THREE ESSAYS ON HOUSEHOLD DETERMINANTS OF CHILD HEALTH AND WELL-BEING

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A DISSERTATION

in

Demography and Sociology

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2016

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For the kids who stood with me in the free lunch line

And for Ben Trumble

ACKNOWLEDGMENTS

I am deeply indebted to my incredible dissertation chair and committee. I would like to thank my chair Irma Elo who has been especially helpful with revisions to the following chapters. Throughout my graduate career she has been an excellent role model in teaching and research, and I will be lucky to emulate even part of her very successful career. Her honest guidance and mentorship has been invaluable. I would also like to express my deepest gratitude to Jere Behrman and Kristen Harknett who continually read drafts and helped me to sharpen my writing, and for inspiring me with their impressive research. I would especially like to thank Michael Gurven for hours of conversations and feedback, for welcoming a demographer into the ranks of anthropologists, and for allowing me to use project data.

I would like to gratefully acknowledge those who first introduced me to demography; Steven Goodreau for my first lesson in life tables, Haidong Wang, whose excitement for demography is evident in all conversations, and Julie Rajaratnam, who helped guide me early in my post-bachelor years. Folks at the London School of Hygiene and Tropical Medicine including Basia Zaba and Ian Timaeus inspired and encouraged further graduate work, and for this I am eternally grateful.

I am thankful for the support of the Graduate Group in Demography here at the University of Pennsylvania and the University of California Santa Barbara’s Broom Center for Demography. I cannot stress how grateful and indebted I am to the directors, staff, and participants of the Tsimane Health and Life History Project, and to Mike Gurven, Hilly Kaplan, Bret Beheim, and Adrain Jaeggi for answering my many data-related questions. I am also grateful to Claudia Valeggia for reading early drafts of papers. My work was supported by the University of Pennsylvania and the National Institute of Child Health and Human Development over the last several years. I have also benefitted from helpful comments from members of the Population Studies Center, the Population Association of America, and the American Association of Physical Anthropologists.

I have been fortunate to have the support of my colleagues in the Graduate Group in Demography, including my cohort- Tom Anderson, Ezra Fishman, Edith

Gutierrez Vasquez, Laura Kelly, and David Frankenfield. From the frisbee pitch to the now-defunct blue room, our time spent studying and supporting each other was invaluable. Other colleagues here at Penn have enriched my graduate career; conversations with Helena Cruz Castanheira, Nikkil Sudharsanan, Luca Maria Pesando, Andres Felipe Castro Torres, and Alejandra Abufhele about our research and lives have further opened my eyes to the world. I am especially grateful to Edith and Alejandra for pushing me along the way, and am so happy to have found surrogate sisters in Edith, Alejandra, and Allison.

I have found an excellent coauthor, friend, and partner in Ben Trumble, who introduced me to academia and has been a source of unwavering support over the last decade. Our many conversations about research have, I hope, improved us both in our respective disciplines. His and the Trumbles' support, encouragement, and love have made all the difference.

ABSTRACT

THREE ESSAYS ON HOUSEHOLD DETERMINANTS OF CHILD HEALTH AND WELL-BEING

Megan Costa

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Cross-disciplinary evidence suggests that household factors including maternal socioeconomic status, maternal health, and living arrangements can affect child health and well-being. This dissertation examines an array of countries and economic contexts to weigh the relative importance of household characteristics for child nutritional status. In Chapter 1, I examine characteristics predicting parental ideal family size and whether children of birth orders exceeding parental ideals experience worse nutritional status among the Tsimane, a high-fertility and high-mortality indigenous population in the Bolivian Amazon. I find minimal evidence that birth orders exceeding parental ideals are associated with worse height-for-age, weight-for-age, stunting, hemoglobin, and anemia in children aged 0-5. The observed mismatch between ideal and achieved family size does not predict lower child nutritional status in this population, perhaps due to mitigation of exceeding ideals via effective buffering strategies. In Chapter 2, I focus on a larger sample of Tsimane children to examine the association between maternal socioeconomic status and childhood nutritional status. I find that maternal Spanish proficiency is associated with improved height-for-age z-scores, a one-third reduction in odds of stunting for children aged 0-2, and nearly a halving in odds of stunting for children aged 2-5. This analysis suggests the importance of Spanish proficiency, which allows for increased access to markets, information, and health care. Chapter 3 examines the association between grandparental coresidence and child nutritional status in Ethiopia, India, Peru, and Vietnam. Grandparents are not uniformly associated with childhood nutritional status by sex, age, or wealth. There is evidence of a positive association between coresident grandmothers and child nutritional status in Peru, but in several countries households with higher wealth indices appear to buffer children against any negative nutritional outcomes stemming from the burden of coresident grandparents. Grandparental coresidence may affect other aspects of child development, but children in multigenerational households in the low- and middle-income countries in this sample have similar nutritional status to peers with non-coresident grandparents.

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ABSTRACT

Context: Although socioeconomic predictors of desired and ideal family size (IFS) are studied across economic contexts, little is known about whether ideals reflect lasting underlying preferences and constraints. This is of particular interest in settings where reported IFS is several children fewer than actual fertility. Evidence of child growth penalties for children with birth order in excess of parental ideals would suggest rigidity of IFS and persistence in preferences, while a lack of evidence may reflect a combination of plasticity in ideals, effective household buffering strategies, or purposely high fertility in anticipation of high infant and child mortality. This study examines predictors of maternal and paternal ideal family size and the odds of exceeding stated ideals in a high-fertility, high-mortality population. Child nutritional status is then assessed as a function of child and parental characteristics, in addition to indicators of whether child birth order exceeds parental IFS.

Methods: Socioeconomic and maternal anthropometric data from the Tsimane Health and Life History Project are used to predict a one-time measurement of maternal and paternal IFS. The odds of exceeding baseline IFS measurement are predicted in 207 partner pairs for a 10-year follow-up period. Height-for-age z-scores (HAZ), weight-for-age z-scores (WAZ), stunting, hemoglobin, and anemia status in 638 children ages 0-2 and 2-5 are predicted as a function of parental socioeconomic status and birth order relative to IFS. Birth order exceeding parental IFS is examined as a key predictor of child growth outcomes.

Results: There is minimal evidence of an association between birth orders exceeding IFS and child nutrition as measured by HAZ, WAZ, stunting, hemoglobin, and anemia. Children born into birth orders beyond paternal IFS experience a slight disadvantage from age 2-5 years in terms of weight-for-age z-score (β=-0.03, p=0.02). Birth orders beyond maternal IFS are associated with decreased hemoglobin among children aged 2-5 (β= -0.04, p=0.06), however, a decrease of 0.04 g/dl in hemoglobin is relatively small.

Conclusion: Though realized fertility exceeds stated ideal family size in this population, there is weak evidence of lower nutritional status in children aged 0-5 with birth orders higher than their parents' stated ideal family size. This suggests that effective buffering strategies shield children from potential risks of being born outside of parents' stated ideal family size, or that preferences for specific family sizes are weak. This is further supported by a lack of evidence of fertility change, suggesting that in this high-fertility, high-mortality population trade-offs favoring fewer children are not yet reflected in age-specific fertility patterns.

INTRODUCTION

Transitions to low and below-replacement fertility have taken place across high-income settings and are well underway in many low and middle income countries (Hirschman 1994, Bongaarts 2002, Kohler 2012). More than half of the world's population lives in regions with total fertility rates (TFR) below replacement levels of 2.1 children per woman (Myrskylä, Kohler et al. 2009). From the 1960s to 2005, the TFR of the developing world declined from 6.0 births per woman to 2.9 births per woman (Bongaarts 2008). Changes in desired or ideal family size is often viewed as a precursor for fertility decline (Behrman 2015). However, relatively few populations remain where initial stages of the fertility transition can be observed. The opportunities to examine how children fare at the start of this transition are limited to subnational studies or historical data. Further, less is known about whether a mismatch between fertility ideals and behavior during the start of the fertility decline is associated with worse child health outcomes, or whether ideal family size reflects an underlying preference strong enough to influence resource allocation within the household. Though regularly measured cross-sectionally in surveys such as the Demographic and Health Surveys (DHS), ideal family size is viewed as a relatively weak measure of preferences due to change over the life course and weak association with fertility outcomes in low-fertility settings (Hagewen and Morgan 2005, Liefbroer 2009). Demographic surveillance of a population such as the Tsimane presents an opportunity to examine a fertility transition at initial stages of the decline when fertility exceeds reported ideal family size. Tsimane demography is characterized by high fertility, mortality, and environmental stressors including food insecurity and high parasite and pathogen burdens (Martin, Blackwell et al. 2013, Blackwell, Trumble et al. 2016, Gurven, Costa et al. 2016)**.** Assessing fertility ideals in this context allows exploration of the strength of measures such as ideal family size and whether there are negative child nutritional consequences of exceeding ideals in terms of child height, weight, and anemia.

This study describes Tsimane population-level fertility patterns and examines the determinants of ideal family size (IFS) in a subsample of 207 partner pairs. Odds of exceeding ideals and the association between birth orders exceeding IFS and child nutritional status are estimated. Fertility levels and trends in this population demonstrate high and even increasing fertility by maternal birth cohort (Mcallister, Gurven et al.

2012). The recent increase may be due to improved nutritional status and healthcare similar to initial increases in fertility observed across transitioning contexts (Ellison 2003, Gibson and Mace 2006). While fertility remains high, stated ideal family size among men and women decline by birth cohort (TFR = 9.1, IFS = 4.6 for women). Baseline measurements of IFS and follow-up measures of child anthropometry are used to examine predictors of child nutritional status when preferences (declining IFS) and behaviors (increasing fertility) are mismatched.

BACKGROUND

Ideal family size may be affected by several factors in a population in the early stages of the demographic transition; parents living in more remote areas may have higher ideals related to the increased utility and relatively low cost of each additional child (Mace 2008). Children may also provide support over the life course and provide a form of old-age insurance (Caldwell 2005). Alternately, parents living in less remote locations may opt for different investment strategies, motivating a quality-quantity tradeoff in favor of fewer children due to increased accessibility to schools, increased cost of raising children, and perceived future access to markets (Montgomery and Casterline 1996). As the social and economic calculus of each additional child begins to shift, so might ideal family size and eventually fertility behavior.

Diffusion theories of fertility decline suggest social learning and social influence affect the amount and type of information an individual has to make decisions (Montgomery and Casterline 1996). If an information diffusion process is underway in this context, we expect individuals who speak Spanish in addition to the Tsimane language to both have lower IFS and exceed their ideals less often because of increased access to information on how to limit fertility or increase birth spacing. Similarly, individuals who live in locations closer to the regional market town might face fewer social constraints to limiting births than their remote counterparts, who may be subject to spousal and parental fertility expectations. These motivating questions are used to address potential associations between Spanish literacy and fluency and proximity to town and exceeding ideal family size.

Fertility intentions and ideals are commonly measured in social surveys. While there is generally a strong relationship between ideals and actual fertility, discord between intentions, ideals, and realized fertility is common in both high and low-fertility populations (Hin, Gauthier et al. 2011, Harknett and Hartnett 2014). In controlled fertility settings, intentions and ideals are one of many determinants of reproduction (Blake 1966). However, the association between ideal family size (IFS) and fertility behaviors in uncontrolled fertility settings is less clear. For example, in Nepal, stated ideals are thought to mask son preference and tend to vary with regard to number of sons already born (Stash 1996). In Demographic and Health Surveys from Ghana and Nigeria, non-numeric responses to IFS questions complicate associations between IFS and fertility behavior, with responses such as “up to God” associated with higher family sizes and disapproval of family planning (Olaleye 1993). In high-income, high fertility control settings such as the United States and much of Western Europe, ideals tend to exceed realized period fertility due to competing interests (Hagewen and Morgan 2005). The amendment of ideals over time will affect whether disparities between observed period fertility and ideals may be classified as unmet demand for children or unmet need for contraceptives (Hin, Gauthier et al. 2011). Thus exploring the predictors and consequences of exceeding IFS in natural fertility populations further elucidates the strength of preferences in changing fertility contexts.

Desired family size differs from fertility intentions in measurement; ideals are unconstrained, a number provided by an individual which is not necessarily tied to immediate resource limitations. Fertility intentions are thought to consider realistic parameters such as socio-economic considerations and partner’s intentions (Iacovou and Tavares 2011). Survey questions measuring intentions ask specifically about the next birth, and are hypothesized to predict fertility behavior when factors predicting behavior and intentions are the same (Schoen, Astone et al. 1999). Survey questions focusing on ideals are more abstract and ask about an ideal number of children for any given individual to have, or for the number of children the respondent would prefer if she were to begin her reproductive career anew. Ideals may shift over the life course, but are informative at the population level when considering directionality of trends in ideal and actual family size.

While women may report an ideal family size reflective of household constraints, there are several historical examples of exceeding ideals across economic contexts. In the United States 12% of women experienced unwanted fertility in the 1980s; estimates from Europe suggest that approximately 7.5-11.2% of fertility is unwanted in the same period (Bongaarts 2001). In the US and other post-transition contexts, there has been a reversal from unwanted fertility toward unmet demand, where long-term ideals remain at about two children but tempo-adjusted fertility levels fail to meet these stated ideals (Morgan and Rackin 2010). In low-income countries, there is some evidence of elevated mortality and higher rates of infection for higher birth orders, through it is difficult to disentangle increasing birth complications with maternal age (and higher parity) from exceeding ideal family size (Scrimshaw 1978). Understanding whether children in resource-sparse, early or mid-transition settings pay a nutritional penalty for birth order in excess of parental ideals helps to elucidate the strength and long-term impact of family size preferences. In a context where ideals are consistently exceeded, do families adapt via effective buffering strategies as the number of children increases? Or does being unwanted imply unequal distribution of resources among wanted and unwanted children, reflected in height for age, weight for age, or anemia status, possibly motivating supplementation in households where ideals are exceeded?

Study Context: The Tsimane

The Tsimane Health and Life History Project is an ongoing study based at the University of California, Santa Barbara and the University of New Mexico and has conducted economic and social surveys continuously from 2002 to present among Bolivian Amerindians living in the Beni department of Bolivia (Gurven, Kaplan et al. 2007). Broad aims of this project include improving the understanding of the impact of environment and evolution on the life course, and focuses on health, aging, economics, and biodemography in forager-farmers practicing a traditional lifestyle thought to approximate the pre-industrial conditions of the past. The Tsimane are a population approximately 16,000 in size spread among more than 95 villages and the larger market town of San Borja (population ≈ 41,000, mostly non-Tsimane). Villages consist of extended family groups ranging from 30-700 people with varying access to the Maniqui River, seasonal logging roads, and market goods (von Rueden, Trumble et al. 2014). Few villages currently have running water or electricity, and only about a third contained schools teaching both Tsimane and Spanish at the start of the study period. The extended family forms the household unit, where grandparents, parents, aunts, uncles, and children typically live in the same household or village (Hooper, Gurven et al. 2015).

A couple is considered married when they live under the same roof for longer than a brief period of time; mean age at marriage is 21 years old for men and 16.5 years old for women (Winking 2005). Approximately two thirds of foodstuffs consist of horticultural goods from small-scale cultivation, including corn, plantains, manioc, and rice, which are supplemented by fishing and hunting (Martin, Lassek et al. 2012). Market integration is limited; cash crops, sporadic wage labor, and trade with merchants comprise the primary market activities, though low-income wage labor is available primarily to men in communities near the market town of San Borja (Mcallister, Gurven et al. 2012).

In addition to a mostly traditional lifestyle, fertility and mortality rates resemble those observed in early stages of the demographic transition. Fertility and infant mortality are high, with a total fertility rate (TFR) of 9.1 and infant mortality rate of 137 deaths per 1,000 live births, though this varies with proximity to San Borja (Gurven 2012). Women living furthest from San Borja experience slightly lower fertility rates (TFR= 8.0) and higher infant mortality (IMR≈178 per 1,000 live births) (Gurven, Kaplan et al. 2007, Gurven 2012, Mcallister, Gurven et al. 2012). Closer to San Borja, fertility is higher (TFR=9.5) and infant mortality is lower (IMR≈100 per 1,000 live births) (Gurven, Kaplan et al. 2007, Mcallister, Gurven et al. 2012). Women located closer to town may have improved nutritional status and access to medical care, improving energy balance, which may have indirect impacts on fecundity (Ellison 2003).

