YOUNG LIVES STUDENT PAPER

Dual Burden of Malnutrition in Andhra Pradesh, India:

Identification of Independent Predictors for Underweight and Overweight in Adolescents with Overweight Mothers

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Paper submitted in part fulfilment of the requirements for the degree of MSc in Public Health Nutrition, London School of Hygiene and Tropical Medicine, University of London.

The data used in this paper comes from Young Lives, a longitudinal study investigating the changing nature of childhood poverty in Ethiopia, India (Andhra Pradesh), Peru and Vietnam over 15 years. For further details, visit: www.younglives.org.uk.

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Young Lives
An International Study of Childhood Poverty

Dual burden of malnutrition in Andhra Pradesh, India:

Identification of independent predictors for underweight and overweight in adolescents with overweight mothers.

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Report of a project submitted in part fulfilment of the regulations for the degree of Master of Science in the Faculty of Medicine, University of London

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Table of Contents

Abbreviations

BAZ – BMI-for-age z-score

BMI – body mass index

HAZ – height-for-age z-score

MICS – Multiple Indicator Cluster Surveys

N/O – normal weight child/overweight mother household

O/O – overweight child/overweight mother household

OW/OB – overweight/obesity

SD – standard deviation

UNICEF – United Nations Children's Fund

U/O – underweight child/overweight mother household

WHO – World Health Organisation

List of tables and figures

Abstract

Background: The nutrition and epidemiologic transition is characterised by changes in diet and activity patterns, leading to the development of a double burden of malnutrition. At the household level this often manifests as an overweight mother and underweight child. However, child and adolescent overweight and obesity also appear to be on the rise in transitional countries, although it is not well studied. Parent and child overweight are associated, and overweight children have a greater risk of becoming overweight adults. Understanding why these two extremes of child malnutrition occur in households with an overweight mother is necessary for policy and programmes to target both effectively.

Methods: This study examined Young Lives data on 256 adolescents with overweight ($BMI>23kg/m^2$) or obese mothers ($BMI>27kg/m^2$) from India. Child weight status was determined using BMI-for-age z-scores based on the 2007 WHO reference median. The aim was to identify independent predictors of child over- and underweight in two categories of dual burden households: 61(23.8%) underweight child/overweight mother (U/O) households, 21(8.2%) overweight child/overweight mother (O/O) households. The reference category was 174(68.0%) normal weight child/overweight mother (N/O) households. Bivariate analysis was used to examine associations between child, parent and household-level indicators and household nutrition status. Polychotomous logistic regression techniques were employed to identify independent predictors of U/O and O/O households compared to the reference N/O households.

Results: After controlling for nutritional and sociodemographic variables, several indicators emerged as being significant. Households were less likely to be U/O compared to N/O if: the child was female (OR=0.35, $p<0.01$) or post-pubertal (OR=0.26, $p<0.01$) or BCG immunised (a proxy for care practice) (OR=0.44, $p<0.05$), or the maternal support network was larger (OR=0.20, $p<0.05$). Households were also less likely to be O/O compared to N/O if the child was female (OR=0.23, $p<0.05$). Relative risk of O/O was increased if the child was post-pubertal (OR=3.47, $p<0.05$) or if the child had a moderate diet diversity (OR=4.97, $p<0.1$). Conclusion: Both U/O and O/O double burden households are present in this sample. Longitudinal data suggests under- and overweight among children in this cohort are both increasing. Indicators for either type of household imply that social and physiological factors may be involved, but more research is required to better define these pathways. In the meantime, nutrition intervention programmes must recognise the existence of both extremes of malnutrition at population and household level, and incorporate this into their targeting strategies in order to manage the dual burden of malnutrition effectively.

1.0 Introduction

1.1 The nutrition transition

The nutrition transition is a continuous process occurring within all societies as patterns of diet and activity evolve over time, although the stage and speed of transition varies by country. In low and middle income countries, urbanisation and economic development have propelled a shift towards a "Westernised" diet and lifestyle. Although this has a positive influence on the reduction of undernutrition, infectious disease and child mortality, it is also characterised by an increase in the prevalence of overweight, obesity and non-communicable chronic diseases. The nutrition and epidemiologic transition in low and middle income countries has occurred at a much faster rate and at earlier stages of development than it did a century ago in countries that are now developed, largely due to the influence of globalisation, mass media and advances in technology[1].

1.2 Obesity patterns and the nutrition transition

The nutrition transition is typified by a greater consumption of fatty and energy-dense foods and decreased physical activity, both of which are linked with an increased prevalence of overweight and obesity (OW/OB)[2]. In some transitional countries, including Mexico, Thailand, China and Indonesia, the annual rate of increase exceeds that seen in developed countries[3]. High socioeconomic status, urban location and female gender are typically associated with OW/OB in adults[4], although this can differ depending on the stage of transition. Prevalence estimates vary by country, but in India, the focus of this study, a national survey measured overweight (body mass index, BMI $\geq 25 kg/m^2$) in women at 12.6%, escalating rapidly from 2.4% at age 15-19 to 23.7% in the 40-49 year age category[5]. A clear urban/rural contrast was also apparent in this survey, with 23.5% of urban women but only 7.4% of rural women overweight[5]. Measuring OW/OB in India is complicated by the fact that standard BMI cut-offs may be too high for Asian populations[6]. As a result the population at risk for obesity-related chronic disease may be even greater than indicated by these numbers.

Although an increased prevalence OW/OB was initially detected among adults[3], it is also emerging as a public health issue for children and adolescents in transitional countries. Child and adolescent obesity is a strong predictor of adult obesity[4], and the risk of OW/OB in this age group is increased if one or both parents is OW/OB[4,7]. Prevalence estimates vary considerably depending on the country, stage of transition and the reference standard and cut-points used to define overweight and obesity. Nationally representative estimates are virtually nonexistent, since anthropometric data on adolescents is often not included in national surveys. Studies on Indian adolescents have reported prevalences of overweight ranging from 5.9-17.8% for boys, and 6.3-15.8% for girls[8, 9].

Comorbidities and pathological consequences associated with OW/OB include chronic conditions such as cardiovascular disease, diabetes and certain forms of cancer. Together these contribute to as much as 50% of the total disease burden in low and middle income countries[10]. These dramatically reduce the productive life years of an individual and represent an enormous strain on health care systems already crippled by the costs of persistent undernutrition. Since OW/OB children are at high risk of becoming OW/OB adults[4] they are also at high risk of non-communicable diseases in adulthood[11]. In addition, the rise in adolescent OW/OB has been matched by an increase in metabolic syndrome in this age group[8], a major risk factor for chronic disease.

