Student Paper

Young Lives
An International Study of Childhood Poverty

Maternal Perceptions of Child Weight and Height and the Double Burden of Malnutrition: Young Lives, Peru

Sophie Budge

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

The data used come from Young Lives, a longitudinal study of childhood poverty that is tracking the lives of 12,000 children in Ethiopia, India (Andhra Pradesh), Peru and Vietnam over a 15-year period. **www.younglives.org.uk**

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Maternal perceptions of child weight and height and the double burden of malnutrition: Young Lives, Peru

Supervisors: Paula Sheppard & Lenka Benova

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ABSTRACT

Levels of overweight and obesity continue to rise for most countries worldwide, whilst throughout many regions undernutrition persists. This has resulted in the "double burden": the coexistence of undernutrition as (stunting) and excess weight. In the Latin American region, particularly in Peru, the double burden within children looms as a serious public health problem. Research suggests that the increase in obesity is related to a decrease in parental awareness, however little research describes child stunting and overweight as comorbidities, nor correlates maternal perceptions of child weight and height with objective longitudinal change. This is pertinent as the double burden escalates.

The Peru Young Lives (*Niños del Milenio*) is one segment of a multi-national, longitudinal cohort study: this report uses data from rounds 1-3 for the younger cohort only (n=2049 at round 1). Anthropometric data collected at each round was used to calculate child BMI-/height-for-age z-scores and maternal BMI. Maternal perceptions of child height and weight were asked at round 1 and 1 and 2 respectively. For analysis, descriptive statistics described demographics and child BMI-/height-for-age at rounds 1 and 2 and Pearson's chi^2 tested maternal perceptions with child BMI-for-age. Accuracy of maternal perception of weight was calculated and binary logistic regression tested incorrect perception as a predictor of child weight gain at round 3.

Of the 2037 children included from round 1, 28.8% were found to be stunted: this was recognised by less than half of mothers. Subsequently at round 2, a greater proportion of stunted children were overweight or obese. Mothers of both non- and stunted children consistently overestimated child height (p=<0.001) but were more likely to underestimate weight in stunted children (p=<0.001). By round 3, stunted children whose mothers had previously incorrectly estimated their weight were almost three and a half times more likely to have gained weight (p=0.016). Multivariate analyses indicated that incorrect maternal weight perception correlated to a two and a half times higher odds (p=<0.001, 95% CI 1.81 – 3.07) and height misperception a 1.36 odds (95% CI 1.06 – 1.76) of a later overweight or obese child.

The results indicate that in Peru, a country experiencing high economic growth and the double burden of malnutrition, high child stunting prevalence is correlated with increased odds of future excess weight as compared with normal height children. This likelihood was strongly related to an inability of the mother to correctly perceive the weight and height of her child; it is likely that this tendency to underestimate paves the way for subsequent obesity. Results may be of interest for public health interventions aimed at tackling the double burden of malnutrition in Peru and neighbouring Andean countries.

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Young Lives is an international study of childhood poverty, following the lives of 12,000 children in 4 countries (Ethiopia, India, Peru and Vietnam) over 15 years, www.younglives.org.uk. Young Lives is funded from 2001 to 2017 by UK aid from the Department for International Development (DFID), and co-funded by IrishAid from 2014-2015. The views expressed are those of the author. They are not necessarily those of, or endorsed by, Young Lives, the University of Oxford, DFID or any other funders.

Introduction

1.1 Background

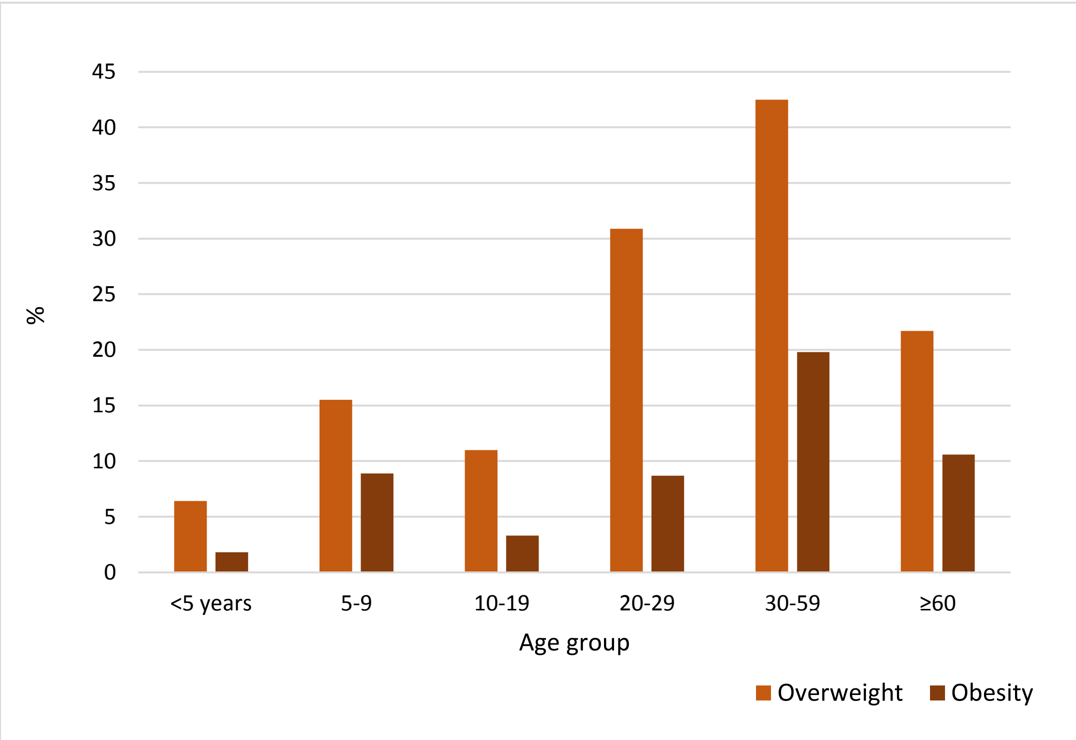
The nutrition transition is a global phenomenon which describes significant cyclical changes in population nutrition profiles, determined by local, national and international scale alterations in dietary intake and physical activity levels[1]. Associated with the rapid and simultaneous processes of urban and economic growth, the transition is a global experience and has been extensively documented[2, 3]. The paradigm describes a shift from traditional, unprocessed staple-based diets towards a diet higher in saturated fats (mostly oils), sugars and refined carbohydrates whilst low in poly-unsaturated fats and fibre[5]. Alongside a marked shift from labour-intensive employment towards an increasingly sedentary workplace and lifestyle, these changes contribute to the multitude of factors responsible for the dismaying explosion in levels of overweight and obesity currently faced on a global scale[3, 6]. The rapid increase in the prevalence of obesity and overweight is occurring at a much faster pace in the developing world[2], particularly so in middle-income countries of Latin America and the Middle East[7], where national policies that shape relative food prices may promote this experience[4].

Whilst overweight and obesity levels continue to rise for the majority of countries worldwide, throughout many regions the issues of undernutrition and persistent poverty remain. This has resulted in what is widely recognised as the dual, or double burden, of malnutrition[8]: defined as the coexistence of undernutrition (mainly stunting, defined as a height-for-age z-score of less than -2) and overnutrition (overweight or obesity, [O/O] defined as a body mass index (BMI) of 25kg/m^2 or greater), which can occur within the same population, household or even individual[8]. This phenomenon has been noted as somewhat surprising, given that in the developing world undernutrition is usually considered a manifestation of household level deprivation[4], and as dietary patterns and dietary intake of households tend to be similar, the dual burden within the same household thus signifies a weakening of this association[4]. The dual burden of malnutrition at the household level represents a household with at least one under-nourished (stunted or underweight) and one over-nourished (O/O) member: most of these cases, and highlighted most frequently in the literature, is that of a stunted or underweight child and an O/O mother[8]. The contrasting difficulties associated with both under- and overnutrition, not only at the population level but within single households, poses a significant task to policymakers who must respond to the challenge.

1.2 The nutrition transition in Peru

Across the Latin American and Caribbean (LAC) region, the epidemic of overweight and obesity has been driven in part by a rapidly developing economic climate[5] which has resulted in varying stages of demographic and nutritional transitions at the national level as each country surfaces from poverty[2, 6]. The World Bank highlights Peru as one of the most emergent economies in the region, where growth averaged 6.4% from 2002-2010[9] and increased to 7% in 2011[10]: predictably, levels of overweight and obesity have also grown, particularly in urban areas and in women[1, 11, 12], resulting in an epidemic of excess weight which now constitutes as a serious public health challenge. Current estimates of levels of excess weight for Peru indicate levels of excess weight have escalated sharply over time: Misipireta *et al.* describe trends in weight prevalence in women from 1991-2005[1]: a growing level of excess weight is defined by the rise in obesity which increased relatively steadily and independently of poverty levels or area of residence. During 1991-1992, 1 in every 5 women of excess weight were obese (BMI ≥30kg/m^2): by 2000 that became 1 in 4; more recent data indicate that by 2010, 55% of women were O/O[13] and thus the tendency towards obesity continues to gain momentum. Figure 1 describes the distribution of excess weight by age group in Peru for years 2009 and 2010 where excess weight affects more than two thirds of women middle-aged and pre-menopausal (62.3%).

Figure 1. Distribution of overweight and obesity (%) in the Peruvian population by age group from 2009-2010. Adapted from Instituto Nacional de Salud, IPE[14].



