Impact of ASF on availability of critical nutrients in breast milk

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ASF intake and human function

Nutrition CRSP (e.g. Allen, Nutr. Rev. 1993)

Even at usual low intakes, higher ASF intake predicted better human function in Mexico, Kenya, Egypt (controlling for SES etc.)

In pregnancy: birthweight, infant growth, Bayley mental & motor scores.

In preschoolers: growth and size, behavior, affect (less apathy, crying, time doing nothing).

In schoolers: growth and size, school performance, Ravens matrices, verbal, block design, arithmetic, affect.

In RCTS, ASF improved growth, cognitive function, school performance, playground activity.

Animal source foods,
compared to plants, provide more:

- Energy, fat, protein
- **Vitamin B-12** (the *only* dietary source – NOT ALGAE!)
- Thiamin, riboflavin, B-6
- **Vitamin A** (the *only* <u>pre</u>formed source)
- Vitamin E
- **Iron** (the *only* dietary source of heme)
- **Zinc** (especially bioavailable)
- **Calcium**
- Vitamin D (the *only* dietary source)
- **Choline**

% increase in maternal nutrient needs, pregnancy and lactation

	P	L
Energy	13	25
Protein	54	54
Vitamin A	10	86
Vitamin C	13	60
Vitamin E	0	27
Thiamin	27	27
Riboflavin	27	45
Niacin	29	21
Vitamin B6	56	54
Folate	50	25
Vitamin B12	8	17

	P	L
Calcium	0	0
Copper	11	44
Iodine	47	93
Iron	50	-50
Magnesium	13	0
Phosphorus	0	0
Selenium	9	27
Zinc	38	50

What are consequences for mother, milk and infant when these requirements not met?

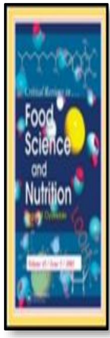
Breast milk quality

- Exclusive breast feeding (EBF) recommended for 6 mo.
- Breast milk:
  - sole source of MN for EBF infants 0 to 6 mo.
  - important source from 6 to ≈24 mo.
- The limited data show maternal MN status/intake affects milk MN, and prevalence of infant MN deficiencies is high at 6 mo.
- But little research or policy on MN status of lactating women, poor information on breast milk MN (milk quality).
- Reasons include:
  - change from prenatal to postnatal health providers;
  - concern that evidence of poor milk quality could affect EBF rates;
  - belief that poor growth and MN status in first 6 mo. of EBF due to other factors.
  - sample collection and analytical challenges.

MN groups in lactation (Allen, 1994 revised)

Group I	**Group II**
Milk MN $\propto$ to maternal status, infant depleted. Supplements can ↑ MN in milk.	Milk MN independent of maternal status, mother depleted. Supplements no effect on milk.
B-1, B-2, B-6, B-12 **Vitamins A, D, K. E?** **Choline** **Iodine** **Selenium**	**Folate** **Iron, copper, zinc** **Calcium**

Development of analytical methods



Critical Reviews in Food Science and Nutrition, 56:494–511 (2016)
ISSN: 1040-8398 / 1549-7852 online
DOI: 10.1080/10408398.2013.783550

Taylor & Francis

Analyzing B-vitamins in Human Milk: Methodological Approaches

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Journal of Chromatography B, 903 (2012) 7–13
Contents lists available at SciVerse ScienceDirect
Journal of Chromatography B
journal homepage: www.elsevier.com/locate/chromb

ELSEVIER

Ultra-performance liquid chromatography tandem mass-spectrometry (UPLC–MS/MS) for the rapid, simultaneous analysis of thiamin, riboflavin, flavin adenine dinucleotide, nicotinamide and pyridoxal in human milk

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4 platforms
5 methodological approaches
1 mL of milk

Food Chemistry 153 (2014) 60–65
Contents lists available at ScienceDirect
Food Chemistry
journal homepage: www.elsevier.com/locate/foodchem

ELSEVIER

Analytical Methods

Competitive chemiluminescent enzyme immunoassay for vitamin B12 analysis in human milk

CrossMark

Daniela Hampel[a,b,*], Setareh Shahab-Ferdows[a], Joseph M. Domek[a], Towfida Siddiqua[a,b,c], Rubhana Raqib[c], Lindsay H. Allen[a,b]

ICP-AES for the rapid, simultaneous analysis of iron, copper, and zinc in human milk

Hampel et al. 2017, submitted

Chromatographia (2012) 75:241–252
DOI 10.1007/s10337-012-2193-9

ORIGINAL

Rapid Isocratic HPLC Method and Sample Extraction Procedures for Measuring Carotenoid, Retinoid, and Tocopherol Concentrations in Human Blood and Breast Milk for Intervention Studies

Tami Turner · Betty J. Burri

PLOS | ONE

RESEARCH ARTICLE

Thiamin and Riboflavin in Human Milk: Effects of Lipid-Based Nutrient Supplementation and Stage of Lactation on Vitamer Secretion and Contributions to Total Vitamin Content