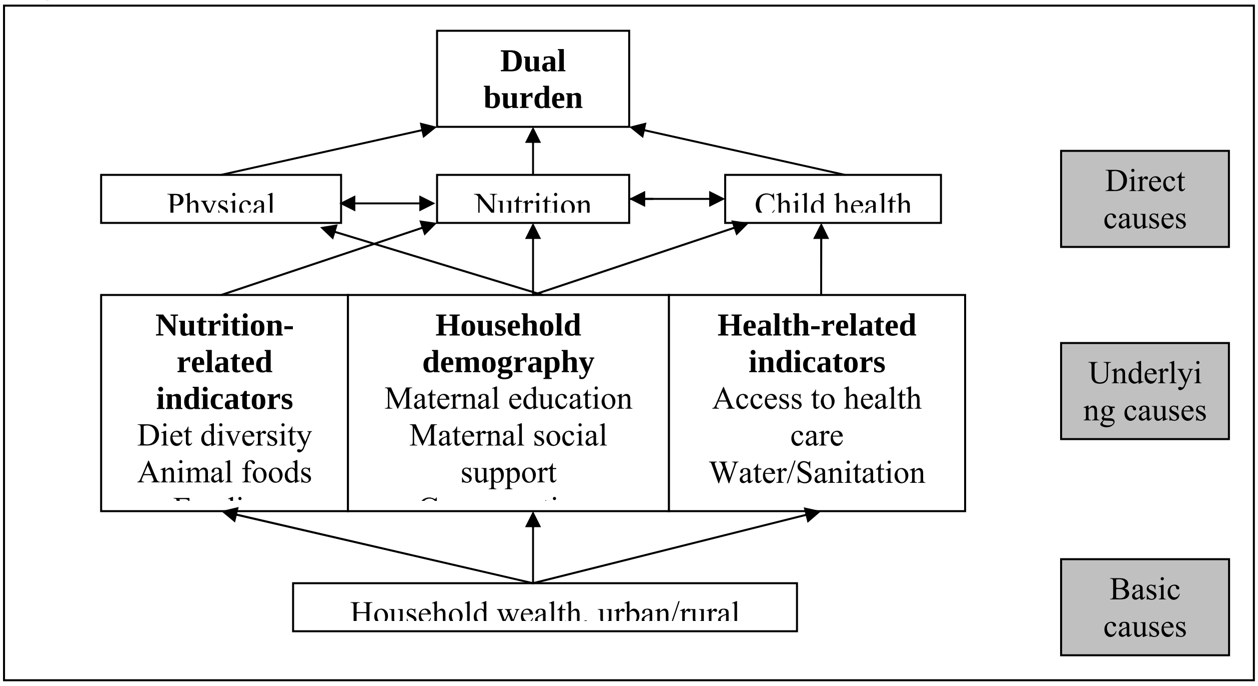
1.3 The double burden of malnutrition

A key feature of the nutrition transition is the existence of both extremes of malnutrition: underweight and overweight. This so-called "dual burden" of malnutrition is evident at population and household level[12], the most common manifestation being an underweight child and an overweight mother[13]. Households where both mother and child are overweight present another type of dual burden, one which is poised to become much more common as the nutrition transition progresses and undernutrition diminishes.

1.4 Conceptual framework of double burden households

The aetiology of both extremes of malnutrition is complex and multifactorial. Nutritional, biological, social, environmental and genetic factors are all involved, and may serve as useful indicators of specific groups at risk of becoming malnourished. Figure 1 shows a conceptual framework for the development of double-burden at the household level. It has been modified from the UNICEF conceptual framework of malnutrition[14] to incorporate known and hypothesised pathways of dual burden and adolescent overweight. The data used for this study precluded investigation of causal pathways involving early life nutrition, birthing details and genetic factors, so these have not been included in order to simplify the model. It is intended to show general directions of association rather than highly specific mechanisms.

Figure 1: Conceptual framework for development of dual burden households.



The central immediate cause of malnutrition is, unsurprisingly, nutrition, both in terms of diet quality and quantity. In particular, an increased consumption of animal food products has been linked to obesity in transitional countries[4]. Physical activity level interacts with nutrition to determine an individual's daily energy balance, which can affect body weight over the longer term. For children and adolescents this balance is especially important, as they require additional energy for growth and development. Child health status also interacts to alter nutritional status, both independently and through the malnutrition-infection cycle.

Underlying these direct causes are a variety of factors acting mainly at the household level. Food security (which incorporates access to, availability and utilisation of food) plays an important role in determining diet quality and quantity, with regular or prolonged shortages having serious implications for nutritional status. Household size and composition may affect food availability at the individual level depending on the intra-household food distribution. Maternal age and education[15] may affect childcare practices and access to information although it has also been suggested that a mother's power to put such knowledge into practice is limited by her standing in the household. Paternal influences have not been studied in much detail but there is some evidence that the education of the father[16], and his level of interaction with the child[17] may play a role in nutritional outcomes. Maternal social capital and support networks may alter childcare through information sharing and financial, material and psychological support. Finally, access to and utilisation of health care clinics and services, clean water and sanitation facilities are fundamental to preventing and treating child illness.

The basic causes influencing the more proximal factors are of course location and socioeconomic status. In transitional countries, urban location and high socioeconomic status are typically associated with OW/OB while the rural poor continue to be underweight, but again this depends on the stage of transition. Other potentially important factors that are not on the causal pathway include child age and gender, particularly if gender-biased care practices are evident[18]. In addition, timing of pubertal development may alter body size and shape[19] and is influenced by both age and sex.

1.5 Rationale

The dual burden of malnutrition presents a challenge for programme and policy-makers in transitional countries. Prioritising one extreme of malnutrition over the other is difficult on a limited budget, but undernutrition, especially in children under 5 years of age continues to be the main focus of research and health care spending. Overweight and obesity - particularly in adolescents - receives very little attention, and is difficult to quantify accurately in this age group due to rapid changes in growth and development, and a lack of consensus over which definition to use. As a result, there is limited understanding of the problem of dual burden and how best to manage it. Examination of the two extremes of malnutrition in households with overweight mothers may provide insight into the nature of dual burden and how to direct prevention strategies, both for the immediate problem of child underweight, and the rapidly increasing problem of child overweight.

1.6 Aims and objectives

The overall aim this study hopes to contribute towards is:

- To help inform policy and programmes in transitional countries to aid in effective management of the double burden of malnutrition and the emerging problem of child overweight, through identification of key indicators and risk groups.

The objectives of this study are two-fold:

- First, to describe the nutrition transition in Andhra Pradesh, India, in terms of two types of double burden households: child underweight/maternal overweight and child overweight/maternal overweight, and what characterises them.