Regarding stunting, linear growth retardation in infancy remains the predominant form of undernutrition worldwide[15]. Around 165 million children under 5 years are stunted, equal to a height-for-age z-score (HAZ) below −2 (that is, 2 or more standard deviations below the population average)[15]. Stunting is an indicator of 'chronic cumulative deprivation'[9] and a principal measure of child malnourishment, arising as a result of a multitude of factors which include an inadequate diet both pre- and postnatally[16], infectious disease, household-level food insecurity and a poor healthcare environment[17]. Infant and childhood stunting holds multiple interrelated, negative implications for both current and future health, and is correlated with impaired cognitive development, physical health problems and both poorer educational achievement and economic productivity in later life[10,16,17]. For Peru, stunting in children under five remains one of the most critical issues impeding the country's economic development.

Figure 2. Prevalence of overweight and obesity (combined) in the population aged <20 years and most recent official figures for stunting prevalence (year in brackets) for selected countries of the LAC region.

Data on stunting for all countries taken from globalnutritionreport.org/.
Overweight and obesity data obtained from Global Burden of Disease Report, Ng. M. et al (2013) Lancet, 384: 766-781

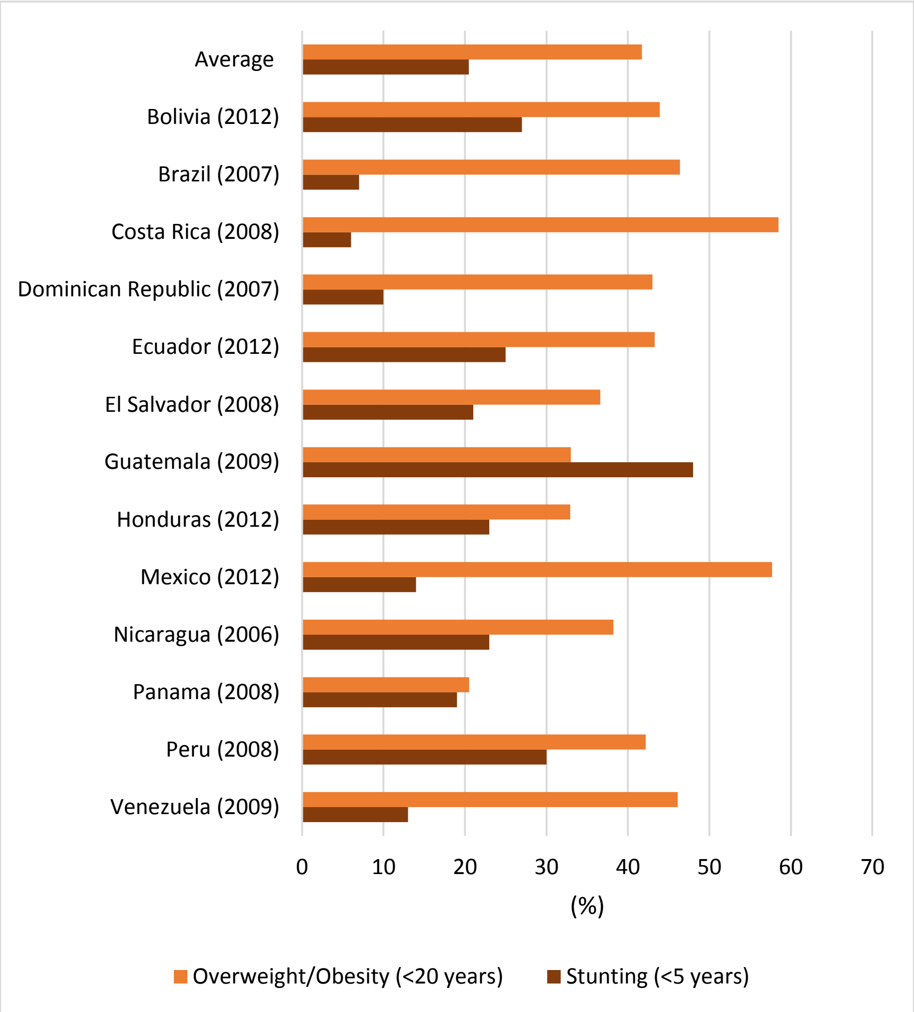


Figure 2 shows the most recent official data on stunting prevalence under five years of age (year in brackets) alongside estimates of overweight and obesity prevalence in under 20 years of age for countries in the LAC region. Levels of stunting are above 10% for all countries (the highest in Guatemala at 48% in 2009) but are greatly outstripped by levels of excess weight. Prevalence of stunting in under five years has receded for most countries over the last decade, correlating strongly with growth in GDP: simultaneously, and conversely, levels of overweight and obesity have risen. It follows that the countries indicating the highest levels of excess weight are also those that have experienced the greatest rates of economic development[9]. As is shown, Peru is placed amongst those top for rates of stunting, more than 10 points higher than the LAC region average (20%) [18] despite that after Panama, Peru experienced the second highest rate of economic growth in the region[9]. A further study which examined stunting and overweight prevalence and trends in Peruvian pre-schoolers using DHS data from 1991-2011 estimated stunting prevalence at 19.3% in 2011[10]: despite this being a 52% reduction since 1991, the 2011 estimate remained at around 8 times the level of the WHO references group. This estimate is in accordance with UNICEF data which found stunting prevalence in 2012 to be at 19.5%[19]. Furthermore, regional analysis of stunting in Peru indicate a severe disparity in prevalence at the departmental level. In the capital, Lima, rates are among the lowest: in other departments, Huancavelica for example, stunting rates in 2009 were similar to regions in Sub-Saharan Africa[9]. Heterogeneity in the prevalence and reduction of stunting rates between departments is an indication that the increased economic growth which has occurred throughout the country has not automatically eased some of the deeper socioeconomic inequalities, despite a dramatic fall in overall malnutrition rates in recent years[9, 20].

1.3 Peru and the transitioning double burden of malnutrition

Whilst as of 2010 around a third of children under five in Peru were stunted and 64% of children aged 15 and over were overweight, 28% of which were obese[21]. Childhood obesity looms as a major threat to public health services in Peru, not least because country-level nutrition policy remain tightly focused on stunting prevention[22]. The transition from malnourishment in childhood to overweight later on suggests Peru may be entering a new stage of the nutrition transition which affects young children. Coupled with the unprecedented rise in levels of overweight and obesity among the adult population, particularly among middle-aged females[23], Peru now faces the paradox of the double burden of malnutrition not only in the same household but also at the individual level within children, a phenomenon that has also been observed recently in other countries of the LAC region[24, 25].

This 'nutritional paradox'[26] hints at the multitude of problems that may be faced when considering nutrition policy and interventions which intend to address both stunting and excess weight as they occur both in the community and in children. Research has come a long way in describing both social factors[16, 17] and biological[27] mechanisms which shape both parallels; furthermore there exists a body of literature which has sought to elucidate and explain the apparent tendency in stunted children to later become overweight and obese[25, 26, 27]. The possible biological mechanisms for the influence of chronic malnutrition on excess weight risk have been extensively reviewed[28], some of which include a 'metabolic programming' of the appetite and regulation of metabolic systems as a result of early dietary deficiencies[28]. Such mechanisms imply that an increased risk of excess weight is in part inherent in stunted children.

Despite this limited research exists which has sought to determine or describe cultural and familial perceptions which relate to stunting and overweight in children. Current evidence suggests that the global increase in levels of overweight and obesity is associated with a lowered accuracy of self-perception of body size among those of excess weight[29] and of decreased parental awareness of overweight in children[30]. High maternal BMI is also correlated to an underestimation of their child's (over)weight status in both low and middle income[31] and high income countries[30, 32, 33.] These findings are particularly pertinent given that they may indicate whether parents are able to accurately manage their child's weight. Furthermore it may be that stunting is only perceived once the child is overweight[40] and so early recognition of chronic stunting may be valuable in defining preventative measures for both stunting and overweight in children.

1.4 Aims and objectives

As most research draws on cross-sectional data, differing datasets from varying time periods mean it remains difficult to establish temporal trends in weight change and maternal awareness[41]. There remains a requirement for a clearer understanding of the less-explored factors which accompany the transition from chronic child malnutrition to overnutrition: that is, not solely maternal awareness of stunting and overweight as mutually exclusive conditions, but of the perceptions which occur alongside. Furthermore whilst it has been documented that stunted children are at higher risk of later overweight and obesity[27, 28], little research exists which has sought to describe the impact of HAZ as a predictor of child overweight: something which seems imperative given the growing issue of the double burden. This study thus sought to investigate the hypothesis that incorrect maternal perception of their child's weight and height is correlated with a higher likelihood of future excess weight gain in their child. Using the Young Lives cohort data, this study aimed to:

- Test whether mothers accurately perceive child height and weight at rounds 1 and 2
- Investigate whether low HAZ (that is, stunting) and maternal perceptions of child height and weight relate correlate with changes in child BMIA from round 1-2
- Test whether low HAZ and inaccurate maternal perception of weight and height correlate with child weight gain at round 3.

Methodology

2.1 Study background

Young Lives is an international study on childhood poverty which follows approximately 12,000 children from 4 countries (Ethiopia, India, Peru and Vietnam) over a 15 year period. In each country, the respective study follows two cohorts of children, made up of approximately equal numbers of boys and girls, a sample of around 2000 children from the younger age-group, and approximately 1000 children from the older age-group.

Peru Young Lives *(known locally as Niños del Milenio)* has to date conducted 4 rounds, 3 of which the data are publically available, collected in 2002, 2006 and 2009 respectively. This study uses the first 3 rounds of data for the younger cohort only (n=2049 at round 1 where there is only one child per mother). As the older cohort were already seven years old at round 1, it would have been impossible to identify children who were stunted early but whom may have experienced catch up growth during those first 7 years. Table 1 below describes the young cohort as they move between each round.

