

Special Anniversary Issue

# Center for Studies of Sensory Impairment, Aging, and Metabolism (CeSSIAM)

BULLETIN OF RESEARCH ABSTRACTS



## Editorial Board

- Dr. Fernando Beltranena
- Dr. Carlos Castellanos
- Dr. Gustavo Hernández Polanco
- Ms. Rosa Amalia de Vásquez

## Editors

- Dr. Mónica Orozco
- Dr. Marieke Vossenaar
- Dr. Noel W. Solomons

## Postal Address:

CeSSIAM in Guatemala  
 P.O. Box 02-5339  
 Section 3136/GUATEMALA  
 Miami, FL 33102-5339, USA

## Visiting Address:

CeSSIAM  
 17 avenida 16-89 (interior)  
 zona 11 Anillo Periférico  
 Guatemala City, 01011  
 Guatemala

## Email:

cessiam@guate.net.gt  
 Tel/Fax: ++(502) 24733942

### Inside this issue:

Editorial: Silver Jubilee <i>Noel W. Solomons</i>	<b>2</b>
CeSSIAM in images	<b>4</b>
The circulating iron response to three oral iron supplement compounds in women with low iron status <i>María Eugenia Romero-Abal, Noel W. Solomons, Günter Weiss, Klaus Schümann</i>	<b>5</b>
Requisite nutrient densities to satisfy nutritional needs across the spectrum of continued breast-feeding through the second year of life <i>Marieke Vossenaar and Noel W. Solomons</i>	<b>6</b>
Validity and diagnostic acumen of a rapid, non-invasive, portable hemoglobin device (Haemospect®): Comparison with whole blood testing for anemia diagnosis under field conditions in rural Guatemala <i>Caitlin R. Crowley, Gabriela Montenegro-Bethancourt, Noel W. Solomons, and Klaus Schümann</i>	<b>8</b>
Expenditures and household investment in complementary foods during the first 6 months of Life <i>Raquel Campos and Liza Hernández</i>	<b>10</b>
List of recent CeSSIAM publications	<b>11</b>
List of CeSSIAM abstracts at the II WORLD CONGRESS OF PUBLIC HEALTH NUTRITION & I LATINAMERICAN CONGRESS OF COMMUNITY NUTRITION, Porto, Portugal, 23 to 25 September	<b>12</b>

# Editorial

## ***CeSSIAM International: A 25-year effort to bring the best of modern concepts to Guatemala and the best of Guatemalan science to the world***

This 25th Anniversary issue of the *Bulletin* will debut for distribution to our friends and readers at the II World Congress on Public Health Nutrition (II WCPHN). Hopefully, all of the professionals currently affiliated with the Center will be in Oporto, Portugal at this gathering to hand them out. In the present downwardly spiraling economic times, this is a major achievement. Attending international gatherings has been a priority for Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) for a quarter of a century, in good times and in bad. It is at these events that one can meet those who have pioneered nutritional sciences, make acquaintance with peers from around the world, exchange ideas, and seek international funding. But a culture for exposition of one's research findings and their interpretation before the critical judgment of other scientists is an indispensable step to individual professional advancement. One or another CeSSIAM affiliate has attended the annual American Society of Nutrition meetings from 1985 to the present, and has attended and presented at all International Congresses on Nutrition from Brighton in 1985 to Bangkok in 2009.

The Congress in Oporto is a special meeting, however, with a particularly unique focus. It has a young tradition, having originated in 2006 in Barcelona as a forum for Exchange of the more applied new developments that nourish community nutrition policy and programs. One of the primary transformational objectives of the WCPHNs is to make a transition toward opening up meetings to the upcoming generation of nutrition leaders. The staff of CeSSIAM has positioned itself, through its efforts over the past year, to making a major contribution in Oporto. Twenty-one free-papers based on our research findings were submitted and accepted; 3 placed among the top 36 in quality ranking and were selected for oral presentation; and 3 more were within the next 100 and selected for the Distinguished Posters section. Two staff members, **Liza Hernández** and **Sheny Romero-Abal**, were offered applications for travel fellowships for the merits of their abstracts. Three more staff members, **Marieke Vossenaar**, **Mónica Orozco**, and **Caitlin Crowley**, will participate in an Anniversary Symposium. **Gabriela Montenegro** will provide a case-study in another II WCPHN symposium on beverages.

Of course, neither the Congress in Oporto nor CeSSIAM is entirely about youth. One of the Honorary Presidents of the Oporto Congress is **Prof. Nevin Scrimshaw**; he is also the President Emeritus of the International Nutrition Foundation (INF). CeSSIAM must give much of the credit for its survival over 25 years to the financial handling of international current funding by the INF. The Hildegard Grunow Foundation (HGF) was founded in Munich in 2007, and is headed by **Prof. Klaus Schümann**. It has become a second foundation front for the origin and management of financing for the projects of CeSSIAM. At the II WCPHN, the HGF will award the first Rainer Gross Award: Innovation in Nutrition, dedicated to the memory and life-work of the man who inspired the multicenter CRONOS protocol (Cross-Cultural Research On Nutrition in Older Subjects). **Manolo Mazariegos**, **Liza Hernández** and **Gabriela Montenegro** of CeSSIAM took up the CRONOS protocol among the Mayans of Quetzaltenango, and thus opened up field research opportunities in this Western Highlands of Guatemala.

In the aforementioned Anniversary Symposium, it will fall upon me to reflect on the 25 years of CeSSIAM history we have been celebrating throughout 2010 and perhaps even the lessons learned. Those reflections have to begin with the motivational origins of the Center. INCAP in 1985 had become a bastion of the conventional and narrow-minded thinking of the Pan American Health Organization (PAHO). CeSSIAM was to be a refuge from INCAP, forged around the principle that broadening the research agenda and giving sway to investigator-initiated research directions was a valid, scientific "*counter-culture*" movement for Guatemala. The courageous support of my co-founders, the late **Oscar Pineda**, **Fernando Beltranena** and **Gustavo Hernández-Polanco**, opened the way. They provided entry into the academic structure of the Guatemalan Committee for the Blind and Deaf, and this received the crucial blessing from its President, the late **Doña Elisa Molina de Stahl**.