Natural fertility is often defined as fertility without effort to limit or control the number of children, however, variation between populations is introduced through non-specific parity controls such as duration and intensity of breastfeeding, post-partum abstinence, and social taboos regarding oldest acceptable age to give birth (Henry 1961). Mean number of children per completed family of women married at age 20 as calculated by Henry 1961 ranged from 6.2 in women living in Guinea in the 1950s to 10.9 in Hutterite women married from 1921-1930 (Henry 1961). The observed TFR in Tsimane women in communities both remote and proximate to San Borja fit well within this range. Little evidence of modern contraception is found in this population, though some intermittent use is documented among women with complicated births (primarily in the form of depo-provera).

Ideal Family Size in the Tsimane

Previous research exploring motivations for high fertility among the Tsimane notes a discrepancy between reported ideal family size (4.6) and TFR (9.1), with most women exceeding their reported IFS by their mid-30s (Mcallister, Gurven et al. 2012). Compared to the Bolivian national estimates for the Beni department (administrative state in which the Tsimane live) during the same time period, both IFS (3.2, Beni) and TFR (4.2, Beni) are higher in the Tsimane (Mcallister, Gurven et al. 2012). Potential mechanisms responsible for high fertility and exceeding ideal family size include limited reproductive autonomy, improved maternal health status, and low return on embodied capital, where women prefer somatic expressions of wealth and status (larger family sizes) rather than material expressions of wealth (Mcallister, Gurven et al. 2012). When women were asked which women were most “influential” or a “model” in their village, respondents chose women with larger families, and when asked why, 81% listed traditional attributes such as being a good mother, good at gathering food, and having many children (Mcallister, Gurven et al. 2012). In the context of the local economy, this quality-quantity tradeoff in support of high fertility makes sense. When traditional skills are ranked more highly than skills that would allow an individual to engage in the Bolivian market economy (which can be costly to acquire), and when children can contribute to the household (or gain skills which will allow them to do so at a later date) there is an incentive for higher fertility. Indeed, it has been noted that “if somatic wealth remains the most important component of status, the motivation to deliberately control fertility will be low and fertility will remain high” (Mcallister, Gurven et al. 2012). Though ideal family sizes are declining by birth cohort in this population, the current low levels of market integration and emphasis on somatic wealth encourage comparatively high ideal and actual fertility relative to the national population, or at minimum do not yet impose constraints suggestive of increasing cost of children.

AIMS OF THE CURRENT STUDY

Frameworks have been introduced for considering factors associated with ideal family size and exceeding ideal family size for women in this population; a study by McAllister and colleagues uses IFS to predict whether a woman will give birth in the three years following IFS measurement. Given the mean inter-birth interval of 2.55 ±0.88 years, this follow-up period may exclude women at the higher end of the inter-birth-interval distribution. Women with longer than average inter-birth intervals may be systematically different from those with a shorter inter-birth interval on both observed and unobserved characteristics. The current study builds upon previous work by extending this cutoff to include all subsequent births from the time of initial IFS measurement in 2002-2006 to the most recent census in 2012, and shifts the focus from predicting maternal IFS to examining partner IFS in greater detail. This paper also examines whether exceeding or similar or discordant parental IFS is associated with child growth or nutritional penalties for children. Including child growth in the analysis sheds additional light on whether cross-sectional measurements of fertility preferences are associated with household resource allocation in the longer term and if exceeding maternal or paternal ideals are more predictive of child nutritional outcomes (HAZ, WAZ, stunting, anemia).

This study first identifies the conditions under which exceeding IFS may have negative consequences for child health, where age-specific fertility is persistently high across maternal birth cohorts yet ideal family size decreases across both maternal and paternal birth cohorts (Figures 1 - 3). Unlike Pritchett's observation of transitional countries generally exceeding their IFS by approximately 1 child across World Fertility Surveys (Pritchett 1994), the mean difference between observed TFR and IFS in this sample is almost 3 children (mean IFS = 4.6 women, 5.5 for men, and parity at end of follow-up mean 7.15). However, differences in fertility ideals appear to decline by birth cohort, with partner differences (paternal - maternal IFS) also declining over birth cohort (Figure 1.4). Age-specific fertility rates, completed fertility, and ideal family size by sex and birth cohort are calculated to provide descriptive evidence of this desire-behavior mismatch.

The subsequent analyses build on previous work by expanding the unit of analysis to all men and women who had a child aged 0-5 after their initial interview (2002-2006) and anthropometric measurements are included for children born until 2009 (anthropometric measurements taken from 2003-2011 following parental IFS interview). Controlling for other parental characteristics, models are used to predict IFS, the odds of exceeding IFS by the end of the study period, and whether birth order greater than ideal family size is associated with worse child nutritional outcomes. Specifications of exceeding parental ideals include a binary indicator for whether a child's birth order exceeds maternal or paternal ideals, and an indicator for whether the child's birth order is greater than both parents' stated ideals. Alternately, a measure of how much a child's birth order exceeded parental ideals is also considered; this is a continuous measure of birth order greater than stated ideal family size and is included to examine whether the extent of exceeding parental ideals is associated with poorer child nutritional status.

Parental Ideal Family Size, Exceeding Ideal Family Size

Both the respondents' and partners' Spanish proficiency and literacy are expected to have a strong negative association with IFS. Partner's IFS and maternal BMI are expected to predict ego's IFS (Figure 1.5). This expectation stems from previous assessments of fertility decline; Spanish speaking and literacy in this population may be linked to exchange of ideas with non-Tsimane Bolivians, a population with a national TFR of 3.3 births per woman in 2010 and marked decline in TFR from 4.89 in 1990 to an estimated 2.97 in 2014 (UNICEF 2010, UNWPP 2015). If social interaction accelerates ideational change, then opportunities for interactions with smaller families may increase for parents with Spanish speaking networks, where ideas about smaller family size are communicated through social connections or Bolivian media (Bongaarts and Watkins 1996). Indeed, a study of 500 women in the town of San Borja found an that average fertility of one's social network is associated with higher respondent fertility, however (Snopkowski and Kaplan 2014). If diffusion is taking place through social connections or exposure to Bolivian media, we expect Spanish speaking, literacy, and proximity to town to be negatively associated with IFS. Similar to the fertility declines observed in France where fertility control diffused along linguistic and class lines prior to widespread availability of modern contraception (Cleland and Van Ginneken 1988, Hirschman 1994, Van Bavel 2004), we hypothesize that Tsimane who speak Spanish will not only have lower IFS, but will have better knowledge of how to avoid additional births and will thus exceed their ideals less often than those who do not speak Spanish. Though access to effective contraception in villages is currently negligible and was not measured in this population at the time of IFS interview, it is proposed that those who speak Spanish, can read, and live closer to San Borja have increased access to information on how to avoid pregnancy albeit perhaps with less effective, more traditional methods such as prolonged breastfeeding, the rhythm method, and abstinence.

A positive association is expected between mothers' BMI and IFS; in a setting in which wealth is measured in body fat as opposed to material possessions, individuals with more 'wealth' will be able to 'afford' more children than women with a lower BMI. When household wealth and long-term security are achieved via higher fertility and more children are desirable, women in better condition are predicted to state higher IFS. Other maternal factors including maternal age and parity at interview are predicted to have a strong positive association with stated ideal family size. A positive association between parity at time of interview and stated IFS is likely to be observed; this stems from social desirability bias, where women may feel they cannot state an IFS lower than their current parity (though 47% to 50% of women in the sample do, Table 1.1). In this population, the older a woman is the higher her parity; it is expected that age will be positively associated with IFS. This potential collinearity is examined and discussed.

Partner's ideals are hypothesized to have a strong association with respondents' IFS for several reasons. The first, as proposed by McAllister and colleagues, concerns a lack of reproductive autonomy. Due to the presence of her husband at the time of interview, a woman may be pressured to report an ideal family size consistent with that of her partner. Additionally, she may have little to no control over her own reproduction through gender-unequal dynamics in the household. There was no evidence of a lack of autonomy in previous analyses, which used husband IFS to predict time to next birth after the IFS interview (Mcallister, Gurven et al. 2012). Partner IFS is considered in this analysis for both husbands and wives. Paternal IFS has not previously been considered as a dependent variable, and the bidirectional predictive power of partner IFS may reflect a convergence of ideals, indicating either assortative mating or post-marital socialization. These two phenomena reflect slightly different strategies; assortative mating indicates partner selection based upon common ideals, while post-socialization involves modification of ideals following marriage to improve the quality of the match (Oppenheimer 1988). In this case, a positive bidirectional relationship is predicted with the expectation that matches are made among like-minded individuals.

<u>Nutritional Consequences for Children Exceeding IFS</u>

The hypothesis that exceeding parental IFS is associated with negative child growth- perhaps due to differential allocation of resources or the household shock of an unwanted child- is tested using the child's nutritional status including weight-for-age z-score, height-for-age z-score, stunting, hemoglobin, and anemia. Height-for-age and stunting indicate longer-term nutritional deprivation, while weight-for-age (a measure of underweight) is associated with acute changes in nutritional status (Onis 2006). In a natural fertility setting in which children represent wealth, it is possible that there will be little evidence of an association between exceeding ideals and child growth outcomes. In this case, somatic indicators of household wealth such as maternal BMI will be more predictive of child growth outcomes than exceeding IFS. According to this hypothesis, shifting ideals still represent changing preferences and perhaps future directions of fertility, but when IFS is routinely exceeded and children are an asset, exceeding IFS will not be associated with the nutritional status of 'excess' children. Alternately, if stated ideals are strongly tied to preferences and household constraints then children with birth orders exceeding stated ideals may experience worse growth outcomes due to limited resources in the household.

DATA AND METHODS

Data

This study uses three types of data to link initial IFS measurements, births of subsequent children, and child anthropometric measurements. Initial demographic interviews asking each mother and father their ideal family size and reproductive history are combined with subsequent censuses to update family size from the observed size at initial demographic interview, and anthropometric data are added for each mother and child under five years of age. A GPS dataset is used to add proximity to San Borja (km) at time of measurement.

Demographic information including reproductive histories and ideal family size were collected from 2002-2006. A total of 217 partner pairs from 22 villages were asked about ideal family size. The ideal family size question specifically asked "What number of children do you think is the best number of children for you to have so that you can live well? Think about your experience, life, and wishes. There are no correct or incorrect answers to this question" (Mcallister, Gurven et al. 2012). Reproductive history modules are used to collect information on all children by birth order. Once a full roster is collected, interviewers restate information on each birth from first to last and record survival information. The present analysis uses only anthropometric information and does not include child mortality data.

The 2012 census collected basic demographic information on all individuals in a household including household rosters and reproductive histories. This census in addition to yearly demographic surveys were used to add children born from the time of initial interview where IFS was measured to 2011-12 so all children from a parents' initial interview to the 2012 census were included in the dataset.

Anthropometric data were collected yearly on all members present in the household at time of survey, resulting in a varying number of measurements per child. Approximately once per year a mobile medical team arrived in each Tsimane community to conduct medical exams and collect biodemographic data. Child height was measured with a portable SECA 213 Stadiometer (Seca, Inc.; Birmingham UK), and weight was measured with a Tanita BC-1500 scale (Tanita Inc, Arlington Heights, IL). Hemoglobin was measured using a QBC Autoread Plus dry hematology autoanalyzer (Drucker Diagnostics, PA). Anthropometric measurements taken from 2002-2013 were added to the updated list of children for whom parental IFS is known. Each observation in the dataset represented a child-measurement under age five. The resulting dataset includes all under-five child-measurements from the date of parental interview to January 2013. Parental information from the initial interview, including maternal and paternal ideals as well as proximity of parental residence to San Borja is included for prediction of parental IFS.

A total of 1,573 child-measurements belonging to 643 children aged 0-5 were linked to 217 parent pairs. Missing information on literacy and Spanish ability of parents reduced the final sample size to 207 parents and 638 children, resulting in 1,561 child-measurements (a 1% loss of parents). Hypotheses predicting IFS and the odds of exceeding IFS were tested on a dataset containing 207 parents. Hypotheses predicting height-for-age z-score (HAZ), weight-for-age z-score, and stunting were tested on the child dataset containing 1,549 child measurements. Some children appear in multiple analyses, as all analyses are stratified from ages 0-2 and 2-5. For example, if a child is measured at ages 2 and 4, they will be included in both regressions. Iron deficiency is also assessed on a subset of children for whom data were available (n=552).

Methods

Ideal Family Size

Ideal family size is predicted for men and women separately using linear regression. Independent variables included BMI of mother, a dummy variable indicating presence of one or more live sons in the household, age at interview, respondent parity at interview, mother's and father's literacy, mother's and father's Spanish proficiency, partner's IFS, and distance to San Borja. Both mothers' and fathers' literacy and Spanish proficiency are dichotomous variables included to proxy for differential access to information and health care. For both women and men, self-reported parity at interview is highly correlated with age at interview (r=0.85 and 0.75, respectively) resulting in a high degree of multicollinearity in models that include both; therefore, models with both controls are followed by models which exclude age and parity in turn (Tables 2 and 3). The odds of exceeding ideal family size are estimated for men and women separately using logistic regression. The same control variables were included in both linear and logistic regressions, with models including age and parity, then age and parity separately in turn (Table 1.4).

Nutritional Indicators

Height-for-age and weight-for-age z-scores were calculated for children aged 0-5 using the World Health Organization 2006 Multicentre Growth Study growth curves (de Onis, Garza et al. 2004, Leroy 2011). This multi-population reference includes optimal growth patterns for children from 6 different countries including Brazil, Ghana, India, Norway, Oman, and the USA (Borghi, De Onis et al. 2006). Anthropometric z-scores measure the number of standard deviations from the reference median by child age. A deficit in height-for-age is accumulated over time and represents consistent undernutrition and infection, whereas lower weight-for-age (referred to as 'underweight') is a symptom of acute changes in nutrition (UNICEF 2013). HAZ and WAZ are predicted for age groups 0-2 and 2-5 as a function of child's age, sex, birth order, maternal BMI, whether the child's birth order exceeds parental ideals (binary, equal to 1 if birth order > IFS), mother and fathers' IFS, parental literacy, and parental Spanish speaking ability using linear regression with clustered standard errors to account for the non-independence of multiple child observations (Tables 5-6). Models are stratified by these broad age groups (0-2 years, 2-5 years) to account for the fact that mean inter-birth interval is 2.47 years in this sample, and constant breastfeeding in infancy is widespread in this population up to 2 years of age. To capture the extent of exceeding ideals, a variable indicating the difference between each child's birth order and parental IFS (parental IFS - birth order = magnitude of exceeding) is used to predict HAZ and WAZ for age groups 0-2 and 2-5 (Table 1.7). Additional analyses examining stunting (Table 1.8) and hemoglobin and anemia (Table 1.9) explore whether birth order in excess of parental ideals is associated with other measures of nutritional deficiencies in children.

RESULTS

High Fertility

There is little evidence that the pattern of age-specific fertility curves across the cohorts are shifting (n=4,643 reproductive histories, Figure 1.1). The peak fertility rate is consistent across cohorts at ages 20-24, with no notable compression restricting fertility to a central age range across birth cohorts. More recent cohorts (1970 onward) appear to be in line with previous cohort patterns of age-specific fertility rates, however, it remains to be seen whether stopping behavior will compress the convex pattern of age-specific fertility (Figure 1.1). Completed fertility is high in this population, ranging from 8.85 children per woman in the 1920 cohort to 9.59 in the 1950 cohort. If fertility remains constant at the age-specific pattern of the 1950 cohort, the 1970, 1980, and 1990 cohorts can expect to have high levels of completed fertility (9.53, 8.84, and 9.93, respectively). The beginning of the age-specific pattern of fertility does not appear to have shifted downward, indicating a lower fertility rate in these age groups. Using the IFS subsample, we examine whether mean age at first birth or mean inter-birth interval are changing by birth cohort (Figure 1.2). Age at first birth and mean inter-birth intervals are not significantly different by maternal birth cohort, with overlapping confidence intervals across cohorts indicating relatively little shift in this pattern.