Daniela Hampel[1,2], Setareh Shahab-Ferdows[1], Linda S. Adair[3], Margaret E. Bentley[3], Valerie L. Flax[3], Denise J. Jamieson[4], Sascha R. Ellington[4], Gerald Tegha[5], Charles S. Chasela[5,6], Debbie Kamwendo[5], Lindsay H. Allen[1,2]
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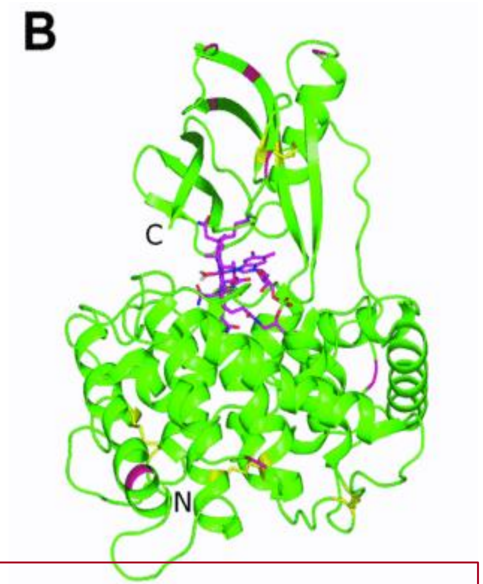
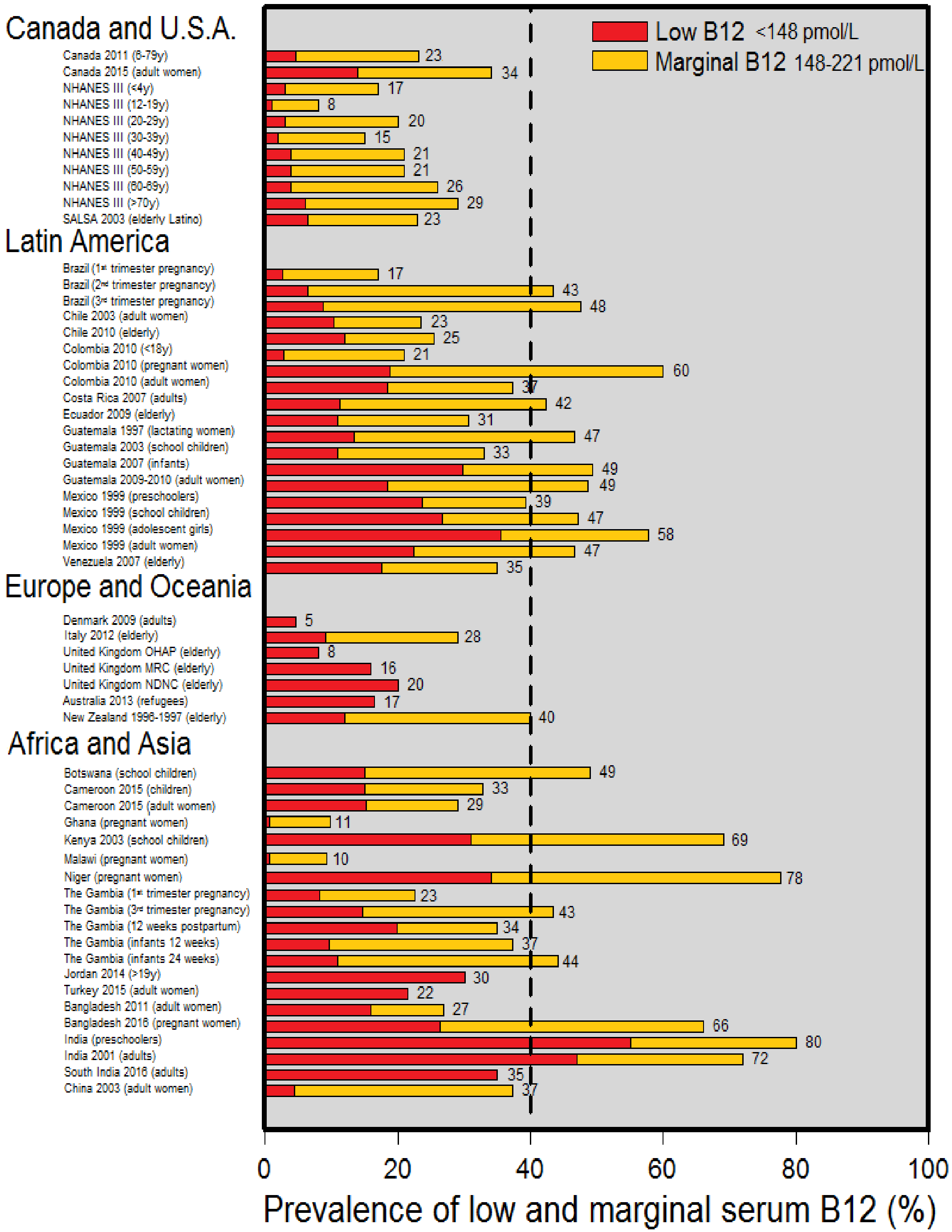
Vitamin B-12

- Deficiency and depletion are highly prevalent, often 30-50%, even >80%.
- Due to low intake of the only food source - animal source foods.
- If mothers pregnancy status poor, infant has low stores at birth, and low breast milk B-12.



