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Dietary inequalities of mother-child pairs in the rural Amazon: Evidence of maternal-child buffering?

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Abstract

This paper explores the expected outcome of maternal nutritional "buffering," namely that children's diets will be more adequate than mothers' diets under conditions of food scarcity. Data on Amazonian mothers and their children, household demography and economics and direct, weighed measures of household food availability and dietary intakes of mother-child pairs were collected from 51 households to address the following research questions: (1) is there evidence of food scarcity in this setting?; (2) are there differences in energy and protein adequacy between children and their mothers?; and, (3) which individual and household-level factors are associated with these mother-child differences in energy and protein adequacy? In this context of food scarcity, we found that the majority of children had more adequate energy ($p<0.001$) and protein ($p<0.001$) intakes than their mothers. Multivariate OLS regression models showed that of the individual-level factors, child age and height-for-age were negatively associated with maternal-child energy and protein inequalities while maternal reproductive status (lactation) was positively associated with energy inequality. While there were no gender differences in dietary adequacy among children, boys had a larger advantage over their mothers in terms of protein adequacy than girls. Household food availability was related to maternal-child energy and protein inequalities in a curvilinear fashion with the lowest inequalities found in households with extremely low food availability and those with adequate food resources. This is the first study to quantify maternal-child dietary inequalities in a setting of food scarcity and demonstrates the importance of the household context and individual characteristics in understanding the degree to which mothers protect their children from resource scarcity.

Keywords

Brazil; Amazon; food security; intra-household resource distribution; parental investment; nutrition; food provisioning

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Introduction

Approximately one billion people world-wide suffer from inadequate access to food, or food insecurity, a state in which people lack access to sufficient food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2009). Chronic food insecurity has both immediate and long-term health effects that undermine individual well-being, societies' productivity, and the ability to break the intergenerational cycle of poverty (Cole & Tembo, 2011; Walker et al., 2008; Weaver & Hadley, 2009). Thus, understanding the strategies people use to cope with low food availability, including intra-household distribution (see Gittelsohn et al., 1997; Haaga & Mason, 1987; Haddad et al., 1996 for an extensive review; Hadley et al., 2008; Hampshire et al., 2009; Messer, 1997), and identifying those at greatest risk of food insecurity is of practical importance. Women and children are at increased risk of suffering food insecurity and malnutrition due to their greater biological needs (Prentice et al., 1996; Torun et al., 1996) and, commonly, lower social status (Pelto, 1987).

Due to children's dependence on adults for their basic needs, their reproductive and economic value, and their biological relatedness, there is an expectation that parents will play an active role in ensuring children's access to food (Bogin, 1997). In environments of food scarcity, this implies a trade-off between parental and child resources, and in the case of food, dietary inequalities. Mothers, in particular, are expected to protect children from food scarcity due to the central role women play in food production, preparation and childcare (Brown et al., 1995). Qualitative research suggests that mothers protect their children from low food supplies by reducing their own food intake (Coates et al., 2006; Fitchen, 1987; Gundersen & Krieder, 2008; Radimer et al., 1992). This idea that child food intake will be prioritized over that of their mother is often referred to as maternal buffering.

Although maternal buffering is a readily accepted and meaningful concept, most empirical evidence of buffering relies on parental reports, which have been shown to inaccurately characterize children's food experiences (Bernal et al., 2012; Fram et al., 2011). Of studies that have considered intra-household differences in food distribution more directly, some indicate better intakes among adults, often men, due to their higher social status, energetic expenditure and/or economic value (Abdullah & Wheeler, 1985; Engle & Nieves, 1993). Other studies have reported the preferential feeding of children (Graham, 1997; Kaiser & Dewey, 1991; Kramer et al., 1997; Leonard, 1991; Oldewage et al., 2005) and thus offer some evidence of buffering. The literature also suggests that individual-level factors, such as child age and gender, determine access to food. Mothers might be expected to preferentially buffer younger children due to their higher level of dependence on others for resources (Graham, 1997), and sons more than daughters due to the higher social status of males in many societies (Fikree & Pasha, 2004; Frongillo & Bégin, 1993), but see Haddad et al. (1996) and Hampshire et al. (2009) for contrary evidence from Africa.

We build on previous work and advance the discussion of intra-household food distribution and concept of buffering by drawing on a unique set of observed dietary data collected from 51 matched mother-child pairs in rural households in the Brazilian Amazon. These data allow us to calculate quantitative differences in dietary adequacy between mother-child pairs in a setting of high poverty. Then, we assess whether matched mother-child pairs differ in their energy and protein adequacies. Evidence of maternal-child diet inequalities that favor children over their mothers would suggest evidence of maternal buffering (or other household strategies) that results in better diets for children than their mothers.

Finally, we consider variation in maternal-child diet inequalities across households; and, whether child, mother, or household characteristics predict the extent to which children's dietary adequacies exceed those of their mothers. We are particularly interested in whether household food adequacy is associated with maternal-child dietary inequalities. In households meeting little of their food needs we may find mothers are less able to direct food towards the child than when households experience higher, but still insufficient, levels of food adequacy. As households reach a point of food sufficiency, we would expect reduced inequalities between children and their mothers as food supplies theoretically enable all household members to meet their dietary needs.

