Short Report

Nutritional status and intellectual development in children: A community-based study from rural southern India

AMITA JACOB, LEAH THOMAS, KEZIA STEPHEN,
SAM MARCONI, J. NOEL, K.S. JACOB, JASMIN PRASAD

ABSTRACT

Background. There is a dearth of recent data on the relationship between nutritional status and intellectual development among children in India. To determine whether such a relationship exists, we studied children in a rural area of Tamil Nadu.

Methods. We stratified villages in Kaniyambadi block, Tamil Nadu, and recruited consecutive children who satisfied the study criteria. We assessed nutritional status by measuring height and weight and recording chronological age, and calculated indices weight-for-age, height-for-age, weight-for-height and their Z scores. We assessed intellectual development using the Indian adaptation of the Vineland Social Maturity Scale. We used a case–control framework to determine the relationship and logistic regression to adjust for common confounders.

Results. We recruited 114 children between the ages of 12 and 72 months. Z score means (weight-for-age −1.36; height-for-age −1.42; weight-for-height −0.78) were much less than 0 and indicate undernutrition. Z score standard deviations (weight-for-age 1.04; height-for-age 1.18; weight-for-height 1.06) were within the WHO recommended range for good quality of nutrition data suggesting reduced measurement errors and incorrect reporting of age. The frequency distributions of population Z scores suggest high undernutrition, wasting and medium stunting. A tenth of the population (9.6%) had values to suggest borderline/below average intelligence (social quotient $\leq$89). Lower height-for-age, height-for-age Z score and weight-for-height Z score were significantly associated with a lower social quotient. These relationships remained statistically significant after adjusting for sex and socioeconomic status using logistic regression.

Conclusion. Chronic undernutrition, wasting and stunting and their association with lower intellectual development demand an urgent re-assessment of national food policies and programmes.

Natl Med J India 2016;29:82–4

Christian Medical College, Vellore 632002, Tamil Nadu, India
AMITA JACOB, LEAH THOMAS, KEZIA STEPHEN, SAM MARCONI, JASMIN PRASAD Department of Community Health
J. NOEL, K.S. JACOB Department of Psychiatry

Correspondence to K.S. JACOB; *ksjacob@cmcvellore.ac.in*

INTRODUCTION

Undernutrition among children in India is common and widely prevalent.[1,2] It has a major impact on their physical and mental health. It is known to affect brain growth and intellectual development through a combination of different mechanisms.[3] Children with brain damage, delayed physical growth and lethargy do not explore the environment, resulting in reduced intellectual stimulation. Delayed milestones in the child often result in lowered parental expectations and impact intellectual growth. Poverty, a primary cause of undernutrition, while increasing the risk of illness also results in a lack of access to educational and medical resources.[3]

The few studies done in India have reported cognitive and neuropsychological deficits in undernourished children.[4–6] We examined the relationship between nutritional status and intellectual development in a community setting in rural southern India.

METHODS

Setting

The study was done in Kaniyambadi block, Vellore district, Tamil Nadu. The Department of Community Health, Christian Medical College, Vellore, has been working in the area for over 50 years.[7] The block is a rural area and has a population of about 110 000. Agriculture and animal husbandry are the main occupations of the people of Kaniyambadi.

Design and framework

We assessed the nutritional status and intellectual development in children and used a case–control framework to evaluate risk factors for delayed intellectual development.

Sampling strategy

We used a stratified sampling technique to obtain a representative sample. We divided Kaniyambadi block into two sectors based on the approximate median distance from Vellore town. We randomly chose two villages from each sector as the study sites. We started from the centre of each village and enrolled local consecutive children aged between 12 and 72 months. We excluded children with a history of birth asphyxia, encephalitis, physical disability, stigmata of mental retardation or epilepsy.

Assessment

We used the following instruments to evaluate each child: (i) *Vineland Social Maturity Scale* (Malin's Indian adaptation).[8] It assesses motor, language, communication and self-help skills. It is used to calculate the social quotient (SQ), a proxy for intelligence quotient (IQ). The data on development was obtained from the mother. (ii) *Anthropometric assessment:* weight, height, mid-arm circumference and other clinical details (e.g. pallor, Bitot spots) were recorded. (iii) *Sociodemographic* and relevant information were recorded on a specially designed proforma, which included Kuppuswamy's socioeconomic status scale, details of health and immunization status, *balwadi* and school enrolment and attendance, etc.