- Second, to identify independent predictors of child nutritional status in households with an overweight or obese mother. To create a better picture of why both extremes of child malnutrition exist when the mother is more than adequately nourished, and who is most at risk.

2.0 Methods

2.1 Data background

The data for this study was provided by the Young Lives project (www.younglives.org.uk), a longitudinal international research project started in 2002 which is investigating the changing nature of childhood poverty. The project is tracking 3000 children (2000 aged 6-18 months and 1000 aged 7.5-8.5 years in 2002) in each of four developing countries: Ethiopia, India (Andhra Pradesh state), Peru and Vietnam. Comprehensive qualitative and quantitative data on individual, household and community-level variables were collected to allow for a wide variety of sub-set analyses to be conducted.

Young Lives is core-funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed here are those of the author. They are not necessarily those of the Young Lives project, the University of Oxford, DFID or any other funders. Ethical approval for the original project was obtained from all participating research institutions, including the London School of Hygiene and Tropical Medicine.

This study serves as a preliminary look at the quantitative second round data (collected in 2006), and focuses on children in Andhra Pradesh, India. Child anthropometric data from the first round (2002) was also used to describe longitudinal changes in child weight status. India was selected, as it is a country in the midst of rapid transition and a prime example of the double burden of malnutrition. It also provided an interesting opportunity to assess nutritional status in this population using the Asian-specific BMI cut-offs for adults[20] and the new WHO 2007 growth reference[21].

Ethical approval for this study was granted by the London School of Hygiene and Tropical Medicine Ethics Committee, approval #07/414.

2.2 Sampling and data collection

Twenty sentinel sites were selected purposively by the Young Lives team. Poor households were deliberately over-sampled using a relative development index created to rank administrative districts according to poverty status[22]. Within each site, 50 households containing a child aged 7.5-8.5 years were randomly sampled. Full details on the sample design and rationale have been published elsewhere[22, 23]. Quantitative and qualitative data were collected in 2002 (round one) and 2006 (round two) by fieldworkers trained in interviewing techniques and anthropometry[22]. Measurements were taken to the nearest 0.1cm for height and 0.1kg for weight. Child anthropometry was collected in rounds one and two but maternal anthropometry was only collected in round two. The data is cross-sectional and therefore inferences of causality cannot be made. Due to the sampling strategy, data are not representative at state or national level and therefore results can not be applied to the wider population.

2.3 Outcome: the dual-burden household

Maternal BMI was calculated from height and weight data. Women were classified as overweight (BMI>23kg/m^2) or obese (BMI>27kg/m^2) in accordance with the WHO recommended public health action points for Asian populations[20]. Child height, weight and age data were analyzed using a WHO macro for STATA to produce BMI-for-age z-scores (BAZ) as standard deviations (SD) relative to the 2007 reference median[24]. The following BAZ cut-points were used[21]: severe thinness (< -3SD), thinness (< -2SD), normal (-2SD to +1SD), overweight (> +1SD), obese (> +2SD). Extreme BAZ values (< -5SD; > +5SD) and extreme height-for-age z-scores (< -6SD; > +6SD) were excluded as outliers. For the analysis, thinness and severe thinness were grouped together and called "underweight", and overweight and obese were categorised as "overweight". For simplicity, and because the analysis did not distinguish between overweight and obesity, these two categories will collectively be referred to as "overweight" for both mothers and children, unless otherwise specified. The children studied may all be classified as adolescents, but will be referred to interchangeably as "children" or "adolescents".

All overweight mothers and the child they cared for were selected for the analysis. Each child/mother pair was classified into one of three outcome categories: underweight child/overweight mother (U/O), overweight child/overweight mother (O/O), and normal child/overweight mother (N/O) which served as the reference group.

2.4 Indicator variables

Most of the explanatory variables were decided *a priori*. A few more were added following close inspection of the data set, provided there was evidence for a plausible association with the outcome. Child, parental and household-level characteristics were all considered. For purposes of analysis, numerical variables were grouped into categories, and a reference group was defined.

Sex of child: coded as 1 for male (reference group), 2 for female.

Age of child (months): categorised as 133-143 (reference group), 144-147, 148-151 and 152-156 months.

Pubertal stage: coded 0 for pre-pubertal (reference group), 1 for post-pubertal. Female children were considered to have reached puberty if they had started having periods; males if they reported hair growth on their chin or a voice change.

Birth order: categorised as first (reference group), second, third and fourth or later.

Feeding frequency: categorised as 2-4 (reference group) and 5-7 times per day. Children were asked if they had eaten a morning, midday or evening meal, and anything outside of mealtimes in the past 24 hours. The maximum possible number that could be reported was seven times per day. Mothers were also questioned about their child's feeding frequency but due to discrepancies between the two sets of answers the "first-hand" child-reported data was used.

Diet diversity: categorised as 2-5 (reference group), 6, 7 and 8-11 food groups. Dietary diversity was measured as the number of unique food groups (out of 11[1]) the child had eaten from in the previous 24 hours. This indicator serves as a useful tool for measuring diet quality and the "access" dimension of food security[25]. Due to its sensitivity to small increases in diversity, care was taken to make the categories as narrow as possible without compromising the validity of the chi-squared test. Categories 6 and 7 had a large number of people in them and so they ended up as separate groups. As for feeding frequency, child-reported data was used instead of the mother's report.

Number of animal food groups consumed: categorised as 0 (reference group), 1 and 2-4 food groups. This was derived from diet diversity data, with a possible total of four food groups[2].

Physical activity: categorised as 1-4 (reference group), 5-6 and ≥7 hours per day. This indicator was calculated from time use data where children were asked how many hours they spent in various activities during a typical day. Time spent doing domestic chores, paid or unpaid work, looking after other children in the household and at leisure or play were all included as physical activity.

Maternal age (years): categorised as 24-30 (reference group), 31-35, 36-40 and ≥41 years.

Maternal education: categorised as none (reference group), any primary (1-5yrs), any upper primary (6-8yrs) and any secondary school or higher (≥9yrs)[26].

Maternal literacy: coded as 0 for no/with difficulty, 1 for yes. Measured as the mother's ability to easily read a newspaper or letter written in the local language of Telugu.

Paternal education: categorised the same way as maternal education, with the same reference group.

Frequency of father-child contact: coded as 0 for weekly or less often, 1 for daily contact.

Support network: categorised as 1-2 (reference group), 3-5, 6-10 and ≥11 people. The number of people the mother felt she could rely on in times of financial or material need.

