Food intake and nutrition in children 1–4 years of age in Yucatan, Mexico

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Abstract

Background: The National Health and Nutrition Survey 2006 (ENSANUT in Spanish) reported high rates of under-nutrition in children of Yucatan. Is food intake the main cause of under-nutrition in children of the state of Yucatan, Mexico?

Aim: Identify the primary causes of under-nutrition in pre-school children in Yucatan.

Subjects: A sample of 111 children (59 girls and 52 boys) aged 1–4 years representing Yucatan was taken from a database of ENSANUT 2006 and another national survey, a federal poverty mitigation programme for the state of Yucatan, Mexico entitled “Oportunidades”.

Methods: A human ecology approach together with life history theory was used to analyse anthropometric indices and food intake data from the ENSANUT 2006 and “Oportunidades”.

Results: Height and weight were significantly correlated to age and total food intake. No correlations were found between age and anthropometric indices or food intake rates. The children in the sample had adequate protein intake but deficient energy intake. No correlation was identified between nutritional status and food intake rates. Pre-schoolers with higher weight-for-height values achieved greater height-for-age. These relationships can be explained by life history theory in that energy intake was used either for maintenance (combating and recovering from infections) or growth.

Conclusion: The poor relationship between food intake rates and nutritional status is probably explained by the interaction between high disease incidence and insufficient energy intake. These conditions are endemic in Yucatan due to widespread poor housing, water and sanitation conditions.

Introduction

The pre-school stage in children (<5 years of age) is one of rapid body growth and brain development (Bogin, 1999). Proper body growth requires an adequate diet and height is a principal growth indicator. In pre-school children, the normal growth rate is near 3.2 cm in the first month of life, but begins to slow thereafter. Height in a normal newborn averages nearly 50 cm, increases to 74 cm after the first year and to 85 cm after 2 years. Synthesis of new tissue accounts for ~20% of the total energy required for body growth (Wiskin et al., 2011). Most immune system development occurs in humans during this stage and then slows after 5 years of age (Teran et al., 2011).

Child under-nutrition has been attributed different origins. Lindsay et al. (1992) suggested that child under-nutrition in Mexico was due to consumption of low protein quality, while Béhar (1977) stated that child under-nutrition in Guatemala was caused by consumption of low-calorie diets. Analysing study results from Guatemala, Mexico and Kenya, Lindsay (1995) determined that the poor relationship between food intake and child nutritional status is best explained in terms of micronutrient deficiencies.

The 2006 National Health and Nutrition Survey (ENSANUT 2006 is the Spanish acronym) in Mexico (Olaiz-Fernandez et al., 2006; Shamah-Levy et al., 2007) showed that preschoolers (<5 years of age) in the state of Yucatan (INSP, 2007) simultaneously exhibited high rates (20.3%) of stunting (WAZ or weight-for-age Z-scores; ranked fourth nationally) and overweight (10%; +2 WAZ or weight-for-age Z-scores; ranked third). Of the stunting rate, 19.3% represented rural areas and 26.3% urban areas. For overweight, 6.1% represented rural areas and 10.6% urban areas. The two most common diseases among children in Yucatan were diarrhoea and respiratory disorders. The incidence of diarrhoea in pre-school children was similar to that reported nationally (12.5%). Acute respiratory diseases were present in 38.2% of children under 10 years of age, a rate due at least partially to the state’s tropical climate. This rate was 16.6% higher than the national minimum rate (21.6%) and 4.5% higher than the national average (33.7%). Mean stunting, overweight and obesity values in Yucatan hide enormous variations between municipalities, the basic
The ENSANUT 2006 also reported estimated food intake rates for Mexico overall, as well as for regions such as the south (i.e. the states of Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatan) (Mundo-Rosas et al., 2009). Estimated national average energy intake among pre-schoolers was 92.4%, whereas in the south it was 84.6% (based on reference tables, Institute of Medicine, 2005). Mundo-Rosas et al. (2009) also observed statistically significant differences in energy intake among nutritional indices and socioeconomic levels in Mexico. Stunted pre-schoolers (<–2 HAZ) consumed 36.55% of the recommended energy intake, while overweight pre-schoolers (>–2 WHZ) consumed 61.2%. Using three socioeconomic status levels (high, intermediate and low), these authors reported recommended calorie intake rates of 52.1% for the high level, 48.3% for the intermediate and 33.9% for the low. In contrast, estimated protein intake was 308.6% at the national level and 275.9% in the south. States in the south had clear deficiencies in energy intake but not in protein intake.

