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1. A structure, typically cylindrical, in which fodder or forage is kept. 2. A pit or underground space for storing grain, green feeds, etc. 3. Military – an underground installation constructed of concrete and steel, designed to house a ballistic missile and the equipment for firing it.

*Source: Dictionary.com, 2012*
Welcome

The Silo Effect – And What We Can Do About It

At the recent Child Survival: Call to Action event in Washington, D.C, a new child survival goal of 20 or fewer child deaths per 1,000 live births by 2035 was set. Through multiple partnerships, focus on high-burden populations, implementing high impact solutions, empowerment of women and mutual accountability, this ambitious target can be achieved. Attending the event myself, I was struck by the fact that health interventions – and thus the treatment rather than the prevention of disease – were the focus of attention. The importance of nutrition as a foundation for health and development was barely mentioned, even by the few participants working both in the health and the nutrition sectors. How can this narrow approach address the pressing problem of child mortality and morbidity? Why do we continue to work in silos in this way?

When I think of silos, I see in my mind’s eye the highest elevations in the corn plains of Iowa, which I witnessed when driving from Des Moines to Ames in the summer of 2001 to participate in a memorial conference in honor of James Allen Olson, a pioneer in vitamin A and carotenoid research. Jim Olson will always be remembered for integrating different disciplines and valuing both young and senior scientists (see the 11th James Allen Olson Memorial Lecture elsewhere in this magazine). Remarkably, silos rarely exist alone: they more commonly occur at least in pairs, or else several in a row – and, interestingly, they are almost all connected in some way. Silos are hugely important, as they are reservoirs for storing significant produce, often grains or other crops – vital sources of life for many. Yet when we use the term ‘silo’ in today’s world, it generally has a negative connotation. It refers to the way that the many sectors which should combine to address the challenges of malnutrition (in its broadest sense) tend to function in isolation, with an inward focus and vertical information and communication. The positive has become a negative.

Nutrition’s biggest missed opportunity

In the last few years, there has been much talk in the public health nutrition space about the need to address the “silo effect”, to “break down silos”, to end the “silo mentality” and to stop “working in silos”; and yet it seems that this is much harder to do than to talk about. A Google search indicates that we are not alone in this battle: I am amazed by the number of courses and books that are available to “train” you on how to break down or manage silos. A closer look reveals that, in business, the reasons given for contemporary management considering silos as damaging are related to their negative impact on employee motivation and team effectiveness. One author writes: “This type of mentality will reduce the efficiency of the overall operation, reduce morale, and may contribute to the demise of a productive culture.” And that sums it up for me. Our continued working in silos (while the deadline for the Millennium Development Goals [MDG] targets and the new emphasis on reducing stunting and non-communicable diseases [NCDs] is keeping us from achieving what needs to be done) is making many feel despondent. Tragically, it could spell the end of all the hard work that has gone into getting nutrition high on the global development agenda and trying to keep it there.

Remaining in our silos could, in fact, lead to nutrition’s biggest missed opportunity.

Yet silos don’t just appear spontaneously. In his book Break Out of the Silo Mentality, Jeffrey Cufaude writes, “They’re created by a mix of mindset, culture, and process factors that many associations share. The good news: If you can correct those factors, you can eliminate silos and keep them from coming back.”

The challenge of behavior change

Behavior change is the hardest of all challenges, and it requires the smartest interventions. So often we lament that behavior change is what makes our work so difficult. How do we get mothers to move back to breastfeeding? How do we get people to abandon their sedentary lifestyles and become more active?
How do we mobilize communities to demand nutritious foods? Now we have to apply such questioning to ourselves! We all need to consider the patterns of behavior and, even deeper, the structures, subconscious beliefs and mental models that may be helping to perpetuate the continued existence of our silos.

The sin of self-interest
The challenge of behavior change is compounded by the fact that while almost all the stakeholders agree that the win-win we can achieve by working together for the greater good could bring benefits to everyone, the harsh reality is that we all, more often than not, act out of self-interest. “I own this area – It’s not my job – Knowledge is power – I have to deliver for my annual report/ shareholders...” We all know these phrases only too well.

“Self-interest is but the survival of the animal in us. Humanity only begins for man with self-surrender.”

Henri Frédéric Amiel

The reforming of competition
Another component in the mix is the competitiveness which has become all-pervasive – and all the more so as many are looking at the same pot for funding, and that pot seems to be shrinking. To reform our way of working, we must perhaps reform the nature of competition itself.

This is a topic in its own right, but the Harvard Business School, in an on-line article on redefining health care (www.hbs.edu/rhc/value.html), defines healthy competition as value-based competition which is ‘positive-sum’ (as opposed to zero-sum or negative-sum). This is because when value improves, all system participants can benefit. We should perhaps apply this principle to our own thinking.

“We Should actively seek out people with different ways of thinking”

Collaborating in conflict
There is a pervasive tendency to view conflict as a negative experience that is to be avoided at all costs. The very definition of conflict – as something which occurs when, due to a disagreement, people (or other parties) perceive a threat to their interests – is enough to make one fearful. Yet conflict can be viewed as a way of generating thinking, for thinking opens the door to innovative solutions. I personally prefer to view conflict as a challenge that we need to tackle. As with all tough issues, avoiding the matter won’t help. We should instead actively seek out people with different backgrounds, different ways of thinking, different experiences and different disciplines, and find ways to engage with them with a view to addressing the challenge.

In a TED Talk posted in August, entitled Dare to Disagree (www.ted.com/talks/margaret_heffernan_dare_to_disagree.html), Margaret Heffernan, author of the book Willful Blindness: Why we ignore the obvious at our peril, eloquently illustrates that good disagreement is central to progress and that the best partners aren’t what she refers to as “echo chambers”. Heffernan says: “Most of the biggest catastrophes rarely come from secret/hidden information but from information that is out there but that we are willfully blind to because we can’t or don’t want to handle the conflict that it provokes. BUT when we dare to see and we create conflict, we enable ourselves and the people around us to do our best thinking.”

Real change comes when we are more afraid of the silence than we are of facing the conflict.

It’s time we stopped talking about the breaking down of silos and the need for dialog and started having the courage to collaborate, as different but equally necessary stakeholders, amid the conflict we face. We should use our best and most innovative thinking to ensure that the universal right guaranteed to all – that to adequate food, which includes adequate nutrition – is accessible to all.

With best regards,

How do we mobilize communities to demand nutritious foods? Now we have to apply such questioning to ourselves! We all need to consider the patterns of behavior and, even deeper, the structures, subconscious beliefs and mental models that may be helping to perpetuate the continued existence of our silos.

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What is a conflict?

Noun: A serious disagreement or argument, typically a protracted one.
Verb: Be incompatible or at variance; clash.
Source: Oxford Dictionaries 2012

The term “silo effect” – Could this explanation apply to us? The term “silo effect” focuses on the gradual draining of the entire silo's grain from a remarkably small opening in the bottom. The homogeneous state of the entire volume of grain makes it highly susceptible to small changes as they occur further and further down. This is because gravity, although apparently ‘unimportant’ to a fully contained silo, suddenly shows itself to be an underlying force binding every single grain – something which becomes apparent when an ‘anomaly’ occurs at the bottom. Moreover, the nature of grain makes it an excellent example of a ‘poorly connected’ substance, prone to cascades of extreme collapse when they occur in favor of the systems overriding unified force – in this case, gravity. If the grain were more like a soapy foam, or even a gel, such a terrible collapse would be intrinsically averted, by means of the distributed multidirectional stability of its parts.

Source: http://en.wikipedia.org/wiki/Information_silo
Copenhagen Consensus 2012
Solving the World’s Challenges

What are the best ways of advancing global welfare (especially in developing countries). Should US$ 75 billion be available over a 4-year period?

“One of the most compelling investments – to get nutrients to the world’s undernourished”

Vernon Smith, Nobel Laureate Economist

TOTAL: US$ 75 BILLION OVER FOUR YEARS

$100 PER CHILD
#1 Best Investment
Copenhagen Consensus 2008:
→ Micronutrient supplements for children (vitamin A, zinc)

#2 | Best Investment
Copenhagen Consensus 2004:
→ Providing micronutrients

**TOP INVESTMENT PRIORITIES**

**BUNDLED MICRONUTRIENT INTERVENTION TO FIGHT HUNGER & IMPROVE EDUCATION**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Amount allocated per year</th>
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<tbody>
<tr>
<td>Malaria Combination Treatment</td>
<td>0.3</td>
</tr>
<tr>
<td>Childhood Immunization</td>
<td>1.0</td>
</tr>
<tr>
<td>Deworming</td>
<td>0.3</td>
</tr>
<tr>
<td>TB Treatment</td>
<td>1.5</td>
</tr>
<tr>
<td>R&amp;D to Increase Yield Enhancements</td>
<td>2.0</td>
</tr>
<tr>
<td>Effective Early Warning Systems</td>
<td>1.0</td>
</tr>
<tr>
<td>Surgical Capacity</td>
<td>3.0</td>
</tr>
<tr>
<td>Hepatitis B Immunization</td>
<td>0.12</td>
</tr>
<tr>
<td>Low Cost Drugs for Acute Heart Attacks</td>
<td>0.2</td>
</tr>
<tr>
<td>Salt Reduction Campaign</td>
<td>1.0</td>
</tr>
<tr>
<td>Solar Radiation Management</td>
<td>1.0</td>
</tr>
<tr>
<td>Conditional Cash Transfers</td>
<td>1.0</td>
</tr>
<tr>
<td>HIV Vaccine R&amp;D</td>
<td>0.1</td>
</tr>
<tr>
<td>Info Campaign on School Benefits</td>
<td>1.34</td>
</tr>
<tr>
<td>Borehole and Hand Pump Interventions</td>
<td>1.89</td>
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**$30 PAY-OFF**

$1 SPENT

LEADS TO
Improved health, schooling & productivity

EQUALS
Chronic undernutrition in developing countries

- 36%
The Relevance of Micronutrients to the Prevention of Stunting

Ellie Souganidis
Johns Hopkins University School of Medicine,
Baltimore, Maryland, USA

Key messages

01. Previous studies investigating the role of micronutrient supplements such as vitamin A and zinc in combating stunting have failed to establish a clear connection.

02. The focus of research has therefore expanded to include multiple micronutrient interventions and other comprehensive approaches.

03. It has been proposed that in populations with multiple micronutrient deficiencies, the effect of multiple micronutrient supplementation on linear growth will be more significant than single nutrient supplementation.

04. However, the results of multiple micronutrient intervention studies have also been mixed.

05. The variable success of single and multiple micronutrient interventions in improving linear growth have encouraged the development of new multifaceted approaches.

06. These strategies typically address holistic nutritional issues, as well as combating disease.

07. Because stunting is more difficult to reverse after 36 months of age, such comprehensive approaches require participation from the mother and the child.

08. Further research is necessary to better understand the various factors that contribute to stunting.

09. Ultimately, stunting cannot be adequately addressed without taking into account socioeconomic factors such as disease and poverty.

10. Nonetheless, the role of nutrition continues to warrant additional attention.

Introduction

Stunting is a major health problem worldwide, affecting approximately 178 million children under the age of five (Table 1). While the etiology of stunting is complex, inadequate nutrition and infection are among factors thought to play major roles in reducing a child’s height-for-age. As child growth and development are widely accepted to be indicators of physical, mental and economic well-being, the high prevalence of stunting in regions such as sub-Saharan Africa and south-central Asia suggests a need for effective prevention strategies that can address both the immediate and underlying causes of stunting.

As a manifestation of chronic undernutrition, stunting has been linked to multiple adverse health outcomes that extend beyond childhood into adult life. Consequently, current approaches to stunting have focused both on reducing the incidence of stunting and on reversing the effects of already impaired growth. Because stunting is intimately connected to nutrition, micronutrients have been the primary focus of scientific investigations related to stunting. However, results have been discouraging and mostly mixed. Consequently, the search for other causative agents has expanded to include the use of multiple micronutrients and other comprehensive approaches.

This article presents the known factors that contribute to stunting and the numerous negative health consequences that can result. The use of zinc, vitamin A, and multiple micronutrient
“Prevention strategies need to address both the immediate and underlying causes of stunting”
fortification and supplementation strategies will be reviewed as they have been the primary focus of studies linking stunting to micronutrient deficiency. As stunting is a multifactorial condition, the roles of socioeconomic and environmental factors will also be considered as well as the contribution of infectious diseases. Finally, stunting in at-risk child populations and the significance of maternal stunting will be discussed.

**“Growth deficits are generally permanent once stunting has occurred”**

**Stunting and its consequences**

“Stunting,” or insufficient height-for-age, is defined as a height that is more than two standard deviations below the World Health Organization (WHO) standards. Whereas growth failure can occur as early as the second trimester in utero, stunting most often emerges at about six months of age, as children transition from breast milk to complementary foods of poor quality or diminished quantity. A growing child’s increased exposure to the environment also increases the probability of infection, which can lead to impairments in growth. Because the potential for catch-up growth is greatest at a very young age, growth deficits are generally permanent once stunting has occurred, increasing the risk for subsequent morbidity and mortality.

Stunting in children can lead to increased severity of diarrheal episodes, higher susceptibility to infectious disease, and greater risks of pneumonia. Poor growth has also been linked to impaired cognitive ability and reduced school performance. More recently, children stunted before the age of two have been shown to have poorer emotional and behavior outcomes later in adolescence, including increased symptoms of anxiety and depression. Because childhood stunting leads to a reduction in adult size, it has also been associated with reduced work capacity in adulthood. Poor reproductive outcomes have been observed in mothers of short stature including obstetric complications and increased morbidity and mortality in the mother. Maternal stunting can restrict uterine blood flow and growth of the uterus, placenta and fetus, resulting in low birth weight offspring, anthropometric deficits in the child, and increased child morbidity and mortality. Ultimately, stunting can lead to adverse intergenerational patterns of impaired growth and development, propagated by poverty and disease.
“A definitive causal relation between vitamin A status and child growth has yet to be established”

**Vitamin A**

Although numerous cross-sectional studies have linked vitamin A deficiency to a greater risk of stunting, a definitive causal relation between vitamin A status and child growth has yet to be established. Previous studies have found vitamin A supplementation to either improve linear growth\textsuperscript{18,19} or to have no significant effect.\textsuperscript{20,21} More recently, the effects of vitamin A supplementation on stunting have been evaluated through a number of meta-analyses. In a 2009 meta-analysis by Ramakrishnan and colleagues, 11 of 17 studies demonstrated positive effect sizes for change in height following a vitamin A regimen. However, the weighted mean effect size of the vitamin A intervention was not statistically significant (effect size $= 0.08$; 95% CI: $-0.18,0.34$), confirming the results from a previous meta-analysis, which concluded that vitamin A supplementation alone is not an effective strategy to improve longitudinal growth in children.\textsuperscript{21}

The potential for vitamin A supplementation to improve linear growth has been more clearly described in children who were clearly vitamin A deficient and were experiencing growth limitations because of the deficiency.\textsuperscript{18,22–25} In a 2000 study in Indonesian preschool children, the growth benefit from vitamin A supplementation was considerably higher in children with low serum retinol concentrations ($< 0.35$ μmol/L).\textsuperscript{25} Breast-feeding was also found to be protective against linear growth deficits attributable to vitamin A deficiency in children six to 24 months of age living in regions where subclinical vitamin A deficiency and stunting were prevalent.\textsuperscript{25} However, in other at-risk populations, recurrent bouts of respiratory infection were observed to blunt the linear growth response to vitamin A supplementation.\textsuperscript{26} Overall, the variable effects of vitamin A supplementation on linear growth indicate that vitamin A may need to be considered as part of a group of coexisting factors that can modify growth.

“The results of studies on zinc supplementation have been mixed”

**Zinc**

Impaired linear growth is considered to be a well-known feature of zinc deficiency among children.\textsuperscript{27–29} Despite the strong evidence linking zinc deficiency to impaired height-for-age, the results of studies on zinc supplementation have been mixed. A 2002 meta-analysis by Brown and colleagues analyzing the effects of zinc supplementation on the linear growth of prepubertal children found a statistically significant effect on height (effect size $= 0.350$; 95% CI: $0.189,0.511$), particularly in children less than six months of age with lower initial height-for-age.\textsuperscript{29} These results were confirmed in a 2009 review article by the same authors that included additional studies (effect size $= 0.170$; 95% CI: $0.075,0.264$).\textsuperscript{30} In contrast, a 2009 meta-analysis published by Ramakrishnan and colleagues demonstrated the opposite effect in children under five years, indicating that zinc supplementation had a minimal and statistically insignificant effect on linear growth ($n=43$; effect size $= 0.07$; 95% CI: $-0.03,0.17$).\textsuperscript{31} Most recently, a meta-analysis by Imdad and Bhutta confirmed Brown’s results in children less than five years of age (effect size $= 0.13$; 95% CI: $0.04,0.21$).\textsuperscript{32} The variability in results amongst the four meta-analyses has been the subject of much debate. Imdad and Bhutta initially attributed the inconsistency in results to differences in inclusion and exclusion criteria.\textsuperscript{32} However, when changes were made to the criteria to better match those used by Brown et al and Ramakrishnan et al, there were no significant changes in the results or direction of the effect.\textsuperscript{31,32} It has also been suggested that improvements in baseline nutritional status from 2002 to 2009 may have contributed to the difference in results because of an overall lower prevalence of stunting. However, these changes would also be expected to affect the 2011 meta-analysis by Imdad and Bhutta, which was not the case.

Using results from their meta-analyses, Imdad and Bhutta estimated that a dose of 10 mg zinc/day would be effective in increasing the linear growth in children under five by 0.37 ($± 0.25$) cm.\textsuperscript{32} However, the authors also reinforced that zinc supplementation must be administered within the framework of a comprehensive approach including improved diet, exclusive breastfeeding, and practices of complementary feeding.\textsuperscript{32} The 2008 Lancet Maternal and Child Undernutrition Series similarly recommended zinc supplementation as an effective intervention to reduce stunting, based on evidence from Brown et al, along with more comprehensive strategies to improve child health.\textsuperscript{33}

Strong evidence also links the use of zinc supplementation to the reduction of morbidity and mortality from infectious disease, particularly diarrheal diseases.\textsuperscript{34,35} The ability of persistent diarrhea to result in growth faltering suggests a dual benefit from zinc supplementation. A 2007 study tested the effects of a two week course of zinc supplementation on the growth of children with persistent diarrhea.\textsuperscript{37} Zinc supplementation effectively reduced episodes of diarrhea and increased growth in more malnourished subjects, demonstrating the positive effects of zinc supplementation in conditions of zinc deficiency.\textsuperscript{37} Similar to its effect on diarrheal disease, zinc supplementation has
also been shown to prevent respiratory disease, with additional efficacy in children with stunted growth.  

“The evidence supporting the potential role of multiple micronutrient interventions in the prevention of stunting is still evolving”  

Multiple micronutrient interventions  

The association between several micronutrient deficiencies and impaired growth has prompted the investigation of multiple micronutrient interventions, and their efficacy compared to single nutrient supplementation efforts. It has been proposed that in populations with multiple micronutrient deficiencies, the effect of multiple micronutrient supplementation on linear growth may be more significant than single nutrient supplementation. However, as with the zinc and vitamin A studies, the results have been mixed, demonstrating that the prevention and reversal of stunting is considerably more complex.

The 2009 meta-analysis by Ramakrishnan et al analyzed the effects of 20 multiple micronutrient interventions, each of which contained a minimum of three micronutrients, and 80% of which consisted solely of vitamin A, iron, and zinc. While no significant effect on linear growth was observed following either vitamin A or zinc interventions, the multiple micronutrient interventions had a small but statistically significant effect on height (effect size = 0.09; 95% CI: 0.008, 0.17). Two-way combinations between iron and zinc, vitamin A and zinc, and iron and folic acid did not significantly improve linear growth compared to the placebo. Overall, this study confirmed the results of a previous meta-analysis by Ramakrishnan and colleagues in 2004, which also found a significant positive effect on height (effect size = 0.28; 95% CI: 0.16, 0.41) in five multiple micronutrient interventions.

Additional intervention studies have supported the effects of multiple micronutrient interventions on improved linear growth, particularly when zinc is included as part of the supplement. In a 1998 trial in Chinese children, a multiple micronutrient supple-

\[ \text{Child Nutrition} \]

\[ \text{Interventions} \]

- Including nutrition services for infants and young children, and micronutrient supplements and fortification
- Including social protection, and agricultural policies and practice to improve nutrition
- Including poverty reduction, governance and political will

\[ \text{Immediate Causes} \]

- Food/Nutrient intake
- Health

\[ \text{Intermediate Causes} \]

- Access to and availability of nutritious food
- Maternal and childcare practices
- Water/sanitation and health services

\[ \text{Underlying Causes} \]

- Institutions
- Political and ideological framework
- Economic structure
- Resources: environment, technology, people

Source: Adapted from UNICEF 1990, Ruel 2008 and World Bank (draft) 2011
Efforts to improve overall nutrient intake include energy and protein supplementation during pregnancy, campaigns to promote exclusive breastfeeding throughout the first six months of life, and complementary feeding strategies, often supported by nutritional education. Of these three interventions, complementary feeding strategies have been most clearly linked with a reduction in stunting, as demonstrated by an increase in height-for-age Z score of 0.41 (95% CI: 0.05, 0.76) in food-insecure populations relative to controls. Complementary feeding strategies used in the Progresa program in Mexico have also been successfully combined with conditional cash transfer programs and nutritional education to improve child growth.

As previously discussed, the use of micronutrient supplementation as a strategy to address stunting has received considerable attention, with a particular emphasis on the role of zinc. Although mixed results have made it unclear as to whether zinc alone is an effective strategy to improve height-for-age, the role of zinc supplementation in the prevention of diarrheal episodes supports its inclusion in a comprehensive approach towards stunting. Furthermore, the emergence of multiple micronutrient interventions and their success in improving linear growth in multiple studies suggest that the role of other micronutrients may still be unknown.

Given that stunting is considerably more difficult to reverse after 36 months of age, comprehensive approaches to reduce stunting ultimately require participation from the mother and the child, as well as implementation strategies that are appropriately timed. Interventions during both the antenatal and postnatal periods are crucial, whereas supplementary feeding intervention beyond 36 months of age may lead to rapid weight gain, resulting in long term negative outcomes. For example, results from a large programmatic intervention in Haiti demonstrated a greater reduction in stunting when behavior-change communication and food supplementation efforts were implemented for children six to 23 months of age compared to strategies targeted at restoring growth in underweight children (under five years) through food-support strategies.

**Conclusions**

Stunting continues to cause significant morbidity and mortality around the world, particularly in developing countries. Although rates of stunting have recently begun to decline (Table 2), further research is necessary to better define the factors that contribute to stunting and their potential roles in prevention. As stunting is a prominent feature of chronic malnutrition, the role of nutrition continues to warrant additional attention, particularly with regards to the timing of interventions, the use of multiple micronutrients, and the potential for other micronutrients to have a role in either preventing or reversing the effects of stunting.
Ultimately, the multifactorial etiology of stunting extends beyond nutrition to involve the global burden of disease and poverty. The ability of stunting to result in adverse health outcomes throughout the life cycle reinforces the need for immediate action, especially to address the intergenerational vicious cycle that can arise from the effects of maternal stunting. As significantly low height-for-age is considered the single strongest predictor of mortality within the first 5 years of life, the integration of education, exclusive breastfeeding, complementary feeding strategies, and nutrition is of vital importance.

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**References**


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### Table 2: Countries with fastest and slowest annual reduction of stunting between 1990 and 2010

<table>
<thead>
<tr>
<th>Countries with fastest annual reduction of stunting</th>
<th>Average annual reduction rate</th>
<th>% children stunted (2010)</th>
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<tbody>
<tr>
<td>Saudi Arabia</td>
<td>7.3</td>
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<tr>
<td>Angola</td>
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<td>29.2</td>
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<td>China</td>
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<td>7.1</td>
</tr>
<tr>
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<td>15.5</td>
</tr>
<tr>
<td>Vietnam</td>
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<td>30.5</td>
</tr>
<tr>
<td>Democratic People’s Republic of Korea</td>
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<td>43.1</td>
</tr>
<tr>
<td>Turkey</td>
<td>3.9</td>
<td>15.6</td>
</tr>
<tr>
<td>Cambodia</td>
<td>3</td>
<td>39.5</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>3</td>
<td>43.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Countries with slowest annual reduction of stunting</th>
<th>Average annual reduction rate</th>
<th>% children stunted (2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Ivoire</td>
<td>-3</td>
<td>39</td>
</tr>
<tr>
<td>Burundi</td>
<td>-2</td>
<td>63.1</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>-1.6</td>
<td>59.3</td>
</tr>
<tr>
<td>Niger</td>
<td>-1</td>
<td>54.8</td>
</tr>
<tr>
<td>Yemen</td>
<td>-1</td>
<td>57.7</td>
</tr>
<tr>
<td>Mali</td>
<td>-0.6</td>
<td>38.5</td>
</tr>
<tr>
<td>Zambia</td>
<td>0</td>
<td>45.8</td>
</tr>
<tr>
<td>Sudan</td>
<td>0.1</td>
<td>37.9</td>
</tr>
<tr>
<td>Cameroon</td>
<td>0.1</td>
<td>36.4</td>
</tr>
<tr>
<td>Malawi</td>
<td>0.5</td>
<td>53.2</td>
</tr>
</tbody>
</table>

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*Negative reduction indicates stunting rate is increasing.*


42. Rah JH, dePee S, Kraemer K et al. Program experience with micronutrient powders and current evidence. J Nutr 2012;142:1S–6S.


Building bridges for better nutrition.
Introduction

Micronutrient deficiencies are still prevalent throughout the world. The prevalence of the deficiency of some micronutrients, such as vitamin A and iodine, has been decreasing steadily over the last decades because of targeted interventions, such as supplementation of vulnerable groups (for example, half-yearly high-dose vitamin A supplements for children between six and 59 months of age) or because of food fortification (national salt iodization programs). However, deficiencies of many other micronutrients are still highly prevalent with, for example, iron and zinc deficiency affecting billions of people. Population groups at risk for micronutrient deficiencies include women of reproductive age, especially pregnant and lactating women, and infants and young children, as (rapid) tissue growth demands higher requirements for micronutrients. Muscle, for example, contains ~81 mg of zinc per kg, and therefore relatively large amounts of zinc (and other type II nutrients) are needed when (lean) body mass is being made – as is typically the case in pregnancy, infancy and early childhood. However, schoolchildren represent a vulnerable group that is often forgotten. This is surprising, as school-aged children need micronutrients not only to sustain optimal growth, even though their growth velocity is less than it is in early childhood, but also to counter infections, and for learning and cognitive development in one of the most crucial periods in their lives.

A neglected group

School-aged children are also a neglected group with regard to nutrition surveys or interventions to improve micronutrient status and health in Vietnam. A survey in 2007 in rural areas in North Vietnam showed a high prevalence of anemia and stunting in school-aged children due to micronutrient deficiencies (TT Nga, personal data). One important reason for the high prevalence of micronutrient deficiencies is low dietary intakes. For example, the same survey in North Vietnam showed an intake of vitamin A in school children of between 39–50% of the Vietnamese RDI, and for iron of between 42–54% of the Vietnamese RDI. In Vietnam, as in most South East Asian countries, the diet consists mainly of rice, vegetables and legumes. Animal foods are an excellent source of several micronutrients, such as iron, vitamin A, zinc and vitamin B₁₂, as nutrient density and bioavailability from these animal sources is much higher than from plant sources. But, even though the intake of animal foods has been increasing gradually over the last 10 years in Vietnam, it still makes only a small contribution to overall intake. Indeed, a recent survey found that zinc deficiency affected over
“School-aged children are a neglected group with regard to nutrition surveys or interventions to improve micronutrient status”
half of children and women of reproductive age. And, although the prevalence of iron and vitamin A deficiency has declined over the last decade, the same nationwide micronutrient survey showed that still >10% of children under the age of five were affected by these deficiencies. Besides malnutrition, intestinal parasite infection is also highly prevalent in Vietnamese schoolchildren, with >80% of children affected in certain areas. Intestinal parasite infestation has been associated with micronutrient deficiency, partly because of blood loss (for example, in hookworm infection), and partly because of reduced appetite and absorption of nutrients. It is not surprising, therefore, that micronutrient deficiencies remain a problem in schoolchildren in Vietnam.

Several studies have investigated possible ways to improve micronutrient status in school-aged children. Comparison of these studies is sometimes difficult, as different indicators, different combinations of micronutrients, and different durations of intervention have been used. However, hemoglobin concentrations and the prevalence of anemia have been measured in most studies – and almost all studies show an increase in hemoglobin concentrations and a decrease in the prevalence of anemia, regardless of the duration of the intervention, which could be as short as eight weeks or as long as one year. In contrast, only a few studies showed an impact on growth, and these studies typically have a longer duration of intervention.