Child is BCG immunised: coded as 0 for no, 1 for yes. This was used as a rough proxy measure for care practices, in terms of health services utilisation, since nearly all households (95.7%) reported having access to health care.

Wealth index, quartiles: categorised as poorest (reference group), very poor, less poor and better off. The index is a composite score of consumer durables, housing quality and access to services and is considered to be a more accurate reflection of socio-economic status in developing countries. It is based on work by the World Bank and Macro International and is used in the UNICEF Multiple Indicator Cluster Surveys (MICS)[27].

Location: coded as 1 for urban, 2 for rural.

Region: categorised as Coastal Andhra (reference), Rayalaseema, and Telangana.

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[1] Cereals; roots/tubers; legumes; milk/milk products; eggs; meat/offal; fish/seafood; oil/fat; sugar/honey; fruits; vegetables.

[2] Milk/milk products; eggs; meat/offal; fish/seafood.

Household size: categorised as 1-4 (reference group), 5-6 and ≥7 people, as reported by the primary caregiver.

Sex of household head: coded as 0 for male, 1 for female, as reported by the caregiver.

Ethnic group of household: categorised as Scheduled caste/Scheduled tribe (reference group), Backward caste and Other caste. Designated according to the father's ethnic group.

Improved water source: coded as 0 for unimproved, 1 for improved. Based on the classification developed by the World Bank and used in MICS[28].

Improved sanitation: coded as 0 for unimproved, 1 for improved. Based on the classification developed by the World Bank and used in MICS[29].

Access to health care services: coded as 0 for no, 1 for yes.

Food shortage in past year: coded as 0 for no, 1 for yes. Used as a rough indicator of food security.

2.5 Statistical analysis

All sorting, editing and analysis of data was carried out using Stata 10.0 software, and a macro downloaded from the WHO was used to calculate child anthropometric indices based on the WHO 2007 reference standard[24]. Range and consistency checks were carried out on all variables, and outliers or improbable values were recoded as missing.

Simple tabulations and proportions were used to summarise the data. Difference in mean child BAZ between the original and sub-sample were assessed using the z-test. Linear regression and ANOVA were used to compare maternal BMI to child BAZ.

Bivariate analysis was carried out using Pearson's chi-squared test for association between each indicator variable and the outcome. All variables showing a significance level of $p<0.1$ in the bivariate analysis were considered for inclusion in the multivariate analysis. Related variables were checked for correlation to avoid problems of multicollinearity and unstable logistic regression models. Pearson's correlation coefficient was used, or Spearman's Rho for non-normal distributions, or the chi-square test for categorical variables. If two or more variables were correlated, the decision whether to include them was based on their role in the causal pathway, strength of association with the outcome and effect on the model. Since the outcome was nominal categorical with three categories, polychotomous logistic regression was used. Regression results are interpreted as the likelihood (or odds, relative to baseline) that a given variable is associated with a given outcome category, compared to the reference outcome category. Robust errors were applied to account for any clustering effect resulting from the sampling strategy.

3.0 Results

3.1 Description of sample

The distribution of demographic and socio-economic characteristics in the sample can be seen in Table 1. During the initial round of data collection, 1008 children aged 7.5 – 8.5 years old were enrolled in the study. A small number of these (14) were lost to follow-up, resulting in a 98.6% response rate (n=994) for the second round of data collection. Following anthropometric data cleaning, 923 records remained. In this sample of 923, child underweight was prevalent at 32.6%, including 10.1% severe thinness, and child overweight was prevalent at 3.5%, inclusive of 0.8% obesity. Underweight and overweight prevalences were both considerably greater than at the first round of data collection when they were 25.8% and 1.2%, respectively.

In the sample of 923, maternal overweight was prevalent at 27.7% (inclusive of 9.6% obesity), which is considerably higher than the 12.6% overweight and 2.8% obesity that was reported for adult women by the 2006 Indian National Family Health Survey[5]. However, these results are not strictly comparable due to differences in sampling and the BMI cut-points used.

The final sub-sample analysed for this study consisted of 167 (65.2%) overweight and 89 obese mothers and their children, for a total sample of 256. All but one mother (99.6%) were the primary caregiver to their child. Among the children in the sub-sample, 23.8% were underweight and 8.2% were overweight (inclusive of 1.6% obesity), representing 65.5% of the overweight children in the original sample.

Table 1: Distribution of child, parental and household level indicator variables, by household type, with p-values corresponding to the chi-squared test for association.

	n*	All households n (%)	Household type (child/mother) U/O n (%)	O/O n (%)	N/O n (%)	p-value†
Sample size	256	256 (100.0)	61 (23.8)	21 (8.2)	174 (68.0)	-
Child characteristics						
Male child	256	116 (45.3)	39 (63.9)	11 (52.4)	66 (37.9)	0.002
Age in months						
133-143	256	48 (18.8)	12 (19.7)	2 (9.5)	34 (19.5)	0.57
144-147		61 (23.8)	13 (21.3)	8 (38.1)	40 (23.0)	
148-151		80 (31.2)	19 (31.1)	4 (19.1)	57 (32.8)	
152-156		67 (26.2)	17 (27.9)	7 (33.3)	43 (24.7)	
Median age, months (IQR)		149 (145-152)	150 (144-152)	148 (146-152)	149 (145-151)	-
Child is post-pubertal	256	71 (27.7)	6 (9.8)	10 (47.6)	55 (31.6)	0.001
Birth order						
First	256	88 (34.4)	18 (29.5)	8 (38.1)	62 (35.6)	0.7
Second		88 (34.4)	19 (31.1)	7 (33.3)	62 (35.6)	
Third		49 (19.1)	14 (23.0)	5 (23.8)	30 (17.2)	
Fourth or later		31 (12.1)	10 (16.4)	1 (4.8)	20 (11.5)	
Feeding frequency, # times/day						
2-4	256	127 (49.6)	31 (50.8)	7 (33.3)	89 (51.1)	0.297
5-7		129 (50.39)	30 (49.2)	14 (66.7)	85 (48.9)	
Diet diversity, # food groups/day						
2-5	256	97 (37.9)	29 (47.5)	4 (19.0)	64 (36.8)	0.016
6		71 (27.7)	16 (26.2)	11 (52.4)	44 (25.3)	
7		60 (23.4)	14 (23.0)	2 (9.5)	44 (25.3)	
8-11		28 (10.9)	2 (3.3)	4 (19.0)	22 (12.6)	
# of animal foods groups eaten						
0	243	46 (18.9)	10 (17.2)	3 (14.3)	33 (20.1)	0.045
1		132 (54.3)	40 (69.0)	9 (42.9)	83 (50.6)	
2-4		65 (26.8)	8 (13.8)	9 (42.9)	48 (29.3)	
Physical activity, hours/day						
1-4	253	101 (39.9)	17 (27.9)	8 (38.1)	76 (44.4)	0.081
5-6		83 (32.8)	20 (32.8)	9 (42.9)	54 (31.6)	
≥7		69 (27.3)	24 (39.3)	4 (19.0)	41 (24.0)	
Parental characteristics						
Maternal age in years						
24-30	256	57 (22.3)	15 (24.6)	4 (19.0)	38 (21.8)	0.752
31-35		114 (44.5)	23 (37.7)	10 (47.6)	81 (46.6)	
36-40		59 (23.0)	14 (23.0)	6 (28.6)	39 (22.4)	
≥41		26 (10.2)	9 (14.7)	1 (4.8)	16 (9.2)	
Mother is literate	256	100 (39.1)	18 (29.5)	15 (71.4)	67 (38.5)	0.003
Maternal education						
None	245	103 (42.0)	25 (44.6)	4 (19.0)	74 (44.0)	0.254
any primary (1-5yrs)		38 (15.5)	11 (19.6)	3 (14.3)	24 (14.3)	
any upper primary (6-8yrs)		36 (14.7)	8 (14.3)	4 (19.0)	24 (14.3)	
any secondary or higher (≥9yrs)		68 (27.8)	12 (21.4)	10 (47.6)	46 (27.4)	
Paternal education						
None	250	59 (23.6)	12 (20.7)	1 (5.0)	46 (26.7)	0.140
any primary (1-5yrs)		43 (17.2)	12 (20.7)	3 (15.0)	28 (16.3)	
any upper primary (6-8yrs)		33 (13.2)	9 (15.5)	1 (5.0)	23 (13.4)	
any secondary or higher (≥9yrs)		115 (46.0)	25 (43.1)	15 (75.0)	75 (43.6)	