Training of investigators

A clinical psychologist trained the investigators in the use of the instrument to assess SQ. A pilot study was done to familiarize the investigators.

Procedure

We explained the details of the study and obtained written informed consent. We interviewed the mothers and examined the children in their homes. We assessed developmental age prior to examining the nutritional status so that exposure did not bias outcome status.

Analysis

We calculated the SQ using the standard formula: developmental age/chronological age ×100. We also calculated the following nutritional indices: weight-for-age, height-for-age, and Z score for weight, height and weight-for-height. We compared the prevalence of undernutrition, wasting and stunting with the WHO recommended classification of severity based on population prevalence.[9–11]

We obtained descriptive statistics (mean, standard deviation) for continuous variables and frequency distribution for categorical data. We used chi-squared test and Student *t*-test for bivariate analysis. We used logistic regression to adjust for sex and socioeconomic status.

We calculated sample sizes, for the prevalence and case–control components of the study, using the computer program Epi Info (version 6.1). A prevalence of 15%[4] and a precision of 7% resulted in a sample size of 100. The sample size calculation was 105 using the following assumptions: confidence 95%, power 80%, case-to-control ratio 1:4, exposure in the case group 40% and exposure in the control group 10%.

RESULTS

One hundred and nineteen children were contacted. Five children were excluded because they had a history of seizures. The age and sex of the children excluded were not statistically significantly different from those included in the analysis.

The majority of the children were boys, were adequately immunized and attended *balwadi/*school. They came from low socioeconomic status households and the majority of their parents had high school education (Table I).

The Z score standard deviations for all indices for the population were all well within the WHO recommended range (height-for-age Z-score: 1.10–1.30; weight-for-age Z-score: 1.00–1.20; weight-for-height Z-score: 0.85–1.10) suggesting good quality of nutrition data with reduced measurement error and incorrect age reporting.

The fact that the Z score means for all the indices were much less than 0 indicate a shift to the left suggesting undernutrition in the population. The prevalence of stunting, underweight and wasting in the study population, using their respective Z score less than 2 standard deviation threshold, was 26.3%, 26.5% and 11.7%, respectively. This suggests high undernutrition and wasting, and medium stunting when compared with the WHO recommended classification of severity based on population prevalence.

About one-tenth of the population (9.6%) had values to suggest borderline/below average intelligence (SQ ≤89). The factors associated with a lower SQ were height-for-age, lower height-for-age Z score and lower weight-for-height Z score (Table II). These relationships remained statistically significant after adjusting for sex and socioeconomic status using logistic regression.

TABLE I. Sociodemographic and clinical variables

Characteristic	Mean (SD)	*n* (%)
Children		
Sex (girl)		54 (47.4)
Age (months)	38.6 (15.3)	
Birth weight (kg)	2.75 (0.42)	
Birth order—first born		48 (42.1)
Immunization adequate for age		108 (94.7)
Enrolment at *balwadi*		43 (37.7)
Attendance at *balwadi* ≥4 per week		41 (36)
Enrolment at school		28 (24.6)
Number of episodes of upper respiratory tract infection in the past year	5.3 (3.4)	
Number of episodes of diarrhoea in the past year	1.7 (2.2)	
Parental and family details		
Mother's age (in years)	27.0 (4.2)	
Mother's education (in years)	9.7 (2.9)	
Mother is housewife		102 (89.5)
Father's age (in years)	33.6 (4.5)	
Father's education (in years)	9.5 (3.2)	
Father employed		105 (92.1)
Total members in family	5.3 (1.97)	
Number of children in family	2.2 (0.8)	
Highest education in family (in years)	10.8 (2.54)	
Family income (₹ per month)	6752.4 (6661.3)	
Kuppuswamy socioeconomic scale score	10.8 (3.5)	
House: *pucca* (brick wall and concrete roof)		99 (86.8)
Water from common tap		77 (67.5)
Use boiled water for drinking		43 (37.7)
Toilet at home		33 (28.9)
Access to private general practitioner healthcare		47 (41.2)
Nutrition status		
Weight (kg)	12.2 (2.7)	
Height (cm)	90.7 (10.4)	
Mid-arm circumference (cm)	14.5 (1.8)	
Weight-for-age	90.8 (11.2)	
Height-for-age	98.5 (5.9)	
Z score weight-for-age	–1.36 (1.04)	
Z score height-for-age	–1.42 (1.18)	
Z score weight-for-height	–0.78 (1.06)	
Z score for weight < –2 SD (underweight)		30 (26.3)
Z score for height <–2 SD (stunting)		30 (26.5)
Z score for weight-for-height <–2 SD (wasting)		12 (11.7)
Indian Academy of Pediatrics classification (weight-for-age)		
Normal		96 (86.2)
Grade I malnutrition		18 (15.8)
McClaren classification		
Normal		99 (87.6)
Short stature		14 (12.4)
Bitot spots present		1 (0.9)
Pallor present		5 (4.4)
Measures of intelligence (social quotient)		
Normal (≥90)		103 (90.4)
Borderline/below average (≤89)		11 (9.6)