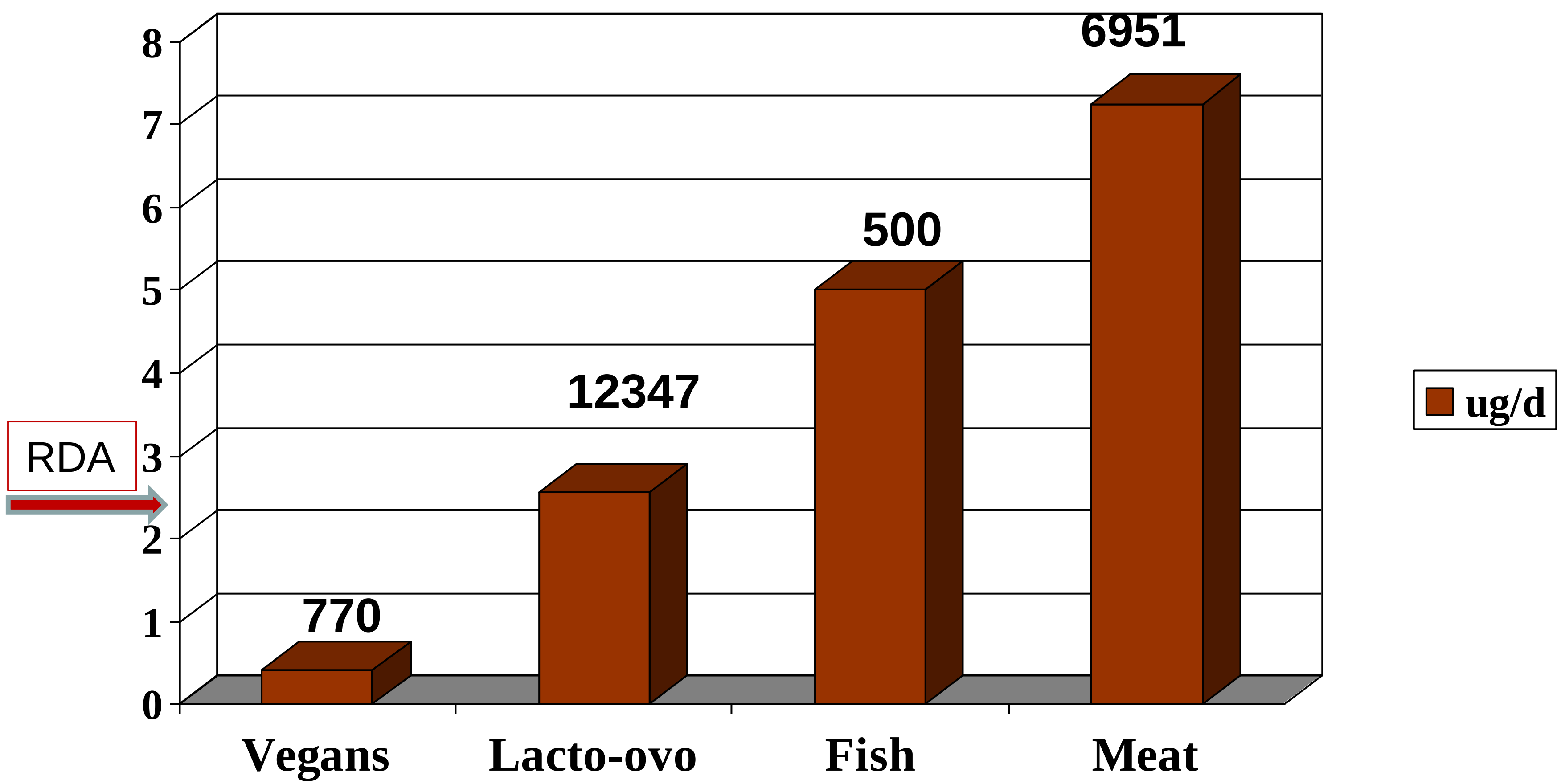
B12 bound to haptocorrin in breast milk



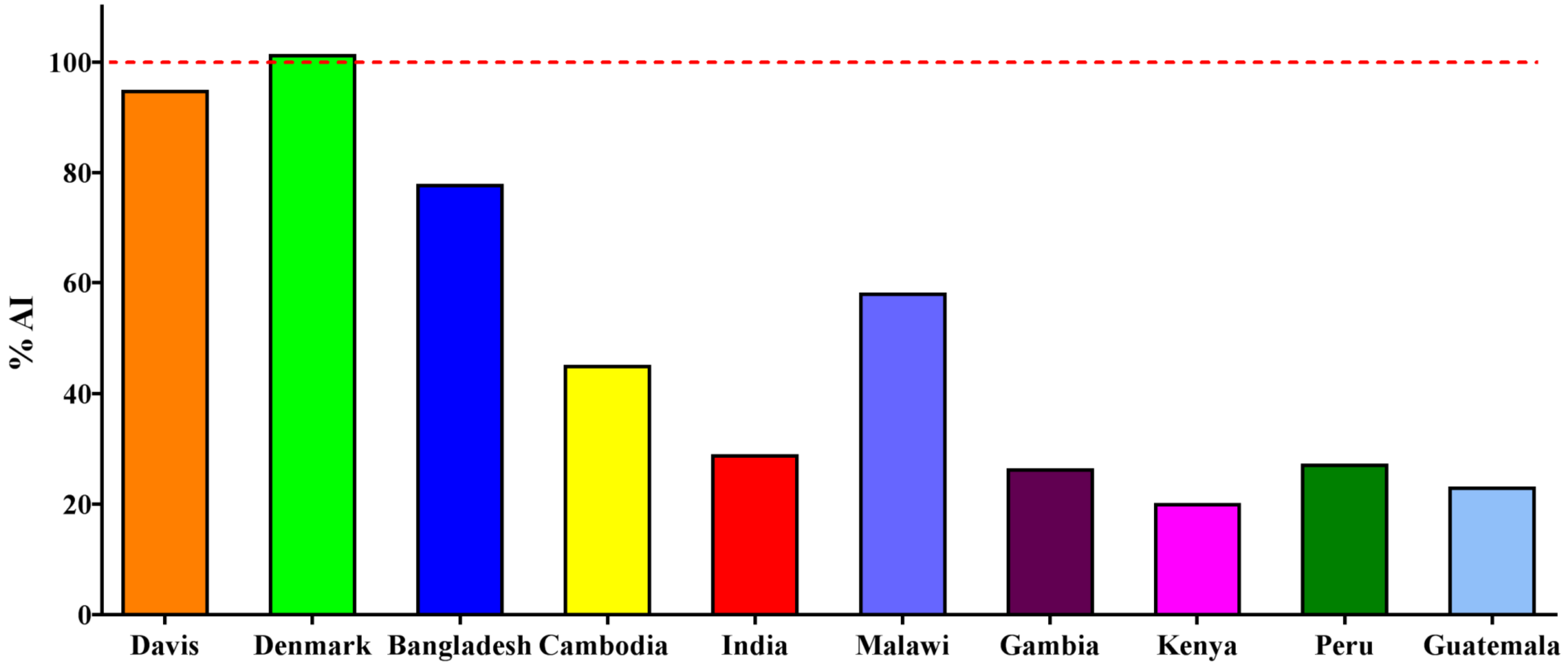
Global prevalence of low and marginal serum B12

Serum B12 correlated with B12 intake in almost every study

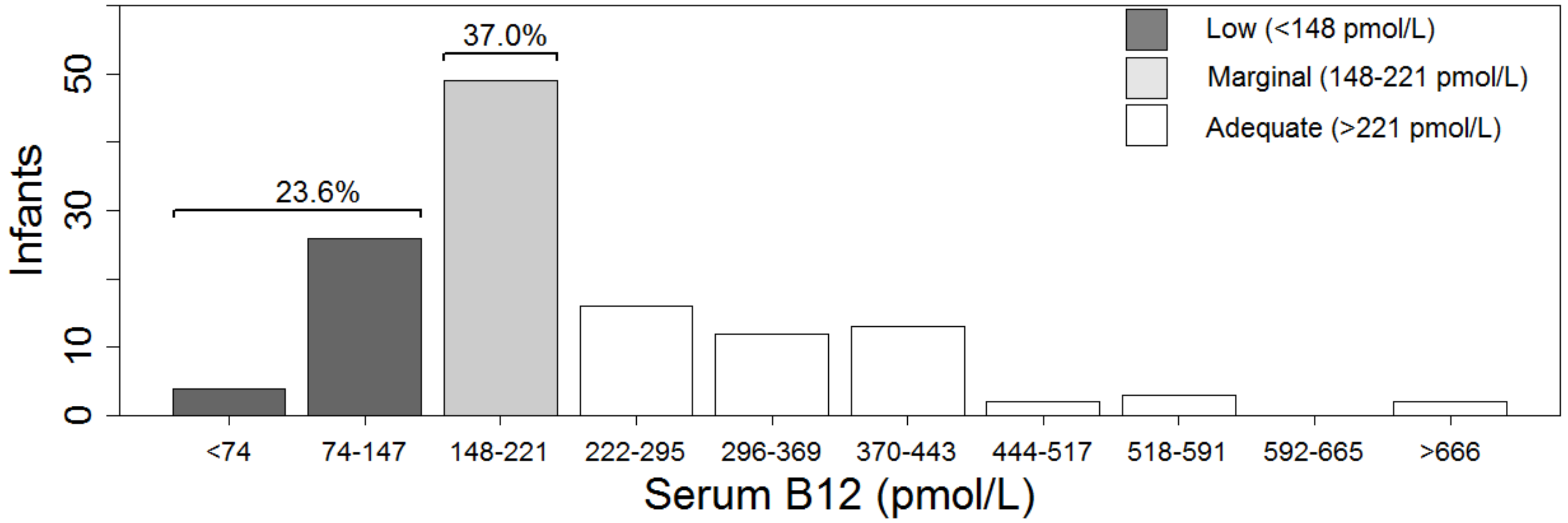
Mean B12 intakes of men by diet groups, EPIC (Davey, 2002)