Table 1. Peru Young Lives study, young cohort: sample numbers rounds 1-3.

	ROUND 1		ROUND 2		ROUND 3	
	6-18 months		4-5 years		8-9 years	
	n	(%)	n	(%)	n	(%)
SEX						
Males	1024	50.0	987	50.4	977	50.5
Females	1025	50.0	973	49.6	963	49.6
TOTAL	2049	100.0	1960	100.0	1940	100.0

2.2 Study sampling methods

Each Young Lives study employs a sentinel site approach to sampling. In Peru sentinel sites were chosen using a multi-stage, cluster-stratified, random sampling approach. The initial sampling frame was at the district level: the most recent poverty map was used as the basis for selecting the 20 sentinel sites, developed by Fondo Nacional de Compensación y Desarrollo Social *(FONCODES, the National Fund for Development and Social Compensation)* in 2000[36]. To fit the main objectives of Young Lives, poor areas were purposively over-sampled and the five per cent of districts ranked highest in wealth were excluded from this sample[36]. Once the districts were chosen, one 'census tract' in each area was randomly chosen. All *manzanas* (blocks of houses) and *centros poblados* (clusters of houses) in the selected census tract were counted and one *manzana* or *centro poblado* was randomly selected per district. Finally all selected households were visited by a fieldworker to ascertain households with at least one child aged between 6-18 months in 2002[37].

2.3 Loss to follow-up

Participating children were followed up for subsequent rounds. Very high levels of internal migration experienced in Peru meant that by the third round, children were dispersed across approximately 74 different communities. The design of Young Lives is such that it is intended to represent children living in poverty and is not a weighted sample: thus this paper aims to describe observations within the study cohort which may not be representative at national level. Despite this, it is estimated that the study (both cohorts) represents around 95% of Peru's child population (excluding 5% with a higher income) [37]. Attrition rates were relatively modest and are described by table 2 by round and category.

Table 2. Young Lives Peru: Attrition by round and category, rounds 1-3.

	ATTRITION						
	Number in sample	Traced	Refusal	Not located	Child deceased	Follow-up (%)	Follow-up (%) (excl. deaths)
Round 1 (2002)							
6-17 months	**2052**	-	-	-	-	-	-
Round 2 (2006)							
4-5 years	2052	**1963**	46	26	17	**95.6**	96.5
Round 3 (2009)							
7-8 years	2052	**1943**	56	33	20	**94.7**	95.7

In terms of loss to follow up, low attrition rates of 4.4% from round 1 to 2 and 5.3% from round 2 to 3 meant the possibility of selection bias was low. Loss to follow up is subsequently described regarding key variables of low HAZ (stunting) and BMIA: whilst the data is not presented in the main text, a table showing exact figures for loss to follow-up may be viewed in Appendix A.

Examining the trends in loss to follow up in terms of key variables attrition indicated no systematic pattern. In terms of those children that refused from round 1 to 2, of a total of 89 lost to follow up from the original 2052, 15 were stunted and 30 of normal height at round 1. Of those who could not be located, 5 were stunted and 20 were of normal height at round 1. In terms of those children who died before round 2, 12 out of 17 were stunted or severely stunted (13.4% of total loss to follow up or 0.6% of the original cohort): the higher bereavement rate in stunted children is not unexpected and was not significant enough to indicate bias. In terms of BMIA and attrition, there were no inconsistencies between those normal weight and those excess weight at round 1: those of normal weight were more likely to have refused than those excess weight (30 versus 15) and passed away (11 versus 6) whereas more children excess weight could not be located (17 versus 9). A larger number of children who passed away were from the Andean areas (likely correlated with stunting).

By round 3, 109 in total were lost to follow up from the original sample at round 1, a further 20 from round 2 to 3. Loss to follow up was calculated as lost from round 1 and not from between round 2 and 3. Thus by round 3, 3 more children of normal height had died (20 in total from round 1 or 1.0%), a further 7 children of normal height and 1 stunted child were not found (33 in total from round 1 or 1.6%) and a further 6 of normal and 4 of stunted children refused follow-up (56 in total from round 1 or 2.7%). In terms of children who were normal or excess weight at round 2, there was no variation in loss to follow-up at round 3. Thus by round 3, a total of 109 were lost to follow up, corresponding to 5.3% of the original cohort at round 1.

2.4 Anthropometrics

Anthropometric data was collected from the children at each round including weight (in kilograms) and height (in centimetres). Height was measured using a free standing measure after removing shoes and bulky clothing and read to within 1 millimetre. Weight was measured using either a clock (spring) balance or a standing balance calibrated to zero with the child wearing minimum clothing (or nude where possible). Length of children in the first round was measured on a flat surface using a length board. It was ascertained the board made contact with the scalp, shoes were removed and length was read to within 1 millimetre. Child length, weight and height were used to calculate height (or length)-for-age (HAZ) and BMI-for-age (BMIA) z-scores estimated using WHO references tables and software[37]. Malnutrition estimators were constructed on the basis of calculated z-scores. The estimators included in the three rounds were stunted or normal height and underweight and overweight as HAZ and BMIA respectively. For due to small numbers in these categories, severe stunting (<-3 SD of height-for-age z-score) and obesity (>3 SD of BMI-for-age z-score) were merged together. Table 3 below provides the definition for each.

Table 3. Cut off points for the 6 malnutrition indicators constructed from WHO z-scores.

INDICATOR	CUT-OFF
Severe stunting	<-3 SD of height-for-age z-score
Stunting	<-2 SD of height-for-age z-score
Underweight	<-2 SD of BMI-for-age z-score
Overweight	>1 SD of BMI-for-age z-score
Obese	>2 SD of BMI-for-age z-score

Maternal height and weight were collected using a free standing measure and standing balance respectively with shoes and bulky clothing removed. To assess maternal weight status, BMI was calculated (weight in kg/height in m^2) and categorized as: underweight (BMI ≤18.5kg/m^2), normal weight (BMI 18.5-<25kg/m^2), overweight (BMI 25.0-<30.0kg/m^2) and obese (BMI ≥30kg/m^2) according to the World Health Organization's recommendations for standard practice[39]. As samples for these subgroups were very small obesity and overweight were collapsed into a single category defined as 'Excess weight' (BMI ≥25kg/m^2). As height was not collected for the mother in round 3, BMI was calculated for those rounds using height as measured in round 2 and weight measured at round 3.

2.5 Outcome variable

2.5.1 Child BMI-for-age (BMIA)

In order to assess the correlation between maternal perception of child weight and future weight outcomes, the dependent variable was child BMIA at round 3. For the purpose of analysis which used binary logistic regression, BMIA outcomes were grouped into two categories, 'overweight/obese' or 'non overweight/obese' (including underweight or normal weight). Cut-off points and categories were constructed according to WHO z-scores as is described in table 3.

2.6 Predictor variables

2.6.1 and 2.6.2 Maternal perception of child weight and height

Maternal perceptions of their child's weight and height were evaluated in rounds 1, 2 and of the study, prior to the collection of anthropometric data. Mothers were asked: *'Compared to other children of this age would you say 'NAME's' weight is the same, heavier or lighter?'* and *'Compared to other children of this age would you say 'NAME's' height is the same, taller or shorter?'* Responses were coded as 'heavier' 'similar' or 'lighter' and 'taller' 'similar' or 'shorter' respectively.

BMIA for rounds 1-3 was generated as a categorical variable so that child weight by HAZ (stunted or not) could be described at each round Following, *changeweight12 and changeweight23* described the change in weight of each child between rounds 1-2 and 2-3. Only changes in weight status to excess weight (or no change in excess weight) are summarized. Excess weight by definition includes overweight and obesity combined.

To test the relationship between maternal perceptions and actual child weight and height, perception accuracy was generated as a separate variable. Thus alongside *changeweight12*, a subsequent variable matched the change in maternal perception (that is, did the change in mother's perception match the change in child weight). The variable, *accuracyweight12*, was categorised as correct perception (change in perception matched weight change), or incorrect (change in perception did not match weight change). As maternal perception was not asked during round 3, an assessment of perception change between rounds 2-3 could not be made and round 3 data was restricted to the outcome variable of child BMIA.

Similarly, maternal perception of child height at round 1 was categorized as correct perception (perception matched child height status), or incorrect (maternal perception did not match child height status).

2.6.3 Child sex

Child gender was included in the logistic model given research which suggests there may exist a gender disparity in stunting prevalence with males experiencing greater stunting prevalence.

Furthermore, differences in growth trajectories and fat accumulation between genders at young ages offer rationale for inclusion of gender.

2.6.4 Child height-for-age (HAZ)

In light that stunting may be considered on the causal pathway for later weight outcome, it is adjusted for in the binary logistic analysis in order to assess whether the effect of maternal perceptions on child weight is mediated by height-for-age as an intermediate variable. For analysis purposes, height-for-age scores were grouped into a binary variable as stunted (a z-score of <-2) versus normal height (a z-score of >-2 to maximum).

2.6.5 Birthweight (g)

Birthweight was asked of the mother at round 1 retrospectively and verified with documentation where possible. If no documents existed but there was documentation of the child's weight in their first week of life (for example with their first vaccination) this weight was recorded (kg): otherwise birthweight was omitted.

It has been documented throughout research that birthweight is usually significantly higher on average for children who are high BMI-for-age[, 43]. Birthweight in grams was therefore included in the first model as a continuous measurement to test the confounding effect on maternal perceptions.