Research collaboration
To inform the Ministry of Health of Vietnam on strategies to improve the micronutrient status of schoolchildren, and thereby improve their health and cognitive performance, two studies using similar biscuits fortified with multiple micronutrients were carried out in a research collaboration between the National Institute of Nutrition (NIN), the Institute of Research for Development (IRD) and GRET, a French non-governmental organization (NGO) for technology exchange. The main objective of both studies was to identify feasible, affordable solutions to improving the micronutrient status of schoolchildren. Food fortification and micronutrient supplementation are regarded as some of the most cost-effective tools to combat micronutrient deficiency. Indeed, the latest Copenhagen Consensus expert panel (2012) ranks micronutrient interventions as the most wanted investment to improve health. Unfortunately, a school meal program is not currently in existence in Vietnam, so simply fortifying a pro-

### Table 1: Vitamin and mineral composition of the fortified biscuits per serving (133 kcal)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Content (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (ferrous fumarate)</td>
<td>6</td>
</tr>
<tr>
<td>Zinc (zinc sulfate)</td>
<td>5.6</td>
</tr>
<tr>
<td>Vitamin D (cholecalciferol)</td>
<td>0.074</td>
</tr>
<tr>
<td>Calcium (CaHPO₄)</td>
<td>150</td>
</tr>
<tr>
<td>Iodine (potassium iodide)</td>
<td>0.035</td>
</tr>
<tr>
<td>Magnesium</td>
<td>40</td>
</tr>
<tr>
<td>Vitamin A (retinyl acetate)</td>
<td>0.30</td>
</tr>
<tr>
<td>Selenium (sodium salt)</td>
<td>0.0068</td>
</tr>
<tr>
<td>Potassium (citrate)</td>
<td>378</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.9</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>70</td>
</tr>
<tr>
<td>Thiamine (thiamine mononitrate)</td>
<td>1</td>
</tr>
<tr>
<td>Vitamin B₆ (pyridoxine hydrochloride)</td>
<td>1.1</td>
</tr>
<tr>
<td>Pantothenic acid (calcium d-pantothenate)</td>
<td>3.0</td>
</tr>
<tr>
<td>Niacin (niacinamide)</td>
<td>10.5</td>
</tr>
<tr>
<td>Vitamin E (all-rac-a-tocopheryl acetate)</td>
<td>0.0028</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>0.0015</td>
</tr>
<tr>
<td>Vitamin K (α-phylloquinone (all-rac))</td>
<td>0.001</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>28.4</td>
</tr>
<tr>
<td>Folic acid</td>
<td>0.120</td>
</tr>
</tbody>
</table>
duct already being used in school canteens was not an option. After considering various options, biscuits were chosen as the food vehicle for the studies, based on considerations of ease of distribution, familiarity with the product, and low price. Moreover, local factories were willing to participate in the studies to contribute to the national effort to prevent micronutrient deficiencies in children. And, importantly, these factories already produced biscuits that targeted school-aged children. Thus, no new product needed to be developed: The product had already been tested and was highly acceptable.

The main objective of the first study to be conducted was to find an effective intervention to improve iron status and reduce anemia prevalence in schoolchildren. One potential intervention to be tested during this study was the impact of daily consumption of multiple micronutrient fortified biscuits (FB) on iron status and anemia prevalence. However, in addition to fortification, supplementation can also be a very effective strategy for the improvement of micronutrient status. Moreover, we previously showed that a weekly iron supplement was effective in improving iron status and anemia in Bolivian schoolchildren, with similar effects to daily iron supplementation. As weekly iron supplementation is potentially cheaper than daily consumption of FB, and as iron supplements are also produced locally in Vietnam, the second intervention to be tested was the impact of a weekly iron supplement as a potential alternative and sustainable intervention for FB.

In total, 381 schoolchildren in Quang Nam province, situated 900 km south of Hanoi, were recruited for the study. Children were randomly divided into three groups: One group of children received FB (fortified biscuit group, FB, Table 1); one group of children received non-fortified biscuits (placebo group, P); and one group of children received non-fortified biscuits and, in addition, a capsule to be taken once per week with an iron supplement of 30–40 mg, depending on body weight (iron supplementation group, FeS). For blinding purposes, the FB and P groups also received one placebo capsule per week. The FB had the same appearance and taste as the non-fortified biscuits. To avoid the exchange of biscuits (and supplements) between the schoolchildren, three different classrooms were reserved in each school for the distribution of biscuits, with each child being assigned a specific color, which matched the color of the packaging of the biscuits. Supervision was carried out by teachers, who had been carefully trained. After the six-month intervention, total body iron was significantly increased in the FB and FeS groups, with higher concentrations of ferritin, indicating higher body iron stores, and lower concentrations of sTfR, indicating better tissue iron concentrations (Figure 1). In contrast to iron status, hemoglobin concentrations were only improved in the FB group as compared to P, with hemoglobin concentrations in the FeS group in between the two other groups.

**Vitamin A and erythropoiesis**

Micronutrient deficiencies other than iron may have caused this lack of improvement in hemoglobin concentrations in the schoolchildren who only received iron (FeS group). One likely candidate for this is vitamin A, which has been shown to be essential for erythropoiesis, the production of new red blood cells. Therefore, a sub-group analysis of the data was performed, looking at the role of vitamin A deficiency at baseline. We hypothesized that the iron supplement might have been more effective in children who had good vitamin A status at baseline. Indeed, in children who were vitamin A sufficient, there was no signifi-
Parasite infestation
The main objective of the second study in Vietnam was to investigate the possible negative impact of parasite infestation on the effectiveness of FB in improving micronutrient status. The study compared the effect of FB with or without de-worming, in a 2 x 2 factorial design. Children (n=510) received either FB or placebo biscuits for four months, in combination with a de-worming drug (albendazole) or a placebo for de-worming. The composition of the biscuits was similar to Study 1 (Table 1). As in the first study, children who consumed FB for four months had significantly better iron, vitamin A, iodine and zinc status at the end of the study, regardless of whether they had been de-wormed or not. Hence, the effectiveness of FB on micronutrient status was not compromised by intestinal parasites. Interestingly, although de-worming did not significantly affect the effectiveness of FB in improving micronutrient status in the schoolchildren, de-worming itself had a modest, non-significant but consistent effect on micronutrient status, with an effect size of between 25% and 50% of the effect of the FB. This indicates that a larger sample size might indeed have shown significant effects of de-worming on improving micronutrient status. Hence, half-yearly de-worming programs do seem to contribute to a better nutritional status, although this method is less efficient than direct interventions to improve micronutrient status, such as fortification or supplementation.
found that schoolchildren who received FB scored significantly better after four months on several cognitive function tests, including the Raven’s colored matrices test, when compared to schoolchildren receiving placebo biscuits. This is an important finding, as it shows that even a relatively short intervention of four months can have a significant impact on the ability of children to learn at school. The effect of FB on cognition was strongest in children who were anemic at baseline, who showed the highest increase in cognitive outcomes after receiving FB. We cannot attribute the improvement in cognitive function to one specific micronutrient in this study, as children received all of the micronutrients together, but two micronutrients that are clearly associated with cognitive function are iodine and iron. Surprisingly, although anemia prevalence was high at baseline at >25%, the prevalence of iron deficiency was low in these schoolchildren, with only 5% of them having a soluble transferring receptor (sTfR) concentration of >8.5 mg/L, indicating a lack of tissue iron. In contrast, in this study conducted in 2008, the prevalence of iodine deficiency at baseline was high, with over 40% of the children having a urinary iodine concentration <100 µg/L. In 2005, mandatory salt iodization was changed to voluntary salt iodization in Vietnam. As a result, the percentage of non-iodized salt being used per household increased dramatically, especially in urban areas around Hanoi and Ho Chi Minh City. This is reflected in the high prevalence of low urinary iodine concentrations in this study. In 2012, mandatory salt iodization was put back in place in Vietnam. In the study in 2008, iodine deficiency, as indicated by a urinary iodine concentration of <100 µg/L, was reduced by almost 50% by the consumption of FB for four months. Hence, improvement in iodine status has certainly contributed to the better cognitive testing of the children consuming FB. Interestingly, recent animal studies have shown that the provision of only iron or only fatty acids in rats deficient in both nutrients exaggerates cognitive defects, instead of bringing improvement. Therefore, although the prevalence of iron deficiency was not high in the Vietnamese schoolchildren, it might be better to include a low dose of iron in the FB.

Conclusion
To conclude, these two studies in Vietnam have shown some important ways to improve health programs for schoolchildren. Providing only iron to improve hemoglobin concentrations and reduce the prevalence of anemia is only partially effective – that

Interestingly, there was a synergistic effect of FB on the effectiveness of albendazole in reducing parasite loads after two and four months. At baseline, >80% of the children had intestinal parasites, mainly Ascaris and Trichuris, and only 5% of the children had hookworms. Children who received FB in combination with albendazole had the lowest egg counts for Ascaris and Trichuris at the end of the intervention, after four months. 4 We speculate that improved immune function in the children receiving FB results in a better defense against re-infection with intestinal parasites after de-worming, thereby enhancing the effectiveness of the albendazole. To test this, we looked at the rate of acquiring a parasite infection in the children without Ascaris (n=170) or Trichuris (n=219) infection at baseline. After four months, 41% and 49% of the children in the placebo and albendazole groups, respectively, were infected with Ascaris. In contrast, only 23% of the children in the FB and 15% of the children in the FB + de-worming groups were infected with Ascaris. This translates into a relative risk of 0.30 of Ascaris infection during the four-month study for children receiving FB. In the case of Trichuris infection, a similar pattern was found, with a relative risk of 0.36 for acquiring Trichuris when consuming FB. Hence, we can conclude that improving the micronutrient status of schoolchildren through FB contributes to reducing the intestinal parasite load, making the two interventions of FB and de-worming truly synergistic. This is another argument for the combination of several health interventions in order to optimize effectiveness. 16

Cognitive function in schoolchildren
In addition to changes in micronutrient status, the study also looked at cognitive function in the schoolchildren. The study
is, only in those children who are not deficient in vitamin A or other nutrients important for erythropoiesis. Therefore, providing both iron and vitamin A is more effective, for example in the form of biscuits fortified with iron, vitamin A and other vitamins and minerals. Currently, it is unknown whether a weekly multiple micronutrient supplement is as effective as daily multiple micronutrient-fortified biscuits, or FB, and more research into this should be conducted. Cognitive function was increased in children receiving FB, suggesting that micronutrient deficiencies impair the optimal development of these children. In addition, the impact of the FB on improving micronutrient status was not significantly affected by intestinal parasites, but the effectiveness of de-worming was enhanced by the FB, showing that combining two different health interventions can work synergistically to improve health. Interventions to improve health and cognition in schoolchildren are available, and should be a priority in countries with a high prevalence of micronutrient deficiencies. This group is often overlooked, but is highly at risk of deficiencies, and is easily targeted. As schooling is one of the most important determinants of socioeconomic potential, supporting schoolchildren during this crucial phase in their development is certainly a good investment, with long-term rewards for nations.

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E-mail: franck.wieringa@ird.fr

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17. Baumgartner J, Smuts CM, Malan L et al. In male rats with concurrent iron and (n-3) fatty acid deficiency, provision of either iron or (n-3) Fatty Acids Alone Alters Monoamine Metabolism and Exacerbates the Cognitive Deficits Associated with Combined Deficiency. J Nutr 2012; 142:1472–1478.
Growing the evidence base for micronutrients.
Food Fortification with Vitamin B12

Potential Benefits and Open Questions

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Food, Nutrition and Health, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Canada

Key messages

› Recent research has indicated a variety of possible health implications associated with subclinical B12 deficiency.

› Vitamin B12 deficiency is common worldwide. The main causes for B12 deficiency are low dietary intake and malabsorption.

› Adding B12 to food fortification programs could have the potential to improve the B12 status of population groups with low dietary B12 intake.

› Research is needed to determine whether low-dose B12 supplementation or fortification would have a measurable health impact.

Introduction

The addition of vitamin B12 (B12) to food fortification programs has been proposed in response to the high prevalence of B12 deficiency worldwide. In countries with implemented folic acid fortification programs, adding B12 is further suggested because of the interdependent metabolic roles of folate and B12, and to thereby address the potential for exacerbation of B12 deficiency symptoms associated with high folic acid intake.

Comprehensive critical appraisals have discussed the lack of causal evidence proving the health benefits of low-dose B12 fortification (or supplementation) and ruling out potential for harm of high-dose B12 intake.1–5

The World Health Organization has released new recommendations for fortification programs (following a technical consultation initiated by the Flour Fortification Initiative in 2008) which include recommendations to add B12.6 Tanzania and Cameroon have very recently adopted this recommendation by including B12 in their fortification protocols.

This review aims to provide an introduction to the topic of B12 fortification. It includes information about the causes and prevalence of B12 deficiency, and considerations for implementation of B12 fortification.

“Micronutrient deficiencies are still occurring at different levels of severity in various population groups”

History of micronutrient food fortification

Fortification refers to “the practice of deliberately increasing the content of an essential micronutrient i.e., a vitamins or mineral (including trace elements) in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health.”7 The public health benefits of micronutrient fortification are recognized in decisions to fortify the food supply with nutrients such as vitamin A, vitamin D, iodine, thiamine, and niacin – to reduce the incidence of blindness, rickets, goiter, beri-beri, and pellagra, respectively – in both developed and developing regions. These initiatives have reduced morbidity and mortality, resulting in significant economic benefits.8 Nevertheless, micronutrient deficiencies are still occurring at different levels of severity in various population groups and the need to address them was placed as a highest-level priority by the 2012 Copenhagen Consensus.9

There has been a reduction in the incidence of neural tube defects (NTD) – developmental abnormalities such as spina bifida affecting physical and neurological health – after wheat flour was fortified with folic acid in several countries in the late 1990s, with direct savings for healthcare systems.10 The decline in NTD rate was 46%, 26%, and 51% post fortification in Canada,11 the
FIGURE 1: Causes of vitamin B₁₂ deficiency

**Risk Factors**

- **Age**
- **Genetic** Single nucleotide polymorphisms in B₁₂ related genes, deficiencies in B₁₂ receptors/transporters, predisposition to disease, Imerslund Grasbeck syndrome
- **Social** Religion, socio-economic status, inhabitation of rural regions, food insecurity, low diet diversity
- **Lifestyle** Obesity, chronic alcohol abuse
- **Infections and Parasites** Diphyllobothrium latum, Helicobacter pylori, Tropical sprue, Giardia lamblia
- **Disease States** Gastrointestinal upset, gastroesophageal reflux disease, peptic ulcers, Zollinger-Ellison syndrome, atrophic gastritis, Crohn’s disease, celiac disease, gastric bypass
- **Pharmacological** Metformin, proton pump inhibitors, H₂ receptor antagonists
- **Dietary** Vegetarian diet (includes lacto-ovo, occasional meat eaters) physical barriers to animal-sourced food consumption (i.e., impaired mastication and/or swallowing abilities)

**Physiological, Metabolic, Behavioral Changes**

- Autoantibodies against intrinsic factor, destruction of parietal cells
- Achlorhydria
- Reduced gastric acid, pancreatic enzymes, removal or scarring of distal ileum
- Insufficient B₁₂ intake
- Reduced function or concentration of B₁₂ transport proteins or receptors

**Effect on B₁₂**

- Complete malabsorption of B₁₂ from gastrointestinal tract to bloodstream and from bile
- Partial malabsorption of B₁₂ from food (biliary absorption and intestinal absorption intact)
- Partial malabsorption of B₁₂ from gastrointestinal tract to bloodstream
- Insufficient replacement of excretory B₁₂ losses
- Incomplete transport of B₁₂ from blood to metabolic tissue

**Result**

- Rapid depletion of B₁₂ stores
- Progressive depletion of B₁₂ stores

**Vitamin B₁₂ deficiency** Requiring correction of disease state, increased dietary intake and/or supplementation, or application of pharmacological doses in severe cases of malabsorption
United States,\textsuperscript{12} and Chile,\textsuperscript{13} respectively. Folate deficiencies are now almost non-existent in Canada.\textsuperscript{14} An increasing number of countries worldwide followed. Mandatory fortification programs with folic acid now exist in South Africa, Brazil, Costa Rica, Argentina, Australia, Iran, Fiji, Kazakhstan, Nepal, Cameroon, Tanzania, and Moldova.\textsuperscript{15}

Health implications and causes of vitamin B\textsubscript{12} deficiency

Vitamin B\textsubscript{12} is an essential nutrient acquired almost exclusively from animal-sourced foods such as meat, eggs, cheese and milk. The digestion, absorption, and transport of B\textsubscript{12} to tissues are complex procedures requiring multiple transport proteins – haptocorrin in the stomach, intrinsic factor released in the stomach and active in the small intestine, and transcobalamin II in the blood – as well as the respective receptors. Intracellularly, B\textsubscript{12} functions as cofactor in one-carbon metabolism for the regeneration of methionine from homocysteine and in odd-chain fatty acid metabolism for the isomerization of methylmalonyl-CoA to succinyl-CoA. Low intracellular B\textsubscript{12} levels reduce the rate of these pathways, leading to increased substrate concentrations, i.e., homocysteine (Hcy) and methylmalonic acid (MMA).

Vitamin B\textsubscript{12} inadequacy can be caused by a range of factors (Figure 1). The lead causes for B\textsubscript{12} deficiency relate to the complexities of acquiring B\textsubscript{12} and successfully delivering it to metabolically active tissue. Healthy individuals with adequate B\textsubscript{12} stores and restricted intake of B\textsubscript{12} may not develop deficiency symptoms for many years because of efficient biliary reabsorption. However, individuals with malabsorption can develop symptoms within one to three years because the absorption of B\textsubscript{12} is impaired from food sources and re-circulated bile.\textsuperscript{16} Infants depend primarily on their mothers’ B\textsubscript{12} intake rather than storage during pregnancy and breastfeeding.\textsuperscript{17} Children born to B\textsubscript{12} deficient mothers show deficiency symptoms rapidly (within months), because of insufficient liver stores and immature guts.\textsuperscript{18}

Symptoms central to classic clinical B\textsubscript{12} deficiency include megaloblastic anemia – resulting from impaired DNA synthesis in red blood cells – and neurological sequelae. Latter are characterized by spinal cord and peripheral nerve degeneration, as well as sensory and motor impairment. Recent research has indicated a variety of possible health implications being associated with subclinical B\textsubscript{12} deficiency (also called marginal B\textsubscript{12} deficiency or B\textsubscript{12} depletion). Subclinical B\textsubscript{12} deficiency has been linked to an increased risk of cognitive impairment (including mild cognitive impairment, Alzheimer’s disease, non-Alzheimer’s dementia, Parkinson’s),\textsuperscript{19} diabetes,\textsuperscript{20} cardiovascular disease,\textsuperscript{21} pregnancy complications,\textsuperscript{22} osteoporosis,\textsuperscript{23} and some cancers.\textsuperscript{24} Children born to B\textsubscript{12} deficient mothers develop symptoms, such as poor growth and refusal of solid food, megaloblastic anemia, convulsion/tremors and developmental regression.\textsuperscript{18} Increased risk for insulin resistance and irregular adiposity,\textsuperscript{25} and impaired cognitive

\begin{table}
\centering
\begin{tabular}{|l|c|c|p{15em}|}
\hline
\textbf{Biomarker} & \textbf{Proposed cut-off}\textsuperscript{a} & \textbf{Subclinical deficiency} & \textbf{Limitations} \\
\hline
\textbf{Direct} & & & \\
Serum/plasma vitamin B\textsubscript{12} & \textsuperscript{62} & \textsuperscript{<148 pmol/L} & \textsuperscript{148–221 pmol/L} \\
\hline
\textbf{Direct} & & & \\
HoloTC & \textsuperscript{62,63} & \textsuperscript{<35 pmol/L} & \\
\hline
\textbf{Functional} & & & \\
MMA & \textsuperscript{65} & \textsuperscript{>370 nmol/L} & \textsuperscript{>210 nmol/L} \\
\hline
\textbf{Functional} & & & \\
tHcy & \textsuperscript{66} & \textsuperscript{>13–15 µmol/L} & \textsuperscript{10–15 µmol/L} \\
\hline
\end{tabular}
\caption{Cut-offs and limitations of biomarkers for vitamin B\textsubscript{12} status assessment\textsuperscript{71–73}}
\end{table}

\textsuperscript{a}Reflects current opinion

HoloTC: holo-transcobalamin | MMA: methylmalonic acid | tHcy: homocysteine
Because serum total B12 lacks the specificity to identify subclinical B12 deficiency, the preferred approach is to use a combination of biomarkers, such as serum B12 and plasma MMA. The measurement of MMA requires sophisticated technology and trained laboratory technicians. Of 127 studies worldwide assessing B12 status in various population groups, only 13% used plasma MMA as a confirmatory biomarker. The measurement of holoTC may provide enough sensitivity and specificity to operate without a confirmatory functional biomarker. Costs however limit accessibility of both MMA and holoTC analysis. Proposed cut-offs for all indicators to reflect subclinical and clinical B12 deficiency are shown in Table 1.

**Vitamin B12 status assessment**

Available biomarkers and suggested cut-offs

Vitamin B12 status can be determined by direct indicators and functional biomarkers (Figure 2). Direct measurement includes the assessment of serum or plasma concentrations of total B12 or holotranscobalamin (holoTC). HoloTC, the “active B12,” is the fraction of circulating B12 being taken up by tissue (approximately 20% of total B12 in blood). Functional biomarkers reflecting intracellular B12 status (Figure 2) include plasma total Hcy (tHcy) and MMA, with MMA being the more specific indicator. The main determinant of plasma tHcy is folate. In countries with folic acid fortification, B12 has become the potentially “limiting nutrient” in regard to the folate-B12 interrelated pathway and, thereby, the main determinant of plasma tHcy.

Because serum total B12 lacks the specificity to identify subclinical B12 deficiency, the preferred approach is to use a combination of biomarkers, such as serum B12 and plasma MMA. The measurement of MMA requires sophisticated technology and trained laboratory technicians. Of 127 studies worldwide assessing B12 status in various population groups, only 13% used plasma MMA as a confirmatory biomarker. The measurement of holoTC may provide enough sensitivity and specificity to operate without a confirmatory functional biomarker. Costs however limit accessibility of both MMA and holoTC analysis. Proposed cut-offs for all indicators to reflect subclinical and clinical B12 deficiency are shown in Table 1.

**Measuring vitamin B12 status in field settings**

In areas where the more laborious assays are not feasible due to high costs and/or lacking infrastructure, dried blood spot (DBS) analysis can be an economical and field applicable substitute. The advantages of DBS analysis include less invasive...
Food Fortification with Vitamin B₁₂

The nutritional needs of population groups are defined by nutrient intake and/or biochemical measurements that both are seldom available on the national level. A review by McLean et al. documented only seven nationwide surveys out of 127 studies that were conducted worldwide to determine prevalence of B₁₂ deficiency. A varied combination of biomarkers, technological assays, and cut-off values was employed for the data available, which impairs the comparability of data sets. Most often serum B₁₂ was used as an indicator of B₁₂ status. The range of cut-off values to classify B₁₂ deficiency however varied greatly: The majority (64%) of studies used a low cut-off between 100–150 pmol/L indicating clinical B₁₂ deficiency. In 26% of the studies, clinical and subclinical B₁₂ deficiency was distinguished by using cut-off values 100–150 pmol/L and 200–250 pmol/L, respectively. Ten percent defined B₁₂ deficiency as having serum B₁₂ concentrations below cut-offs in the range of 200–250 pmol/L, and thus of subclinical deficiency. Internationally harmonized cut-off values should be enforced.

Worldwide prevalence of vitamin B₁₂ deficiency

Vitamin B₁₂ deficiency is common worldwide. The most frequent causes for B₁₂ deficiency are low dietary intake and malabsorption. Dietary insufficiency could be more responsible for the prevalence of B₁₂ deficiency in the developing world as opposed to industrialized countries. Vegans, vegetarians, lacto-ovo vegetarians (vegetarians who consume milk and eggs) and low animal-sourced food consumers have a higher deficiency risk compared to omnivores. These types of diets are quite prevalent in developing countries. Religious beliefs, culture, economic limitations and physical access affect animal-sourced food intake. In developing regions, the prevalence of B₁₂ inadequacy in women of child-bearing age, infants, and children has been relatively higher compared to developed countries (Table 2). It was observed that dietary intake was the most significant predictor of B₁₂ status in studies of lactating women and schoolchildren in Guatemala, and of schoolchildren in Kenya. Breastfed infants of deficient mothers in developing regions are especially vulnerable to developing clinical symptoms such as developmental delays. In most cases, low B₁₂ status caused by insufficient dietary B₁₂ intake is reversible with increased intake of B₁₂.

Malabsorption of B₁₂ is the other major cause of B₁₂ deficiency and affects mostly older adults with progressive, age-related decline in gastric acidity. In Chile, older men and women were 51% and 31% B₁₂ deficient, respectively, despite achieving adequate intakes of B₁₂. A poor correlation was also observed between B₁₂ intake and B₁₂ status in older adults in India. In Canada, 10% of older women were found to be B₁₂ deficient (<150 pmol/L). A population-based survey in Canada, however, showed that there is no trend towards increased rates of B₁₂ deficiency with advancing age, which is suggested to be due to high supplement usage in older adults. In Canada, higher rates of B₁₂ deficiency are observed in select subpopulations such as South Asians (46% below 132 pmol/L) and women of childbearing age (14% below 150 pmol/L). These observations suggest that dietary insufficiency might play a role in rates of B₁₂ deficiencies in Canada.

Adding B₁₂ to food fortification programs might have the potential to increase the B₁₂ status of population groups with low dietary B₁₂ intake

While low-dose fortification would likely bypass the group of (mostly) older adults with impaired absorption capacity, adding B₁₂ to food fortification programs would increase the nutritional status of population groups with low dietary B₁₂ intake.

Food fortification with folic acid has a clearly defined health target – NTD reduction

Considerations for vitamin B₁₂ food fortification programs

Goals and open questions for vitamin B₁₂ fortification

The addition of B₁₂ to flour fortification programs could achieve, but is not limited to, the following goals:

1. Improve B₁₂ status and prevent B₁₂ depletion and deficiency in the general population;
2. Reduce the occurrence of suggested health implications related to subclinical B₁₂ deficiency, e.g., further reduce NTD incidence; and
3. Reduce the risk of high-dose folic acid intake to mask and/or to aggravate clinical symptoms of B12 deficiency.

The third goal refers to recent observations and addresses the concern that B12 deficiency symptoms might be exacerbated if folate status is simultaneously high. For instance, increased risk of elevated tHcy, cognitive decline and anemia, and insulin resistance have been observed in populations with concurrent high folic acid intake and low B12 status, although it is not fully elucidated whether the relationship is causal and what the underlying mechanisms are. It should be noted that some studies have failed to observe an adverse effect of high folate status.

Food fortification with folic acid has a clearly defined health target – NTD reduction. The potential of folic acid to reduce NTD occurrence was shown in randomized controlled trials before introducing fortification programs. To date, no controlled intervention study has been conducted to test whether low-dose B12 intake from supplements and/or fortified foods reduces the occurrence of diseases associated with subclinical B12 deficiency. For example, NTD risk is increased in women with marginal B12 deficiency, but it is unknown to date whether treatment with B12 would result in further reduction in NTD rates.

Defining the optimal dosage

In fortification programs, the goal is to provide a consistent dose of the specific micronutrient to – ideally – the entire population. The suggested additional intake of B12 through fortification is 1.0 µg/day, independent of the age group. The amount of B12 added to the fortification vehicle (e.g. wheat flour) would be determined by average consumption patterns. For example, the B12 fortification level of wheat flour would be 0.005 mg B12 per kg flour in a population with an average consumption of wheat flour of 200 g per day (600 g/day, 95% percentile).

The design of fortification programs is complicated by the diversity of population groups and dietary habits. The etiological variation between subclinical and clinical B12 deficiency makes a uniform fortification dose unfeasible. Bioavailability of B12 greatly varies between cases of subclinical and clinical B12 deficiency, i.e., between impaired absorption and complete B12 malabsorption. In healthy individuals, only approximately...
50% of a 1–2 μg dose of food-bound B_{12} is absorbed. With malabsorption or dysfunction of the transfer proteins, this can decrease to 1.2% absorption via diffusion. Those with B_{12} deficiency are therefore the least likely to benefit from a modest fortification protocol. The proposed 1 μg dose would not benefit individuals with complete malabsorption. Individuals with food-bound B_{12} malabsorption, who still have functional transport proteins but cannot cleave B_{12} from food, may also require a higher dose than healthy individuals.

**Industrial versus home fortification**

The effectiveness of fortification in economic terms is measured by the cost-benefit analysis, taking into account the savings accumulated from the number of deaths or disability-adjusted life years averted. The benefit-to-cost ratios could be high in areas with malnutrition where healthcare systems might not have the opportunity to address nutrient deficiencies. If future research showed that low dose B_{12} supplementation or fortification reduces the occurrence of B_{12} associated diseases, B_{12} fortification programs would have the potential to improve quality of life and increase longevity in deficient populations. In order to validate the proposal of population-based food fortification with B_{12}, the potential health benefits and resulting economic savings and social gains need to be determined.²

Fortification relies on an efficient food vehicle and the existence of infrastructure to support manufacturing, regulation, and distribution. Commercial fortification could result in disproportionate consumption of added micronutrients, because some could consume more than the recommended intake, or because it might be more accessible to affluent, health-conscious, and/or more highly educated individuals. Restricted access to industrially manufactured foods, especially in rural communities, would limit access to fortified products in developing regions. Home fortification, an approach in which families are provided with pre-packaged micronutrient supplementation that they add to their own food, is more expensive per dose than industrial fortification but is possibly cheaper to transport and distribute. Figure 3 illustrates the different production-to-consumption processes for industrial and home fortification.

Multiple micronutrient home fortification may be an especially practical tool for addressing B_{12} deficiency in infants in developing countries, because of limited access to fortified complimentary food products. Micronutrient powders (MNP) were developed as a convenient home fortification method, and were shown to be successful in reducing micronutrient deficiencies such as iron deficiency anemia.⁵⁰ MNPs are single-dose sachets containing micronutrients in powder form, which are easily added to any complementary food prepared in the household. Multi-micronutrient formulations of MNPs typically provide 0.9 μg of B_{12} per sachet. Intervention trials should be initiated to evaluate the utility of home fortification programs in different population groups for correcting B_{12} deficiency.