Methods

Field location and study participants

The participants in this study self-identified as *Ribeirinhos* (Indigenous Amerindian/ Portuguese/African) and lived in seven, rural communities located around the Caxiuanã National Forest in the Brazilian state of Pará. The communities were approximately eight hours by small motorboat from the nearest town, Portel. People lived in small, wooden houses along rivers and had no piped water. Only 40% of households had access to a few hours of electricity in the evening using a generator. The majority of households consisted of a nuclear family, although a few included extended kin such as grandparents.

While there has been a decline in subsistence activities over the past 10 years, most households continued to practice slash and burn agriculture with bitter manioc as the staple crop (Piperata et al., 2011a). Manioc, a non-seasonal crop, was consumed primarily in the form of *farinha*, a dry, toasted meal. Fish and hunted game (*paca*, armadillo, wild pig, turtles) were the most important local sources of protein and *açaí*, a local palm fruit, was a source of energy and fat (Piperata et al., 2011a). Local foods were complimented with sugar, coffee, crackers, beans, rice and domesticated meats (*charque*, a dry, salted fatty beef product and *mortadella*, a bologna-like processed meat, chicken and canned sardines) which were accessed through the barter of *farinha* or with cash earned through male wage labor or government programs.

The daily food consumption pattern was similar to that seen throughout Latin America with the mid-day meal being the most significant. Breakfasts were small and almost always included highly-sugared coffee and *beiju*, a manioc-starch pancake, or purchased crackers. Lunch included *farinha* accompanied by fish, game or purchased meats, and/or beans. Dinner typically consisted of leftovers from lunch and was skipped when food availability was low.

Prior data indicate that access to adequate food is problematic for rural Amazonian peasants, with implications for child and adult health. Anthropometric data show that growth faltering begins around the time infants cease breastfeeding (1–2 years) (Piperata et al., 2011b) and rates of stunting are high among children (2 – 18 years) (males, 57%; females 58%) and adults (males, 45%; females 58%) (Guigliano et al., 1981, 1984; Piperata et al., 2011b). Dietary data collected at the individual (Piperata et al., 2011a) and household-level demonstrate that access to sufficient energy, more than protein, is a challenge (Guigliano et al., 1978; Murrieta & Dufour, 2004). Finally, as will be discussed in greater detail below, administration of the Brazilian perceived food insecurity scale (*Escala Brasileira de Insegurança Alimentar,* EBIA) (Melgar-Quiñonez et al., 2008) revealed high levels of food insecurity. Thus, this is a setting where household food scarcity and maternal buffering are expected to be high.

Study design and data collection

The data presented here were collected between May and July, a period which falls between the wet and dry seasons, in 2009. Previous dietary data collected from these same communities revealed no seasonal differences in macro-nutrient intakes (Piperata et al., 2011a). Based on field research we estimate there are ~1,200 people living in ~200 households within 2.0 hours, by motorized boat, of the Ferreira Penna Research station located in the Caxiuanã National Forest. Data were collected from a convenience sample of households that met the following criteria: (1) home was located within 1.5 hours of the research station where we had reliable boat access essential for travel within the region; (2) household was dual-headed, (3) a non-breastfeeding child under 16 years of age lived in the home and (4) the female head was not in *resguardo*, the 40-day postpartum period when women follow work and food taboos (Piperata, 2008). Single-headed households are rare in this region due to the local subsistence pattern. In visits to 72 households, we identified only one such home. We limited the sample to non-breastfeeding children due to the complication of estimating the macro-nutrient intakes of breastfeeding infants. Our inclusion of children through 16 years was due to our interest in how maternal-child dietary adequacy might vary as children age. Starting from the station, we invited all households who met the above criteria to participate, spreading out until we reached a total sample of 54 households or ~25% of the homes in the region. None of the households invited to participate refused. Errors in food measurements and missing anthropometric data resulted in an analytical sample of 51 mothers and 51 focal children (one per mother). We found no differences in the composition or economic characteristics of the three excluded households and the 51 included in the final sample.

Measures

Dietary Intake—Dietary data were collected over a period of three consecutive days using the weighed-inventory method which consists of weighing all foods consumed in the household, as well as by the individual subjects of interest, in this case the mother and selected child (Gibson, 1990). Dietary intakes do not vary between week days and weekends and data were collected during both. Four researchers, all trained by the first author, assisted in dietary data collection. To collect these data a researcher arrived in the home in the morning and remained in the vicinity of the home until after the evening meal. During this period the researcher weighed all foods consumed. In the case of recipes, the researcher weighed all individual ingredients, the final weight of the prepared dish and, finally, the portions consumed by the mother and selected child. The weights of any discarded items (e.g. bones, seeds) were subtracted from the served weight. Occasionally, a dish was prepared or an item was consumed when the researcher was not in the home. This was most common with the consumption of coffee in the early morning. In such instances, the researcher asked the mother to recall the recipe and served amount. This estimated amount was then weighed and recorded. Data on species of fish, fruit and game were collected at the same time the foods were weighed.