Ideal Family Size

Of the 207 partner pairs included, 51% of mothers and 89% of fathers speak at least some Spanish, and 32% of mothers and 58% of fathers are literate (Table 1.1). By the 2012 census, 76% of mothers and 67% of fathers exceeded their ideal family sizes (Table 1.1). Mean ideal family size tends to be higher among fathers than mothers

($\bar{x}^{Father}$= 5.51, $\bar{x}^{Mother}$= 4.62). Mothers and fathers' IFS appear to decline by birth cohort, with younger cohorts reporting a smaller ideal family size (Figure 1.3). Women born from 1980-1990 had mean IFS of 3.6, whereas men born in the same period had mean IFS of 3.8 (Figure 1.3). The discrepancy between fathers' and mothers' IFS is also declining over birth cohort, however, 95% confidence intervals overlap across all cohorts (Figure 1.4). Descriptively, IFS is declining over birth cohort, but high fertility and low contraceptive use in this population results in a high correlation coefficient between parity and age (r=0.85 for women and 0.75 for men). This affects modeling strategies and interpretation as well as interpretation of any observed cohort patterns in IFS. It may be the case that cohort membership is associated with lower IFS or that lower parity is associated with lower IFS. If the former is the case, IFS is declining over birth cohorts and we may see some association of exceeding ideals and child nutrition in the face of preference- behavior mismatch. If the latter is the case, it is current parity and not age that influences ideals and thus individuals are more likely to state an IFS similar to their current parity (or adjust IFS over time). It is worth noting, however, that 50% of mothers and 47% of fathers are over their stated IFS at their initial interview, and 76% of mothers and 67% of fathers exceed their IFS by the end of the follow-up period (Table 1.1). While the parity-IFS convergence scenario may be possible, a trend of declining IFS by birth cohort is possible given increases in schooling and Spanish fluency among younger cohorts.

Predicting Ideal Family Size

Factors hypothesized to affect IFS include literacy, Spanish proficiency, maternal BMI, and partner IFS. Models reported here include the best fit using AIC and r-squared statistics, included at the bottom of each table. Holding household and individual characteristics constant, parity at interview is positively associated with increased maternal IFS (β= 0.20, p<0.001, Table 1.2 "Parity"). There is no evidence of an association between maternal literacy or Spanish proficiency and IFS at the α-0.05 level, however, husband's literacy is marginally associated with a lower maternal IFS (β= -0.63, p =0.06). Husband's IFS is also strongly associated with wife's IFS; a one-child increase in husband's IFS is associated with a 0.19 increase in wife's IFS which might suggest post-socialization or assortative mating (p<0.001, Table 1.2 "Parity").

A similar framework is used to predict paternal IFS (Table 1.3). Parity at interview is positively associated with increased reported IFS, where a one-unit increase in parity is associated with a 0.46-child increase in paternal IFS ($p < 0.001$, Table 1.3 "Parity"). Wife's IFS is positively associated with paternal IFS, consistent with the previous prediction of maternal IFS ($\beta = 0.31$, $p<0.001$, Table 1.3 "Parity"). Though maternal and paternal IFS are correlated ($r = 0.43$), post-estimation correlations and variance inflation factors (VIFs) were below acceptable cutoffs (VIF cutoff 2.5). Wife's Spanish speaking ability is negatively associated with husband's IFS, where speaking Spanish is associated with 1.18 fewer children ($p=0.020$, Table 1.3 "Parity"). This is the largest magnitude increase or decrease observed thus far; when examining the standardized coefficients, a one SD increase in wife's Spanish speaking is associated with a 0.17 SD decrease in paternal IFS in the parity-only model. A one km increase in distance from the market town of San Borja is associated with 0.03 higher paternal IFS, consistent with a quality-quantity tradeoff favoring more children in remote areas ($p = <0.001$, Table 1.3 "Parity").

Odds of Exceeding Ideal Family Size

Odds of exceeding IFS were hypothesized to decline with proficiency in Spanish and literacy. Spanish proficiency and literacy have differential results depending on which parent's IFS is estimated, however, all associations are non-significant (Table 1.4). Respondent's parity at interview is positively associated with the odds of exceeding IFS by the end of the follow-up period; for both mothers and fathers, increased parity at interview is associated with increased odds of exceeding IFS in the follow-up period (Table 1.4). For both women and men, higher IFS is associated with lower odds of exceeding IFS by the end of the period (Table 1.4). For men, higher wife's IFS is associated with increased odds of exceeding one's own IFS; that is to say, for each one-unit increase in wife's IFS, the odds of exceeding the man's own IFS are 25% higher ($p= 0.062$, Table 1.4 "Parity"). There is no evidence of an association between distance to the market town of San Borja and the odds of exceeding IFS for either parent.

Child Nutritional Status

Height-for-age, weight-for-age (a measure of underweight), stunting, hemoglobin, and anemia were predicted as a function of parental IFS and household and individual characteristics (Figure 1.5). Weight-for-age and weight-for-height z-scores are normally distributed, with some right skew in height-for-age (Figure 1.6). This is likely due in part to the high prevalence of parasitic and infectious disease in this population, where the majority of children are or have been infected for a prolonged period, affecting stature. For ages 0-2 HAZ and WAZ, basic models include individual and parental characteristics followed by a model including parental Spanish fluency (Table 1.5, Models 1 and 2, Models 4 and 5). After including Spanish speaking abilities, the strongest predictor of both HAZ and WAZ s child's age at measurement, where a one-year increase in age is associated with a one-SD decline in HAZ and a 0.45 decline in WAZ. This is likely due to the difference between what might be considered a 'healthy' growth curve for the Tsimane, and perhaps use of a local standard such as the Bolivian national average would be more appropriate. Initial models included a binary variable indicating whether the child's birth order is in excess of the stated IFS for mothers and fathers separately. To test whether it is worse for a child to be in excess of both parent's ideals rather than only one parent, a binary indicator is included after dropping parental IFS from the model ("Exceeded both parents' Ideals," Table 1.5, Models 3 and 6). For HAZ ages 0-2 years, being male is associated with a 0.30 SD decrease in height-for-age z-score ($p= 0.0321$). For weight, being male is marginally significant ($\beta=-0.20$, $p=0.0945$). Maternal BMI is positively associated with child WAZ ages 0-2 ($\beta=0.0549$, $p=0.0037$).

Analogous models were tested for ages 2-5. For children aged 2-5, males had on average a decreased height-for-age z-score ($\beta=-0.16$, $p=0.084$, Table 1.6 Model 2). Birth order greater than parental ideals (maternal, paternal, or both) is not associated with height-for-age z-score. Similar to the 0-2 age group, maternal BMI is associated with an increased weight-for-age z-score ($\beta=0.040$, $p=0.002$, Table 1.6 Model 6). Higher paternal IFS is associated with a decreased WAZ, however, the magnitude of the association is modest ($\beta=-0.029$, $p=0.025$, Table 1.6 Model 6). Mother speaking Spanish had a positive, marginally significant association with WAZ for children aged 205 ($\beta=0.1523$, $p=0.0731$). Across HAZ and WAZ for children aged 2-5, there is no observed association between z-scores and exceeding parental ideals.

As we consider potential consequences of birth orders in excess of ideals it might be worth including some measure of extent of exceeding ideals. For example, to be birth order six when parents' IFS is five may not be as detrimental as being birth order nine when parents' IFS is five. A version of models from Table 1.6 were run with a variable for each parent indicating the number over or under IFS for each child. The larger the number, the more the child is over their parents' stated IFS. For children aged 2-5, there is an association between being in excess of paternal ideals and decreased weight-for-age z-score. Each one-unit increase in number over paternal ideals is associated with a 0.03 decrease in weight-for-age z-score, holding all other variables in the model constant (β= -0.0302, p=0.0244, Table 1.7). Child characteristics are associated with HAZ and WAZ in these models. For children ages 0-2, both age at measurement and being male are negatively associated with height-for-age z-score (Table 1.7). For children aged 2-5, the model does not explain a large proportion of the variance (r-squared = 0.01, Table 1.7). For children aged 0-2, age at measurement is associated with a 0.44 decrease in weight-for-age Z-score ($p<0.001$). The strong negative associations across models for this age group may indicate a deviation from the WHO standard in this portion of the age range. For children aged 2-5, both maternal BMI and Spanish speaking are associated with an increased weight-for-age z-score, however, the association with Spanish speaking is only marginally significant (p=0.0679, Table 1.7).

Additional measures of nutritional deprivation including the odds of stunting, anemia, and hemoglobin levels were examined, stratifying by the same age groups. Stunting uses a HAZ cutoff of -2, and despite the difference in measure the results were similar to those for HAZ; for children aged 0-2 age at measurement and being male were associated with increased odds of stunting (Table 1.8). For children aged 2-5, being male is associated with increased odds of stunting (OR = 1.44, p=0.0291, Table 1.8). For children aged 2-5, birth order is negatively associated with hemoglobin (g/dL), while the continuous measure for exceeding maternal IFS is associated with decreased hemoglobin (β=-0.0443, p=0.0631, Table 1.9).

DISCUSSION AND CONCLUSION

Ideal Family Size

The analyses undertaken here do not support the hypothesis that maternal BMI, a measure of current household resources, is associated with increased IFS for men or women. Partner Spanish proficiency and literacy are associated with IFS, but in opposite directions depending on sex; for paternal IFS, wife's Spanish speaking ability is associated with a one child lower IFS, while husband's Spanish proficiency has a positive but non-significant association with maternal IFS. Husband's literacy, on the other hand, is associated with a 0.63-child lower wife's IFS. Literacy and Spanish speaking ability measure different domains of education; literacy is a proxy for schooling, whereas Spanish proficiency may be more of a measure of market integration. It is possible for an individual to have stopped school very early yet have proficient Spanish skills as a necessity for buying or selling goods and services in San Borja where individuals in stores and medical facilities do not speak Tsimane. Husband's literacy likely indicates an increased ability to access and synthesize written information. This Spanish and literacy dichotomy by sex likely indicates the measurement of slightly different domains; women who speak Spanish will have increased exposure to smaller family sizes in the form of popular media or perhaps through engagement in market activities and hold increased bargaining power within the household. Alternately, the "types" of households where women are fluent in Spanish are also those where men have lower IFS. For husbands, Spanish may have a positive association with wife's IFS because it increases his likelihood of engaging in wage labor, so a household may be able to afford more children if a father speaks Spanish. Male literacy could work in the opposite direction as well, where the ability to read and write for men is associated with wives adopting ideals closer to that of market-integrated Bolivian women.

There is evidence of an association between partner IFS and parity at time of interview on IFS for both men and women. Post-socialization or assortative mating may underlie this convergence, where individuals mold their partner's views to match their own or partners select each other because of similar beliefs. Interviewing individuals in the presence of their partners is also likely to have impacted this convergence, where interviews taking place in households result in some explicit discussion or implicit agreement on what an ideal number of children might be for that particular household. The association between stated IFS and parity suggests measurement of IFS may be influenced by post-rationalization, where men and women provide higher ideals when they have higher realized fertility. As has been noted previously, however, almost half of individuals have exceeded their stated IFS at time of interview and over 60% actually do so by the 2012 census.

Hypothesized relationships between individual's literacy, Spanish proficiency, and odds of birth order exceeding ideals are not supported. Instead, partner IFS and respondent's parity at interview are associated with increased odds of birth order exceeding IFS for women. Though only marginally significant, a one-unit increase in husband's IFS is associated with a 25% increase in odds of exceeding IFS for women (OR = 1.26, p=0.06 Table 1.4 "Parity"). This association is not observed for men, perhaps suggesting some partner influence on women's odds of exceeding IFS by 2012. Though tables 2 and 3 suggest a strong association between partner and one's own IFS, the differential association between paternal IFS and maternal odds of exceeding her own IFS might suggest unequal bargaining power with respect to total number of children in the longer term.

Fertility behavior and preferences appear to be mismatched in this population. While unclear whether IFS is declining by birth cohort, it is lower than achieved fertility, and by more than previously observed at a population level (Pritchett 1994). This population has been referred to as both a high fertility and a natural fertility population. While completed fertility rates fall well within the range of Henry's classic examples, it is a lack of parity-specific control or intention that defines a natural fertility population. A strong association between non-ideal birth orders and worse nutritional outcomes would support the proposition that this is a high fertility population in the midst of fertility transition and decline, where investments are allocated differently between ideal and non-ideal children. The modest associations found here along with the high fertility of younger cohorts might suggest a lack of these trade-offs as yet, where lower-than-achieved ideals do not reflect dire household circumstances or limited resources shunted toward 'preferred' children. However, lacking information about parity-specific controls or intentions limits the conclusions we are able to draw.

Nutritional Status

These analyses examine any potential associations between birth order eceeding parental ideals and worse child nutrition. After stratifying by age, we estimated a modest negative association between birth orders greater than paternal ideals and WAZ and birth order in excess of maternal ideals and lower hemoglobin. If there is any association, it appears to be in the age range of 2-5, when children are likely to be completely weaned. This is a time of increased vulnerability, when children develop nutrient deficiencies and are at higher risk of consuming contaminated foods and experience the synergistic effects of hampered nutrient absorption due to parasite infection (Black, Allen et al. 2008).

The lag between period fertility and ideals is likely a product of the current level of market integration. The importance of more immediate factors for child nutrition such as maternal BMI as opposed to IFS indicates that the cost of raising undesired children has not yet reached a level that causes economic strain in households, encouraging delay or spacing of childbearing (Davis and Blake 1956). Further, women's tendency to value traditional skills and hold women with large family sizes in high regard is consistent with previous observations that wealth correlates with family size in small, homogenous populations (Mace 2008, Mcallister, Gurven et al. 2012). In the Tsimane context where children are an expression of wealth and the cost of raising each additional child is marginal, exceeding ideals of either parent is not yet associated with nutritional or growth penalties for children in excess of parental ideals. This is interwoven with the possibility that at this level of fertility stated ideals are weak preferences that are adjusted upward over age to accommodate a woman's current parity. The modest observed negative associations between IFS and child nutritional status suggests that in high-fertility, low-resource settings a mismatch between preferences and behavior may not yet be detrimental for child health.

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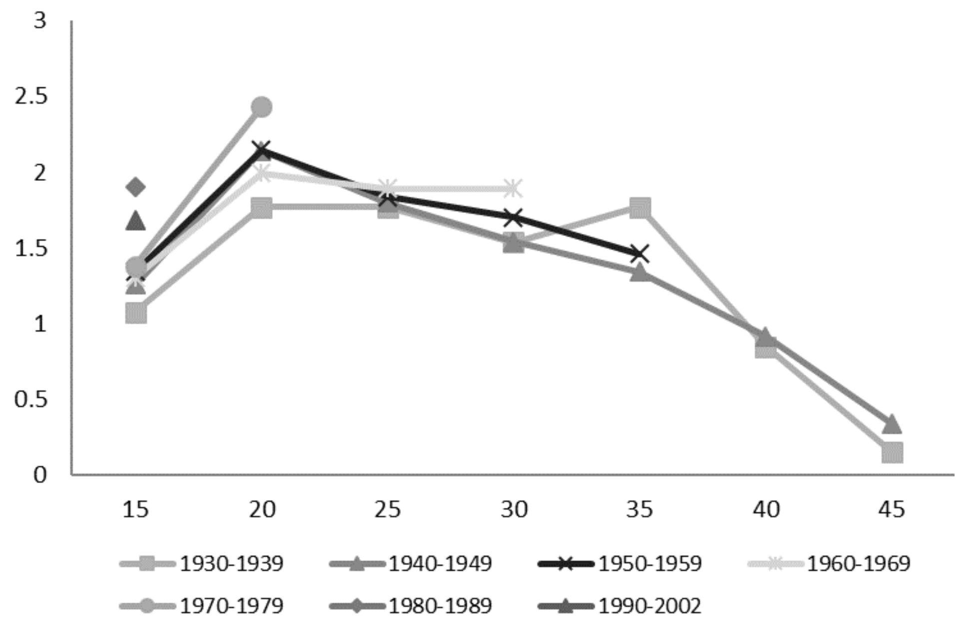
FIGURES AND TABLES

Figure 1.1. Age-Specific Fertility by Birth Cohort (A) and Completed Fertility by Birth Cohort (B), (N= 4,643), Females

