Preventing zinc deficiency through dietary diversification & modification

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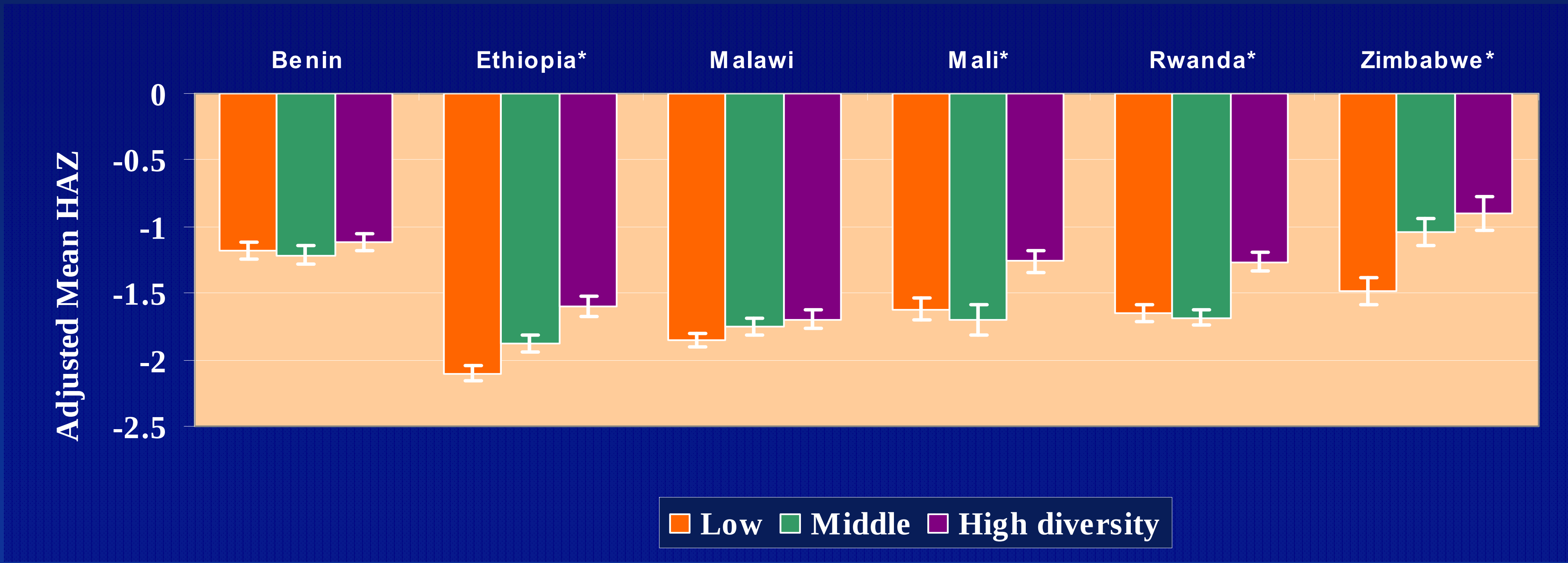
Preventing Zn deficiency through dietary diversification & modification (DDM)

Strategies

- Increase production & consumption of Zn-rich foods
- Reduce phytate via household processing
  - soaking; germination; fermentation
- Exclusive breastfeeding to 6 mos
- Promote safe & appropriate complementary foods at 6 mos + continued breastfeeding to $\geq$ 2 y

See IZiNCG Technical Brief No. 5

Why is DDM important?: Adjusted mean HAZ by diet diversity tercile in six African countries (DHS data)



Means adjusted for child age, maternal height and BMI, # children < 5 y, and 2 wealth/welfare factor scores

Arimond & Ruel (2004)

What are the advantages of DDM?

- Can be designed to be sustainable
- Culturally acceptable and safe
- Community-based: ability to empower community to help themselves
- Prevent concurrent micronutrient deficiencies
- Limited risk of antagonistic interactions
- Enhance MN status of entire household & across generations
- Minimal inputs *once* behavior change achieved

How can they be implemented and evaluated?

Designed and tested using formative research

Implemented via nutrition education & behavior change

Monitored & then evaluated via Zn intakes & functional outcomes

How can we assess risk of inadequate intakes of Zn to monitor & evaluate interventions?