The collection of data on children's dietary intakes can be challenging. In these rural communities, households are typically separated from one another and travel between them is by canoe. This reduced the opportunity children had to eat in the homes of others. We observed very few instances of children foraging on their own, however, we asked children about any foods they consumed when outside the home and when reported we estimated the weight of the recalled item and added it to the child's daily intake.

Daily energy (kcal) and macro-nutrient [carbohydrate (g), protein (g), fat (g)] consumption of each mother, child, and household as a whole was calculated using Brazilian databases (*see* Piperata et al., 2011a for details) and Nutritionist Pro Software (Axxya Systems, Stafford, TX). When packaged foods were consumed, nutritional information was taken directly from the packaging label. Here we report the three-day average and standard deviation.

Anthropometry—The ages of all household members were determined through interviews and verified with birth certificates when available. All anthropometric data were collected by the first author following Lohman et al. (1988) and included height (cm) and weight (kg). These data were used to calculate body mass index (BMI) (kg/m^2). EpiInfo was used to calculate z-scores for height-for-age (HAZ) and BMI (BMIZ) for children 5 years and under (WHO 2007 reference standard). The international references standard (NHANES III, Frisancho, 2008) for height and BMI were used to calculate height-for-age (HAZ) and BMI (BMIZ) z-scores for all those over age 5.0 years. At the time of anthropometric data collection, mothers were asked about the health status of all family members. Mild respiratory infections were commonly reported however, only one mother reported a child with more severe symptoms which included diarrhea. This household was dropped from the study due to missing anthropometric values.

Energy and protein adequacy—The adequacy of energy intake was determined by comparing an individual's intake to their estimated total daily energy expenditure (TDEE) which included their basal metabolic rate (BMR) and estimated energy expenditure in physical activity (EEact). For adults, BMR was estimated using the age and sex appropriate equations of Henry & Rees (1991) for tropical populations. In this study we were unable to collect detailed activity data. Therefore, to estimate EEact for the women we relied on continuous activity diaries collected from women from these same communities in 2002 (Piperata & Dufour, 2007). Based on those findings and spot observations of women's activity levels in 2009 we used a physical activity level (PAL: TDEE/BMR) of 1.56, which is considered sedentary/light (FAO/WHO/UNU, 2001). For the adult men we also used a PAL of 1.56. We consider this PAL as minimal to average for the population, thus any calculations of energy adequacy based on these values could be viewed as conservative. The additional caloric demands of pregnancy (FAO/WHO/UNU, 2001) and lactation (Prentice et al., 1996) were added when appropriate. Protein adequacy was determined by comparing each adults' protein intake to FAO/WHO/UNU (1985) recommendations (protein needs = weight (kg) × 0.75). As with energy, the additional protein requirements of pregnancy and lactation were added when appropriate (FAO/WHO/UNU, 1985). For children, we used the age and sex-appropriate equations published by FAO/WHO/UNU (2001) to calculate TDEE and estimate protein requirements.

For the household, energy adequacy was calculated by adding the energy needs of all individuals who ate in the home on the days of data collection and comparing it to the total kcal consumed in the home: [*(total household energy consumed/total daily energy needs of all household members)*100*]. For the mothers and focal children, individual energy and protein adequacies were calculated as: [(*total energy intake/TDEE)*100*] and [*(total protein intake/estimated protein needs)*100*], respectively.

Economic and food security interviews—We conducted interviews with the female head to collect household demographic, economic, and perceived food security data. Household food security data were collected using the validated Brazilian Food Insecurity Scale (EBIA) (Melgar-Quiñonez et al., 2008). The instrument consists of 15 questions of increasing severity, ranging from worry regarding running out of food to a situation where a child in the home went an entire day without eating a meal due to lack of food. A score of zero (a "no" response to all questions) signifies food security while a score of between one and five indicates low food insecurity. Moderate food insecurity is defined as a score between 6–10. A score greater than 10 implies severe food insecurity. The instrument was face-validated in the communities prior to use. All data collection methods were approved by the Institutional Review Board at The Ohio State University (IRB # 2009B0056) and the *Comite de Ética* at the Universidade de São Paulo, Brazil.

Data Analysis

To address our first research question, quantifying the level of food scarcity in the study sample, we present descriptive statistics regarding perceived food insecurity, and actual diet adequacies (at the household, mother and child levels) obtained following the above analytical methods. We also present findings of the types of food that contributed to children's and mothers' diets to assess the extent to which differences in adequacy reflect type versus quantity of food eaten.

The second research question addresses the presence and extent of differences in dietary adequacy between mother-child pairs. We used paired Student's t-tests to test for significant differences in maternal-child pairs' energy and protein adequacy (SPSS ver. 19; $p < 0.05$) and then calculated the extent of these differences by subtracting the mother's dietary adequacy score from that of the child for the relevant category (energy and protein). Here we present the mean, median and range of what we call *maternal-child dietary inequalities* found in this sample for both energy and protein.