Poverty rates (in terms of household income) in Yucatan are remarkable: 51.7% of the total population was poor and 18.1% had insufficient income to feed themselves (CONEVAL, 2008). Estimates in the ENSANUT 2006 also showed that overall livelihood in Yucatan was poor in terms of economic and social condition, with 39.4% of households belonging to the lowest income group (monthly household income <273 US$). Illiteracy in the population older than 15 years was 10.6% and in those younger than 14 years it was 7.7%. A shortage of running water, especially in the dry season, limited sanitation facilities: 23.7% of households had no exterior hook-up to a potable water system and 16.4% had no drainage. Other acute conditions included unavailability of safe drinking water, a shortage of interior space (4.7 persons per household) and a lack of medical coverage (54.4% of the population received no government medical support). As a result, a notable proportion of Yucatan’s population was at average levels below those of ENSANUT 2006 figures. The state also experienced a high prevalence of diseases associated with living conditions: for example, public and private medical units reported 631 000 appointments for respiratory ailments annually and 122 000 for gastrointestinal diseases and disorders (SINAVE, 2005).

Public policies intended to prevent malnutrition and improve nutrition in Mexico have been aimed primarily at food intake. They have provided nutrition courses, vitamins and micronutrient supplementation for pregnant women and school meals for children (Hernandez et al., 2003). Little importance has been given to other factors such as disease prevention and unhealthy living conditions. Pre-schoolers in Yucatan exhibited wide variability in nutritional status and food intake in the ENSANUT 2006 (cited in INSPI, 2006). The present study objective was to highlight possible alternative solutions to the serious human nutrition challenges among pre-school children in Yucatan by studying the relationships between anthropometric indices and food intake and how the resulting data can be applied to improve existing public health policy.

Available data for the population of Yucatan were analysed using a human ecology framework and life history theory. Human ecological principles were applied in which humans are considered as dynamic, internally controlled entities (systems) that are exposed to the environment from which they draw the information and energy needed to perform their living functions. The condition of these entities was defined by several dynamic and complex interactions between internal and external environmental components or factors. Specifically, life history theory (Oyama, 1985/2000; Perrin & Sibly, 1993) was used as a framework to highlight the main challenges and demands responsible for human nutritional status. The initial premise was that human beings, like all living organisms, utilize and store energy and are designed to grow, develop and function in physical, biotic and social environments. It was also assumed that the energy environment-mentally available to these systems was used in maintenance, growth and/or reproduction, but that once used for one of these functions the energy could not be forwarded to another function. Excess energy could be stored and used in the future for any one of these functions (Perrin & Sibly, 1993; McDade et al., 2008). Using this approach, human growth can be seen as a dynamic system that evolves and adapts to different and changing environmental conditions. The ENSANUT 2006 data provided the opportunity to identify the possible causes influencing nutritional status in pre-school children and, thus, support formulation of public policy aimed at improving child and overall welfare in Yucatan.

**Methods**

The overall analysis was based on data collected as part of the ENSANUT 2006 programme, as well as a complementary data sub-sample taken from the federal “Oportunidades” (meaning “opportunities” in English) poverty mitigation programme for Yucatan and obtained from the National Institute of Health (Shamah-Levy et al., 2007). This data was used to study the relationship between the major nutritional indexes and age and food intake. A human ecology approach was applied to better understand the factors behind nutritional status in this population and inform formulation of more effective public policies for improving pre-school child welfare programmes in Yucatan.

Samples were probabilistic and sampling was stratified by regions and clustered by households. The sampling unit was the household, defined as all persons, related or not, with some degree of kinship, usually sleeping in the same house or under one roof, who had a source of income provided by one or more of its members. In Yucatan, the ENSANUT 2006 survey sampled 1553 households and a total of 6985 persons, representing the state’s 1804 035 inhabitants at that time. A sub-sample from the “Oportunidades” programme covered 38.9% (n = 1263) of households in the programme. Anthropometric data were gathered by trained personnel who measured child height (length in children under 2 years) and weight following standard international
protocols. Birth date of pre-schoolers of both sexes was recorded as part of both surveys (ENSANUT 2006 and ‘‘Oportunidades’’).