2.6.6 Maternal education

It is recognized that rates of child overweight and obesity generally increase at lower levels of maternal educational attainment[10, 40, 41] and furthermore, that mothers of a lower educational background are more likely to misclassify their child's weight as well as underestimate associated health problems[41, 43-45]. As in Young Lives maternal education was asked according to enrolment status, for analysis education was grouped into 4 categories: none (illiterate), primary incomplete or complete, secondary incomplete or complete and further/higher education complete or incomplete (this also included enrolment into an adult education programme).

2.6.7 Maternal BMI

The literature indicates that taking into account the weight status of the parent, particularly of the mother[32] elucidates differences in accuracy of perception between overweight and normal weight parents[30]: in particular, there appears a common trend that overweight mothers tend to underestimate their child's weight[32, 41]. Studies in various countries on maternal perceptions of child weight have described that even when mothers are able to correctly recognize themselves as overweight, they do not recognize overweight in their children[46]: this seems especially so when their child is young[47]. This has implications for the future weight trajectory of the child. Maternal BMI was classified according to the World Health Organization's recommendations for standard practice[39] and collapsed into three weight categories as described in the Anthropometrics section of this report.

2.6.8 Wealth index for socioeconomic status

Studies have noted lower socioeconomic status (SES) is strongly related to a higher incidence of both stunting[10] and overweight and obesity[12] as distinct parallels and also as comorbid conditions[24, 25, 45]. This has been noted particularly within the Latin American region[23-25] where the rapidly changing economic climate is resulting in a greater degree of urbanization and changes in dietary patterns[22] which are proposed to affect the poorest disproportionally[48]. SES is also strongly correlated to educational achievement outcomes. The wealth index is the primary measure used in Young Lives to assess household SES; the index values range between 0-1, whereby a higher value indicates a higher level of SES. It is calculated as an average of three individual indexes which range from 0-1: housing quality, consumer durables and access to services[49]. For purposes of analysis, in this study the wealth index was collapsed into tertiles, corresponding to *poorest/poor, average* and *wealthier/wealthiest.*

2.6.9 Settlement type

Numerous survey data has shown urban children generally have an improved nutritional status and healthier anthropometric indicators than their rural equivalents[50]. This appears especially true for linear growth retardation and normal weight[50]: von Braun et al utilised UNICEF data sets from 33 countries in Africa, Asia, and the Americas, which indicated that stunting was on average 1.6 times larger in rural settings[51]. In terms of overweight and obesity, the general impression has been that in low-income countries higher obesity rates are more common in urban areas[51]: recent research however suggests this paradigm is inverting, whereby increasing rates of excess weight in rural households hold grave implications for health inequalities. Furthermore, increasing maternal overweight in rural areas is leading to a greater proportion of stunted-child-overweight-mother pairs ("SCOWT" pairs[4]), driven in part by a higher prevalence of child stunting; this has been particularly documented in rural Peru[4].

2.7.0 Region

Similar studies which have sought to describe both under- and overnutrition in Peru have noted disparities and inequalities between regions. Peru is characterized by three distinct geographical territories, jungle, coast and highland: it has been widely acknowledged that the associated physical environment and metabolic impact, occupations, physical activity levels, dietary patterns and calorie availability, social-cultural attitudes and beliefs impact heavily on health indicators[1, 9, 22]. Specifically, highland children have a far greater likelihood of stunting than coastal children or those from the Amazon[10]: furthermore child overweight and obesity appears more prevalent in urban areas, particularly metropolitan Lima[12]. In light of Peru's limited nation-wide nutrition policies, it is argued that there is a strong requirement for a 'decentralization' of policy which varies according to the needs of each area[22].

Statistical modelling

3.1 Data processing

Following registration, data for rounds 1-3 were downloaded from the UK Data Archive website where it is publically available (see Appendix B). The three rounds were subsequently combined using the *merge* function in Stata/IC 13.1 and cleaned and analysed using Stata/IC 13.1 (1996–2015 StataCorp, Texas, USA).

3.2 Descriptive analysis

Descriptive analysis was performed using Stata descriptive commands including summarize for the distribution of selected variables, tabulate for frequency count tables and Pearson's chi square contingency tests. According to the intended study design, no sample weights were used.

3.3 Multivariate analysis

Multivariate analysis was performed using binary logistic regression. The association between maternal perceptions of height and weight and child weight at round 3 was tested first on its own (model 1), then controlling for birth weight (model 2), and lastly controlling for HAZ status, child sex, maternal BMI, maternal education, region, type of site and wealth index category (model 3). Results are reported using odds ratios, 95% confidence intervals and p-values.

3.4 Ethics

The design and procedures of Peru Young Lives have undergone two instances of ethical approval: the Ethics Committee of the University of Oxford (CUREC: Central University Research Ethics Committee) as well as by the Committee of ethics of the Institute of Nutritional Research. Peru Young Lives also has the formal authorization of the Peruvian State, through the Ministry of Health. In addition, any survey of children and parents is carried out with written consent of without conditions on participation. Answering the survey is a voluntary decision of families and communal authorities.

Ethical approval for secondary analysis of the data was approved by the London School of Hygiene and Tropical Medicine MSc Research Ethics Committee.

Results

4.1.1 Demographics

Table 4. Demographic indicators by height status: round 1

	ROUND 1 BY HEIGHT-FOR-AGE CATEGORY					
	Round 1					
	6-17 months					
DEMOGRAPHIC INDICATOR	Normal height n = 1451 % = 71.2		Stunted n = 586 % = 28.8		Total cohort n = 2037 % = 100	
	(n)	(%)	(n)	(%)	(n)	(%)
SEX						
Male	684	47.1	334	47.1	1018	50.0
Female	767	52.9	252	43.0	1019	50.0
REGION						
Coast	622	42.9	85	14.5	707	34.7
Mountain	615	42.4	411	70.1	1026	50.4
Jungle	214	14.8	90	15.4	304	14.9
TYPE OF AREA						
Urban	1104	76.1	292	49.8	1396	68.5
Rural	347	23.9	294	50.2	641	31.5
MATERNAL BMI CATEGORY						
Underweight (≤18.5kg/m²)	21	1.5	8	1.5	29	1.5
Normal weight (18.5-<25kg/m²)	806	55.7	389	66.6	1195	58.8
Overweight/obese (25.0-≥30kg/m²)	620	42.9	187	32.0	807	39.7
MATERNAL EDUCATION LEVEL						
None	59	4.1	103	17.6	162	8.0
Primary incomplete/complete	464	32.1	296	50.6	760	37.4
Secondary incomplete/complete	639	44.2	149	25.5	789	38.8
Further/higher education complete/ incomplete	285	19.7	37	6.3	322	15.9
NUMBER IN HOUSEHOLD						
1-2	13	0.9	4	0.7	17	0.8
3-5	797	54.9	279	47.6	1076	52.9
6+	641	44.2	303	51.7	944	46.3
NUMBER OF CHILDREN BORN						
1-2	975	67.2	276	47.1	1251	61.4
3-5	384	26.5	206	35.2	590	29.0
6+	92	6.3	104	17.8	196	9.6
WEALTH INDEX CATEGORY						
Poorest/Poor	598	41.3	422	72.1	1020	50.2
Average	536	37.0	113	19.3	649	31.9
Wealthier/Wealthiest	313	21.6	50	8.6	363	17.9

Of the total sample for the young cohort, data from 2037 children were identified which constituted 99.4% of the original 2049 children of the young cohort in round 1. The remaining 0.6% had no height-for-age score available for analysis. Of the 2037 children age 6-17 months at round 1, 28.8% were found to be stunted or severely stunted with a height-for-age score of <-2.0 SD. By round 2 at age 4-5 years, this had increased to 33.5%; by round 3 at 7-8 years however stunting prevalence decreased to 22.9%, presumably where children may have experienced catch up growth or where those who were only slightly over the cut-off margin fell into a subsequent group.

Table 4 shows a detailed description of the cohorts' demographic characteristics and sample size for round 1. Males were found to be 1.5 times more likely to be stunted than females at round 1 (95% CI 1.22-1.82, data not shown): by round 2 this had dropped to 0.9 (95% CI .76-1.12). As has been previously documented, stunting prevalence was found to be noticeably higher in the Andean regions[4, 10]. There was no significant difference in maternal age between stunted or normal height children. In terms of maternal educational enrolment, stunted children were almost 5 times as likely to have an illiterate mother (95% CI 3.55-7.16) and children of normal height 3.7 times more likely to have a mother enrolled into a college or university programme (95% CI 2.43-5.98). There was no striking difference between maternal BMI and child height status at round 1: stunted children appeared slightly more likely to be born to a mother of normal weight (66.6% versus 55.7%) but less likely to be born to an O/O mother (32.0% versus 42.9%). 16.7% of stunted children were born low birthweight (<2500g) compared with 5.9 of normal height: this corresponded with the literature as described in section 3.5.7%. As was anticipated, stunted children were 3.6 times more likely than normal height children to be in the poorest wealth category, as defined by the wealth index.

Table 5. Mean, standard deviation and 95% confidence intervals (CI) for key variables by HAZ status.

