物强化

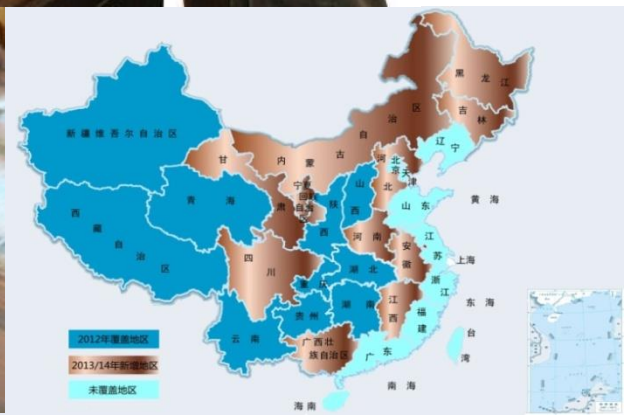
**Composition of Nutritional Anaemia Formulation Sprinkles:**

| Micronutrient | Amount |
|---|---|
| Iron | 12.5 mg |
| Zinc | 5 mg |
| Folic Acid | 160 µg |
| Vitamin A | 300 µg RE |
| Vitamin C | 30 mg |

**Composition of 'Multi-Micronutrient Formulation' Sprinkles:**

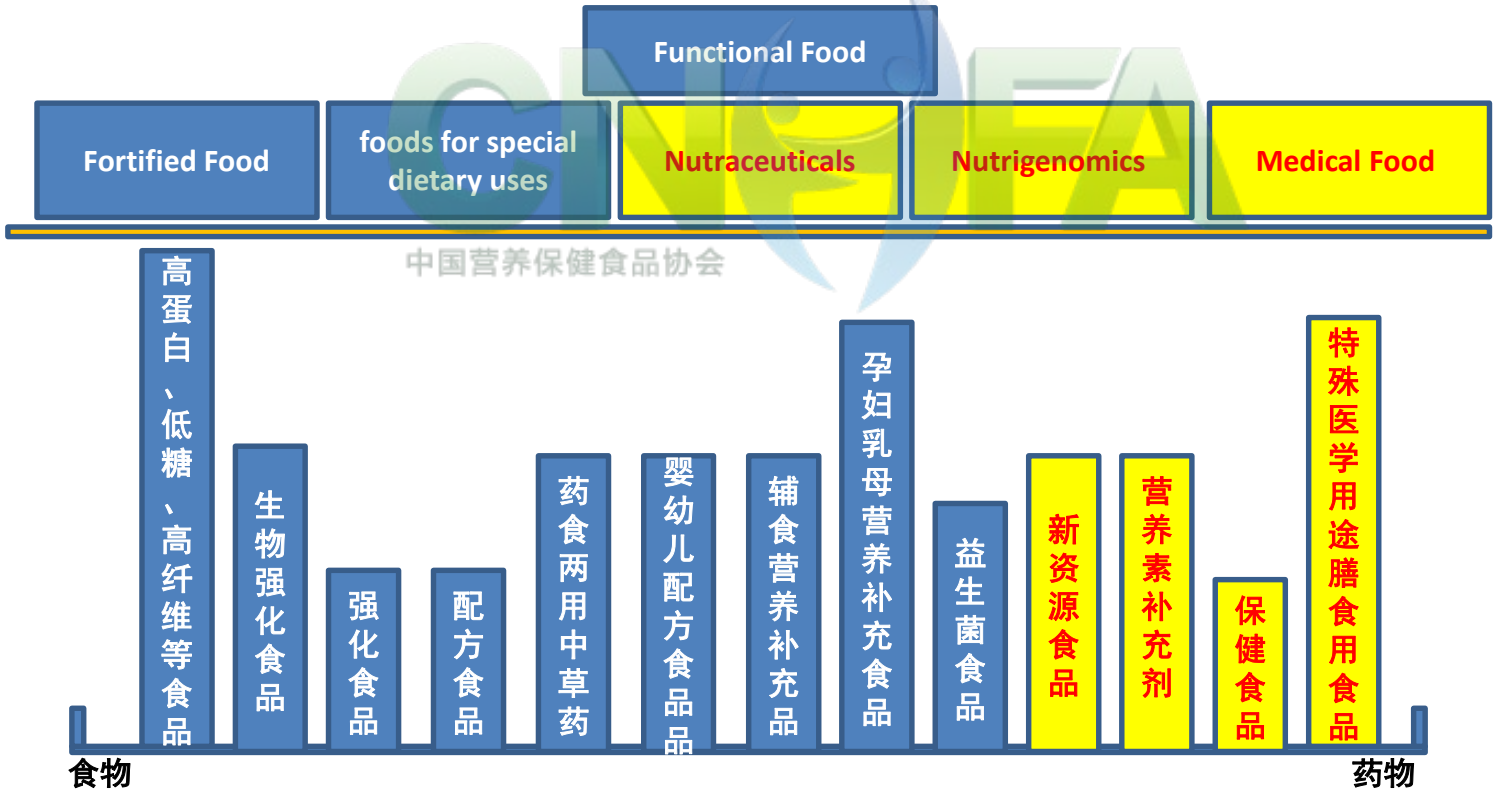
| Micronutrient | Amount |
|---|---|
| Vitamin A | 300 µg RE |
| Vitamin C | 30 mg |
| Vitamin D | 5.0 µg |
| Vitamin E | 6 mg a-TE |
| Vitamin B1 | 0.5 mg |
| Vitamin B2 | 0.5 mg |
| Vitamin B6 | 0.5 mg |
| Vitamin B12 | 0.9 µg |
| Folic Acid | 160 µg |
| Niacin | 6 mg |
| Iron | 12.5 mg |
| Zinc | 5 mg |
| Copper | 0.3 mg |
| Iodine | 90 µg |


《贫困地区儿童营养改善项目》于2012年由卫生部和全国妇联联合启动，免费发放营养包并进行营养与喂养知识普及。截止2015年底已惠及341个集中连片贫困县，收益6-24月龄儿童400余万。



# 营养素或营养强化剂已经发展成为产业

- 我国的维生素C、叶酸等营养素为全球主要供应国。
- VA和VD来自海鱼鳕鱼鱼肝油。
- 碘来自海藻。
- DHA和EPA来自深海鱼油或微藻。
- 磷脂：海洋鱼、虾类。
- 钙、锌：海洋贝类。



非常感谢！