Dietary zinc intakes in low income and developed countries

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Outline

- Steps for assessing “usual dietary Zn intakes”
- How to determine the prevalence of inadequate and potentially excessive intakes of Zn
- Using these methods to assess inadequate and excessive intakes of Zn for :
  - Infants & young children
  - older children aged 4 to 14 years
  - pregnant women
- Factors associated with inadequate & excessive Zn intakes
- Conclusions

Steps to assess the prevalence of inadequate or excessive Zn intakes

1. Select sample representative of the study population
2. Measure food intake : using appropriate method & design
3. Convert foods to nutrients
4. Determine distribution of `usual' zinc intakes via PC-SIDE
5. Evaluate dietary adequacy via cutpoint method

    Apply appropriate EAR for risk of inadequate intakes

    Apply appropriate UL for risk of excessive intakes

    See IZiNCG Technical Brief No. 3

2: Measure food intake using design appropriate for study objective

- **Level 1: Average intake of a group**
  - **Single recall/record per person**
- **Level 2: Proportion of population 'at risk' to inadequate or excessive intakes**
  - **Repeat recalls/ records (on non-consecutive days) on each individual**
  - ***OR* Repeat on sub-sample only (30-40) per stratum**
- **Level 3 or 4: 'Usual' intakes of individuals for ranking (level 3) or correlation (level 4)**
  - **Multiple recalls or records**

3: Convert foods to nutrients

NB: Zn content of plant-based staples depends on soil Zn

- **Compile local food composition database with values for zinc and phytate**
  - **–Analyze staple plant-based foods**
  - **–Compile best estimates of Zn & phytate from other sources**
- **Useful resource: WorldFood Dietary Assessment System**

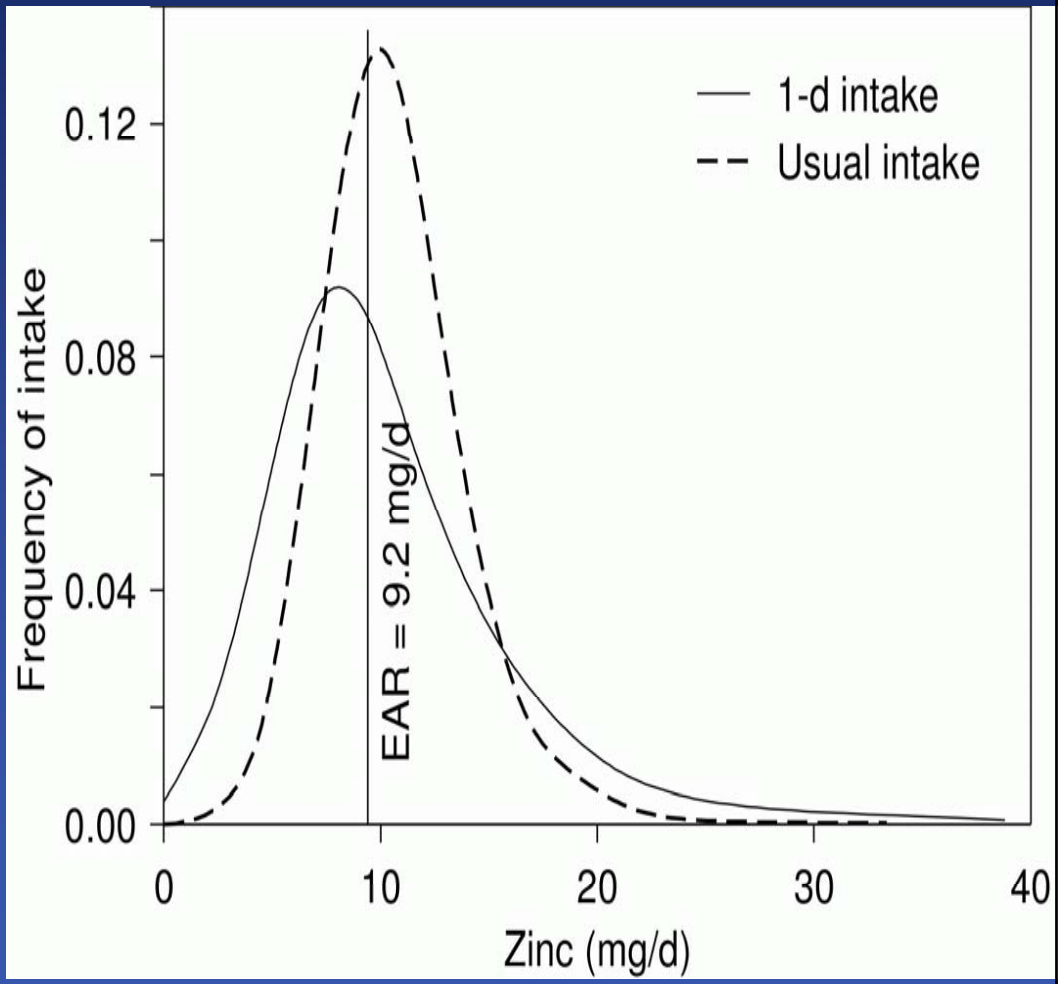
  http://www.fao.org/ifoods/
- **Calculate phytate: Zn molar ratio of diets to estimate bioavailability of Zn**