Once established within the Rodolfo Robles Eye and Ear Hospital, CeSSIAM was positioned to look at research projects with a self-determined agenda. It would never have gotten out of the starting blocks were it not for the adherence of a cadre of local medical students, **Francisco Rosales**, **Carolina Barrillas-Mury**, **Carolina Vettorazzi**, **Mei-Ling Siu** and others, who worked collectively on common investigation projects at the start. It never would have found a way to operate without the embrace by hospital professionals, **Juan Carlos García**, **Isabel Massanet de Ramírez** and **Liliam Barrantes**. It never would have found its footing with its alternative research agenda were it not for the leadership of a quintet of young, but dedicated, Guatemalan physicians, **Jesús Bulux**, **Susana Molina**, **Carlos Grazioso**, **Manolo Mazariegos** and **Iván Mendoza**, who took leadership across the spectrum of issues embraced by the name of CeSSIAM. And it would never have lasted were it not for the financial side, and the generosity of US entrepreneur, **Alan Kligerman** of the AkPharma Inc and for the administrative and clerical assistance of **Mrs Julisa Gallego**.

In a two-score and five year retrospective, two factors seem to have been the most important keys to the direction of CeSSIAM. The first was adapting the technological and scientific currents of the moment to an application in Central America, and an adaptation to conditions in the field. Body composition and overweight, aging in tropical countries, zinc and riboflavin status, and application of stable isotope technology in free-living populations were all neglected or counter-current ideas in the 1980s and 1990s; each became an important theme of research at the Center. The second factor was joining hands with academic professionals and research institutions overseas. Germany, the Netherlands, Canada and the United States have been the major partner nations in our history, both early on and in the current phase. Over 100 exchange students from those four nations have passed through our doors, and 11 students, from all 4 countries, but including two from Spain and two Guatemalans, have worked on doctoral dissertations with CeSSIAM.

Vitamin A emerged as an international topic in the mid 1980s, and it was closely linked to our “sensory impairment” mandate in the title. Assessment measures, less invasive than those using venous blood, were explored in Guatemala. These included conjunctival impression cytology, dried capillary blood spots and breast milk for vitamin A, in links with the universities of Arizona, Johns Hopkins and Wageningen, and the Craft Technology Co, led mostly by **Jesús Bulux**. Application of stable-isotope technology in field studies of vitamin A bioavailability and metabolism came through a partnership with the Tufts University and the Human Nutrition Research Center on Aging (HNRC-A) in Boston, in the domain of **Manolo Mazariegos**.

An broader affiliation with the latter institution emerged in part from the “aging” in the title of our institution, and our willingness to address the upper end of the age spectrum in a developing country setting. With **Rob Russell** and **William Boisvert** of the HNRC-A and **Iván Mendoza** of CeSSIAM, the bases for the dietary recommendations for riboflavin in the elderly were developed. I have mentioned that **Rainer Gross**’ CRONOS protocol was applied in Quetzaltenango; it was also applied by **Manolo** and **Liza** in the central highlands in and around the capital. **Ivan**, with **Dena Herman** from a German University and **Carolina González**, a local medical student, applied the Food Habits in Later Life multi-center protocol of **Prof. Mark Wahlqvist** in Antigua Guatemala.

The current that follows the winds of contemporary public health nutrition concern is that of iron as a two-edged sword. With funding and inspiration from the HGF and **Klaus Schümann**, studies by **Caitlin Crowley** and **Gabriela Montenegro** have picked up on another area, also pioneered by **Rainer Gross**, namely the non-invasive assessment of hemoglobin using a laser-probe of white light across the skin. Meanwhile, **Sheny Romero-Abal** and **Mónica Orozco** are examining the factors influencing the appearance of loosely-bound iron in the circulation after oral iron supplements, and **Mónica** has developed and applied a method to examine the oxidative effects of oral iron in the human intestine and mitigate the effects with antioxidants.

In summary, the importance of bi-lingual skills, international training, and publishing in recognized scientific journals were virtues that **Nevin Scrimshaw** promoted in the golden age of INCAP, founded 36 years before CeSSIAM. These virtues are essentially universal. In fact, most of the CeSSIAM-affiliated persons have embraced English, making themselves worthy of full participation in international meetings; some, however, as a matter of personal preference, have adhered to the language of Cervantes to the exclusion of that of Shakespeare. CeSSIAM has facilitated training abroad for almost its entire Central American staff and for some local students. Many took the opportunity to stay on in the country of study after their degrees, whereas others have returned to continue in Guatemala. All have benefited society with the fruits of their studies. The truly glorious evolution over the 25 years, however, has come in the acceptance of the merits of publishing in international journals and establishing independent reputations in science. From resistance to the written word through the early years to “*can I publish these data?*” today, there is the notable transformation, accentuating in the interval from our 20<sup>th</sup> to 25<sup>th</sup> year; thus, most worthy of celebration has been manuscript and grant-writing success within the institution, combined with improvement in scientific management skills.

In fact, musing over these reflections is motive to lift a glass of port wine with all of the staff, bringing CeSSIAM to an international meeting in Oporto.

Dr. Noel W. Solomons, MD  
Scientific Director, CESSIAM

## CeSSIAM in Images



Dr. Noel W. Solomons in Evora , Portugal



During the CANIA meeting, Venezuela, 2010



At ConverCienca, Guatemala City, 2010



Professor Klaus Schümann in Dortmund, Germany



With Dr. Javier Aranceta at SLAN, Chile



Dr. Solomon's induction in the Academia Española de Nutrición y Ciencias de la Alimentación

## The circulating iron response to three oral iron supplement compounds in women with low iron status

María Eugenia Romero-Abal, Noel W. Solomons, Günter Weiss, Klaus Schümann

Iron treatment exposures can have adverse effects in malarial regions among iron deficient subjects, as the Pemba study revealed. This concern has uncovered the need for Fe supplements with bioavailability high enough to treat the deficiency, but not that high to provoke an increase on non-transferrin-bound iron (NTBI). A proxy indicator for the risk of NTBI exposure is the serial measurement of circulating Fe after a single oral dose.

