Original Article

Seasonal variation in the nutritional status of children aged 6 to 60 months in a resettlement village in West Timor

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Childhood malnutrition remains a public health issue in Indonesia with a national prevalence of wasting of 13% and stunting of 36%. In rural areas nutritional status depends on local agriculture and may fluctuate in relation to harvest time. The aim of this study was to characterise seasonal variations in nutritional status in two resettlement villages in the Oesao district, Nusa Tenggara Timur. A cross sectional study was conducted in a convenience sample of children after the wet season (March). Children aged 6 to 60 months were assessed for nutritional status using anthropometric and biochemical measures. A subset of these children was re-assessed for anthropometry after the dry season (November). Weight-for-height z scores improved significantly from mean±SD of -1.7± 0.9 in March to -1.3±0.9 in November (p<0.001). There was no significant change in height between seasons. Prevalence of wasting, (weight-for-height z score <-2), was 42% in March and 19% in November (p<0.001). However, stunting rates increased significantly from 42% in March to 45% in November (p<0.001). Thirty six per cent of children were anaemic (Hb level <11 mg/100 mL), 68% were vitamin A deficient (plasma vitamin A level <0.8 µmol/L) and 50% were zinc deficient (plasma zinc <9.94 µmol/L). All children except one were positive for intestinal parasites. These data indicate seasonal changes in anthropometry with inconsistent effects depending on the anthropometric index measured. Wasting and stunting were higher than the national average, alongside high rates of anaemia, zinc and vitamin A deficiencies.

Key Words: anthropometry, child, preschool, growth, malnutrition, micronutrients

INTRODUCTION

Childhood malnutrition rates remain a serious issue in Indonesia with national rates of underweight of 18% and stunting rate (WHO height-for-age z score <2) of 36% in 2010, in children less than 5 years old.[2] The national prevalence of wasting (WHO weight-for-height z score <2) of 13.3% remains a serious public health issue. Several rural provinces of Indonesia, where subsistence farming is practised, have a wasting prevalence higher than the national average.[2] In the province of Nusa Tenggara Timur, the incidence of underweight is reported as 19%, equivalent to the national average,[2] however, there are rural pockets within this province that have not been sampled and may have a much higher incidence.

In rural areas, subsistence farming is determined by seasonal climatic changes. Hence, seasonal food production is likely to impact on nutritional status, as has been shown in other parts of Asia,[3,4] and Africa.[5-7] Low income populations are also more likely to depend on cereal crops as staples, with limited amounts of the more nutrient-dense animal products in their diet. Predominantly plant based diets tend to be high in phytate and other anti-nutrients which inhibit absorption of important dietary minerals such as iron and zinc and result in micronutrient deficiencies.[8] Hence it is not only the quantity of food, but also the quality which impacts on nutritional status. The consequences of inadequate dietary intake during childhood include stunting and wasting, susceptibility to infections and sub-optimal cognitive development which

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Manuscript received 29 November 2012. Initial review completed 13 February 2013. Revision accepted 22 April 2013.
doi: 10.6133/apjcn.2013.22.3.10

perpetuates poverty.[9,10] Nutritional status is also impacted by environmental diseases such as parasitic infections and insect borne diseases.[10] There is a complex interplay between these factors: malnutrition increases susceptibility to disease,[10] and diseases such as environmental enteropathy reduce dietary absorption of micronutrients leading to further nutritional deficiencies.[11] Malaria and other infections may lead to reduced dietary intake and reduced work capacity in adult care-givers,[10] which in turn enforces poverty and money available for food.

In order to adequately plan for child health and nutrition programs, data on nutritional status from recent population based surveys are required. Within the province of Nusa Tenggara Timor, the Oesao district includes the resettlement villages of Manusak and Raknamo which are characterised by low socio-economic status, subsistence farming and high levels of food insecurity. The aim of the present study was to determine the seasonal variation in nutritional status and the burden of infectious disease in children aged between 6 and 60 months in the Oesao district, Nusa Tenggara Timor.

MATERIALS AND METHODS

Subjects and setting

A cross-sectional study was conducted in March 2010, at the end of the wet season (Time 1), in Manusak and Raknamo, two resettlement villages in Nusa Tenggara Timur. A follow-up field trip was conducted in November 2010, at the end of the dry season (Time 2). The months preceding Time 1 coincide with food shortage, where the previous year's harvest has run out and the current maize has just been harvested. Food is more plentiful for a few months between March and July and then starts to diminish again between August and November.