NB there should be *NO* missing values in a food composition database

4. Adjusting distribution of observed to usual intakes via PC-SIDE

- Adjust 1-d intakes to usual intakes w. PC-SIDE
  - use internal or external within-person variance
- Select appropriate EAR & UL
- Use cutpoint method to assess:
  - % inadequate intakes
  - % excessive intakes

Elevated risk >25% < EAR for Zn



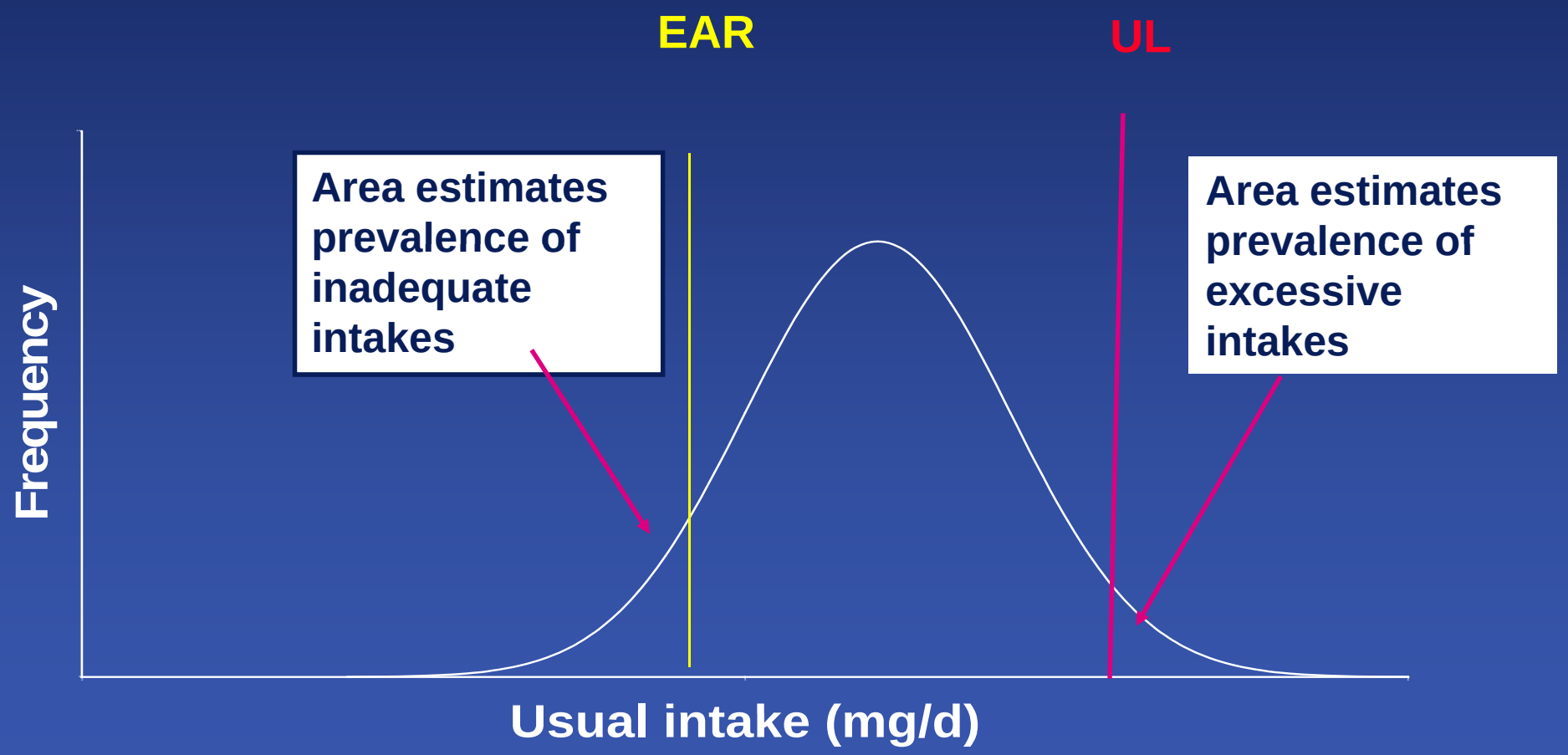
See IZiNCG Brief No. 3

Selecting appropriate EARs & ULs for Zn

- **IZiNCG (2004):** provide EARs; NOAEL for Zn
  - EAR for mixed/refined vegetarian diets; Phy:Zn: 4 to 18
  - *OR* unrefined cereal-based diets; Phy:Zn > 18
- **WHO (2005):** give EARs & UL's
  - EAR based on three levels of Zn bioavailability
- **Country-specific EARs & ULs if available**
  - eg: IOM DRV's; UK DRI's etc
  - Bioavailability: based on habitual diets