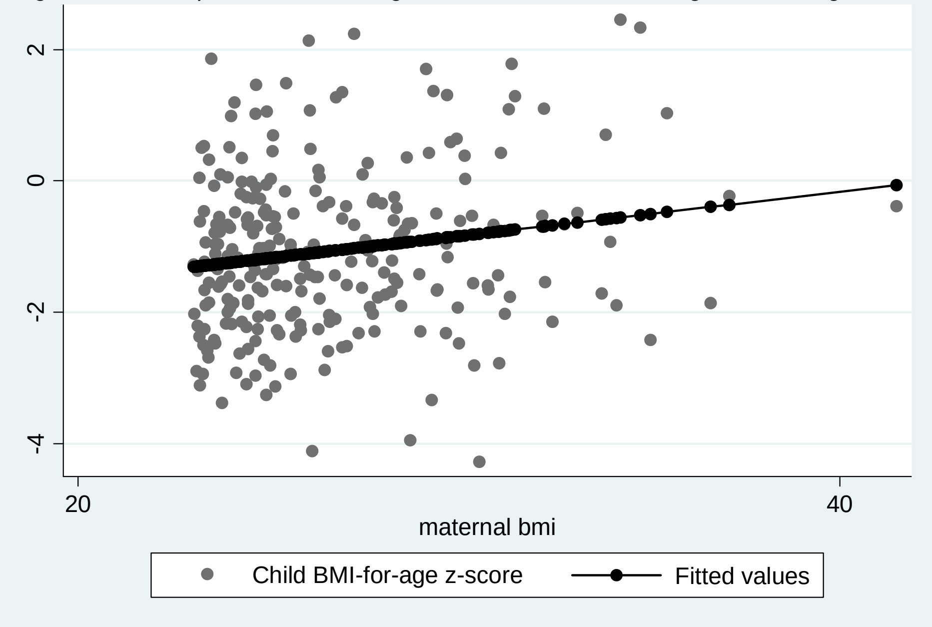
Table 1 continued…

	n*	All households n (%)	Household type (child/mother) U/O n (%)	O/O n (%)	N/O n (%)	p-value†
Frequency of father-child contact						
Weekly or less often	234	25 (10.7)	8 (14.3)	2 (10.0)	15 (9.5)	0.605
Daily		209 (89.3)	48 (85.7)	18 (90.0)	143 (90.5)	
Support network in time of need						
1-2 people	256	48 (18.8)	19 (31.2)	4 (19.1)	25 (14.4)	0.022
3-5		115 (44.9)	30 (49.2)	8 (38.1)	77 (44.2)	
6-10		60 (23.4)	6 (9.8)	7 (33.3)	47 (27.0)	
≥11		66 (12.9)	6 (9.8)	2 (9.5)	25 (14.4)	
BCG immunization		112 (43.8)	19 (31.2)	12 (57.1)	81 (46.6)	0.049
Household characteristics						
Wealth index, quartiles						
Poorest	256	64 (25.0)	15 (24.6)	2 (9.5)	47 (27.0)	0.027
Very poor		64 (25.0)	21 (34.4)	2 (9.5)	41 (23.6)	
Less poor		64 (25.0)	13 (21.3)	6 (28.6)	45 (25.9)	
Better off		64 (25.0)	12 (19.7)	11 (52.4)	41 (23.6)	
Location						
Urban	256	122 (47.7)	28 (45.9)	15 (71.4)	79 (45.4)	0.075
Rural		134 (52.3)	33 (54.1)	6 (28.6)	95 (54.6)	
Region						
Coastal Andhra	256	98 (38.3)	20 (32.8)	11 (52.4)	67 (38.5)	0.344
Rayalaseema		59 (23.0)	12 (19.7)	5 (23.8)	42 (24.1)	
Telangana		99 (38.7)	29 (47.5)	5 (23.8)	65 (37.4)	
Household size						
1-4 people	256	101 (39.4)	25 (41.0)	10 (47.6)	66 (37.9)	0.746
5-6		120 (24.9)	27 (44.3)	10 (47.6)	83 (47.7)	
≥7		35 (13.7)	9 (14.8)	1 (4.8)	25 (14.4)	
Male head of household	256	227 (88.7)	54 (88.5)	18 (85.7)	155 (89.1)	0.899
Ethnic group						
Scheduled caste or tribe	256	54 (21.2)	12 (20.3)	4 (19.0)	38 (21.8)	0.570
Backwards caste		114 (44.9)	22 (37.3)	11 (52.4)	81 (46.6)	
Other caste		86 (33.9)	25 (42.4)	6 (28.6)	55 (31.6)	
Improved water source	256	247 (96.5)	58 (95.1)	21 (100.0)	168 (96.6)	0.571
Improved sanitation facility	256	158 (61.7)	34 (55.7)	19 (90.5)	105 (60.3)	0.015
Access to health care	256	245 (95.7)	58 (95.1)	20 (95.20)	167 (96.0)	0.951
Household has experienced food shortage in past 12 months	256	14 (5.5)	5 (8.2)	0 (0.0)	9 (5.2)	0.346