A



B

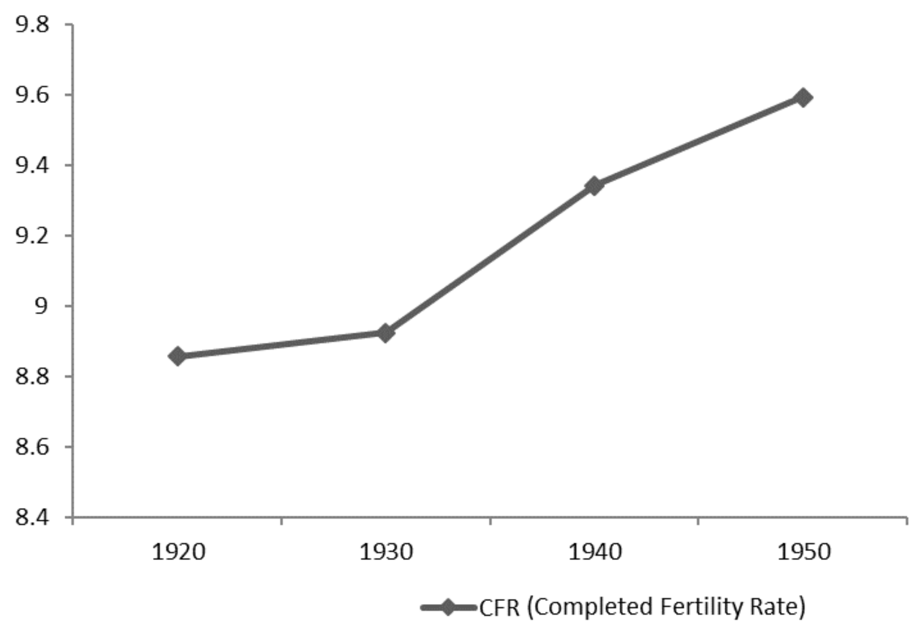


Figure 1.2. Mean age at first birth and inter birth interval (years) by maternal birth cohort, IFS sample (N = 211)

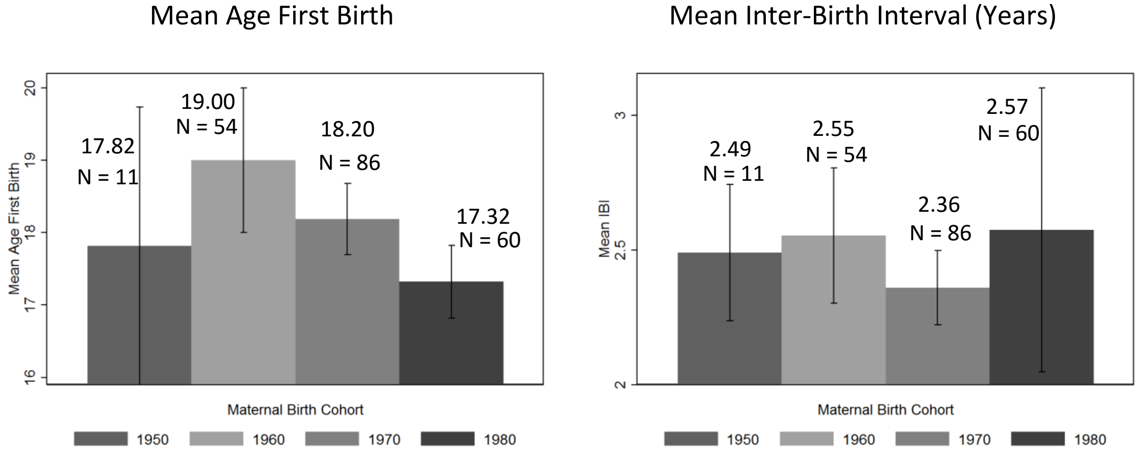


Figure 1.3. Mothers' and Fathers' mean ideal family size by birth cohort, IFS sample (N = 211)

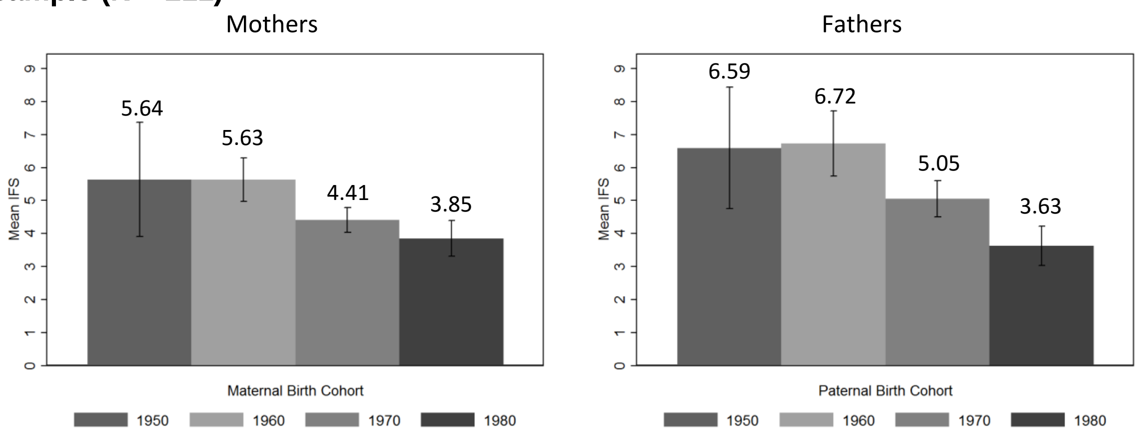


Figure 1.4. Discrepancy between paternal and maternal IFS by maternal birth cohort, IFS subsample (N=211)

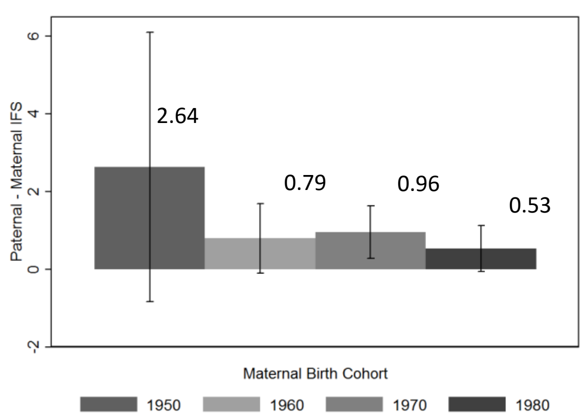


Figure 1.5. Conceptual model of hypothesized associations between socioeconomic variables and IFS and child outcomes with predicted directions

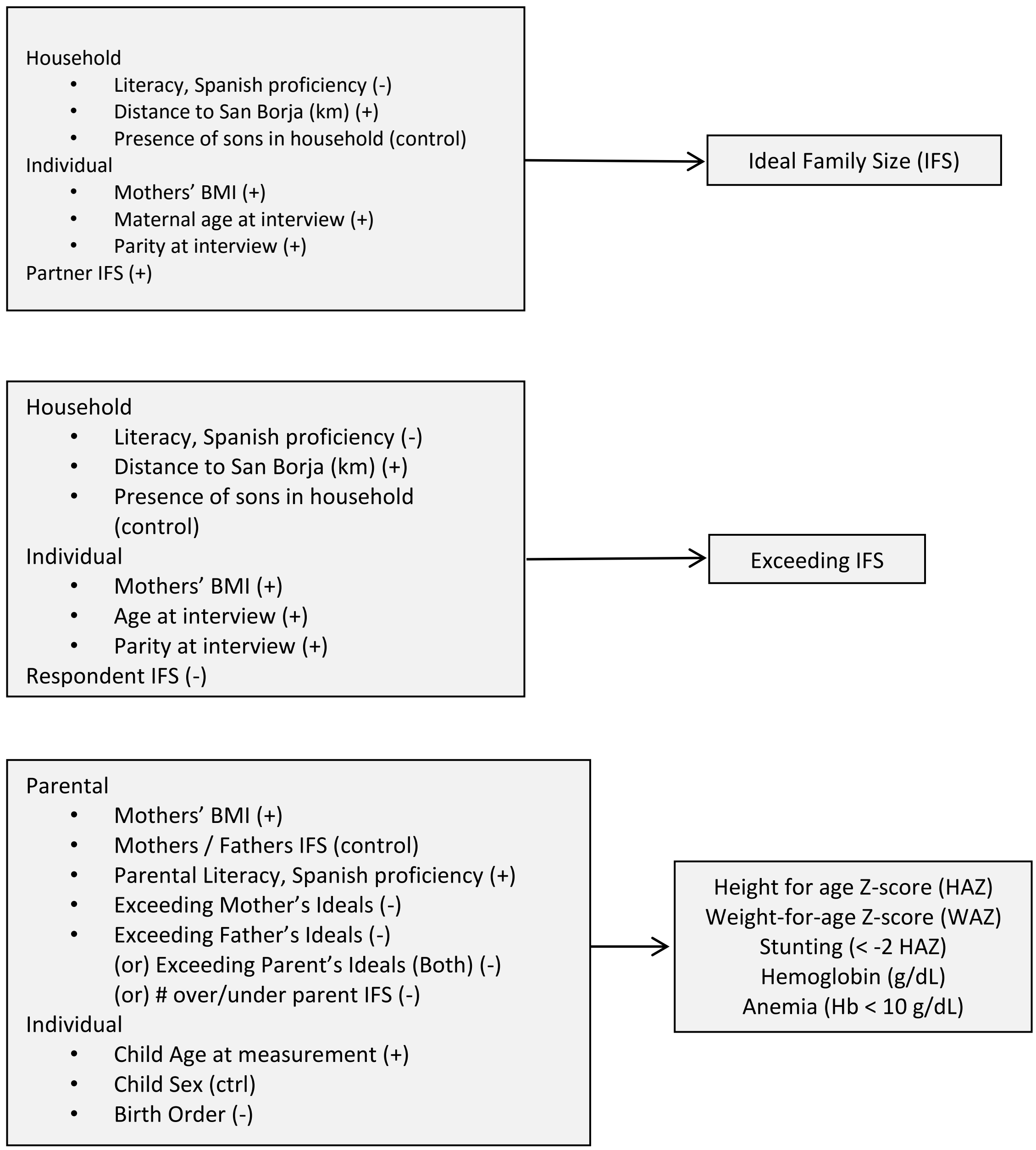


Figure 1.6. Distribution of HAZ and WAZ in Sample

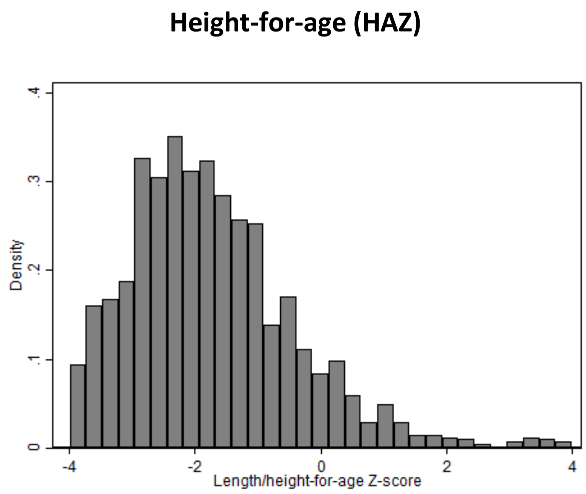


Table 1.1 Child and Parent Characteristics, 211 Partner Pairs

	Fathers			Mothers			T-Test (P-value)		
Parent Characteristics	**Mean**	**95% CI**	**SD**	**Mean**	**95% CI**	**SD**	**T<t**	**|T|>|t|**	**T>t**
Proportion with Parity > IFS at Interview (n=211)	0.47	0.41, 0.54	0.50	0.50	0.43, 0.57	0.50	0.78	0.44	0.22
Proportion with Parity > IFS by end of Follow-Up Period (n=211)	0.67	0.60, 0.73	0.47	0.76	0.71, 0.82	0.43	1.00	0.00	0.00
Parity at Interview (n=211)	5.88	5.40, 6.36	3.56	5.56	5.13, 5.99	3.17	0.01	0.02	0.99
Proportion Literate (n=209)	0.58	0.51, 0.65	0.49	0.32	0.26, 0.38	0.47	1.00	0.00	0.00
Proportion Speaking Spanish (n=209)	0.89	0.85, 0.94	0.31	0.51	0.44, 0.58	0.50	0.00	0.00	1.00
Household Characteristics	**Mean**	**95% CI**	**SD**						
Maternal BMI (n=209)	23.78	23.37, 24.20	3.05						
Proportion with one Son Living in Household (n=211)	0.97	0.95, 0.99	0.17						
Distance to SB in km (n=211)	43.81	40.87, 46.74	21.75						
Child Characteristics (n=643, obs = 1573)	**Mean**	**95% CI**	**SD**						
Age at measurement in years	2.66	2.59, 2.73	1.43						
Proportion Male	0.51	0.49, 0.54	0.50						
Birth order	5.81	5.65, 5.96	3.13						
Proportion Exceeded Mother's IFS	0.57	0.55, 0.59	0.50						
Proportion Exceeded Father's IFS	0.49	0.47, 0.51	0.50						
Proportion Exceeded both parents' IFS	0.44	0.42, 0.47	0.50						
Amount exceeded IFS (maternal IFS-birth order)	-1.14	-1.30, -0.97	3.28						
Amount exceeded IFS (paternal IFS-birth order)	-0.25	-0.44, -0.06	3.82						
Height-for-age Z-score (HAZ)	-1.72	-1.78, -1.65	1.34						
Weight-for-age Z-score (WAZ)	-0.91	-0.97, -0.86	1.11						
Proportion Stunted	0.47	0.44, 0.49	0.50						
Hemoglobin g/dL (n=484, obs=766)	11.43	11.35, 11.51	1.12						
Proportion Anemic (n=484, obs=766)	0.08	0.06, 0.10	0.27						

Table 1.2. Predictors of Maternal Ideal Family Size

	Age and Parity			Parity			Age		
	β	**β(std)**	**p**	**β**	**β(std)**	**p**	**β**	**β(std)**	**p**
BMI	0.001	0.002	0.977	0.001	0.001	0.986	-0.007	-0.009	0.885
One Living Son in Household	1.364	0.105	0.100	1.358	0.104	0.100	1.383	0.106	0.099
Age at Interview	-0.003	-0.012	0.923	-	-	-	**0.062**	**0.223**	**0.002**
Parity at Interview	**0.198**	**0.289**	**0.020**	**0.192**	**0.279**	**<0.001**	-	-	-
Literate	0.467	0.100	0.225	0.468	0.100	0.223	0.370	0.079	0.340
Speaks Spanish	-0.083	-0.019	0.829	-0.084	-0.019	0.825	0.005	0.001	0.990
Husband IFS	**0.192**	**0.295**	**<0.001**	**0.192**	**0.295**	**<0.001**	**0.218**	**0.334**	**<0.001**
Husband Literate	-0.635	-0.143	0.060	-0.630	-0.142	0.059	-0.624	-0.141	0.067
Husband Speaks Spanish	0.796	0.112	0.111	0.804	0.113	0.103	0.964	0.136	0.054
Distance to San Borja (km)	0.007	0.068	0.322	0.007	0.067	0.321	0.006	0.057	0.408
Number of Parents		207			207			207	
Adj R-squared		0.25			0.25			0.23	
AIC		863			861			867	

Table 1.3. Predictors of Paternal Ideal Family Size

	Age and Parity			Parity			Age		
	β	**β(std)**	**p**	**β**	**β(std)**	**p**	**β**	**β(std)**	**p**
Wife's BMI	-0.017	-0.016	0.772	-0.02	-0.019	0.734	-0.028	-0.025	0.675
One Son Living in Household	0.793	0.04	0.479	0.761	0.038	0.499	1.033	0.052	0.406
Age at Interview	-0.059	-0.147	0.089	-	-	-	**0.111**	**0.277**	**<0.001**
Parity at Interview	**0.56**	**0.597**	**<0.001**	**0.46**	**0.49**	**<0.001**	-	-	-
Literate	0.228	0.034	0.62	0.373	0.055	0.412	0.647	0.095	0.202
Speaks Spanish	-0.111	-0.01	0.87	0.009	0.001	0.99	0.311	0.029	0.677
Wife IFS	**0.318**	**0.208**	**0.001**	**0.317**	**0.207**	**0.001**	**0.481**	**0.314**	**<0.001**
Wife Literate	0.627	0.087	0.233	0.708	0.099	0.179	0.231	0.032	0.69
Wife Speaks Spanish	**-1.086**	**-0.162**	**0.034**	**-1.184**	**-0.176**	**0.02**	-1.082	-0.161	0.056
Distance to San Borja (km)	**0.031**	**0.203**	**0.001**	**0.032**	**0.21**	**0.001**	**0.033**	**0.215**	**0.001**
Number of Parents		207			207			207	
Adj R-squared		0.41			0.41			0.28	
AIC		989			990			1032	