Global values for milk B12: analyses from the Allen lab
Median values as % of Adequate Intake value



Serum B12 in Guatemalan infants



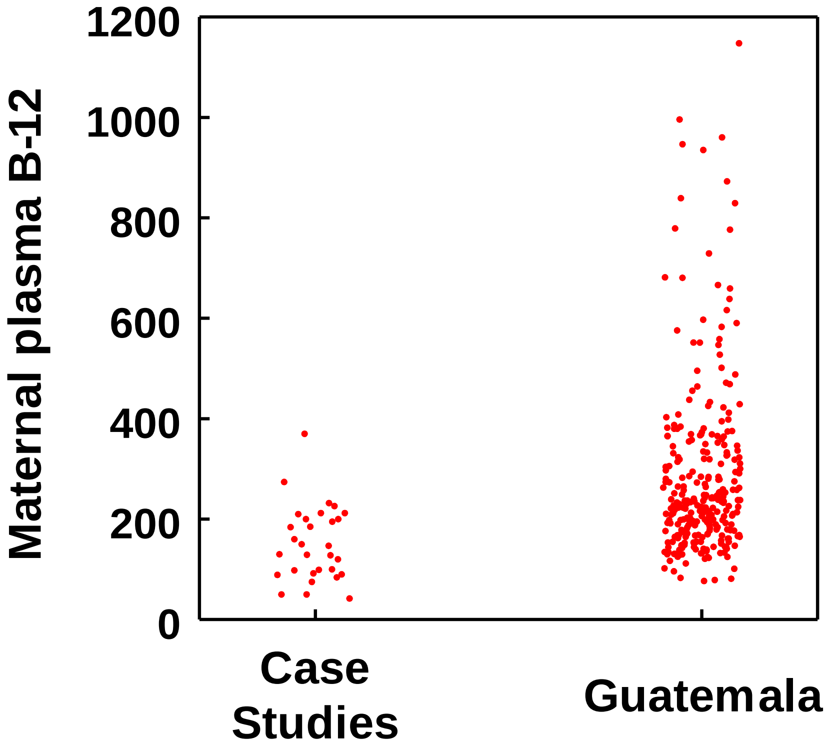
61% infants age 7 months had deficient or low serum B12

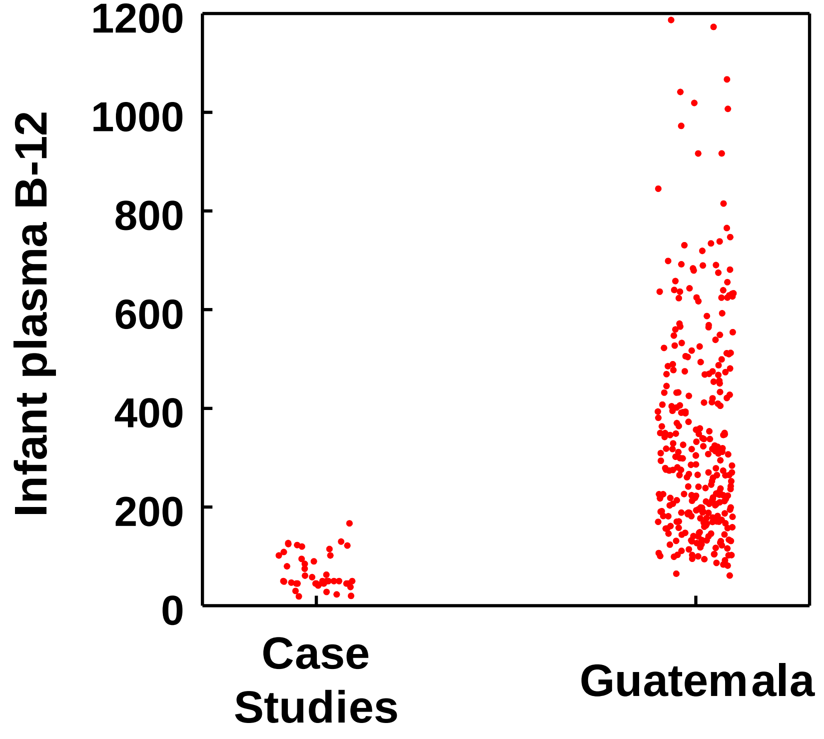
% Infants with symptoms in case studies of B-12 deficiency

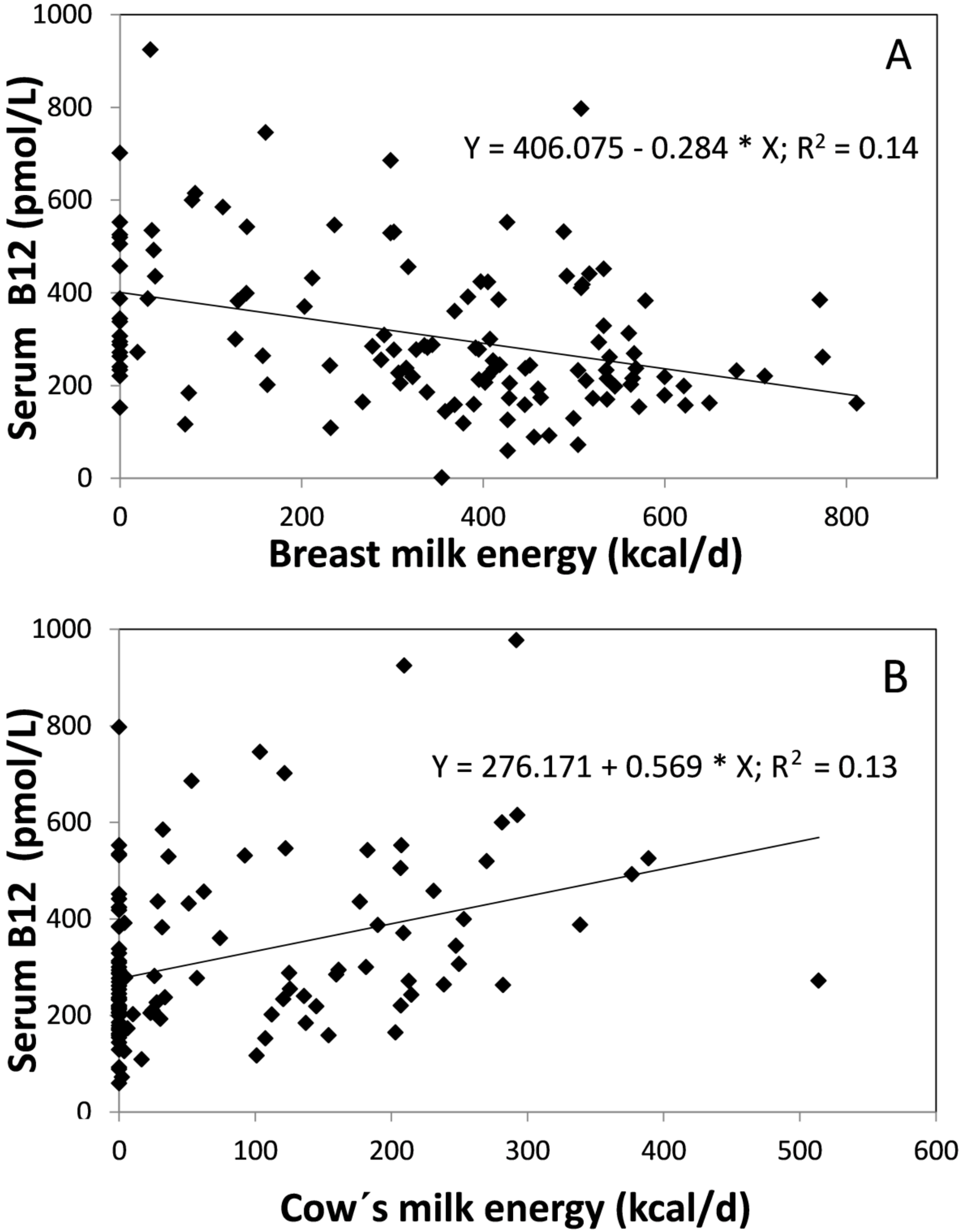
	Mother pern. anemia (n=18)	Mother vegan (n=30)
Wt <10 pcle	93	89
L <10 pcle	83	60
Head <10 pcle	91	77
Hypotonia	61	63
Developmental delay	56	60
Lethargy	50	63
Slow/abnl EEG	50	33
Not able to sit alone	33	43
Convulsions/tremors	33	23
Cerebral atrophy	28	37
Irritable	20	28
Not smiling	11	23