**Observations regarding adverse effects**

With regard to folic acid fortification, there have been increasing concerns about potential adverse health effects of high-dose folic acid intake from fortified foods, most often in combination with vitamin supplement usage – e.g., promotion of cancer development.⁵¹ Folate and B_{12} contribute to the process of cell division, which under circumstances of pre-existing cancer may induce promotion of tumor growth. Supplementation with B_{12} and folic acid was observed to increase risk of cancer and all-cause mortality in patients with ischemic heart disease.⁵¹ The study design, however, does not allow for the extrapolation of the effect of only folic acid or B_{12} on cancer outcomes. Vitamin B_{12} is currently considered safe at all levels of intake and does not have a tolerable upper intake level. In a dose-response trial in older adults (aged >70 years), no adverse effects were reported after high-dose (1000 μg) supplementation with B_{12} for 16 weeks.⁵² However, the effect of being exposed to high-dose supplements over a lifetime is unknown. Vitamin B_{12} undergoes a highly efficient enterohepatic conservation system, which prevents large excretory losses and would thereby limit the body’s ability to rapidly reverse accumulation of excess storage. Safety evaluations of long-term exposure to high-dose intake of non-food-bound B_{12} are needed.

**Conclusion**

Vitamin B_{12} would be a valuable addition to fortification protocols, given the high prevalence of B_{12} deficiency in nearly all population groups worldwide. The majority of cases of B_{12} deficiency are the result of insufficient dietary B_{12} intake or malabsorption. The proposed B_{12} fortification level could address dietary insufficiency, but would not be high enough to impact cases of malabsorption. A high-dose fortification program would significantly increase cost, and lead to oversupply for a large part of the population.

The higher needs for supplemental B_{12} of specific subpopulations could be addressed more efficiently by targeted supplementation; tailoring a fortification program to meet their needs would unlikely be feasible. Women of childbearing age, pregnant women, and their children are an important target group, as their nutritional status can have a profound effect on the cognitive and physical condition of children who will eventually contribute to the social and economic potential of a nation as adults. Home fortification could provide the opportunity to target vulnerable subpopulations, overcome some limitations of initiating food fortification in developing regions, and address the concerns of providing fortification universally.
**FIGURE 3:** Comparison of fortification approaches

### Industrial Fortification
- Funding from government and/or food industry
- Industry addition of vitamins and/or minerals into food vehicle (i.e., fat/oil, infant formula, milk/milk products or beverages, cereals/cereal-based products)
- Distribution to food outlets
- Purchase of pre-fortified food item at food outlet
- Consumption of fortified food

### Multiple Micronutrient Home Fortification (Multiple Micronutrient Powders)
- Funding from government, NGOs, corporations
- Industry manufacturing of pre-packaged micronutrient powders
- Transport and distribution of micronutrient powders
- Delivery of micronutrient powders to population of interest
- Addition of micronutrient powders to food and consumption of micronutrient powders in food vehicle
Research is needed to determine whether low-dose B12 supplementation or fortification would have a measurable health impact and thus whether conditions associated with subclinical B12 deficiency respond to increased B12 intake. Biomarkers for assessing B12 status should be revalidated and cut-off values harmonized; with the use of latter, B12 deficient regions should be identified by assessing the rate and determinants of B12 deficiency in various population groups with priority for women of childbearing age and children. Further, research should contribute to the understanding of the complex folate/B12 interaction and elucidate whether chronic exposure to high-dose B12 intake can be confirmed as safe.

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Ritual Fluids in Relation to Early Child Nutrition in Quetzaltenango, Guatemala

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Introduction
Guatemala has the highest prevalence of one of the main forms of childhood malnutrition in Latin America, with 69% of children chronically undernourished, i.e., stunted. Bhutta et al show that education about complementary feeding can increase height-for-age Z score by 0.25. Nutrition-related interventions can also reduce stunting at 36 months by 36%, and mortality between birth and 36 months by about 25%. Adherence to the World Health Organization (WHO) Complementary Feeding Guidelines has also been shown to prevent weanling diarrhea. (The guidelines are related to better micronutrient status and growth.)

In addition to having the highest chronic undernutrition in the Americas, Guatemala also scores most poorly on adherence to complementary feeding guidelines. Ruel and Menon attributed the low score for complementary feeding practices to the relative poverty of Guatemala. Together, lack of complementary feeding practices and poverty may explain Guatemala’s high rate of stunting as shown in the surveys included (42% and 39% in 1995 and 1999, respectively). On the other hand, recent research (completed and published), supported in part by a Sight and Life grant to the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), shows that in Guatemala, the intakes of most micronutrients were near recommended levels.

It is unclear whether the nutrients contained in complementary foods are lost due to diarrhea. However, complementary feeding is so strongly linked to diarrhea that the syndrome is described as “weanling diarrhea.” Weanling diarrhea leads to impaired absorption and/or poor retention of nutrients, particularly vitamins and minerals. There is insufficient information about complementary feeding practices to explain the paradox of consumption of adequate micronutrient levels by Guatemalan infants in the face of widespread undernutrition and deficiency.

Understanding child feeding practices requires a participatory perspective and building local capacity for research. Capacity building is a process in which “the development of knowledge, skills and attitudes in individuals and groups of people relevant in design, development, management and maintenance of institutional and operational infrastructures and processes that are locally meaningful.” These processes include different actors and levels of interventions, such as individuals, groups, organizations, institutions and societies, among others. The WHO encourages research organizations to include capacity-building goals in their research proposals in order to strengthen local health research systems. Thus, this research includes additional specific objectives that aim to strengthen local capacity in Guatemala.

“The primary aim of the project is to understand cultural beliefs relating to the complementary feeding practices of 6–24 month-olds in Quetzaltenango, Guatemala”

The primary aim of the project is to understand cultural beliefs relating to the complementary feeding practices of 6–24 month-olds in Quetzaltenango, Guatemala. These beliefs were explored quantitatively to establish whether previously identified cultural practices were associated with chronic undernutrition, i.e., child stunting. We make use of a mixed-methods design, integrating quantitative and qualitative studies, and use both perspectives to generate new knowledge. Formative
Capacity Building: Capacity building was carried out in the form of a short course, training dietetics students in qualitative research. This course included an introduction to theoretical principles, data collection and methods of analysis. In addition to providing training, this project helped generate formative data for an evidence-based intervention plan, which will target the factors most likely to improve weanling diets in Quetzaltenango, Guatemala. A VU University investigator travelled to Guatemala to set up the qualitative research, and to train local staff in qualitative research methods. A group of VU University students also travelled to Guatemala and collected data, together with the local research team. The study was developed collaboratively with CESSIAM co-investigators, drawing on their existing wealth of knowledge, expertise and cultural experience. Qualitative analysis provided formative data, which was then used to identify associations to explore quantitatively, and also to identify possible intervention strategies.

Figure 1 shows the inter-relationship between the qualitative studies and the quantitative data. Mothers of children aged 6–24 months were selected for either the qualitative or the quantitative study. The initial plan was to carry out focus group interviews; however, too few mothers showed up for focus groups for this to be feasible. The strategy was therefore changed to conducting key informant interviews, with the specific aim of identifying reasons why mothers did not attend the initial focus groups. These interviews were conducted in three phases, to identify relevant information both for focus groups and for informing quantitative analysis. Formative research explored mothers’ practices and beliefs regarding complementary feeding practices, with particular emphasis on probing questions related to water, sanitation, and hygiene related to fluid intake and complementary feeding in health and in illness. Beliefs and practices identified qualitatively were also used to identify hypotheses to be explored quantitatively. The quantitative results were then used to formulate probing questions, to be utilized in focus group interviews carried out at the end of the study. The following capacity-building objectives were embedded within the qualitative study: training CESSIAM staff and students from Guatemala in qualitative interviewing skills and in developing semi-structured questionnaires; training local experts to develop an appropriate theoretical framework; and training students from Guatemala and the Netherlands to code and analyze qualitative data.

Methods

Study setting: The fieldwork for this study was conducted in the health centers of Quetzaltenango City and La Esperanza, between February and October 2011. Quetzaltenango City and La Esperanza are both urban municipalities, which are situated in the Western Highlands of Guatemala, in the Province of Quetzaltenango, with a mixed population of indigenous and ladino inhabitants. In Quetzaltenango, 65% of the inhabitants are indigenous and in La Esperanza 71% are indigenous. Quetzaltenango is the second largest city in Guatemala; by comparison, nearby La Esperanza is more suburban.
ing the Theory of Triadic Influence\textsuperscript{13} and the Theory of Planned Behavior. Together, these two models integrate the individual, social and environmental factors influencing health behaviors (triadic influences), together with health behavior theory (the theory of planned behavior). The students developed a framework to help formulate initial questions testing for motivating factors encouraging, as well as barriers to, complementary feeding practices, based on the three streams of influence: individual, social and environmental factors. Questions focused on identifying behaviors that might reduce the risk of weanling diarrhea, improve micronutrient content, and improve child growth.

The students were also asked to work in groups, using the theoretical framework to develop questions for focus group interviews as originally planned. The formulated questions were then compiled, discussed in class, and pared down to a final list of questions, which the students, working in pairs, then used to practice qualitative interview techniques in class in preparation for the actual focus group interviews scheduled for the second week. As mentioned above, however, only two participants showed up for the first focus group, so the students carried out key informant interviews instead of the scheduled focus group interviews.

Key informant interviews were carried out in an iterative process in three phases (Figure 1). Mothers of children aged 6–24 months were invited to participate, and the interviews were recorded on tape, with the mothers’ consent. Phase one of the process consisted of 12 key informant interviews, conducted at the Quetzaltenango health center by eight local dietetic students. The importance of agüitas (the local term for liquids – usually herbal infusions or thin cereal gruels – fed to infants in accordance with cultural practices) emerged from answers to questions on early feeding practices, which were collected during the first interviews. The WHO refers to agüitas by the more generic term “ritual fluids”,\textsuperscript{14} but we use the local Spanish term throughout.

Based on these findings, questions related to agüitas were added to the questionnaire in later interviews. In the second phase of the study, Claudia Arriaga conducted 15 interviews in the health centers of Quetzaltenango and La Esperanza. The aim of this second phase of study was to further explore questions about agüitas. Claudia Arriaga was brought in to conduct this stage of the interviews, as a member of the CeSSIAM staff and a native-speaking Guatemalan researcher. In the third phase, a local native-speaking interviewer with qualitative research experience was hired to conduct the final sets of interviews (n=22). This final phase aimed to address certain methodological issues which had arisen in previous interviews, specifically to obtain more in-depth answers than before, and to lengthen interview times. Content-wise, the aim of the final phase was to establish the differences between previous answers given by indigenous and non-indigenous mothers. Rosario García began by testing the questionnaires to see which questions proved most problematic. She then adjusted the questions to improve the mothers’ comprehension of them, and to allow more in-depth information to be obtained. Reflecting demographic differences in the two study locations, most of the interview subjects in Quetzaltenango were non-indigenous, whereas most of the interview subjects in La Esperanza were indigenous.

Qualitative Analysis: This was carried out as follows: The key informant interviews from the first and second phases were transcribed verbatim by the dieticians and Claudia Arriaga. The interviews carried out by Rosario García were transcribed by non-native speakers (Leonie Peters and Robine van der Starre). Transcriptions were checked by local collaborators afterwards. Analysis of the key informant interviews was carried out in MS Excel by Leonie Peters and Robine van der Starre. This involved copying the original transcripts and organizing their contents into categorized groups, based on themes taken from the conceptual frameworks.

Quantitative analysis: Quantitative analysis identified and recorded relevant details regarding complementary feeding practices, including the exact ages at which complementary foods were introduced, and the average age of introduction. A separate analysis explored which foods or fluids are given or withheld in response to weanling diarrhea. Special attention was given to

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*Guatemalan dietetics students were trained in qualitative interviewing methods at a two-week course at the local university*
Results from qualitative analysis

General characteristics: In total, 49 mothers visiting the health centers in Quetzaltenango and La Esperanza were interviewed by eight dietetics students (Phase 1), Claudia Ariaga (Phase 2) and Rosario García (Phase 3). The age range of the interviewed mothers was 16–47 years, with a mean age of 25.5 years. During the 12 interviews conducted in Phase 1, the theme of agüitas first emerged. In the later phases, additional probing questions were added to further explore the issue of agüitas. Most mothers named their mother or mother-in-law as the person influencing their decision to give agüitas to their child. Doctors were also mentioned as influencing factors.

Table 1 summarizes the different types of agüitas given for health reasons, along with their specific purposes. These findings combine results from all 47 interviews. All of the mothers interviewed reported using agüitas mainly as a warming food, to “heat” the body in order to maintain healthy digestion, or to treat gastrointestinal complaints such as constipation, diarrhea and colic. Additionally, mothers also reported using agüitas to alter the quantity or quality of their breast milk. Only indigenous mothers mentioned using agüitas to treat worms, or for respiratory complaints.

“Infants who were introduced early to agüitas were 1.6 times as likely to be stunted at the time of the interview”

Results from quantitative analysis

General characteristics: Table 2 shows the key demographic characteristics of the quantitative sample. The larger sample size for Quetzaltenango is due to the inclusion of a separate sample of children aged five months, selected entirely from Quetzaltenango. In children over six months old, an equal number of children were interviewed in the Quetzaltenango (n=150) and La Esperanza (n=150) health centers; exactly half the children selected were boys. This sample (5–23 months) was used to explore hypotheses generated from the qualitative results, in which mothers reported that some agüitas were given to maintain health and were also used in response to disease. In particular, mothers reported the belief that agüitas would help to maintain the healthy functioning of certain organs, particularly the gastrointestinal tract and lungs. Given the associations between feeding practices and child nutrition, we tested the early introduction of agüitas in relation to current health-related outcomes. Early introduction of agüitas, namely within the first 2.9 weeks of life, was not associated with current morbidity, such as diarrheal or respiratory outcomes. However, infants who had agüitas introduced early were...
1.6 times as likely to be stunted at the time of the interview (CI = 1.0, 2.5). However this association was strongest in the youngest age group and attenuates with age, dropping below unity in the oldest age group.

**Capacity Building**
As part of the activities related to capacity building, the project established a collaboration between the Quetzaltenango branch of the Universidad Rafael Landivar (a local university), and CESSIAM in Guatemala. The qualitative training course held at the university taught new skills in qualitative research to 18 nutrition dietetics undergraduates. These skills were then put into practice during the students’ own university research projects, which included qualitative methods such as unstructured interviews and focus groups, and the use of triangulation methodology for analysis. The local university has maintained its collaboration with CESSIAM, and the training sessions are continuing to be held for new batches of students. Annual qualitative research training is planned. Students who are interested in research subjects relating to ongoing CESSIAM projects will have the opportunity of collaborating with CESSIAM on these as part of their graded theses.

“Training local students in qualitative research and involving them in the data collection process helped to draw out valuable new information”
Discussion

In addition to the analysis shown here, Rosario García carried out a post-training dialogue with the students, to discuss issues related to the training process. Students who participated in the qualitative research methods sessions provided some useful insights for the further development and continuation of the training. It became evident that the students considered the methods learned to be valuable, and wanted to take their training further. More specifically, a majority of the participants expressed an interest in, and need for, more “hands on” training, which would allow them to put the skills they had learned into practice. Students also recommended the introduction of formal diplomas that recognized their training in the subject. These discussions show a clear need for, and interest in, more qualitative research training. In the instance of this study, training local students in qualitative research and involving them in the data collection process helped to draw out valuable new information, namely the findings about agüitas presented here.

More information is needed about the possible role agüitas may play in displacing breast milk, thereby contributing to micronutrient deficiency. In particular, the early introduction of agüitas may contribute to micronutrient deficiency in infants before they have reached sixth month of age. The frequency and quantity of agüitas given also has implications for the micronutrient status of infants who are six months and older. It is important to note that, during or after illness, mothers are indeed following the recommendation of giving liquids to replace fluid losses. During or after illness, the use of agüitas could be beneficial in that mothers report boiling the leaves they use, thus making agüitas administered in this instance more hygienic than other liquids. However, agüitas do not contribute micronutrients and, when given in microbiologically contaminated cups or bottles, may result in micronutrient losses caused by diarrheal infection. From a micronutrients perspective, the practice of giving breast milk (reported to be given as an extra fluid during illness by only 7% of mothers) should be encouraged further, as a means of improving micronutrient intake, and as the most hygienic, essential source of liquid during recovery from illness. The fact that most mothers of children aged 6–24 months report continued partial breastfeeding means that this is a feasible recommendation. Analysis carried out at this point also tested for the possibility that the use of agüitas may be beneficial to child growth, or may lessen a later risk of infectious disease. Based on cross-sectional analysis, however, we were unable to find evidence to support mothers’ beliefs that the use of agüitas was beneficial to their child’s overall health and preventive of later infectious disease risk. Thus, we were unable to confirm a health benefit for agüitas.

The qualitative and quantitative results show agüitas to be a deeply culturally embedded practice, however. Interventions could stimulate mothers to take agüitas themselves, rather than give them directly to infants. Many mothers have reported doing so already, based on an existing belief that the “heating” qualities of agüitas will carry over into the breast milk. Thus, instead of exposing infants to potentially contaminated agüitas, mothers could take the agüitas themselves and instead provide nutrient-dense breast milk to infants.

These results show the importance of agüitas as a concern, which needs further exploration in relation to child nutritional status, micronutrient intake, energy intake and overall health. In particular, these findings raise questions about the programmatic approach to be taken with respect to counseling for infant feeding. As ritual fluids, agüitas fit within the WHO definition of full breastfeeding. In our initial analysis on older children, agüitas in older children appeared to be protective against child stunting. However, after further analysis including younger children, the associations turned in the opposite direction, showing an increased risk. Upon closer analysis, these findings appeared to be consistent with recall bias, and firm conclusions require further longitudinal analysis. Given the fact that agüitas are firmly embedded in local beliefs and practices, we would tend to ignore, or even encourage, this deeply rooted cultural practice. However, if there is the possibility of microbiological risk or adverse medium-term consequences, we might seek to dissuade their use altogether, despite their acknowledged cultural roots.

“The inclusion of a capacity-building approach led to new and otherwise unattainable knowledge”

Conclusions

This study provides an example of a capacity-building model, in which developing local research capacity is embedded in all stages of the research process. The inclusion of a capacity-building approach ultimately led to new and otherwise unattainable knowledge – insights into the cultural practices and beliefs involving agüitas which directly affect child feeding habits would not otherwise have emerged. Likewise, these results show the added value of qualitative research in understanding early child feeding practices in a low-income setting. In particular, the training of dieticians in Guatemala and the inclusion
of a qualitative perspective in the study resulted in identifying the importance of agüitas in early child feeding practices. Using the qualitative results, agüitas were then explored quantitatively from the perspective of the WHO guidelines, from a biological perspective, and also explored based on the mothers’ stated beliefs linking agüitas and child health. Understanding agüitas from all of these perspectives may well be the key to understanding and improving the child feeding practices most relevant to improving child nutrition in Guatemala.

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Sharing knowledge for improved nutrition.
Xanthophylls as Provitamin A Carotenoids

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Introduction
James Allen Olson was a scholar who thought about things very deeply. In preparation for this review of the provitamin A activity of xanthophyll carotenoids, three questions emerged:

1. Is the dietary value of β-cryptoxanthin really the same as α-carotene?
2. Are all animals created equal?
3. Is α-cryptoxanthin a provitamin A carotenoid or not?

This review highlights research to assist the reader in answering these questions and in considering what Dr Olson would have thought about these questions.

The “Sherry” factors will act as an organizational outline for this review. These factors were presented at the Bioavailability 2010 meeting in Asilomar, California, USA, as a way to organize our thinking about what factors specifically affect the provitamin A activity of carotenoids. Table 1 lists these factors. While many of these factors have been studied in detail, the effects of resistant starch on provitamin A bioavailability have not been fully elucidated and therefore will not be extensively reviewed herein.

In 1996, Parker published an elaborate schematic, outlining the path of carotenoids during digestion in humans. Briefly, carotenoids must be released from the food matrix, dissolved in lipid, and available for absorption in mixed micelles. This is commonly referred to as bioaccessibility. After absorption into the enterocytes of the small intestine, provitamin A carotenoids can either be cleaved to retinal, reduced to retinol, and esterified to a fatty acid, or incorporated intact directly into chylomicra. After circulation through the lymph, the chylomicra are released into the blood stream. A decade ago, when most people thought about provitamin A carotenoids, only β-carotene came to mind, because it is abundant in foods and yields two retinal molecules for each carotenoid molecule. However, since then more emphasis has been given to β-carotene and β-cryptoxanthin as sources for humans, and the term β-carotene equivalents (BCE) has been more broadly used. The Institute of Medicine (IOM) has defined the bioconversion factor for β-carotene from a mixed diet as 12 μg β-carotene to 1 μg of retinol (12:1) and α-carotene and β-cryptoxanthin as 24:1, which is based predominantly on the chemical structure (Figure 1). The following section will discuss recent research to try to persuade the reader that the dietary value of β-cryptoxanthin may not be the same as α-carotene.

Key Points

- For humans, the most important provitamin A xanthophyll is β-cryptoxanthin. The Institute of Medicine assigns the same bioconversion factor to β-cryptoxanthin and α-carotene, based on theoretical yield.
- Many fish and birds meet their vitamin A needs by using unique xanthophylls.
- Some common names for hydroxylated derivatives of α-carotene may refer to different chemical structures.
- Maize is being biofortified for release to Africa. In addition to β-carotene, β-cryptoxanthin levels should be increased.
Is β-cryptoxanthin’s dietary value the same as α-carotene?

The first of the “Sherry” factors is Species of Carotenoid. For humans, the most important provitamin A carotenoids are indeed β-carotene, α-carotene, and β-cryptoxanthin (Figure 1), which all contain at least one unsubstituted β-ionone ring. The other half of the molecule is quite different for each of these species. β-carotene provides another molecule of retinal; α-carotene provides a molecule of α-retinal, which can be reduced to α-retinol but does not bind to retinol-binding protein and instead accumulates in tissue as the esterified form; and β-cryptoxanthin, which contains a hydroxy group that vastly alters its polarity compared to the hydrocarbons, yields 3-hydroxy-retinal.

Based on two studies in which Mongolian gerbils and humans were fed high carotene carrots, a follow-up study was performed to truly test the bioefficacy of highly purified α-carotene compared directly with β-carotene. In the first gerbil study, the α-carotene concentration in the liver increased dose-dependently and did not contribute significantly to vitamin A stores in vitamin A-adequate animals. In the human study, typical carrots were compared with high α-carotene content carrots; there was no difference in serum α-carotene concentrations during uptake and clearance between the groups. This led us to isolate and carefully purify α-carotene from carrots and feed it at twice the molar amount of β-carotene in a controlled dosing study. Although the value obtained (i.e., 5.5 μg α-carotene : 1 μg retinol) was greater than the IOM value of 4 μg α-carotene in oil, it was almost exactly twice that for the β-carotene (i.e., 2.8 μg β-carotene : 1 μg retinol). Thus, α-carotene tracks β-carotene in mammals with regard to predicted bioavailability and bioefficacy.

Intrigued by the influence that the hydroxy group may have on the polarity of β-cryptoxanthin and the fact that some lines of orange maize may have substantial β-cryptoxanthin, we decided to test the bioefficacy of β-cryptoxanthin with an identical study design as that used in the α-carotene study. The bioconversion factor was not only much better than that found for α-carotene (i.e., 2.74 μg β-cryptoxanthin : 1 μg retinol); it was almost identical to that of β-carotene on a weight basis (i.e., 2.52 μg β-carotene : 1 μg retinol) under the same experimental conditions. Subsequently, studies with orange maize were performed to see if the ratio of β-cryptoxanthin to β-carotene would influence the bioefficacy of the provitamin A carotenoids from maize. In these studies, which were based on preliminary studies with maize that determined a bioconversion factor of 2.8 μg β-carotene : 1 μg retinol, maize performed as well as β-carotene supplements and the proportion of vitamin A equivalents as β-cryptoxanthin or the ratio of major dihydroxy xanthophylls to provitamin A carotenoids did not appreciably change the vitamin value of orange maize. This work was supported by concurrent in vitro studies with maize.

---

**TABLE 1:** Factors that affect the bioavailability of provitamin A carotenoids from foods

<table>
<thead>
<tr>
<th>S &gt; Species of Carotenoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>H &gt; Host-related Factors</td>
</tr>
<tr>
<td>E &gt; Effectors of Absorption</td>
</tr>
<tr>
<td>R &gt; Relative Amounts of Carotenoids</td>
</tr>
<tr>
<td>R &gt; Resistant Starch</td>
</tr>
<tr>
<td>Y &gt; Yet to be Determined</td>
</tr>
</tbody>
</table>

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**FIGURE 1:** β-Carotene, α-carotene, and β-cryptoxanthin are the most common forms of provitamin A carotenoids considered in the human diet. While the Institute of Medicine has assigned the same vitamin A value to α-carotene and β-cryptoxanthin based on their chemical structure, recent studies in Mongolian gerbils and humans suggest that the bioavailability and perhaps bioconversion of β-cryptoxanthin is superior to α-carotene.
Favorable bioconversion factors for provitamin A carotenoids from orange maize have also been obtained in young women ($n = 6$; $6.5 \pm 3.5 \mu g \beta CE : 1 \mu g$ retinol) from the United States and Zimbabwean men ($n = 9$; $3.2 \pm 1.5 \mu g \beta CE : 1 \mu g$ retinol). Furthermore, a review of many human studies determined that the apparent bioavailability of $\beta$-cryptoxanthin is much higher than that of $\beta$-carotene in Western diets. Based on these data from animal and human studies, the consensus was that Dr Olson would have concluded that the bioconversion factor for $\beta$-cryptoxanthin is likely to be better than that for $\alpha$-carotene, and certainly can be more efficient than $24 \mu g : 1 \mu g$ retinol for some foods.

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**FIGURE 2:** Fish are able to use many different xanthophylls to support their vitamin A needs. For example, black bass can make retinol from canthaxanthin and 3,4-didehydroretinol from astaxanthin, lutein, and tunaxanthin. Other freshwater fish cleave $\beta$-cryptoxanthin and make retinol from the retinol half of the molecule or 3,4-didehydroretinol by dehydrating the 3-hydroxy half of the molecule depending on whether the fish preferentially uses retinol or 3,4-didehydroretinol.

---

“Birds use a variety of carotenoids, not only in relation to their plumage colors but also for their vitamin A needs”

Are all animals created equal?
The second of the “Sherry” factors is *Host-related Factors*. The vitamin A status of the host drives the bioconversion factor for provitamin A carotenoids from fruits and vegetables in mam-
While β-cryptoxanthin is the major provitamin A xanthophyll that humans have in their diet and convert to vitamin A, other species of animals can utilize very unique xanthophylls for their vitamin A needs. A paper published by Bendich and Olson\textsuperscript{22} considered the fact that fish and birds can take other oxygen-containing carotenoids and biosynthesize retinal, which included astaxanthin and canthaxanthin. For example, black bass can make retinol from canthaxanthin and 3,4-didehydroretinol from astaxanthin, lutein, and tunaxanthin\textsuperscript{23} (Figure 2). In addition to β-carotene, the common, colorful freshwater guppy can form vitamin A from isozeaxanthin, canthaxanthin, and astaxanthin.\textsuperscript{34} Another fascinating finding in fish is that those that typically contain retinol use the retinol portion of β-cryptoxanthin for their vitamin A needs, while those that predominantly contain 3,4-didehydroretinol will utilize the 3-hydroxy portion of the molecule and dehydrate it to form 3,4-didehydroretinol\textsuperscript{25} (Figure 2).

Birds also use a variety of carotenoids, not only in relation to their plumage colors,\textsuperscript{26} but also for their vitamin A needs. Penguins, for example, have circulating β-cryptoxanthin and high serum retinol concentrations, but do not circulate β-carotene.\textsuperscript{27} It is likely that they convert β-carotene predominantly to retinal. This is in contrast to gulls, which circulate all the major carotenoids found in humans (including lutein, zeaxanthin, canthaxanthin, β-cryptoxanthin, echinenone, and β-carotene), and typically have a toxic vitamin A status,\textsuperscript{28} which is sometimes defined as >1 μmol/g liver in humans.\textsuperscript{29} Nonetheless, even among birds, there is much variety. Chickens, in particular, do other things with xanthophylls than just make vitamin A. In fact, a very early paper showed that chickens can make vitamin A from β-carotene but not crude xanthophylls from spinach.\textsuperscript{30}

“Visually, the egg yolks in the high β-cryptoxanthin maize-fed group were perceivably distinct from the eggs in the white maize-fed group”

Typically, xanthophyll lutein is added to chicken feed to enhance egg yolk color. In many African countries that eat white maize as a staple crop, white maize is also fed to chickens, giving the yolk an off-white hue. Because orange maize is currently being considered for release in Africa,\textsuperscript{31,32} we decided to determine its effect on egg yolk color. In particular, we were interested in the deposition of β-cryptoxanthin into the yolk.\textsuperscript{33} Therefore, we fed chickens two types of orange maize (i.e., high β-carotene and high β-cryptoxanthin) and compared these to typical yellow and white maize. Using a colorimeter to determine color space, we found that the eggs in the high β-cryptoxanthin maize group had the most significant changes. The L dimension (light/
dark) became darker, the A dimension (red/green) became more red, and the B dimension (yellow/blue) remained relatively stable. In fact, visually, the egg yolks in the high β-cryptoxanthin maize-fed group were perceivably distinct from the eggs in the white maize-fed group 28 days after the study began (Figure 3). After analysis with HPLC, β-cryptoxanthin concentrations increased 7.6 times and provitamin A value twice in the eggs from the chickens fed with maize high in β-cryptoxanthin, compared with the eggs from the chickens fed with white maize during the washout period. The same parameters in the eggs from the white maize-fed group did not change. Thus, it appears that chickens predominantly cleave β-carotene to vitamin A, but β-cryptoxanthin is deposited into the yolk (similarly to lutein and zeaxanthin).

