Zinc fortification of cereal flours: Rationale for current recommendations

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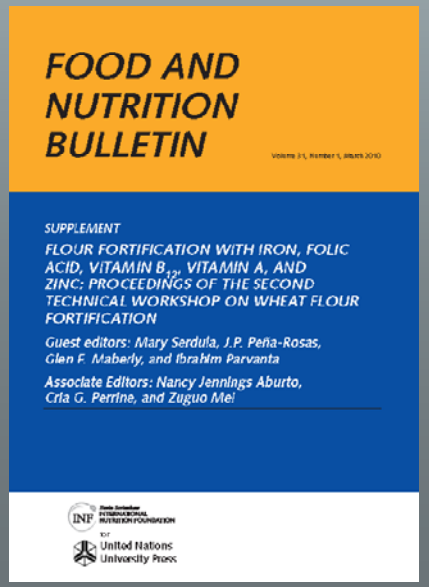
Overview of presentation

- Background – new recommendations of FFI & WHO
- Impact of zinc fortification
  - Tracer studies of zinc absorption
  - Intervention trials
- Appropriate levels and forms of zinc fortification
  - Simulations of effects on TAZ, UL-TAZ
- Potential adverse effects
  - Sensory trials
  - Mineral absorption
- Summary of recommendations



Recommendation for zinc fortification

- Zinc is required for normal immune function, physical growth, pregnancy outcome
- Intervention strategies include supplementation, fortification, and dietary modification
- In March, 2010 the Flour Fortification Initiative and WHO issued new recommendations on flour fortification, including zinc

Zinc absorption as a function of the dose of zinc sulfate in aqueous solution[1–3]

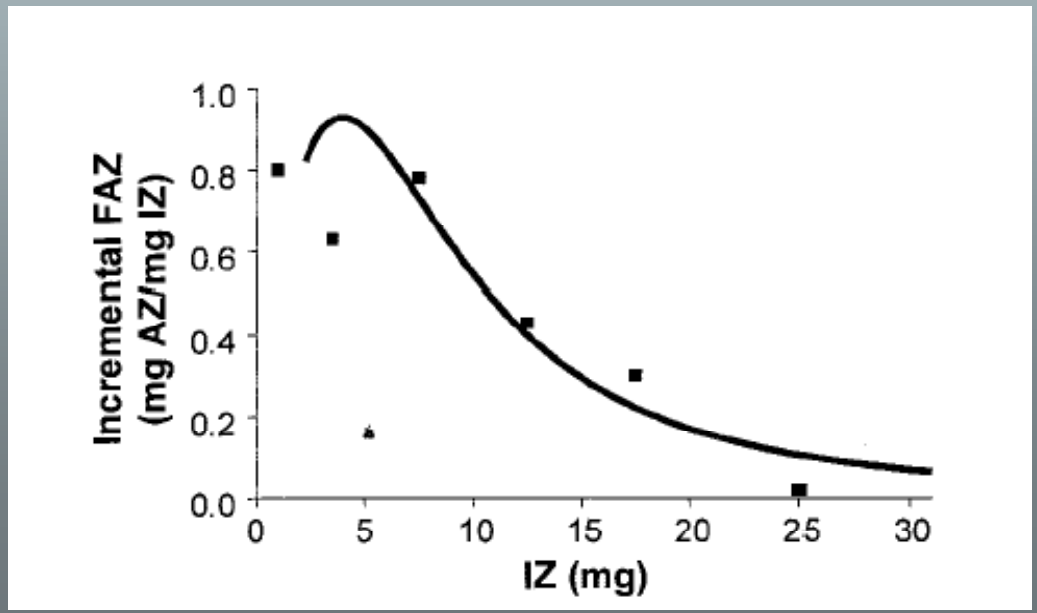
Cuong D Tran, Leland V Miller, Nancy F Krebs, Sian Lei, and K Michael Hambidge