  - NB: Bioavailability *not* taken into account for UL

5. Determining prevalence of inadequate & excessive intakes by cutpoint method



Study groups and objectives

Study groups

- Infants (7-12 mos) & children aged 1-4 y
- Older children
- Pregnant women

Objectives

1. To determine usual Zn intakes and phytate: zinc molar ratios of the diets
2. To assess the prevalence of inadequate and excessive intakes of Zn
3. To examine factors associated with inadequate and excessive intakes of Zn

Infants and children aged 1-4 y: methods

County (n)	Age	Description	Method
Mongolia* (179)	1 - 3 y	Ulaanbaatar + 4 provincial capitols: random sample	1- 24HR*
Cambodia* (177)	1- 3 y	Urban poor, Phnom Penh: convenience sample	1- 24HR*
Bangladesh (480)	2 - 4 y	2 Rural agricultural districts; random sample	1X WR; 1-24HR
NZ *(176) Non-Breast fed	1- 2.2 y	3 urban centers of S Island : random sample	3 x 1 WRs
Canada (128)	3 y	5 areas in Ontario: convenience sample	3 x 1 ER
USA (3908) Non-Breast fed	< 1; 1- 3 y	CSFII Nation-wide survey Over sampling low-income	2 x 24HR

*External within-person variance used

Intakes of infants & children 1-4 y: results

Country	Zn intake mg/d	Phy:Zn molar ratio	Cu intake mg/d	Zn:Cu* molar ratio
Mongolia 1-3y	4.9 ± 0.19	4 ± 3	0.48 ± 0.43	12.0 ± 4.9
Cambodia 1-3y	2.9 ± 1.6	6 ± 3	0.66 ± 0.40	5.0 ± 3.4
Bangladesh 2- 4y	2.5 (2.1, 2.9)	11	-	-
NZ S Island 1-2y	4.8 ± 1.5	-	1.68 ± 0.51	10.2 ± 4.5
Canada 3y	6.8 ± 0.3	-	-	-
USA 1-3 y	7.6 ± 3.3	5 ± 3	0.71 ± 0.29	11.0 ± 4.0
USA < 1 y	6.6 ± 3.3	3 ± 2	0.67 ± 0.21	9.8 ± 2.5

*Zn:Cu close to < 10:1 = ratios of EARs for Zn & Cu except Mongolia

Older children - 4 to 14 y: methods

Country: (n)	Age	Description	Method
Malawi (321)	4-7 y	Subsistence HHs	2 x 24 HR
Canada (126)	4-5 y	Ontario; 5 areas; Convenience	3 x 1 ER
USA (2668)	4-5 y	CSFII nation-wide survey Over sampling low-income	2 x 24 HR
NZ (671) (908)	5-9 y 9-14 y	National survey: Over sampling of Maori + Pacific	1 x 24 HR + repeats
NE Thailand (228)	5-13 y	10 Low SES schools	1 x 24 HR*