Table 1.4. Predicted Odds of Exceeding Paternal and Maternal Ideal Family Size

	Paternal						Maternal					
	Age and Parity		Parity		Age		Age and Parity		Parity		Age	
	OR	p	OR	p	OR	p	OR	p	OR	p	OR	p
Respondent's IFS	**0.326**	**<0.001**	**0.321**	**<0.001**	**0.414**	**<0.001**	**0.416**	**<0.001**	**0.418**	**<0.001**	**0.544**	**<0.001**
Partner IFS	1.251	0.066	1.256	0.062	**1.275**	**0.037**	0.978	0.724	0.977	0.704	1.003	0.959
Maternal BMI	1.012	0.843	1.015	0.804	1.001	0.986	1.031	0.599	1.021	0.704	1.007	0.893
One Living Son in Household	1.410	0.732	1.443	0.717	1.559	0.654	0.322	0.392	0.267	0.324	0.317	0.353
Respondent's Parity at Interview	**1.470**	**0.002**	**1.546**	**<0.001**			**1.847**	**<0.001**	**1.618**	**<0.001**		
Respondent's Age at Interview	1.024	0.503			**1.107**	**0.000**	0.938	0.145			**1.099**	**0.001**
Mother Speaks Spanish	0.899	0.837	0.924	0.876	0.967	0.946	0.713	0.508	0.681	0.451	0.918	0.856
Father Speaks Spanish	2.370	0.260	2.163	0.303	3.133	0.124	1.402	0.619	1.540	0.530	1.908	0.307
Mother Literate	0.910	0.858	0.882	0.810	0.753	0.579	1.453	0.462	1.502	0.420	1.064	0.896
Father Literate	1.150	0.763	1.090	0.850	1.298	0.560	0.977	0.959	1.119	0.797	1.111	0.800
Distance to San Borja (km)	1.004	0.674	1.004	0.696	1.001	0.926	0.999	0.875	0.999	0.925	0.997	0.683
Number of Parents	207		207		207		207		207		207	
Pseudo R-squared	0.35		0.35		0.32		0.28		0.28		0.19	
AIC	208		207		217		228		228		252	

Table 1.5. Factors Predicting HAZ and WAZ (underweight) in Children ages 0-2, Dummy for exceeding (Unstandardized)

	HAZ						WAZ					
	(1)		(2)		(3)		(4)		(5)		(6)	
	β	p	β	p	β	p	β	p	β	p	β	p
Age at Measurement (Years)	**-1.061**	**<0.001**	**-1.051**	**<0.001**	**-1.047**	**0.000**	**-0.450**	**<0.001**	**-0.448**	**0.000**	**-0.442**	**<0.001**
Male	**-0.314**	**0.028**	-0.325	0.024	**-0.307**	**0.032**	-0.171	0.168	-0.199	0.115	-0.208	0.095
Birth Order	-0.009	0.813	-0.002	0.956	-0.040	0.278	-0.021	0.582	-0.016	0.683		
Maternal BMI	0.029	0.257	0.025	0.337	0.025	0.336	**0.055**	**0.003**	**0.055**	**0.004**	**0.054**	**0.004**
Exceeded Mom's Ideals	-0.014	0.956	-0.103	0.682			0.125	0.555	0.039	0.853		
Exceeded Dad's Ideals	0.023	0.928	0.090	0.711			-0.030	0.872	0.019	0.921		
Maternal IFS	-0.017	0.739	-0.027	0.602	0.001	0.989	0.046	0.264	0.036	0.376	0.029	0.375
Paternal IFS	0.014	0.674	0.013	0.695	0.022	0.435	-0.025	0.312	-0.021	0.401	-0.023	0.251
Mother Speaks Spanish			-0.135	0.392	-0.123	0.431			0.006	0.965	0.002	0.989
Father Speaks Spanish			0.092	0.782	0.061	0.852			-0.017	0.938	-0.036	0.869
Exceeded both parents' Ideals					0.281	0.193					0.021	0.870
N Obs, (Clusters)	549, (385)		543, (381)		543, (381)		549, (385)		543, (381)		543, (381)	
R-squared	0.15		0.15		0.15		0.06		0.06		0.06	
AIC	2009		1982		1979		1852		1834		1831	

Table 1.6. Factors Predicting HAZ and WAZ (underweight) in Children aged 2-5, Dummy for Exceeding (Unstandardized)

	HAZ						WAZ					
	(1)		(2)		(3)		(4)		(5)		(6)	
	β	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Age at Measurement (Years)	-0.012	0.730	-0.010	0.762	-0.009	0.798	0.030	0.323	0.027	0.373	0.029	0.345
Male	-0.166	0.073	-0.161	0.084	-0.149	0.105	-0.047	0.553	-0.048	0.547	-0.043	0.586
Birth Order	-0.029	0.254	-0.026	0.316	-0.036	0.116	-0.009	0.694	-0.012	0.598		
Maternal BMI	0.005	0.723	0.006	0.718	0.005	0.739	**0.040**	**0.002**	**0.041**	**0.002**	**0.040**	**0.002**
Exceeded Mom's Ideals	-0.178	0.278	-0.182	0.270			-0.083	0.538	-0.094	0.485		
Exceeded Dad's Ideals	0.234	0.149	0.224	0.167			0.170	0.195	0.176	0.176		
Maternal IFS	0.003	0.902	0.002	0.935	0.018	0.422	0.028	0.220	0.028	0.224	0.032	0.104
Paternal IFS	0.012	0.606	0.010	0.679	0.002	0.930	-0.024	0.153	-0.018	0.287	**-0.029**	**0.025**
Mother Speaks Spanish			-0.023	0.809	-0.024	0.799			0.162	0.058	0.152	0.073
Father Speaks Spanish			0.067	0.699	0.068	0.693			0.072	0.569	0.076	0.551
Exceeded both parents' Ideals					0.125	0.374					0.045	0.608
N Obs, (Clusters)	1012, (533)		1006, (530)		1006, (530)		1012, (533)		1006, (530)		1006, (530)	
R-squared	0.02		0.01		0.01		0.04		0.05		0.05	
AIC	2988		2977		2977		2743		2727		2725	

Table 1.7. Factors Predicting HAZ and WAZ (underweight) in Children aged 0-2, 2-5, Magnitude of Exceeding

	HAZ				WAZ			
	Ages 0-2		Ages 2-5		Ages 0-2		Ages 2-5	
	β	p	β	p	β	p	β	p
Age at Measurement (Years)	**-1.050**	**<0.001**	-0.011	0.759	**-0.449**	**<0.001**	0.027	0.391
Male	**-0.325**	**0.025**	-0.150	0.102	-0.202	0.107	-0.042	0.596
Birth Order	-0.017	0.691	-0.015	0.594	0.001	0.989	-0.001	0.970
Maternal BMI	0.025	0.346	0.005	0.734	**0.055**	**0.004**	**0.041**	**0.002**
Number Over/Under Maternal IFS	-0.018	0.687	0.012	0.585	0.031	0.340	0.031	0.106
Number Over/Under Paternal IFS	0.004	0.881	-0.006	0.776	-0.022	0.284	**-0.030**	**0.024**
Mother Speaks Spanish	-0.140	0.372	-0.030	0.756	0.004	0.974	0.156	0.068
Father Speaks Spanish	0.093	0.781	0.079	0.647	-0.016	0.942	0.082	0.519
N Obs, (Clusters)	543, (381)		1006, (530)		543, (381)		1006, (530)	
R-squared	0.15		0.01		0.06		0.04	
AIC	1979		2977		1830		2725	

Table 1.8. Factors Predicting Odds of Stunting in Children aged 0-2, 2-5, Magnitude of Exceeding IFS

	Ages 0-2		Ages 2-5	
	OR	p	OR	p
Age at Measurement	**3.758**	**<0.001**	0.949	0.424
Male	**1.620**	**0.021**	**1.448**	**0.029**
Birth Order	0.986	0.804	1.001	0.987
Maternal BMI	0.990	0.767	0.995	0.855
Number Over / Under Maternal IFS	0.987	0.827	0.976	0.563
Number Over / Under Paternal IFS	1.027	0.447	1.013	0.683
Mother Speaks Spanish	0.921	0.700	1.069	0.712
Father Speaks Spanish	1.771	0.303	1.003	0.994
N Obs, (Clusters)	543, (381)		1006, (530)	
Pseudo R-squared	0.09		0.008	
AIC	647		1398	

Table 1.9. Factors Predicting Hemoglobin and Odds of Anemia (Hb <10), Magnitude of Exceeding IFS

	Hb Ages 0-2		Odds(Anemia) Ages 0-2		Hb Ages 2-5		Odds(Anemia) Ages 2-5	
	β	p	OR	p	β	p	OR	p
Age at Measurement	0.123	0.682	**0.271**	**0.001**	**0.122**	**0.000**	0.922	0.330
Male	-0.260	0.372	1.030	0.959	-0.086	0.332	1.070	0.847
Birth Order	-0.060	0.316	0.971	0.819	**-0.043**	**0.047**	1.002	0.974
Maternal BMI	0.099	0.062	0.867	0.139	0.016	0.243	0.962	0.455
Number Over/ Under Maternal IFS	-0.015	0.796	0.988	0.936	-0.044	0.063	1.022	0.810
Number Over/ Under Paternal IFS	0.048	0.164	1.031	0.684	-0.005	0.711	0.991	0.866
Mother Speaks Spanish	0.184	0.496	0.669	0.451	-0.052	0.589	1.096	0.800
Father Speaks Spanish	0.491	0.542	0.113	0.109	0.257	0.148	0.825	0.800
N Obs, (Clusters)	102, (97)		102, (97)		658, (455)		658, (455)	
R-squared, Pseudo R-squared	0.09		0.12		0.07		0.006	
AIC	350		112		1915		301	

CHAPTER 2 SOCIOECONOMIC DIFFERENCES IN NUTRITIONAL STATUS AMONG CHILDREN AGED 0-5 IN THE BOLIVIAN AMAZON

ABSTRACT

Context: The association between maternal socioeconomic status, maternal health, and child health outcomes are well documented across countries. This paper describes the relationship between maternal socioeconomic characteristics and child nutritional status in the Tsimane of Bolivia, a high fertility and high mortality indigenous population living in the Bolivian Amazon. Maternal Spanish fluency, grade in school, and distance to market as well as inter-birth intervals, birth order, total siblings, and maternal height and body fat are used to predict nutritional status in Tsimane children aged 0-5 years. Maternal Spanish fluency and education are considered as proxies for access to markets and information in a population with high fertility and mortality, low levels of market integration, and a subsistence lifestyle.

Methods: Prevalence of stunting and wasting were calculated for a total of 6,200 child-measurements from a sample of children aged 0-5 years. Odds of stunting (height for age z-score (HAZ) < -2) were estimated as a function of maternal characteristics using logistic regression with robust standard errors and stratified by age group to account for weaning ages (n=1,799 children aged 0-2, mean 1.5 measurements per child, n=2,236 children aged 2-5 years, mean 2.05 measurements per child). Height-for-age and weight-for-height z-scores were predicted using ordinary least squares (OLS) regression with robust standard errors, testing multiple metrics for distance to market and village-level fixed effects. Odds of wasting were estimated, however these estimates are considered less stable due to low prevalence by age group.

Results: Mean HAZ is below zero for both age groups in this population, while mean WHZ is above zero. Nearly half of children under age 5 are stunted. Maternal height, representing a combination of factors (e.g. maternal developmental environment, genetic endowments) have a small but significant association with higher HAZ and lower odds of stunting in both age groups. Age in months is negatively associated with HAZ in the 0-2 age group. For ages 2-5, age is positively associated with HAZ indicating some recovery of height during this period. Maternal Spanish proficiency is associated with improved HAZ and a 33% reduction in odds of stunting for 0-2 and 48% reduction in ages 2-5. This finding remains statistically significant across specifications of distance from town and after including village-level fixed effects. Weight-for-height z-scores are also positively associated with maternal Spanish proficiency and grade for children aged 2-5, however this association is nonsignificant for children aged 0-2 years.

Conclusion: This study considers a number of factors associated with child nutritional outcomes and highlights the importance of maternal socioeconomic characteristics in a high-fertility population with low levels of market integration into the Bolivian national economy. Across both age groups, maternal Spanish fluency is associated with increased HAZ and nearly a halving of the odds of stunting in age group 2-5. The relatively low explanatory power of the logistic model for ages 0-2 suggests this age group may be buffered from risk by breastfeeding whereas children in the age group 2-5 are impacted by maternal Spanish and maternal educational characteristics. This analysis suggests the importance of maternal market integration and access to services and information (proxied by Spanish ability) for protection against lower HAZ and WHZ in this population.

INTRODUCTION

The relationship between maternal socioeconomic status (SES) and infant and child health outcomes is well documented across populations (Mosley and Chen 1984, Parker, Schoendorf et al. 1994). Among indicators comprising SES, maternal education is one of the strongest predictors of improved infant and child health and survivorship, though causality is contested (Caldwell and McDonald 1982, Desai and Alva 1998). In high-fertility, low-resource settings where slowed growth is associated with undernutrition, maternal illiteracy and low income are strongly associated with increased stunting and wasting (Khatun, Stenlund et al. 2004). In addition to SES, maternal nutritional status is predictive of child growth outcomes and health conditions later in life (Schroeder, Martorell et al. 1999). Poor child growth outcomes are associated with decreased developmental pace and increased health risks across the life course, thus perpetuating initial maternal disadvantages in subsequent generations (Grantham-McGregor, Cheung et al. 2007). To date, many studies assess the relationship between maternal SES, maternal health and nutrition, and child nutritional status across diverse settings. However, several additional biological factors pertaining to a maternal life history are believed to affect child growth outcomes, including maternal depletion, fetal programming, and intergenerational transfer of birth weights (Lucas, Fewtrell et al. 1999, Ramakrishnan, Martorell et al. 1999, Lindsay 2005). This study explores the association between maternal and child characteristics and short- and long-term nutritional status. Specifically, height-for age, stunting, weight-for-height, and wasting are considered as a function of current maternal SES and indicators of maternal developmental environment in a high-fertility, resource-limited population, the Tsimane of Bolivia.

Maternal education, income, and rural/urban residence are among the most common predictors of child nutrition. Increased maternal education is associated with increased utilization of healthcare services for pre- and post-natal care in low-income settings (Cleland and Van Ginneken 1988, Elo 1992). Maternal education is proposed to increase responsiveness to new ideas and services, social confidence (e.g. increased willingness to interact with medical professionals) and ability to travel for health services, especially in areas where local language differs from the national language used by medical personnel (Cleland and Van Ginneken 1988). However, rural residence can modify this association, where increased distance from health facilities is associated with differentials in utilization (Elo 1992). Analyses of the Bolivia Demographic and Health Survey (DHS) suggest several different pathways in which maternal characteristics are associated with likelihood of stunting in children, including maternal education, household wealth, health care utilization, ethnicity, parity, and inter-birth intervals (Frost, Forste et al. 2005). This 2005 analysis of Bolivian DHS concludes that half of the association of maternal education and child health is attributable to socioeconomic status and residence, emphasizing rural/urban status in the Bolivian national context. The Tsimane are a Bolivian indigenous population with high fertility and mortality facing a high-pathogen, low-resource environment thought to be more representative of the human evolutionary past than current conditions in industrial populations. Exploring the relationship between maternal characteristics including reproductive histories, maternal early life conditions, socioeconomic status, residence, and child nutritional status while early in the process of market integration provides an additional perspective on the relative importance of maternal socioeconomic status for child health.