The objective of this study was to compare the circulating Fe response to three different iron supplements using the equivalent of 100 mg Fe in each case. The compounds were: ferrous sulfate (FeSO<sub>4</sub>); iron polymaltose (IPM) and sodium iron EDTA (NaFeEDTA), along with placebo (Water).

Plasma Fe response, was measured at 0, 90, 180 and 270 min, after a single Fe dose in a group of 10 women (22 – 60 y, chosen for low iron status: ferritin = 17±8 mg/L) and 10 men (18 – 54 y, chosen for adequate iron status: ferritin = 114±50 mg/L).

Plasma Fe response was expressed as the sum of serial changes in Fe levels, as a proxy for area under the curve (Fe-AUC), and compared among treatments and between sexes for the 4 test situations. The mean maximum peak reached was recorded and compared among treatments and gender (MANOVA test).

The maximal AUC and max peak were produced by FeSO<sub>4</sub> in both groups with significant differences among treatments and sex (p>0.001) followed by NaFeEDTA which showed significant differences by sex and treatment (p<0.0001). The IPM showed no differences compared to water or by sex.

**Conclusion:** As could be expected, the female group had a 3-fold greater excursion of circulating Fe over the 4.5 h of observation with FeSO<sub>4</sub>. But if we are looking for minimum peaks post-iron treatment, we could hypothesize that IPM had the best overall performance profile as a compound that would minimize post-dose Fe excursion in the blood in both Fe-status conditions; in the effort to limit adverse consequences in malarial areas. But more studies are required to evaluate the intermediate effects offered by NaFeEDTA, which showed a more modest plasmatic reaction

**Table 1** Maximal changes for Fe concentration (µg/dL)

					p-value
	WATER	FeSO <sub>4</sub>	NaFeEDTA	IPM	
Women	6 ± 19	292 ± 106*	43 ± 18	14 ± 22	*p<0.05
Men	3 ± 21	93 ± 67*	7 ± 10	18 ± 17	*p<0.05
p-value	0.5	3x10 <sup>-7</sup>	2x10 <sup>-5</sup>	0.4	

**Table 2** Σ 3 hourly changes for plasmatic Fe (µg/dL)

					p-value
	WATER	FeSO <sub>4</sub>	NaFeEDTA	IPM	
Women	-2 ± 52	731 ± 239*	98 ± 51	11 ± 60	*p<0.05
Men	4 ± 45	202 ± 198*	-5 ± 37	41 ± 40	*p<0.05
p-value	0.6	2x10 <sup>-5</sup>	0.3	0.2	



Maria Eugenia Romero Abal is a research Chemical Biologist at CeSSIAM

Noel W. Solomons is the Scientific Director at CeSSIAM

Günter Weiss is Professor at the Medical University of Innsbruck, Austria

Klaus Schümann is the Director of the Hildegard Grunow Foundation

## Requisite nutrient densities to satisfy nutritional needs across the spectrum of continued breast-feeding through the second year of life

Marieke Vossenaar and Noel W. Solomons

The World Health Organization (WHO) recommends exclusive breastfeeding for 6 mo, with the introduction of nutritionally-adequate, safe and appropriate complementary foods (CF) followed by continued breastfeeding (CBF) up to 2 years and beyond (WHO 2003).

The World Alliance for Breastfeeding Action (WABA) supports CBF and states that breastmilk should provide 75% of total energy at 6-8 mo, 50% at 9-12 mo and 40% at 12-24 mo (WABA 2008). Furthermore, WABA and the International Baby Food Network (IBFAN) postulate optimal use of customary “family foods” rather than commercial formulas and “baby foods” (IBFAN 2009).

The concept of desired nutrient densities of CF was introduced in 1998 in a WHO publication entitled “Complementary feeding of young children in developing countries: A review of current scientific knowledge” (Brown et al. 1998). In a similar manner, we created theoretical models to determine the requisite nutrient densities of CF for infants with CBF up to 2 years following the IBFAN and WABA recommendations.

Requisite nutrient densities were determined by age group, gender and body weight as follows:

**STEP 1:** Daily energy and nutrient requirements of the total diet. Age- and gender-specific energy (UNU/WHO/FAO 2004) and protein requirements (WHO 2007) were calculated assuming children to be in the 15<sup>th</sup> and 50<sup>th</sup> weight percentile (WHO 2006). Requirements for 10 selected micronutrients were based on Recommended Nutrient Intakes (RNI) for children aged 7-12 mo and 1-3 yrs (WHO 2004).

**STEP 2:** Energy and nutrient contribution from breastmilk. Breastmilk provided 75% of total energy at 6-8 mo, 50% at 9-12 mo and 40% at 12-24 mo (WABA 2008). The energy and nutrient composition was assumed to be constant (Brown 1998).

**STEP 3:** Energy and nutrient needed from CF. The requirements of CF were computed as the difference between daily requirements and the contribution from breastmilk. Critical nutrient densities were computed per 100 kcal.

The required nutrient densities from CF assuming CBF are presented in **Table 1** by gender, age and assumed body weight. Substantial gaps emerge for calcium, iron and zinc, especially at the commencement of the 2<sup>nd</sup> year of life, when high milk volumes are consumed, and especially in thin, but healthy, toddlers.

In order to examine how well “family foods” complement CBF, we examined the habitual diet of 301 rural and 298 urban poor Guatemalan adult participants of the “Concordance Project” (Vossenaar 2009). The Positive Deviance approach was used to select participants with nutritionally-adequate diets (Vossenaar 2009, 2010) and the nutrient density of their diets was calculated and used to represent the ideal “family foods”.

Energy complementation with these diets provided adequate nutrient density for protein, riboflavin, thiamin, vitamins B6, C and A, but not folate and niacin. Major gaps for calcium, iron and zinc remained whatever the family food pattern placed into the simulation model (**Table 2**).

The simulated diet of Guatemalan children aged 6-24 mo receiving CBF and “family foods” proved to be nutritionally inadequate in several “problem nutrients”. These findings suggest a need either to home-fortify family foods or feed commercial baby foods during extended CBF.