In 2010 there were a total of 656 households in the villages with a total population of 3, 621 people.[12] Four hundred and twenty five households (65%) were classified as below the poverty line, and a further 165 as borderline. The main occupation was farming (453/644) with a further 116 people employed in the army.[12] Families were recruited through notices in the local church service and by word of mouth. Inclusion criteria were children aged between 6 and 60 months, with a parent or guardian. Where there was more than one child within the age range in the family, all were eligible to be included in the study. Exclusion criteria were children with a major disability or those living outside the village area. This was a convenience sample of children living in the villages.

Ethical approval of the study protocol was granted by the Flinders Clinical Research Ethics Committee, Adelaide, South Australia. Informed consent was obtained from parents or guardians once the study had been verbally explained to them and they had the opportunity to consider the information and seek advice. All information was translated into Indonesian.

Medical and public health students from University Nusa Cendana (UNDANA), who were fluent in both Indonesian and English, served as interpreters and assisted with data collection.

Observations

At Time 1 a structured questionnaire was used to obtain socio-economic and demographic data, as well as health and sanitation behaviours such as access to water, toilets and waste disposal. A non-quantitated food frequency questionnaire (FFQ) was used to characterise the usual intake of key foods over the previous month. A clinical examination was performed by a paediatrician and past medical history and current medical problems were documented. Anthropometric measurements were taken as detailed below. A non-fasting blood sample was collected for a subset of children whose parents consented to this procedure and this was analysed for haemoglobin (Hb), vitamin A and zinc status. All children were invited to provide a faecal sample for examination of parasites. A ^{13}C-Urea Breath Test (UBT) for *Helicobacter pylori* and a timed blood dual sugar intestinal permeability test were also performed on a subset of children whose parent consented to this procedure.

At Time 2 only the anthropometric data for the children who attended at both time points (longitudinal cohort) will be considered for this analysis.

Anthropometry and nutritional status

Measurements of weight, height (or recumbent length if the child was less than 2 years of age), head circumference, triceps skin fold thickness (TSF) and mid-upper arm circumference (MUAC) were taken by two measurers, using standardised WHO procedures,[13] with children wearing light clothing. Each pair of measurers consisted of a senior measurer and a student from UNDANA. The senior measurers (LC, JM and COL) had significant experience in paediatric anthropometry. UNDANA students were provided with formal classroom training in performing anthropometric measurements according to World Health Organisation (WHO) guidelines Child Growth Standards Training Course.[14] Measurements were repeated if the discrepancy between the two original measurements was greater than acceptable (7 mm for height, 5 mm for circumferences and 2 mm for skinfolds) according to the WHO procedures.[13] Height or recumbent length was measured to the nearest 0.1 mm using a recumbent length board (O'Leary, Ellard Instruments, CA). Weight was measured with electronic digital scales (Propert, Australia) to the nearest 0.1 kg. Children too young to stand on the scales were measured by taring the scales with the mother standing on them, and then taking a measurement of the mother holding the infant or child. Head circumference (HC) and MUAC were measured with disposable paper tapes and triceps skin folds were measured with a Harpenden skin fold calliper (Baty, International Sussex, United Kingdom). Z-scores for weight-for-age (WAZ), weight-for-height (WHZ), height-for-age (HAZ), HC-for-age (HCAZ), MUAC-for-age and TSF-for-age were computed using the WHO Anthro software.[15] A HAZ, WAZ and WHZ score of less than -2 was used to define stunting, underweight and wasting, respectively. Severe stunting, underweight and wasting were defined as the relevant scores less than -3.

Biochemical data collection

A non-fasting blood sample of 5-10 mLs via venepuncture was collected, transferred into lithium heparinised tubes and refrigerated for 30-40 mins until blood clots

formed. The samples were then centrifuged at 3000 × g for 10 mins and the plasma samples were collected and stored in 2 separate tubes, one tube for Hb (refrigerated) and the other tube for zinc and vitamin A analyses. The latter samples were frozen at -20°C and transported in dry ice to Adelaide for analyses. Plasma samples for Hb analysis were transported on ice to Prodia Laboratory in Kupang, West Timor. Haemoglobins were measured using the Sysmex XT-1800i automated haemoglobin analyser (Sysmex Asia Pacific, Singapore). Hb of <11 mg/100 mL was classified as anaemia.[16] The plasma samples transported on dry ice to Adelaide were placed in a -20°C freezer immediately on arrival until analysis. Zinc analysis was performed on an Inductively Coupled Plasma Mass Spectrometer (Perkin Elmer Sciex, Elan II DRC; MDS Sciex, Concord, Ontario Canada). Briefly, samples were diluted 1:41; 100µL sample to 4.0 mL diluent (0.05% EDTA, 0.02% Ammonia and 0.02% Triton X-100), were mixed and centrifuged before analysis. A wash solution (2% nitric acid, 1.0% hydrochloric acid and 0.05% triton X-100) was used between samples. Zinc levels <9.94 µmol/L were classified as zinc deficient.[17,18] Vitamin A (retinol) was measured by reverse-phase HPLC using ultraviolet detection. A 100 µmol sample of plasma was deproteinised with ethanol. Tocopherol- acetate was added as an internal standard and the retinol was extracted into hexane. After centrifugation, an aliquot of the hexane phase was evaporated, re-suspended in methanol, injected onto a RP-18 column and eluted using methanol as the mobile phase. The absorbance of retinol and the internal standard are measured at 324 and 292 nm, respectively. Peak area ratios are used to quantify each vitamin.