Aside from socioeconomic status, two aspects of maternal life history are considered here as precursors to child nutritional status; current maternal health status (current state of maternal fat stores at time of child measurement, an indicator of depletion and household conditions) and the growth of mothers during their childhood and adolescence (past growth measured by height). Several prenatal mechanisms may be at work in determining child growth; maternal depletion, fetal programming, and intergenerational transfer of growth patterns. Fetal programming is not directly tested in this analysis because anthropometric measures are not available during pregnancy, nor are birth weights available due to very low prevalence of in-facility births. Evidence of maternal depletion syndrome as measured by multiple characteristics including body mass index (BMI) and body fat percentage have been studied as a function of parity and birth spacing, providing some evidence of a failure to recover following short inter-birth intervals resulting in worse infant outcomes, however, the association varies by age and socioeconomic context (Winkvist, Rasmussen et al. 1992, Miller, Rodriguez et al. 1994, Shell-Duncan and Yung 2004). Maternal depletion is theorized to have a cumulative effect; all else equal, high-order, closely spaced births suffer most from depletion when maternal fat stores have not sufficiently recovered between births and therefore breast milk and other maternal somatic resources are diminished. Birth order and inter-birth intervals are considered in the subsequent analyses, however, there is minimal evidence of impacts of pace of reproduction and parity on maternal fat stores in this population cross-sectionally, and longitudinal analyses suggest no statistical evidence of declining maternal nutritional status with increased parity and pace of reproduction (Stieglitz, Beheim et al. 2015, Gurven, Costa et al. 2016). Maternal fat stores can, however, represent food security within the household in this calorie-restricted context. It is worth noting that across countries currently undergoing the nutrition transition, poorer households are more likely to have both underweight and obese members (Doak, Adair et al. 2000, Popkin 2001) which can vary by sex (Prentice 2006). Small increases in mean population weight have been observed in the Tsimane in the past decade, primarily for women (Rosinger and Godoy 2016). A sample of women in 13 villages documented an increase of 0.64% in BMI per year from 2002 to 2006 (Rosinger and Godoy 2016). While there is not yet evidence of a rapid increase, increased body fat percentage and maternal BMI may shift to represent disadvantage among the Tsimane as nutrition and lifestyle change from hunter-horticulturalist to more sedentary lifestyles with increased consumption of processed foods.

Early life conditions including the fetal environment and childhood growth are associated with later-life health and socio-economic outcomes (Lucas, Fewtrell et al. 1999, Alderman, Hoddinott et al. 2006). For example, early life exposure during specific critical periods to epidemic and famine is associated with increased later-life morbidity and all-cause mortality (Roseboom, de Rooij et al. 2006, Myrskylä, Mehta et al. 2013). Independent of these early life exposures, intergenerational effects on linear growth have been documented among low-resource populations, where maternal birth size is a significant predictor of child size at birth (Ramakrishnan, Martorell et al. 1999). Mixed, cross-population evidence of maternal depletion, fetal programming, and intergenerational patterns of growth combined with maternal socio-economic factors point to a complex mosaic of early life growth with long-term impacts on adult health and productivity.

This study explores how maternal socioeconomic status, proxies for past nutritional status, current energy stores, and birth histories predict longitudinal nutritional status of children aged 0-5 years among the Tsimane, an indigenous population of approximately 16,000 living in the Beni department of Bolivia. Child growth is examined in the context of the maternal life history, including parity, prior birth intervals, education and Spanish proficiency, childhood growth, and maternal energy stores at the time of the measurement of the index child. This approach explores biological and socioeconomic relationships by addressing one primary question: in a high-fertility low-resource setting, are immediate maternal indicators (current maternal body fat, Spanish speaking ability) more closely associated with child growth outcomes than longer-term maternal life history traits, such as indicators of maternal depletion, intergenerational growth patterns, or maternal early life conditions?

Each component associated with child growth holds implications for nutritional policy. Improvement of maternal nutrition, education, and increased access to health services may serve as early interventions to improve child nutrition and growth outcomes, which are associated with development, productivity, and disease in adolescence and adulthood. Understanding whether the long arm of maternal early life conditions or shorter-term indicators of maternal wellbeing are associated with child nutrition in a high-fertility, low-resource setting deepens our understanding of how environmental conditions can be buffered in a population undergoing rapid changes in market integration.

STUDY POPULATION – THE TSIMANE

This study makes use of longitudinal demographic and anthropometric datasets collected by the Tsimane Health and Life History Project, a joint study undertaken by the University of New Mexico and the University of California at Santa Barbara which collects social, demographic, and health data continuously from 2002 in a population of Bolivian Amerindians (Gurven, Kaplan et al. 2007). Project aims are to improve the understanding of how evolution and the environment affect the life course by focusing on health, aging, economics, and biodemography in a population practicing a traditional lifestyle thought to better approximate the conditions faced throughout much of human evolution prior to industrialized and sedentary lifestyles. This population numbers approximately 16,000 people spread across over 95 villages and the larger market town of San Borja (n≈41,000, mostly non-Tsimane Bolivian nationals). Villages are made up of extended family groups ranging from 30-700 people with variable access to the Maniqui River, seasonal logging roads, and market goods via these transit routes (von Rueden, Trumble et al. 2014). Only a few villages currently have running water or intermittent electricity. Approximately 30 villages contain schools teaching both Tsimane and Spanish at the start of the present study, but fewer contained schools when the mothers included this study were school-aged. Households consist of one to four nuclear families and serve as the unit of resource production and distribution. Grandparents, parents, aunts, uncles, and children typically live in the same household or village. More than ninety percent of the Tsimane diet is self-produced, with approximately sixty percent of food consisting of small-scale cultivation, including corn, plantains, manioc, and rice, supplemented by fishing and hunting (Martin, Lassek et al. 2012, Mcallister, Gurven et al. 2012). Participation in the local cash economy is limited; cash crops, sporadic wage labor, and trade with merchants are the major sources of goods and income. Low-income wage labor (typically on ranches) is available for men, but only in communities near the town of San Borja and main roads (Mcallister, Gurven et al. 2012).

Marriage is not a formal process; a couple is married when they live under the same roof for longer than a brief period of time. Mean age at marriage is 21 years old for men and 16.5 years old for women (Winking 2005). These unions are fairly stable, with fewer than 20% of unions ending in dissolution within the first years of marriage; after the birth of a couple’s second child, union dissolution is negligible (Winking 2005). Polygyny is rare, with approximately 6% of the male population engaging in polygyny, most of which involve two sisters married to the same man (Winking 2005). Parental time spent childrearing is disproportionally female; women contribute on average 39.4% of their time to child care compared to 8.6% of time spent by men, whose contributions to direct childcare are mostly in the form of play (Winking, Gurven et al. 2009).

In addition to a hunter-horticulturalist lifestyle, fertility and mortality are high. With a total fertility rate (TFR) of 9.1 and infant mortality rate of 130 per 1,000, demographic conditions resemble the pre-transition phase of the demographic transition (Gurven, Kaplan et al. 2007). Total fertility rate (TFR) is slightly lower for women living further from town (TFR= 8.0) and infant mortality is higher (IMR≈250 per 1,000) (Gurven 2012, Mcallister, Gurven et al. 2012). The reverse is true for women living closer to the market town of San Borja, where fertility is higher (TFR=9.5) and infant mortality is lower (IMR≈100 per 1,000) (Mcallister, Gurven et al. 2012). This population has been referred to as a “natural fertility” population, and observed TFRs fall well within the range of Henry’s now-classic examples, including TFRs ranging from 6.2 in women living in

Guinea in the 1950s to 10.9 in Hutterite women married from 1921-1930 (Henry 1961). Natural fertility populations are expected to vary in terms of TFR, due to variation between populations in non-parity specific controls such as lactational amenhorrea due to breastfeeding and post-partum taboos and abstinence (Henry 1961). Though TFRs fall within this range and prevalence of contraceptive use is low at a population level, the current study does not measure parity-specific intentions. However, fertility and mortality reach pre-demographic transition levels in this population.

Studies of child growth in this population have focused on the growth curve difference between US and Tsimane children aged 9 years and below (n=309, 58 villages), noting that stature is much smaller while muscularity remains similar to children of a comparable age (Foster, Byron et al. 2005). The rates of stunting are consistent with other studies of growth in indigenous populations in lowland South America, where prevalence is high relative to the national population, key micronutrients are missing from diets, and prevalence of infection is high. To build on this initial framework, this study focuses on young children from ages 0-5 stratified by broad age group (0-2 years, 2-5 years); by age 2, the majority of children will have been weaned and are still in what forms a critical period for development and productivity in later life (mean weaning time 19.2 months) (Veile, Martin et al. 2014).

CHILD GROWTH IN LOW RESOURCE SETTINGS

Maternal socioeconomic status measured using maternal education, household wealth, and residence (rural/urban) are strongly associated with child mortality across low-resource countries. A study by Caldwell and colleagues found evidence of reduced child mortality with increased maternal education across ten low-resource countries varied in geography and culture using World Fertility Surveys (WFS), including Jamaica, Panama, South Korea, Sri Lanka, Jordan, Colombia, Indonesia, Kenya, Peru, and Bangladesh. This comparison of q(2) (probability of death between birth and exact age 2) by educational category finds that across countries, lower q(2) by education of both parents controlling for occupational advancement is 90 per thousand, or “equivalent to a change in expectation of life at birth of at least twelve years” (Caldwell and McDonald 1982). The authors propose maternal education is more important than both income and access to health facilities combined (Caldwell and McDonald 1982). This association has been replicated across a much broader set of 175 countries from 1970-2009; maternal education is credited with decreasing child deaths (at ages 0-5) by 51.2% over the 40-year time period (Gakidou, Cowling et al. 2010).

In addition to strong associations between maternal education and child mortality, the literature suggests maternal education and SES have strong positive associations with child nutritional status. A study using the Bolivian DHS suggests that maternal education has a significant association with likelihood of stunting (Frost, Forste et al. 2005). Controlling for region, household wealth, paternal education and occupation, health care utilization, maternal age at first birth, parity, and inter-birth intervals, each unit increase in educational category (none, 1-5 years, 6-8 years, or 9+ years) was associated with a 0.197 decrease in likelihood of having a stunted child (Frost, Forste et al. 2005). The authors find that approximately half of the association between maternal education and child stunting is diminished by socioeconomic status and geographic residence, however, this 0.197 decrease in odds is predicted after controlling for these variables. This finding has been replicated across contexts, controlling for both paternal education and occupation and rural residence (Caldwell and McDonald 1982). Longitudinal studies in Bangladesh (BRIC) and Guatemala (INCAP) have also documented this relationship, citing similar reasons to the Bolivia DHS study, including improved health knowledge, increased ability to navigate the health system, and gender-sensitive care practices among mothers (Khatun, Stenlund et al. 2004).

Biological factors including maternal depletion and intergenerational transfer of growth provide an additional level of complexity to understanding patterns of child nutrition and growth. Maternal depletion syndrome is defined as the inability to recover from a birth in terms of energy stores between births; the syndrome is theorized to occur when short inter-birth intervals or a high volume of births leaches nutrients from mothers in calorie-deficient settings. In this framework, first and second born children are least likely to experience the negative health consequences of many births clustered together, however, resources will continue to be spread across many subsequent children (Miller, Rodriguez et al. 1994). Both short and long inter-birth intervals are associated with higher risk of low birth weight and lower child nutritional status (Conde-Agudelo, Rosas-Bermúdez et al. 2006, Dewey and Cohen 2007). Short inter-birth intervals and high parity are thought to be the underlying causes of maternal depletion. These variables in addition to maternal body fat percentage (a direct measure of maternal energy stores) will be used in this study. Body fat percentage is negatively associated with prolonged lactation and breast feeding among Filipino women (Adair and Popkin 1992). In a population in which children are breastfed exclusively, mothers may rely on existing fat stores for nutritional transfer to their children via breast milk. However, among the Tsimane, cross-sectional data suggest higher parity is not associated with decreased fatty acids in breast milk, so perhaps the quality of breast milk does not decrease (n=35) (Martin, Lassek et al. 2012). Additionally, Tsimane women have higher proportions of fatty acids in breast milk than US women, which may be due to regular consumption of freshwater fish and wild game and lower intake of processed foods. This lack of degradation of breast milk quality with increased parity could signal one of two scenarios; either maternal depletion is not occurring and children are not negatively affected via nutrient intake, or maternal depletion is occurring and maternal fat stores are reallocated to compensate for what may have been degrading quality of milk over time. In the latter case, the consequences of depletion may not be borne out in quality of milk with advanced parity (and therefore growth of higher-order offspring), rather, by a decrease in maternal fat stores over time. Alternately, the costs of childbearing may not occur to the child or the mother until after reproductive ages are complete. However, Martin et al (2012) followed women over only one pregnancy and birth, investigating parity but not birth intervals, so closely clustered births and any subsequent declining quality of milk could not be observed. A larger anthropometric study undertaken since has suggested no negative association between maternal parity and pace of reproduction longitudinally (Gurven, Costa et al. 2016).

In addition to current maternal nutritional status, height is included as a proxy for maternal early life conditions which may include fetal environment, nutrition and infection in childhood, and growth in adolescence (Barker 2006, Hall, Hewitt et al. 2008, Victora, Adair et al. 2008). Birth weight is proposed to have an additional non-genetic inheritance component whereby future generations are at increased risk for transference of low birth weight and subsequent coronary heart disease, diabetes, hypertension, and stroke in later life (Drake and Walker 2004, De Boo and Harding 2006). Early life exposures during critical periods such as fetal development are proposed to affect morbidity and mortality later in life because physiological processes are altered in utero. Alternately, improved maternal nutrition early in life may be associated with higher human capital, which would allow women to provide additional resources to children. Longitudinal studies suggest protein-rich nutritional supplementation in women up to 15 years of age is associated with improved nutritional status in the next generation (Behrman, Calderon et al. 2009). Child growth and development may therefore be impacted by processes in flux long before conception, whether the mechanism is epigenetics or transfer of human capital via improved nutritional status of mothers. Regardless of the pathway, both child and maternal life history play a role in current child growth trajectories and future health and human capital implications (Roseboom, de Rooij et al. 2006, Victora, Adair et al. 2008, Myrskylä, Mehta et al. 2013).

DATA AND METHODS

DATA

Anthropometric, demographic, and socio-economic indicators are collected on an annual or biannual basis in waves of data collection from 2002 to present. Traveling teams of physicians, lab technicians, anthropologists, and trained interview personnel visit 95 communities ranging in size from 30-700 individuals approximately once per year conducting interviews, taking anthropometric and biological measurements, and providing medical care. A range of 18 to 95 villages were visited per wave, with fewer villages visited at the start of the project, expanding over time from August 2002 (18 villages) to December 2012 (95 villages) as the project grew in scope. Medical care is provided while collecting anthropometric indicators and other clinical evaluations of the population. Anthropometric measurements include weight (kgs), height (m) and body fat (%) measured using a Tanita scale. Clinical evaluations include anthropometry, medical histories, current symptoms and diagnoses, dental evaluation, hematology, and fecal and urine analysis (Gurven, Costa et al. 2016). Initial in-depth demographic interviews took place from 2002-2005 and are updated at each wave, cataloging births, deaths, and migration since last interview, forming a population register to present.

This study combines anthropometric measurements with demographic and socio-economic indicators to generate a child-centered longitudinal dataset. The combined dataset consists of 6,874 child-measurements over a 10-year period of data collection for children aged 0-5, with up to two measurements per year. Some children have over 5 measurements from age 0-5 for the period, indicating they were measured twice in a given wave of data collection (2.11%). Measurement dates are recorded and included in analysis so children with multiple measures in a wave are retained.

Of 6,874 child-measurements aged 0-5 years in the anthropometric data, 6,200 have available covariates including maternal height, grade, and Spanish proficiency. Of these 6,200 child-measurements with maternal covariates, 5,961 child-observations have non-missing maternal body fat percentage on the same measurement date, resulting in a 3.85% loss of observations from the analytic sample (Table 2.1). This corresponds to a loss of 239 child-observations from 216 children who do not have statistically different measurements of HAZ, WAZ, stunting, or wasting on average. The final analytic sample includes 2,441 measurements among 1,770 children aged 0-2 and 3,759 measurements among 2,170 children aged 2-5 for whom maternal body fat percentage or other explanatory variables are not missing.

VARIABLE CONSTRUCTION

Height-for-age, weight-for-height, stunting, and wasting are the nutritional outcomes considered in the present study. Height-for age (HAZ) and weight-for-height (WHZ) z-scores calculated using World Health Organization (WHO) growth standards (Onis, Dewey et al. 2013). Weight in children was measured using a Tanita scale and height was measured using a Seca 210 length measuring mat for infants (Seca 214 portable stadiometer for older children). Z-scores were calculated by comparing the observed values of weight and height for age to growth charts compiled by the WHO Multicentre Growth Reference Study. The study guidelines recommend excluding HAZ measurements outside ±6 SD from the median, WAZ below -6 or above +5, WHZ ±5 from the median, and BMIZ ±5 because these values are likely the result of data entry errors (Mei and Grummer-Strawn 2007). Measurements in these ranges have been excluded and comprise less than 5% of the sample. The zscore06 command in STATA uses child age in months, weight, and height to generate HAZ and WHZ for children under 5 (Table 2.2). This study follows the WHO Global Database on Child Growth and Malnutrition guidelines defining stunting and wasting, where a z-score cutoff of less than -2 standard deviations of height-for-age is classified as stunted and a z-score cutoff of less than -2 standard deviations of weight-for-height is defined as wasting (Onis 2006).