Finally, to address our last research question regarding the child, maternal, and household characteristics associated with the level of *maternal-child dietary inequalities,* we used multivariate regression (STATA 11.0) with maternal-child energy and protein inequalities as the dependent variables (energy and protein inequalities are modeled separately). In the models, we include the basic child, maternal, and household characteristics listed in Table 1.

We were particularly interested in how household-level food scarcity was associated with maternal-child inequalities, net of these other basic characteristics. We selected household energy adequacy as our measure of scarcity, since achieving energy adequacy is more problematic than achieving protein adequacy in the region. Although we report the general level of perceived household food security (EBIA instrument) in the sample, we do not use this measure in analyses because all households reported being moderately or severely food insecure.

In assessing the association between household energy adequacy and mother-child diet inequalities, we hypothesized a non-linear relationship. First, as households move from very high scarcity (low levels of adequacy) to moderate scarcity, we might expect more of the child's needs to be able to be met, and thus a growing gap between the mother-child diet adequacies. As households move from inadequately to adequately meeting all members' energy needs (i.e., household energy adequacy ≥ 100%), we hypothesized that mothers may be able to increase their own dietary intakes and thus "catch up" to their children's adequacy measures, reflecting a decline in the inequalities gap. This was tested through the significance of a quadratic term for household energy adequacy in the model. The models accounted for the clustering in the data due mother/child pairs living in the same communities (Snijders & Bosker, 2011) and we considered p-values less than 0.05 as statistically significant.

Results

Table 1 reports the descriptive statistics of the sample children, mothers, and household characteristics. Approximately half of the children were male, and average child age was 9.4 years. The age distribution of the children was as follows: children (4.0–6.9 years) n = 12; juveniles (7.0–11.9 years) n = 27 and adolescents (12.0–16 years) n = 12. Average height-for-age z-score (HAZ) of the children was −1.7, with 50% of the children stunted (HAZ< −2). Among the mothers, 12% (n=6) were pregnant and 29% (n=15) were lactating. Average maternal age was 35.5 years and their mean HAZ was −1.9 (46% stunted). Average household size was 6.8. Most were nuclear families, only 29% had a salary or wage income,

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and 67% had a manioc garden, reflecting their continued, albeit declining, reliance on subsistence agriculture.

Evidence of dietary scarcity at the household and individual level

Results regarding the degree of dietary scarcity are summarized in Table 2. Results of the perceived household food security scale (EBIA) revealed that all households were moderately or severely food insecure. In fact, mothers in all but one household reported that some member of the household had a less than a healthful diet, and all but two of the women reported that the household ran out of food at some point in the past three months.

An advantage of this study, however, was the ability to also consider actual food availability at both the household and individual levels in a context of perceived food insecurity. Based on the 3-days of measured food preparation and distribution, average daily household energy adequacy was estimated at 74% and only 12% of the sample households met or exceeded their total daily energy needs (Table 2). Reflecting the ability to better meet their protein needs, average daily household protein consumption was 154% of estimated need and 81% of the households met or exceeded their protein needs (Table 2).

Individual measures presented in Table 2 further illustrate food scarcity in this sample. Mothers, on average, consumed 62% of their daily energy needs (only one reached 100% of her energy needs). In terms of protein, mothers, on average, met 94% of their needs; however, 54% of sample mothers did not meet their daily protein needs. Children averaged 76% of their daily energy needs (only 12% met or exceeded their energy needs). Like their mothers, children were better able to meet their protein needs. On average, children met 172% of their protein needs and 88% met or exceeded their daily needs. We found some difference in adequacy by age group but no differences in energy or protein adequacy between boys and girls.

Finally, analysis of the meal patterns of mothers and children (Table 3) revealed the key dietary sources of energy and protein in the sample. Particularly import is the remarkable similarity in the diets of mothers and their children.

These average differences in dietary adequacies that emerge amidst general food scarcity are further explored below through an assessment of dietary inequalities between mother-child pairs.

Maternal-Child dietary Inequalities

Our second research question asked if, in this environment of scarcity, there was empirical and quantitative evidence of inequalities in the dietary intakes of mothers and their children that favored children. The results of mother-child matched-pairs t-tests show that mothers' dietary adequacy was significantly lower than that of their children for both energy ($t = 4.0$; $p < 0.001$) and protein ($t = 10.0$; $p < 0.001$).

Although our results suggest an overall advantage for children over their mothers in terms of both energy and protein intakes, this was not the case in all households. Indeed, the descriptive statistics in Table 2 suggest substantial variation in the level of inequalities between mothers and their children. The mean level of child-mother energy inequalities was 14.6%, but ranged from −79% to 62% and while 75% of children had higher energy adequacy levels than their mothers, 25% had levels at or below their mothers'. For protein, average child-maternal inequality was greater (88%) as was the range (−83% to 64%). Compared to energy, fewer children were at or below maternal protein adequacy levels (10%).