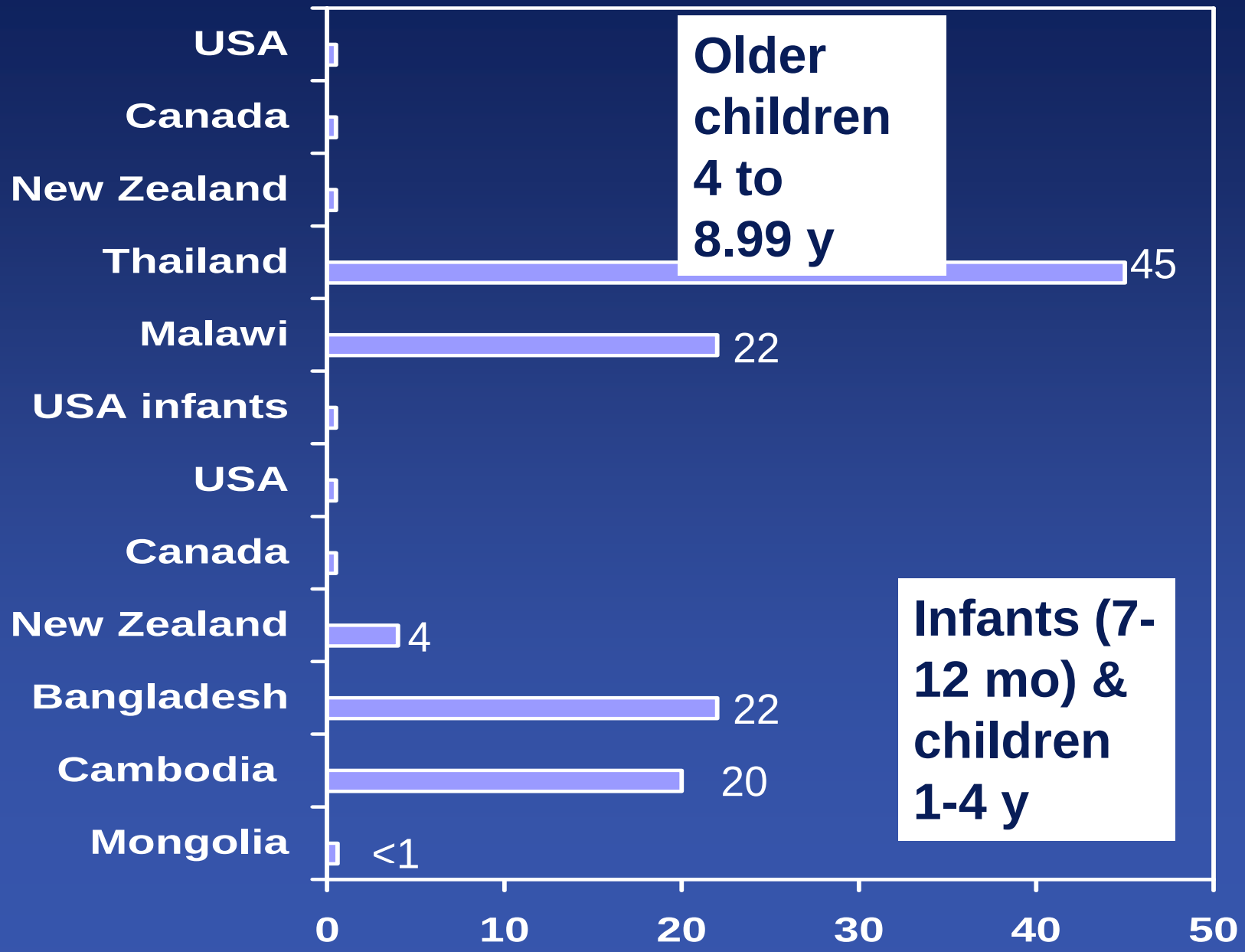
* External within-subject variance used

Intakes of older children: results

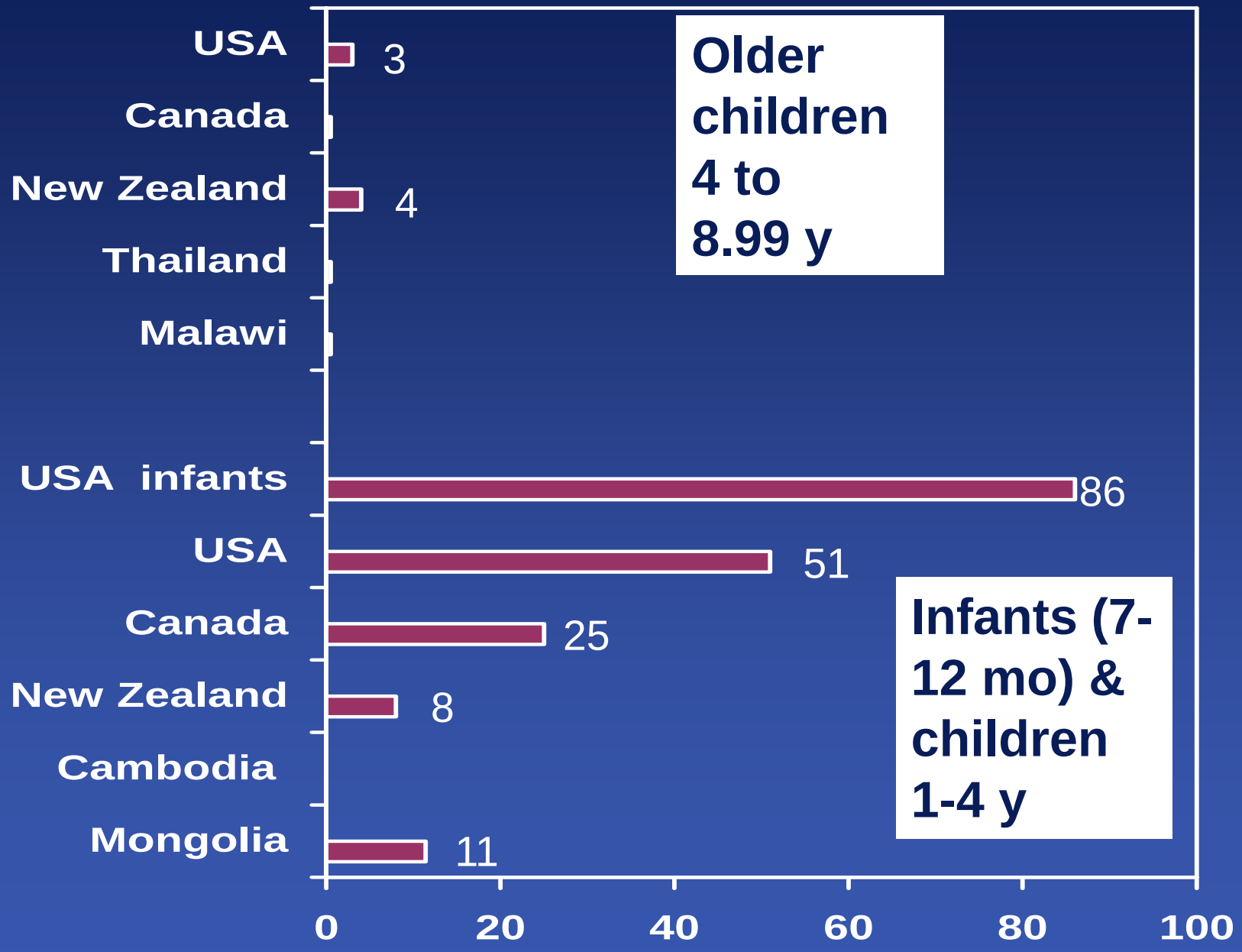
Country	Zn intake mg/d	Phy:Zn Molar ratio	Cu intake mg/d	Zn:Cu Molar ratio
Malawi 4-7y	6.7 ± 3.8	21 ± 12	-	-
Canada 4-5y	7.0 ± 0.4	-	-	-
USA 4-5y	9.1 ± 3.7	6 ± 3	0.85 ± 0.34	10.9 ± 3.8
NZ S Island 5-9y	8.7	-	-	
NZ S Island 9-14y	10.0	-	-	
NE Thailand 5-8y	4.1	<1	0.96 ± 0.42	5.4 ± 1.8
9-13y	4.4		1.01 ± 0.46	5.2 ± 2.1