	CHILD HEIGHT-FOR-AGE CATEGORY					
VARIABLE	**Normal height**			**Stunted**		
	Mean	SD	95% CI	Mean	SD	95% CI
MATERNAL AGE						
R1	26.8	6.7	26.42 - 27.11	27.0	7.0	26.47 - 27.60
R2	31.1	6.8	30.78 - 31.50	31.2	6.8	30.60 - 31.72
R3	34.1	6.9	33.71 - 34.48	34.0	6.6	33.42 - 34.52
MATERNAL BMI (KG/M^2)						
R1	25.1	3.8	24.77 - 25.16	24.0	3.3	23.82 - 24.36
R2	26.4	4.1	26.04 - 26.48	25.5	0.2	17.51 - 68.40
R3	27.5	6.3	27.07 - 24.77	26.4	3.9	25.97 - 26.66
BIRTHWEIGHT (G)						
R1	3279.7	489.3	3253.26 - 3306.33	2981.2	491.3	2936.2 - 3026.11
HEIGHT-FOR-AGE (Z-SCORE)						
R1	-.7	.97	-.72 - -.62	-2.8	.8	-2.91 - -2.78
R2	-1.2	.98	-1.24 - -1.14	-2.5	1.1	-2.57 - -2.39
R3	-1.3	1.0	-1.33 - -1.22	-1.2	1.0	-1.32 - -1.15
BMI-FOR-AGE (Z-SCORE)						
R1	.6	1.2	.74 - .86	.7	1.5	.63 - .88
R2	.7	1.0	.66 - .77	.7	1.1	.51 - .70
R3	.6	1.1	.56 - .67	.9	.9	.18 - .32

Table 5 displays the mean, standard deviation and 95% confidence interval for key variables. Differences between the two height-for-age categories differ expected with a lower overall mean height-for-age z-scores (which however has decreased in variance by round 3). Interestingly, mean height-for-age of normal children still remained below zero, highlighting the low overall average height of the population. Mean BMI-for-age scores of stunted children remained consistently marginally higher. Mean birthweight of stunted children was lower, as anticipated. Mean maternal BMI of stunted children remained marginally lower than those of normal height children across rounds 1-3, although it is worth noting across both categories mean maternal BMI correlated to overweight at each round, save round 1 for stunted children.

4.1.2 Child BMIA by HAZ status for each round

Table 6. Objective child BMIA as measured at rounds 1, 2 and 3: by height-for-age status

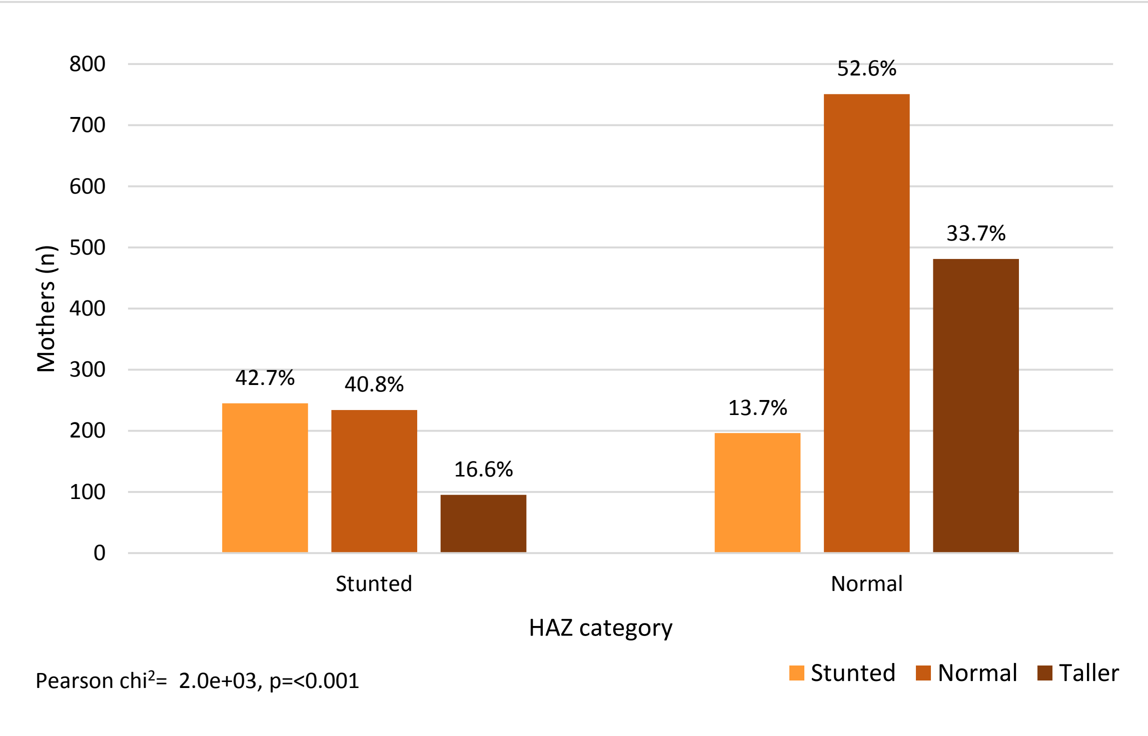
	HEIGHT-FOR-AGE STATUS BY ROUND											
	Round 1				**Round 2**				**Round 3**			
	6-17 months				4-5 years				7-8 years			
	Stunted		Normal		Stunted		Normal		Stunted		Normal	
BMI-FOR-AGE	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Underweight	12	2.1	30	2.0	3	0.5	6	0.5	4	0.9	14	1.0
Normal weight	357	60.9	787	54.3	423	64.8	891	68.6	308	60.5	1069	72.2
Overweight/obese	217	37.0	633	43.7	227	34.8	401	30.9	125	38.6	398	26.9
Total	586	100	1450	100	663	100	1298	100	438	100	1483	100

Table 6 shows measured child HAZ and BMIA categories, grouped by round of survey. At 6-17 months at round 1, stunted children were slightly more likely to be of normal weight than normal height children (60.9% vs 54.3%). Of those normal height, around 7% more were O/O. By round 2 at age 4-5 years, fewer children of stunted height were of normal weight (63.8% versus 68.6% of normal height) and a greater proportion of stunted children were O/O (34.8% versus 30.9%). By round 3 the number of stunted children who were overweight had further exceeded those of normal height by a substantial 12% (38.6% versus 26.9% of normal height). There was very little differences in underweight by HAZ category across the three rounds, of whom there were very few.

Change in child BMIA category by HAZ category across the three rounds is not displayed but can be viewed in Appendix C. Presenting the results was limited to showing possible changes in BMI category to excess weight only. Fundamentally, from round 1 to round 2, almost twice as many stunted children became O/O from normal weight compared to those children of normal height (17.9% versus 9.5%). A larger percentage of children of normal height than stunted who were previously overweight had decreased by round 3 (21.3% to 17.4%). By round 3, 16.7% of stunted children remained excess weight with no change from round 2.

4.1.3 Maternal perceptions of child height

Figure 3. Bar graph displaying maternal perceptions of child height at round 1 as categorized by HAZ status.



The bar graph in figure 3 illustrates the relationship between maternal perception of child height and actual child height, broken down by child HAZ category. As is shown, less than half (42.7%) of mothers of stunted children recognised them as shorter whilst 40.8% believed their stunted child to be of normal height. A further 16.6% believed their stunted child taller than average. A larger proportion of mothers (52.6%) correctly identified their normal height child as such whilst 33.7% felt their child to be taller; the results indicate an overestimation of height which is consistent independent of HAZ score. The Pearson's chi square contingency test with the full data can be viewed in appendix D.

4.1.4 Maternal perceptions of child weight

Table 7. Pearson's chi square showing maternal perception of child weight by child HAZ category (stunted or non-stunted): as asked at round 1

	BMI-FOR-AGE BY HEIGHT-FOR-AGE															
	Stunted								Normal height							
	Over-weight		**Normal**		**Under-weight**		**Total**		**Over-weight**		**Normal**		**Under-weight**		**Total**	
MATERNAL WEIGHT PERCEPTION	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Heavier	49	23.1	37	10.5	1	8.3	87	15.1	255	40.8	152	19.4	7	24.1	414	28.8
Similar	85	40.1	103	29.6	4	33.3	192	33.3	289	46.2	344	44.0	11	37.9	644	44.9
Lighter	78	36.8	212	60.2	7	58.3	297	51.7	81	13.0	286	36.6	11	37.9	378	26.3
Total	212	100.0	352	100.0	12	100.0	576	100	625	100.0	782	100.0	29	100.0	1436	100.0

Stunted: Pearson's chi^2= 33.1430, p=<0.001

Normal height: Pearson's chi^2= 131.0146, p=<0.001

Table 8. Pearson's chi square showing maternal perception of child weight by child HAZ category (stunted or non-stunted): as asked at round 2

	BMI-FOR-AGE BY HEIGHT-FOR-AGE															
	Stunted								Normal height							
	Over-weight		**Normal**		**Under-weight**		**Total**		**Over-weight**		**Normal**		**Under-weight**		**Total**	
MATERNAL WEIGHT PERCEPTION	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Heavier	99	43.6	126	29.8	1	33.3	225	34.5	216	53.9	505	56.8	2	33.0	723	55.8
Similar	40	17.6	86	20.3	0	0.0	126	19.3	140	34.9	294	33.1	0	0.0	434	33.5
Lighter	88	38.8	211	49.9	2	66.7	299	45.8	45	11.2	90	10.1	4	66.7	139	10.7
Total	227	100.0	423	100.0	3	100.0	653	100.0	401	100.0	889	100.0	6	100.0	1296	100.0

Stunted: Pearson's chi^2= 25.5935, p=<0.001

Normal height: Pearson's chi^2= 104.1170, p=<0.001

Mother's perception of their child's weight as assessed at the time of survey is shown for round 1 (table 7) and round 2 (table 8) and stratified again by child HAZ category. At round 1 (table 7) only slightly more than half of mothers of stunted children recognised their overweight child as such (23.1% versus 40.8% of mothers of normal height children), and were almost 3 times as likely to think they were lighter (36.8% of stunted versus 13.0% of normal). On the other hand, more mothers of stunted children were able to perceive if their child was lighter (that is, underweight), although again, small numbers in this category are unreliable. Mothers were more likely to recognise their normal weight child as such if the child was also of normal height (44.0% versus 26.9% of mothers of stunted children).