Child, Maternal, and Household Predictors of Diet Inequalities

The regression results in Table 4 are reported for inequalities in both energy and protein adequacy, modeled separately. Overall, child-level characteristics emerged as the main determinants of the level of maternal-child dietary inequalities. Maternal and basic household characteristics (excluding our measure of household diet adequacy, which was highly significant), proved less important. When considering child characteristics, boys showed larger advantages over their mothers in terms of both energy and protein adequacy, although the effect was statistically significant only in the protein model. The male coefficient in the protein model suggests that boys had, on average, a 29 percentage point higher advantage in protein adequacy over their mothers than did girls, holding all else constant (Table 3, model 2). Child age was negatively associated with maternal-child dietary adequacy inequalities in both models, indicating a decline in inequality between children and their mothers as child age increased. Finally, the child HAZ coefficients indicate that, for energy and protein, the taller a child is for his or her age, the lower the dietary advantage the child has over his or her mother.

In terms of maternal characteristics, only lactation was associated with maternal-child dietary inequalities, and this was significant only for the energy models. The coefficient reflects that children with lactating mothers had a dietary advantage over their mothers that was 13 percentage points higher than those with non-lactating mothers.

At the household level, none of the basic characteristics (size, salary, or garden) were associated with mother-child dietary inequalities when the other model variables were held constant. However, as Table 4 shows, the association between household energy adequacy and maternal-child diet inequalities was significant and relatively large. For each percentage point increase in household adequacy, children's dietary adequacy advantage over their mothers increased by 2.3 percentage points for energy and 3.6 percentage points for protein, on average, when taking into account the linear and squared terms and holding all else constant. As we hypothesized, the effect was curvilinear as illustrated by the significant squared term and joint significance (F-test) of the household adequacy linear and squared terms in both the energy and protein inequalities models ($p<0.05$).

Figure 1 illustrates the curvilinear association between household energy adequacy and maternal-child energy and protein inequalities by plotting the predicted inequality levels at various household energy adequacy levels while holding child, maternal, and other household factors constant.

As Figure 1 shows, household energy adequacy has a positive effect on children's energy and protein advantages over their mothers when moving from the lowest adequacy level (30% of household need met) to an adequacy level of ~100%. Once a household meets its energy needs, the association between higher levels of household energy adequacy and children's dietary advantage over their mothers begins to decline. Comparing the lines indicates that with increasing household energy adequacy, children's protein advantage over their mothers grows quickly and declines less at the high end of household adequacy compared to energy inequalities. Energy inequalities are predicted to increase up to just under a 20 percentage point advantage for a child over their mother when approaching full household adequacy (100%). Once household energy needs are met, the gap between the mothers and their children declines as mothers' energy adequacies "catch up" to those of their children.

Discussion

This paper sought to extend our understanding of the relationship between the dietary adequacies of children and their mothers in an environment of food scarcity due to the well-recognized vulnerability of these two groups to food insecurity and malnutrition (Pelto, 1987) and the expectation that under conditions of scarcity, adults, particularly mothers, should demonstrate buffering behaviors which result in children having more adequate intakes (Bogin, 1997; Brown, 1995; Fitchen, 1987; Radimer et al., 1992). In addition, we sought to identify individual and household-level factors that affected differences in dietary adequacy between matched mother-child pairs. To do this we directly measured daily household food preparation, as well as the intakes of mothers and their children living in poor, rural households in the Brazilian Amazon.

The data presented illustrate an environment of food scarcity, especially in terms of energy, which is congruent with the small number of other studies that have reported dietary data on Amazonian peasant populations (Guigliano et al., 1978; Murrieta & Dufour, 2004; Piperata & Dufour, 2007) and the one other study which used the same scale (EBIA) to assess perceived food insecurity (Yuyuma et al., 2008). The fact that protein needs were more easily met than energy needs is due to the availability of high quality, animal sources (especially fish) in this context, cultural preferences and dietary patterns which will be discussed below.

Generally, it is expected that under conditions of scarcity, adults, especially mothers, will exhibit buffering behaviors in order to divert scarce resources toward their children resulting in better intakes among children. However, most of the published literature on this topic relies solely on reports of such behaviors and does not include data on actual dietary intakes of matched mother-child pairs (e.g., Fitchen, 1987; Gundersen & Krieder, 2008; Radimer et al., 1992; Hadley et al., 2008). In responding to the food insecurity questionnaire, the mothers in this study reported buffering behaviors especially reducing portion sizes but also skipping meals in effort to protect their children. Our data suggest these behaviors impact intake. For both energy and protein, children had significantly better intakes than their mothers. The data also indicate that the gap in adequacy between mother-child pairs was greater for protein than energy indicating that it was harder for mothers to buffer their children in terms of energy. A possible explanation for this finding is the characteristics of the local diet. Mothers distributed the protein source between household members at mealtimes and were keenly aware of the amount available and importance of fish, meat and beans and their accompanying broth in improving overall intakes among children. This is because *farinha*, placed in broth, softens and became more palatable. The idea that the bulky nature of *farinha* may limit energy intakes, especially among children, has been raised by other scholars (Dufour, 1992). Thus, mothers may have strategically given their children highly valued proteins in an effort to get them to consume more of the staple food. The juice of the *açaí* fruit was used in a similar way, which may explain its greater importance in the diets of the children over their mothers in this study. Kaiser & Dewey (1991) also found more adequate protein intakes among children compared to their mothers in rural Mexico, which may have been for similar reasons.