Zn:Cu close to < 10:1 = ratios of EARs for Zn & Cu

Prevalence of Zn intakes below EAR (%)



Prevalence of Zn intakes above UL (%)



Zn intakes of pregnant women: methods

Country: (n)	Age	Description	Method
Malawi (141)	14-45y	Subsistence farming HHs	2 x 24HR*
Ethiopia (99)	27.8 ± 4.6	Subsistence farming HHS	1 WR + repeats
Egypt (50)	17-36 y	Rural village	2 X WR per mo for 6 mo
USA (104)	24.4 ± 5.3	Low income of Mexican descent	1 X 24HR at 20 wk gestation
USA (244)	22.8 ± 5.4	Low income African-American	FFQ

Usual Zn intakes & Phy:Zn molar ratios of diets of pregnant women

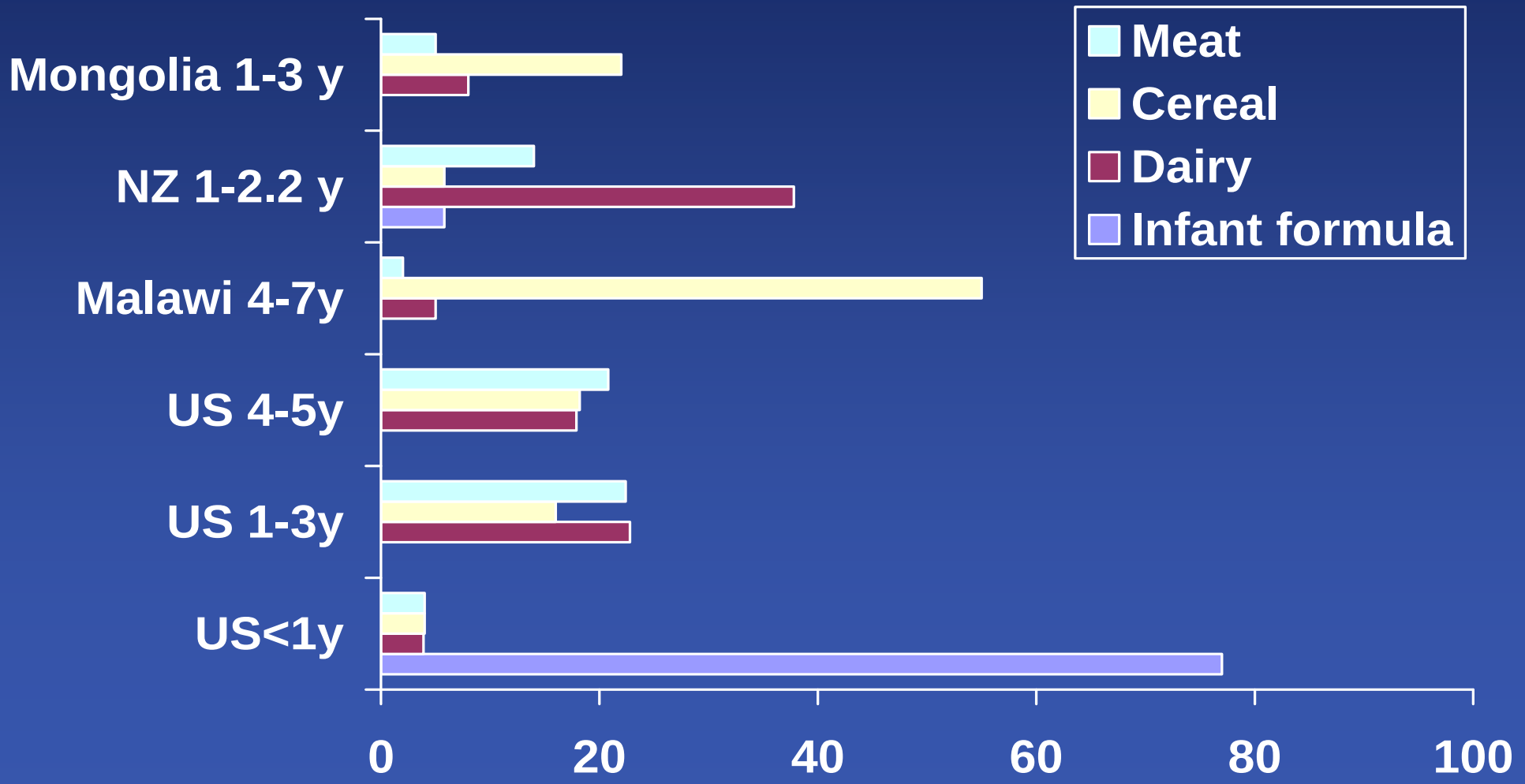
Country	Zn intake mg/d	Phy:Zn molar ratio	% with intakes < EAR	% with intakes > UL
Malawi	9.0	17	33	0
Ethiopia	5.7**	19	99	0
Egypt	9.4	15	36	?
US Mexican*	9.7	-	24	?
US African-American*	13.2 ± 5.6	-	6	?