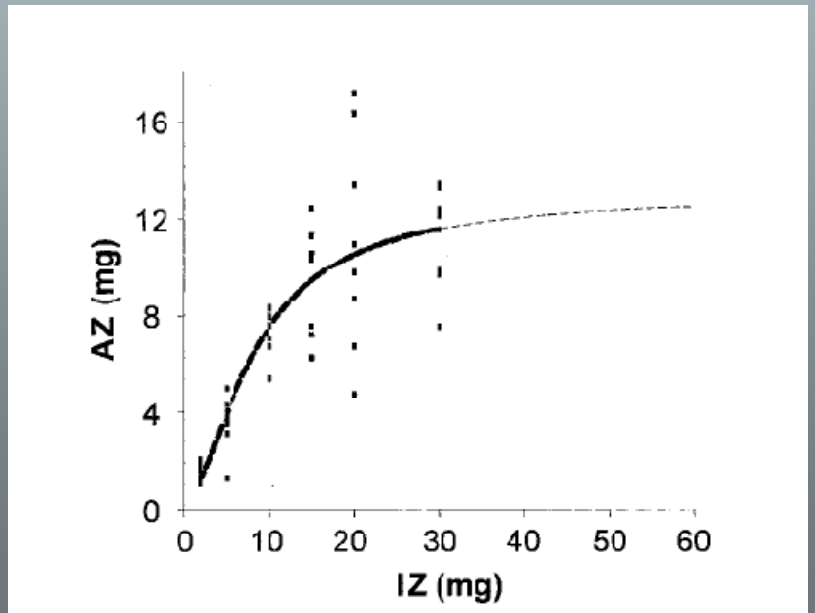
ABSTRACT

Background: Zinc supplements are used extensively in medicine and research and for public health purposes in the prevention and treatment of zinc deficiency. However, little is known about the efficiency of zinc utilization after different doses.

Objective: The objective was to determine the relation between dose of aqueous zinc and absorbed zinc (AZ) in healthy adults

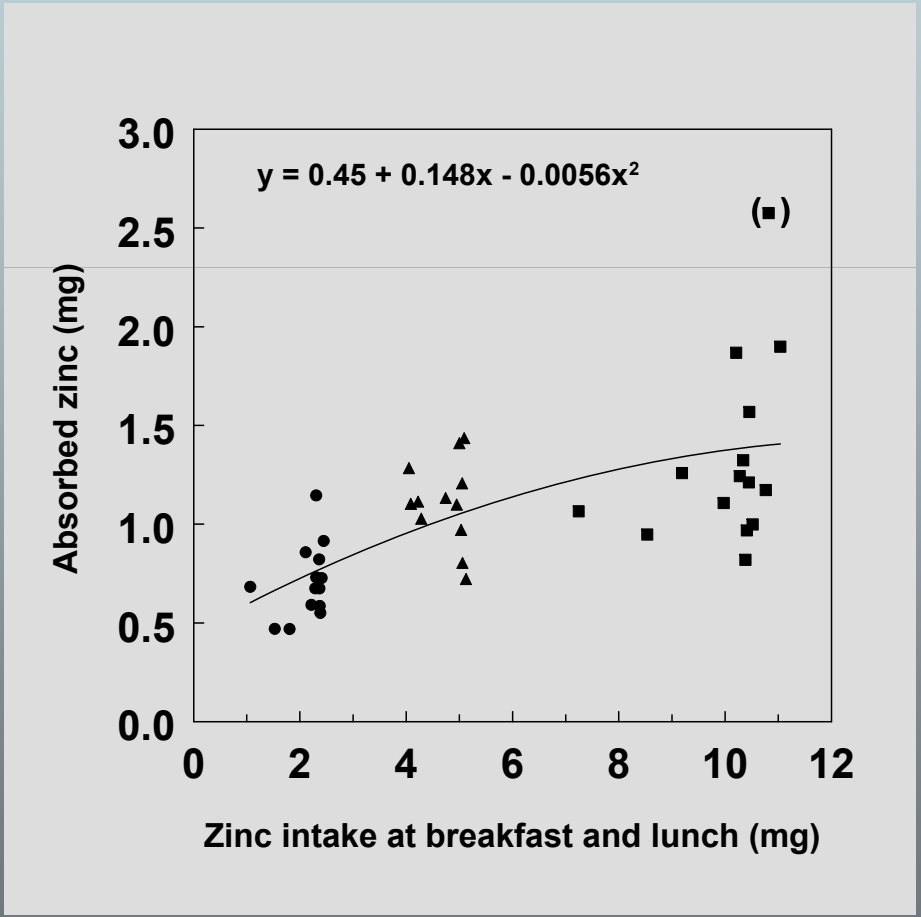
dosage guidelines for short-term relatively high-dose zinc supplementation. No such data are available currently for young children, and even adult studies are remarkably limited (8, 9). The objective of this study was to determine the quantity of zinc absorbed from a range of oral doses of an aqueous solution of a soluble inorganic zinc salt administered to healthy young adults in the postabsorptive state