Dror & Allen, 1998

Overlap between maternal and plasma B12 values in clinical cases of infant deficiency, and at 12 months in Guatemala







In Guatemala, infant serum B12 at 7 mo. is *inversely* related to breast milk intake, and positively to cow's milk intake.

Cows milk has much more B12 than breast milk, especially in Guatemala, where breast milk can supply only 10% AI.

Continuum of mother-child B12 depletion

Maternal depletion in pregnancy

↓

Low B12 stores in infant at birth
& in colostrum, breast milk

↓

Infant depletion

Breastfed (-)

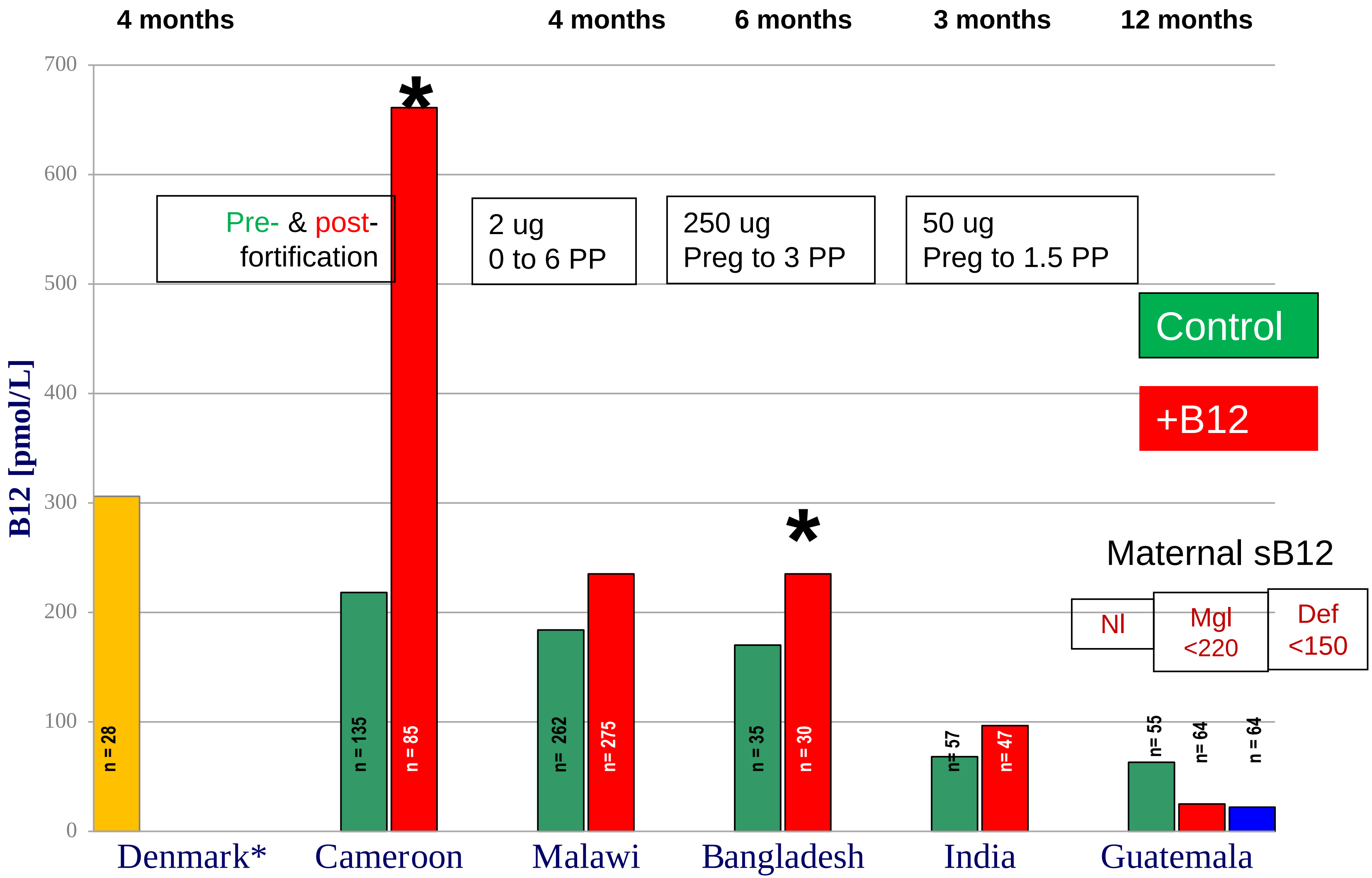
Formula/milk (+)

↓

Depletion at 21 months (still correlated with early maternal B12 status)