** Staples is Enset: very low in Zn; * Low income; IZiNCG EAR=10 mg; UL=40 mg

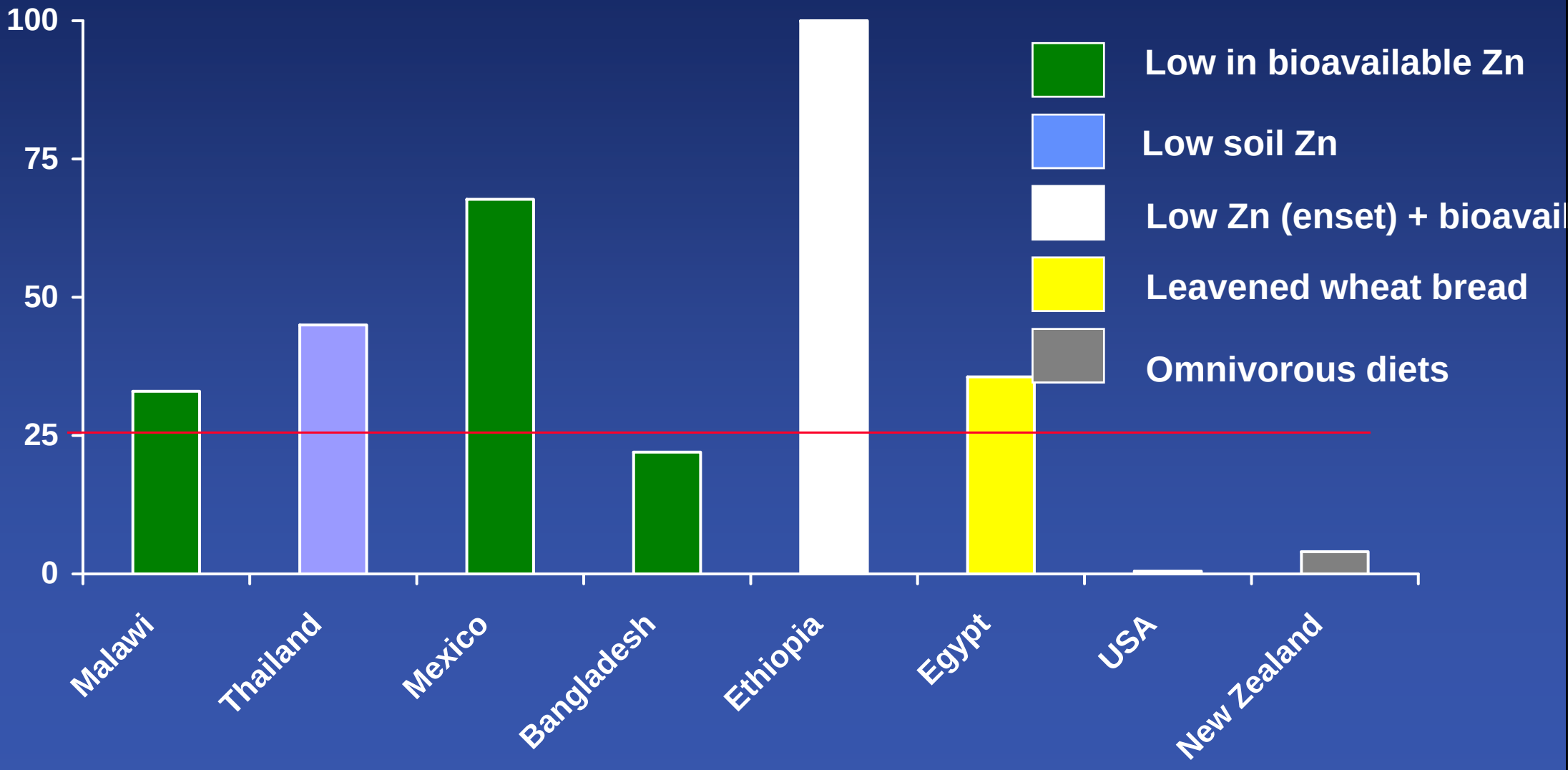
What are the factors associated with inadequate intakes of Zn?