- Step 1: Determine survey design
  – for prevalence of inadequate intakes OR mean Zn intake
- Step 2: Select representative population sample
  – Consult Table 1 or sample size
- Step 3: Determine food intakes: 1 day + some repeats
  – use weighed records or 24-hr recalls
- Step 4: Estimate dietary intake of absorbable Zn
  – via Phytate: Zn molar ratios; OR diet type only: low or average Zn bioavailability
- Step 5: Estimate prevalence of inadequate Zn intakes by:
  – % usual Zn intakes < EAR; OR Crude estimates with mean Zn intake alone

Elevated risk > 25% with intakes < EAR

See IZiNCG Technical Brief No. 3

Evidence: Increasing production or promotion of high Zn foods on intakes of bioavailable Zn

- Agricultural interventions (n=10: no RCTs)
  - None measured Zn or phytate intakes
  - 5 with nutrition education: focused on vit A-rich foods

Conclusion:
- Cereals & legumes have potential to increase Zn intakes
- BUT Zn bioavailability poor unless phytate also reduced

- ASFs interventions with (n=7) or without (n=9) Agriculture
  - Nutrition education or behavior change (10/16)
  - Intakes of ASFs increased in n=8: only when Nut Ed included
  - Zn intakes measured in n=2; intakes of Zn↑in n=1; phytate ↓in n=1

Conclusion:
- Potential to increase intakes of *absorbable* Zn with Nut Education
- Also increases intakes of haem Fe, vits B-12,B-2, vit A (+Ca: fish)

Evidence: Household phytate-reducing strategies on Zn absorption

•No isotope studies using home processing

•Isotope studies (6/6): ⇈ in Zn absorption w. ↓ in phytate

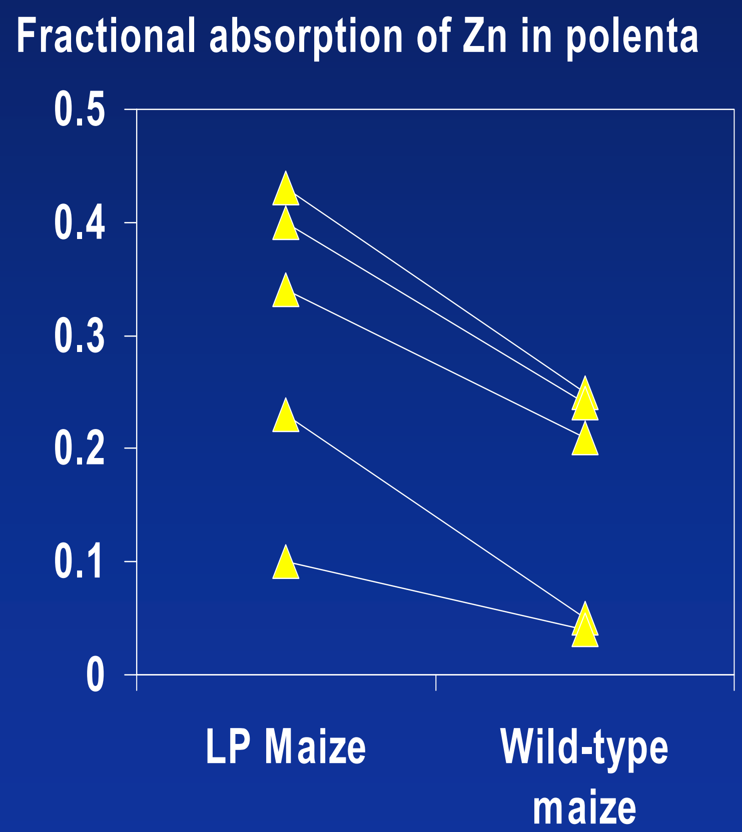
•Isotope studies w. phytase enzyme (3/3): ↑ in Zn absorption w. ↓ in phytate

•~50% loss in phytate in maize via home-based methods: ~ loss in low phytate (LP) maize

• Significant increase in Zn absorption w. LP maize w. 60% loss (see Fig.)

Conclusion: improved Zn absorption w. 50% phytate reduction via home processing likely

BUT intake of ASFs also needed to meet EAR for absorbed Zn for young children



Adams et al. (2002)

Evidence : Supply or promotion of ASFs on Zn status & health outcomes of children

- ASFs in CFs (n=6; 5RCTs) or school snack (n=1 RCT):
  - Sig. increase in Zn intakes (n=4/5)
  - No increase in serum Zn (n=0/4); BUT ↑ in other MNs (e.g. Fe, B-12)
  - Sig. increase in growth (n=5/6)
  - Sig. increase in cognitive performance (1/1)
  - No reduction in morbidity (0/4)

Conclusion:

- Enriching CFs or school meals with ASFs can positively impact on growth and some aspects of development, irrespective of whether biochemical Zn status increases
- Promoting ASFs can increase ASF intake over short-term
- Long-term sustainability & impact of promoting ASF intake unknown

Evidence: Factors modifying impact of DDM

- Baseline nutritional status
- Baseline household SES status
- Infection and possibly sex

NB: These factors are often not measured so evidence isn't strong

What are possible adverse effects of DDM?