Parasitology

Fresh faecal samples were examined within 4 hours of collection. The specimen was first examined macroscopically. A small amount of faecal material was then mixed with a drop of Lugol's iodine solution. This was covered with a coverslip and examined microscopically for the presence of helminth eggs and protozoan parasites.

^{13}C-Urea Breath Test (UBT) for helicobacter pylori and timed blood dual sugar intestinal permeability test

After a 4 hour fast, each subject received a solution to drink containing 75 mg of ^{13}C-urea (Novachem Pty Ltd, Vic, Australia), lactulose (5 g; Dupholac®, Solvay Pharmaceutical, NSW, Australia) and rhamnose (1 g; Sigma Aldrich, Sydney, Australia) dissolved in 70 mL of water. For the UBT, a baseline sample of expired air was collected immediately before administration of the substrate, by blowing through a straw and into a 10 ml vacutainer (Labco Exetainer, Buckinghamshire, UK) and a further sample collected 30 mins after administration of the substrate. The ratio of ^{13}C to ^{12}C in the breath samples was determined using isotope ratio mass spectrometry (Sercon, Australia) and results expressed as delta (δ) over baseline. The UBT was positive in this study if the δ over baseline was ≥5.0%.[19,20]

For the dual sugar intestinal permeability a minimum intake of 60 mL of the solution was required to ensure the test was valid. At 90 mins post drinking the solution a 5 ml blood sample was taken via venepuncture for measurement of lactulose/rhamnose (L/R) ratio, a marker of small intestinal permeability. Blood samples were placed in tubes containing EDTA, left on ice or refrigerated for 30-40 min and centrifuged at 3000 × g for 10 min to remove all blood cells. Plasma was collected, stored in cryovials and frozen at -20°C until analysis. For analysis of intestinal permeability, plasma samples were thawed and treated with ice-cold 15% trichloroacetic acid, samples were then centrifuged and the supernatant treated with 0.5 vol mixed-bed ion exchange matrix MTO-Amberlite MB-1 (Sigma Aldrich, Sydney Australia) for 30 mins. Samples were subsequently subjected to ultrafiltration. The treated plasma was analysed using the Dionex BioLC, High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection system (Dionex Pty Ltd, Lane Cove, NSW), chromatograms recorded and evaluated through a computer interface using Chromeleon Client Version 6.80 software. The measurement of lactulose and L-rhamnose were reported as a recovery L/R ratio as previously described.[21,22] Normal L/R ratio in healthy children has been previously reported with a mean of 2.5 and 95% confidence interval of 1.8-3.4.[22]

Statistical analysis

Statistical analyses were performed using PASW Statistics (IBM Version 18, USA) with statistical significance set at $p<0.05$. Descriptive data are presented as n (%) and mean±SD if normally distributed or median (25^{th}, 75^{th}) if not normally distributed. Paired t-test was used to determine the difference between anthropometry at the two time points for longitudinal cohort. Chi-squared was used to detect difference between categorical variables. Pearson's correlation was used to determine the relationship between plasma zinc and vitamin A concentrations. The difference in sample size for variables is typically due either to parents not consenting to certain procedures such as taking a blood sample, or children not adhering to the fasting protocol for the UBT for *Helicobacter pylori* and timed blood dual sugar intestinal permeability test.

RESULTS

Characteristics of participants and households

At Time 1, 139 children from 103 households participated in the study. The median age (25^{th}, 75^{th}) of children was 35 (18-47) months and 50% (n=70) were male. Eighty children from 55 households attended both visits (longitudinal cohort). Of the longitudinal cohort, at Time 1 the median age (25^{th}, 75^{th}) was 27 (16-41) months and 49% (n=41) were male.