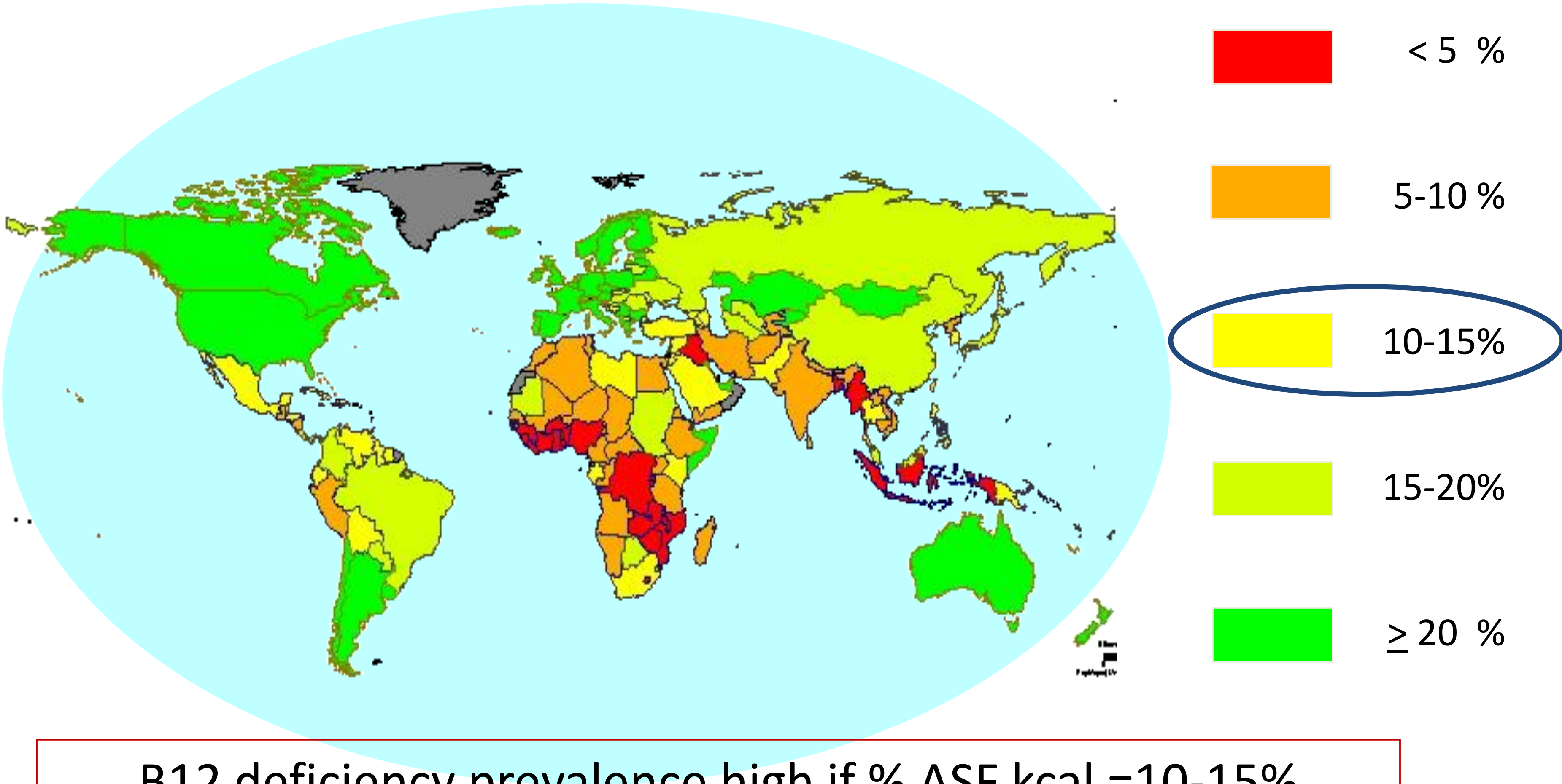
↓ weight, length, motor development

Maternal supplement dose vs B12 in milk



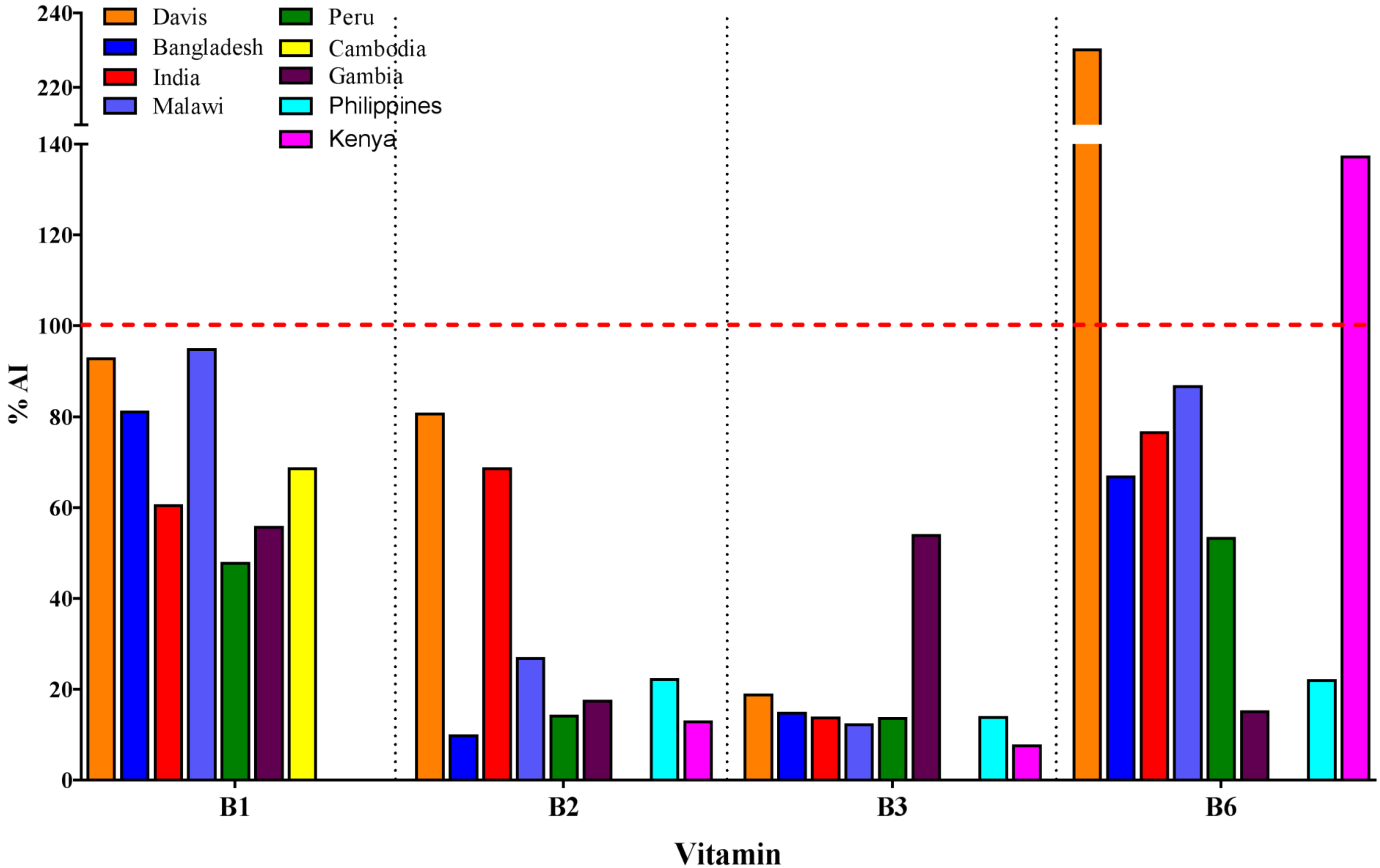
No dose normalizes milk B12

How much ASF do we need?
%energy in food supply from ASF

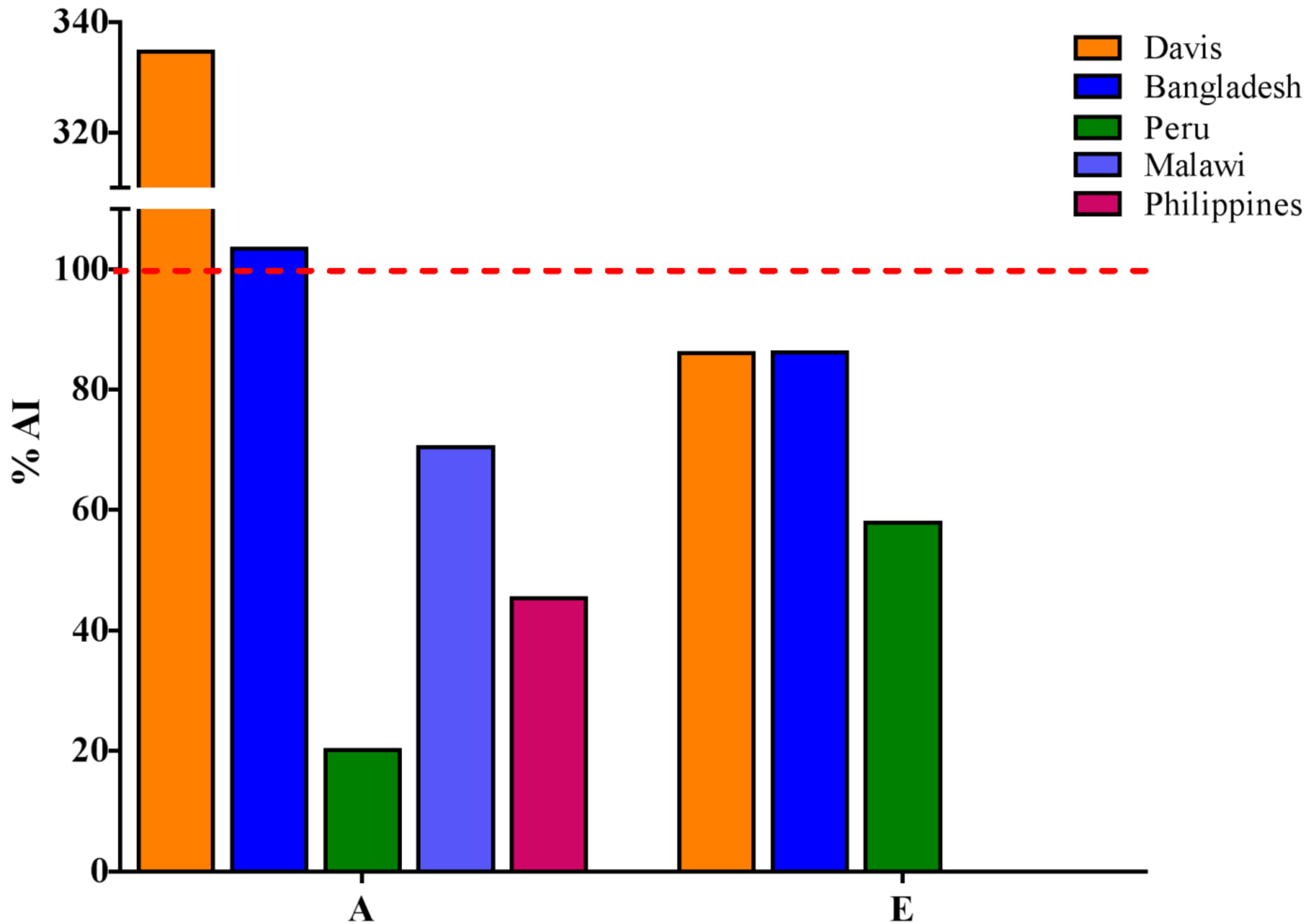


B12 deficiency prevalence high if % ASF kcal =10-15%

Median relative concentrations of vitamins B1, B2, B3, and B6 in milk as % of value assumed to set Adequate Intake

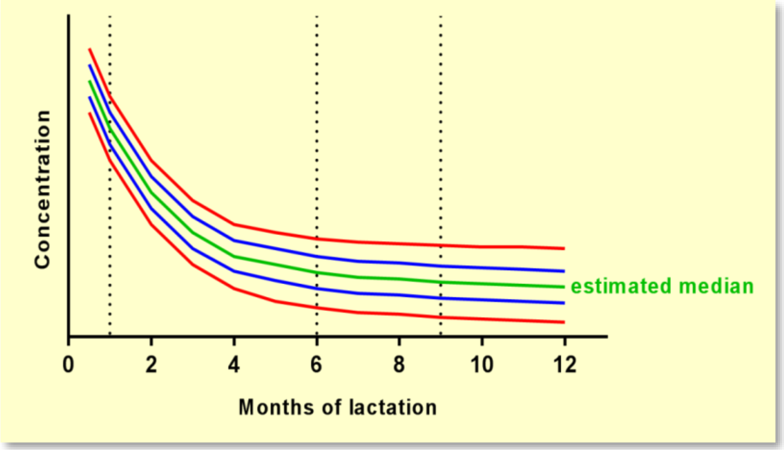


Relative median concentrations of vitamins A and E in milk as % of value assumed to set Adequate Intake



MILQ study

- Funded by BMGF to establish Reference Values for each nutrient across first 9 months lactation.
- To interpret values (lack of specific MN and foods, need for supplements/fortification, impact of interventions).
- To improve DRIs for infants, young children, lactation.
- Well-nourished (but not supplemented) mothers.
- 4 countries, same methods.
- Supported by data on diets, status, milk volume, other factors.