### References:

- Brown KH, Dewey KG & Allen LH (1998) *Complementary feeding of young children in developing countries: A review of current scientific knowledge*. Geneva: WHO.
- IBFAN (2009) *What is complementary feeding? A philosophical reflection to help a policy process. A discussion paper developed for the International Baby Food Action Network (IBFAN)* by

Gabrielle Palmer. September 2009.

- UNU/WHO/FAO (2004) *Human energy requirements. Report of a Joint FAO/WHO/UNU Expert Consultation, 17-24 October 2001, Rome, Italy*. Rome.
- Vossenaar M, Solomons NW, Valdes-Ramos R & Anderson AS (2009) Concordance with dietary and lifestyle population goals for cancer prevention in Dutch, Scottish, Mexican, and Guatemalan population samples. *Nutrition* 26, 40-52.
- Vossenaar M, Mayorga E, Soto-Mendez MJ, Medina-Monchez SB, Campos R, Anderson AS & Solomons NW (2009) The positive deviance approach can be used to create culturally appropriate eating guides compatible with reduced cancer risk. *J Nutr* 139, 755-762.
- Vossenaar M, Bermudez OI, Anderson AS & Solomons NW (2010) Practical limitations to a positive deviance approach for identifying dietary patterns compatible with the reduction of cancer risk. *J Hum Nutr Diet* [in press].
- WHO (2003) *Global strategy for infant and young child feeding*. Geneva: World Health Organization.
- WHO & FAO (2004) *Vitamin and mineral requirements in human nutrition*, Second edition. pp. editors] World Health Organization, Food and Agriculture Organization.
- WHO (2006) *The WHO Child Growth Standards*. Geneva: World Health Organization.
- WHO (2007) *Protein and amino acid requirements in human nutrition. Report of a joint FAO/WHO/UNU Expert Consultation (WHO Technical Report Series ; no. 935)*. Geneva: World Health Organization.
- WABA (2008) *Protecting, Promoting and Supporting Continued Breastfeeding from 6-24 + Months: Issues, Politics, Policies & Action*.



Marieke Vossenaar is a post-doctoral fellow at CeSSIAM

Noel W. Solomons is the Scientific Director of CeSSIAM

**Table 1** Required nutrient density from complementary feeding (CF) for infants aged 7 to 24 mo assuming continued breastfeeding and using the WHO energy (2004) and nutrient (2004, 2007) requirements.

	Boys					Girls				
	50 <sup>th</sup> percentile body weight of WHO growth standards (2006)									
Age (mo)	7-9	10-12	12	18	24	7-9	10-12	12	18	24
Volume of breastmilk (mL)	761	561	487	546	600	690	513	440	497	550
Energy from CF (kcal)	170	376	489	549	603	154	344	442	500	553
	Nutrient density (unit/100 kcal)									
Protein (g)	1.9	1.7	1.3	1.0	0.9	2.0	1.7	1.3	1.1	1.0
Folate (µg DFE)	9.0	8.6	22.2	18.9	16.4	13.9	10.6	25.5	21.6	18.7
Thiamine (mg)	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Riboflavin (mg)	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1
Niacin (mg)	1.7	0.8	1.1	0.9	0.8	1.9	0.9	1.2	1.1	0.9
Vitamin B <sub>6</sub> (mg)	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
Vitamin C (mg)	0.0	2.0	2.2	1.5	1.0	1.6	2.8	2.8	2.0	1.4
Vitamin A (µg RE)	11.5	31.8	32.0	23.1	16.6	35.7	41.7	40.7	30.3	22.6
Calcium (mg)	110.0	64.6	74.4	63.2	55.1	134.3	74.5	85.2	72.2	62.6
Iron (mg)	10.8	4.9	2.3	2.1	1.9	11.9	5.4	2.6	2.3	2.1
Zinc (mg)	4.4	2.1	1.6	1.4	1.3	4.9	2.3	1.8	1.5	1.4
	15 <sup>th</sup> percentile body weight of WHO growth standards (2006)									
Age (mo)	7-9	10-12	12	18	24	7-9	10-12	12	18	24
Volume of breastmilk (mL)	681	501	433	487	531	611	454	387	440	483
Energy from CF (kcal)	152	336	435	489	534	137	304	389	442	485
	Nutrient density (unit/100 kcal)									
Protein (g)	1.9	1.7	1.3	1.0	0.9	2.0	1.8	1.3	1.1	1.0
Folate (µg DFE)	14.5	11.1	26.0	18.4	19.6	20.5	13.6	30.1	25.5	22.5
Thiamine (mg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Riboflavin (mg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Niacin (mg)	2.0	1.0	1.2	0.9	1.0	2.3	1.1	1.4	1.2	1.1
Vitamin B <sub>6</sub> (mg)	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
Vitamin C (mg)	1.8	3.0	2.9	1.8	1.6	4.1	3.9	3.7	2.8	2.2
Vitamin A (µg RE)	39.1	44.5	42.2	26.6	25.2	69.0	56.9	53.1	40.7	32.7
Calcium (mg)	137.7	77.3	87.1	61.7	65.8	167.1	89.8	100.7	85.2	75.2
Iron (mg)	12.1	5.5	2.6	1.9	2.1	13.4	6.1	3.0	2.6	2.4
Zinc (mg)	5.0	2.3	1.8	1.3	1.4	5.6	2.6	2.0	1.8	1.6

**Table 2** Nutrient density gap between required nutrient density and the nutrient density of “family foods” based on the for adults nutritionally adequate diets of participant of the “Concordance Project” (n=82)