DISCUSSION

This community-based study adds to the meagre literature from India on the impact of undernutrition, rampant in the population, on intellectual development. Its strengths include a representative population sample, and standard assessments of nutritional status and SQ. The study with its case–control framework has limitations of such design. However, prospective cohorts are expensive in terms of time, effort and money. The limitations include a small sample and the use of a test for developmental/SQ as a proxy for IQ. Nevertheless, elaborate tests traditionally used to assess diverse facets of intelligence and lobe function were considered

TABLE II. Nutritional factors associated with borderline/low average social quotient (SQ≤89)

Characteristic	Case (SQ≤89)	Control (SQ≥90)	Bivariate statistics t; df; p value	Adjusted statistics* OR CI; p value
Weight	12.13 (2.63)	12.25 (2.67)	–0.15; 112; 0.89	1.00; 0.77–1.30; 0.99
Height	87.86 (12.28)	91.05 (10.15)	–0.97; 111; 0.35	0.97; 0.91–1.04; 0.44
Weight-for-age	89.49 (11.04)	90.92 (11.28)	–0.40; 112; 0.69	0.98; 0.92–1.05; 0.61
Height-for-age	94.94 (4.66)	98.91 (5.89)	–2.16; 111; 0.03	0.84; 0.73–0.97; 0.019
Z score weight-for-height	–0.05 (1.25)	–0.85 (1.02)	2.20; 101; 0.03	2.24; 1.08–4.65; 0.031
Z score weight-for-age	–1.46 (1.13)	–1.35 (1.04)	–0.34; 112; 0.73	0.92; 0.48–1.76; 0.80
Z score height-for-age	–2.20 (0.92)	–1.33 (1.18)	–2.35; 111; 0.02	0.52; 0.28–0.97; 0.039

* adjusted for sex and socioeconomic status using logistic regression
The following variables were not significantly related to nutritional status: age, sex, mother's age, father's age, mother's education, father's education, socioeconomic status, adequate immunization, *balwadi* and school enrolment and attendance, birth order, birth weight, mid-arm circumference, pallor, Bitot spots, and number of episodes of diarrhoea and upper respiratory tract infection in the past year

impractical for use in a community-based population sample. Detailed dietary histories would have added information. However, many other details of socioeconomic status, parental education, details of housing and family, immunization status, birth order and weight, facilities at home, common medical illness and access to healthcare, which impact nutritional status were ascertained. Recent dietary history would not provide the overall picture while longitudinal and detailed dietary histories are difficult to obtain.

The high prevalence of undernutrition in the sample, despite many programmes (mid-day meal scheme, the Integrated Child Development Services, immunization, vitamin A and iron supplementation for children, iron and folic acid supplementation for pregnant mothers and food through the public distribution system) and a comprehensive community health programme deserves comment. Local data suggest a reduction in very severe undernutrition over the past few decades with kwashiorkor and marasmus now non-existent in the population. However, mild-to-moderate undernutrition continues to be common and is reflective of chronic poverty. Poor rainfall and drought conditions over the past many years have had a major impact on agriculture and animal husbandry, the main occupations in the region, resulting in chronic poverty and is reflected through undernutrition in children.