At round 2, a larger proportion of mothers were able to recognise if their stunted child was overweight than at round 1, even as more children became overweight. As was observed at round 1, at round 2 a larger proportion of women still felt their stunted, O/O child was lighter than its peers (38.8%). Nearly half (49.9%) of women also felt their stunted child of normal weight was lighter, indicating consistent underestimation across weight categories. As in round 1, more women were able to correctly identify normal weight if their child was normal height. Across the two rounds, at round 1 most women felt their stunted child was lighter than its peers (51.7% majority) and this remained at round 2 (45.9% majority).

4.1.5 Maternal perceptions of child weight change from round 1 to 2

Figure 4. Bar graph illustrating the relationship between maternal perceptions of child weight change from rounds 1-2 and actual change in child weight from rounds 1-2: stratified by child HAZ

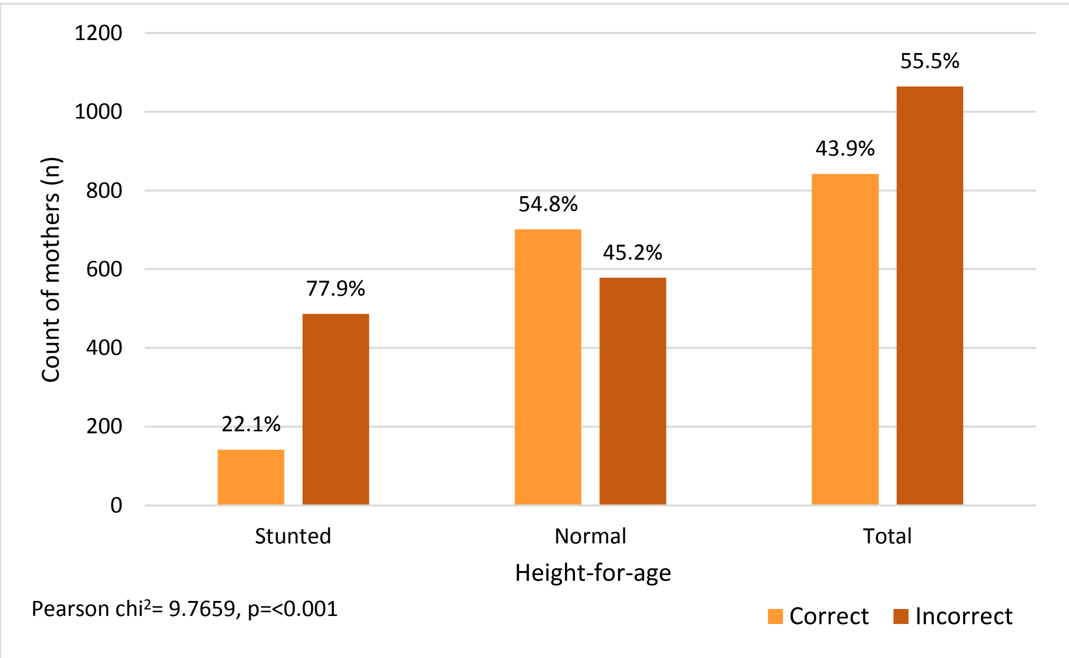


Figure 4 describes how maternal perceptions of child weight change from rounds 1 to 2 correlated with actual measured change in child weight rounds 1-2. This is again stratified by height-for-age. Considering stunted children, almost three times as many mothers incorrectly as correctly perceived the change in weight of their child (77.8% versus 22.1%): this is appeared much more significant than mothers of normal height, of whom 45.2% perceived incorrectly versus 54.8% correctly. Furthermore more than twice the amount of mothers correctly perceived the change in child weight if the child was of normal height than if stunted (54.8% of normal versus 22.1% of stunted). Perception as a majority was incorrect (55.5%). The Pearson's chi square testing this relationship can be viewed in Appendix E. The low p-value of the contingency test indicates these associations are unlikely due to chance (<0.001).

4.1.6 Maternal perception of child weight from rounds 1-2 and subsequent child weight at round 3

Table 9. Pearson's chi square showing maternal perceptions of child weight change from rounds 1-2 and resulting child weight at round 3: stratified by child height-for-age.

	CHILD WEIGHT CHANGE FROM ROUNDS 2-3 BY HEIGHT-FOR-AGE STATUS											
	Stunted						Normal height					
	n=623						*n=1252*					
	Gained weight		**No change in excess weight**		**Total***		**Gained weight**		**No change in excess weight**		**Total***	
MATERNAL PERCEPTION OF WEIGHT CHANGE AT ROUNDS 1-2	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Correct	7	22.6	277	63.8	284	45.6	61	38.1	650	67.2	711	56.8
Incorrect	24	77.4	157	36.2	181	29.1	99	61.9	317	32.8	416	33.2
Total	31	100.0	434	100.0	465	74.6	160	100.0	967	100.0	1127	90.0

*Total calculated as percentage of possible changes in weight, excluding 'lost weight'

Stunted: Pearson's chi^2=8.2500, p=0.016
Normal height: Pearson's chi^2= 8.3937, p=0.015

Finally, table 9 describes the relationship between the accuracy with which mothers perceived their child's weight change from rounds 1-2 (figure 4) as it related to the subsequent outcome of child weight at round 3. As is apparent from the table, stunted children whose mothers incorrectly estimated their weight between rounds 1-2 were almost three and a half times more likely to have gained weight at round 3 (77.4% versus 22.6%, p=0.016). This correlation appeared stronger than for children of normal height, of whom 61.9% gained weight as opposed to 38.1%% who did not. Interestingly, even if maternal perception was correct between rounds 1 to 2, this did not lead to a change in excess weight for either stunted or normal height children: or at least, no attempts to lose weight were made. Slightly fewer stunted children stayed excess weight if their mother's perception was correct than those of normal height (63.8% versus 67.2%): (that is, a slightly larger proportion of stunted children had lost weight by round 3 if maternal weight perception was correct), although the significance of the difference in these figures is contentious.

Multivariate analysis

5.2.1 Binary logistic regression

Table 10. Binary logistic regression testing the correlation between child BMI-for-age at round 3 and accuracy of maternal perception of weight and height and other predictor variables.

	MODEL 1 *N=1905*	MODEL 2 *N=1668*	MODEL 3 *N=1576*
		CHILD BMI-FOR-AGE	
		(BMI-for-age >+1SD - BMI ≥25 kg/m²)	
	O/O[a]	O/O	O/O
PREDICTOR VARIABLES	OR (95% CI)	OR (95% CI)	OR (95% CI)
MATERNAL PERCEPTION			
MATERNAL PERCEPTION OF WEIGHT			
Incorrect	2.30*** (1.85 –2.86)	2.33*** (1.85 –2.95)	2.36*** (1.81 – 3.07)
MATERNAL PERCEPTION OF HEIGHT			
Incorrect	1.36** (1.09 – 1.68)	1.36** (1.01 –1.60)	1.36** (1.06 – 1.76)
BIRTHWEIGHT (g)			
Continuous (g)		1.00*** (1.00 - 1.00)	1.00 (1.00 - 1.00)
CHILD HEIGHT-FOR-AGE			
Stunted			1.24 (0.89 – 1.73)
MATERNAL BMI			
O/O (BMI ≥25kg/m²)			1.85*** (1.43 – 2.39)
DEMOGRAPHICS			
CHILD GENDER			
Male			1.53*** (1.20 – 1.96)
MATERNAL EDUCATION			
No education			1.02 (0.54 – 1.94)
Secondary complete/ incomplete			1.31* (0.95 – 1.81)
Further/higher education complete/incomplete			2.18*** (1.47 – 3.24)
REGION			
Coast			2.06*** (1.53 – 2.79)
Jungle			0.87 (0.58 – 1.30)
SETTLEMENT TYPE			
Rural			1.00 (0.68 – 1.51)
WEALTH INDEX CATEGORY			
Poorest/poor			0.71** (0.50 – 0.99)
Wealthier/wealthiest			1.47** (1.07 – 2.02)
CONS_	0.27*** (0.23–0.31)	0.49*** (0.02 - 0.10)	0.97***(0.04 –0.24)
	LR Chi² (2): 61.63 P= <0.001	LR Chi² (3): 83.77 P= <0.001	LR Chi² (14): 274.06 P= <0.001

a O/O = Overweight or obese (as in main text)
* P=<0.1
** P=<0.05
*** P=<0.001

Binary logistic regression models tested the effect of predictor variables on child BMI-for-age at round 3 as O/O (shown in table 10). The first model tested the effect of both maternal perception of weight and height. As indicated, in comparison with mothers who correctly perceived child weight, incorrect perception of weight at rounds 1-2 was associated with 2.3 times the odds of their child becoming O/O at round 3 (p=<0.001). Similarly but less significantly, incorrect perception of height was associated with 1.36 times the odds of a child becoming O/O (p=<0.05). The 95% confidence intervals indicate closer precision in the effect of misperception of height.

The second model included birthweight (g) as a continuous measurement to control for the potential mediating effect (that is, birthweight is independently associated with both HAZ and high BMIA). The odds ratio of 1 indicates birthweight did not affect the odds of an O/O child at round 3: however whilst the effect of incorrect perception of height did not change, the magnitude of the effect of incorrect weight perception increased. The adjusted odds ratio (2.30 to 2.33, p=<0.001) indicate the adjusted summary measure is a more accurate estimate of the effect of weight perceptions on child weight outcome than the bivariate model since it controls for the effect of birthweight. It is worth noting the standard error (as 95% CI) increased in the presence of the confounder but not sufficiently as to affect the significance, which remained as strong evidence against no effect even as the model sample size decreased.