The characteristics of the households, and the longitudinal cohort, are described in Table 1. Socio-demographic characteristics were similar for the whole group and the longitudinal cohort. Families were generally large, with a median of six members, one working member and one child under the age of 5. Approximately a quarter of the carers responsible for raising the child were illiterate. The majority of households were not connected to electricity or a generator nor were connected to a water supply.

Anthropometry

Anthropometric data for the longitudinal cohort are sum-

Table 1. Characteristics of households†

Characteristic	Attended Time 1 (n= 103)	Attended both times (Longitudinal cohort) (n=55)
Number of family members	6 (4, 8)	6 (4, 7)
Number of children <5 years of age in the family	1 (1, 2)	1 (1, 2)
Number of working family members	1 (1, 2)	1 (1, 2)
House connected to water supply	18 (18)	11 (20)
Mosquito netting used	88 (85)	47 (86)
Connected to electricity or generator	15 (15)	6 (12)
Wood used as cooking fuel inside the house	66 (64)	36 (67)
Person responsible for raising child is literate	74 (72)	42 (78)

†Data presented as median (25^{th}, 75^{th}) or n (%)

marised in Table 2 and these have been divided into age groups: 6 to 23 months and 24 to 59 months. With the exception of mean HAZ and MUACZ, all mean z scores improved between Time 1 and Time 2 in the whole cohort of children, as well as both age sub- groups. There was a statistically significant improvement in mean±SD WHZ scores between Time 1 and 2 (-1.76±0.87 and -1.33 ±0.88, respectively, $p<0.01$) and this effect was also seen in each age sub-group. WAZ scores also improved at Time 2 and this was statistically significant for the whole cohort (-2.16±1.04 to -1.98±1.01, $p=0.04$) but not for the age sub-groups. Mean TSF-for-age z scores increased significantly between the time points for the whole cohort (-0.64±0.86 and -0.37±0.86, respectively, $p=0.01$). However, this was only statistically significant for the younger age group (-0.71±0.92 to -0.26±0.87, $p=0.01$).

The prevalence of stunting (HAZ) and wasting (WHZ) for the longitudinal cohort at each time point is also summarised in Table 2. At Time 1 the prevalence (95% CI) of wasting was 34% (25-33) with the younger children more likely to be wasted compared to older children (42% (32-52) and 27% (18-36), respectively). At Time 2 the prevalence (95% CI) of wasting had significantly decreased for the whole cohort (19% (11-27), $p=0.001$). This was statistically significant for the older subgroup (14% (7-21), $p = 0.005$) but did not reach significance for the younger subgroup (28% (19-37), $p=0.16$). At Time 1 the prevalence (95% CI) of stunting was 45% (35-56) with the older children more likely to be stunted compared to the younger children (52% (42-62) and 36% (27-45), respectively). At Time 2 the prevalence of stunting significantly increased for the whole cohort (48% (38-58), $p<0.001$) as well as for the older- (55% (45-65), $p<0.001$) while it significantly decreased for the younger subgroup (39% (29-49), $p=0.002$).

Clinical data

Clinical data from Time 1 are summarised in Table 3. Of the 139 children who attended the March visit, 97 provided a blood sample. All of these were analysed for Hb but 11 samples were insufficient to allow for any further analysis and a further 10 samples were of sufficient volume to allow for zinc analysis but not vitamin A. Of the 97 samples tested for Hb, 68% of children aged 6 to 23 months and 23% of children aged 24 to 59 months were

Table 2. Longitudinal cohort anthropometric data†

Measure	Time 1 (March)			Time 2 (November)			*p*-value
	Whole cohort (n=80)	6-23 months (n=36)	24-59 months (n=44)	Whole cohort (n=80)	6-23 months (n=18)	24-59 months (n=62)	
HAZ	-1.68±1.46	-1.33±1.66	-1.97±1.22	-1.91±1.28 (n=79)	-1.5±1.75 (n=7)	-2.02±1.12	
WAZ	-2.16±1.04*	-2.04±1.15	-2.25±0.95	-1.98±1.01*	-1.87±1.31	-2.01±0.91	0.02 ‡
WHZ	-1.74±0.87*	-1.87±0.92	-1.64±0.83**	-1.33±0.88* (n=79)	-1.75±0.95 (n=17)	-1.22±0.83**	*<0.001 **<0.001‡
MUACZ	-1.42±1.02 (n=79)	-1.32±1.19 (n=35)	-1.49±0.87	-1.40±0.9 (n=78)	-1.17±0.94 (n=17)	-1.47±0.89 (n=61)	
TSFZ	-0.65±0.91* (n=79)	-0.78±1.0**	-0.55±0.83 (n=43)	-0.35±0.86* (n=78)	-0.26±0.87** (n=17)	-0.42±0.86 (n=61)	*0.009 **0.008‡
Wasting %, (95% CI)	34 (25-43)*	42 (32-52)	27 (18-36)**	19 (11-27)* (n=79)	14 (7-21) (n=17)	28 (19-37)**	*0.001 **0.005 §
Stunting %, (95% CI)	45 (35-55)*	52 (42-62)**	36 (27-45)***	48 (38-58)* (n=79)	39 (29-49)** (n=17)	55 (45-65)***	*<0.001 **<0.002 ***<0.001§