Am J Clin Nutr 80:1570-3, 2004

Total absorbed zinc by amount of zinc intake from fortified foods



López de Romaña et al. Am J Clin Nutr, 2005

Impact of fortification

Impact of zinc fortification of wheat flour* on mean serum zinc conc (µg/dL), China

Month of study	EDTA arm		Elemental iron arm	
	Control	EDTA iron + zinc	Control	Elem iron + zinc
0	73±25	75±27	73±16	72±17
12	72±24	75±28	72±14	74±18
24	72±19	**78±16**	74±13	**76±12**
36	71±19	**79±16**	75±13	**78±11**

* Wheat fortified with 25 mg/kg flour as zinc oxide (Huo Junsheng, China CDC, unpublished)

Countries with zinc fortification programs (2009)

Country	Type of flour	Type of program	Fortification level (mg zinc/kg flour)
Azerbaijan	Wheat	Voluntary	18
Bangladesh	Wheat	Voluntary	33
China	Wheat	Voluntary	25
Fiji	Wheat	Voluntary	30
Ghana	Wheat	Voluntary	20
Guinea	Wheat	Voluntary	14
Indonesia	Wheat	Mandatory	30
Jordan	Wheat	Mandatory	20
Kazakhstan	Wheat		18
Kenya	Wheat		30
Kyrgyzstan	Wheat		18
Lesotho	Wheat		15
Mexico	Wheat and maize		16
Mongolia	Wheat		18
Palestine	Wheat		15
South Africa	Wheat and maize		15
Tajikistan	Wheat	Voluntary	18
Tanzania	Wheat	Voluntary	30
Uganda	Wheat and maize	Voluntary	30
Uzbekistan	Wheat	Voluntary	18
Vietnam	Wheat	Voluntary	30
Zambia	Wheat and maize	Voluntary	15

22 countries with zinc fortification programs (14-33 ppm)

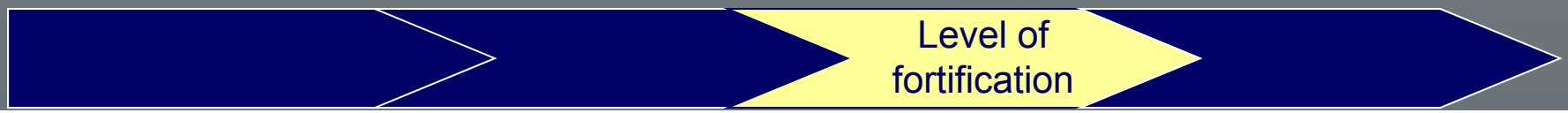
Estimation of zinc absorption

Based on model by Miller LV *et al* model (J Nutr, 2007), which uses physiological assumptions (saturation kinetics) and empirical data from 32 data sets*