	Boys					Girls				
	50 <sup>th</sup> percentile body weight of WHO growth standards (2006)									
Age (mo)	7-9	10-12	12	18	24	7-9	10-12	12	18	24
Volume of breastmilk (mL)	761	561	487	546	600	690	513	440	497	550
Energy from CF (kcal)	170	376	489	549	603	154	344	442	500	553
	Nutrient density gap (unit/100 kcal)									
Protein (g)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Folate (µg DFE)	0.0	0.0	8.9	5.6	3.1	0.6	0.0	12.2	8.3	5.4
Thiamine (mg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riboflavin (mg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niacin (mg NE)	0.9	0.0	0.3	0.1	0.0	1.1	0.1	0.4	0.3	0.1
Vitamin B <sub>6</sub> (mg)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Vitamin C (mg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin A (µg RE)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calcium (mg)	73.3	27.9	37.7	26.5	18.4	97.6	37.8	48.5	35.5	25.9
Iron (mg)	9.7	3.8	1.2	1.0	0.8	10.8	4.3	1.5	1.2	1.0
Zinc (mg)	4.1	1.8	1.3	1.1	1.0	4.6	2.0	1.5	1.2	1.1
	15 <sup>th</sup> percentile body weight of WHO growth standards (2006)									
Age (mo)	7-9	10-12	12	18	24	7-9	10-12	12	18	24
Volume of breastmilk (mL)	681	501	433	487	531	611	454	387	440	483
Energy from CF (kcal)	152	336	435	489	534	137	304	389	442	485
	Nutrient density gap (unit/100 kcal)									
Protein (g)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Folate (µg DFE)	1.2	0.0	12.7	5.1	6.3	7.2	0.3	16.8	12.2	9.2
Thiamine (mg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riboflavin (mg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niacin (mg NE)	1.2	0.2	0.4	0.1	0.2	1.5	0.3	0.6	0.4	0.3
Vitamin B <sub>6</sub> (mg)	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Vitamin C (mg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vitamin A (µg RE)	0.0	0.0	0.0	0.0	0.0	12.5	0.4	0.0	0.0	0.0
Calcium (mg)	101.0	40.6	50.4	25.0	29.1	130.4	53.1	64.0	48.5	38.5
Iron (mg)	11.0	4.4	1.5	0.8	1.0	12.3	5.0	1.9	1.5	1.3
Zinc (mg)	4.7	2.0	1.5	1.0	1.1	5.3	2.3	1.7	1.5	1.3

## Validity and diagnostic acumen of a rapid, non-invasive, portable hemoglobin device (Haemospect®): Comparison with whole blood testing for anemia diagnosis under field conditions in rural Guatemala

Caitlin R. Crowley, Gabriela Montenegro-Bethancourt, Noel W. Solomons, and Klaus Schümann

The need for a rapid, non-invasive, cost-effective, and culturally-acceptable method for accessing hemoglobin (Hb) status has recently intensified. In the wake of the adverse events among iron-replete children receiving iron supplementation in Pemba, Tanzania, (Sazawal et al, 2006). In the wake of that occurrence, in which there was a 12% excess of the combination of hospitalizations and deaths from malaria among the groups receiving iron versus controls (Sazawal et al), a study group, convened by the World Health Organization, produced some interim directives toward the safer application of oral supplementation in populations with intense malarial transmission (Lyon Consultation Supplement, 2007). Foremost among them, from our point of view, was the call for screening of recipients of iron, to exclude those who have adequate iron status from additional exposure to oral iron.

To the end of providing a screening method, which would not only be accurate in separating the iron sufficient from the iron needy, but also be painless and non-invasive, we have explored the application of a new device (the Haemospect® from MBR Optical Systems in Wuppertal, Germany), which uses white-light laser technology to measure Hb concentration in subcutaneous capillary beds. As participants in the exploratory studies, we enrolled 40 men, living at high altitude, from the department of Totonicapán (2600 m) and 40 pregnant women, living at low-altitude in a hookworm invested region in Retalhuleu (240 m) in an effort to maximize the range of Hb values to be collected. A venous blood sample for a colorimetric Hb determination and digital readings taken at the hand and forearm, using the Haemospect®, were collected from all subjects. WHO diagnostic criteria for anemia were used to generate sensitivity, specificity, and positive and negative predictive values of non-invasive readings

versus the reference standard, a whole blood sample. Hb “registrations” were processed during a blinded reevaluation of the spectra collected in the field by an improved software version at the site of the manufacturer in Germany, due to a problem with the readouts produced by the digital device’s internal software.

Hb values from whole blood samples ranged from 7.8 to 18.5 g/dL, with a mean value of 12.9±2.3 g/dL. The Haemospect® was only able to attain viable registrations from 70 of the 80 subjects on the palm, and from 60 sampled on the forearm. Mean Hb registered at both the palm and forearm sites were similar to the whole blood samples (13.2±2.1 and 12.7±1.8 g/dL, respectively) (**Figure 1**). Ranges were more narrowly distributed (9.1-17.5 and 8.7-15.8 g/dL, respectively). Pearson correlation coefficients between digital and blood Hb values were extremely strong at both palm and forearm sites:  $r=0.94$  ( $p<0.001$ ,  $n=70$ ) and  $r=0.90$ , ( $p<0.001$ ,  $n=60$ ) respectively (**Figure 2, Panels A and B**). Furthermore, a high Lin Concordance coefficient between readings taken at the palm and forearm demonstrates the strong correlation between the two sites ( $r=0.84$ ) (**Figure 2, Panel C**). Diagnostic discrimination was most satisfactory around the 12.0 g/dL WHO cutoff guidelines for determining anemia at sea level. Specificities were high (>90%) across the entire range of cutoff points, within the complete sample. Sensitivity was 100% at 12.0 g/dL, falling to 93% at 11.5 g/dL, and 58% at 11.0 g/dL at the forearm site.

In conclusion, the Haemospect® shows much promise for use in a field setting. It has limitations for application at sea-level (where most of the world’s endemic malaria would be found), do to its still poor discrimination at the Hb cut-offs relevant to young children. With the application of fully-functioning software, however, it should offer a promising new screening technique

**Acknowledgements:** We are very thankful for the collaboration of the personnel of the local health centers of San Francisco El Alto and Retalhuleu. We appreciate the assistance from Gloria Hidalgo, Juergen Kotzerke; Dr. Michael Schietzel; and the Hildegard Grunow Foundation for funding.

### References:

Sazawal S, Black Re, Ramsan M, et al. Effects of routine prophylactic supplementation with iron and folic acid on admission to hospital and mortality in preschool children in a high malaria transmission setting: community-based, randomised, placebo-controlled trial. *Lancet* 2006;367:133-43.