- Displacement of breast milk: minimized by promoting continued breastfeeding
- Soaking: small loss of zinc and water soluble vitamins but this offset by loss in phytate
- Microbiologically unsafe water: but enteropathic micro-organisms destroyed during cooking
- Germination: aflatoxin contamination can be avoided by drying and storing in covered pot
- Increased preparation & cooking time: no empirical evidence

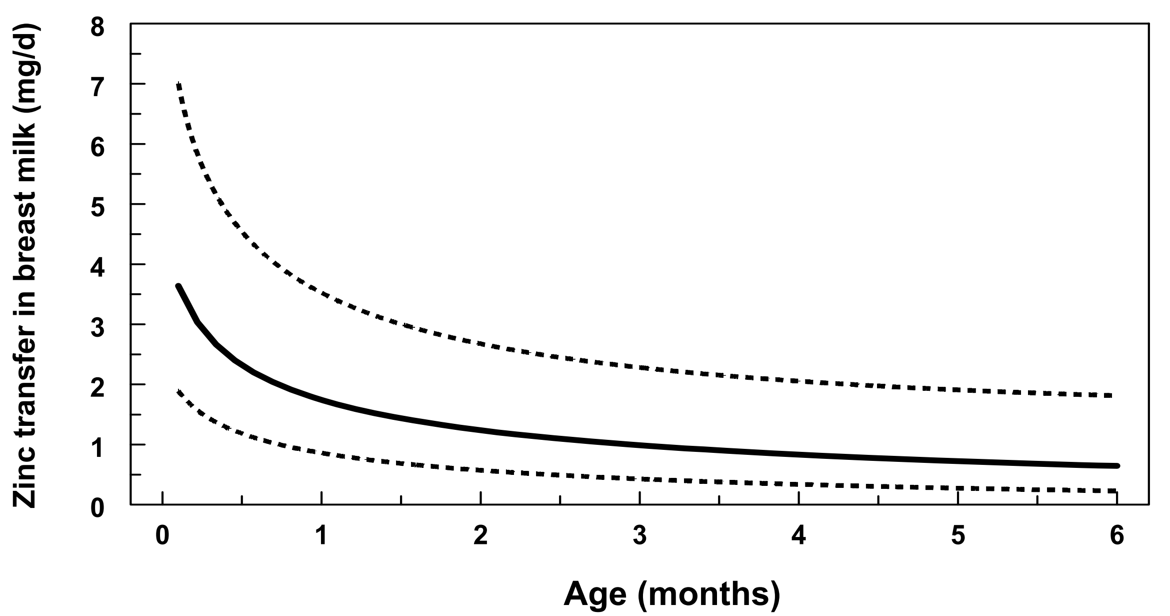
Evidence: Zn transfer in breast milk to exclusively BF infants < 6 mos vs. requirements for absorbed Zn

Curves show range of daily Zn intakes from BM by age: based on BM [Zn] (n=33) & BM volume from WHO (1998)

•Zn intake from BM is ~ 4 mg/d, then ~1.75 mg/d by 1 mo, & ~ 1mg/d by 6 mo

•BM FAZ: ~0.4-0.6 (n=2): so BM Zn intake< EAR for absorbed Zn after 1 mos *but* demand is augmented by hepatic Zn reserves at birth

•BM Zn *probably* adequate for exclusively BF term infants until ~ 6 mos (n=3; RCTs)



Simulated mean & 95th prediction interval of daily Zn transfer in breast milk (BM) to exclusively breastfed infants by age

Brown et al. (2009)

Evidence: Zn transfer in breast milk to BF children < 24 mos who are also consuming CFs

- Breast milk at age 6-8 mos provides ~ 0.7 mg absorbed Zn/d; ~0.5 mg/d thereafter
  - –EAR absorbed Zn: ~ 0.8 to 0.5 depending on age & FZA used
  - –BUT CFs provide additional Zn. However they may also affect Zn absorption from breast milk

What are the programmatic implications to these two Qs?