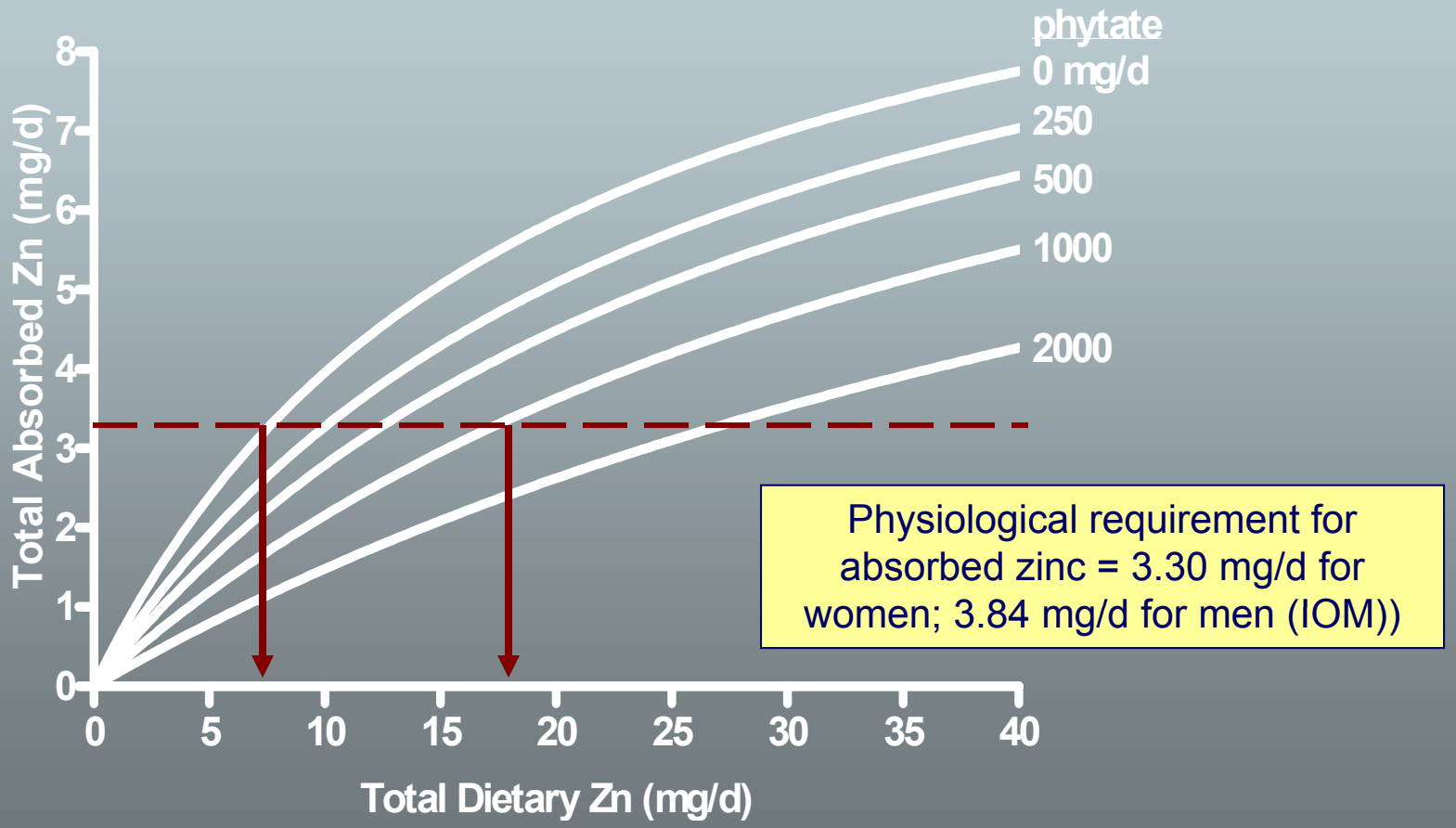
Dietary zinc and phytate are two dietary factors that affect total absorbed zinc (TAZ)

Model fit, $r^2 = 0.86$

*Revised model parameters as per Hambidge *et al*, FASEB J, 2008



Factors affecting zinc absorption: dietary zinc and phytate



Data derived from: Miller LV et al, J Nutr 2007

Estimation of zinc absorption from zinc-fortified cereal flour

- Zinc absorption can be estimated by applying Miller equation
- Information needed:
  - Amount of flour consumed
  - Level of extraction of flour (hence zinc and phytate content of flour)
  - Level of zinc fortification
  - Amounts of zinc and phytate consumed from the rest of the diet

Simulations of effects of zinc fortification

- Flour intakes from 50-800 g/d
- Zinc and phytate contents of 80% and 95% extraction wheat flour
- Assumed Zn and phytate intakes from non-wheat sources
- Level of zinc fortification
- “UL-TAZ”