A dietary intake questionnaire was prepared by trained personnel and standardized during data collection. The collected data were transformed into calories and proteins (Rodríguez-Ramírez et al., 2009). The questionnaire included 101 foods classified into 14 groups. For each food, items determined the number of days eaten per week, number of times eaten a day, portion size and number of portions consumed during the 7 days prior to the interview date. The questionnaire included types of food and serving size (very small, small, medium, large and very large). Serving size and weight were specific for each age group. By adding the sub-sample from the ‘‘Oportunidades’’ programme to the ENSANUT 2006 data, a more representative sample was created covering the state’s entire pre-school child population profile, including the poor. Data were included on protein intake (Prot), carbohydrate intake (Chdt), total calorie intake (Engkcl), proportion of calories recommended for age (kclRc) and its percentage (%kclR), protein recommended for age (ProtRc) and its percentage (%ProtR).

The anthropometric data from the ENSANUT 2006 included 237 subjects and that from the ‘‘Oportunidades’’ programme 77 subjects. Food intake data was available for 126 subjects. First, the ENSANUT 2006 and ‘‘Oportunidades’’ anthropometric records were merged and any subjects present in both eliminated. Second, the anthropometric and food intake records were matched and those with both data types selected for analysis. The final sample consisted of 111 records (59 girls and 52 boys).

The ENSANUT 2006 used WHO growth reference standards (WHO, 1995) to estimate standard deviation (Z) scores for height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ). Pre-schoolers with a WAZ score greater than 2 SD were classified as having excess weight (overweight or obese). Those with HAZ scores less than −2 SD (standard deviation) were designated as stunted.

The FAO/WHO/UNO (2004) recommended daily dietary energy and protein intakes by weight for pre-school children were used rather than those of the Institute of Medicine (2005). Although both references are similar, the first was chosen because its energy and protein requirements are worldwide estimates, while the second emphasizes US and Canadian populations. The recommended daily calorie intake for age and energy were calculated based on ideal weight reported by the WHO (1995) using interpolation based on simple linear regression functions.

Use of the anthropometric indices HAZ, WAZ, WHZ and body mass index (BMI), as well as the calorie proportion and protein intake values allowed comparison between pre-school children by age and sex. Body mass index (BMI) was calculated as a ratio of weight (kg) divided by height squared (m²).

Statistical analyses were run using the SPSS (version 15.0), Microsoft Excel (Version 2010) and Statgraphics Centurion XV computer programs. Pearson’s correlation and regression analyses were used to estimate both the amount and type of inter-relationships between variables. Fisher’s analysis of variance (ANOVA) was used to compare average values between populations at a 5% probability level.

Results
No differences were identified between sexes for mean age, body weight, height, HAZ, WAZ, BMI, protein intake and energy intake values, so the data for both sexes were pooled.

As expected, Pearson’s correlation coefficients between age and weight, carbohydrate intake and total energy intake were highly significant. Also as expected, correlation coefficients between age and HAZ, WAZ, WHZ and BMI were not significant. The age/protein intake correlation coefficient was also not significant.

The correlation coefficients between anthropometric indices and food intake (Table 1), clearly show a lack of correlation between anthropometric indices and different types of dietary intake rates. The HAZ, WAZ, WHZ and BMI indices did not correlate to protein, carbohydrate or total calorie intake, proportion of calories recommended for age or proportion of protein recommended for age. However, there was a positive correlation (0.1680) between the HAZ and BMI values, but it was only significant at a 7.8% probability.

The highly significant correlation (p < 0.00) between the HAZ and WHZ indexes (Figure 1) shows that the co-existence of stunting and excess weight (overweight + 2 Z) was relatively small. This indicates that the pre-schoolers did not have a high rate of malnutrition in terms of stunting and excess weight. It also shows the trend for these pre-schoolers to grow in height-for-age as weight-for-height values increased.

Average calorie and protein intake for different levels of HAZ showed a remarkable proportion (20.7%) of the analysed children to be stunted (Table 2). The value range showed no consistent pattern for average calorie and protein intake, expressed either as absolute values or as a percentage of total recommended intake. As expected, averaging intake minimized the effect of both daily variation and technical errors in data collection.

Contrasting average calorie and protein intake with different WHZ intervals showed wasting or overweight rates to be relatively low (Table 3). There was a pattern of decline in that calorie and protein intakes tended to decrease as WHZ rose.

The relationship between age and food intake in terms of calories compared to minimum recommended intake (FAO/WHO/UNO, 2004) shows children distributed both above and below the minimum recommended level, although a large proportion did have low calorie intake (Figure 2).