The third of the “Sherry” factors is Effectors of Absorption. In particular, with provitamin A xanthophylls, esterification to fatty acids is a point to consider. According to Pérez-Gálvez and Mínguez-Mosquera, Dr Olson was the first to suggest that xanthophyll esters would be hydrolyzed in the gut before absorption. Papaya and loquat (sources of β-cryptoxanthin esters) were tested with a variety of enzymes. Cholesterol esterase was the most active in freeing the β-cryptoxanthin compared with pancreatic lipase in in vitro assays. In humans, only free β-cryptoxanthin was found in chylomicra, when fed β-cryptoxanthin esters from tangerine, suggesting prior hydrolysis before release into lymphatic circulation. Similarly, the chylomicron response was the same when humans were fed 1.3 mg esterified or non-esterified β-cryptoxanthin isolated from papaya. Potential effectors of absorption include enhancers and inhibitors. In keeping with the observation that the bioavailability of β-cryptoxanthin is high among carotenoids, bioavailability was not affected by co-ingestion of phytoestrogens derived from pine tree in humans. This was supported by an in vitro digestion assay using the same treatments.

The fourth of the “Sherry” factors is Relative Amounts of Carotenoids. It is quite clear that when provitamin A carotenoids are fed, there seems to be a plateau reached in the body for conversion to vitamin A. In other words, the principle of diminishing returns operates and more provitamin A fed does not necessarily mean more vitamin A produced. When the liver has a sufficient amount of vitamin A, the bioconversion factor increases and less vitamin A is produced. This protects the body from hypervitaminosis A, which could occur if this regulatory process was not in place with a diet high in fruit and vegetables. Nonetheless, more carotenoid is absorbed intact and stored in tissues that are not typically measured in the human body. For example, in Mongolian gerbils, the same amount of β-carotene fed from orange maize enhanced liver β-carotene by 100% over an equalized supplement. Liver vitamin A was starting to reach a plateau in a secondary study, when increasing provitamin A from orange maize was fed and this was exemplified again with yellow cassava feeding with a similar study design. The provitamin A value of orange maize does not seem to be affected by the amount of lutein and zeaxanthin, or the ratio of β-cryptoxanthin to β-carotene. In a recent feeding study of orange maize to Zambian children, within one week the children adapted to eating their traditional foods made with orange maize, which included thin and thick porridge locally called nshima (Figure 4). Because these ratios do not seem to drastically affect provitamin A bioavailability, we have encouraged maize breeders to breed for increases in all carotenoids because of the known health benefits of lutein and zeaxanthin for eye health and the associations of β-cryptoxanthin with bone health.

The fifth of the “Sherry” factors is Resistant Starch. We have hypothesized that resistant starch, an indigestible food matrix component, may limit provitamin A bioavailability based on others’ findings of high resistant starch content, and our preliminary results with commercially prepared banana flour. Specifically, raw banana starch may be greater than 80% resistant to digestion in humans. Most bananas, however, do not appreciably contain provitamin A xanthophylls, so we will not consider this factor further in this review. Another term that should be considered for the second “R” in “Sherry” is Regulation. Provitamin A carotenoid metabolism and conversion to retinal is highly regulated in the human and the comparison of β-cryptoxanthin to β-carotene requires more definition.
Table 2: Some controversy exists in the literature concerning whether or not α-cryptoxanthin is a provitamin A xanthophyll or not

<table>
<thead>
<tr>
<th>Structure</th>
<th>α-Cryptoxanthin</th>
<th>Zeinoxanthin</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Structure of α-Cryptoxanthin" /></td>
<td>Schlatterer and Breithaupt</td>
<td>Schlatterer and Breithaupt</td>
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<td>Pubmed structure</td>
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<td>Schlatterer and Breithaupt</td>
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<td></td>
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<td>Pubmed structure</td>
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Is α-cryptoxanthin a provitamin A carotenoid or not?

The final question proposed in this review is whether or not α-cryptoxanthin is the provitamin A form of the β-cryptoxanthin isomer. Further, the final “Sherry” factor is yet to be determined! In the process of preparing a review article on maize, we determined some controversy in the literature on whether or not α-cryptoxanthin, a common name, contains the unsubstituted β-ionone ring (Table 2). In the literature, the hydroxylated derivative of α-carotene is often referred to as zeinoxanthin; it is not a provitamin A xanthophyll for humans because the unsubstituted ring is in the α-configuration (Table 2). While many scientists have decided which way they will name them as referenced (Table 2), some of us are still a little uncertain.

It is interesting to note that, in the review published by Bendich and Olson in 1989, of the 12 carotenoids mentioned as those found in foods and animal tissues, neither α-cryptoxanthin nor zeinoxanthin were structurally shown or listed. Perhaps Dr Olson was just trying to avoid controversy.

Concluding remarks

Moreover, there are other oxygen-containing carotenoids that have the unsubstituted β-ionone ring. Recently, Maoka and Akimoto identified two unusual provitamin A carotenoids in catfish. The names given for these compounds were 7,8-dihydro-β-carotene and 7,8-dihydro-β-cryptoxanthin. Furthermore, an older publication by Morton and Rosen detailed their discovery that frogs can absorb and store various kinds of carotenoids and vitamin A. This short review is obviously not comprehensive.

Although it is very clear from this review that the dietary value of β-cryptoxanthin is likely to be better than that of α-carotene, and that all animals are not equal when metabolizing carotenoids to vitamin A, there is still some confusion among scientists over whether or not α-cryptoxanthin is the provitamin A form derived from α-carotene for humans. Nonetheless, as we strive to eradicate vitamin A deficiency in the world, let us keep in mind that β-cryptoxanthin does provide vitamin A to humans and that some types of maize and fruits provide ample amounts of this xanthophyll in the human diet. In addition, intact β-cryptoxanthin may have other health benefits and therefore deserves more attention in the research arena.

Acknowledgements

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Micronutrient Status in Vietnam

Comparisons and Contrasts with Thailand and Cambodia

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Key messages

> In Vietnam, vitamin A status in women and pre-school children has improved considerably over the last 20–30 years, and is now comparable with that in the UK and USA.

> Stunting is still present in 23% of urban and rural pre-school children in Vietnam, indicating that nutritional problems still exist.

> More than 50% of Vietnamese women and children have marginal zinc concentrations, as assessed by international standards.

> Plasma zinc concentrations are not good indicators of zinc status as they constitute only ~1% of total body zinc, are depressed by inflammation, and appear to reflect primarily the bioavailability of dietary zinc.

> Experimentally, riboflavin deficiency (as well as zinc deficiency) inhibits growth, but I know of no attempt to investigate the importance of riboflavin in the etiology of stunting.

> Dietary evidence suggests that riboflavin deficiency is extensive in Vietnam.

> The prevalence of anemia in Vietnam was only ~10% and only half of this was associated with iron deficiency.

Introduction

At the twentieth International Vitamin A Consultative Group (IVACG) meeting in Hanoi in 2001, we heard about the considerable improvements in nutrition that had taken place in Vietnam over the previous two decades. It was therefore with some considerable interest that I read a recent publication on public health issues among women and children in Vietnam, to see what progress a further decade had produced. The paper was published jointly by workers at the Global Alliance for Improved Nutrition (GAIN), the National Institute of Nutrition in Hanoi, and the Institute for Research and Development in Montpellier, France, and reported national biochemical information on vitamin A, iron and anemia, folate, vitamin B12 and zinc. It concluded that the prevalence of zinc and vitamin B12 deficiencies represented public health problems. In addition, while recognizing that the prevalence of anemia and iron deficiency had markedly reduced over the last decade, the authors suggested that a large part of the population was still at risk of other deficiencies such as vitamin A and folate, especially the youngest children (aged 6–17 months) and the poorest groups in the population. In this commentary, I compare certain aspects of nutritional status in Vietnam, Thailand, and Cambodia.
Eradication of vitamin A deficiency

A concerted effort to improve the nutritional status of the Vietnamese people was initiated in the 1980s. By the early 1990s, it was recognized that the average Vietnamese person reached a calorie adequacy of 2,100 kcal per day. Alongside an increased calorie intake, food quality was also improved. At the IVACG meeting in Hanoi, the Deputy Prime Minister, Pham Gia Khiêm, reported that Vietnam had been chosen to host the symposium because of its achievements in eradicating blindness caused by vitamin A deficiency. The Vietnamese government launched a program to improve vitamin A status after a national survey in 1985–88 showed that the prevalence of severe xerophthalmia was seven times greater than the acceptable maximum adopted by the World Health Organization (WHO). The program was launched in eight pilot districts and was then gradually expanded, covering the whole country by 1993. In 1994, surveys showed that awareness of vitamin A had considerably improved, and the prevalence of the deficiency had fallen below the WHO criteria for a significant public health problem. This progress has continued and, in the most recent National Survey in 2010, mean plasma retinol concentrations in 586 children aged 6–75 months, randomly selected from both rural and urban locations, were identical to those found in British pre-school children (Table 1). This suggests that the problem of vitamin A deficiency in Vietnam has been effectively overcome.
The method that was introduced to improve vitamin A and micronutrient status in general. A food-based approach had been adopted that encompassed the efforts of whole communities in what was called the VAC farming method. The acronym stood initially for garden (V, later “all land farming”), pond (A, including lakes, streams and the sea), and animal husbandry (C, cattle, pigs, poultry, etc.). Villagers everywhere were encouraged to participate in all three components. In addition, a program of nutritional education promoted the consumption of green leafy vegetables. These methods have stimulated positive economic growth since 1985, an annual growth rate in food production of ~2.2% during the period 1979–1993, and a remarkable improvement in socioeconomic conditions compared to 1980. During the same period, a number of trials conducted in Vietnam demonstrated the efficacy of the micronutrient fortification of fish sauce, milk, biscuits, complementary food, and noodles, and the efficacy of micronutrient supplements. The initial objective when the VAC program started was the elimination of vitamin A deficiency via improved food production, but the program also aimed to increase the quantity and quality of food. By increasing the production of fish and animal foods, increased food quality reduces the risk of vitamin A and other vitamin and mineral deficiencies. Food consumption surveys showed that changes in food quality were particularly evident during the 1990s for, although calorie adequacy for most people was reached by the early 1990s, overall calorie intake did not really change for another 10 years. However, during the nineties, the structure of the diet changed to include fewer starchy cereals and a higher proportion of meat and fish (i.e., more energy-dense foods). These changes in food intake occurred during a period of increased food availability and reducing poverty.

**The current nutritional situation**

The paper by Laillou and colleagues reports national data on the micronutrient status of women of reproductive age and children aged 6–75 months. The Vietnamese National Nutrition Survey in 2000 showed that the population’s dietary intake had improved since 1987, but information from the same survey showed that 20% of the population was not meeting its energy requirements. The most recent food consumption survey was conducted in 2006 and reported in 2009. The data were used to provide estimates of energy and micronutrient status. The results showed that, on average, rice consumption currently contributed 59% of dietary calories (384 g/day, i.e., 1385 kcal), but that the proportion was higher among rural populations (62.5%, 411 g) than urban ones (48.5%, 303 g). Likewise, total daily calorie intakes were also slightly higher in rural than in urban districts (2,376 and 2,265 kcal respectively), presumably reflecting a higher level of manual labor in rural areas. Further analyses of these data to calculate the level of undernutrition in the two groups (energy consumption <2,100 kcal/day) suggested that there was less undernutrition in rural areas than there was...
in urban areas (36% and 44.6% respectively). However, further analysis of micronutrient composition data suggested that more than 70% of the population received less than the required nutrient intake of calcium, iron and vitamins A, C, B2 and niacin – and, in the case of all those nutrients, intake was lower in rural than in urban communities (Table 2). These data, and the most recent paper by Laillou and colleagues, suggest that the nutritional situation in Vietnam still needs further improvement.

Vitamin A status
Although the data in Table 2 suggest that 88% of the Vietnamese population consumed inadequate amounts of dietary vitamin A in 2006, plasma retinol concentrations in the majority of Vietnamese children appear to be adequate when compared with retinol concentrations in British children of a similar age (Table 1). Part of the explanation for this may be that the National Institute of Nutrition’s “required amount” is the value per capita in the population, i.e., it is not specifically related to children’s requirements of ~400 μg RE. The standard deviations for the two groups of children suggest that the range of retinol concentrations was wider for the Vietnamese children than it was for British children. However, only 10% of Vietnamese children were at risk of vitamin A deficiency (retinol <0.7 μmol/L), and the proportion in Britain was similar. Vietnamese retinol concentrations may, however, have been slightly depressed by chronic inflammation. Although Laillou and colleagues partially corrected their retinol values for acute inflammation (8% of the children had a raised C-reactive protein (CRP) concentration), the authors did not measure α1-acid glycoprotein (AGP). Elevated AGP concentrations are usually more common than raised CRP concentrations, so retinol concentrations are probably still slightly depressed. Consequently, the figure of 10% with a risk of vitamin A deficiency may be a slight overestimation.

Laillou and colleagues used the retinol concentration range of 0.7–1.05 μmol/L as an indication of marginal vitamin A status, and suggested that 47% of Vietnamese children had this status. This is most unlikely since, as shown in Table 1, the reference mean value for retinol in children <6 yr in vitamin A-adequate countries such as the UK and the USA is ~1.05 μmol/L. Therefore, by definition, 50% of the population is bound to be below the mean – but that does not mean to say that these members of the population are marginally malnourished in vitamin A. However, the range may have more validity in terms of assessing vitamin A status in adults, where the reference mean concentration in healthy Western adults is closer to 1.8 μmol/L (Table 3). The concentrations of plasma retinol in the Vietnamese women were certainly lower than those in British or American women, but

### Table 2: Per capita daily mineral and vitamin intakes in Vietnam in 2006

<table>
<thead>
<tr>
<th>Group</th>
<th>Minerals</th>
<th>Vitamins</th>
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<tr>
<td></td>
<td>Calcium mg</td>
<td>Iron mg</td>
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<tr>
<td>All subjects</td>
<td>395</td>
<td>12.8</td>
</tr>
<tr>
<td>Rural</td>
<td>382</td>
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<tr>
<td>Urban</td>
<td>434</td>
<td>13.6</td>
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<td>Required amount NIN*</td>
<td>535</td>
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</tr>
<tr>
<td>% Inadequate</td>
<td>87</td>
<td>80</td>
</tr>
<tr>
<td>RNI</td>
<td>1000</td>
<td>19.6–58.8***</td>
</tr>
<tr>
<td>FAO/WHO **</td>
<td></td>
<td></td>
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</tbody>
</table>

Data from DEPOCEN

*Required amounts per capita of population as determined by the National Institute of Nutrition 1995

**FAO/WHO Vitamin and Mineral Requirements for women of reproductive age

***Varying amounts to accommodate differing bioavailabilities of iron and other dietary factors
this may be due to hormonal factors. Estrogenic hormones tend to increase plasma retinol concentrations by 20–50%. 14, 16

In conclusion, vitamin A status has virtually normalized over the last 30 years in Vietnam. However, there may still be 10–15% of women and children who are at risk of vitamin A deficiency.

Iron status
The conclusions of the 2006 food consumption paper with respect to iron, namely that 80% of Vietnamese people consumed inadequate amounts of iron (Table 2), also appear to be contradicted by the biochemical results of Laillou and colleagues. 1

As far as the women were concerned, there were no differences between urban and rural areas. The mean hemoglobin concentration was 131.4 g/L. Of the women, 11.6% were anemic (Hb <120 g/L) and 5.4% had iron-deficiency anemia. Mean ferritin concentrations (48.5 μg/L, Table 4) suggested that iron status was reasonably good for most women. Plasma ferritin concentrations were corrected for acute inflammation but, as mentioned above, a biomarker of chronic inflammation was not available and therefore not taken into account. Thus, ferritin concentrations may be slightly overestimated and the proportions with iron deficiency (<15 μg/L), and with iron deficiency anemia, underestimated. As it stands, however, much of the anemia (~50%) was not explained by iron deficiency. Several other factors may also contribute to anemia; principally, deficiencies of folate and vitamins B12, A and pyridoxine. However, thalassemia and other hemoglobinopathies are also important contributors to anemia in SE Asia. 3, 17 The broad conclusion, however, is that there is little anemia in Vietnamese women, and that iron deficiency explains about half of this.

The children showed a similar picture to that found in the women (Table 5). The mean hemoglobin concentration was 125.3 g/L and only 9.1% had anemia (Hb <110 g/L). Ferritin concentrations were reasonable (mean 33.8 μg/L) and 13.7% were iron deficient. As previously indicated, since chronic inflammation was not compensated for, the prevalence of iron deficiency and iron deficient anemia (3.2%) may be underestimated. However, similar conclusions can be drawn for both women and children – namely that that there is now very little anemia in Vietnam, and that iron deficiency currently only accounts for 50% or less of that anemia.

### Table 3: Plasma retinol concentrations in Vietnamese and British women

<table>
<thead>
<tr>
<th>Country</th>
<th>Group</th>
<th>n</th>
<th>Retinol μmol/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>All women</td>
<td>1475</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>769</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>706</td>
<td>1.48</td>
</tr>
<tr>
<td>Great Britain</td>
<td>All women</td>
<td>943</td>
<td>1.80</td>
</tr>
</tbody>
</table>

*Vietnamese data obtained in 2010 and the British data in 1990.

### Table 4: Anemia and iron status in Vietnamese women of reproductive age

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean/Prevalence</th>
<th>SEM/SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/L)</td>
<td>1526</td>
<td>131.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Anemia % (Hb &lt;120 g/L)</td>
<td>1526</td>
<td>11.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Ferritin μg/L</td>
<td>1523</td>
<td>48.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Iron deficiency % (Ferritin &lt; 15 μg/L)</td>
<td>1523</td>
<td>13.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Iron deficient anemia % (Hb &lt;120 g/L &amp; Ferritin &lt; 15 μg/L)</td>
<td>1522</td>
<td>5.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Table shows means and prevalences.

SEM: Standard error of the mean
SEP: Standard error of the prevalence
Vietnamese folate and vitamin B₁₂ status

The analysis of the Food Consumption Survey reported by DEPOCEN provided no data on folate or vitamin B₁₂ status. Analysis of the plasma folate concentration in the Vietnamese women suggested that 25% of the population had marginal status (6.8–13.4 nmol/L) but very few were at risk of deficiency (2.7%, <6.8 nmol/L). In the children, there were 6.4% with marginal status and <1% at risk of folate deficiency. Vitamin B₁₂ status was only examined in a sub-sample of the women (n=550). The distribution appeared bimodal, with a risk of deficiency in 11.7% (<148 pmol/L), but only 3.8% with marginal status (148–220 pmol/L).

1. The prevalence of stunting in Vietnamese children is evidence of continuing malnutrition

2. Fortification of foods may be the best option, as dairy foods are not a part of traditional diets

Vietnamese nutritional status

The prevalence of stunting in the Vietnamese children (height for age Z score (HAZ) < -2) was 23.2% in the 2010 Micronutrients Survey. Although the proportion was slightly higher in the rural areas, the difference was not significant (Table 6). Stunting is an indicator of chronic undernutrition. It is the result of extended periods of inadequate food intake, poor dietary quality, high prevalence of morbidity, or a combination of these factors. A number of nutritional indices were obtained on the children in these studies, but no attempt was made to evaluate whether any of the different factors contributed to the stunting – even though the authors reported that several were of public health importance. According to WHO classifications, the prevalence of anemia suggested a mild public health problem (5–20%) in both the women and children. In addition, the authors also suggested that vitamin A deficiency was possibly a mild public health problem in children (<10% below 0.7 μmol/L).

However, as previously noted, the data were not fully corrected for inflammation, so low retinol values may have been overestimated. CRP concentrations indicated that inflammation was present in 8% of the children, and plasma zinc concentrations in the Vietnamese children were low by international standards, with 51.9% of children at a risk of zinc deficiency (plasma zinc <9.9 μmol/L). Plasma zinc concentrations were significantly lower in rural as opposed to urban children. Plasma folate concentrations were also measured in the children. Although there was very little evidence of folate deficiency, an analysis of the variance in HAZ explained by the biochemical data – or a comparison of relationships in stunted and non-stunted children – would have been very interesting to see.

The recent report by UNICEF on stunting in children under the age of five showed that the mean prevalence in South East (SE) Asia for the period 2006–2010 was 34%, and 31% in Vietnam (Table 7). In the 2010 Micronutrients Survey, the mean prevalence of stunting in Vietnam was 23.2% (Table 6), which is in line with the general trend downwards in time for stunting in all countries. The prevalence of stunting in Vietnam is slightly better than average, in comparison with other SE Asian countries. This would suggest that the large improvements in iron and vitamin A status may have had very little impact on stunting in Vietnam. Of the growth-limiting nutrients, zinc deficiency is widely believed to be of considerable importance in the etiology of stunting. Experimentally, withholding zinc restricts growth

**TABLE 5: Anemia and iron status in Vietnamese children aged 6–75 months**

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean/Prevalence</th>
<th>SEM/SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/L)</td>
<td>358</td>
<td>125.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Anemia % (Hb &lt;110 g/L)</td>
<td>583</td>
<td>9.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Ferritin μg/L</td>
<td>568</td>
<td>33.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Iron deficiency % (Ferritin &lt; 15 μg/L)</td>
<td>568</td>
<td>12.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Iron deficient anemia % (Hb &lt;120 g/L &amp; Ferritin &lt; 15 μg/L)</td>
<td>564</td>
<td>3.2</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table shows means and prevalences

SEM: Standard error of the mean
SEP: Standard error of the prevalence
with extraordinary rapidity and, anecdotally, stunting has been regarded as a proxy for zinc inadequacy. However, there is no easy way to assess zinc status. Plasma concentrations of zinc are not a good indicator of zinc status, as the concentration in the blood is <1% of the total amount in the body, the biomarker lacks sensitivity, and there is the potentially confounding factor that hypozincemia is part of the acute phase response to infection. Plasma zinc concentrations are depressed by both infection and inflammation, and corticosteroids initially elevate and later depress zinc concentrations.

The relationship between stunting and plasma zinc concentrations is, however, poor. For example, the prevalence of stunting in the Vietnamese pre-school children was 23% and the mean plasma zinc concentration was 10.2 μmol/L. In rural areas, relevant figures were 27% and 9.7 μmol/L. In Thailand, however, a study on school children where dietary evidence suggested that zinc nutrition was poor only found 10% stunting and very similar mean concentrations of plasma zinc in stunted and non-stunted boys and girls (Table 8). The Thai workers were interested in comparing nutritional factors in stunted and non-stunted children, and found that median intakes of fat, total protein and phosphorus were significantly lower in the stunted group (P<0.05). There was also a tendency for association with lower intakes of energy (P=0.06) and zinc (P=0.09). The poor appetite of the stunted children may be a consequence of poor zinc status, or diets inadequate in macronutrients may restrict growth and produce a stunted child. The authors did find a significant and positive relationship between stunting among the male children in the study and serum zinc concentrations, but there were no relationships with protein, vitamin A, iron or iodine. However, the authors reported that zinc deficiency existed in the Thai children, since there was a significant rise in serum zinc concentrations following a randomized control trial using school lunches, one of which was fortified with zinc (plus vitamin A, iron and iodine). However, I question whether an increase in plasma zinc concentration really does confirm the previous existence of a metabolic deficiency of zinc. A major difficulty in establishing a clear relationship between dietary zinc and blood zinc concentrations is due to factors in the diet that influence bioavailability. The principal factor is phytate, of which cereals, especially rice, contain large amounts. No difference in the phytate content of the diet of the stunted and non-stunted children was detected.

### Table 6: Anthropometric characteristics of Vietnamese children

<table>
<thead>
<tr>
<th>Country</th>
<th>National % Stunting (%HAZ&lt;-2)</th>
<th>Urban % Stunting (%HAZ&lt;-2)</th>
<th>Rural % Stunting (%HAZ&lt;-2)</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>23.2</td>
<td>18.9</td>
<td>26.7</td>
<td>0.13</td>
</tr>
<tr>
<td>Urban</td>
<td>18.1</td>
<td>14.8</td>
<td>20.8</td>
<td>0.11</td>
</tr>
<tr>
<td>Rural</td>
<td>6.3</td>
<td>5.2</td>
<td>7.2</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Abbreviations are HAZ (height for age z-score), WAZ (weight for age z-score) and WHZ (weight for height z-score).

*Chi-square test.

Data from reference.

### Table 7: Percentage of under-fives (2006–2010) suffering from moderate and severe stunting in countries in SE Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>Prevalence</th>
<th>Country</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>NA</td>
<td>Philippines</td>
<td>32</td>
</tr>
<tr>
<td>Cambodia</td>
<td>40</td>
<td>Singapore</td>
<td>NA</td>
</tr>
<tr>
<td>Indonesia</td>
<td>37</td>
<td>Timor-Leste</td>
<td>58</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>48</td>
<td>Thailand</td>
<td>16</td>
</tr>
<tr>
<td>Myanmar</td>
<td>35</td>
<td>Vietnam</td>
<td>31</td>
</tr>
</tbody>
</table>

Obtained from reference, where moderate and severe stunting is defined as <-2SD (Z scores).

NA is not available.
but when one group is given a supplement of a highly bioavailable zinc, it is not surprising that there is an increase in the plasma zinc concentration.

The prevalence of stunting in the Vietnamese children is evidence of continuing malnutrition in spite of the enormous improvements in vitamin A and iron status over recent years. The change in dietary patterns has indicated that the quality of the diet has improved, with an increased intake of animal and fish products, and a reduction in rice consumption. However, consumption of one food type may not have increased substantially over the last two decades: dairy products. Dairy products are an important source of riboflavin, and the food survey in 2006 found that 98% of respondents failed to obtain required amounts of this (Table 2). Experimentally, a lack of riboflavin like zinc, inhibits growth and the unavailability of dairy products, as well as an inability to digest lactose (milk sugar), in many developing countries may also be a factor that contributes to poor growth. We previously reported that biochemical riboflavin deficiency was common in pre-school children in north east Thailand, where milk was rarely consumed. Low riboflavin intakes are likely to be common in many of the countries where plasma zinc concentrations are low. Cow’s milk has previously been reported to have beneficial effects on linear growth, and it is suggested a high lactose concentration may have a prebiotic effect, improving absorption of minerals. A six-month fortified milk intervention study was recently carried out on school children aged 7–8 years who attended three primary schools in the Northern delta province of Vietnam, in order to determine the effect on micronutrient and anthropometric status. Vitamin A and hemoglobin concentrations of these children, as well as the amount of stunting, were similar to those measured in the National Survey, but ferritin concentrations were almost three times higher (Table 9). However, these workers took no account of inflammation, so vitamin A

<table>
<thead>
<tr>
<th>Table 8: Mean serum zinc concentrations in Thai boys and girls with and without stunting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Serum zinc in μmol/L</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Males</td>
</tr>
</tbody>
</table>

CI: Confidence interval
Data from reference

<table>
<thead>
<tr>
<th>Table 9: Impact of six-month fortified milk consumption on nutritional biomarkers in Vietnamese children aged 7–8 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Baseline vitamin A (μmol/L)</td>
</tr>
<tr>
<td>Baseline ferritin (μg/L)</td>
</tr>
<tr>
<td>Baseline hemoglobin (g/L)</td>
</tr>
<tr>
<td>% Fall in anemia (Hb &lt; 115 g/L); baseline to endline</td>
</tr>
<tr>
<td>Baseline stunting (% HAZ &lt;-2)</td>
</tr>
<tr>
<td>Fall in stunting % Fall in HAZ &lt;-2; baseline to endline</td>
</tr>
<tr>
<td>Baseline plasma zinc (μmol/L)</td>
</tr>
<tr>
<td>% Fall zinc (&lt;10.8 μmol/L) baseline to endline</td>
</tr>
</tbody>
</table>

Data from reference
Additional amounts of nutrients in 100 mL fortified milk were calcium (45 mg), phosphorus (90 mg), iron (1.26 mg), zinc (0.7 mg), iodine (0.022 mg), manganese (0.26 mg), vitamin A (2.9 IU), D3 (58.1 IU), E (2.44 mg), B6 (0.09 mg), B2 (0.07 mg), C (32 mg)

Children in two separate schools received 500 mL regular or fortified milk six days per week for six months. Children in a third control school received nothing. ANOVA shows differences between groups

N.B.: The cut-offs for deficiencies of hemoglobin and plasma zinc used in this study are different to those used in the rest of the paper
concentrations were probably lower and ferritin concentrations higher.

There were a number of small changes as a result of the intervention. The most significant of these may have been a reduction in anemia and a reduction in zinc deficiency (Zn <10.8 μmol/L) in the treatment groups that was greater than in the control. There appeared to be a reduction in the amount of stunting, but this did not differ between groups (Table 9). However, the children received 500 mL of regular or micronutrient-fortified milk six days per week for six months. It is important to note that even the unfortified milk (0.8 mg riboflavin/500 mL) will have potentially doubled the per capita intake of riboflavin found in the 2006 Food Consumption Survey (Table 2). Unfortunately, riboflavin status was not measured. There was a fall of ~10% in the number of stunted children in the milk-treated groups. This was not significant, but six months may have been too short a period to show any effects on growth.