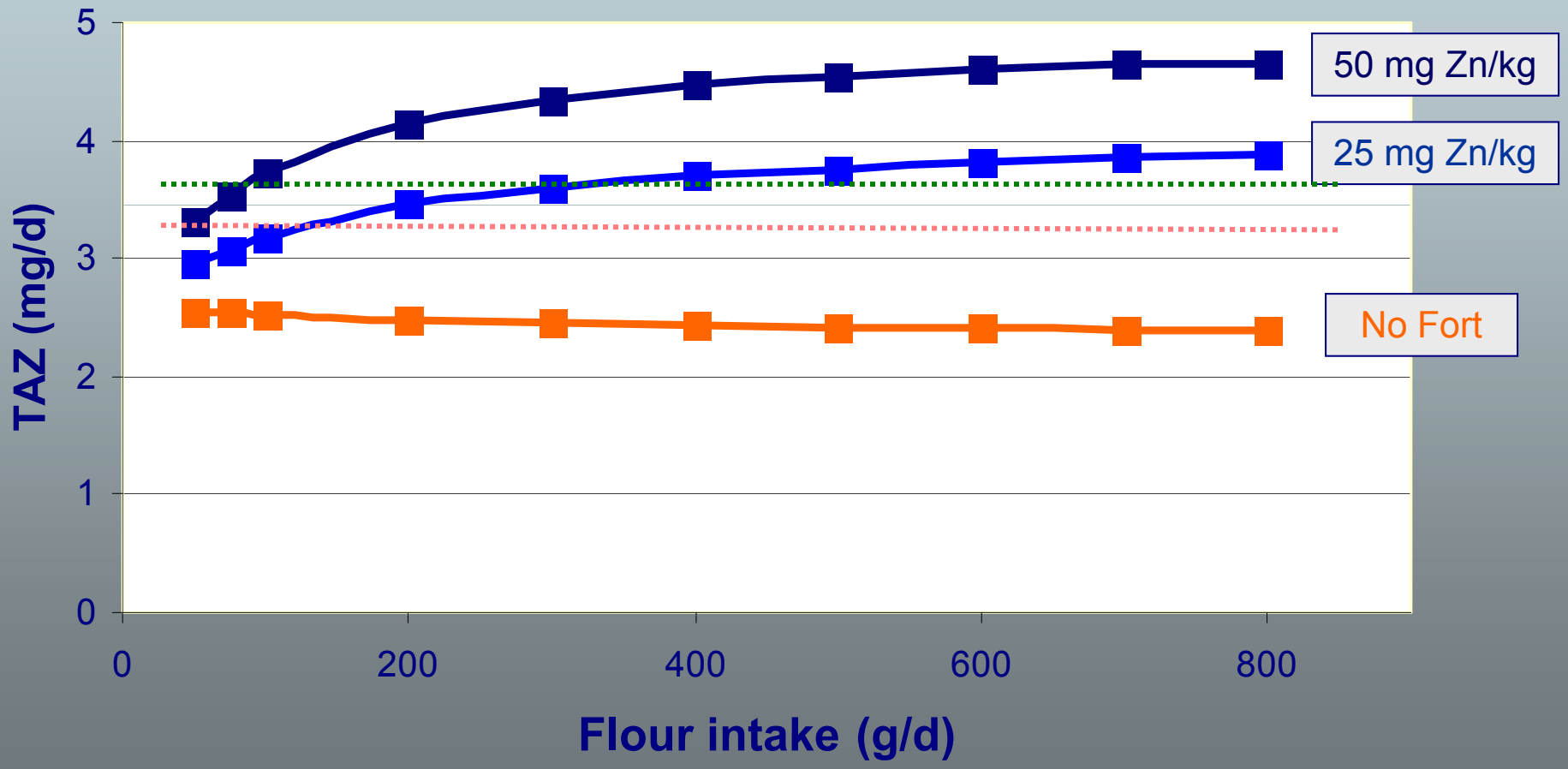
Safe upper level of zinc intake (“UL”)

- IOM set UL for adults at 40 mg Zn/d, but did not consider effect of phytate on zinc absorption
- With zinc intake of 40 mg/d and low phytate diet (~500 mg/d), 6.4 mg zinc is absorbed
- UL-TAZ calculated based on the amount of zinc intake that results in absorption of 6.4 mg Zn/d for different levels of phytate intake

Amount of zinc intake that results in TAZ of 6.4 mg Zn/d, by amount of dietary phytate intake