1. **Low zinc intakes**
   - diets based on roots & tubers: enset (Ethiopia), cassava, sweet potatoes, sago
   - diets low in cellular animal foods: rich sources of Zn
   - low energy intakes (Ethiopia, Thailand)
2. **Poor bioavailability of zinc**
   - unrefined cereals/legumes: high phytate diets (Malawi)
   - low in cellular animal foods: rich in absorbable Zn
3. **Environmental factors**
   - low soil Zn: NE Thailand; Egypt; Iran; Turkey; Bangladesh; Pakistan
   - low Zn content of staples grown on low Zn soils
     - » maize>beans>rice>sorghum

Major food sources of Zn (as %) for non breast fed children from Mongolia, NZ, Malawi, & US



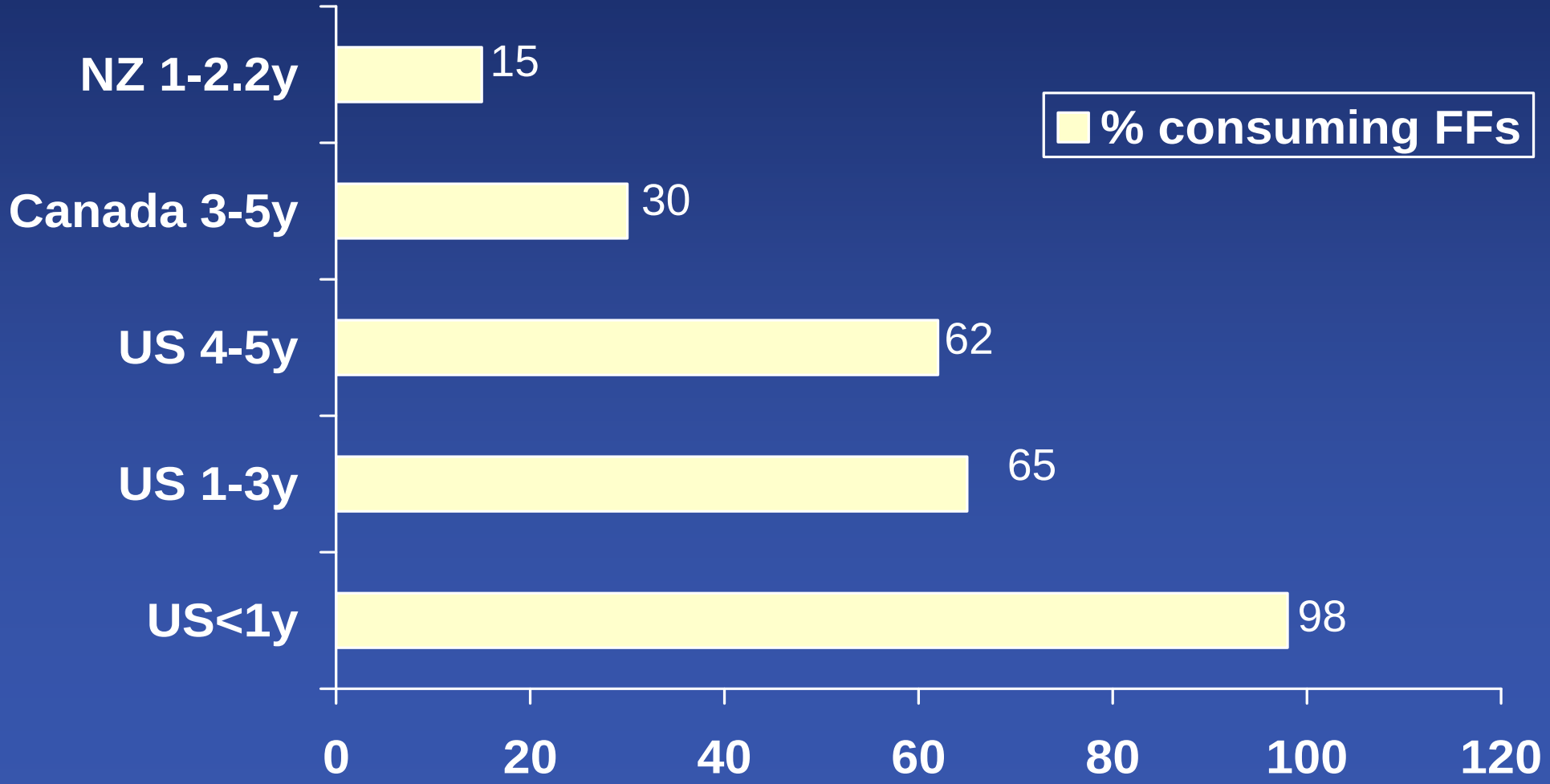
Prevalence of inadequate intakes of Zn (as %) in relation to diet type