Predictor variables are grouped by child, maternal, and environmental characteristics (Table 2.3). Child characteristics including age in months, birth order, birth interval, and sex are used to predict nutritional status. Child birth order and previous birth interval are combined into a single, interacted variable. Child age and sex are included as controls because of possible systematic deviations from the WHO reference growth curve for this population. Maternal factors including body fat percentage were measured using bioelectric impedance using a Tanita scale and height using a portable Seca 213 stadiometer. Highest grade attended and Spanish proficiency was assessed in social surveys, where completion of the survey in Spanish denotes proficiency. Maternal Spanish and education are included in place of household wealth, as these data are only available for a limited subset of households and are not contemporaneous with child anthropometric measurements. Environmental characteristics include distance to town (km) which was measured for each village of residence and date of measurement (used to assess wet/dry season and period of measurement) for each child weigh-in. Season of measurement is included as a control variable to hold differences in food availability and infectious environment constant; food scarcity and increased parasite burdens are higher in the wet season (Blackwell, Trumble et al. 2016). Period of measurement (2002-2007, 2008-2012) are included in all analyses to control for secular changes in childhood nutritional status.

METHODS

A series of bivariate and multivariate regressions were estimated for each of the outcomes. Initial exploratory models include bivariate regressions for each of the child, maternal, and environmental characteristics of interest for each of the anthropometric outcomes and age groups (HAZ, stunting, WHZ, wasting: Supplement S1-S4). All bivariate and multivariate regressions include robust standard errors to account for the clustering of multiple observations within each child. Ordinary least squares (OLS) regression was used for continuous HAZ and WHZ and logistic regression was used to estimate odds of stunting and wasting using robust standard errors. The clustering approach was favored over a multilevel modeling strategy because of the relatively few observations per child per age group (1.33 observations per child 0-2, 1.65 observations per child 2-5). Three forms of distance from village to the market town of San Borja were tested, including linear, nonlinear, and quintiles of distance (km). All three are included in subsequent analyses. Additional regressions with the favored form of distance to San Borja (quintiles) and an analogous model with village-level fixed effects were estimated to assess consistency across environmental contexts (Supplement S5-S12).

RESULTS

Among 6,200 child-measurements 0-5, mean height-for-age z-score is 1.78 standard deviations below the median of the WHO multicentre growth study (Table 2.2). After classifying measurements as stunted (0/1), the proportion of children with HAZ <-2 SD from the median is 0.48; nearly half of Tsimane child measurements are lower than the recommended cutoff for stunting, indicating chronic undernutrition. This proportion of stunting among children aged 2-5 years is at almost double the prevalence of stunting in children under-5 in the world (27%) (De Onis, Blössner et al. 2004). This is also almost double the proportion of stunting in Bolivia among children 0-5 years of age according to UNICEF (26%). HAZ and stunting differ by age group, where children aged 0-2 who are more likely to still breastfeed have a slightly higher mean HAZ (-1.32) and lower prevalence of stunting (39%) compared to children aged 2-5 (HAZ =-2.08, stunting = 55%) (Table 2.2). This pattern of declining HAZ in the first 24 months has been observed across nutritionally compromised populations regardless of growth reference used (WHO 1994, WHO 2002, de Onis, Garza et al. 2007). Stunting for the Bolivian national population for this period is lower than the overall figure for this period for the Tsimane; 32% of child-measurements aged 0-5 years were stunted in the 2003 Bolivian DHS compared to 48.5% in this sample (Frost, Forste et al. 2005).

The mean weight-for-height z-score for children under 5 is 0.17 standard deviations above the WHO multicenter growth study, where a z-score of 0 would indicate median performance among the populations included in the WHO standard growth curve (Table 2.2). WHZ scores are lower among children aged 0-2 but still positive at 0.03, with a prevalence of wasting at 0.11 or 11%. Mean WHZ is higher among children aged 2-5 (WHZ = 0.27) and wasting prevalence is much lower (0.03 or 2.7%) (Table 2.2). Overall for children aged 0-5, prevalence of wasting is 0.059 which is still higher than the prevalence reported in the Bolivian 2003 DHS (~2%), however, stunting is much more frequent than wasting across all age groups and mean values of WHZ are positive (Frost, Forste et al. 2005).

Both the 0-2 and 2-5 samples are split approximately equally by sex (Table 2.3). The mean age of the 0-2 sample is 1.04 years and 4.2 years in the 2-5 sample (Table 2.3). Maternal highest grade attended is approximately equally distributed between none, some to 2, and 2 or more years. The majority of mothers of children included in both 0-2 and 2-5 samples speak some Spanish (~50%) or no Spanish (~30%) (Table 2.3). Mean maternal body fat hovers at about 24%, which is within the average range for percentage of body fat for women with healthy BMIs (Gallagher, Heymsfield et al. 2000).

Figure 2.1 shows the distribution of child measurements of HAZ and WHZ by age of the child in years for the 5,961 child-measurements (see Table 2.1, row 3). A median spline was fit using calculated cross-medians as knots to fit a cubic spline and is primarily meant for demonstrative purposes. HAZ follows a very typical pattern of child height over age; the initial period is marked by a median value close to zero and falls off over the weaning period. As reflected by the overall mean WHZ for this population, the median spline remains around zero and increases slightly (Table 2.2 and Figure 2.1). Figure 2.2 shows the proportion of child-measurements stunted and wasted by age; the proportion of stunted child-measurements increases with age while the proportion of wasting decreases with age (note the y-axes, as stunting is more prevalent than wasting).

Height-for-age z-scores

Height-for-age z-scores are predicted as a function of child age in months, birth order*previous birth interval, sex, maternal body fat percentage, maternal height in centimeters, grade, Spanish proficiency, season of measurement, period of measurement, and distance to San Borja (specified in quintiles, linearly, and nonlinearly). Among children aged 0-2, increased age in months is associated with a decrease in HAZ ($\beta=-0.103$, $p<0.001$, Table 2.4). This remains consistent across specifications of distance to San Borja and after including village-level fixed effects (Supplement S5). Boys are more likely to have lower HAZ in this age group than girls ($\beta=-0.345$, $p<0.001$, Table 2.4). Increased maternal height is associated with a small but significantly higher HAZ, where a one-inch increase in maternal height is associated with a 0.05-SD increase in child HAZ. Maternal Spanish proficiency is associated with a large and significant increase in HAZ; children of women with Spanish proficiency have an estimated 0.365 increase in HAZ over children of mother who do not speak Spanish (β=0.365, $p<0.05$, Table 2.4).

Among children aged 2-5, a one-month increase in age is associated with a 0.004 increase in HAZ ($p<0.05$, Table 2.5). Maternal height is associated with increased HAZ, where a one-inch increase in maternal height is associated with a 0.124 increase in HAZ ($p<0.001$, Table 2.5). This is more than twice the increase in z-score associated with maternal height in children aged 0-2 years. Maternal grade of "some to 2 years" is associated with a 0.162 decrease in HAZ compared to no years of education ($p<0.05$). This association is consistent across functional forms of distance; however, it is no longer significant after including village-level fixed effects (Supplement S6). Maternal Spanish proficiency is associated with a 0.342 increase in HAZ ($p<0.001$, Table2.5). Child age, maternal height, and Spanish proficiency are consistent across functional forms of distance and village level fixed effects (Supplement S6).

Stunting

Odds of for ages 0-2 are shown in table 2.6. Holding birth order, maternal body fat percentage, grade, distance, season (wet vs. dry) and period of measurement constant, child age, sex, maternal height, and maternal education (proficient or more) are significantly associated with stunting. The direction of odds is consistent with the continuous measure of height-for-age z-scores; an additional month of age is associated with a 10% increase in odds of stunting for children aged 0-2 ($p<0.001$, Table 2.6). Males aged 0-2 have an estimated 48% increased odds of stunting compared to females (OR = 1.481, $p<0.001$, Table 2.6). Increased maternal height (cm) is associated with a slight decrease (2.6%) in odds of stunting. Maternal Spanish proficiency (proficient or more) is associated with a 33% reduction in odds of stunting compared to children with mothers who speak no Spanish (OR = 0.667, $p<0.05$, Table 2.6). These results are consistent across functional forms of distance and after inclusion of village-level fixed effects (Supplement S7).

Significant associations between child and maternal characteristics and continuous HAZ were consistent with the estimated odds of stunting among children aged 2-5. Age in months, maternal height (cm), and maternal Spanish proficiency were associated with decreased odds of stunting (Table 2.7). Holding birth order and birth interval, sex, maternal body fat percentage, maternal grade, and distance and season of measurement constant, increased age was associated with a slight decrease in the odds of stunting in the 2-5 age group (OR = 0.986, p<0.01, Table 2.7). Maternal height was associated with an 8.4% decrease in the odds of stunting (Table 2.7). Maternal Spanish proficiency is associated with nearly a halving in odds of stunting for this age group (OR = 0.518, p<0.001, Table 2.7). These covariates remain significant across specification of distance from San Borja and the maternal Spanish proficiency becomes more protective after including village-level fixed effects (OR= 0.440, p<0.001, Supplement S8).

Weight-for-height z-scores

Few maternal characteristics that predict height-for-age z-scores and stunting remain significant in weight-for-height z-score models. Maternal body fat, distance to San Borja, and season of measurement are associated with weight-for-height z-scores for children aged 0-2 years. A 5% increase in maternal body fat is associated with a 0.07 increase in WHZ (p<0.01, Table 2.8). Wet-season measurements were associated with a 0.147 decrease in WHZ. Across quintiles of distance from San Borja, quintiles 2-5 (beyond 29.9 km on average) were associated with decreased WHZ (Table 2.8). Controlling for village-level fixed effects, maternal body fat, season, and period of measurement are associated with WHZ, where wet season is associated with a 0.25 decrease in WHZ (p<0.01) and the WHZ measures in the later period are associated with an increase in (WHZ 0.160, p<0.05. Supplement S9). Among children aged 2-5, age, maternal grade, and maternal Spanish proficiency are associated with increased WHZ (Table 2.9). Wet season of measurement and distance to San Borja are associated with decreased WHZ (β=-0.086 p<0.05, β=-0.001 p<0.01, respectively). This is consistent across alternate specifications of distance, however, after adding village-level fixed effects maternal Spanish proficiency is no longer significant (Supplement S10).

Wasting

Logistic models estimating odds of wasting for ages 0-2 have low explanatory power, with pseudo-R^2 values ranging from 0.019 (distance quantile model) to 0.021 ($distance^2$ model). Age in months and maternal body fat are associated with reduced odds of wasting (OR = 0.957 p<0.01, OR = 0.980, p<0.05, respectively). However, maternal body fat is no longer statistically significant after including alternate specifications of distance to San Borja (Table 2.10). Distance to San Borja is associated with a slight increase in odds of wasting (OR =1.012, $p<0.05$, Table 2.10). Age, maternal body fat, and season of measurements are associated with wasting after including village-level fixed effects (Supplement S11).

Wasting in ages 2-5 is far less common (prevalence = 2.7%) and explanatory power of logistic models is limited. Child age in months is associated with a 6.5% reduction in odds of wasting for this age group (Table 2.11). This finding remains consistent across specification of distance and village-level fixed effects. After including village-level fixed effects, maternal grade category (2 or more) is associated with an odds ratio of 0.463 compared to children of women with no education (Supplement S12). Though this is a large and significant reduction in odds, estimates are likely to be unstable due to the relatively small proportion of children who are wasted and large a number of controls (n = 84 villages).

DISCUSSION AND CONCLUSION

Height-for-age z-scores are low and prevalence of stunting is high among Tsimane children, including children aged 0-2 years who are likely to be breastfeeding at the time of measurement. At the same time, mean weight-for-height is above zero and prevalence of wasting is comparatively low to that of stunting. Falling below a growth standard in terms of height is a cumulative process where malnutrition accumulates over time and results in a deviation from an optimal growth trajectory (De Onis, Blössner et al. 2004, Borghi, De Onis et al. 2006). Stunting and low HAZ are indicators of chronic, rather than acute, undernutrition (Winichagoon, Kavle et al. 2014). The cause of stunting in this environment may be inadequate nutrition, however, the high parasite and pathogen burden is likely a significant contributing factor. Approximately 65% of children under the age of 10 are infected with at least one type of helminth, with 16% of children infected with more than one species (Martin, Blackwell et al. 2013). The synergistic relationship between child nutrition and infection is well-documented, and should further be explored as a mediating factor in this population (Pelletier, Frongillo Jr et al. 1995, Scrimshaw 2003, Bourke, Berkley et al. 2016). Additionally, breastfeeding can confer immune benefits to infants (Field 2005). A study of 215 Tsimane maternal interviews suggests introduction of complimentary foods at 4.1 months and a mean weaning age of 19.2 months (Veile, Martin et al. 2014). While breastfeeding was not measured in this sample, age stratification was included to mitigate any potential confounding by breastfeeding. The relatively low prevalence of wasting suggests that acute malnutrition is not as common, though it is possible children do not survive long after falling into the wasting category of <-2 SD WHZ. Further assessment of infection, breastfeeding, nutrition, and mortality is required to better understand these patterns.

Maternal early life health proxied by height has a small but significant association with higher HAZ and lower odds of stunting in children in both age groups 0-2 and 2-5 years. This finding may reflect both genetic components of height and maternal health status during early life and adolescent growth. Current maternal condition measured using body fat percentage is associated with WHZ for both age groups, indicating the contribution of current household factors in both maternal and child nutrition.

Maternal Spanish proficiency remained a strong predictor of improved nutritional status across age groups, outcomes, and specifications. In both age groups 0-2 and 2-5, maternal Spanish ability was associated with a significant decrease in the odds of stunting (Tables 2.6 and 2.7) and increased WHZ for children aged 2-5 after controlling for maternal grade. Maternal grade was also associated with increased WHZ among children aged 2-5. The emergence of Spanish ability as a strong predictor of improved outcomes suggests the relative importance of Spanish over grade attended in this population.

Maternal Spanish fluency, which enables access to the Bolivian national economy, information, and health care in a context where Tsimane is not spoken by health professionals or Bolivian nationals in San Borja is also beneficial to children under 5 years of age. Whether this mechanism represents increased ability to advocate for better care or eases more basic issues of communication, it is striking that this relationship persists after holding maternal grade constant. Given the generally low levels of market integration, remote location, and marginalization of this population, schooling does not appear to confer the same benefits as speaking the national language. However, school schedules in this location are not consistent, as it is difficult to persuade teachers (often Bolivian nationals) to live in remote locations that are at times inaccessible depending on road or river conditions. It is also possible that for many mothers, fewer schools were available in the past so the lack of association between maternal education and child nutritional status may be an artefact of universally weak or absent schools. Overall, the relative importance of maternal Spanish suggests that neither the long arm of maternal developmental conditions nor indicators of current maternal health are as predictive of child nutrition as maternal socioeconomic factors in this sample.

Prevalence of stunting among Tsimane children under 5 is higher than the prevalence for the population of Bolivian children under 5. Prevalence of stunting is much higher in the 2-5-year age group, (54.7% of child-measurements) suggesting a vulnerability within an age range that could be amenable to intervention. Increased resources and access to translators for women who speak no Spanish may present an opportunity for narrowing the nutritional gaps in this population, with a specific focus on weaned children. Further analyses assessing infection in these age groups would better illuminate the types of medication and supplementation that would mitigate nutritional differences between groups, and provide guidance on which types of services should be targeted to mothers.