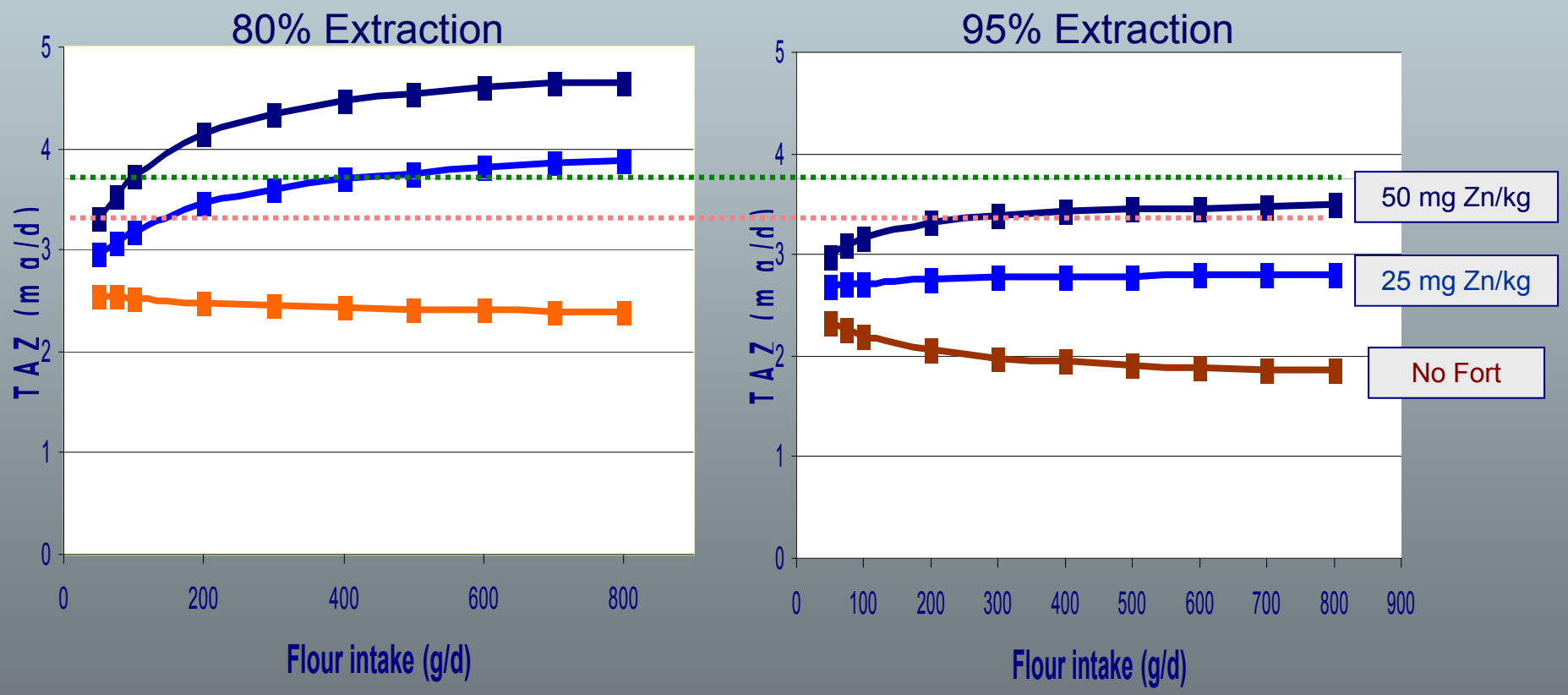
Phytate intake (mg/d)	Zinc intake (mg/d)
0	27
500	40
1000	52
2500	90
5000	152

Estimated TAZ (mg/d) by amount of flour intake and 3 levels of zinc fortification, 80% extraction flour*



* Assumes 5 mg zinc and 0 mg phytate from non-flour food sources

Estimated TAZ (mg/d) by amount of flour intake and 3 levels of zinc fortification*