In conclusion, stunting is still present in almost a quarter of Vietnamese children. The recent survey suggests that deficiencies of vitamin A and/or iron may no longer be major contributors to this chronic malnutrition. However, zinc and – possibly – riboflavin deficiencies, both of which suppress growth, may contribute to impaired growth, and dietary changes may be needed to combat the problems. In the case of zinc, reducing phytate concentrations in food, or adding phytase, may be the more efficient approach, and this would improve the bioavailability of other minerals too, such as iron, calcium, magnesium and phosphorous. In the case of riboflavin, fortification of foods may be the best option, as the intake of dairy foods is not a part of traditional diets in SE Asia.

**“There was a high prevalence of anemia in Cambodian pre-school children”**

### Micronutrient deficiencies, hemoglobinopathies and anemia in SE Asia

In 2000, a critical review of the role of micronutrient deficiencies in the causing of anemia concluded that, while iron deficiency is regarded as the major cause of nutritional anemia, changes in vitamins A, B₁₂, C and E, folic acid and riboflavin status have also been linked to its development and control. Vitamin A can improve hematological indicators and enhance the efficacy of iron supplementation. Both folate and B₁₂ can cure and prevent megaloblastic anemia. Riboflavin enhances hematological responses to iron; its deficiency may account for a significant proportion of anemia in many populations. Vitamin C enhances the absorption of dietary iron, although population-based data that show its efficacy in reducing anemia or iron deficiency are lacking. vitamin B₆ effectively treats sideroblastic anemia. Multivitamin supplementation may raise hemoglobin concentration, but few studies have isolated the effect of multivitamins from iron on hematological status. In SE Asia, there are further contributing factors to anemia; namely, the presence of thalassemia and other hemoglobinopathies. The influence of infection on many aspects of iron metabolism must not be overlooked either.

In Vietnam, the recent survey found only a small proportion of people with anemia, but iron deficiency explained only ~50%
The study in Cambodia collected data on anthropometry, fecal parasites and blood from ~2,000 children aged 6–59 months in three rural provinces in Cambodia. The anti-coagulated blood was analyzed for hemoglobinopathies, hemoglobin, ferritin, sTfR, CRP, AGP and retinol binding protein (RBP) as a proxy for vitamin A. Anthropometry and iron status was much poorer, and inflammation much more common, in the Cambodian children than it was in the Vietnamese children, but there was little evidence of poor vitamin A status. The nutritional status of the Cambodian children was also poorer in rural rather than urban areas (Table 10). Of interest were the prevalences of the inflammation biomarkers, where the number of children with a raised AGP concentration was more than double that of those with a raised CRP in both rural and urban areas.

Four main hemoglobin variants linked with hemoglobin E and thalassemia were identified. In normal adult hemoglobin, the globin molecule comprises four polypeptide chains, two alpha and two beta, and is denoted as HbAA. Hemoglobin E disease arises from a genetic alteration in the physical structure of hemoglobin; specifically, a single amino acid substitution in one of the beta-globulin chains. When only one gene in the nucleus is affected, it is denoted as HbAE and, in the homozygous form when two genes are affected, as HbEE. In alpha-thalassemia, there is impaired synthesis of one or more of the alpha-globulin chains. When the deletion affects one alpha-chain, it is known as the alpha-thalassemia trait, which can occur alone or be accompanied by HbAE. Both the latter forms tend to be asymptomatic and are known as thalassemia minor. The prevalences of all five forms in Cambodia were: HbAA 42%, HbAE 23%, alpha-thalassemia trait 16%, the combination of alpha-thalassemia trait and HbAE 8.3%, and homozygous HbEE 5.2%.

The influence of the four predominant hemoglobin variants on iron status is shown in Table 11. Hemoglobin concentra-

### Table 11: Mean hematologic variables and RBP for normal hemoglobin type HbAA and the four major hemoglobin variants in Cambodian children aged 24–59 months

<table>
<thead>
<tr>
<th>Variable</th>
<th>HbAA</th>
<th>Hb E trait (HbAE)</th>
<th>alpha-Thalassemia trait</th>
<th>Hb E trait with alpha-thalassemia trait (HbEE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>531</td>
<td>325</td>
<td>204</td>
<td>122</td>
</tr>
<tr>
<td>Hb (g/L)</td>
<td>114</td>
<td>110*</td>
<td>111*</td>
<td>108*</td>
</tr>
<tr>
<td>sTfR (mg/L)</td>
<td>7.1</td>
<td>7.4*</td>
<td>7.5*</td>
<td>7.5*</td>
</tr>
<tr>
<td>Ferritin**</td>
<td>31.6</td>
<td>32.5</td>
<td>30.4</td>
<td>30.1</td>
</tr>
<tr>
<td>RBP** (μmol/L)</td>
<td>1.16</td>
<td>1.18</td>
<td>1.22</td>
<td>1.14</td>
</tr>
<tr>
<td>Hb (g/L)</td>
<td>114</td>
<td>110*</td>
<td>111*</td>
<td>108*</td>
</tr>
<tr>
<td>sTfR (mg/L)</td>
<td>7.1</td>
<td>7.4*</td>
<td>7.5*</td>
<td>7.5*</td>
</tr>
<tr>
<td>Ferritin**</td>
<td>31.6</td>
<td>32.5</td>
<td>30.4</td>
<td>30.1</td>
</tr>
<tr>
<td>RBP** (μmol/L)</td>
<td>1.16</td>
<td>1.18</td>
<td>1.22</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Data from reference 3 where sTf is soluble transferrin receptor and RBP is retinol binding protein

* Different from concentration in HbAA group. In addition mean corpuscular volume was significantly lower and red cell count significantly higher in variant Hb groups (P<0.05)

** Values for ferritin and RBP were corrected for sub-clinical inflammation

of that anemia. Thai workers reported similar findings in school children,17 where 31% had anemia, but the contribution of iron deficiency was low and the main factors were hemoglobinopathies, sub-optimal vitamin A status and age. Similar findings to those of the Thai study have now emerged in a study from Cambodia, where genetic hemoglobin disorders were found to be present in ~60% of pre-school children.3 Cambodia lies directly to the west of South Vietnam and shares its eastern land border. Disease and environment will have exerted similar pressures on the people of the two countries, so we would expect similar prevalences of abnormal hemoglobins in the Vietnamese people. As most hemoglobin disorders are not amenable to intervention, alternative procedures to deal with the residual anemia would have to be considered if the prevalence of hemoglobin disorders is as high as it is in Vietnam.

The fall of the prevalence of anemia in Vietnam is encouraging. The study in Cambodia collected data on anthropometry, fecal parasites and blood from ~2,000 children aged 6–59 months in three rural provinces in Cambodia. The anti-coagulated blood was analyzed for hemoglobinopathies, hemoglobin, ferritin, sTfR, CRP, AGP and retinol binding protein (RBP) as a proxy for vitamin A. Anthropometry and iron status was much poorer, and inflammation much more common, in the Cambodian children than it was in the Vietnamese children, but there was little evidence of poor vitamin A status. The nutritional status of the Cambodian children was also poorer in rural rather than urban areas (Table 10). Of interest were the prevalences of the inflammation biomarkers, where the number of children with a raised AGP concentration was more than double that of those with a raised CRP in both rural and urban areas.

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The influence of the four predominant hemoglobin variants on iron status is shown in Table 11. Hemoglobin concentra-
tion was lower in all variant hemoglobin groups and stFR and ferritin concentrations were all higher. Ferritin concentrations were higher in the groups with abnormal hemoglobins, in spite of correcting the values for the presence of sub-clinical inflammation. All four common genetic hemoglobin disorders were major risk factors for anemia. Of the tested children who had any hemoglobin disorder, 62% had anemia, compared with 43% in the HbAA children. The anemia observed was predominantly microcytic hypochromic anemia, which is the form commonly attributed to iron deficiency. Anemia in the Cambodian infants and children was slightly more common in younger age groups, and more likely to be associated with iron deficiency than in older age groups. Anemia was also more common – and linked to poor iron status – in younger Vietnamese children, as well. Both groups of workers associated this with a relatively short period of lactation and low iron-containing complementary foods.

In conclusion, there was a high prevalence of anemia in the Cambodian pre-school children and this was strongly linked to genetic hemoglobin disorders. If the proportion of genetic hemoglobin disorders is similar in Vietnam to that in Cambodia, it would seem that the Vietnamese government’s policy of promoting the VAC farming method to provide good nutrition for the whole community has been very successful. The VAC farming method has promoted better nutrition in urban and rural communities alike, as the differences in nutritional status between the two communities are very small. In contrast, in the Cambodian children, malnutrition in rural children was more than double that of those in urban communities. However, the fact that the prevalence of anemia has fallen to such low levels in Vietnam encourages us to believe that good, balanced nutrition can increase levels of hemoglobin, even in the face of potentially very high prevalences of hemoglobin disorders. It is interesting to note that mean ferritin concentrations in Vietnamese children (33.8 μg/L) were very similar to those in Cambodian HbAA children (31.6 μg/L), although the proportions of low ferritin concentrations were different (12.9 and ~21% respectively). The comparability of the mean ferritin concentrations, however, suggests that not just dietary iron has benefited the Vietnamese children, but also improvements in some of the other hemopoietic nutrients that were not measured in these studies. Iron deficiency only explained half of the anemia in the Vietnamese children. More work is needed to explain the other 50%, as providing more iron is unlikely to be of any benefit if hemoglobin disorders are responsible.

References


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The remaining cases of anemia in women and children (11.6% and 9.1% respectively) could be due to deficiencies of other micronutrients or the presence of infection or parasitic infestation (which has been shown to be as high as 80% in school children). The suggestion that thalassemia and related hemoglobinopathies may be a contributing factor deserves further investigation.

In the north and northeastern regions of Thailand, adjacent to Laos and Cambodia, the majority (up to 60%) of the population are carriers of hemoglobin E (HbE trait) and up to 25% are carriers of α-thalassemia. The iron status indicators of the HbE trait were not different from those of the control, while other groups of hemoglobinopathies showed a range from mild to severe impairment. A similar phenomenon was observed in Cambodian children (Table 10).

A complex relationship
The relationship between micronutrient status and intake is always complicated. While the status is a result of micronutrient exposure over time, the intake is a snapshot of foods consumed during a particular period. In the case of vitamin A, which can be stored in the body, the absence of vitamin A intake during the time of assessment does not always imply an inadequate status. The bioavailability and bioconversion of pro-vitamin A carotenoids adds to the complication. Such factors form the basis of the discrepancy between the high percentage of those with an inadequate vitamin A intake in the 2006 survey (Table 2) and the normal range of plasma retinol concentrations (Table 1). The apparent contradiction between iron intake and the biochemical evidence of iron deficiency can be explained in a similar way. Despite the general improvement in diet quality, the high prevalence of zinc and vitamin B₁₂ deficiency (based on the evidence of plasma concentrations) raises a public health concern. Foods rich in both micronutrients come from animal sources (which are relatively expensive). This helps to explain why, in
the 2010 survey, the highest risk of major micronutrient deficiencies was found among people in the youngest and the poorest categories.

**Stunting**

The etiology of stunting is unclear. While zinc is a potential candidate for the promotion of linear growth, more concrete evidence is needed to establish a definite causal relationship. The study in Thailand that was cited was an efficacy study using a multiple micronutrient-fortified seasoning powder among primary school children in northeast Thailand. The study was not designed to address the question of the relationship between zinc and stunting. However, the evidence it accumulates regarding low zinc intake, low soil zinc, and low serum zinc – and the significant association it finds between serum zinc and stunting in boys – helps build a case that zinc malnutrition could be an important factor warranting further investigation.

The suggestion that riboflavin deficiency is a contributor to stunting, based on dietary intake alone (Table 2), still requires solid evidence, in particular a biomarker of status. The benefit of any intervention to stunted children also needs to be demonstrated before an appropriate course of action can be recommended.

**The role of infection**

I am in agreement that a biomarker of chronic inflammation is useful for the estimation of micronutrient status based on biochemical indices. In addition, it is useful to provide current statistics on the infection burden in Vietnam, compared to data from two decades previously, because the effective control of infection could contribute to the improvement of micronutrient status – especially vitamin A and iron, as demonstrated.

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**References**


**Opinion 2: How to Reduce Stunting: Going Beyond the Well-Recognized Micronutrients**

Saskia de Pee
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“Great progress has been made in Vietnam in the last two to three decades with reducing micronutrient deficiencies”

The paper by David Thurnham highlights the great progress that has been made in Vietnam in the last two to three decades with reducing micronutrient deficiencies, such as vitamin A and iron. Vitamin A status among under-fives as well as women is now comparable to that observed among the same groups in the British population. The prevalence of anemia and iron deficiency has also been reduced to remarkably low levels. Furthermore, data from hemoglobinopathies in Cambodia suggest that no more than half of the anemia observed in Vietnam is likely to be due to iron deficiency. The prevalence of stunting (23.2%) is yet to be further reduced, however. While Thurnham states that the large improvements in iron and vitamin A status had little impact on stunting, data collected between...
1986 and 2007 showed a decline of stunting prevalence from 59.7 to 34% in rural areas and from 40.6 to 20.6% in urban areas. This means that, concurrent with the decrease in vitamin A and iron deficiency, stunting prevalence also declined.

Stunting still prevalent
That the prevalence of stunting is still considerably higher than in the reference population, where it is 2.3%, is not too surprising because a large number of nutrients need to be consumed in order for a child’s bones and muscles to grow adequately, and the child should be in good health for most of the time. Meeting the nutrient requirements of young children requires the consumption of plant-source foods, as well as animal-source and fortified foods.

Nutrients that are particularly important for linear growth are phosphorus, magnesium, calcium, zinc and vitamin D. It is difficult to determine adequacy of status for most of these nutrients, because they are used to build bones and muscles and the excess is not stored. Thus, when the availability of one or more nutrients limits further growth, the excess of the other nutrients is excreted.

Dairy products are a good source of bioavailable phosphorus and calcium, and also increase insulin-like growth factor (IGF-1) levels. However, as Thurnham says, consumption of milk in Vietnam is limited. Milk can be consumed in its primary form, but also as yoghurt, or milk powder – which can be added as an ingredient in other foods, particularly complementary foods. Lactose intolerance develops with age. Breastfed children can digest lactose, but can lose that ability when milk is no longer consumed. Therefore, most young children will be able to consume dairy, or dairy-containing, products.

Zinc deficiency risks
Thurnham also cites a prevalence of risk of zinc deficiency of 51.9%, which could be another important factor limiting linear growth. Since zinc and, particularly, iron bioavailability are limited by phytate, reducing phytate content and concurrently increasing zinc and iron intake are both important. Such an approach is best applied to specific foods for older infants and young children, including home-fortificants and specially formulated foods.

While Thurnham attributes much of the improvement in micronutrient status to the VAC farming program, economic development has also played an important role and, as seen in other Asian countries, has increased dietary diversity and access to animal-source and fortified foods, in particular in urban areas.

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References
Advocating better nutrition for brighter futures.
A Day in the Life of Dr Noel W Solomons

**Sight and Life (S&L):** Dr Solomons, you are Director of the Center for Studies of Sensory Impairment, Aging and Metabolism (CESSIAM). How long have you been in this role, and what does it entail?

**Noel Solomons (NS):** I have been in this position since July 1, 1985 – the day the new center was founded. I am also its Senior Scientist. The Center is the operative arm of a non-profit association, the ASOCIACION CESSIAM. I’ve been the Vice President of the Board of Directors of ASOCIACION CESSIAM since 1987.

The role involves projecting the vision and the mission of the institution, both internally and externally. Above all, the Center is about discovery and the creation of new knowledge. It is also about training young scientists and building capacity for knowledge creation. It is not about participating in public health programs per se. External projection involves contacting potential donors of research financing in foundation, government and industry sources and communicating with potential collaborators and researchers.

Reviewing research manuscripts and free-paper abstracts for scientific meetings occupies much of my time. The role also involves financial administration.

**S&L:** Can you tell us something about the team that supports you at CESSIAM?

**NS:** There is an external (international) team and an internal (local) team. The external team consists of the Nevin Scrimshaw International Nutrition Foundation in Boston and the Hildegard Grunow Foundation in Munich, Germany. We also have productive ongoing academic collaborations with several other international universities.

The internal support team consists of two loyal staff members in clerical and custodial positions. We have five full-time professionals based in the Headquarters – two with international doctoral degrees in nutritional sciences – and one coordinating our outpost in Quetzaltenango in the Western Highlands.

**S&L:** Can you tell us something about the history, values and objectives of CESSIAM itself?

**NS:** CESSIAM was born out of values: our guiding principle is to encourage creative and unfettered lines of research outside of the constraints and orthodoxies of any institutional oversight. From 1977 to 1984, I perceived a weakening of the investigative mission of INCAP due to the politicization of research. As a conscious counter-reaction, CESSIAM’s most important value was to provide a refuge for the expression of scientific curiosity originating from the inspiration of the investigator, with strict adherence to the objectivity of the scientific method. We also wanted to develop young scientists as ‘human capital’ for innovative biomedical investigation.

We originally had four divisions for the center, but this has evolved to two: Diet and Health; and Safety and Efficacy of Iron.

**S&L:** Your website states that “CESSIAM is located in Guatemala City, Guatemala. The small, modest building belies the copious amounts of cutting-edge nutrition research going on within!” Could you tell us more?
“It may be immodest to state it, but I usually enjoy reading my own articles. I like sharing a narrative with the readership.”
NS: The small building on the website photo is but one of a number of small buildings that make up the Center. In our white office headquarters, we have the offices; in a twin building attached, there is a space used for a clinic or simple laboratory, as well as a meeting room for seminars and some offices for our students. In the city of Quetzaltenango, in the Western Highlands of Guatemala, we have two locales in a commercial center. I have never subscribed to the “edifice complex” of some institutions, where the grandeur of the physical facilities becomes a status symbol. Our current facilities are ample compared to the space in the eye and ear hospital in our early years.

S&L: CESSIAM celebrated the 25th anniversary of its foundation in 2010. What did that milestone mean to you and your colleagues?

NS: Our 20th anniversary in 2005, celebrated in Guatemala, had already made clear how many diverse individuals had participated in projects over the previous two decades, and how successful many had become in their own right. Following on from that, our 25th anniversary was celebrated during the course of the whole calendar year of 2010. The centerpiece was an afternoon wine-tasting party in Oporto on the occasion of the second World Congress on Public Health Nutrition. Virtually all of our staff and students had free-papers accepted to the Congress, and some won awards. The entire worldwide staff from Sight and Life was present to honor us with a toast and a commemorative plaque. The celebration will be remembered by all.

S&L: You are an officer of the Nevin Scrimshaw International Nutrition Foundation (INF). What is the relationship between INF and CESSIAM?

NS: Around the time of the founding of CESSIAM it was “awkward” to have large amounts of funds in local banks. We worked out a means to have hard currency deposits held in Boston and released as needed on a monthly basis. This arrangement persists through today, helping us to obtain equipment and reagents that are difficult to purchase directly in Central America.

S&L: CESSIAM is based in Guatemala. What is the health and nutritional status of the population of Guatemala, and how has it changed in the past quarter-century?

NS: Infant and under-five mortality have progressively declined over the past 25 years, but overweight and obesity have emerged in urban populations. Anemia remains a problem. We have mosquito-borne infections of Vivax malaria and Dengue fever on the coastal plain. We are among the nations most infested by intestinal worms. Guatemala has two glaring manifestations of poor public health. The first is the maternal mortality ratio, with women dying in childbirth in numbers upwards of 300 per 100,000 live births in some parts of the Western Highlands. The second – and the most immediately relevant to CESSIAM and Sight and Life – is the rate of stunting in children from 6 to 59 months. In the most recent survey, this was 54% – the highest of any Latin American nation.

S&L: What are your hopes for public health in Guatemala and in Latin America as a whole?

NS: I’d like to see a focus on the two imposing problems just mentioned. And I would like to see an even greater improvement in the technical skills, equipment and instrumentation available for public health research in Latin America. Researchers should focus on how emerging concepts may relate to our own regional problems. There is an ideological tendency in the region to eschew objective inquiry and rely on doctrinaire formulations of the causes of social ills; I hope that objectivity trumps ideology in the near term.

S&L: How do you view the Scaling Up Nutrition (SUN) movement, and what are your expectations of this initiative?

NS: SUN represents the kind of coalition of institutions that I like to see working together. I am a fervent devotee of private-public collaborations. The persistence of stunting in 36 selected developing countries – including Guatemala – is a blemish on the world’s public report card. Furthermore, the paradigm of the first 1,000 days of life, from conception to the second birthday of a child, as the window of opportunity for assuring normal growth, development and health is based on firm and proven biological and epidemiological evidence.

My only concern with SUN is the danger of it becoming too focused on diet and nutrition as the only tools to reverse poor linear growth. I have long been party to the theory that environmental stressors in the surroundings of the mother, fetus and infant contribute to the impaired utilization of nutrients. Dietary and nutrient interventions are a necessary – but far from complete and sufficient – redress to impaired early growth and development.

S&L: You are a doctor of medicine by training. In what ways has this identity influenced your work?

NS: Being a physician in first instance has enabled my work, permitting me to take a leadership role in research with human subjects and populations. Moreover, a physician is less likely to become too narrowly focused on one problem or experimental
technique. Medical doctors are also committed to the Hippocratic tradition, which is based on the dictum of “first do no harm.” This is relevant to areas such as iron administration in malarial regions.

S&L: Do you have a hero who has inspired you in your career?

NS: There are three heroes who have acted as inspirational mentors. In 1965, my political leanings were considered too radical for Top Secret clearance in the Office of Scientific Affairs, so I was relegated to USAID and war-vintage out-buildings in the flats of Foggy Bottom in Washington DC. Again, a modest setting! There I was to meet Dr Harald Frederiksen, a tropical disease physician (and also somewhat of a political renegade), with whom I did a summer internship after my junior year at Harvard College. The topic he proposed would introduce me to the world of international nutrition, and turn my career aspirations from biochemistry to medicine.

Returning to campus, I headed over to cross-register at MIT for an honors thesis on nutrition and infection with Prof. Nevin Scrimshaw, Chair of the Department of Nutrition and Food Science. Nevin, at age 31, had been the founding director of INCAP in Guatemala. Over the years, working with him later on the faculty of his Department and subsequently with his International Nutrition Foundation, I would learn the art of science in broad and relevant topics, as opposed to narrow specialization.

Prof. Irwin Rosenberg, Dean Emeritus of Tufts University’s Friedman School of Nutrition: Science and Policy is another major influence. Closely allied in the 1970s with Dr. Scrimshaw, he was a gastroenterologist with an interest in folic acid and vitamin B12. We first linked up at the Harvard Medical School as part of the civil rights movement. After finishing my medical training, I became a trainee in the Division of Gastroenterology at the University of Chicago, which Irv was by then running. There I became involved in intestinal handling of lactose, zinc and bile acids in Chicago, and I carried those three interests to Guatemala, when he pointed me to a final, fellowship year abroad at the INCAP.

S&L: The mission of Sight and Life has changed considerably in the past quarter century. How does Sight and Life interact with CESSIAM today, and how do you view the organization’s overall evolution?

NS: Sight and Life began as a voluntary organization largely involved with vitamin A as a way of addressing nutritional blindness. Its present scope runs across the gamut of micronutrients and into core, complex issues such as stunting and overweight. This is a most favorable evolution, as is Sight and Life’s leadership and collaborative positions on vexing issues of the day – such as anemia eradication.

CESSIAM has received partial funding from Sight and Life for a series of studies, including descriptive studies on complementary feeding patterns. Currently, we are looking to partner with Sight and Life in an expanding study on the fortification of maize flour. A further interaction is editorial: I have served as an author for a chapter in the monograph, Nutritional Anemia, and as a Contributing Editor for Sight and Life magazine.

S&L: What does the magazine itself mean to you? Which parts do you most enjoy reading, and are there any things that you would wish to change about the magazine?

NS: It may be immodest to state it, but I usually enjoy reading my own articles. I like sharing a narrative with the readership. The magazine has a very flexible approach and publishes a broad diversity of articles.

S&L: If you could change one thing about your working life, what would it be?

NS: I wish that I could spend more time with the staff and students at CeSSIAM’s outpost in the Western Highlands. It’s a remote – but vibrant – location.

S&L: How do you switch off from work? Do you have interests outside your professional existence?

NS: “So much to do … so little time” is my usual perspective. I enjoy photography, dancing and socializing, but usually in the context of a professional activity.

S&L: Is there anything else that you would like our readers to know?

NS: Being a “transnational” professional is a unique experience. For example, in 2010 I was honored to be the first non-Guatemalan to receive the Guatemalan Medal for Science and Technology. International organizations such as Sight and Life provide some form of grounding in my tumbleweed jaunt through my career.

Dr Noel W Solomons was interviewed by Jonathan Steffen
Sir Jack Cecil Drummond
DSc, FRIC, FRS

A hero of nutrition science and advocacy

Jonathan Steffen
The Corporate Story, Windsor, United Kingdom

2012 is being celebrated worldwide as the Year of Vitamins in recognition of the development of the concept of the “vitamine” by Casimir Funk in 1912. *Sight and Life* is marking this milestone with a series of articles on some of the heroes of vitamins – figures whose work has made the benefits of these naturally occurring micronutrients available to a world that greatly needs them.

In our 1/2012 issue, we discussed the contribution of Funk himself, the “Godfather of Vitamins”. In the present issue, we turn our attention to one of Funk’s research assistants, Sir Jack Cecil Drummond, whose work both as a scientist and as a policy-maker influenced an entire generation and still resonates to this day.

What might a visionary and public-spirited nutrition scientist reasonably expect from a lifetime’s work? Intellectual challenge, certainly: the chance to make new discoveries that might transform our understanding of the world. Influence, as well: the opportunity to translate new scientific findings into policy recommendations that change our approach to existing problems. One could add: the companionship of like minds; the pleasures of writing, lecturing and publication; the stimulation of travel; the prospect of recognition; even the hope of honors. But being murdered would not be on the list. To be more precise: being murdered together with your wife and ten-year-old daughter by the side of a road in the middle of a hot August night in the south of France. That, surely, would not be on the wish-list of any budding nutrition scientist.

L’Affaire Dominici

News of this savage triple murder spread instantly. Journalists flocked to the scene of the crime, destroying potentially valuable evidence before the site could be secured by the police and examined by forensic experts. The murder of the British scientist and his family was blamed on a local French peasant of Italian extraction, one Gaston Dominici, and the affair became known in France as “l’Affaire Dominici.”

To this day, l’Affaire Dominici remains unsolved. It is, in fact, the most famous unsolved 20th-century murder in France, and is much better remembered in that country than in the United Kingdom. Wikipedia has an extensive French-language entry on the subject, numerous books and films have been devoted to it, and in 1955 no less a director than Orson Welles travelled to France to interview the surviving protagonists and shoot a 26-minute documentary film entitled *The Tragedy of Lurs*. Intended for screening by the newly launched independent British television channel ITV, it was to be Orson Welles’ debut as a director for television. Mysteriously, the film was never completed during his lifetime.¹

The tantalizing drama of Drummond’s murder – worthy of the combined pens of Georges Simenon, Graham Greene and John Le Carré – threatens to overshadow the towering achievements of his life’s work. Sixty years on from his death, it is apposite to reflect on his enduring legacy. For “Sir Jack”, as he liked to be known, was a pioneer of science as well as of policy-making, and can arguably be classed the most influential nutritionist ever to have been produced by the British Isles. If there was ever a person able to use his powers as an advocate to translate nutrition science into effective dietary programs, it was he.

“What many a well-to-do father has given far greater attention to the feeding of his own horses, dogs or farm stock than to the diet on which his son might be subsisting at a famous public school.”²
“Many a well-to-do father has given far greater attention to the feeding of his own horses, dogs or farm stock than to the diet on which his son might be subsisting at a famous public school”
From vitamine to vitamin

Jack Drummond was born in Leicester (or London, according to some sources) in 1891. He was the son of Colonel John Drummond of the Royal Horse Artillery and his wife (or lover) Gertrude. Jack’s father died when he was three months old, and the boy was brought up in London by his father’s sister, Maria Spinks. If his start in life was less than ideal, his rise through academia was meteoric: He took First Class honors in Chemistry at East London College in 1912, moving on to become a research assistant under Otto Rosenheim and WD Halliburton at the Department of Physiology of King’s College London, and then, in 1914, to work with the Polish-American biochemist Casimir Funk at London’s Cancer Hospital Research Institute. It was his work with Funk that first stimulated his interest in nutrition. Funk had coined the term “vitamine” (from “vital” plus “amine”) in 1912. In 1920, Drummond proposed that the final “e” should be dropped from Funk’s neologism, as not all vitamins are an amine. Drummond went on to become the first Professor of Biochemistry at University College London in 1922, when he was just 31. He succeeded in isolating pure vitamin A during the 1930s. However, it is for his genius at translating original science into practical dietary programs that he is perhaps best remembered.