While the data demonstrate more adequate intakes among children compared to their mothers, it is important to note that, on average, children still fell short of meeting their energy needs and thus still experienced the nutritional effects of food insecurity. These data support the work of Bernal et al. (2012) and Fram et al. (2011) who argue that despite caregiver reports of protecting children from food scarcity, children still experienced food insecurity.

Of the child individual-level variables considered, younger age and poorer nutritional status (lower HAZ) were associated with a larger gap in maternal-child dietary adequacy which favored the child. This is consistent with our ethnographic observations which included seeing younger children crying, tugging on their mothers' clothes while begging for food and, in some cases, acting aggressively towards their mothers when she did not immediately respond to their food demands. Typically, mothers responded with whatever they had in hand which included purchased, industrialized foods that required no preparation, such as crackers. This was not the case with older children who were rarely observed complaining of hunger or asking for food, which mothers attributed to their having a better understanding of the household food scarcity situation. In addition, older children were often responsible for the collection of food such as fish and *açaí*, giving them an awareness of the effort it takes to secure resources. Graham (1997) reported that among high-altitude Peruvian households, younger children had better intakes and Leonard (1991), working in a similar context, argued that adults protected their children from low household food availability due to children's year-round involvement in key subsistence tasks. While children in these Amazonian communities did participate in subsistence tasks as well as forage on their own, their time invested in these activities has diminished as they now spend half their day in school. In addition to not vocalizing hunger and spending less time in the home, older children had energy and protein needs closer to those of their mothers due to their larger body size and increased nutritional needs to support growth (Torun et al., 1996). Together these factors may account for the negative relationship between child age and gap in maternal-child energy and protein adequacies we observed. Importantly, previous studies of intra-household food allocation have considered a more restricted child age range (0–5 years) although see Hadley et al. (2008) for data on adolescents. By including a larger age range, this study highlights the important role age may play in access to food and overall dietary adequacy which have important health and educational implications (Walker et al., 2008).

Gender has also been shown to affect the dietary adequacies of children (Fikree & Pasha, 2004; Frongillo & Bégin, 1993). In these Amazonian communities we found no differences in dietary adequacy between boys and girls, which is in agreement with the findings of Hampshire et al. (2009) in their study in rural Niger and with the conclusions of Haddad et al. (1996) based on their extensive literature review. In addition, our dietary findings are congruent with long-term field observations which indicate limited gender bias in treatment or access to resources, at least among children, as well as the anthropometric data which show no differences in nutritional status between boys and girls. While we found no significant gender differences in energy or protein adequacy, we did find that boys had a larger dietary advantage over their mothers than girls. This was significant only for protein inequalities, suggesting that boys', more than girls', protein intake may be prioritized over that of their mothers.

The negative relationship between child growth status (HAZ) and buffering is a new and noteworthy finding. Scheper-Hughes (1993) in her now classic ethnography of urban poverty in Northeastern Brazil argued that under conditions of extreme resource deprivation and high infant mortality, mothers limit investment in their children, especially those who appeared weak (poor nutritional status). While the *Ribeirinhos* in this study lived in poverty, the degree of poverty was not as extreme as described by Scheper-Hughes. Under these less severe conditions, adults seemed to respond to child illness and signs of poor health with increased vigilance (contra Hampshire et al., 2008), which may account for the greater dietary advantage those with lower HAZ scores had over their mothers. Several authors have made a similar argument to explain the negative association between child growth status and duration of breastfeeding (Caulfield et al., 1996; Marquis et al., 1997; Simondon & Simondon, 1998). Taken together with child age, these findings may indicate that mothers actively divert food resources toward children who are visibly needier (emotionally or nutritionally) or, conversely, that due to the lower dietary requirements of these smaller children, the same amount of food met a greater proportion of their needs.

Of the maternal characteristics considered, only lactation status had an effect on the gap between mother-child dietary adequacies and only for energy. The larger gap in energy adequacy between lactating women and their children is related to the significant increase in energy needs of breastfeeding women (Prentice et al., 1996). Previous research on the energetic strategies of lactating women in these communities demonstrated that, unable to meet the energy demands of breast milk production via their diet, women relied on body fat stores (Piperata & Dufour, 2007). Aside from *resguardo* (first 40-days postpartum) there are no other known cultural beliefs or practices that would affect the consumption patterns of pregnant or lactating women.

Of the household variables considered, only energy availability was related to maternal-child dietary inequalities. The data supported our hypothesis of a curvilinear relationship where the difference in adequacy between mothers and their children (favoring children) would be lowest when household food adequacy was either very low or close to the combined nutritional needs of its individual members. At the lowest level of household food adequacy, the smaller gap likely represents the inability of mothers to give up their intake any further to divert resources to their children. At the highest levels of household food adequacy, there was no need for mothers to reduce their own intake, since available food was sufficient to meet all household members' needs. In the middle of the household adequacy distribution, the relationship was positive, with the gap in energy and protein intake favoring children increasing as household energy adequacy increased. Given the similarities in the types of food consumed by mothers and their children in these households, the child dietary advantages appear to be driven by mothers eating less rather than different foods than their children.