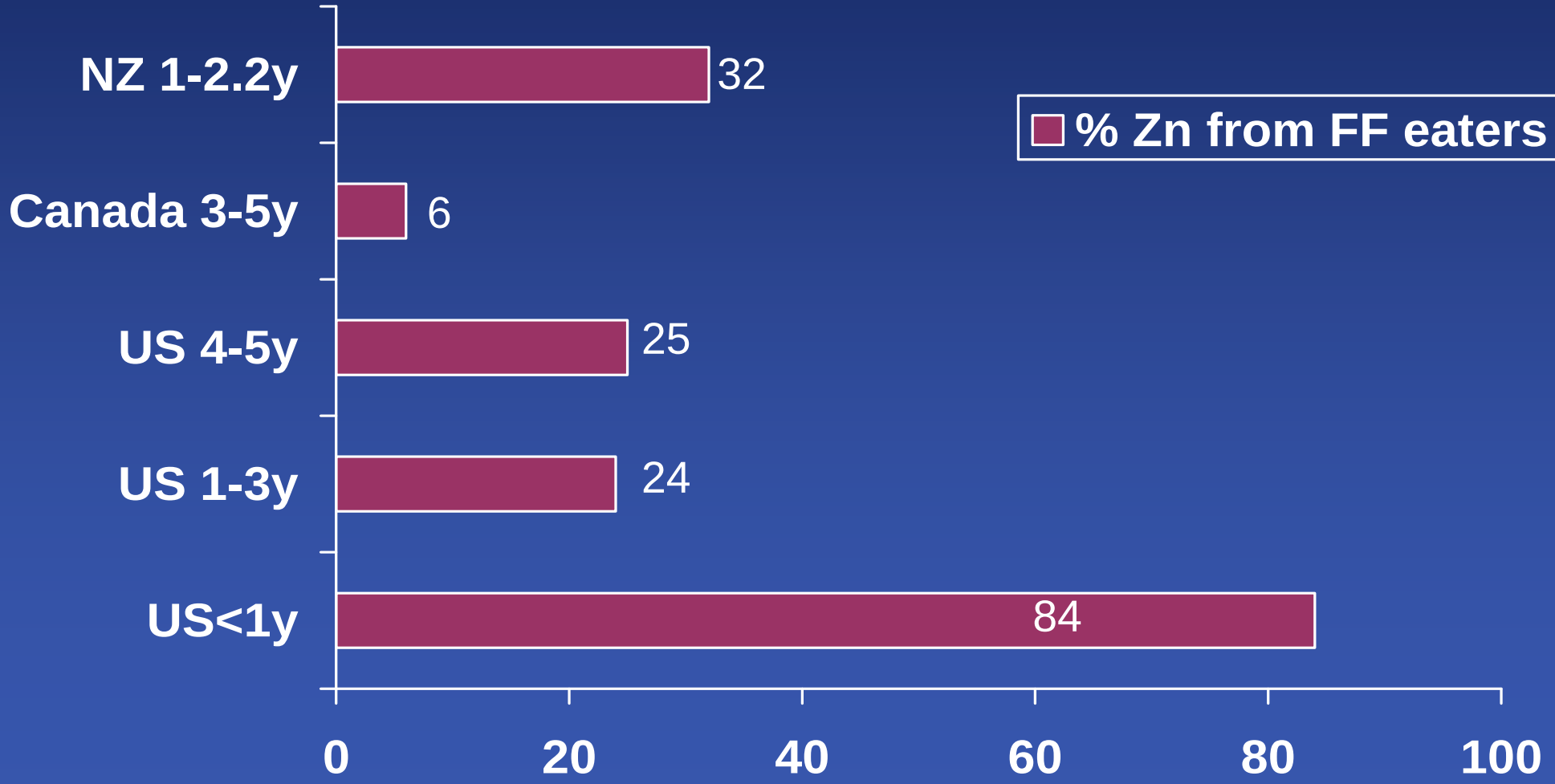
What are the factors associated with potentially excessive intakes of Zn ?

1. **Use of Zn-containing supplements in young children:**
   USA: 20%; Canada: 3%; NZ: 0%
2. **Consumption of Zn-fortified foods**
   - **Zn-fortified formula (ZnFF)**
     - **USA: 84%; NZ: 15% 1-2.2 y**
   - **Ready-to-eat Zn-fortified breakfast cereals**
     - **USA: 78%; Canada: 24%; NZ: 0%**
3. **Higher protein intake: Canada**
4. **Higher energy intake : Canada; US; Mongolia**

Percent of non-breastfed infants & young children from US, Canada, & NZ consuming Zn-fortified foods (FFs)



Percentage of total Zn intake from Zn-fortified foods among infants & young children consuming Zn fortified foods from US, Canada, & NZ



Conclusions

- Countries differ in their risk for inadequate & excessive intakes of zinc
- Infants & young children from low income countries are at high risk of Zn intakes below the EAR
- Infants & young children from North America are at high risk of Zn intakes above the UL
- Consumption of zinc-fortified foods in North America, notably zinc fortified formula & zinc-fortified breakfast cereals, are associated with high risk of zinc intakes > UL
- No evidence that there is a health risk for infants & young children with zinc intakes > UL
- Need to collect data on intakes & biomarkers of copper status and immune function in studies of children consuming zinc fortified foods

Thank you!

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