Pressing the claims of nutritionally vulnerable groups

Perhaps Drummond’s name is most closely associated with the provision of special foods for mothers and children. From the outset he pressed the claims of nutritionally vulnerable groups. The success of his efforts in this direction is seen in the schemes that were gradually evolved for the cheap supply and priority rationing of liquid milk, in the early experiments with blackcurrant syrup and rosehip syrup as sources of vitamins for expectant mothers and young children, in the subsequent provision of concentrated orange juice and cod-liver oil to these two groups, and in the generous allocation of rationed foods for school meals and the provision of national milk cocoa for adolescents.3

“At the time of his death in 1952 no fewer than nine of his pupils were Professors of Biochemistry in Great Britain or in other countries.”1

A war on “dietetic ignorance”

Drummond’s work on the effect of poison gases on food brought him to the attention of the British government at the outbreak of World War II. In 1940, he was appointed chief scientific adviser to the Ministry of Food. On account of the trading patterns that came with the British Empire, Britain imported two thirds of its food from abroad at the time. The Nazi blockade of merchant shipping bound for Britain was therefore potentially devastating.

Drummond developed a system of national rationing to ensure that everyone, whether rich or poor, had an adequate nutritional intake. As James Ferguson writes in his 2007 publication The Vitamin Murders, “It was the moment Drummond might have been waiting for all his life. Advising the Ministry was more than just an interesting job to him. From the start he regarded rationing as the perfect opportunity to attack what he called ‘dietetic ignorance’ and recognized early on that, if successful, he would be able not just to maintain but to improve the nation’s health ... He did more than perhaps any other single individual to ensure that island Britain survived the Nazi U-boat blockade without starving. In fact the health of the British nation, schoolchildren included, was not just maintained during the Second World War but improved ... [T]he incidence of almost every diet-related illness was lower than it had ever been. Drummond was a genuine home-front hero.”2 As Ferguson continues, “Under the patriotic banner slogan ‘Dig for Victory’, self-sufficiency became the new Holy Grail. It was considered the duty of all householders to turn their back gardens into vegetable patches. Windsor Great Park was given over to wheat. Even Lord’s cricket ground was not spared ... And Drummond provided the science behind the spadework.”

“Jack Drummond’s nutritional policy-making changed the course of history in World War II”

Changing the course of history with diet

Drummond’s guidelines were based not only on his pioneering work in the laboratory but also on his lifelong interest in food. His bibliography runs to nearly 200 titles, but he only brought out one actual book in his lifetime, co-authored with his second wife, Anne Wilbraham. Entitled The Englishman’s Food: Five Centuries of English Diet, it was heralded as a breakthrough publication when it first appeared in 1939, was fully revised (by Dorothy Hollingsworth, and in accordance with Drummond’s plans) in 1957, and was republished in 1991.4

As Tom Jaine writes in his introduction to the 1991 edition, “Drummond was working during the heroic period of nutritional science when the constituents of food necessary to maintain, and then improve, the quality of life were finally defined. This... was the era when deficiency diseases received their full investigation. For centuries rickets, scurvy, pellagra, beri-beri, night blindness and hunger-oedema had been the scourge of various societies. Sometimes, remedy had been chanced upon by empirical means – the British navy’s eventual adoption of lemon
juice as an anti-scrotum, for example – but it needed the new nutrition to fully explain the treatment and to rapidly extend the benefits of cure to as many populations as possible. The Englishman’s Food attempted to describe how such deficiencies affected the health of earlier centuries, how a proper diet might have changed the course of history."

Jack Drummond’s nutritional policy-making did change the course of history in World War II, and he was knighted in 1944 in recognition of the contribution he had made to the British war effort. Not only Britons benefited from his practical application of the scientific principles of nutrition: at the end of the war, he made "an easily digested porridge for the emergency treatment of the seriously starved. Known as ‘Drummond mixture’, it was deployed at Bergen-Belsen and other Nazi death camps as they were liberated, and undoubtedly saved thousands of lives.”

Ironically, however, it was the association between food and war that may have proved his doom. 

Tourist or secret agent?

Despite the myriad investigations into the murder of Sir Jack and his wife and daughter, the facts of what went on that fateful night in 1952 remain unclear. According to one line of interpretation, Drummond and his family were on a simple holiday in the south of France. Based in a rented villa in Villefranche-sur-mer on the

### Recipe for Parsley Honey

**Cooking time:** ¾ hour  
**Quantity:** 1 lb (454 g)  
5 oz (142 g) parsley (including stalks)  
1½ pints (850 mL) water  
1 lb (454 g) sugar  
½ teaspoon vinegar

**Method.** Pick parsley and wash well. Dry. Chop stalks up roughly. Put into a pan with 1½ pints (850 mL) boiling water and boil until it reduces to a pint (570 mL). Strain. Add 1 lb (454 g) sugar and boil until syrupy (like honey) about 20 minutes, then add ½ teaspoonful of vinegar. Pour into pots and cover. This gels by the next day, and tastes and looks like heather honey.

### THE MINISTRY OF FOOD WANTS YOUR COOKING SECRETS

Source: The British Ministry of Food during World War II

“If all medical students could be inspired by as stimulating a teacher as Drummond, their subsequent attention to problems of nutrition might be more extensive.”

### Table 1: British weekly food rations during World War II

<table>
<thead>
<tr>
<th>Item</th>
<th>Maximum level</th>
<th>Minimum level</th>
<th>Rations (April 1945)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacon and Ham</td>
<td>8 oz (227 g)</td>
<td>4 oz (113 g)</td>
<td>4 oz (113 g)</td>
</tr>
<tr>
<td>Butter</td>
<td>8 oz (227 g)</td>
<td>2 oz (57 g)</td>
<td>2 oz (57 g)</td>
</tr>
<tr>
<td>Cheese</td>
<td>8 oz (227 g)</td>
<td>1 oz (28 g)</td>
<td>2 oz (57 g)</td>
</tr>
<tr>
<td>Lard</td>
<td>3 oz (85 g)</td>
<td>2 oz (57 g)</td>
<td>2 oz (57 g)</td>
</tr>
<tr>
<td>Loose Tea</td>
<td>4 oz (113 g)</td>
<td>2 oz (57 g)</td>
<td>2 oz (57 g)</td>
</tr>
<tr>
<td>Margarine</td>
<td>12 oz (340 g)</td>
<td>4 oz (113 g)</td>
<td>4 oz (113 g)</td>
</tr>
<tr>
<td>Meat</td>
<td>1s. 2d.</td>
<td>1s.</td>
<td>1s. 2d.</td>
</tr>
<tr>
<td>Preserves</td>
<td>1 lb (0.45 kg) per month</td>
<td>8 oz (227 g) per month</td>
<td>2 lb (0.91 kg) marmalade</td>
</tr>
<tr>
<td></td>
<td>2 lb (0.91 kg) marmalade</td>
<td></td>
<td>2 lb (0.91 kg) marmalade</td>
</tr>
<tr>
<td></td>
<td>1 lb (0.45 kg) sugar</td>
<td></td>
<td>1 lb (0.45 kg) sugar</td>
</tr>
<tr>
<td>Sugar</td>
<td>16 oz (454 g)</td>
<td>8 oz (227 g) per month</td>
<td>8 oz (227 g)</td>
</tr>
<tr>
<td>Sweets</td>
<td>16 oz (454 g) per month</td>
<td>8 oz (227 g) per month</td>
<td>8 oz (227 g)</td>
</tr>
</tbody>
</table>

Source: The Home Front Handbook
French Riviera, they were touring the Basses-Alpes (now called les Alpes-de-Haut-Provence) in their Hillman estate car. They decided to camp by the side of the N96 on the evening of August 4, and fell afoul of the Dominicus – a family of peasants who inhabited a nearby farm called La Grand'Terre.

This interpretation, however, fails to account for many factors: the ransacked state of Drummond’s Hillman, from which a 5,000 franc note had mysteriously not been removed; the disappearance of Drummond’s camera with its top-quality Zeiss lens; the disappearance (and later reappearance) of Drummond’s pocket diary; and, perhaps most disconcertingly of all, the intense savagery of the murder of his ten-year-old daughter Elizabeth.

Conspiracy theories therefore abound. Drummond had left academia for government service during World War II; after the war, he joined the private sector, taking the role of Director of Research at the Boots Pure Drug company. The move surprised many at the time. The Boots of the day was not the retail chemist found all over Britain today, but a large-scale chemical operation, whose agrochemicals division vied with that of the massive ICI. Drummond’s Hillman was parked by a milepost on the N96 – not a good place to camp, but a good place for a rendezvous at night. And it was some 10 kilometers from the chlorine plant at Saint-Auban, which had been established during World War I to manufacture chlorine and chlorine-derived poison gases for use on the Western Front ...

Although manufacturing chlorine-based herbicides designed to promote agricultural productivity in the early 1950s, the Saint-Auban plant still had the potential to produce what are now termed “weapons of mass destruction”. If we add into the mix the rivalry between Britain and the USA in the field of agrochemicals during the early years of the Cold War, France’s close ties with the Communist Soviet Union during the period, and the fact that the workforce of the Saint-Auban plant included numbers of former maquisards – members of the rural-based Communist French Resistance from World War II – then the possibility that Sir Jack was on some form of secret mission begins to become plausible. Drummond might have joined Boots with a double mission – one given to him by the British Secret Intelligence Service, MI6. He may have been exploring the Saint-Auban plant’s links with the maquis, and specifically its potential to provide technology transfer to the USSR – in the field of agrochemicals or of poison gases.

If we reflect on his actions during World War II, such a motivation is conceivable. “Drummond was evidently not the sort to confine himself to dispensing advice and theory from the safety of the rear,” writes James Fergusson.5 “From D-Day onwards, his attention turned increasingly to the continent and its starving millions who had not had the benefit of his scientifically organized diet. In May 1945 he travelled in secret with a party of other scientists and doctors through the collapsing enemy lines in the western Netherlands. He found a population subsisting on sugar beet and fried tulip bulbs, and teetering on the brink of mass starvation. Some 30,000 people had already starved to death during the notorious ‘Hongerwinter’ of 1944. Negotiation with the German occupiers led to Operation Manna, in which RAF (Royal Air Force) Lancasters swapped their bouncing bombs for K-rations6 and air-dropped some 7,000 tons of food to the starving Dutch in a single week. Drummond was on hand to advise which food should be sent where.”

So although not a spy, nor by any means a “bumbling scientist”, Sir Jack might have been engaged that fateful August night in some form of covert mission which he regarded as being in Britain’s national interests. He had visited Lurs at least three times before, in 1947, 1948 and 1951. And he is said to have met in Lurs, two days before his death, with a certain Father Lorenzi – a celebrated hero of the Resistance.7 One conjectural theory – unsubstantiated, but intriguing – was that Drummond was investigating the fate of a British agent who had been parachuted into the area in the latter stages of the war and was thought to have been killed by a member of the maquis. It is possible to imagine a scene whereby Drummond had an arrangement to meet with a contact who was supposed to provide him with information and that someone – fearing the potential consequences of such a disclosure – decided to eliminate him at the rendezvous.8

“A profound effect on all who had contact with him”
Sir Jack might have been on a secret mission that fateful night of August 4–5, 1952; but he might equally well have not. Sixty years after his murder, the facts remain maddeningly fragmentary. Perfectly clear and coherent, however, is his stature not only as a nutritionist but as a man. As Alice M Copping of Queen Elizabeth College, University of London, wrote in the biographical sketch of him she produced for The Journal of Nutrition, “... he found time in life for so very many other things than work. He was no mean artist and could quickly illustrate a point of design on paper. He appreciated art in pictures, in the theatre and in music. Moreover he showed those who worked with him the way towards appreciation of the finer things of life. He was good company
and enjoyed good food and wine. He liked dancing and often organized parties from his Department to dances and entertainments of the societies to which he belonged. He was gay and debonair and seemed eternally young. He made friends quickly but displayed a tonic critical faculty that had a profound effect on all who had contact with him in his many spheres of influence... He took life with both hands and made great use of his opportunities, so that the news of the murder on August 4, 1952, of Sir Jack and Lady Drummond and their ten-year-old daughter while they were on camping holiday in France caused infinite dismay to all who had known them. Although he was 61 at the time of his death he was described as a man of 40 by a French newspaper reporter who came to the scene of the crime before the identity of the victims was established. This is perhaps a last tribute to his youthful vitality.”

## Sir Jack Cecil Drummond: Awards and honors

<table>
<thead>
<tr>
<th>Year</th>
<th>Award/Title</th>
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<tbody>
<tr>
<td>1918</td>
<td>DSc from University of London</td>
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<tr>
<td>1944</td>
<td>Knighted</td>
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<tr>
<td>1944</td>
<td>Elected FRS (Fellow of the Royal Society)</td>
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<tr>
<td>1946</td>
<td>Commander (Civil Division) of the Order of Orange-Nassau</td>
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<tr>
<td>1946</td>
<td>Elected Honorary Member of the New York Academy of Sciences</td>
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<tr>
<td>1947</td>
<td>Lasker Group Award of the APHA (American Public Health Association)</td>
</tr>
<tr>
<td>1948</td>
<td>Honorary doctorate from University of Paris</td>
</tr>
<tr>
<td></td>
<td>United States Medal of Freedom with Silver Palms</td>
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### References

01. Orson Welles’ documentary film was completed with an introductory narrative by Christophe Cogne and is available as *L’Affaire Dominici* par Orson Wells (2000.)

02. Drummond’s comments in his foreword to *The Schoolboy: His Nutrition and Development* by GE Friend, 1931


06. One shilling and twopence, or fourteen pennies, sterling. Approximately equivalent to six pence in decimal currency. Roughly equivalent to £1.40 (US$ 2.17) in today’s currency.


08. The K-ration was an individual daily combat food ration which was introduced by the United States Army during World War II. It was originally intended as an individually packaged daily ration for issue to airborne troops, tank corps, motorcycle couriers, and other mobile forces for short durations. The K-ration provided three courses: breakfast, dinner (lunch) and supper (Wikipedia 2012).


10. Writing in *The Guardian* of April 17, 2004, Alex Kirtsa puts forward the theory that the Drummond family may have been murdered by contract killers working for a communist organization in Frankfurt am Main in Germany.
Partners in the Nutrition Space:

GAIN – The Global Alliance for Improved Nutrition

With nutrition playing an increasingly prominent part in the global public health agenda, Sight and Life is launching a regular feature in which we profile some of the key players in the nutrition space. In the inaugural interview of this new series, Marc Van Ameringen, the Executive Director of GAIN, shares with us the experiences of that organization’s first decade and reflects on the challenges still to be met.

Sight and Life (S&L): There are a number of major players in the nutrition arena, each with their own objectives, structure and approach. What makes GAIN unique, Marc?

Marc Van Ameringen (MVA): GAIN was created ten years ago with a view to refocusing the world’s attention on nutrition, which had received inadequate focus for more than two decades prior to that. There were three key elements to our approach. Firstly, given the scale of the problem, we needed to move away from multiple small pilot programs to large-scale interventions that could reach large numbers of people and show impacts at scale. Secondly, we needed to find ways of harnessing markets more effectively. Until then, I think people had seen nutrition mainly through the lens of the public health sector. Very few perceived it as something that had to engage with market players in order to have an impact. Thirdly, we realized that no single stakeholder can be successful alone. To reach billions of people, you have to think from the outset in terms of multi-stakeholder approaches and partnerships. These three elements are central to what GAIN has been about, and what makes us unique, in my opinion.

S&L: Why did nutrition receive inadequate attention for so long?

MVA: Nutrition did in fact receive a lot of attention in the early 1970s and 1980s, and was a key program area for donors, including the World Bank. This changed in the late 1980s, however, and for two reasons. One was that a range of other public health issues came to the fore and competed for attention and budgets – HIV/AIDS, for instance, tuberculosis, malaria, and vaccines. The other was that the nutrition sector itself was highly fragmented and found it difficult to agree its key priorities. This made the sector less attractive to potential donors. Nutrition found its way back onto the global public health agenda on the heels of the food crisis in 2008, when people became concerned about the issue of food security. The very successful Lancet series on Maternal and Child Undernutrition, which identified pregnancy to 24 months as the priority area for intervention, was also very influential here.

S&L: 2012 is the 10th anniversary of the foundation of GAIN. What difference has GAIN made to the world during the past decade, would you say?

MVA: I think that GAIN has made an impact in a number of different ways. One is that we work together with partners to implement programs that can be scaled up, and whose impact can therefore be increased so as to benefit many more people in the world. Our programs are now providing over 600 million people with enhanced nutritional products. We had set ourselves the ambitious target of reaching a billion people by this point in time and have not achieved it yet, but we’re definitely on track to meet it over the next few years. This will happen as the projects we set up years ago begin to generate big impacts. Our work is also having a significant effect on a range of micronutrient deficiencies that are being addressed variously by the provision of fortified staple foods, complementary foods, and supplements. Such interventions have never been delivered on a large scale, however, so both we and the community as a whole still have a lot to learn in this area.

GAIN is one of the organizations leading the way in the development of innovative delivery models. Not only are we scaling things up; we’re also trying to make them sustainable, and this makes our approach unique. A number of GAIN programs to date have been nurtured to the point at which they are sustainable: they still require a certain amount of technical support, but no longer the major financial investments that were previously necessary.
“No single stakeholder can be successful alone”
We’ve learnt a great deal over the past ten years about where our delivery models do and do not work, and about how to apply lessons learned in population-based programs such as staple food fortification to targeted interventions focused on the 1,000-day window. On the basis of our learning to date, and the long-term investments we have made in more than thirty countries, I think we’re definitely on track to reach close to a billion and a half people with our programs by 2016 or 2017.

I also think that we’ve been making the whole notion of public-private partnerships much more acceptable within the nutrition sector. We’ve taken great pains to incentivize, facilitate and support these, and also to demonstrate their benefits to the wider nutrition and donor community. This again is another area where we’re still learning.

S&L: What has been the impact of the global economic crisis which started in 2008, and of the accompanying rises in food prices?

MVA: When prices go up, individuals have less choice regarding what they eat. So while the poor may already have little diversity in their diet, as prices go up, they become increasingly dependent on a few staple products like maize or rice as their only source of food, and they consume more limited amounts. This of course impacts negatively on their nutritional status. It’s no surprise, therefore, that we have witnessed a rise in the incidence of micronutrient deficiencies, stunting and wasting as a direct result of the global economic crisis.

The pattern has not been uniform worldwide, however. In many of the nations that we think of as “developing countries” with a high burden of undernutrition, we are also seeing rapid economic growth. So you have a strange situation whereby levels of obesity are exploding in certain countries that also have the highest levels of stunting – India, for instance. This double burden is widespread in both South Asia and Sub-Saharan Africa, where malnutrition is rife but some groups are enjoying a quite rapid rise in incomes.

Looking at the economic crisis from our own perspective, it has of course limited the potential donor money available to us for our work. The importance of nutrition is being appreciated more keenly due to a new awareness of the topic of food security, but funds for food security have been limited, and funds for nutrition even more so.

S&L: You were interviewed in our Day in the Life feature in issue 2/2009. What have been the major developments within GAIN in the intervening three years?

MVA: Firstly, we have set a new strategic vision for the organization, and have developed a strategy for the next five years. We have begun to shift our focus more aggressively in high-burden countries, where we are trying to layer a number of our programs together, focusing on the same target populations. If you’re trying to address malnutrition, you have to turn a number of keys at the same time to demonstrate the impact that’s being made on the lives of women and children. We’re trying to focus on a growing number of interventions that reach the same target populations, and which, combined, will help to reduce levels of malnutrition.

The second big shift has been expanding our portfolio around the 1,000 days effort. We have had programs dedicated to maternal, infant and young child nutrition in about a dozen countries, and we’re looking to expand that investment even further. Programs of this type tend to be more expensive than our fortification programs and also more difficult. Another major change has been to focus more on the links between agriculture and nutrition, which involves improving nutritional outcomes along agricultural value chains. We’re additionally investing more in the creation of enabling environments that will create the conditions for successful program implementation. Whereas GAIN was initially very grant-orientated, we’re now looking at a range of financing mechanisms, some of which are very innovative and involve new financial partners. We’re also examining other enablers. For example, some 3–4 years ago we created a facility to procure premixes globally for micronutrient powders, which play a crucial role in the delivery of our programs. Last year, the facility provided approximately 170 million people with high-quality, certified, and affordable vitamins and minerals. This is a great advance, as previously the cost and quality of the micronutrients we were supplying varied greatly from country to country. We’re also focusing much more attention now on understanding...
the regulatory environment worldwide, and how it can influence the nutrition agenda in high-burden countries.

“We have significantly expanded our technical capabilities”

Besides this, we have developed greatly ourselves as an organization. GAIN began as a very small Secretariat within the United Nations. After some time, we moved outside the UN to have more flexibility. Switzerland kindly gave us International Organization status, which has been very helpful, but we soon realized that we needed to expand our organizational platform beyond our Geneva headquarters in order to achieve our objectives. Today we have close to 15 offices worldwide, with approximately 120 employees and 200 consultants. This numerical expansion has been accompanied by a significant expansion of our technical capabilities, which is vital for running the kind of highly complex programs in which we are involved. The results of this growth are clear: whereas our work touched the lives of 400 million in 2009, it now helps over 600 million people worldwide, and that figure continues to grow.

S&L: You were speaking recently at the Rio+20 Summit on Transformational Partnerships. What do you mean by “Transformational Partnerships”?

MVA: There are several different types of partnership in the nutrition space. One of them is the national multi-stakeholder partnership model that has driven large-scale interventions such as staple food fortification. Then there is the sectoral partnership – for example, our current work with UNICEF to promote the iodization of salt in 13 of the make-or-break countries. We have a number of players working together at present to support salt iodization with the object of increasing coverage to 90 per cent. The third kind of partnership is with a company in the private sector. Britannia in India is a good example. They are one of the biggest biscuit makers in that country, and are now fortifying approximately half of the biscuits they sell. These then reach all the way down the pyramid in India. Partnerships become transformational when ownership for them is taken locally and they become self-supporting. They are no longer GAIN programs, that is to say, and have their own momentum.

S&L: The SUN (Scaling Up Nutrition) movement has attracted a lot of attention over the past couple of years. What difference does it make to the work of GAIN?

MVA: It’s been a very positive development for the nutrition movement, and has addressed some of the barriers which in the past prevented the nutritional sector from moving forward. It’s brought everyone into one tent, so to speak. Nutrition has now been firmly embedded together with food security on the global agenda. There’s been some excellent leadership from David Nabarro and Tony Lake. When GAIN talks to its partners – whether these be developing country governments or donors – they’re better informed now about nutrition because of the SUN process. At the country level we’re seeing some very positive engagement. Some 30 countries have identified the SUN movement and process as critical, and are coming up with appropriate strategies and plans. There are a lot of obstacles still, and more focus on prioritization and delivery is required, but on the whole, I think the work of SUN to date has been very positive.

“We will continue to show how the partnership model can deliver improved nutrition”

S&L: You mentioned that GAIN is aiming to reach that target of 1 billion people relatively soon, but what are the main strategic areas of focus for the next five years?

MVA: One of our big priorities will be shifting the dial on key nutritional indicators such as micronutrient deficiency, stunting, wasting and underweight in our priority countries. Another will be showcasing many of the models that we have developed and encouraging other organizations to adopt them. And we will certainly continue to be an enabler, trying to show how the partnership model can help deliver improved nutrition for millions of people worldwide. GAIN wants to make markets work for the poor, so as to give the poor sustainable access to nutritional products at affordable prices. Getting across the notion that the poor have a right to a nutritious diet will remain central to what we do in the future.

S&L: Thank you, and good luck to you and your colleagues around the world for the next decade!

MVA: Thank you.

Marc Van Ameringen was interviewed by Jonathan Steffen
GAIN at a Glance

GAIN has a mission to reduce malnutrition through sustainable market-based strategies aimed at improving the health and nutrition of populations at risk. Created at a Special Session of the UN General Assembly on Children in 2002, GAIN supports public-private partnerships to increase access to the missing nutrients in diets necessary for people, communities and economies to be stronger and healthier. GAIN’s goal is to reach 1.5 billion people with fortified foods that have sustainable nutritional impact.

In a joint letter in the GAIN 2010–2011 Annual Report, Chairman Jay Naidoo and Executive Director Marc Van Ameringen write: “GAIN defines platforms as innovative alliances of public and private partners. Through these platforms, we seek game-changing, long-term impact, and aim to ensure that trend lines for nutrition improve by making markets work for the poor. These alliances aspire to deliver nutritional impact at scale by encouraging innovation and policy environments that successfully enable change.”

Major initiatives and projects
GAIN operates on both national and global levels, working on a wide range of nutrition-related initiatives in alliance with public and private partners. Some major recent projects include:

**Global**
- With partners, established the **1,000 Days** partnership, promoting investment in early childhood nutrition
- Initiated **Future Fortified**, a global movement promoting nutrition for millions of women and children
- Supporting the development of the **Access to Nutrition Index**, a global benchmark for food and beverage companies
- Support for the **Amsterdam Initiative against Malnutrition (AIM)** milk fortification project in Kenya

**The Story So Far**
In less than a decade, GAIN has:
- invested in and worked alongside more than 600 companies;
- operated in more than 30 countries;
- reached over 610 million people with nutritionally enhanced food products.

**GAIN’s Key Progress Highlights for 2010–11**
- 610 million individuals consuming more nutritious foods
- More than 290 million women and children reached (half of GAIN’s beneficiaries are women and children.)
- A better start in life for 4.3 million infants through targeted nutrition programs
- 30+ countries benefit from GAIN support
- US$ 0.29: cost to reach each individual across all GAIN projects

**GAIN around the globe**
GAIN’s global presence includes headquarters in Geneva, an office in Washington D.C. and regional and country representatives in New Delhi, Johannesburg, Nairobi, Kabul, Abuja, Dhaka and Amsterdam.

**Funding and partners**
GAIN has received funding from a number of public and private sector donors including: the Bill and Melinda Gates Foundation, the Canadian International Development Agency (CIDA), the Children’s Investment Fund Foundation (CIFF), the Department for International Development (DFID), Dubai Cares, the Goldsmith Foundation, the Government of the Netherlands, Irish Aid, the Khalifa Bin Zayed Al Nahyan Foundation (KZNF), the United States Agency for International Development (USAID), the Welcome Trust and the World Bank.

Source: www.gainhealth.org
Coming in our next issue: The New Micronutrient Forum (MN Forum)

In late 2011, the MN Forum was revitalized by a group of organizations and individuals with a common interest in improving the nutritional status of populations and strengthening our ability to prevent micronutrient malnutrition. There was agreement among many of those involved in the prevention and control of micronutrient deficiencies that the absence of the MNF had left a technical and programmatic void. We will report on the new MN Forum in our 3/2012 issue.
When asked to evaluate how the world might prioritize the spending of $75 billion (US), a panel of leading economists has named the fight against malnutrition as the key priority.

The eminent Copenhagen Consensus 2012 Expert Panel, which includes four Nobel Laureates, has adjudged that fighting malnourishment should be the top priority for policy-makers and philanthropists. This year-long project (the third of its kind, and which involves more than 65 researchers) culminated in the identification of “bundled interventions to reduce malnutrition in pre-schoolers” as the smartest way to allocate money in response to 10 of the world’s biggest challenges.

According to the Copenhagen Consensus Center (CCC), for just $100 per child, interventions including micronutrient provision, complementary foods, treatments for worms and diarrheal diseases, and behavior change programs, could reduce chronic undernutrition by 36% in developing countries.

The number one solution

Given the budget restraints, the Copenhagen Consensus 2012 Expert Panel found 16 areas worthy of investment. Of these, fighting malnutrition and, in particular, micronutrient fortification, came out at number one. This echoes the findings of the Copenhagen Consensus 2008, which pinpointed micronutrient supplements for children (vitamin A and zinc) as the number one solution.

Other key investments ranged from expansion of the subsidy for malaria combination treatment through investing in early...
warning systems to protect populations against natural disaster to hepatitis B immunization. According to Lomborg, this Nobel Laureates’ list clearly sets out future strategies for policy-makers and philanthropists.

“Solving the problems of diarrhea, worms and malnutrition will do good for more of the world’s poor than other more grandiose interventions,” Lomborg said. “That is the conclusion of some of the world’s brightest minds. If the world’s policymakers and humanitarian charities were to reorient their priorities around adopting these and other smart solutions, the world would be a better place.”

Fighting malnutrition
The CCC recommends that expenditure on fighting malnutrition should surpass $3 million per annum, noting that “each dollar spent reducing chronic undernutrition has a more than $30 payoff.”

In its 2012 statement, it notes that more than 100 million children start their lives with inadequate nutrition, which impairs their mental abilities and causes physical defects. To provide both short- and long-term benefits, the CCC says that this sum of money would provide micronutrients, complementary foods, treatments for worms and diarrheal diseases, and behavior change programs. According to the CCC statement 2012, “This would reduce chronic undernutrition by 36 per cent in developing countries. It would also improve cognitive functions, increase learning and in adulthood increase incomes.”

Source: www.copenhagenconsensus.com

About The Copenhagen Consensus Center
The Copenhagen Consensus Center (CCC) is a think-tank in Denmark that publicizes the best ways for governments and philanthropists to spend aid and development money. Established at the Copenhagen Business School in 2006, it commissions and conducts new research and analysis into competing spending priorities. In addition, it works with international organizations and policy-makers to develop projects of national and international concern.

Cost-efficient solutions
In particular, the CCC focuses on the international community’s effort to solve the world’s biggest challenges, and on how to do this in the most cost-efficient manner. Working with governments, NGOs and multilateral organizations on projects around the world, it creates a framework in which solutions are prioritized explicitly with the goal of achieving the most good for people and the planet.