Several study limitations need to be taken into account when considering these findings. First, the study sample is only generalizable to the specific setting characterized by subsistence farming and chronic low access to food. It is not clear how variability in and the social determinants of maternal-child dietary inequalities might differ in communities where food is obtained through different means or food availability varies more dramatically (due to seasonality, access to markets, fluctuating food prices, etc.). Second, by including only one focal child per household, we were unable to assess if and how maternal-child dietary inequalities varied among children within the same home. Our findings regarding child age and nutritional status are suggestive of differences by child characteristics, but a better test would be through the use of sibling data (see Hadley et al., 2008). Future work that gathers dietary data on all family members and direct observations of food distribution would be ideal for assessing the full range of buffering, including the role of other household members such as fathers. However, our experiences and past research suggests that detailed data on the intakes of all household members is difficult to accomplish with accuracy (Kaiser & Dewey, 1991).

While ethnographic data help explain some of these quantitative findings, we recognize the limits of our methodological approach for demonstrating causal relationships between individual-level factors and mother-child dietary inequalities. Longitudinal data that allow for the development of change models would provide a better approximation of causal processes and allow for assessing how changes in household access to food may alter dietary behavior. Due to our primary interest in documenting the dietary patterns of mothers and children under conditions of food scarcity, we did not collect detailed data on mothers' motivations while measuring the diet. This limits our ability to determine the degree to which the dietary inequalities we observed were the result of mothers' conscious efforts to buffer their children at their own expense.

Notwithstanding these limitations, this paper describes one of the first studies to quantify the predicted outcome of maternal buffering, using detailed measures of maternal-child food intake. In addition, the paper demonstrates the importance of individual and household-level factors in shaping these inequalities. The results show a significant disadvantage for rural Amazonian women in conditions of food insecurity. Considering the nutritional demands of pregnancy and lactation and the known effects of poor dietary intakes during reproduction on maternal and child health outcomes, as well as the potential effects poor intakes have on women's abilities to perform their daily activities, including childcare, this finding is concerning and deserves further attention. The results also point to child characteristics that may produce more dietary advantages for some children than for others.

Future research will be important to further our understanding of the extent and determinants of maternal/child dietary adequacies in other settings, the costs (to mothers) and benefits (to children) of maternal buffering behaviors that result in important intra-household dietary inequalities, and the strategies utilized by mothers to ensure adequate food for children in food insecure settings.

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Research Highlights

- This paper provides quantitative evidence of dietary inequalities between mothers and their children, the expected outcome of nutritional buffering, in food insecure Amazonian households
- Household food availability was associated with differences in dietary adequacy between mothers and their children
- The dietary advantages children had over their mothers was lowest in households with very low food availability and those with adequate resources and most pronounced in households in the middle of the spectrum where resources were more available but still inadequate
- Child age and nutritional status were negatively associated with the difference in protein and energy adequacy of mothers and children

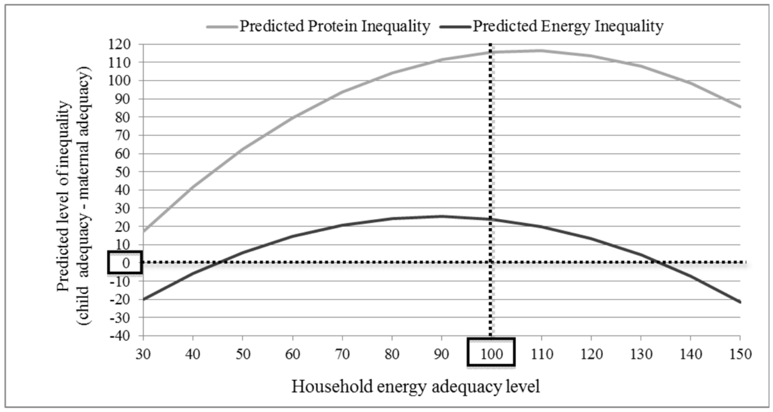

Figure 1.
Predicted Maternal/Child Energy and Protein Diet Inequalities by Level of Household Energy Adequacy. Based on regression results from Table 4.

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Table 1

Descriptive Statistics of Key Variables (n=51 households).

Variable	Mean/%	SD	Min	Max
Child characteristics				
Male	37%		0	1
Age (years)	9.4	3.5	3.5	16.7
HAZ	−1.8	0.9	−4.1	0.9
Maternal characteristics				
Pregnant	12%		0	1
Lactating	29%		0	1
Age (years)	35.5	10.8	20.0	57.4
HAZ	−1.9	0.8	−4.2	0.0
Household characteristics				
Household size	6.8	2.2	3	15
Has salary (1=yes, 0=no)	29%		0	1
Has garden (1=yes, 0=no)	67%		0	1

Table 2

Evidence of Food Scarcity and Maternal/Child Diet Inequalities in Sample Households (n=51).