Undernutrition is a major public health concern in many low- and middle-income countries. Its impact on physical health and development is well recognized. The use of Z score to evaluate indices of nutritional status of this rural population and its comparison with internationally recommended standards highlights the continuing severity of the undernutrition epidemic in the region. However, the adverse effects of undernutrition on mental health and intellectual development are rarely highlighted. We confirm the results of investigations, which have reported the major impact of poor nutrition on intellectual development. The long-term impact of childhood undernutrition on adolescents and adults merits further study.

Wasting (indicative of severe weight loss often associated with acute starvation and/or severe disease) and stunted growth (reflecting suboptimal health and/or nutritional conditions) seem to be associated with poorer intellectual function. The levels of stunting recorded suggest poor socioeconomic conditions and frequent and early exposure to illness and/or inappropriate feeding practices.

India's many national nutrition programmes have reduced severe undernutrition with a considerable reduction in rates of kwashiorkor and marasmus. However, the nutritional status of India's poor continues to be alarming[12] and is confirmed by many indicators such as adult weights, heights, body mass index (BMI), percentage of undernourished children, mean birth weights, infant mortality rates, dietary intakes and unconfirmed starvation deaths.[1] Chronic hunger and undernutrition are widespread as they are invisible to the scientific eye. A simplistic classification of foods and indices, the search for low-cost diet, and an undue focus on calories resulted in cereal overload, nutritional depletion and the current crisis of hunger. Cheap rice and wheat grain, available through the public distribution systems, destroyed many other regional food options with their richer sources of nutrients. Mid-day meal schemes and school nutrition programmes, while improving the nutritional status of India's children, are unable to reverse the impact of the current cereal overload. Children unable to eat the amount of cereals required to even meet the daily calorie requirement, let alone ingesting a healthy balanced diet, end up with childhood undernutrition. The cereal overload leads to obesity and metabolic syndrome in adults in addition to lowered immunity, making them prone to infections and chronic disease.[1]

The costs in terms of intellectual development also have a major impact on the nation's economy. While there are no simple or cheap solutions, there is a need to rethink agricultural and food policies for India; not just for improvement in our physical health but also for improved intellectual development of our children.

REFERENCES

1 Shatrugna V. The career of hunger: Critical reflections on the history of nutrition science and policy. In: Zachariah A, Srivatsan R, Tharu S on behalf of the CMC-Anveshi Collective (eds). *Towards a critical medical practice: Reflections on the dilemmas of medical culture today.* New Delhi:Orient Blackswan; 2010:116–35.
2 Naandi Foundation. *The HUNGaMA Survey Report 2011.* Hyderabad:Naandi Foundation. Available at *http://hungamaforchange.org/HungamaBKDec11LR.pdf* (accessed on 10 Sep 2014).
3 Brown LJ, Pollitt E. Malnutrition, poverty and intellectual development. *Sci Am* 1996:38–43.
4 Kar BR, Rao SL, Chandramouli BA. Cognitive development in children with chronic protein energy malnutrition. *Behav Brain Funct* 2008;**4:**31.
5 Agarwal DK, Awasthy A, Upadhyay SK, Singh P, Kumar J, Agarwal KN. Growth, behavior, development and intelligence in rural children between 1–3 years of life. *Indian Pediatr* 1992;**29:**467–80.
6 Choudhary M, Jain A, Chahar C, Singhal AK. A case control study on specific learning disorders in school going children in Bikaner city. *Indian J Pediatr* 2012; **79:**1477–81.
7 Joseph A, Joseph KS, Kamaraj K. Use of computers in primary health care. *Int J Health Sci* 1991;**2:**93–101.
8 Bharatraj J. *Vineland social maturity scale and manual: Indian adaptation A.J. Malin, enlarged version.* Mysore:Swayamsiddha Prakasam; 1992.
9 WHO global database on child growth and malnutrition. WHO/NUT/97.4. Geneva:WHO; 1997. Available at *www.who.int/nutgrowthdb/about/introduction/en/index5.html* (accessed 3 Jan 2014).
10 World Health Organization. Physical status: The use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995;**854:**1–452.
11 WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. *Acta Paediatr Suppl* 2006;**450:**76–85.
12 Planning Commission, Government of India. *Addressing India's Nutrition Challenges: Report of the multi stakeholder retreat.* New Delhi:Planning Commission, Government of India; 2010. Available at *http://planningcommission.nic.in/reports/genrep/multi_nutrition.pdf* (accessed 3 Jan 2014).