† Data presented as mean±SD unless otherwise specified
* denotes statistically significant difference between values with the same symbol in that row of the table
‡ Paired t-test
§ Chi-square test for independence with Yates continuity correction

Table 3. Clinical data from Time 1 [†]

Measure	All (total n = 139)	Age 6 to 23 months (total n = 49)	Age 24 to 59 months (total n = 90)	Longitudinal cohort (total n = 80)
	n/N [‡]	n/N	n/N	n/N
Immunisation (partial or full)	110/134 (82)	42/45 (93)	64/81 (79)	63/73 (86)
Vit A supplementation in last 6 months	74/118 (63)	29/42 (69)	45/76 (59)	43/67 (64)
Anaemic	35/97 (36)	19/28 (68)[*]	16/69 (23)[*]	23/55 (42)
Vit A deficient	52/97 (68)	16/21 (76)	36/55(66)	29/43 (67)
Zinc deficient	43/97 (50)	9/21 (42)	34/65 (52)	24/46 (52)
Positive for intestinal parasite	77/78 (99)	25/25 (100)	52/53 (98)	48/48 (100)
Episodes of cough in last 6 months	1.73±1.83 132/139	1.62±1.74 47/49	1.79±1.90 85/90	1.76±2.0 76/80
Episodes of diarrhoea in last 6 months	0.96±0.6 131/139	1.28±2.10 46/49	0.79±1.20 85/90	1.05±1.8 80/80
Episodes of skin infections in last 6 months	0.36±0.87 130/139	2.00±0.50 46/49	0.45±1.01 84/90	0.28±0.61 74/80

[†] Data represented as n (%) or mean ± SD
[‡] Incidence/number of participants either tested or who responded to question (whichever relevant)
[*] Statistically significant difference between age subgroups ($p<0.001$) (Chi-square test for independence with Yates continuity correction)

Table 4. Faecal Parasites

Parasite	Number of children infected (%) (n = 78)
All Protozoans	65 (83)
Giardia	48 (62)
All Helminths	30 (39)
Ascaris	9 (12)
Trichuris	1 (1.3)
Hookworm	13 (16.7)
Hymenolepsis	7 (9)
Fasciola	1 (1.3)

anaemic. Of the 86 blood samples that were analysed for zinc levels, 42% of children aged six to 23 months and 52% of children aged 24 to 59 months were zinc deficient. Seventy six blood samples were analysed for vitamin A and 76% of children aged 6 to 23 months were vitamin A deficient compared to 66% of children aged 24 to 59 months. There was a weak positive, non-significant correlation between serum zinc and vitamin A concentrations, r=0.2, p=0.08, n=72, using a Pearson product-moment correlation coefficient.

Seventy-eight children (56%) provided a stool sample and 99% of these tested positive for intestinal parasites, with giardia and hookworm the most common parasites (Table 4). Forty five children were tested for *Helicobacter pylori* infection and 8 (18%) were positive using the ^{13}C UBT. Seventeen children were tested for intestinal permeability using the L/R ratio. The mean±SD L/R ratio of these children was 59.6±22 and all children were above the threshold of 3.5 which is considered to be indicative of small intestine damage.[22]

Dietary intake and food security

Most households (87%) grew crops. Of those that grew crops, 79% grew them for household consumption only while 21% grew them for household consumption plus sale. The most commonly grown crops were corn, tubers and beans. Sixty six per cent of households also raised animals either for family consumption only (44%) consumption and sale (44%) or sale only (12%). The most commonly raised animals were chickens and pigs. Rice and corn were staple foods and were consumed a median of three times and once a day, respectively. Other commonly consumed food items included biscuits, peanuts, cassava and noodles. Cassava leaf and papaya leaf were the most commonly consumed vegetables and banana and papaya were the most commonly consumed fruits. Animal protein was consumed less frequently with milk and egg being the most commonly consumed. Nineteen per cent (n=27) of children did not report eating any animal protein over the last month and approximately half of these children (n=14) also did not report eating any vegetable protein within the last month. Thirty seven per cent of children were receiving food aid from the government, usually in the form of rice, and 86% were receiving supplementary feeding from a non-government organisation, usually fortified biscuits from the World Food Program which contained 8 g protein, 450 µgm vitamin A, 8 mg of both iron and zinc per 100 g. Almost all households reported experiencing food shortage at some time during the year. The peak times for reported food shortage were July through to February with August the most common month families experienced food shortage. Water shortage peaked during the months of July to November.