- For full-term infants: breast milk alone adequate for 3 mos & probably ~ 6 mos
- For LBW infants : period of adequacy is still uncertain
- Breastfeeding should be promoted and supported to ensure adequate Zn intake into second year of life

Examples of scaling up DDM interventions

Country	Design: Target Grp	Interventions	Outcomes
Bangladesh Cambodia Nepal (HKI) Homestead Food Production	Pre- & post; Mothers and children < 5 y from HFP HHs & controls	Home gardens; fish ponds; milking cow Nut Ed to ↑↑ intakes of eggs, meat, liver, milk, & MN-rich plant sources Food intakes via 24-h VASQF	HFP HHs vs. controls: ↑ % children 6-59 mos eating ASFs ↓ anemia in non-pregnant women & children No data on Zn intakes or status
Peru: Gov Health Centers	Cluster-RCT: Infants from birth to 18 mos n= 187: Interv n=190: Control	↑Nut Ed to: ↑ responsive feeding; ↑ quality CFs: thick purees + chicken liver, eggs, or fish at each meal: demonstrations	Interv vs. controls: ↑ Energy, Fe & Zn intakes ↑ linear growth & weight gain 3 X less likely to be stunted at 18 mos No change in morbidity

Biofortification of plant-based staples

- **Zn fertilizers** on low zinc soils
  - to increase grain Zn content: Turkey
- **Plant-breeding** for higher content of:
  - Zn in grains and beans
- **Genetic modification** to:
  - increase content of grain Zn
  - incorporate thermostable phytase to decrease grain phytic acid
  - decrease content of phytic acid *per se*

Effect of Zn fertilizer on Zn content of soil, rice grains in Pakistan

Zn g/ha	Soil Zn kg/ha	Grain Zn µg/g
0	0.400	20.20
5	0.590	32.26
10	0.860	38.04
15	0.990*	46.64*

$P<0.05$; Khan et al.(2002)

Simulated impact of Zn biofortified crops on prevalence of inadequate Zn intakes

National survey n= 1072 children < 5 y

Total Zn intake   Phytate:Zn molar ratio

↘ ↙

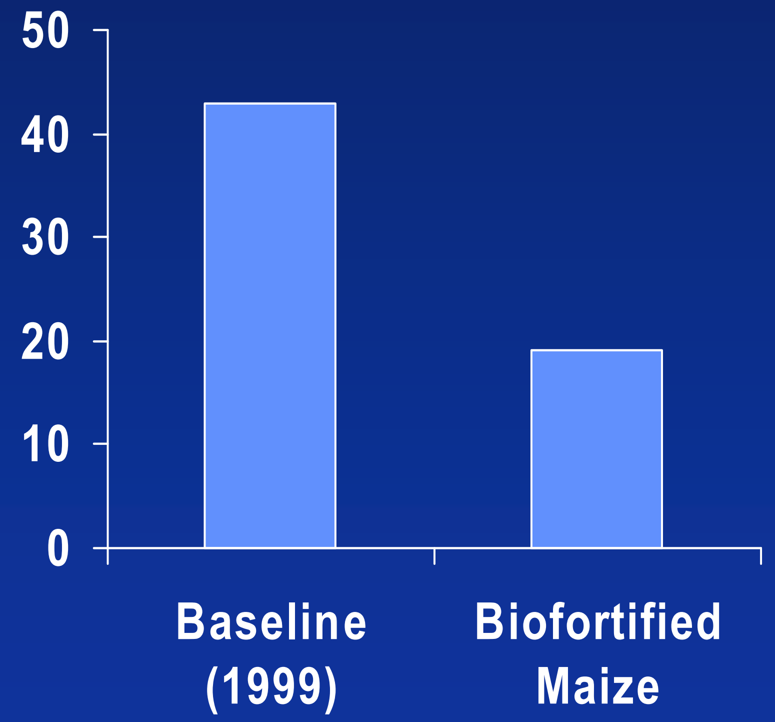
% Bioavailable Zn (IZiNCG)

↓

Bioavailable Zn (mg/d)

25% CV in inter-individual intakes assumed to give the estimated proportion with intakes < physiological requirements

Rural Mexican preschoolers



Maize Zn, baseline: 18 mg/kg
Maize Zn, biofortified: 33 mg/kg

Denova et al.(2008)

What are implications of DDM strategies for programs?

- Breastfeeding (BF) should be promoted & supported to ensure adequate Zn intakes
- All DDM programs should include BF (where appropriate) & *effective* nutrition education & behavior change
- A combination of BF + DDM & Nut Ed that promotes ASFs can increase intakes of absorbable Zn & promote growth, even if no +ve response to serum Zn occurs
- DDM + Nut Ed + BF should be included as integral part of *ALL* dietary guidelines
- DDM should continue to be monitored to assess whether there is a positive effect on Zn status & Zn-related health outcomes

Thank you!

Please visit the IZiNCG web site:
www.izincg.org