The multivariate model tests the effect of maternal perception of weight and height on child weight outcome at round 3 in the presence of 8 predictor variables: birthweight (g), child-height-for-age, maternal BMI, child sex, maternal education, region, settlement type and wealth index category. Interestingly, by round 3 birthweight had lost significance, suggesting the inclusion of the other predictor variables improved the model fit at explaining the exposure-outcome relationship. Child HAZ at round 1 (that is, stunted or not) was associated with 1.24 higher odds (95% CI 0.89 – 1.73) of an O/O child at round 3, which however held low evidence of effect as indicated by the large standard error. Maternal BMI of ≥25kg/m^2 (O/O) correlated to a 1.85 odds of an O/O child at round 3 (p=<0.001). Male gender was also strongly evident in predicting O/O (p=<0.001), as was living in the coastal region (p=<0.005). The odds of an O/O child at round 3 were increased within the highest level of education (adult education class, college or university enrolment) and within the highest level of wealth category (both p=<0.05). In the presence of the predictor variables, the effect of incorrect maternal perception of weight on an O/O child at round 3 increased from an odds of 2.33 to 2.36 (p=<0.001). Again, despite a larger standard error and wider 95% CI the low p value indicated strong evidence against the null hypothesis of no association. The effect of incorrect perception of height did not change ($p=<0.05$).

Discussion

Of the 2037 children age 6-17 months at round 1, 28.8% were found to be stunted or severely stunted. Stunting was found to be strongly correlated to male sex, living in an Andean region, maternal illiteracy, low birthweight (<2500g) and pertaining to the 'poorest/poor' wealth category (table 4). Of the 28.8% stunted children, less than half of mothers recognised them to be shorter than average: the remaining perceived them as either normal height or taller than average. Misperception of weight was similarly inaccurate: at round 1 37% of stunted children were already O/O, however less than a quarter of mothers identified this. Fewer children of normal height were O/O at that point (30.9%) but mothers were nearly twice as likely to recognise this compared with mothers of stunted children. The tendency to underestimate weight was consistently higher by mothers of stunted children at rounds 1 and 2. As a whole, more than three-quarters of mothers of stunted children incorrectly perceived their child's weight – of which almost all children gained weight.

In terms of child weight change from rounds 1 to 2, the results indicated that stunted children were almost twice as likely to become O/O compared to those children of normal height (17.9% versus 9.5%, table 10). Despite the low evidence for stunting as a predictor of O/O at round 3 as tested by the multivariate model, when testing for an overall effect of height-for-age, low-height-for-age (stunting) corresponded to a 3 times higher odds of O/O at round 3 than normal height-for-age ($p=<0.001$, 95% CI 2.34-3.85, data not shown). Such high odds lend evidence to the research which suggest a biological mechanism of stunting on future weight gain[25, 27]: however, since the association disappeared once HAZ was included in the model, it is likely a factor which has a strong interaction with maternal perceptions and awareness, as well as the other variables present. Current research has documented underestimation of weight to be common amongst mothers[51], particularly underestimation of weight of young children[30] which is also much higher among O/O as opposed to normal weight children[52], but current literature has not attempted to describe these findings in consideration of HAZ. It is thus also of interest that testing the overall effect of correct perception of weight on child O/O at round 3 indicated weight perception alone had less evidence of an effect ($chi^2(1)=0.67$, $p=0.41$, data not shown);

this may indicate an interaction with height perception, on which the significance of weight perception is dependent (that is, without an incorrect perception of height incorrect perception of weight is less predictive of child O/O at round 3).

Interestingly, child O/O at round 3 was correlated with pertaining to the 'wealthier/wealthiest' wealth category and to the highest level of maternal education (table 13), contrary to the descriptive data which found stunting to be most prevalent among those poorest and with only primary education (table 4). This may indicate the strong correlation between educational level and wealth index as a measure of socioeconomic status. Despite much research which documents both O/O and stunting to be most prevalent amongst the poor[10] and lowest educated[40, 48] recent research describes findings for the contrary. It has been proposed that "the current economic growth and increase in urbanization has led to the adoption of new lifestyles in middle-income countries" which has resulted in "a new middle class, rising out of poverty [as] the most exposed to central adiposity" (53, p171) as has been seen in Mexico[53] . These findings oppose the assumed inverted U-shaped relationship between SES and BMI as has been previously suggested[12, 46]: indeed in Latin America this professed "new middle class" "will account for about a third of the region's population over the next decades; as … size and income rises" (54, p11). In explanation, it is described that when an increase in income is not succeeded by an increase in health-related knowledge (especially nutrition), resulting undesirable behaviours may lead to significant health problems[55]: this is also relevant in lieu of the nutrition transition, whereupon jobs become more sedentary and daily life more mechanized. This change in SES is not proposed to differ greatly by urban or rural areas which may explain the low evidence for this effect in the model (table 13). Furthermore, economic development in Peru has occurred mostly within the coastal areas[19, 22] where the majority of those of the highest socioeconomic group reside: this is reflected in the multivariate model with strong evidence that living within the coastal area resulted in more than twice the odds of later child O/O ($p=<0.001$). Despite the overwhelming majority of stunted children living within the Andean region (much research has documented genetic differentiation in physiology which occurs at intermediate to high altitude, including growth limitation of the limbs[56]): this reflects the growing trend that overweight and obesity in children is acting as the predominant driver of the double burden as stunting prevalence begins to recede.

5.1 Study limitations

There are some limitations regarding both the data set and the analysis. In terms of the study design, the analysis of maternal weight and height perception was limited by the use of only one question: it is possible that where mothers were asked to compare their child's weight and height to other children of his or her age, the result may not have represented if the mother actually considered her child tall or short or overweight or underweight in absolute terms. Furthermore mothers may not have been able to effectively evaluate their child's weight without the use of a visual aid; the use of a silhouette scale may have been more appropriate and cross-validated the questions: other similar studies assessing weight perceptions employed the use of the Figure Rating Scale to good effect[57] and in addition with proven validity in Latin America[58]. Furthermore with regards to the anthropometric data, it is widely acknowledged that BMI serves only as a crude determination of weight status[59] that does not reflect body composition nor the distribution of adipose tissue[60]: BMI also appears to differ by demographic factors such as age, ethnicity and gender[61]. Other methods of anthropometric assessment such as skinfold thickness measurement using standardized examination procedures and calibrated equipment may have been more reliable in the evaluation of anthropometric trends over time. Lastly, all discussion should bear in mind the geography of the study and the relatively small sample size of the young cohort. Young Lives is not intended to be a nationally representative survey; children were selected from 20 sentinel sites which, although is intended to form purposive sampling (whereby each cluster is deemed to be representative of a specific population) it remains that findings are not wholly applicable to, nor are they representative of the Peruvian population. It has been noted that differences in weight levels and dietary patterns vary heavily across the departments of Peru[22] which may not have been fully accounted for in the study design.

Despite these limitations, this is among the first of studies which attempts to illustrate maternal perception of child weight and height in comparison to both child BMIA and HAZ status via the use of longitudinal data. The original longitudinal design of the Young Lives study, with its moderate sample size and multiple measured variables, offers a valuable opportunity for further analysis of the influences contributing to the rise in excess weigh among children in Peru. There is a great requirement for further research on this issue, whereby this study presents an insightful starting point. Complementary research might consider the effect of other social and environmental factors as they interact with perceptions, values and beliefs; it is also pertinent to take into context the wider determinants of weight change, including those which relate to trade, the economy, the global nutrition transition and subsequent changes in the food system[3].

Conclusion

Whilst much research has explained the tendency for mothers to underestimate the weight of their child and the resulting strong effect on likely future weight gain of the child, little to no research has described this in consideration of child height-for-age status: the results of this study may be of interest for public health strategy and interventions aimed at tackling the double burden of malnutrition in Peru and also in neighbouring Andean countries. The results indicate that in Peru, a low-middle income country experiencing high economic growth and the "double burden of malnutrition" within households and individuals, high stunting prevalence in children (almost a third under 5 years) is correlated with increased odds of future overweight or obesity in comparison to their normal height counterparts. Furthermore, the likelihood of later excess weight was strongly correlated to an inability of the mother to correctly perceive the weight, and height, of her child. Of the children who gained weight at round 3, particularly of those stunted, the majority of their mothers felt them to be both taller and lighter. Factors which increased the odds of later O/O alongside maternal misperception of height and weight included maternal O/O, child gender (male) and living in the coastal region. The strong correlation between later child O/O and higher income and education describes a paradigm whereby those of a higher SES are becoming increasingly more exposed to factors which lead to weight gain. This has been described as true in low-middle income countries where changes to new and different dietary patterns (typically containing greater amounts of processed foods high in sugar and fat) and increasingly sedentary lifestyles lead to overweight and obesity[56].

The trend toward underestimation in the results (particularly among mothers of stunted children) suggests that the perception of what is a normal weight is beyond what is the clinical level: it is possible that this tendency to underestimate may pave the way for subsequent obesity. A body of research illustrates the relationship between accurate weight perception, risk awareness and subsequent attempts to then modify weight[62, 63]: mothers of overweight children who do not perceive the excess weight may be less likely to seek the advice needed to make changes to dietary habits and lifestyle choices or employ strategies to lower their child's weight if they do not believe them to be at risk[29]. Furthermore the results also indicated a noticeable trend of the degree and direction of misperception between mothers of stunted and non-stunted children: thus it is likely that public health programmes would be more highly effectual if they are 'decentralized' and tailored[22], adapted to specific groups of the population, as well as across departments experiencing different stages of the nutrition transition[64]; it is also important to highlight that the causal factors of overweight and obesity in children are multidimensional and complex without conveying a sense of guilt or blame[65].