DISCUSSION

Overall, in this population, we observed significant improvements in weight between seasons but not height. Rates of anaemia, zinc and vitamin A deficiencies were high as was the burden of parasitic intestinal infections. In a subgroup examined small intestinal permeability was abnormal in all children.

All anthropometric indices, with the exception of HAZ and MUACZ, improved in November, possibly reflecting an improved food supply in the preceding months. This is consistent with other studies that have found the monsoon season, before the harvest, to be the time of greatest nutritional deficit.[4] However, the differences in some of the indices are small and should be interpreted with caution. For a girl of the median age at time 1 (35 months), the change in WAZ equates to approximately 240 g differ-

ence in weight. While clothing was similar at each visit other factors such as food and drink intake immediately prior to weighing or measurement error could account for some of this difference. The clinical and public health significance of this result is unclear without further monitoring over a longer time period. Similarly, the change in HAZ for a 35 month old girl equates to a difference in height of approximately 2 mm. Given that the allowed measurement error for height measurement was 7 mm it is unlikely that there has been a real difference.

In our study the mean WHZ for the whole cohort significantly improved from -1.74±0.87 to -1.33±0.88 between seasons and this small change was enough to reduce the incidence of wasting by almost half. A statistically insignificant change in HAZ between seasons in 24-50 month old children (-1.97±1.22 to -2.02±1.12) was enough to change the rate of stunting in the opposite direction from 36 to 55%. Thus small changes around the cut-off of stunting or wasting (<-2) can dramatically change the number of children who fall into this category and are indicative of the marginal nutritional status of this group.

The lack of difference in HAZ between seasons may be explained by growth tending to occur in spurts which often lag behind weight gain.[4,23] Alternatively it's possible that the quality of the extra food available between time points was poor and a lack of growth nutrients, such as zinc, may have affected linear growth. It is interesting to note that TSFZs in the whole cohort improved markedly between seasons with no significant change in MUACZ. This may indicate more energy stores being laid down as fat rather than an increase in muscle protein and could be secondary to poor protein intake. However, without body composition data we are not able to confirm this.

This is the first study to compare nutritional status of children of subsistence farmers in West Timor across seasons and confirms the seasonal fluctuations in growth. Dietary intakes were dictated by seasonal agricultural practices and were based on plant foods such as rice, maize and cassava leaf which contain high levels of anti-nutrients.[24,25] Our findings indicate that micronutrient deficiencies were relatively high, despite the fact that the majority of households received food supplements in the form of fortified biscuits from the World Food Program. Zinc deficiency was over double the prevalence indicative of a need for a national zinc intervention as recommended by the WHO/UNICEF/IAEA/IZiNCG Interagency Meeting on Zinc Status Indicators.[26] However, zinc supplementation without concurrently treating the environmental enteropathy may not be effective. Zinc is known to be an important growth nutrient and deficiency associated with stunting.[27] Rates of anaemia were also high with the children under 2 years of age having a prevalence rate almost 3 times higher than older children. This may be due to the use of nutrient poor weaning foods and heavy reliance on breast milk as well as maternal anaemia. Further research is warranted to address this issue. It is unclear why zinc deficiency was at a lower prevalence in the younger age group, in contrast with anaemia. This may be due to the small number of children under 2 who were tested (n=21).

A surprising number of children were also vitamin A deficient (68%) despite the fact that 63% of children reportedly received vitamin A supplementation within the previous 6 months and the majority consumed a vitamin A fortified biscuit. Zinc status is known to influence vitamin A metabolism,[28] however, in our data there was no significant correlation between serum zinc and vitamin A concentrations. Environmental enteropathy, as demonstrated from the abnormally high intestinal permeability results in those children tested, together with the high burden of intestinal parasitic infection are likely to be significant factors contributing towards malabsorption and the poor growth observed in this cohort of children.

This study has some limitations which should be mentioned. Firstly, this was a convenience sample of families who were recruited through the local church and although this area is predominantly Christian, this may have introduced some bias. However, as these were resettlement villages, the socio-economic status of the population is quite homogenous. Our dietary assessment tool was not quantitated and did not allow for an in-depth analysis of dietary intake. We were only able to collect biochemical data from a subset of children in the study and at only one time point. This was partly due to the logistical difficulties and cost of handling specimens in the field but also influenced by the families' resistance to this procedure. The changes in anthropometry seen between seasons are small, and given the inter-observer and measurement errors, these may not be significant. In addition, we were only able to measure the incidence of diarrhoea and respiratory infections at Time 1 and have not accounted for the possibility that differences in infection rate may influence anthropometry.