Summary

- Maternal MN status in lactation is neglected.
- Poor knowledge of milk composition around world – better data needed to improve estimates of requirements and gaps.
- Most MN in milk are affected by maternal status and/or intake, especially B vitamins and vitamin A; sole or major source of MN for 180-800 days.
- Milk MN *reflect* dietary quality and importance of ASF.
- Few data on effect of maternal interventions on milk and young infant – but likely *multiple* MN required (as in ASF).
- Food-based strategies – especially ASF, fortification – improve maternal intake before and throughout perinatal period; may be more effective than current supplement policy.

Collaborators in milk research

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Janet Peerson

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Kenya: A. Williams, C. Stewart

Madagascar: C. Golden

Malawi: P. Bentley, L. Adair, K. Dewey, P. Ashorn

Peru: Theresa Gyorkos

Importance of measuring milk MN

- What is prevalence of low/inadequate milk MN concentrations?
- Useful as a biomarker for population MN status; can show need for/importance of ASF and MN interventions.
- Evaluate effects of dietary change, fortification and supplementation.
- Concentrations used to:
  1. set AI for infants/young children

     AI = MN concentration X 780 mL milk/d
  2. set MN recommendations for lactation
  3. estimate MN gaps in complementary feeding.
- What are consequences for infant status and development?

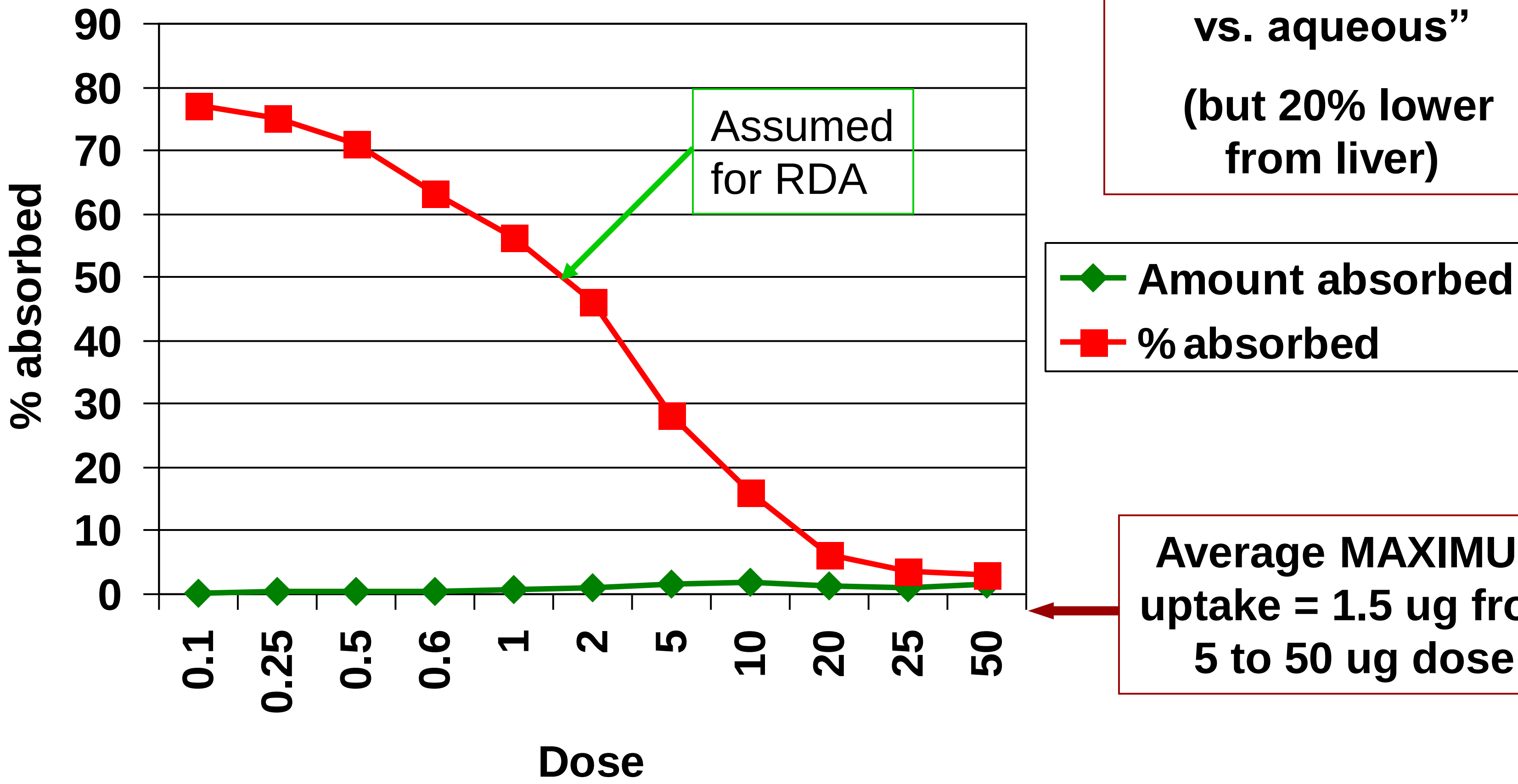
Measurement schedule (n=250 dyads x 4 sites)

	Delivery	1 – 3.4 m	3.5 – 5.9 m	7 – 8.9 m
Screen/enroll	X			
Colostrum/breast milk	X	X	X	X
(Milk volume, Hartmann) Milk volume, deuterium		X	X X (n=30)	X X (n=30)
Blood mother		X	X	X
Blood infant		X	X (n=125)	X (n=125)
Dried blood spot infant			X	X
Urine mother and infant		X	X	X
Anthrop. mother	X	X	X	X
Anthrop. infant	X	X	X	X
Development milestones		X	X	X
Diet mother (2 d)	X	X	X	X
Diet infant (2 d)	X	X	X	X
Feces mother and infant		X	X	X

Foods in “Top 10” for vitamins

Nutrient	Food
Thiamin	Fish, pork
Riboflavin	Cheese/milk, beef, lamb, eggs, pork, seafood
Niacin	Fish, poultry, pork, liver, beef
B6	Fish, poultry, pork, beef
B12	Shellfish, liver, fish, crab, beef, milk, cheese, eggs
A	Liver, butter, eggs

% B12 absorbed is inversely proportional to dose
(Chanarin)



"% Absorbed similar from meat vs. aqueous"

(but 20% lower from liver)

Average MAXIMUM uptake = 1.5 ug from 5 to 50 ug dose

≈50% of 1 ug absorbed