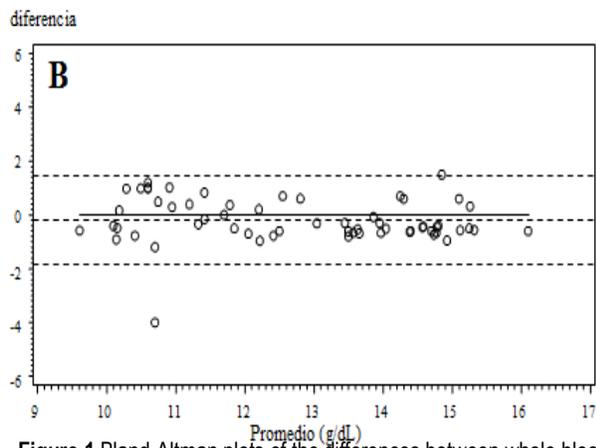
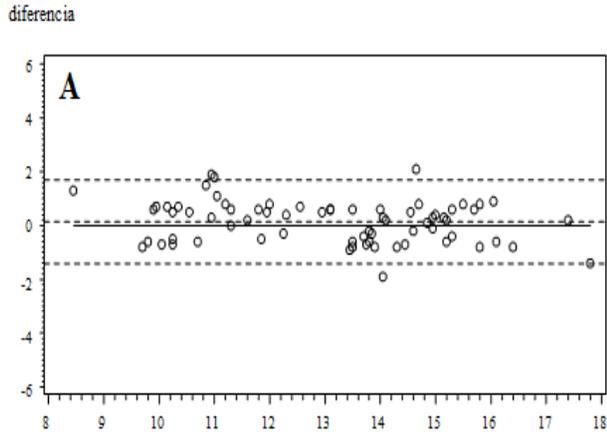
Consultation WHOSobotptt. Conclusions and recommendations of the WHO Consultation on prevention and control of iron deficiency in infants and young children in malaria-endemic areas. *Food and Nutrition Bulletin* 2007;28:S621-S7.



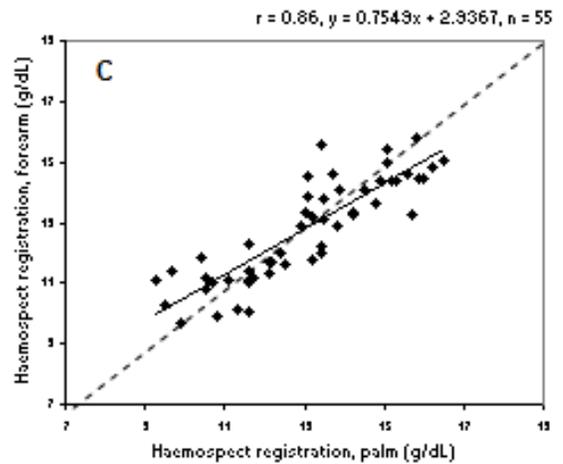
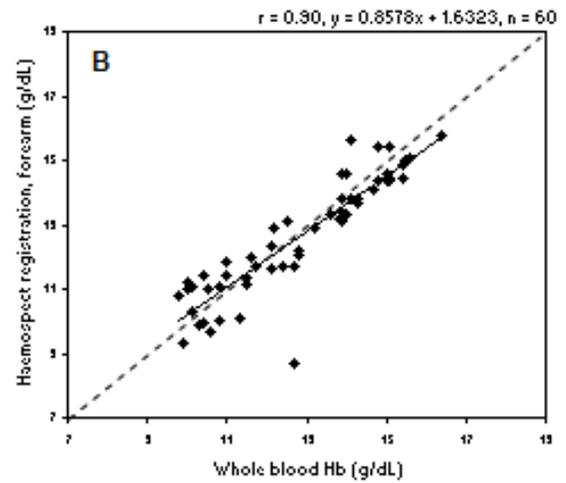
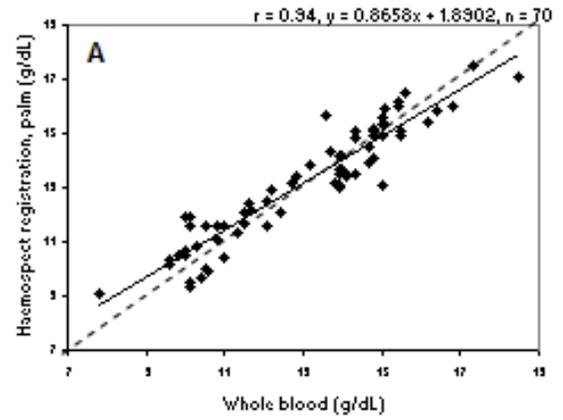
Caitlin R. Crowley is a research fellow at CeSSIAM

Gabriela Montenegro-Bethancourt, is a Research Nutritionist at CeSSIAM  
Noel W. Solomons, is Scientific Director at CeSSIAM

Klaus Schuemman, is Director of the Research Center for Nutrition and Food Sciences, Technische Universität München in Germany.



**Figure 1** Bland-Altman plots of the differences between whole blood samples and both the palm (panel A) and forearm (panel B) digital readings



**Figure 2.** Panel A displays paired values of the digital registration and whole blood sample from the 70 subjects who produced a valid palm registration with the Haemospect®. Panel B displays paired values of the digital registration and whole blood sample from the 60 subjects who produced a valid forearm registration with the Haemospect®. Panel C represents paired values of registrations from the Haemospect® taken at the palm and forearm sites among the 55 subjects who provided viable readings at both sites.

## Expenditures and household investment in complementary foods during the first 6 months of Life

Raquel Campos and Liza Hernández

Food accessibility is determined by income and food prices. More nutritious diets are often more expensive, and consequently out of the reach of financially-constrained families.

In this analysis, we determine the cost of the complementary food items, and estimate the relative “cost” and “expenditure” for the macronutrients in the complementary foods offered to infants of rural and urban areas of Guatemala; we also estimate the expenditure needed to provide adequate protein intake to infants.

Sixty-four infants from Santo Domingo Xenacoj, a rural town in Guatemala, and 64 infants from a low-income area of Guatemala City, participated in the study. Infants were aged 6 to 11 mo at recruitment. Intakes were based on 3 non-consecutive maternal 24-h recalls of foods given to the infants. The food cost for three days in USD was estimated using the prices for food items, obtained from the local town market in the rural area (94 food items), and from supermarkets and markets in the urban area (140 food items).