*n, number of complete records; †p-value for Pearson's chi-squared test

Child BMI-for-age z-scores were fairly normally distributed but shifted to the left of the reference mean, with a mean z-score of -1.07 (95% CI: -1.22, -0.92; SD=1.24). This is significantly greater ($p<0.001$) than the mean z-score seen in the overall sample of -1.46 (95% CI: -1.53, -1.38; SD=1.23). Linear regression (Figure 2) showed a small but significant positive increase in child BAZ with maternal BMI (coeff: 0.07, 95% CI: 0.02, 0.12, p=0.007) but correlation is low. However, analysis of variance returned significant differences in mean maternal BMI between outcome categories, with overweight children having the heaviest mothers (p=0.004).

Figure 2: Scatter plot of child BAZ against maternal BMI, showing the fitted regression line



3.2 Bivariate analysis

The distributions of all explanatory variables considered in this analysis are shown in Table 1, along with the p-values produced by Pearson's chi-squared test for association.

Child characteristics

Child gender and pubertal stage showed very strong association with the outcome and with each other (p=0.002, data not shown). When stratified by gender, the relationship between pubertal stage and weight status was only significant in girls (p=0.007, data not shown). Stratifying by pubertal stage revealed a strong association between gender and weight category among pre-pubertal adolescents only (p=0.007, data not shown).

Dietary diversity and animal food groups consumed both showed a significant association with household type, but physical activity was only weakly associated with overall distribution of household type. No clear pattern was seen between the nutritional or physical activity indicators and O/O households. Overweight children appeared to eat more frequently, with 67% eating 5-7 times per day compared to only 49% for underweight and overweight kids, but this difference was not significant (p=0.297).

Parental characteristics

Neither maternal nor paternal education was associated with overall distribution of household weight category, although maternal literacy was. Neither measure of paternal influence (education and contact with child) showed association with the outcome. Maternal support network was also associated with the outcome. Child BCG immunisation, as a proxy for care practices, was also significant with a smaller proportion of underweight children immunised compared to overweight and normal weight children.

Household characteristics

Wealth index and sanitation facilities were the only variables significantly associated with the outcome. Location was only weakly related to weight category, with U/O and N/O households distributed fairly evenly between urban and rural areas, but 70% of O/O households located in urban areas. Similar proportions of U/O and N/O households had improved sanitation facilities, but significantly more O/O households did. Nearly all households had access to health care services and improved drinking water sources, and very few reported experiencing food shortage in the previous year.

Region was not associated with the outcome despite more than half of the O/O households being located in Coastal Andhra. Further analysis (not shown) revealed that every O/O household in this region was urban and in the top two categories of the wealth index. In fact, 73.5% of households sampled in this region were urban, and 41.8% were in the top wealth quartile. By comparison, Rayalaseema was only 32.2% urban and 40.7% of its households were in the bottom quartile of wealth.

3.3 Multivariate analysis

All variables showing a significance level of $p<0.1$ in the bivariate analysis were considered for inclusion in the multivariate analysis. Household wealth was strongly associated with maternal literacy (chi-square=54.9, $p<0.001$) and improved sanitation (chi-square=138.8, $p<0.001$). Wealth index was retained because it explained more of the variation in the model and was considered a more sensitive measure of socio-economic status than maternal literacy. Improved sanitation was also retained because it directly related to one of the basic causes of undernutrition. Dietary diversity and number of animal food groups also correlated (chi-square=99.9, $p<0.001$) but were being used to measure different aspects of diet, so both were retained in the model. Although number of animal foods was not significant in the crude analysis, it affected the final model enough to justify its place there.

Using the indicators selected from the bivariate analysis, a hierarchical framework was developed to help direct the multivariate analysis strategy. Indicators distal to the outcome were controlled for first, so that the effect of proximal exposures could be evaluated without the potentially confounding effect of e.g. gender or socio-economic status. The results of the analysis are presented separately for U/O households (Table 2) and O/O households (Table 3).

Table 2: Crude and adjusted odds ratios (95% confidence interval) for U/O households compared to N/O households, by socio-demographic and nutritional indicator variables.

Indicator	Crude odds ratio (95% CI)	Adjusted relative risk ratio† (95% CI)
Gender of child		
Male	1.00	1.00
Female	0.34 (0.19, 0.63)*	0.35 (0.17, 0.73)*
Pubertal stage		
Pre-pubertal	1.00	1.00
Post-pubertal	0.24 (0.10, 0.58)*	0.26 (0.09, 0.72)*
Location		
Urban	1.00	1.00
Rural	0.98 (0.55, 1.76)	0.78 (0.34, 1.78)
Wealth index, quartiles		
Poorest	1.00	1.00
Very poor	1.60 (0.73, 3.52)	1.31 (0.49, 3.51)
Less poor	0.91 (0.39, 2.12)	1.12 (0.26, 4.74)
Better off	0.92 (0.38, 2.19)	1.24 (0.30, 5.22)
Sanitation facilities		
Unimproved	1.00	1.00
Improved	0.83 (0.45, 1.49)	0.47 (0.14, 1.56)
Support network in time of need		
1-2 people	1.00	1.00
3-5	0.51 (0.25, 1.07)***	0.57 (0.23, 1.38)
6-10	0.17 (0.06, 0.48)*	0.20 (0.06, 0.72)**
≥11	0.32 (0.11, 0.92)**	0.30 (0.09, 1.00)***
Diet diversity (# of food groups consumed in previous 24hrs)		
2-5	1.00	1.00
6	0.80 (0.39, 1.65)	1.49 (0.60, 3.70)
7	0.70 (0.33, 1.48)	0.81 (0.30, 2.19)
8-11	0.20 (0.04, 0.91)**	0.17 (0.01, 2.34)
# of animal food groups eaten in previous 24hrs	1.00	1.00
0	1.59 (0.71, 3.55)	1.96 (0.70, 5.53)
1	0.55 (0.20, 1.54)	1.13 (0.27, 4.63)
2-4		
Physical activity (hours/day)		
1-4	1.00	1.00
5-6	1.66 (0.79, 3.46)	1.72 (0.71, 4.20)
≥7	2.62 (1.26, 5.43)**	1.97 (0.84, 4.64)
BCG immunisation		
no	1.00	1.00
yes	0.52 (0.28, 0.97)**	0.44 (0.20, 0.95)**

†adjusted for gender, pubertal stage, location, wealth index, sanitation, support network, diet diversity, # of animal food groups eaten, physical activity and BCG immunisation.
* $p<0.01$; ** $p<0.05$; *** $p<0.1$

U/O vs. N/O households

Crude analysis showed the risk of child underweight compared to normal weight was lower for female children, post-pubertal children, a maternal support network of three or more people, high diet diversity and BCG immunised children. High levels of child physical activity greatly increased risk of U/O relative to N/O. Following adjustment for all other variables included in the analysis, the estimates for diet diversity and physical activity lost meaningful significance. Female gender and post-pubertal stage remained highly significant and virtually unchanged as indicators of decreased risk of child underweight.