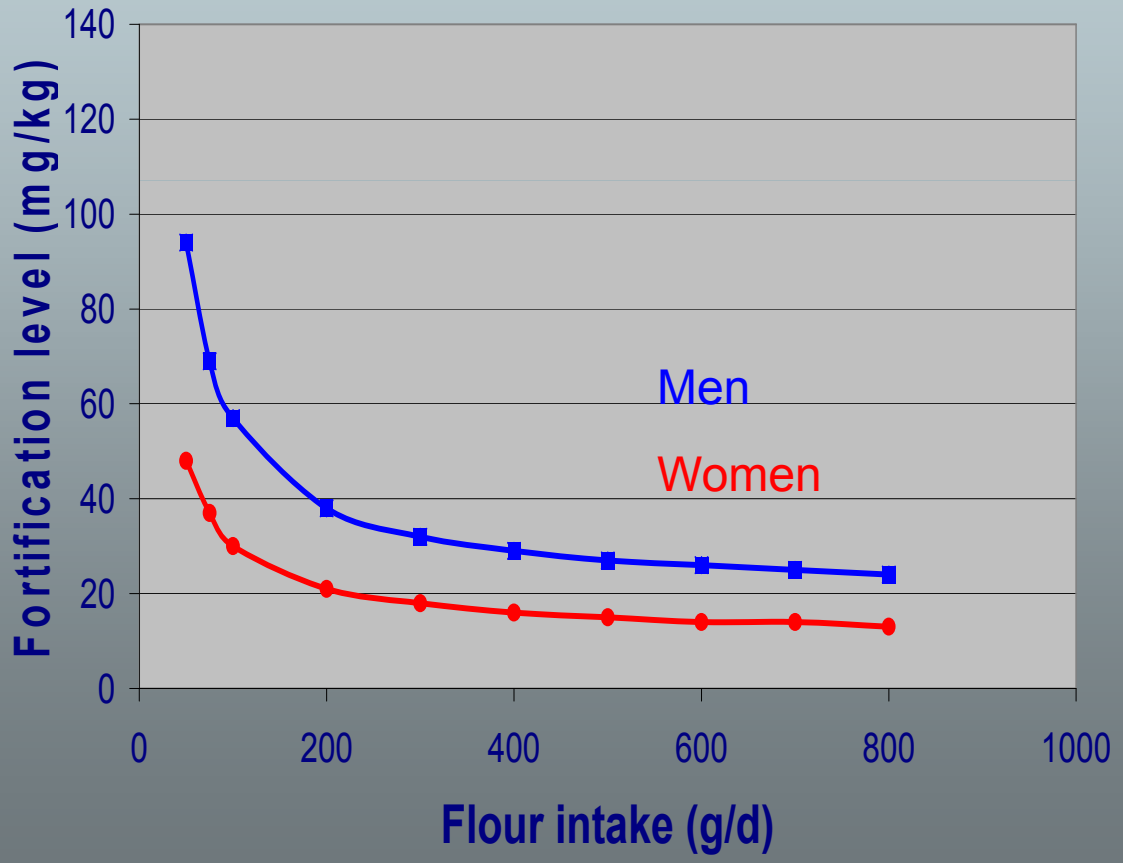
* Assumes 5 mg zinc and 0 mg phytate from non-flour food sources

Conclusions from simulation studies

- TAZ increases with zinc fortification
- Appropriate level of fortification depends on
  - Usual flour intake
  - Degree of flour extraction
  - Usual zinc intake from other sources
  - Usual phytate intake from other sources
- In all cases (among adults) zinc fortification will not exceed UL-TAZ

Recommended level of zinc fortification of wheat flour (mg/kg), by amount of flour intake (80% extraction)*

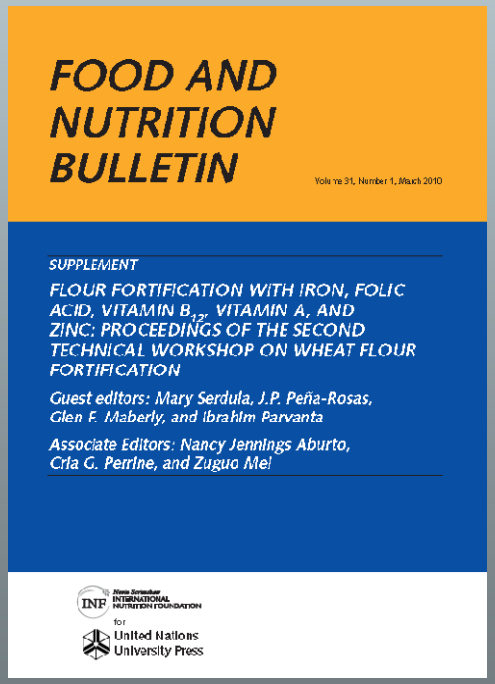
Flour intake (g/d)	Men	Women
50	94	48
75	69	37
100	57	30
200	38	21
300	32	18
400	29	16
500	27	15
600	26	14
700	25	14
800	24	13