The Copenhagen Consensus approach originated in late 2002, as a small group of people headed by Bjørn Lomborg, then Director of the Danish Environmental Assessment Institute. During 2003, an outline for a global conference was created. In May 2004, its first conference took place, bringing together eight of the world’s leading economists, including four Nobel Laureates and 30 of the world’s top specialists within 10 problem areas.

Combating micronutrient deficiencies
Among other events, in 2009 the Copenhagen Consensus Center worked on the Denmark Consensus, the Copenhagen Consensus on Climate, and malnutrition conferences in New York and Nairobi, at which new research was released on ways to effectively combat micronutrient deficiencies.

Source: www.copenhagenconsensus.com
In-Home Fortification with Micronutrient Powders

An update on evidence and safety

Sight and Life
Basel, Switzerland

Key messages

01. Micronutrient deficiencies are still widespread and the use of micronutrient powders (MNP) is a promising approach to fighting them.

02. MNP are efficacious at improving iron status, while evidence for their effect on the status of other micronutrients, as well as functional outcomes such as growth and cognitive development, is only starting to emerge.

03. The improvement of zinc bioavailability has not been studied much and low absorption might be one reason for a lack of consistent effect of MNP on zinc status.

04. Acceptability of, and compliance with, MNP tend to be high, especially if flexible administration regimes are applied.

05. Commercial schemes for the distribution of MNP need to be further explored to allow for sustainable large-scale interventions.

Introduction

Deficiencies of micronutrients are still widespread in developing countries and infants and children are among the groups most at risk due to their increased needs for growth and development. A promising approach to improving micronutrient status is the use of micronutrient powders (MNP) containing various micronutrients. The powders are generally packaged in single-dose sachets of one gram, and are added to foods prepared in the household just before consumption. One sachet normally contains the amount that is needed in a healthy diet for one day or slightly less.¹

In 2007, the use of MNP, particularly in emergency situations, was endorsed by the WHO, WFP, and UNICEF in a joint statement, as an effective way of improving the micronutrient status of nutritionally vulnerable population groups, such as children < 5 years of age and pregnant and lactating women.² In August 2011, WHO published a guideline on the use of MNP for home fortification of foods consumed by infants and children aged 6 to 23 months.³ The report concluded that home fortification of foods with MNP containing at least iron, vitamin A and zinc was recommended to improve iron status and reduce anemia among infants and children aged 6 to 23 months.

“In August 2011 a WHO report recommended home fortification of foods with MNP to improve iron status and reduce anemia among infants and young children”

Evidence that MNP can reduce iron deficiency

Numerous studies have tested MNP in regard to iron, primarily among young children, and showed that MNP is efficacious in the treatment and prevention of iron deficiency anemia.⁴ The effectiveness of MNP in large-scale programs has been demonstrated in various settings in developing countries as reviewed by Rah et al,⁵ for refugee camps⁶ and in emergency situations in Indonesia and Bangladesh. The results of a recent review on home fortification of complementary foods indicate that MNP were as effective for treating anemia and iron deficiency as iron drops at comparable doses.⁹

Evidence that MNP can reduce zinc deficiency

While there is sound evidence for the beneficial effect of MNP on the prevalence of anemia and iron deficiency, their impact on other nutrients is still limited and inconsistent. In one study, adding zinc to iron-containing MNP did not have a significant effect on mean plasma zinc, but it resulted in a lower prevalence of low plasma zinc.¹¹ In another study in which around half of the
Micronutrient powders have much to offer in the fight against micronutrient deficiencies.

infants had low plasma zinc at the beginning of the study, home fortification products containing zinc had no significant effect on mean plasma zinc concentration or the percentage of infants with low plasma zinc. These inconsistencies or negative results are partially due to the lack of a reliable biomarker for zinc status. While serum zinc is useful for populations, it is less reliable to assess an individual’s response to an intervention with zinc, as it is strongly affected by other factors. (See also David Thurnham’s paper in this issue for further information regarding plasma zinc as a biomarker of zinc status.)

Based on studies using iron and zinc combined in cereal fortification, it has been suggested that iron prevented or diminished a beneficial response on zinc status. However, a comprehensive review of the subject concluded that there is no strong evidence to discourage joint supplementation. Studies using milk-based products fortified with both iron and zinc did find increased serum zinc levels, indicating that inhibitors such as phytate rather than iron are responsible for the lack of response. Absorption studies showed that reducing the amount of phytate significantly improved zinc absorption. Phytate in the food is known to reduce mineral bioavailability and its reduction improves iron and zinc absorption.

Bioavailability of a mineral is defined as the proportion of ingested mineral which is absorbed and utilized. For iron, this has been addressed by using more bioavailable forms such as NaFeEDTA or by the addition of ascorbic acid, which mitigates the negative impact of phytate on iron absorption. Improving zinc bioavailability has not been in the focus of most MNP and this might be part of the reason that there is no conclusive evidence for MNP to improve zinc status. A study that used an MNP containing a microbial phytase capable of degrading phytate during stomach transit time did find a reduction in the prevalence of zinc deficiency in school-aged children.

Evidence for other outcomes

The two studies assessing the effect on vitamin A included in a recent meta-analysis did not find a significant effect of MNP on serum retinol levels in infants compared to a placebo.
Moreover, only limited data is available on the impact of nutrients other than iron. These effects should be further explored, using functional outcomes such as physical and cognitive development, or morbidity combined with more direct biomarkers of micronutrient status. Ideally, a systematic assessment of interventions with multiple MNP, as part of a national infant and young child feeding program, should be implemented. Evidence collected from large-scale programs in refugee and emergency settings indicates a positive effect of MNP on stunting. But, in most previous research, there was no positive effect on linear growth.

Acceptability of MNP and compliance

Adherence to the standard treatment for anemia using ferrous sulfate drops was often poor, likely due to the disagreeable side effects associated with these drops. They include an unpleasant metallic taste in the mouth, teeth staining and abdominal discomfort. A recent review found that the acceptability of MNP was generally high, and that compliance was in the range of 32% to 90%. The percentages of mothers who reported no problems using home fortification products or who liked using them have mostly been >90%. In a study in rural Ghana, using microencapsulated iron in MNP, only 16% of the mothers in the MNP group reported problems with giving their children the supplement, compared to 74% of mothers in the group who received the ferrous sulfate drops. The mothers did not perceive that the MNP changed the color or texture of the food to which it was added. In another study in Ghana, 95–99% of the caregivers in the MNP groups reported the sachets were easy to use, compared with 82% in the drops group. In a study in rural Bangladesh which used an MNP containing five micronutrients including iron, 85–90% of mothers reported that their children’s appetites had increased from the pre-intervention period. This was also reported in a study in Nigeria as a positive effect, while a minority of mothers were worried about how they would provide the additional food that was consequently needed. A study in western Kenya confirmed that an increased appetite was indeed regarded as a positive development that did not hamper the use of MNP.

Some studies indicate the benefits of intermittent or flexible administration of the MNP on adherence, without affecting effectiveness. In a recent study in rural Bangladesh, children aged six to 24 months received 60 sachets of a microencapsulated-iron-containing MNP, either daily over two months, flexibly over three months or flexibly over four months. Within a flexible regimen, mothers decided how frequently to use the MNP, without exceeding one sachet per day. Albeit generally high, mean adherence was significantly higher in the flexible-four-month group compared to the flexible-three-month and daily-two-month groups. No mother reported giving more than one sachet a day to her child. Such schemes need to be further explored.

Safety of MNP

Acute iron poisoning is a well-known potential risk of iron syrups if a child accidentally consumes a very high dose. According to a systematic review carried out in 2009, this is highly unlikely with MNP as the powder is packaged in single-dose sachets and does not have an appealing taste. The side effects encountered were rare and mild and consisted mainly of diarrhea, affecting 10–15% of children receiving MNP, which is similar to what was found with drops. In a study performed in a Chinese kindergarten, no side effects such as the staining of teeth, a metallic taste or a stomach upset were reported following supplementation with an iron-containing MNP. Direct observations by research staff suggested that children did not comment on any change in the taste of the food with which the MNP was served, and accepted it well. In a study in Ghana, rates for the darkening of stools and episodes of diarrhea were similar for children receiving the MNP and those receiving iron drops. Fewer caregivers reported staining of children’s teeth in the MNP groups than in the drops group.

A study in India of infants aged six to 18 months showed that diarrhea, vomiting and staining of teeth were significantly higher with drops than with MNP. In a study performed in rural Haiti, using a five-micronutrient MNP, diarrhea was slightly more prevalent among the supplemented group compared with the control group during the first month of MNP distribution, but not thereafter. This initial occurrence was also reported in a study in western Kenya, where mothers felt that the slight side effects at the beginning, as well as the darkened stool, were far outweighed by the positive effects on appetite, activity levels and perceived weight gain – especially as they had been informed of such side effects beforehand. The authors of a meta-analysis concluded that the lack of adverse effects on morbidity in all of the studies reviewed was somewhat reassuring, although the sample sizes in these trials were generally not large enough to detect increases in occurrence of severe morbidity.

MNP and malaria

When a large-scale study in Pemba in 2006 showed that iron and folic acid supplementation increased morbidity and mortality in malarial areas, a discussion on how to address iron deficiency safely in these areas was prompted. A WHO Consultation concluded that, at the time, insufficient evidence was available to assess the safety of home fortification in malarial areas, whereas food fortification programs were regarded as safe. In the meantime, a review that included several studies conducted in high malaria transmission areas stated that no adverse effects were noted following the administration of iron-
containing MNP, but also that these studies were not powered to detect such outcomes.9 Due to the scarcity of evidence, the recent WHO Guidelines on MNP still recommend using MNP in malarial areas in combination with “measures to prevent, diagnose and treat malaria.”3

Non-transferrin-bound iron (NTBI), thought to be generated by bolus iron doses, potentially increases the sequestration of the malaria-infected red blood cells in the small blood vessels of the intestine and other tissues.35 If the intestinal barrier is breached, pathogens can enter the blood stream, which can cause blood poisoning. Moreover, recently published results indicate that unabsorbed fortification iron modifies the colonic microflora in African children toward a potentially more pathogenic profile.36 A recent study showed that a low dose of 6 mg of iron as ferrous sulfate administered with food did not lead to the generation of NTBI.35 Therefore, an MNP mix designed for malaria endemic areas contains a low dose of highly bioavailable iron.36 Reducing the iron dose while increasing bioavailability leads to a reduction in unabsorbed iron, but can still provide sufficient iron to correct low iron status.30,37 Its safety in areas where malaria is endemic is currently being tested in infants in rural Kenya (M Zimmermann, personal communication).

Scaling up MNP programs
In most of the initial studies on MNP, the powders were provided for free to the caregivers, and the cost of MNP in usual circumstances was perceived by some mothers as a potential barrier to their widespread use.25 As large-scale programs which hand MNP out for free are not sustainable, a number of recent studies have investigated the potential of market-based approaches to MNP distribution as an intervention to reduce micronutrient deficiencies. One study found that special foods for small children and preventive health products were habitually bought in the assessed communities in Niger, and that 98% reported that they would buy MNP at a price of US$ 0.03.26 When assessing the effectiveness of MNP sold in communities in western Kenya, it was found that even the infrequent use observed had a beneficial effect on hemoglobin levels and reduced iron and vitamin A deficiency.38

“In Western Kenya, even the infrequent use of MNP was observed to have a beneficial effect”

Conclusion
MNP – even at low dose of highly bioavailable iron – have been shown to be an efficient approach to improve iron status in infants and young children. However, more studies need to assess their effect on other micronutrient deficiencies, and ways to optimize their bioavailability need to be explored. Given the phytase’s potential to degrade phytate in plant-based diets, its impact on the uptake of minerals such as zinc, calcium, magnesium and phosphorus should be further evaluated. Moreover, more research on MNP specifically formulated for malarial areas is warranted. Last but not least, commercial schemes for the distribution of MNP need to be established to achieve a significant improvement in the availability of MNP, and as such in the health and development of children.

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The annual Carotenoid Research Interest Group (CARIG) conference was held in the Bayfront Hilton Hotel in San Diego, chaired by Dr Liz Johnson. As has been customary over the past 11 years, the keynote speech was the James Allen Olson Perspectives on Carotenoids Memorial Lecture. Dr Sherry Tanumihardjo of the University of Wisconsin-Madison, who worked for over 20 years with Prof Olson at Iowa State University, was the distinguished lecturer for the 11th Perspectives. Her topic was “Xanthophylls as Provitamin A Carotenoids,” which took in the biological considerations currently directed at disease prevention, as well as the context of nutritional adequacy of vitamin A in developing countries. The speech ran the gamut, from the bio-pathways for the production of β-cryptoxanthin as a neglected provitamin A, to its importance in high-carotenoid maize varieties for vitamin A interventions in Africa. The full lecture can be read on pp 48–55 of this issue of Sight and Life Magazine.

Four additional talks filled out the conference theme of “Xanthophylls: Dietary Sources and Impact Through the Life Cycle” for the remainder of the session’s program. B Randy Hammond Jr, of the Visual Science Laboratory of the University of Georgia-Athens, started off with a talk entitled “Xanthophylls and eye development.” He began with the chicken and the egg, demonstrating that the ability to absorb xanthophylls in poultry is related to their accumulation in the yolk sac before hatching. Dr Hammond also cited literature on the supplementation of broiler chicken diets with canthaxanthin, and the positive effects of this on the health and fecundity of the birds. This suggests benefits from exposure to xanthophylls in avian settings.

Human xanthophyll concentration

Transitioning to humans, the concentration of xanthophylls is highest in prostatic tissue in men and ovarian tissue in women; the latter is epitomized by the corpus luteum (yellow body), which is left in the ovary after ovulation. This illustrates specificity in distribution of xanthophylls. There are 50 different such compounds in the human diet, but only 20 carotenoids are found in the human serum. Interestingly, moreover, only lutein and zeaxanthin are found in the eye, at concentrations 500 to 1,000-fold higher than in the bloodstream. These same two carotenoids are found in the higher central nervous system.

Within the eye, these xanthophylls are concentrated in the macula (fovea) of the retina. They are variable in normal people and can be augmented with oral supplementation. In human development, these xanthophylls are highest in the vitreal space of the fetal eye at six weeks, but are redistributed to the lens and the retina by 20 weeks of gestation. During pregnancy, the concentration of these oxy-carotenoids rises with advancing trimesters, and it is the highest fraction of the carotenoids family in cord blood at birth. Lutein in cord blood correlates with its concentration in the maternal circulation. The combined blood levels of lutein and zeaxanthin double from the first to the second year.

In postnatal life, in colostrum lutein is in very high concentration among the carotenoids, falling by half in mature maternal milk. At one month of life, the lutein plasma levels in infants fed regular infant formula are one fourth those of breastfed ones. The lutein in milk tracks that in the circulation of the lactating mother. However, a lutein-supplemented formula can produce comparable levels to natural lactation, al-
though the efficiency of uptake is superior from maternal milk compared to supplemented formula.

“Increased antioxidant capacity and decreased inflammation with lutein supplementation is demonstrated in several animal models”

Dr Hammond outlined an array of xanthophylls’ functions important to early life and development (Table 1). Increased antioxidant capacity and decreased inflammation with lutein supplementation is demonstrated in several animal models. Recently, it has been shown that supplementation increases antioxidant capacity in infants as well. Pretreatment with lutein reduces inflammation in an animal model of inflammatory challenge.

Simple physiochemical principles dictate that yellow pigments, such as xanthophylls, absorb the blue spectrum of visible light, which can be damaging to tissues. But, from the external crystalline lens to the macula or the retina to synaptic connections in the visual cortex of the brain, there is rapid development and maturation in early life and through childhood. Xanthophylls condition the transmission and reflection of light and effect the interaction with light damage at the aforementioned levels of the visual system. Supplementation of preterm infants with a xanthophyll-rich formula improved visual receptor function.

The evidence trail (Table 1) was therefore followed throughout. A final concern relating to children is the accelerating obesity epidemic. Circulating carotenoid levels are inversely
related to body adiposity, and overweight and obese children may sequester xanthophylls and limit their distribution to functional sites.

**Xanthophylls in the infant brain**

Rohini Vishwanathan mobilized an impressive amount of inferential, as well as direct, evidence to discuss the theme of “Xanthophylls in the infant brain.” The essential argument was a two-stage syllogism:

1. That the xanthophylls dominate in the brain and are related to cerebral function; and
2. That xanthophylls dominate, particularly in early life.

“Cerebral lutein may be a correlate of the high central nervous functions of vision and cognition”

This inductive journey began at the other extreme of the life-span, with an illustration of retinal lutein and zeaxanthin’s relationship with macular degeneration and the differentiation of the pattern of circulating carotenoids (dominated by β-carotene) and of cerebral carotenoids (dominated by lutein), with the material coming from federally run brain tissue banks. Functional associations were demonstrated for the elderly in macular xanthophyll density and resistance to degenerative ocular disease, and cerebral xanthophyll levels and slower rates of cognitive decline. Finally, evidence from non-human primates was shown, suggesting that brain xanthophyll concentrations correlated with macular lutein and zeaxanthin. From this tour of evidence, it was concluded that cerebral lutein may be a correlate of the high central nervous functions of vision and cognition.

The second departure of Dr Vishwanathan related more directly to the theme of the presentation: circulating levels of lutein plus zeaxanthin transition from 0.9 to 1.8 μmol/L over the first month of life. Approximately 27% of the carotenoids in human milk are constituted by lutein. Concentrations of the two xanthophylls increased in milk over time of lactation, whereas carotenes are stable. There is evidence for the active transport of lutein into the mammary gland. Later in early childhood, average daily lutein and zeaxanthin intakes vary with age beginning at around 60 and 300 μg, respectively from one to three years of age, and rising to above 100 and 1,000 μg respectively in adulthood.

“Lutein may be important in early neural development”

Postmortem cerebral material from 30 infants (with an average age of 113 days) who died from SIDS and other acute illnesses was obtained from tissue banks and analyzed for carotenoid content. Lutein was the most abundant carotenoid, at 50 pmol/g and without variation across regions of the brain. Zeaxanthin, β-cryptoxanthin, β-carotene and lycopene were all below 15 pmol/g, on average. No β-carotene was detected in infant brains. The only carotenoid that varied significantly with age, within infancy, was β-carotene, which doubled in concentration after four months of age. The auditory cortex had higher concentrations of zeaxanthin than the prefrontal cortex and higher content of β-carotene than in the hippocampus. Finally, if we compare the pattern of average dietary carotenoids intake from two to 11 months, using National Health and Nutrition Examination Survey (NHANES) data, with the concentrations of the respective carotenoids in the brain, we find abundant evidence for selectivity: Lutein constitutes 12% of dietary carotenoids and 60% of brain content. Dr Vishwanathan tentatively concluded that lutein may be important in early neural development, and called for further investigation in that regard.

**Maize breeding**

Maize is a staple crop in many parts of the world. Originally a New World crop, corn was imported into Africa to improve the efficiency of the slave trade, and has become a staple crop in west and southern Africa. As discussed in the Olson Memorial lecture, plant breeding can produce a variety of maize presentation determined by the content of xanthophyllic and carotene carotenoids. To the detriment of vitamin A nutrition, which is precarious across the continent, the major preference is for white maize. Across the world, yellow corn is often associated with animal fodder and rejected for human consumption. Of course, since maize has been bred to be white, the acceptability...
of deeply hued corn as a population staple is uncharted territory. This connects directly to the presentation entitled “Breeding for enhanced carotenoid profiles” by Dr Torbert Rocheford of Purdue University, exploring research to understand the genetic bases of the cross-breeding of maize for greater expression of provitamin A carotenoids, which can be sources of active vitamin A.

The diverse array of colors among different varieties of maize is a product of the expression and hierarchy of expression of various enzymes of the carotenoid pathways. The biosynthetic pathways of carotenoids are well understood. What the group has done, with the help of funding from HarvestPlus, is to understand the genetic basis of the natural variation of the traits determining carotenoids, with a specific focus on maximizing β-carotene, and other provitamin A carotenoids (Figure 1). The author demonstrated a kind of genetic mapping for maize varieties, which can be performed with high performance liquid chromatography (HPLC) analysis, genetic polymorphism assessment and gene sequencing. In this way, the investigation can determine the association of the phenotypic trait (color) and the genetic make-up of the corn plant. Then, with inbreeding and intensification of the trait, the relationship with the genetic constitution can be assessed. This approach proved valid for selecting genotypes that stream more of the carotenoid pathways into the provitamin A (β-carotene) expression.

In practice, one does not need the expensive and cumbersome procedures of HPLC to determine the β-carotene content. A simple visible inspection and color chart will allow farmers to identify the varieties richer in provitamin A from hybridization for preferential selection in cultivation. It is inexpensive, easy and low-tech, but it is now confirmed in its validity by the association with the determinant synthetic enzymes.

Food composition data

Dr Joanne Holden of the Nutrient Data Laboratory (NDL) of the United States Department of Agriculture at the Beltsville Human Nutrition Research Center wrapped up the day’s session with an update on food composition data for carotenoid content in foods and beverages. She defined her objectives as threefold:

1. To present the history of carotenoid databases in NDL;
2. To discuss the status of efforts to expand carotenoid data for foods; and
3. To feature data for lutein and for zeaxanthin.

“The impetus behind creating carotenoid databases began in 1983, when it was considered imperative to go beyond “total carotenoids””

With respect to the first objective, the impetus behind creating carotenoid databases began in 1983, when it was considered imperative to go beyond “total carotenoids” and to specify individual carotenoids. Ten years later, a provisional database with five carotenoids in 206 foods was released. Pressure from the ongoing NHANES process pushed the process forward, to the extent that, in 2012, the National Diet Library (NDL) provides information on the carotenoid content of 3,000 foods.

The method is based on a five-step process: Acquisition of data sources; evaluation of data quality; aggregation of acceptable values; compilation and calculations; and, finally, dissemination of the database. The data sources include the literature, food industry data, label information and various specific public and private sources. These are churned through a central database before going into the Standard Reference, and finally on to the Food and Nutrition Database for Dietary Surveys (FNDDS). The National Food and Nutrient Analysis Program (NFNAP) provides a steering element for this process, overseeing various areas including identifying key foods and critical nutrients of interest, evaluating existing data quality, devising and implementing a nationally based sampling plan, analyzing sampled foods and the validity of the analytical methods, and making representative estimations. In terms of lutein and zeaxanthin, there have admittedly been relatively few recent and ongoing new analyses.
Not all values are analyzed. In the entire database for lutein/zeaxanthin, only 8.6% are analyzed values. Some 48.3% is calculated data, and the remaining 42.8% material is assumed to be negligible. Green leafy vegetables, spinach and kale, have the highest specific values. Broccoli, pistachio nuts, and raw egg yolks are other foods with high lutein levels, whereas three forms of maize (popcorn, boiled sweet corn and tortilla chips) and raw egg yolks have the highest levels of zeaxanthin. Levels of both xanthophylls are negligible in sweet potato and cauliflower.

Poster winners

There were three winners in the poster competition for graduate students and post-doctoral fellows in the evening’s CARIG/VARIG Reception Social. Rohini Vishwanathan of Tufts University was given an award for her poster “Relationship between brain lutein (L) and zeaxanthin (Z) and retinal L and Z in humans.” Amy Elsen of the University of Illinois-Champaign/Urbana won with her presentation “Genotypic differences impact serum and hepatic lipids in mice lacking carotenoid cleavage enzymes.” Finally, Tristan Lipkie of Purdue University shared the competition prize on the basis of her work “Effect of lactation stage on the content and bioaccessibility of carotenoids in human milk.”

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Promoting partnerships and capacity building.
Laing Sokne, 32, and her husband live in Sompong Village, Kantaout commune, some 32 kilometers from the provincial town of Kratie, Cambodia. She and her husband plant cassava in a 0.15 hectare rented farm lot for their livelihood. They have one child named Phorm Sela, aged one year and two months.

When the Health Center (HC) staff and Village Health Volunteers (VHV) conducted a nutrition screening of all children in Sompong Village, Laing Sokne’s daughter, Phorm Sela, fell with-

in the moderately acute malnourished (MAM) category, based on the mid-upper arm circumference (MUAC) measurement. The VHV and HC staff told her that, since her child was malnourished, she and her child were to be the direct beneficiaries of a new project. She needed to attend the orientation meeting scheduled for the following week, together with other mothers of malnourished children in the village.

In the meeting, the staff from Kratie Provincial Health Department discussed the nutritional status of the children and the effects of malnutrition. Participants were informed about the activities involved in the project and the expected results. Mothers were then asked if they were willing to give their full support to the project, and to commit to participating in it in order to improve the nutritional status of their children. All the mothers responded in the affirmative.

“The Nutrition for Children and Everyone project provided supplementary feeding 12 days a month over a three-month period”

Educating through participation

The Nutrition for Children and Everyone project, funded by Sight and Life and jointly implemented by the Provincial Health Department of Kratie Province, Cambodia and Voluntary Service Overseas (VSO), provided supplementary feeding 12 days a month for a period of three months. Multivitamins and anti-helminthic tablets were provided as well as, most importantly, education sessions on health and nutrition for mothers.

Feeding was carried out in the village. The meals consisted of low-cost but nutritious food, such as porridge, bean dessert...
with milk, or sardines with vegetables. Mothers helped with preparing vegetables, cooking, and washing the dishes, and they sometimes brought along leafy vegetables from their gardens. Having taken part in these activities, Laing Sokne said that she had learned how to improve the plain babor (porridge), a food commonly given to children. She made it more nutritious by adding either fish, eggs, meat, pumpkins, carrots, sweet potatoes or green leafy vegetables, and by using iodized salt instead of the table salt in common use. Laing Sokne added that she now appreciated the value of vegetables for the health and nutrition of her family members. She also learned about hand washing, which she practices at home – especially before eating – and said that she uses boiled water for drinking to prevent diarrhea.

Laing Sokne was able to increase the output of her vegetable garden with the seeds provided by the project. She grows morning glory, Chinese cabbage and other vegetables. “Having food readily available at home is a big saving in money and time,” she says.

She is very grateful for the project. Aside from all the knowledge she has gained, the nutritional status of her daughter has greatly improved: from 7.6 kilograms at the start of the project to 8.6 kilograms after three months. Her daughter has a consistently improved appetite and no longer feels unwell.

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Report from South Africa

Putting Smiles on Faces in Ivory Park, While Building Bridges to Better Nutrition

Jane Badham
*Sight and Life, Johannesburg, South Africa*

*Sight and Life* supports the Sedimosang daycare center in Ivory Park, one of the poorest townships between Johannesburg and Pretoria. We provide MixMe™, a micronutrient powder developed by DSM, which is added to the daily lunch meal received by some 100 local children, who come from very poor homes, or who are orphans. Recently, we were able to bring additional smiles to the children’s faces when we gave each of them brightly colored t-shirts bearing the new *Sight and Life* logo. In addition, we provide MixMe™ as part of the daily school feeding program at a nearby primary school, which feeds approximately 1,200 children each day. This school meal is often the first of the day for many of these children.

Not to forget the older generation, *Sight and Life* also provides a fortified biscuit to around 100 elderly people, who meet twice a week at a community hall to spend time together, receive assistance with their various needs from a dedicated team, and ensure that they get not only a cup of tea and a biscuit, but also a good meal.

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“Recently, we were able to bring additional smiles to the children’s faces when we gave each of them brightly colored t-shirts bearing the new *Sight and Life* logo”
A grandmother enjoying a fortified biscuit at the Community Center, which she visits twice a week.
At the May G8 Summit at Camp David in the US, African leaders committed to a New Alliance for Food Security and Nutrition as the next phase of their shared commitment to achieving global food security. A press release states that: “Our goals are to increase responsible domestic and foreign private investments in African agriculture, take innovations that can enhance agricultural productivity to scale, and reduce the risk borne by vulnerable economies and communities.

"The aim is to raise 50 million people out of poverty over the next 10 years"

This will be achieved by: aligning commitments to drive effective country plans and policies for food security; the commitments of private sector partners to increase investments where the conditions are right; and G8’s commitments to expanding Africa’s potential for rapid and sustainable agricultural growth. The good news is that nutrition is also included where specific mention is made of actions towards improving nutritional outcomes and the reduction of child stunting, such as:

- active support of the Scaling Up Nutrition (SUN) movement and a focus on the first 1,000 days;
- a pledge that the G8 members will maintain robust programs to further reduce child stunting;
- a commitment to improving tracking and disbursements for nutrition across sectors, and ensuring the coordination of nutrition activities across sectors;
- support of the accelerated release, adoption and consumption of bio-fortified crop varieties, crop diversification, and related technologies to improve the nutritional quality of food in Africa; and

US Secretary of State Hillary Clinton Highlights Nutrition in a Speech on Global Food Security

“The second topic I want to emphasize is nutrition. In recent years, we have learned that improving access to food does not automatically lead to improved nutrition. Neither does raising incomes nor creating new markets. What leads to improved nutrition is focusing on nutrition itself and integrating it into all our food security initiatives. Nutrition is just too important to be treated as an afterthought. Children’s entire lives are shaped by whether they receive enough of the right nutrients during those crucial 1,000 days from pregnancy to their second birthday. And this, in turn, heavily influences whether a country will have a healthy and educated workforce. So when we overlook nutrition, we set ourselves up for a less healthy, less productive, less prosperous future.”
development of a nutrition policy research agenda and support of the efforts of African institutions, civil society and private sector partners to establish regional nutritional learning centers.

Partnerships are key to the actions outlined. The Obama administration has drafted 45 of the world’s largest food and finance companies to invest more than US$3 billion in projects aimed at helping the world’s poorest farmers to grow enough food, not only to feed themselves and their families, but also to earn a livelihood. USAID administrator Rajiv Shah said: “We are never going to end hunger in Africa without private investment.” There have been some complaints from NGOs and African countries that money pledged in the past has not been spent as promised. Thus, the proof of this renewed and expanded commitment will be in the delivery of these promises.