Cumulative costs for the items in a child’s diet, there was a greater outlay for infants above 9 mo than for those below this age in the rural, but not the urban areas. With respect to the mean and median total expenditure overall by area, rural families spent  $0.36 \pm 0.24$  USD per child-day (median: 0.35 USD), significantly lower than the  $66 \pm 0.46$  USD (median: 48 USD). Highest expenditure for total consumption by the top ten foods (Table 1) and by serving size offered was determined in each residential area. Macronutrients costs in USD were calculated using two methods: 1) Individually: disaggregating by cost per macronutrient in relation to the relative contributions to total energy intake and then averaging; and 2) cumulatively: estimating from purchase of the composite food items the expenditure needed to cover 80% of the total reported intake per macronutrient (Table 2).

The expenditure for food sources to cover protein of the Recommended Nutrient Intake (RNI, WHO/FAO, 2004) was estimated prioritizing least expensive sources. The most expensive specific food items by standard portion size were Pedisure® in the rural area and Nan Soya® infant formula in the urban area.

One interest finding was that, whereas tap water was used exclusively in the rural area, bottled water was the norm in urban homes; it constituted the third highest expenditure item in the latter zone, representing a daily cost of  $0.03 \pm 0.02$  USD (5% of the total cost of feeding infants); however, the prevention of household expenses for diarrhea infections that may be caused by contaminated tap water could compensate this cost. The family expenditure for food sources to cover protein needs of infants recommended in the WHO/FAO RNI (2004) was 0.27 USD in the rural area and 0.41 USD in the urban area. For both, this represented 63% of total daily expenditure.

In conclusion, the choice of complementary feeding and the daily expenditures differed between mothers from the two settings, probably because the greater variety and higher disposable income in

### References:

Drewnowski A, Darmon N.(2005). *The economics of obesity: dietary energy density and energy cost* Am J Clin Nutr. 82 (suppl):265S-73S.

WHO & FAO (2004) *Vitamin and mineral requirements in human nutrition, Second edition*. World Health Organization, Food and Agriculture Organization.



Raquel Campos and Liza Hernández are Research Nutritionists at CeSSIAM

Noel Solomons is the Scientific Director of CeSSIAM

**Table 1** Top ten of food items with the highest expenditure by area

No.	Rural Area	Urban Area
1	White rolls	Nan 1® infant formula
2	Beef broth	Nan 2® infant formula
3	Green chayote	Bottled water
4	Pasta	Beans broth
5	Incaparina® gruel	Nestum® rice cereal
6	Mashed beans	Apple baby food
7	Boiled egg	Nido crecimiento® enriched bovine milk
8	Maize tortilla	Coffee
9	Nestum® wheat-milk	Mashed beans
10	Apple baby food	Potatoes

**Table 2** Prorated cost (individually) and the expenditure (cumulatively) in USD for each

	INDIVIDUALLY Mean±SD (Median)			CUMULATIVELY Σ sum	
	Rural Area n=64	Urban Area n=64	P value	Rural Area n=64	Urban Area n=64
Protein	0.08±0.05 (0.07)	0.11±0.10 (0.08)	0.098	0.20	0.39
Carbohydrates	0.24±0.17 (0.22)	0.43±0.30 (0.35)	<0.001	0.12	0.37
Fat	0.01±0.01 (0.01)	0.10±0.10 (0.04)	<0.001	0.20	0.31

## List of recent CeSSIAM Publications

Solomons NW, Schümann. The Rainer Gross Legacy. *Nutriview* 2010/3:2-4.

Vossenaar M, Sinak C, Montenegro-Bethancourt G, Bermudez OI, Groeneveld I, Doak CM, Solomons NW. Concordance with selected population recommendations for cancer prevention among third- and fourth-grade schoolchildren in Quetzaltenango, Guatemala. *Food Nutr Bull* 2010;31:181-192.

Solomons NW. Bioethics and Innovation in Pediatric Nutrition Research. *Nestle Nutr Workshop Ser Pediatr Program*. 2010;66:173-189.

Montenegro-Bethancourt G, Vossenaar M, Doak CM, Solomons NW. Contribution of beverages to energy, macronutrient and micronutrient intake of third- and fourth-grade schoolchildren in Quetzaltenango, Guatemala. *Matern Child Nutr* 2010;6:174-189.

Montenegro-Bethancourt G, Vossenaar M, Doak CM, Solomons NW. Total daily water intake in Guatemalan children. *Food Nutr Bull* 2009;30:340-350.

Bermudez OI, Toher C, Montenegro-Bethancourt G, Vossenaar M, Mathias P, Doak C, Solomons NW. Dietary intakes and food sources of fat and fatty acids in Guatemalan schoolchildren: a cross-sectional study. *Nutr J* 2010;9:20.

Orozco MN, Solomons NW, Schümann K, Friel JK, de Montenegro AL. Antioxidant-rich oral supplements attenuate the effects of oral iron on in situ oxidation susceptibility of human feces. *J Nutr* 2010;140:1105-1110.

Vossenaar M, Bermúdez OI, Anderson AS, Solomons NW. Practical limitations to a positive deviance approach for identifying dietary patterns compatible with the reduction of cancer risk. *J Hum Nutr Diet* 2010;23:382-392.

Montenegro-Bethancourt G, Vossenaar M, Kuijper LD, Doak CM, Solomons NW. Ready-to-eat cereals are key sources of selected micronutrients among schoolchildren from public and private elementary schools in Quetzaltenango, Guatemala. *Nutr Res* 2009;29:335-342.

Enneman A, Campos R, Hernández L, Palma AV, Vossenaar M, Solomons NW. Contribution of complementary foods to the total daily water needs of urban Guatemalan infants. *J Hum Nutr Diet*. 2010 (in press)

Mazariegos M, Hambidge KM, Westcott JE, Solomons NW, Raboy V, Das A, Goco N, Kindem M, Wright LL, Krebs NF. Neither a zinc supplement nor phytate-reduced maize nor their combination enhance growth of 6- to 12-month-old Guatemalan infants. *J Nutr* 2010;140:1041-1048.