*Assumes 5 mg Zn, 0 mg phytate from other dietary sources; level of fortification that exceeds UL-TAZ = 266 to 936 mg Zn/kg flour

Recommended levels of zinc fortification*

Flour intake (g/d)	80% extraction	95% extraction
50	95	135
75	70	110
100	55	100
200	40	80
300	30	75
400-500	30	70
500-800	25	70

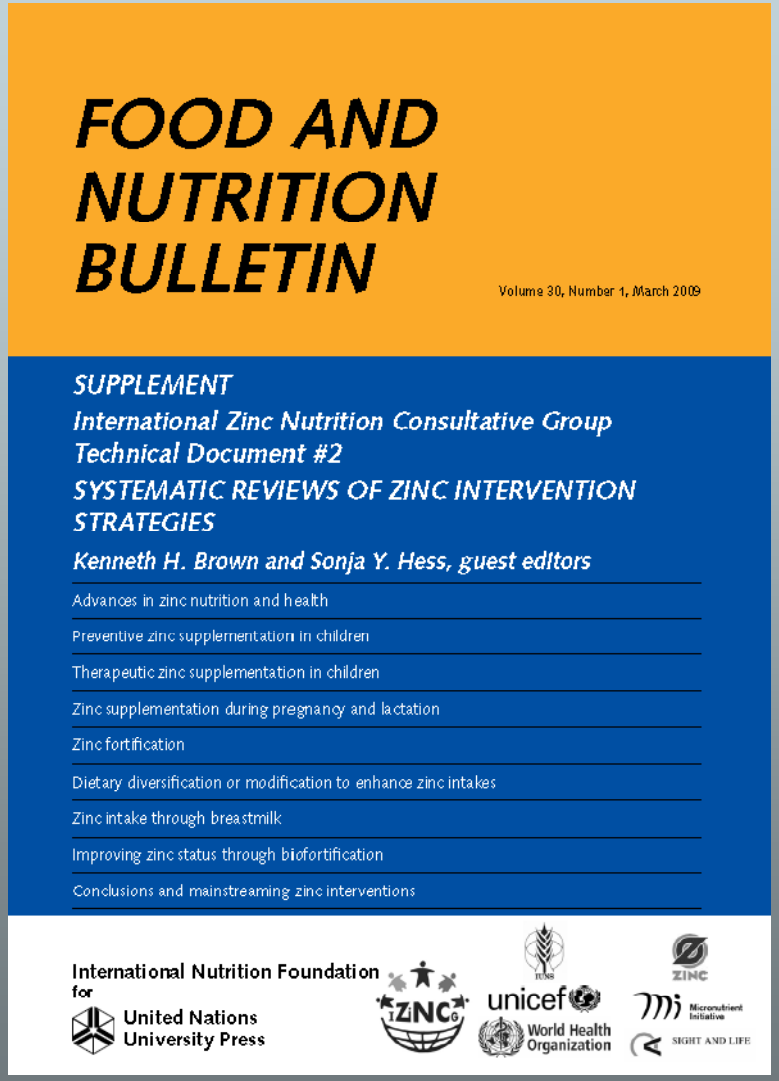


* Assumes 5 mg zinc and 0 mg phytate intake from other sources

Recommend-ations

Conclusions

- Zinc fortification of cereal flour is a safe and effective low-cost method to increase zinc intake, total absorbed zinc, and (in selected population groups) zinc status
- Zinc fortification should be included in flour fortification programs in countries with an elevated risk of zinc deficiency, if flour is consumed in sufficient amounts by target groups
- Zinc oxide is the fortificant of choice because of cost
- The appropriate level of zinc fortification depends on the amount of flour consumption, the degree of flour extraction, and the usual dietary intake of zinc and phytate
- Recommended levels of zinc fortification will not exceed UL-TAZ



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