Despite these limitations, we have been able to collect some valuable cross seasonal information on this population, which may allow for more targeted interventions in the future.

In conclusion, seasonal variations in anthropometric measurements exist but this effect is small and different depending on which anthropometric index is examined. This has implications for the timing of population based surveys. This population of children have unacceptably high rates of wasting, stunting, micronutrient deficiencies and parasitic infections. Intervention strategies may have to be seasonally related for greatest effect. Health workers need to recognise this complex interplay of confounding factors in order to find a mix of interventions to address this problem.

ACKNOWLEDGEMENTS

The authors would like to thank the people of Raknamo and Manusak for participating in this study and to acknowledge the help of Sr Jacinta and her workers who helped with the field visit. Thanks also to students from Nusa Cendana for helping with the data collection and acting as interpreters.

AUTHOR DISCLOSURES

The authors declare no conflict of interest.

REFERENCES

1. Vaitla B, Devereux S, Swan SH. Seasonal hunger: A neglected problem with proven solutions. PLoS Med. 2009;6: e1000101. doi: 10.1371/journal.pmed.1000101

2. Agency for Health Research and Develoepment, Ministry of Health, Republic of Indonesia, Basic Health Research, Jakarta; 2010
3. Chen L, Chowdhury A, Huffman S. Seasonal dimensions of energy protein malnutrition in rural Bangladesh: The role of agriculture, dietary practices, and infection. Ecol Food Nutr. 1979;8:175-87. doi: 10.1080/03670244.1979.9990564
4. Brown KH, Black RE, Becker S. Seasonal changes in nutritional status and the prevalence of malnutrition in a longitudinal study of young children in rural Bangladesh. Am J Clin Nutr. 1982;36:303-13.
5. Maleta K, Virtanen SM, Espo M, Kulmala T, Ashorn P. Seasonality of growth and the relationship between weight and height gain in children under three years of age in rural Malawi. Acta Paediatrica. 2003;92:491-7. doi: 10.1111/j.1651-2227.2003.tb00584.x
6. Chotard S, Mason JB, Oliphant NP, Mebrahtu S, Hailey P. Fluctuations in wasting in vulnerable child populations in the Greater Horn of Africa. Food Nutr Bull. 2011;32(3 Suppl):S219-S33.
7. Branca F, Pastore G, Demissie T, Ferro-Luzzi A. The nutritional impact of seasonality in children and adults of rural Ethiopia. Eur J Clin Nutr. 1993;47:840-50.
8. Gibson RS, Perlas L, Hotz C. Improving the bioavailability of nutrients in plant foods at the household level. Proc Nutr Soc. 2006;65:160-8. doi: 10.1079/PNS2006489
9. Pelletier DL. The relationship between child anthropometry and mortality in developing countries: implications for policy, programs and future research. J Nutr. 1994;124(10 Suppl):2047S-81S.
10. Blössner Monika, de Onis Mercedes. Malnutrition: quantifying the health impact at national and local levels. Environmental Burden of Disease, Series 12. Geneva;WHO; 2005.
11. Gibson RS. The role of diet- and host-related factors in nutrient bioavailability and thus in nutrient-based dietary requirement estimates. Food Nutr Bull. 2007;28(1 Suppl Int): S77-100.
12. Ministry of Health Republic of Indonesia. Profil Kesehatan Indonesia Tahun 2011 [Indonesian Health Profile in the Year 2011]. Jakarta : Ministry of Health; 2012.
13. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull. 2004;25(1 Suppl):s27-36.
14. World Health Organisation. WHO Child Growth Standards, Training course on child growth assessment. 2006 [cited 2007 12th July]; Available from: http://www.who.int/childgrowth/training/en/.
15. World Health Organisation. WHO Anthro, Version 3, 2009. 2009 [cited 24/02/2010]; Available from: http://www.who.int/childgrowth/ software/en/.
16. World Health Organisation. WHO Global Database on Anaemia. 2006 [cited 2010 30/01/10]; Available from: http://www.who.int/vmnis/anaemia/data/en/index.html.
17. Hotz C, Peerson JM, Brown KH. Suggested lower cutoffs of serum zinc concentrations for assessing zinc status: reanalysis of the second National Health and Nutrition Examination Survey data (1976-1980). Am J Clin Nutr. 2003;78:756-64.
18. Karr M, Mira M, Causer J, Earl J, Alperstein G, Wood F, Fett MJ, Coakley J. Age-specific reference intervals for plasma vitamins A, E and beta-carotene and for serum zinc, retinol-binding protein and prealbumin for Sydney children aged 9-62 months. Int J Vitam Nutr Res. 1997;67:432-6.
19. Herold R, Becker M. 13C-urea breath test threshold calculation and evaluation for the detection of Helicobacter pylori infection in children. BMC Gastroenterol. 2002; 2:12.
20. Miwa H, Murai T, Ohkura R, Nagahara A, Watanabe H, Terai T, Watanabe S, Sato N. Usefulness of the [13C]-urea breath test for detection of Helicobacter pylori infection in fasting patients. J Gastroenterol Hepatol. 1998;13:1039-43. doi: 10.1111/j.1440-1746.1998.tb00567.x
21. Haase AM, Kukuruzovic RH, Dunn K, Bright A, Brewster DR. Dual sugar permeability testing in diarrheal disease. J Pediatr. 2000;136:232-7. doi: 10.1016/S0022-3476(00)70107-7
22. Kukuruzovic RH, Brewster DR. Small bowel intestinal permeability in Australian aboriginal children. J Pediatr Gastroenterol Nutr. 2002;35:206-12. doi: 10.1097/00005176-200208000-00020
23. International Dietary Energy Consultancy Group. Causes and Mechanisms of Linear Growth Retardation. Proceedings of an IDECG Workshop. London, January 15-18, 1993. Eur J Clin Nutr. 1994;48 Suppl 1:S1-216.
24. Montagnac J, Davis C, Tanumihardjo S. Processing techniques to reduce toxicity and antinutrients of cassava for use as a staple food. Compr Rev in Food Sci Food Saf. 2009; 8:17-27. doi: 10. 1111/j.1541-4337.2008.00064.x
25. S134-46Gibson RS, Bailey KB, Gibbs M, Ferguson EL. A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. Food Nutr Bull. 2010;31(2 Suppl):S134-46.
26. de Benoist B, Darnton-Hill I, Davidsson L, Fontaine O, Hotz C. Conclusions of the Joint WHO/UNICEF/IAEA/ IZiNCG Interagency Meeting on Zinc Status Indicators. Food Nutr Bull. 2007;28(3 Suppl):S480-4.
27. Golden MH. Proposed recommended nutrient densities for moderately malnourished children. Food Nutr Bull. 2009;30 (3 Suppl):S267-342.
28. Christian P, West KP Jr. Interactions between zinc and vitamin A: an update. Am J Clin Nutr. 1998;68(2 Suppl): 435S-41S.