Age compared to protein intake rates showed the children to have an intake consistently higher than the recommended minimum (FAO/WHO/UNO, 2004) (Figure 3); they clearly did not suffer any protein intake deficiency. It is important to remember that both the minimum recommended energy and protein requirements (FAO/WHO/UNO, 2004) apply for healthy pre-school children, whereas a sick individual is reported to have minimum/average requirements 2–3 times higher than those of a healthy person (Powanda & Beisel, 2003).

Discussion
That age significantly correlated to weight, height and carbohydrate intake and exhibited no correlation with
Figure 1. Relationship between $Z$-scores of height-for-age (HAZ) and weight-for-height (WHZ) for 111 pre-school children in Yucatan, Mexico.

Table 1. Correlation coefficients between anthropometric and food intake variables and their significance level ($p$) for 111 pre-school children in Yucatan, Mexico.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Height</th>
<th>HAZ</th>
<th>WAZ</th>
<th>WHZ</th>
<th>BMI</th>
<th>Prot</th>
<th>Chdt</th>
<th>Engkcl</th>
<th>kclRc</th>
<th>%kclR</th>
<th>ProtRc</th>
<th>%ProtR</th>
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Table 2. Calorie and protein intake for height-for-age Z-score (HAZ) intervals for 111 pre-school children in Yucatan, Mexico.

<table>
<thead>
<tr>
<th>HAZ interval</th>
<th>Number of children</th>
<th>Frequency %</th>
<th>Mean kcal/day</th>
<th>Mean protein g/day</th>
<th>% Calorie intake</th>
<th>% Protein intake</th>
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</thead>
<tbody>
<tr>
<td>&lt; −2</td>
<td>23</td>
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<td>33.8</td>
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</table>

Table 3. Calorie and protein intake for weight-for-height Z-score (WHZ) intervals for 111 pre-school children in Yucatan, Mexico.

<table>
<thead>
<tr>
<th>WHZ interval</th>
<th>Number of children</th>
<th>Frequency %</th>
<th>Mean kcal/day</th>
<th>Mean protein g/day</th>
<th>% Calorie intake</th>
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anthropometric measurements or percentage of recommended food intake, confirmed the reliability of the analysed data. When compared to both absolute and proportional energy and protein requirements for pre-school children (FAO/WHO/UNO, 2004), the pre-schoolers in Yucatan exhibited insufficient calorie intake but adequate protein intake (Figures 2 and 3). These results coincide with other reports on pre-school children in Yucatan (Cuanalo et al., 2007; Rivera et al., 2001). They also agree with results for pre-school children in the states of southern Mexico, where pre-schoolers had an 84.6% average calorie intake rate and a 275.9% protein intake (Mundo-Rosas et al., 2009). Similar results have also been reported previously from Guatemala, Kenya and Mexico (Lindsay, 1995). Energy intake was deficient in the analysed sample, whereas protein intake was above recommended levels, suggesting that any sick individuals in the sample had energy and protein deficiencies (Powanda & Beisel, 2003).

No association between nutritional status and food intake was identified in the analysed sample when using correlation coefficients between nutritional status and dietary intake and the distributions of average dietary intake vs height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) Z-scores. Other socioeconomic factors were probably affecting the health and nutritional status of the sampled pre-school children.

A number of factors may have caused the lack of significant relationships between the anthropometric indices and food intake, including variation in daily intake, errors in the estimation technique and the effect of other variables (e.g., disease) on nutritional status in pre-school children. A lack of relationships between anthropometric indices and dietary intake in children, especially energy intake, has been reported in other studies in Mexico (Lindsay et al., 1992), Guatemala, Mexico and Kenya (Lindsay, 1995) and in Guatemala (Béhar, 1997). In these studies, the authors attributed malnutrition to type of food, food absorption problems and/or consumption of low quality protein.

More recent studies have drawn attention to the synergism between malnutrition and disease, noting the importance of an infection prevention policy against malnutrition (Scrimshaw, 2003). As mentioned above, both energy and protein intake requirements in unhealthy adults are 2–3 times higher than in healthy adults (Powanda & Beisel, 2003). Moreover, in an explanation of life history theory, McDade (2003) suggested that the lack of a relationship between growth and food intake can be attributed mainly to the developing immune system. This was later supported in a study showing that growth rate in children in Bolivia was directly related to immune activation, as estimated by the presence of C-reactive protein in the blood of children from

Figure 2. Relationship between age and real and recommended calorie intake for 111 pre-school children in Yucatan, Mexico.