Alvarado VJ, Mayorga E, Molina S, Solomons NW. Correspondence of two procedures to measure abdominal circumference in a convenience sample of urban, middle-class schoolchildren in Guatemala City. *Asia Pac J Clin Nutr* 2010;19:14-21.

Campos R, Montenegro-Bethancourt G, Vossenaar M, Doak CM, Solomons NW. Volume, frequency and participation in plain drinking water consumption by third and fourth-grade schoolchildren in Quetzaltenango, Guatemala. *Asia Pac J Clin Nutr* 2009;18:164-170.

Enneman A, Hernández L, Campos R, Vossenaar M, Solomons NW. Dietary characteristics of complementary foods offered to Guatemalan infants vary between urban and rural settings. *Nutr Res* 2009;29:470-479.

Vossenaar M, Solomons NW, Valdés-Ramos R, Anderson AS. Concordance with dietary and lifestyle population goals for cancer prevention in Dutch, Scottish, Mexican, and Guatemalan population samples. *Nutrition* 2010 Jan;26:40-52.

Solomons NW. Developmental origins of health and disease: concepts, caveats, and consequences for public health nutrition. *Nutr Rev* 2009;67 Suppl 1:S12-S16.

## List of CeSSIAM Abstracts

II WORLD CONGRESS OF PUBLIC HEALTH NUTRITION & I LATINAMERICAN  
CONGRESS OF COMMUNITY NUTRITION, Porto, Portugal, 23 to 25 September



- Adaptation of an analytic method for the quantification of reactive oxygen species (ROS)** Arriaga, Claudia<sup>1</sup>, Orozco, Monica<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Cost calculation of complementary foods of infants aged 6 to 12 months in rural and urban areas of Guatemala** Campos, Raquel<sup>1</sup>, Hernández, Liza<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Household expenditures of complementary foods in rural and urban areas of Guatemala: the bottled water factor** Campos, Raquel<sup>1</sup>, Hernández, Liza<sup>1</sup>, Vossenaar, Marieke<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Cost Calculation of Macronutrients and Macronutrient-Sources in Complementary Foods of Infants aged 6 to 12 months in Guatemala** Campos, Raquel<sup>1</sup>, Hernández, Liza<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Correspondence of a non-invasive, cutaneous-contact method to determine hemoglobin values with conventional whole blood samples in a Guatemalan field setting** Crowley, Caitlin<sup>1</sup>, Montenegro-Bethancourt, Gabriela<sup>1</sup>, Arriaga, Claudia<sup>1</sup>, Schumann, Klaus<sup>2</sup>, Solomons, Noel W.<sup>1</sup>
- Calibration of a Portable, Non-Invasive, Short-Contact-Time, Digital Hemoglobin-Assay Device with Whole Blood under Field Conditions in rural Guatemala** Crowley, Caitlin<sup>1</sup>, Montenegro-Bethancourt, Gabriela<sup>1</sup>, Schumann, Klaus<sup>2</sup>, Solomons, Noel W.<sup>1</sup>
- Abdominal and total adiposity and the risk of obesity in Guatemalan adults** Hernández, Liza<sup>1</sup>, Mazariegos, Manolo<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Body mass index and waist-to-height ratio for predicting hypertension in two aged groups of Guatemalan adults** Hernández, Liza<sup>1</sup>, Mazariegos, Manolo<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Validity of self-reported weight among women from the highlands of Guatemala** Hernández, Liza<sup>1</sup>, Mazariegos, Manolo<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Is there a secular trend in nixtamalized maize contribution to urban institutional menus in Guatemala?** Mayorga, Evelyn<sup>1</sup>, Soto, María José<sup>1</sup>, Vossenaar, Marieke<sup>1</sup>
- Application of non-invasive salivary collections for DNA sampling for metabolism-related polymorphisms studies in nutrition: the case of bcr1** Montenegro-Bethancourt, Gabriela<sup>1</sup>, Solomons, Noel W.<sup>1</sup>, Lietz, Georg<sup>3</sup>, Sud, Sohil<sup>4</sup>, Schumann, Klaus<sup>2</sup>
- Vitamin D and circulating blood glucose in elderly Mayans** Montenegro-Bethancourt, Gabriela<sup>1</sup>, Solomons, Noel W.<sup>1</sup>, Bermudez, Odilia<sup>4</sup>, Sud, Sohil<sup>4</sup>, Heaney, Robert<sup>5</sup>, Armas, Laura<sup>5</sup>
- Production of reactive oxygen species (ROS) in the colon in response to supplementation with three different types of iron supplements in healthy male adults** Orozco, Mónica<sup>1</sup>, Arriaga, Claudia<sup>1</sup>, Solomons, Noel W.<sup>1</sup>, Schumann, Klaus<sup>2</sup>
- Fecal generation of reactive oxygen species (ROS) in women from rural and urban areas of Guatemala** Orozco, Mónica<sup>1</sup>, Arriaga, Claudia<sup>1</sup>, Solomons, Noel W.<sup>1</sup>, Schumann, Klaus<sup>2</sup>
- Comparison of two methods (ELISA and Ridaquick dipstick test) for the diagnosis of Giardia colonization in young children** Ríos, María José<sup>1</sup>, Montenegro-Bethancourt, Gabriela<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Plasma iron (Fe) response to weekly iron supplementation: comparative results between iron-deficient women and non-deficient men** Romero-Abal, María Eugenia<sup>1</sup>, Solomons, Noel W.<sup>1</sup>, Günter Weiss<sup>6</sup>, Klaus Schumann<sup>2</sup>
- Self reported physical activity and BMI among school-aged children of Guatemala City** Romero-Abal, María Eugenia<sup>1</sup>, Alvarado, Virginia<sup>1</sup>, Solomons, Noel W.<sup>1</sup>
- Dietary fiber consumption in a sample of rural and urban Guatemalan adult women** Soto, María-José<sup>1</sup>, Campos, Raquel<sup>1</sup>, Hernández, Liza<sup>1</sup>