Table 3: Crude and adjusted odds ratios (95% confidence interval) for O/O households compared to N/O households, by socio-demographic and nutritional indicator variables.

Indicator	Crude odds ratio (95% CI)	Adjusted relative risk ratio† (95% CI)
Gender of child		
Male	1.00	1.00
Female	0.56 (0.22, 1.38)	0.23 (0.07, 0.82)**
Pubertal stage		
Pre-pubertal	1.00	1.00
Post-pubertal	1.97 (0.79, 4.92)	3.47 (1.06, 11.34)**
Location		
Urban	1.00	1.00
Rural	0.33 (0.12, 0.90)**	0.74 (0.22, 2.54)
Wealth index, quartiles		
Poorest	1.00	1.00
Very poor	1.15 (0.15, 8.54)	0.89 (0.12, 6.50)
Less poor	3.13 (0.60, 16.40)	1.66 (0.14, 19.63)
Better off	6.30 (1.32, 30.20)**	2.16 (0.30, 15.29)
Sanitation facilities		
Unimproved	1.00	1.00
Improved	6.24 (1.41, 27.73)**	5.09 (0.45, 57.20)
Support network in time of need		
1-2 people	1.00	1.00
3-5	0.65 (0.18, 2.35)	1.10 (0.30, 4.08)
6-10	0.93 (0.25, 3.50)	1.03 (0.27, 3.90)
≥11	0.50 (0.08, 2.99)	0.56 (0.06, 5.01)
Diet diversity (# of food groups consumed in previous 24hrs)		
2-5	1.00	1.00
6	4.00 (1.19, 13.41)**	4.97 (0.93, 26.64)***
7	0.73 (0.13, 4.16)	0.49 (0.05, 4.50)
8-11	2.91 (0.67, 12.66)	2.42 (0.36, 16.37)
# of animal food groups eaten in previous 24hrs)	1.00	1.00
0	1.19 (0.30, 4.70)	0.56 (0.09, 3.34)
1	2.06 (0.52, 8.22)	0.80 (0.11, 5.74)
2-4		
Physical activity (hours/day)		
1-4	1.00	1.00
5-6	1.58 (0.57, 4.37)	1.65 (0.44, 6.17)
≥7	0.93 (0.26, 3.27)	2.17 (0.45, 10.33)
BCG immunisation		
no	1.00	1.00
yes	1.53 (0.61, 3.83)	1.25 (0.44, 3.56)

†adjusted for gender, pubertal stage, location, wealth index, sanitation, support network, diet diversity, # of animal food groups eaten, physical activity and BCG immunisation.
p<0.01; **p<0.05; ***p<0.1

O/O vs. N/O households

Crude analysis showed a greatly increased risk of overweight compared to normal weight for children from the wealthiest households, for children with access to improved sanitation facilities and those with moderate dietary diversity. Children in rural areas had significantly lower risk of overweight. However, all confidence intervals were very wide, and after adjustment these estimates all lost significance, although dietary diversity was marginally significant. Gender and pubertal stage both gained significance, with girls at lower risk and post-pubertal children at greater risk of being overweight relative to normal weight.

4.0 Discussion

This study set out to examine maternal overweight and child nutritional status in the context of the nutrition transition in Andhra Pradesh, India. Maternal overweight in this cohort was high, affecting more than a quarter of the women. The prevalence of child overweight is comparatively low but has increased nearly three-fold since the first set of measurements four years earlier. The prevalence of child underweight has also increased substantially. This may be reflective of adolescent growth patterns, where increases in height are not matched by weight gain until later (the adiposity rebound). Alternatively, it may point to lifestyle changes specific to this age group, such as having to take up paid work or participate more in domestic and farm chores.

High maternal BMI is known to be associated with high child BMI in the general population[4]. Even in this sub-sample of overweight women and their children, mean maternal BMI increased significantly with each category of child BMI-for-age, although the relationship shown in the linear regression model was not well correlated. The reasons for this association can not be speculated on with any degree of validity, but it would be interesting to see if the linearity would improve in a larger sample size.

Several independent predictors for child under and overweight in households with an overweight mother were identified in this study population, after adjusting for gender, pubertal stage, location, wealth index, sanitation, maternal support network, diet diversity, animal foods consumed, physical activity and BCG vaccination status. Male children, pre-pubertal children, BCG non-immunised children and those with a small maternal support network were more likely to be in U/O households than N/O households. For O/O households, male children and post-pubertal children emerged as significant indicators following adjustment. Moderate diet diversity showed marginal association with O/O households, but its confidence interval was very wide, meaning its usefulness as an indicator is questionable. In general, confidence intervals for the estimates were quite wide, decreasing their precision and raising the possibility that the observed effects may have been the result of the sampling strategy.

The major limitation of this study is the sample size. The small number of O/O households and the groupings selected for some of the variables resulted in very small numbers in some of the categories. The possibility of associations arising by chance can not be ignored, and therefore the results must be treated with caution. Furthermore, the initial sample size of 1000 has limited statistical basis since the study was intended to look at many different exposure-outcome combinations. The sub-sample of 256 may have further reduced the power of the study to detect small associations that may have been picked up with a larger sample size. However, loss to follow-up for the second round of data collection was very low, so the integrity of the original sampling scheme is still fairly well intact. In addition, data collection was very thorough and only a few variables used had missing values. Another major limitation is that the results can only be extended to the population contained in the sentinel sites selected by Young Lives. Although not representative of the wider population, they may provide a picture of the situation in the poorer segment of the population of Andhra Pradesh.