To read more about the G8 Summit, go to: www.state.gov/e/eb/ecosum/2012g8/index.htm

The World Food Programme (WFP) asserted that “food” was not just one of the important areas. The WFP said: “We think hunger actually underpins the whole debate about sustainable development: We can’t achieve ‘the future we want,’ without first dealing with hunger.”

“For us, these are among the most important issues that need to be addressed if we are going to reach the Millennium Development Goals. The goal is to end child stunting, to end all forms of malnutrition, to end child hunger and to ensure that all children have a full and balanced diet. That is why we are calling for a Zero Hunger Challenge: all world leaders should commit to end hunger on the planet by 2025.”

Secretary-General of the United Nations Ban Ki-moon used the event to launch a “Zero Hunger Challenge,” which invites all countries to work for a future where every individual has adequate nutrition, and where all food systems are resilient.

The challenge has five main objectives: to achieve 100 percent access to adequate food all year round; to end malnutrition in pregnancy and early childhood – towards putting an end to childhood stunting; to make all food systems sustainable; to increase growth in the productivity and income of smallholders, particularly women; and to achieve a zero rate of food waste.

The sad reality is that many feel the Rio+20 outcomes failed to address urgent child health and poverty needs. While it is a step in the right direction, several decisive actions need to follow quickly, if the lives of millions are to change for the better.
Definition of Food and Nutrition Security

A Task Team under the Committee on World Food Security (CFS) is currently looking at setting a single definition of the term “food and nutrition security,” which best reflects the conceptual linkages between food security and nutrition security, while also expressing a single integrated development goal to help guide effective policy and programmatic action. The current definition to have been put forward is: “Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life.”

What do you think?
Share your thoughts on what you believe the best definition for food and nutrition security is, and/or how you believe we can ensure food and nutrition security for all into the future and/or how you or your organization are contributing to the Zero Hunger challenge.

Send an email to info@sightandlife.org and we will share your feedback in a future issue.

Nutrition in the Spotlight at the 65th World Health Assembly in Geneva

Every two years, nutrition gains a bigger share of the voice at the World Health Assembly (WHA). This year was no exception. Although a number of topics were discussed, including universal health coverage, mental disorders, Millennium Development Goals (MDGs), adolescent pregnancy and polio eradication, nutrition was also a central theme in both the discussions on non-communicable diseases (NCDs) and maternal, infant and young child health. The WHO Comprehensive Implementation plan for Maternal, Infant and Young Child Nutrition was adopted after much debate and intense negotiations. The plan includes six global nutrition targets:

> **Global target 1**: 40% reduction of the global number of children under five who are stunted by 2025

> **Global target 2**: 50% reduction of anemia in women of reproductive age by 2025

> **Global target 3**: 30% reduction of low birth weight by 2025

> **Global target 4**: No increase in childhood overweight by 2025

> **Global target 5**: Increase exclusive breastfeeding rates in the first six months up to at least 50% by 2025

> **Global target 6**: Reducing and maintaining childhood wasting to less than 5%.

The resolution that was passed also requested the Director General (who was appointed for another term of office) to provide clarification and guidance on the inappropriate promotion of foods for infants and young children. Integral to infant and young child health are both the promotion and protection of breastfeeding, and the use of appropriate and affordable complementary foods. The International Code for the Marketing of Breast-milk Substitutes, which should be regulated by Member States, goes a long way towards addressing the former. However, guidance is required regarding appropriate marketing of complementary foods and food supplements that have clearly been shown to have a role in optimal infant and young child feeding practices.

As the prevalence of the double burden of malnutrition rises, NCDs and a strategy to address them were stressed as...
being critical. The assembly adopted the global target of a 25% reduction in premature mortality from NCDs by 2025 (known as “25 by 25”). The discussion included Member States setting voluntary targets relating to raised blood pressure, tobacco, salt/sodium, physical inactivity, obesity, fat intake, alcohol, cholesterol, and health system responses, such as availability of essential medicines for NCDs.

Feedback on how the resolutions have been followed and implemented is to be provided at the 67th World Health Assembly in 2014.

To read the full resolution (WHA 65.6) on maternal, infant and young child nutrition, go to http://apps.who.int/gb/ebwha/pdf_files/WHA65/A65_R6-en.pdf

If you have not yet subscribed to the SCN Newsletter or their other publications, you are missing out! Visit http://www.unscn.org/en/publications/publications-mailing-lists/mailing-lists.php to sign up.

Now Available: Landscape Analysis Tool

The WHO has launched a tool package for Landscape Analysis Country Assessments. This aims to accelerate action in nutrition, and is a systematic approach to assessing where and how to best invest to accelerate action in nutrition. The in-depth country assessment provides a way to identify gaps, constraints, and opportunities for integrating new and existing effective actions in nutrition, using a participatory approach. The tool is comprehensive and provides all the guidance necessary for the preparation and implementation of a country assessment.

To date, 18 countries (Burkina Faso, Comoros, Ivory Coast, Egypt, Ethiopia, Ghana, Guatemala, Guinea, Indonesia, Madagascar, Mali, Mozambique, Namibia, Peru, South Africa, Sri Lanka, Tanzania, and Timor-Leste) have gone through the readiness assessment.

The Landscape Analysis Country Assessments tool can be downloaded from www.who.int/nutrition/publications/landscape_analysis_assessment_tools/en/index.html

Global Health Expert Jim Kim Becomes 12th President of the World Bank

In what many are calling an inspired move, Korean-born Jim Kim was appointed head of the World Bank on July 1, 2012. Before joining the World Bank, Kim was President of Dartmouth College in the USA. He previously headed up the WHO’s HIV department, where he was instrumental in creating and implementing the “3 by 5” initiative: to provide three million people living with HIV/AIDS in the developing world with antiretroviral therapy by 2005. Kim is a public health specialist, and trained as both a physician and an anthropologist.

In an editorial in The Lancet (Volume 380, Issue 9836) on Kim’s appointment, Jeffery Sachs, President of the Earth Institute, Columbia University, USA said: “Jim will be outstanding.
Global Alliance for Improved Nutrition (GAIN) Turns 10

The Global Alliance for Improved Nutrition (GAIN), an alliance driven by the vision of a world without malnutrition, celebrated its 10th birthday earlier this year. Created in 2002 at a Special Session of the UN General Assembly on Children, GAIN’s mission is to reduce malnutrition through sustainable market-based strategies aimed at improving the health and nutrition of populations at risk.

In a joint letter in the 2010–2011 GAIN Annual Report, Chairman Jay Naidoo and Executive Director Marc van Ameringen wrote: “GAIN defines platforms as innovative alliances of public and private partners. Through these platforms, we seek game-changing, long-term impact, and aim to ensure that trend lines for nutrition improve by making markets work for the poor. These alliances aspire to deliver nutritional impact at scale by encouraging innovation and policy environments that successfully enable change.”

In the 10 years of GAIN’s existence, 30 plus countries have benefitted from GAIN support, with 67% of beneficiaries being located in Africa. 530 million people have been reached with more nutritious foods – of whom 253 million are women and children, and 1.3 million are infants and young children aged between six months and two years. The cost per target individual reached across all GAIN projects is $0.32.

For more information on GAIN and its projects, visit www.gainhealth.org

Child Survival Call to Action as Millions of Children Never Get to Celebrate Their Fifth Birthday

One in four children die before their fifth birthday. This is a tragedy and a crisis: Even though global under-five mortality has been declining, about seven million children under the age of five still die annually. Roughly 40% of these deaths occur in the first month of life. Children at greatest risk of dying before their fifth birthday live in remote villages or in under-served urban areas. It was therefore timely that, at a recent event in Washington (jointly convened by the governments of the US, India and Ethiopia with the close cooperation of UNICEF), governments and partners were urged to sign “A Promise Renewed,” a pledge to work toward greater child survival. In her address, US Secretary of State Hillary Clinton said: “We are all here today with one vision – to make sure every child everywhere reaches his or her fifth birthday; to eliminate preventable child deaths in a generation.”

“We are all here today with one vision – to make sure every child everywhere reaches his or her fifth birthday; to eliminate preventable child deaths in a generation.”
Clinton continued: “Not everyone agrees that goals like this are achievable or that we should set our sights so high, but I believe in setting goals and I believe we have good reasons for optimism. We already have many of the tools and much of the knowledge we need.” The Child Survival Call to Action has convened 700 leaders and experts from the public and private sectors, along with faith-based communities, to map out ways to significantly reduce the numbers of children who die before their fifth birthday. Lending support to the campaign is actor Ben Affleck.


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Every Woman and Every Child in the Spotlight

Visit [www.everywomaneverychild.org](http://www.everywomaneverychild.org) to learn more about the Every Woman Every Child initiative, which aims to save the lives of 16 million women and children by 2015. The initiative is an unprecedented global movement, which mobilizes and intensifies international and national action by governments, multilaterals, the private sector and civil society to address the major health challenges facing women and children around the world.

You can download the Global Strategy for Women’s and Children’s Health from [www.everywomaneverychild.org/images/content/files/global_strategy/full/20100914_gswch_en.pdf](http://www.everywomaneverychild.org/images/content/files/global_strategy/full/20100914_gswch_en.pdf)

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Celebrating 100 Years of Vitamins

For 100 years, vitamins have been nourishing children, building stronger families and creating more vibrant communities. In 1912, the term “vitamin” was coined to describe the bioactive substances proven to be essential to human health. Over the past century, we have seen remarkable advancements in our understanding of vitamins. Exciting new breakthroughs continue today, as researchers around the world uncover new benefits that vitamins offer for human health.

Read all about vitamins and access great resources at the new microsite launched by [Sight and Life](http://www.sightandlife.org) and DSM in honor of vitamins at [www.100yearsofvitamins.com](http://www.100yearsofvitamins.com).

You can also follow us on [Twitter](http) @sightandlife or on [Facebook](http), by searching for Sight and Life, and keep up to date with latest vitamin and health news and events.
Scaling Up Nutrition (SUN) Update

Haiti is the latest country to join the SUN movement. First Lady of the Republic of Haiti Sophia Martelly affirmed that nutrition is at the top of the Government’s agenda and is at the core of the national flagship program against hunger and undernutrition, “Aba Grangou.”

The UN Secretary General has appointed a high-level, multi-stakeholder SUN Lead Group, made up of 27 influential leaders headed by Anthony Lake, committed to advancing progress in nations by scaling up nutrition. One of the first tasks of the Lead Group is to develop a strategy for the SUN Movement, which will revise the SUN Road Map developed in 2010. The new strategy, which will be shared at the Lead Group meeting in September 2012, is being developed in consultation with SUN Country Focal Points, stakeholder networks and the SUN Movement Secretariat. The strategy will outline ways in which the Movement can support countries as they scale up nutrition.

Visit www.scalingupnutrition.org to see who makes up the SUN Lead group.

The Economist “Feeding the World” Series

November 15 and 16, 2012 will see The Economist host an event in Johannesburg entitled “Africa’s role in Solving the Global Food Crisis.” Africa has the greatest amount of arable land to be left fallow, but very low current levels of trade in food. Contrary to Brazil, which in less than 30 years has turned itself from a food importer into one of the world’s breadbaskets, Africa – during these same 30 years – has gone from being a net food-exporting continent to being a net food importer. Bringing policy-makers together with agribusiness, donors, farmer organizations and civil society, the event will discuss what Africa needs to do in order to reproduce the Brazilian miracle. Sight and Life will be present at the conference.

For more details on the event, visit http://cemea.economistconferences.com/event/feeding-world-africa
Sight and Life were delighted to sponsor the award for the best final-year student in Community Nutrition 2011 of the Department of Human Nutrition at Stellenbosch University in South Africa. The community nutrition module integrates therapeutic nutrition, food service management, and research and community nutrition. It requires the application of knowledge of and practical insight into all these subjects towards effective nutrition planning and interventions. Congratulations to winner Taryn Anderson, who we trust will go on achieve a great deal in her career, and serve communities with the same passion that she has demonstrated in her studies.
Editor’s note: Sight and Life reviews recent publications which may be of particular interest to our readers. However, no publications other than Sight and Life publications are available from us, nor do we have any privileged access to them.

The Vitamins
Fundamental Aspects in Nutrition and Health

The fourth edition of this bestselling text provides up-to-date coverage of the biochemistry and physiology of vitamins and vitamin-like substances. Extensively revised and expanded on the basis of recent research findings, with enlarged coverage of the health effects of vitamin-like factors, it is ideally suited to students, and will be an important reference for anyone interested in nutrition, food science, animal science or endocrinology. It contains a cohesive and well-organized presentation of each of the vitamins, as well as the history of their discoveries and information about their current roles in nutrition and health.

This new edition incorporates many updates, with approximately 30% new material. Substantial additions have been made to chapters on vitamins A, C, E, K, folate, and the quasi-vitamins. It also provides checklists of systems affected by vitamin deficiencies, food sources of vitamins, key concepts, learning objectives, vocabulary, case studies, study questions and additional reading lists – all of which make this excellent reading material for students.

The book has also been thoroughly updated with important recent research results, including citations to key reports, many added tables and several new figures. There is also the addition of National Health and Nutrition Examination Survey (NHANES III) data and updated dietary reference values.

The author, Gerald F Combs Jr PhD, is an Emeritus Professor of Nutrition at Cornell University, Ithaca, New York. His specialties are the nutritional biochemistry of trace elements and vitamins, clinical intervention studies, and the linkages of agriculture and human health in national development. He has authored or co-authored 279 publications, including two major reference books.

For more information, please visit http://www.amazon.com/The-Vitamins-Fundamental-aspects-nutrition/dp/012183493X#
A Sustainability Challenge: Food Security for All

There is no area where the challenge of sustainability is clearer than in food and agriculture because, by definition, farmers must use the natural resources available to them to generate a continuous supply of food that is adequate to satisfy the needs of an ever-increasing number of people. Sustainable management of natural resources and the environment is fundamental to future food security, and yet there is much evidence that the current global food system is not sustainable.

“There is much evidence that the current global food system is not sustainable”

In the developed world, use of “improved” technologies (both scientific knowledge and capital investment) has enabled producers to generate substantial volumes of food per unit of natural resource input, at affordable prices. The same cannot be said for the developing world, where much of the agriculture is based on traditional technologies. The reality is that neither system assures long-term food security for all. In effect, failure to incorporate environmental costs into costs of production results in transfers from current to future generations; that is, future generations will face higher costs of production because of the failure to incorporate environmental costs into the equation now. On the other hand, incorporating the costs of environmental degradation would increase food prices and, if inappropriately managed, could cause increasing hunger and malnutrition in current generations of people with low incomes.

In order to better understand how sustainable food security could be achieved the National Research Council’s Science and Technology for Sustainability Program hosted two workshops, which addressed the sustainability challenges associated with food security for all. The first workshop was entitled “Measuring Food Insecurity and Assessing the Sustainability of Global Food Systems.” A second workshop was entitled “Exploring Sustainable Solutions for Increasing Global Food Supplies.” The report entitled “A Sustainability Challenge: Food Security for All” serves to summarize the presentations and discussion of both workshops, and makes interesting and thought-provoking reading.

The report is available as a free PDF download from http://www.nap.edu/catalog.php?record_id=13378#toc
Global Health
diseases, programs, systems, and policies

Recognized as the most prestigious comprehensive text on global health for graduate programs in public and global health, *Global Health, Third Edition* (formerly titled *International Public Health*) brings together contributions from the world’s leading authorities into a single text. It examines the wide range of global health challenges facing low- and middle-income countries today, and the various approaches nations adopt to deal with them. These challenges include the measurement of health status, infectious and chronic diseases, injuries, nutrition, reproductive health, global environmental health, and complex emergencies.

This thorough revision also explores emerging health systems, their financing and management, and the roles of nation states, international agencies, the private sector and non-governmental organizations in promoting health. Readers will come away with a clear understanding of how globalization is impacting global health, and of the relationship between health and economic development.

For this edition, data has been fully updated throughout. The latest information on new global health initiatives is included, as well as three new chapters, as follows:

1. **Social Determinations of Health (Chapter 3)**
   This chapter considers the term “health” in a historical perspective, presents contemporary examples of patterns of health inequity arising as a consequence of social determinants, illustrates policy implications of the existence of health gradients, and reviews models and theories that explain how some determinants affect health outcomes. The deliberations of the recent Commission on the Social Determinants of Health serve as a key basis.

2. **Pharmaceuticals (Chapter 14)**
   This chapter focuses on access to and the availability (both upstream issues and country-level distribution and management systems) and affordability of pharmaceuticals, and their safe and effective use. It also discusses the pharmaceutical system architecture, and provides reflections on coordination and priority-setting in a complex global environment.

3. **Evaluations of Large-Scale Health Programs (Chapter 16)**
   This chapter covers the area of evaluation science, and the rationale for and the design of summative impact evaluations of programs being scaled up and delivered to large populations and aimed at delivering several biological and behavioral interventions together. In describing the planning, design, and execution of program evaluations and data analyses, the authors use three evaluations as examples: an integrated management of childhood illness program; an accelerated child survival development initiative; and a voucher scheme for insecticide-treated bed nets.

The authors – Michael H Merson, Robert E Black, and Anne J Mills – have a wide field of experience between them. Professor Merson, MD, is the Wolfgang Joklik Professor of Global Health at Duke University and the founding Director of the Duke Global Health Institute and Vice Chancellor for Duke-National University of Singapore Affairs. Robert E Black, MD, MPH, is the Edgar Berman Professor and Chair of the Department of International Health, and Director of the Institute for International Programs of the Johns Hopkins University Bloomberg School of Public Health in Baltimore, Maryland. Anne J Mills, MA, DHSA, PhD, is Professor of Health Economics and Policy at the London School of Hygiene and Tropical Medicine, and Head of its Faculty of Public Health and Policy.

For more information, please visit http://www.amazon.com/Global-Health-ebook/dp/B007KOYORE
Classic Book Review
The Englishman’s Food: Five centuries of English diet

JC Drummond and Anne Wilbraham

In a world in which two billion people are malnourished, one might be tempted to question the topicality of a book about what the English ate during the course of five centuries. King Henry VIII, who had no fewer than six wives, two of whom he had beheaded, regularly ate porpoise and seal; but the relevance of such a historical nugget to a world in which two in seven people do not have a nutritious diet could seem questionable.

The Englishman’s Food: Five centuries of English diet, by the great British nutrition scientist Jack Drummond and his second wife Anne, is, however, a remarkably topical book. First published in 1939, it appeared just before the outbreak of the Second World War. So popular was it that a revised and updated edition was brought out in 1957, five years after the tragic murder of Drummond, his wife and daughter, on which we report elsewhere in this edition. By the time it was reprinted in 1991, it was recognized as a classic that was timelessly relevant.

As Tom Jaine writes in his 1991 introduction to the book, “lunch is a bundle of chemicals whose impact we should seek to understand.” Sir Jack Cecil Drummond, a pioneering vitamin scientist and nutrition policy-maker, was also a great lover of food and wine. He was an early member of the Wine and Food Society, founded in 1933 by the French vintner and gastronome André L Simon, and he contributed to the Society’s Journal. His understanding of food and nutrition embraced breakthrough science on the one hand and a deep understanding of history on the other. It is this ability to grasp the experience of the past and see it through the prism of contemporary scientific knowledge that gives Drummond’s writing such elegant authority: Here is an author who can fully appreciate the pleasures and struggles, the quirks and achievements of previous eating practices, while remaining quietly coherent and level-headed in his analysis of them. For a world still trying to strike a balance between over-consumption and starvation, between junk food and gourmet cuisine, between the tried and tested recipe and the latest TV chef’s signature dish, this is a work that has a great deal to tell us.

Plus ça change, plus c’est la même chose
The book surveys in chronological order: Medieval and Tudor England, the seventeenth century, the eighteenth century, the nineteenth century, and the twentieth century. We learn of farming and cooking practices, the influence of herbs and spices, and the differences between the diet of the peasantry and the aristocracy, the country and the city. It is interesting to discover that medieval London had sophisticated convenience food outlets, that stringent controls existed to ensure purity of ingredients and accuracy of measures, and that, until very recent times, consumption of fruit and vegetables was regarded by many English people as actually unhealthy (the intense seasonality of agricultural production would have tempted people to eat excessive quantities of produce that was either unripe or else in a state of decomposition). The received idea that the Anglo-Saxon peasants all starved while their Norman overlords waxed fat would appear to be something of a misconception, for Drummond argues that for long periods at
a stretch, the common people had access to a reasonably balanced and nutritious, if somewhat dull, diet. What is striking, however, is the prodigious appetite for meat among all classes of society, the devastating effects of war, disease and poor harvests, and the intimate link between the vagaries of the global economy and the man in the street’s belly. Plus ça change ...

Despite the historical sweep of the narrative, and the lucid account of the rise of nutrition science in the nineteenth century, it is hard to read Drummond’s account without being reminded of King Solomon’s dictum that there is nothing new under the sun. The link between food policy and politics is demonstrated time and again: in Elizabethan England, for example, the government attempted to introduce the compulsory eating of fish not only on Fridays (as was traditional) but also on Wednesdays. The object of this was to make more men go to sea, so as to have a bigger population of experienced mariners to draw on for the royal navy. We see the same with the interesting connection between wealth and malnourishment. In the seventeenth and eighteenth centuries, it was fashionable for the rich to farm out their babies to wet nurses; only the poor breastfed their own children. The wet nurses employed by the wealthy were generally poor and undernourished, with the result that the blue-blooded babies they fed were particularly prone to develop rickets. One is reminded obliquely of the ravages of ‘cocaine chic’ in the most affluent sections of some of today’s western societies.

As a companion to the history of England, The Englishman’s Food provides color, detail and surprise on every page, like sunlight flooding a well-worn tapestry. It is equally compelling as an introduction to some of the ravaging diseases brought about by malnutrition: The accounts of scurvy, not just among seafarers but also among the common people on land, are harrowing in their detail.

The characteristics of starvation

Perhaps the most haunting passage in the book, however – and certainly the most relevant to readers of Sight and Life magazine – is Drummond’s characteristically concise account of what happens when people have too little to eat:

“The most usual reaction to shortage of food is decreased activity. Even a slight shortage leads to irritability, complaint and unrest; a severe shortage results in lack of initiative, apathy and an unwillingness to co-operate in any kind of activity, physical or mental. The body conserves itself to the greatest possible extent, but if the shortage continues long enough body weight is inevitably lost.

“People dying of acute starvation seldom show any particular symptoms. There is increasing weakness and emaciation followed by overwhelming lethargy merging into a state of coma. If the shortage of food is less severe but more prolonged the decline is correspondingly slower and a condition known today as ‘hunger-oedema’ may appear. The limbs, and sometimes the whole body, swell as in dropsy, the circulation is impeded and death follows from failure of the heart.”

The Englishman’s Food is indeed about much more than the eating habits of a procession of defunct societies on a little island in the North Sea. It is, at the deepest level, an essay on the relationship between the resources of the planet and the fate of the people who live and die in accordance with their access to those resources.

Reviewed by:
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Handbook of Growth and Growth Monitoring in Health and Disease

Growth is one of the human body’s most intricate processes: Each body part or region has its own unique growth patterns. Yet, at individual and population levels, growth patterns are sensitive to adverse conditions, genetic predispositions, and environmental changes. And, despite the body’s capacity to compensate for these developmental setbacks, the effects may be far-reaching, even life-long.

The Handbook of Growth and Growth Monitoring in Health and Disease brings this significant and complex field together in one comprehensive volume. Issues covered include the impact of adverse variables on growth patterns; issues at different stages of prenatal development, childhood, and adolescence; aspects of catch-up growth, endocrine regulation, and sexual maturation; screening and assessment methods; and international perspectives. Tables and diagrams, applications to other areas of health and disease, and summary points help make the information easier to retain. With 180 self-contained chapters in 15 sections, the book covers every area of human growth, including:

- Intrauterine growth retardation
- Postnatal growth in normal and abnormal situations
- Cells and growth of tissues
- Sensory growth and development
- Effects of disease on growth, and
- Methods and standards for assessment of growth, and more.

The Handbook of Growth and Growth Monitoring in Health and Disease will be an invaluable addition to the reference libraries of a wide range of health professionals, among them health scientists, physicians, physiologists, nutritionists, dieticians, nurses, public health researchers, epidemiologists, exercise physiologists, and physical therapists. It will also be useful to college-level students and faculty in the health disciplines, and to policy-makers and health economists.

The authors are international experts from leading institutions. The handbook’s experienced editor, Victor R Preedy, is from one of the foremost health divisions and hospitals in the UK. Preedy is currently Professor of Nutritional Biochemistry in the Department of Nutrition and Dietetics, King’s College London, and Honorary Professor of Clinical Biochemistry in the Department of Clinical Biochemistry, King’s College Hospital. He is also Director of the Genomics Centre, King’s College London, a member of the School of Medicine, King’s College London, and a Fellow of the Royal Society for the Promotion of Health (FRSH), the Royal Institute of Public Health (FRIPHH), the Royal Society for Public Health (RSPH), and the Society of Biology (FSB). Preedy has written or edited over 550 articles, including over 160 peer-reviewed manuscripts based on original research, 85 reviews and 30 books.

The Handbook of Growth and Growth Monitoring in Health and Disease contains everything you need to know about normal and abnormal growth in health and disease at the cellular, tissue, organ and whole-organism level.

For more information, please visit
Bringing Agriculture to the Table
How Agriculture and Food can Play a Role in Preventing Chronic Disease

It has been widely accepted that, in order to achieve success in addressing food and nutrition security, agriculture and nutrition have to come together and work together – we cannot have one without the other. In the foreword for this report, President of the Chicago Council on Global Affairs Marshall Bouton highlights three themes in this regard. These include long-standing abundance, uneven distribution, and the rising energy density of food in the form of greater production of animal-based foods and greater processing of all foods. He proposes that the first two are well-recognized, and that ongoing policy discussions and actions are underway. However, he says that the third has, until now, received less attention, yet prompts the important question: How can the global food supply help people become healthier?

In September 2011, the United Nations General Assembly turned the spotlight on the issue of the rise in non-communicable diseases (NCDs), especially in developing countries. The recent World Health Assembly also had this issue on its agenda. The double burden of malnutrition and how to address it is a topic about which we will hear much in the coming years. Just as food and nutrition security cannot be referred to independently of each other, neither can hunger and NCDs. Once again, a multi-sectoral response is being stressed, together with the need for indicators to monitor progress. Both are easier said than done so, yet again, numerous challenges have to be faced and overcome if we are to succeed.

This report, developed as the result of a six-month project chaired by Rachel Nugent, with input from a wide range of stakeholders, is a good opener for the conversation. It offers an integrated look at agriculture, food, nutrition, and the growing threat of diet-related chronic diseases. “It presents analysis and recommendations suggesting that the farm and food systems across the globe are dynamic and robust, capable of producing adequate food to meet people’s needs for the foreseeable future, but in need of significant course corrections as well,” says Bouton.

The Chicago Council on Global Affairs is a leading independent nonpartisan organization committed to influencing the discourse on global issues through contributions to opinion and policy formation, leadership dialogue and public learning.

To find out more, read www.thechicagocouncil.org

The full report can be downloaded from: www.thechicagocouncil.org/UserFiles/File/GlobalAg Development/Report/Bringing_Agriculture_To_The_Table.pdf
The Life of Children in an Increasingly Urban World ...

In February 2012, UNICEF launched its annual State of the World’s Children Report, this year focusing on children in an urban world. Considering that half the world’s children now live in urban areas, the report is both timely and important. Anthony Lake, Executive Director of UNICEF, says it all, when he writes in the foreword: “When many of us think of the world’s poorest children, the image that comes readily to mind is that of a child going hungry in a remote rural community in Sub-Saharan Africa – as so many are today. But as The State of the World’s Children 2012 shows with clarity and urgency, millions of children in cities and towns all over the world are also at risk of being left behind.”

Traditionally, families and children moved to cities in search of better opportunities. However, these environments are becoming increasingly harsh – children live in ramshackle and overcrowded dwellings, and are forced to endure violence and exploitation, and to face a lack of basic necessities such as clean water and education. This makes their lives extremely difficult. The report turns on its head the notion that all children who live in cities are necessarily better off than those in rural communities. It shows that, although disadvantaged children may live minutes away from schools and clinics, they are cut off from these facilities by poverty and discrimination.

“Every disadvantaged child bears witness to a moral offense: the failure to secure her or his rights to survive, thrive and participate in society. And every excluded child represents a missed opportunity”

It is fascinating but disturbing to learn how, as the report explains, the use of statistical averages (which are commonly used as the basis for resource allocation decisions) can and does conceal the hardships endured by urban children. This is because averages lump populations together. Thus, the poverty of some is obscured by the wealth of others.

One consequence of this is that already-deprived children remain excluded from essential services. The report calls for a deeper understanding of the issues surrounding poverty and inequality in cities, and for increased political will to improve the lives of the most marginalized. In what could be seen as one of the most distressing reports of the year, there are also some wonderful examples of successes. These convey the clear message that, with political will, and the inclusion of the marginalized in urban planning and decision-making, advancements in, for example, literacy, infrastructure and safety have been made possible.

The full report is available from www.unicef.org/sowc2012/
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Building bridges for better nutrition.

We care about the world’s most vulnerable populations and exist to help improve their nutritional status. Acting as their advocates, we guide original nutrition research, disseminate its findings and facilitate dialog to bring about positive change.