Troublingly, levels of excess weight in Peru have risen considerably in recent years and continue to do so, independent of poverty level or area of residence[1]. This research attempts to highlight current gaps in the literature: additional research may attempt to further understand the impact of cultural influences and reasons for maternal misperception of weight, especially of children who are stunted. An effective intervention aimed at reducing the levels of child overweight within a community is likely insightful, multifaceted and culturally sensitive, appreciating that cultural beliefs and values are a central element of an individual's self-perception and wellbeing.

Key Points

- Of the 2037 children at round 1, 28.8% were found to be stunted
- By round 2, a greater proportion of stunted children were overweight or obese
- Less than half of mothers of stunted children recognised their child to be stunted
- Mothers of both stunted and non-stunted children consistently overestimated child height
- Mothers of stunted children were more likely to underestimate weight
- More women were able to identify correct weight if their child was of normal height
- By round 3, stunted children whose mothers previously incorrectly estimated their weight were almost three and a half times more likely to have gained weight than those who correctly estimated
- Multivariate analyses indicated early incorrect maternal weight perception correlated to a two and a half times higher odds of later overweight or obese child
- Despite little evidence for stunting as a predictor of overweight, testing for an overall effect showed stunting corresponded to a 3 times higher odds of overweight than normal height
- As this association disappeared after multiple predictors were included in the model, it is likely stunting interacts strongly with maternal perceptions of both height and weight.
- Results may be of interest for public health strategy and interventions aimed at tackling the double burden of malnutrition in Peru and in neighbouring Andean countries.

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Appendix

Appendix A: Loss to follow-up for selected key variables between round 1 and round 2 and round 1 and round 3.

	ATTRITION											
	Original sample		Traced		Refusal		Not located		Child deceased		**Total attrition**	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Rounds 1-2 (2002-06)												
587 (100)	555	(94.5)	15	(2.6)	5	(0.9)	12	(2.0)	**32**	**(5.5)**		
1445 (100)	1397	(96.1)	30	(2.1)	21	(1.5)	5	(0.3)	**48**	**(3.9)**		
1186 (100)	1136	(95.8)	30	(2.53)	9	(0.8)	11	(0.9)	**50**	**(4.2)**		
853 (853)	815	(95.6)	15	(1.8)	17	(2.0)	6	(0.7)	**38**	**(4.4)**		
1406 (100)	1339	(95.2)	31	(2.2)	24	(1.7)	12	(0.9)	**67**	**(4.8)**		
646 (100)	624	(96.6)	15	(2.3)	2	(0.3)	5	(0.8)	**22**	**(3.4)**		
1035 (100)	982	(94.9)	28	(2,7)	14	(1.4)	11	(1.1)	**53**	**(5.1)**		
308 (100)	297	(96.4)	8	(2.6)	2	(0.7)	1	(0.3)	**11**	**(3.6)**		
709 (100)	684	(96.5)	10	(1.4)	10	(1.4)	5	(0.7)	**25**	**(3.5)**		
1027 (100)	990	(96.4)	19	(1.9)	13	(1.3)	5	(0.5)	**37**	**(3.6)**		
1025 (100)	973	(94.9)	27	(2.6)	13	(1.3)	12	(1.2)	**52**	**(5.1)**		

	ATTRITION											
	Original sample		Traced		Refusal		Not located		Child deceased		**Total attrition**	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Rounds 1-3 (2006-09)												
Stunted	587	(100)	550	(93.7)	19	(3.3)	6	(1.0)	12	(2.0)	**37**	**(6.3)**
Normal height	1445	(100)	1382	(95.6)	36	(2.5)	27	(1.9)	8	(0.6)	**63**	**(4.4)**
Normal weight	1186	(100)	1136	(95.8)	24	(2.0)	15	(1.3)	11	(0.9)	**50**	**(4.2)**
Overweight/Obese	853	(100)	796	(93.3)	30	(3.5)	18	(2.1)	9	(1.1)	**57**	**(6.7)**
Urban	1406	(100)	1323	(94.1)	39	(2.8)	30	(2.1)	14	(1.0)	**83**	**(5.9)**
Rural	646	(100)	620	(95.9)	17	(2.6)	3	(0.5)	6	(0.9)	**26**	**(4.1)**
Mountain	1035	(100)	976	(94.3)	33	(3.2)	14	(1.4)	12	(1.2)	**59**	**(5.7)**
Jungle	308	(100)	297	(96.4)	7	(2.3)	2	(0.7)	2	(0.7)	**11**	**(3.6)**
Coast	709	(100)	670	(94.5)	16	(2.3)	17	(2.4)	6	(0.9)	**39**	**(5.5)**
Male	1027	(100)	980	(95.4)	25	(2.4)	16	(1.6)	6	(0.6)	**47**	**(4.6)**
Female	1025	(100)	963	(94.0)	31	(3.0)	17	(1.7)	14	(1.4)	**62**	**(6.0)**

Appendix B: Registration to the UK Data Archive

Your account
Your details
Usage details
Order history
Special Conditions

Usage details : usage 91814

Usage title: MSc Demography and health

Intended use: Non-commercial

Subject category: Nutrition - Health; Population studies - Population, vital statistics and censuses; Social attitudes and behaviour - Society and Culture; Child development and child rearing - Social stratification and groupings;

Brief description of usage

Please provide a description of at least thirty words and include information about funding sources for this usage. Where it is necessary to pass this information to data depositor(s), we may need to contact you to request more details if insufficient information is provided.

I am a current MSc student at the London School of Hygiene and Tropical medicine and intend to use the Peru data, rounds 1-3 for my MSc final project. I have ethics clearance from LSHTM ethics committee and am in contact with the Young lives study at Oxford and Mary Penny of the Peru cohort. I am using anthropometric variables of children and mothers as well as indicators on maternal weight perceptions to identify stunted child-overweight mother pairs and a temporal trends over the three rounds.

Update brief description GO

Share usage details:

UK Data Service has a facility to enable you to view the information given by researchers applying to use UK Data Service data. These details are available from the Data in use pages.

To share your name, institution, usage title and description, and information about the datasets used for this usage, please select the checkbox ☑

Users associated with this usage

Surname	Forename	Delete
Budge	Sophie	

Appendix C: Change in child weight between rounds

Appendix C illustrates the numbers of children who changed weight status to one of excess weight between rounds 1-2 and 2-3. This is stratified by HAZ category. Weight at round 3 acted as the outcome for the influence of maternal perceptions on child weight at rounds 1 and 2.

	HEIGHT-FOR-AGE CATEGORY BY ROUND							
	Round 1 to Round 2				**Round 2 to Round 3**			
	Stunted		Normal		**Stunted**		Normal	
CHANGE IN BMI-FOR-AGE	**n**	**(%)***	n	(%)*	**n**	**(%)***	n	(%)*
Under- to excess weight**	**3**	**0.5**	2	0.2	**1**	**0.2**	-	-
Normal to excess weight	**116**	**17.9**	122	9.5	**47**	**10.9**	140	9.6
No change in excess weight	**108**	**16.7**	275	21.3	**76**	**16.7**	253	17.4

* All percentages calculated as a % of total possible changes in BMI-for-age status.
** Excess weight by definition including overweight and obesity.

Appendix D: Maternal height perception and measured child height

Pearson's chi^2 contingency test between maternal perception of child height (Correct vs Incorrect) and actual child height-for-age at round 1 (Stunted or normal height). Accuracy of maternal perception is convened into total correct or incorrect.

MATERNAL HEIGHT PERCEPTION		HEIGHT-FOR-AGE ROUND 1: **Stunted** n	**(%)**	Normal n	(%)	Total n	(%)	Accuracy n	(%)
Correct	Correct - Stunted	**245**	**42.7**	-	-	245	12.2	996	49.7
	Correct - Normal height	-	-	751	52.6	751	37.5		
Incorrect	Incorrect normal –stunted	**234**	**40.8**	-	-	234	11.7	1006	50.3
	Incorrect taller - stunted	**95**	**16.6**	-	-	95	4.8		
	Incorrect taller - normal	-	-	481	33.7	481	24.0		
	Incorrect stunted - normal	-	-	196	13.7	196	9.8		
	Incorrect stunted - taller	-	-	-	-	-	-		
	Incorrect normal - taller	-	-	-	-	-	-		
	Total	**574**	**100.0**	1428	100.0	2002	100.0	2002	100

Pearson chi^2= 2.0e+03, p=<0.001

Appendix E: Maternal perception of child weight change and actual change in child weight

Pearson's chi^2 contingency testing the accuracy of maternal perception of child weight change (correct vs incorrect) from rounds 1-2 with actual child weight change from rounds 1-2. Stratified by child height-for-age category (stunted or normal height).

	HEIGHT-FOR-AGE					
	Stunted		Normal		Total	
MATERNAL PERCEPTION OF WEIGHT CHANGE ROUNDS 1-2	**n**	**(%)**	n	(%)	n	(%)
Correct	**141**	**22.1**	701	54.8	842	43.9
Incorrect	**486**	**77.9**	578	45.2	1064	55.5
Total	**637**	**100.0**	1279	100.0	1916	100.0

Pearson chi^2= 9.7659 , $p=<0.001$