The structure of the questionnaire and the type of data collected present further limitations to the results. First, women were not assessed for pregnancy and children were not assessed for oedema which may have resulted in an overestimation of the proportion of overweight women and underestimation of the proportion of underweight children. Furthermore, since anthropometric data was only taken for one child in the household, it is conceivable that a household categorised as N/O was in fact dual burden in one sense or the other. Second, the nutritional data used was based on one 24-hour recall and some of the other data was based on responses to a hypothetical question, or when asked for details of a "typical day". These types of questions are open to recall bias and may not be an accurate reflection of the true situation. The questionnaire was very thorough in the range of data it aimed to acquire, making it a valuable resource for investigating associations between a wide variety of variables, particularly in a research area that has not been well described. However, this resulted in lengthy interviews, which may have compromised the accuracy of the data as boredom or a desire to speed up the process may have influenced how carefully the respondent considered their answers.

Finally, the cross-sectional design limits interpretation of the results to terms of association rather than causality. Thus, the results of this study should be seen as a starting point for generating hypotheses and conducting more in-depth, focussed research into the double burden of malnutrition in transitional countries.

There are only a few existing studies that examine dual burden households in the classic sense (underweight child/overweight mother). Even fewer look at adolescent overweight in transitional countries, either on its own or in conjunction with maternal overweight. Comparisons with other studies are also complicated by the fact that cut-off values, reference curves and indicators used vary widely in the literature. It is not surprising, therefore, that there is limited and mixed support for the results found by this study.

Gender

The result that boys are more likely to be both over and underweight in households with an overweight mother is intriguing. Only one other study on dual-burden households, involving children aged 6-10 in Thailand, describes child weight status by gender[30]. It reports higher proportions of obese male and underweight female children with normal weight mothers, but no effect of gender on weight status after adjustment for other factors. A higher prevalence of male than female overweight in adolescents was seen in studies from urban India[31] and Vietnam[32], which also reports a higher prevalence of underweight in males. A large systematic review on gender differences in adolescent obesity concluded that observed differences are small and inconsistent but may vary by ethnic group, with Asian (but not Middle Eastern) populations showing a higher obesity prevalence in males[9].

Due to the dearth of focussed studies on this topic, and the inconsistencies in their results, little has been suggested as a potential explanation for the gender differences in weight status. Care practices biased towards boys may account for the higher prevalence of male overweight, but would fail to account for the association between males and underweight. In addition, gender inequities in care practices seem to have receded in India[33], although a recent study in Bangladesh found they still exist for certain aspects of health care[18]. High levels of physical activity could explain the greater risk of underweight in boys, if they were required to take on work. In this study, physical activity was only weakly associated with U/O households in the adjusted multivariate model and disaggregation by household type showed no association between gender and hours of physical activity in U/O ($p=0.5$, results not shown). However, the assessment of activity used here was imprecise and could not take into account caloric expenditure for different activities. A third hypothesis is that girls have more access to food through their involvement in food preparation tasks and are thus more likely to maintain a healthy body weight. In this present study, 75.0% of girls participated in one or more hours of household chores daily (compared to 47.4% of boys, $p<0.001$), but the lack of detailed information prevents making any solid conclusions.

Pubertal stage

In this present study, post-pubertal children of both sexes were 75% less likely to be in U/O households and nearly 3.5 times more likely to be in O/O households than pre-pubertal children (compared to N/O households). In addition, the relationship between puberty and household type was stronger for girls (chi-square=9.87, $p=0.007$) than for boys (chi-square=4.43, $p=0.1$). This is consistent with results from a South African study which reports higher BMI in post-menarcheal girls, and age as significant determinant of overweight in girls, likely because it is associated with commencement of menstruation[34]. In the present study age was not associated with the outcome, but this may have been due to the narrow age range of the study sample. Biological data confirm that increased adiposity in girls is a consequence of menarche, and may also contribute towards early pubertal development.

Maternal support network and care practices

Large maternal support networks ($\geq$ 6 people) were protective against U/O. This finding is supported by other studies in developing countries, including India, which show positive association between maternal social support and child nutritional status in young children[8, 26-29]. Hypotheses for the mechanism of this relationship include information sharing within the network[35], greater availability of resources for childcare[36] and economic, material and social support[15].

Children receiving better maternal care (i.e. BCG immunised) had a lower risk of U/O compared to N/O than those with poorer care (non-immunised). It should be noted that this was only a rough proxy measure for care practices, and it is possible that BCG immunisation resulted in a lower risk of child underweight because of its protection against disease, rather than maternal care practices. However, if this is the case, it may be acting as a marker of child health status, in which instance the result could be interpreted as healthier children having a lower risk of U/O relative to N/O.

Urbanisation and increased household wealth are key features of the nutrition transition, particularly with respect to obesity[3], but their use as predictors of household type is inconsistent and varies between countries. In one multi-country study, dual burden (U/O) households were more likely to be urban than other households but no clear pattern for income was seen[13]. A similar study, including three Asian countries, found that sociodemographic household profiles differed between U/O and 'underweight only'(at least one underweight and no overweight members), but U/O and 'overweight only' were indistinguishable[12]. The present study found no difference between U/O or O/O and N/O households on location and socioeconomic characteristics, after controlling for other indicators. However, this only means they are not the strongest predictors of household type in this particular sample. Adult overweight in transitional countries is generally associated with higher income, urban households, although other studies have found similar distributions of overweight between urban and rural areas[3]. It is possible that this present study lacked a wide enough range of wealth index values to facilitate comparison. Despite this limitation, wealth and location were both associated with O/O households at the unadjusted stage so perhaps the other indicators in the model simply had a much more powerful influence on the outcome. Alternatively, the presence of overweight in poorer and rural sectors of society may be indicative of the rapid progression of the nutrition transition in India[3].

5.0 Conclusions and Recommendations

Maternal OW/OB is highly prevalent and adolescent OW/OB is increasing in this sample of households from Andhra Pradesh, India. Although not representative of the wider population, it may give an idea of the nutritional situation, at least among the poorer households of the state. Child gender and pubertal stage seem to be important predictors of child nutritional status in dual burden households but more in-depth assessment in the wider population is needed to better understand this relationship. Maternal support network is also an important indicator for U/O households. Building up maternal social capital could be a useful programming tool for improving child health outcomes.

It is crucial that this impending child obesity epidemic be pre-empted while it is still in its infancy. Carefully targeted intervention programmes which prevent excessive weight gain in high-risk groups without compromising the nutritional status of those who are underweight are needed. This will undoubtedly require some level of financial commitment at the public health level, but other avenues involving food production, processing and marketing, and trade legislation should also be explored. Finally, as part of the global commitment to the Millennium Development Goals it is important that the developed world does not actively seek to export its negative health and nutrition practices to transitional countries in the name of globalisation and free trade. Such "freedoms" have already had a crippling effect on health and well-being in Western societies; their impact on the fragile health care systems of transitional countries will almost certainly be devastating.

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