Figure 3. Relationship between age and real and recommended protein intake for 111 pre-school children in Yucatan, Mexico.
2–4 years of age (McDade et al., 2008). In this study, growth rate in children decreased as blood C-reactive protein levels increased, except in individuals with a reserve of subcutaneous fat.

The present results for pre-school children in Yucatan can be explained using human life stages (Bogin, 1999), human ecology and life history theory. Childhood is a stage of near-zero energy expenditure for reproduction, which is why no significant difference was observed between the sexes, in anthropometric indexes and in calorie and protein intake rates (Table 1). Energy is therefore used solely for growth and maintenance and any excess is stored. The relationship between HAZ and WHZ (see Figure 1) indicated that the children with higher height-for-age and weight-for-height values grew in direct relation to their energy reserves. In addition, protein requirements for healthy children were satisfactory (Figure 2) and partially met standard calorie requirements (Figure 2). Consequently, if energy intake was used marginally in growth, it was used mainly for maintenance and in defending the children from illness. This suggests that the main cause of the poor nutritional status of pre-school children in Yucatan was a combined effect of chronic illness, low food intake and the interaction between them. Similar results have been reported for children in Bolivia (McDade et al., 2008).

The high rate of stunting in the sample was not due only to food intake shortfalls, but rather to overall poor socioeconomic conditions originating in the individual and combined effects of insufficient and unhealthy food intake; poor sanitation and housing conditions; improper clothing to protect against abrupt climatic changes; irregular availability of safe drinking water; and in many cases unrestricted contact with domestic animals. This interpretation is supported by the results of a study of pre-school children in the poor village of Tabi, Sotuta municipality, Yucatan (Cuanalo et al., 2007). The mothers of 43 under-nourished children (<5 years old) were counselled on how to improve their children’s dietary habits, but this failed to improve the children’s poor nutritional condition. This lack of improvement was better explained by recurring illness/recovery episodes that had a complex interaction with food intake. In another study in the same village in 2007 (Cuanalo et al., 2009), an analysis was done of length/height data for 44 children of either sex born between 1998–2000 and documented in the public health centre. The children were measured whenever they visited the health centre, a minimum of 19 times during their first 5 years of life. Of the total sample, five individuals of either sex were selected from those with the best nutrition status (i.e. high HAZ) and five others of either sex from those with the poorest nutrition status. None of these children (n = 10) had a history of either low birth weight (WAZ > 2 Z) or short length at birth (HAZ > 2 Z). The first group exhibited higher data variability than the second in the form of fluctuating HAZ values and had experienced repeated illness and recovery episodes. The sub-sample of under-nourished children exhibited lower HAZ than the first group and had been frequently ill and, therefore, unable to recover their height. All the children showed a minor recovery in height-for-age between 4–5 years of age, when the immunological system reaches full development.

Conclusions

A number of previous studies support the present results showing a deficiency of energy intake rather than protein intake in pre-school children in Yucatan. However, if it is considered that sick individuals require 2–3-times more energy and protein than healthy age-peers, the incidence of nutritional deficiency (stunting) and disease prevalence in the region can largely be explained by the frequency of illness among poor children. The available circumstantial evidence suggests that the lack of association between dietary intake and the studied anthropometric indices may be explained mainly by simultaneous and complex interactions between several variables including human growth stage (height growth, brain development, immune system development and growth), disease incidence and food intake. High disease incidence and the insufficient food intake observed in some cases were mainly due to the complex interaction of low income and poor housing conditions, a common situation in Yucatan.

Current public health policy prevents starvation but does little to prevent or cure under-nutrition in children. One of the primary factors affecting nutritional status in pre-school children in Yucatan is disease, since frequent illness negatively affects a child’s ability to develop properly. Therefore, the first step in preventing malnutrition in pre-school children is to lower disease frequency and intensity while increasing healthy food intake. Government health agencies (Public Health Ministry, clinics, hospitals, health centres) need to analyse living conditions in Yucatan and then create policies and actions that emphasize long-term disease prevention, rather than focusing primarily on treating existing disease. In other words, an effective public malnutrition eradication programme will need to focus on preventative healthcare for poor children, including measures to improve their overall socioeconomic condition.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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