Original Article

Seasonal variation in the nutritional status of children aged 6 to 60 months in a resettlement village in West Timor

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西帝汶移置村中 6 至 60 個月的孩童在不同季節的營養狀況

印尼全國兒童消瘦及發育遲緩的盛行率，分別為 13 及 36%，顯見兒童營養不良仍是印尼重要的公衛議題。鄉村地區居民的營養狀態取決於當地的農業，且可能隨產季波動。本橫斷面研究，觀察東努沙登加拉省 Oesao 區兩個移置村的兒童在不同季節的營養狀況變化。研究起始於雨季過後(三月)，以便利抽樣的方式召募當地 6 至 60 個月孩童。以體位及血液生化測量評估孩童的營養狀況。部分孩童於旱季過後(十一月)，再追蹤量測一次體位。三月份的體重-身高指數 Z 值(WHZ)為-1.7±0.9，十一月份顯著改善為-1.3±0.9 (p<0.001)。孩童身高在兩個季節間，並無顯著變化。三月份消瘦(WHZ<-2)比例為 42%，十一月時顯著下降至 19% (p<0.001)。然而，發育遲緩的比例從 42%上升至 45% (p<0.001)。受測孩童中 36%患有貧血(血色素濃度<11 mg/100 mL)；68%為維生素 A 缺乏(血漿維生素 A 濃度<0.8 μmol/L)；鋅缺乏比例為 50%(血漿鋅濃度<9.94 μ/L)。除一人外，其餘孩童腸道寄生蟲檢驗皆呈陽性。此資料顯示季節變化對於孩童體位影響不一致，而這取決於不同體位指標的測量。該地區孩童消瘦與發育遲緩比例皆高於國家平均值，且伴隨貧血、鋅及維生素 A 缺乏的高盛行率。

關鍵字：體位、孩童、學齡前、成長、營養不良、微量營養素