Variable	Mean/%	SD	Min	Max
Household Food Scarcity				
Perceived food insecurity moderate (6–9 affirmative)	4%		0	1
Perceived food insecurity severe (10–15 affirmative)	96%		0	1
Household % energy adequacy	74.7	25.2	22.8	150.9
Household % protein adequacy	153.6	60.2	36.7	349.4
Individual dietary adequacy				
Mothers' % energy adequacy	62.5	20.3	25.4	140.5
Mothers' % protein adequacy	94.2	39.3	31.3	235.6
Children's % energy adequacy	77.2	24.3	23.8	135.6
Children's % protein adequacy	182.9	60.1	44.4	300.6
Maternal/child dietary inequalities				
Energy:				
Child – Mother % energy adequacy	14.6	26.7	−79.0	61.9
Child exceeds mother's adequacy	75%		0	1
Protein:				
Child – Mother % protein adequacy	87.9	63.4	−83.3	215.9
Child exceeds mother's adequacy	90%		0	1

Table 3

Important Sources of Energy and Protein by Meal of Mothers and Children

Meal	Children		Mothers	
Breakfast	*Energy (kcal)*	*% total*	*Energy (kcal)*	*% total*
	Cereals (wheat)	45%	Cereals (wheat)	36%
	Root crop (*beiju*)	24%	Root crop (*beiju*)	35%
	Coffee	15%	Coffee	16%
	Powdered milk	7%	Vegetable oil (margarine)	5%
	Vegetable oil (margarine)	6%	Powdered milk	5%
	Other (fruit)	3%	Other (meat, animal fat)	3%
	Protein (g)		*Protein (g)*	
	Cereals (wheat)	64%	Cereals (wheat)	57%
	Powdered milk	21%	Powdered milk	17%
	Root crop (*beiju*)	7%	Root crop (b*eiju*)	12%
	Sugar crop (coffee, other)	8%	Sugar crop (coffee, other)	9%
			Other (meat, fruit)	5%
Lunch	*Energy (kcal)*		*Energy (kcal)*	
	Root crop (*farinha*)	47%	Root crop (*farinha*)	50%
	Cereals (rice, pasta)	15%	Cereals (rice, pasta)	15%
	Pulses (beans)	15%	Pulses (beans)	15%
	Meat (domestic & game)	9%	Meat (domestic & game)	8%
	Fish	8%	Fish	7%
	Fruit (*açaí*)	4%	Other (oil, coffee, nut)	5%
	Other (coffee, oil)	2%		
	Protein (g)		*Protein (g)*	
	Fish	29%	Fish	29%
	Meat (domestic & game)	28%	Meat (domestic & game)	28%
	Pulses (beans)	25%	Pulses (beans)	26%
	Cereals (rice, pasta)	8%	Cereals (rice, pasta)	10%
	Root crop (*farinha*)	6%	Root crop (*farinha*)	6%
	Other (fruit, cracker)	4%	Vegetable oil	1%
Dinner	*Energy (kcal)*		*Energy (kcal)*	
	Root crop (*farinha*)	47%	Root crop (*farinha*)	50%
	Fruit (*açaí*)	15%	Meat (domestic & game)	13%
	Cereals (rice, pasta)	12%	Cereals (rice, pasta)	10%
	Meat (domestic & game)	10%	Fruit (açaí)	9%
	Pulses (beans)	6%	Pulses (beans)	7%
	Fish	5%	Fish	6%
	Other (coffee, nuts)	5%	Other (oil, coffee, nuts)	5%
	Protein (g)		*Protein (g)*	

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Meal	Children		Mothers	
	Meat (domestic & game)	38%	Meat (domestic & game)	42%
	Fish	23%	Fish	29%
	Pulses (beans)	12%	Pulses (beans)	12%
	Cereals (rice, pasta)	8%	Cereals (rice, pasta)	8%
	Root crop (*farinha*)	7%	Root crop (*farinha*)	6%
	Fruit (*açaí*)	6%	Fruit (*açaí*)	3%
	Other (coffee, nuts)	6%		

Note: coffee is sweetened with refined sugar

Table 4

Regression Results of Maternal/Child Diet Inequalities (n=51 mother/child pairs).

Variables	Energy Inequality	Protein Inequality
Child Characteristics		
Boy (ref=girl)	9.56 (5.80)	28.8** (14.0)
Child age (years)	−4.43** (0.94)	−9.95*** (2.26)
Child HAZ	−11.4** (3.12)	−28.2*** (7.50)
Maternal Characteristics		
Mother pregnant	−4.59 (8.53)	−3.91 (20.5)
Mother lactating	13.1* (6.23)	20.5 (15.0)
Mother age (years)	0.52 (0.32)	−0.12 (0.76)
Mother HAZ	6.43 (3.67)	12.3 (8.83)
Household Characteristics		
Household energy adequacy	2.29** (0.51)	3.57*** (1.22)
Household energy adequacy squared	−0.013** (0.0030)	−0.017** (0.0071)
Household size	0.71 (1.44)	4.44 (3.47)
Household receives salary/wage	0.17 (6.24)	18.0 (15.0)
Household has garden	−3.28 (6.02)	6.00 (14.5)
Constant	−113** (29.1)	−154** (69.9)

Standard errors in parentheses.

** $p<0.01$,

* $p<0.05$