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FIGURES AND TABLES

Figure 2.1. HAZ and WHZ over age in years, all measurements in analytic sample

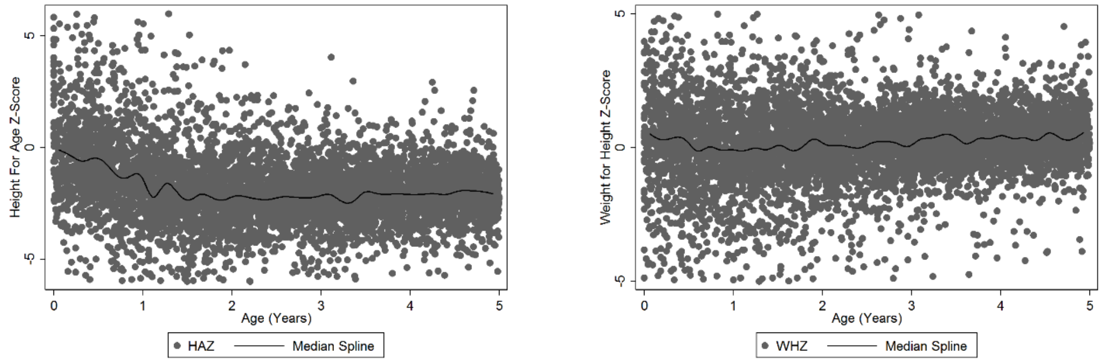

Figure 2.2. Prevalence of stunting and wasting over age in years, all measurements in analytic sample

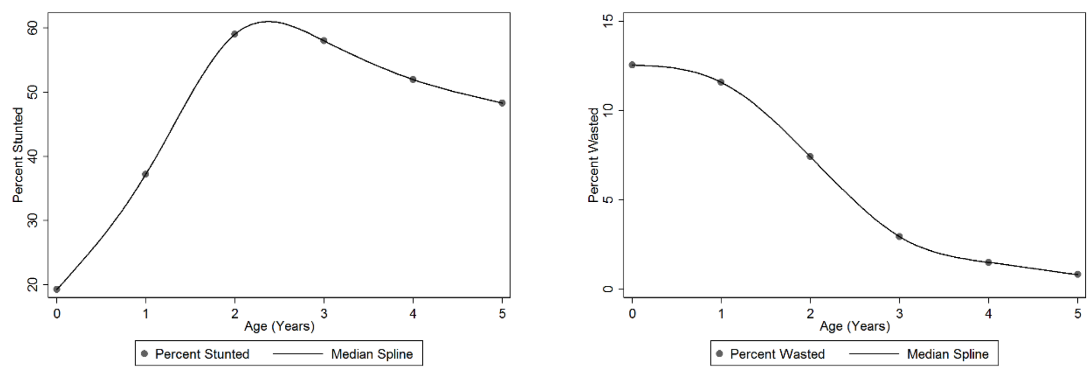

Table 2.1. Attrition from adding maternal measures to child anthropometric data

	Measurements by Age Group			Unique Children in each Age Group		
	0-2	2-5	Total	0-2	2-5	Total*
Original Sample: Nonmissing on Outcomes (from anthropometry)						
# Moms (n=1478)				1206	1256	2462
# Children (n=3301)	2696	4178	6874	2002	2519	4521
Analytic Sample (With Missing Maternal Body Fat (BF) %)						
# Moms (n=1280)				1069	1098	2167
# Children (n=2906)	2441	3759	6200	1798	2236	4034
Analytic Sample (Without Missing Maternal BF %)						
# Moms (n=1267)				1039	1049	2088
# Children (n=2862)	2364	3597	5961	1772	2175	3947

Table 2.2. HAZ, WHZ, and proportion of stunting and wasting among children aged 2-5, analytic sample with missing maternal body fat %

Age Group		HAZ	WHZ	Stunting	Wasting
0-2	Mean	-1.328	0.026	0.390	0.109
	SD	1.997	1.661	0.488	0.312
	# Measurements	2441	2441	2441	2441
2-5	Mean	-2.076	0.271	0.547	0.027
	SD	1.205	1.094	0.498	0.162
	# Measurements	3759	3759	3759	3759
Total	Mean	-1.781	0.174	0.485	0.059
	SD	1.607	1.351	0.500	0.236
	# Measurements	6200	6200	6200	6200

Table 2.3. Maternal and child characteristics, analytic sample, N=6,200

	0-2		2-5	
	mean	**SD**	**mean**	**SD**
Age (months)	12.42	6.91	41.94	10.32
Birth Order * Birth Interval	**n**	**%**	**n**	**%**
Order 1, no previous IBI	369	15.12%	596	15.86%
Order 2-4, IBI <2 years	331	13.56%	473	12.58%
Order 2-4, IBI 2+ years	576	23.60%	908	24.16%
Order 5+, IBI <2 years	286	11.72%	427	11.36%
Order 5+, IBI 2+ years	879	36.01%	1,355	36.05%
Female	1,221	50.02%	1,846	49.11%
Male	1,220	49.98%	1,913	50.89%
	mean	**SD**	**mean**	**SD**
Maternal BF%	24.38	7.01	25.17	6.97
Maternal Height (cm)	150.83	4.83	151.09	4.66
Distance to San Borja (km)	61.28	45.28	61.50	44.34
Maternal Highest Grade Attended	**n**	**%**	**n**	**%**
None	751	30.77%	1,258	33.47%
Some to 2	868	35.56%	1,372	36.50%
2 or More	822	33.67%	1,129	30.03%
Maternal Spanish Proficiency				
None	763	31.26%	1,174	31.23%
Some	1,242	50.88%	1,989	52.91%
Proficient or More	436	17.86%	596	15.86%
Region Type				
Forest	176	7.45%	253	6.92%
River	1,340	56.73%	2,098	57.42%
Road	846	35.82%	1,303	35.66%
Season of Measurement				
Dry	1,142	46.78%	1,862	49.53%
Wet	1,299	46.78%	1,897	50.47%
Period of Measurement				
2002-2007	854	34.99%	1,360	36.18%
2008-2012	1,587	65.01%	2,399	63.82%

Table 2.4. OLS Coefficients: HAZ 0-2, three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	β	SE	β	SE	β	SE
Age (months)	-0.103***	0.006	-0.103***	0.006	-0.103***	0.006
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.023	0.156	0.016	0.157	0.005	0.156
Order 2-4, IBI 2+ years	-0.036	0.132	-0.033	0.132	-0.041	0.131
Order 5+, IBI <2 years	-0.122	0.169	-0.134	0.170	-0.162	0.168
Order 5+, IBI 2+ years	0.013	0.129	0.010	0.129	-0.007	0.128
Male (Female)	-0.345***	0.081	-0.344***	0.081	-0.344***	0.081
Maternal BF%	0.004	0.006	0.004	0.006	0.004	0.006
Maternal Height (cm)	0.020*	0.009	0.020*	0.009	0.021*	0.009
Maternal Grade Category (None)						
Some to 2	0.168	0.112	0.162	0.113	0.151	0.113
2 or More	0.081	0.126	0.076	0.126	0.059	0.126
Maternal Spanish Category (None)						
Some	-0.028	0.104	-0.026	0.104	0.001	0.105
Proficient or More	0.365*	0.148	0.398**	0.145	0.479**	0.149
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	-0.115	0.125				
3 (mean 46.00 km)	-0.190	0.136				
4 (mean 91.19km)	-0.057	0.124				
5 (mean 149.51km)	-0.101	0.170				
Distance to San Borja (km)			-0.001	0.001	0.004	0.003
Distance^2					0.000	0.000
Wet Season (Dry Season)	-0.080	0.078	-0.084	0.076	-0.050	0.077
Time Period 2008-2012 (2002-2007)	-0.247**	0.090	-0.259**	0.087	-0.234**	0.088
Constant	-2.792*	1.413	-2.874*	1.372	-3.189*	1.388
AIC	9598		9593.95		9591.38	
Observations	2364		2364		2364	

Baseline categories included in parentheses

Table 2.5. OLS Coefficients: HAZ 2-5, three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	β	SE	β	SE	β	SE
Age (months)	0.004*	0.002	0.003	0.002	0.003*	0.002
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.067	0.098	0.061	0.098	0.070	0.099
Order 2-4, IBI 2+ years	-0.010	0.074	-0.021	0.074	-0.017	0.074
Order 5+, IBI <2 years	-0.028	0.100	-0.031	0.100	-0.024	0.101
Order 5+, IBI 2+ years	-0.003	0.077	-0.023	0.076	-0.017	0.077
Male (Female)	-0.034	0.051	-0.045	0.051	-0.046	0.051
Maternal BF%	0.003	0.004	0.003	0.004	0.003	0.004
Maternal Height (cm)	0.049***	0.005	0.051***	0.005	0.051***	0.005
Maternal Grade Category (None)						
Some to 2	-0.162*	0.068	-0.184**	0.069	-0.178*	0.069
2 or More	-0.151	0.078	-0.197*	0.077	-0.187*	0.078
Maternal Spanish Category (None)						
Some	-0.010	0.068	0.003	0.067	-0.012	0.068
Proficient or More	0.342***	0.090	0.409***	0.088	0.368***	0.090
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	-0.147	0.076				
3 (mean 46.00 km)	0.010	0.080				
4 (mean 91.19km)	-0.167*	0.075				
5 (mean 149.51km)	0.113	0.107				
Distance to San Borja (km)			0.001	0.001	-0.002	0.002
Distance^2					0.000	0.000
Wet Season (Dry Season)	0.012	0.040	0.033	0.040	0.015	0.040
Time Period 2008-2012 (2002-2007)	0.042	0.053	0.086	0.051	0.073	0.051
Constant	-9.528***	0.823	-10.01***	0.815	-9.887***	0.818
AIC	11302.67		11318.45		11316.14	
Observations	3597		3597		3597	

Baseline categories included in parentheses

Table 2.6. Odds of Stunting 0-2: three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	OR	SE	OR	SE	OR	SE
Age (months)	1.104***	0.007	1.105***	0.007	1.106***	0.007
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	1.179	0.199	1.185	0.201	1.206	0.204
Order 2-4, IBI 2+ years	1.137	0.174	1.134	0.173	1.151	0.176
Order 5+, IBI <2 years	1.183	0.228	1.194	0.230	1.250	0.241
Order 5+, IBI 2+ years	1.025	0.153	1.024	0.152	1.052	0.157
Male (Female)	1.481***	0.140	1.479***	0.140	1.480***	0.140
Maternal BF%	0.995	0.007	0.995	0.007	0.994	0.007
Maternal Height (cm)	0.974*	0.011	0.975*	0.011	0.973*	0.011
Maternal Grade Category (None)						
Some to 2	0.937	0.119	0.944	0.120	0.961	0.122
2 or More	0.925	0.136	0.921	0.134	0.948	0.138
Maternal Spanish Category (None)						
Some	0.927	0.111	0.927	0.110	0.886	0.107
Proficient or More	0.667*	0.116	0.659*	0.110	0.575**	0.100
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	1.060	0.152				
3 (mean 46.00 km)	1.178	0.182				
4 (mean 91.19km)	1.065	0.153				
5 (mean 149.51km)	1.304	0.242				
Distance to San Borja (km)			1.002	0.001	0.994	0.003
Distance^2					1.000**	0.000
Wet Season (Dry Season)	1.094	0.103	1.110	0.101	1.052	0.098
Time Period 2008-2012 (2002-2007)	1.163	0.119	1.191	0.119	1.142	0.116
AIC	2913.17		2906.15		2899.7	
Observations	2364		2364		2364	

Baseline categories included in parentheses

Table 2.7. Odds of Stunting 2-5: three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	OR	SE	OR	SE	OR	SE
Age (months)	0.986***	0.003	0.987***	0.003	0.986***	0.003
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.845	0.139	0.848	0.139	0.846	0.139
Order 2-4, IBI 2+ years	1.155	0.160	1.171	0.162	1.170	0.163
Order 5+, IBI <2 years	0.963	0.168	0.966	0.168	0.965	0.168
Order 5+, IBI 2+ years	1.035	0.140	1.058	0.142	1.057	0.142
Male (Female)	1.019	0.089	1.029	0.090	1.030	0.090
Maternal BF%	0.995	0.006	0.995	0.006	0.995	0.006
Maternal Height (cm)	0.916***	0.010	0.915***	0.009	0.915***	0.009
Maternal Grade Category (None)						
Some to 2	1.160	0.137	1.188	0.140	1.187	0.140
2 or More	1.159	0.161	1.218	0.167	1.216	0.167
Maternal Spanish Category (None)						
Some	0.954	0.108	0.943	0.106	0.946	0.108
Proficient or More	0.518***	0.084	0.494***	0.077	0.498***	0.081
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	1.042	0.138				
3 (mean 46.00 km)	0.912	0.131				
4 (mean 91.19km)	1.154	0.153				
5 (mean 149.51km)	0.818	0.133				
Distance to San Borja (km)			0.999	0.001	1.000	0.003
Distance^2					1.000	0.000
Wet Season (Dry Season)	1.030	0.075	1.003	0.072	1.006	0.074
Time Period 2008-2012 (2002-2007)	0.973	0.088	0.919	0.081	0.922	0.082
AIC	4772.04		4774.61		4776.56	
Observations	3597		3597		3597	

Baseline categories included in parentheses

Table 2.8. OLS Coefficients: WHZ 0-2, three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	β	SE	β	SE	β	SE
Age (months)	-0.004	0.005	-0.005	0.005	-0.004	0.005
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.044	0.129	0.022	0.129	0.040	0.129
Order 2-4, IBI 2+ years	0.094	0.114	0.080	0.114	0.095	0.113
Order 5+, IBI <2 years	-0.209	0.142	-0.241	0.141	-0.193	0.141
Order 5+, IBI 2+ years	-0.012	0.112	-0.039	0.112	-0.009	0.112
Male (Female)	-0.082	0.070	-0.082	0.070	-0.083	0.070
Maternal BF%	0.015**	0.005	0.015**	0.005	0.014**	0.005
Maternal Height (cm)	0.005	0.008	0.009	0.008	0.007	0.008
Maternal Grade Category (None)						
Some to 2	-0.148	0.094	-0.164	0.094	-0.145	0.094
2 or More	-0.041	0.111	-0.077	0.110	-0.046	0.110
Maternal Spanish Category (None)						
Some	0.057	0.090	0.090	0.091	0.042	0.091
Proficient or More	0.075	0.128	0.203	0.122	0.061	0.130
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	-0.174	0.107				
3 (mean 46.00 km)	-0.266*	0.114				
4 (mean 91.19km)	-0.531***	0.106				
5 (mean 149.51km)	-0.314*	0.140				
Distance to San Borja (km)			-0.002**	0.001	-0.011***	0.002
Distance^2					0.00005***	0.000
Wet Season (Dry Season)	-0.147*	0.071	-0.086	0.068	-0.144*	0.069
Time Period 2008-2012 (2002-2007)	0.107	0.069	0.153*	0.068	0.108	0.069
Constant	-0.753	1.247	-1.425	1.232	-0.872	1.246
AIC	9098.99		9112.55		9097.24	
Observations	2364		2364		2364	

Baseline categories included in parentheses

Table 2.9. OLS Coefficients: WHZ 2-5, three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	β	SE	β	SE	β	SE
Age (months)	0.012***	0.002	0.012***	0.002	0.012***	0.002
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.021	0.074	0.013	0.075	0.024	0.075
Order 2-4, IBI 2+ years	-0.041	0.064	-0.052	0.064	-0.048	0.064
Order 5+, IBI <2 years	-0.015	0.088	-0.019	0.088	-0.011	0.088
Order 5+, IBI 2+ years	0.073	0.063	0.054	0.062	0.062	0.063
Male (Female)	0.026	0.041	0.020	0.041	0.018	0.041
Maternal BF%	0.022***	0.003	0.022***	0.003	0.021***	0.003
Maternal Height (cm)	-0.007	0.005	-0.006	0.005	-0.006	0.005
Maternal Grade Category (None)						
Some to 2	0.119*	0.057	0.094	0.056	0.102	0.056
2 or More	0.178**	0.063	0.138*	0.062	0.151*	0.062
Maternal Spanish Category (None)						
Some	0.035	0.054	0.055	0.053	0.036	0.054
Proficient or More	0.227**	0.077	0.291***	0.074	0.241**	0.076
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	-0.083	0.062				
3 (mean 46.00 km)	-0.043	0.070				
4 (mean 91.19km)	-0.264***	0.062				
5 (mean 149.51km)	-0.074	0.078				
Distance to San Borja (km)			-0.001**	0.000	-0.004***	0.001
Distance^2					0.00001**	0.000
Wet Season (Dry Season)	-0.086*	0.037	-0.058	0.035	-0.079*	0.036
Time Period 2008-2012 (2002-2007)	-0.037	0.041	0.005	0.040	-0.011	0.040
Constant	0.328	0.735	0.046	0.721	0.200	0.723
AIC	10658.02		10671.78		10666.07	
Observations	3597		3597		3597	

Baseline categories included in parentheses

Table 2.10. Odds of Wasting: 0-2, three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Distance^2	
	OR	se	OR	se	OR	se
Age (months)	0.975**	0.009	0.976**	0.009	0.975**	0.009
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.892	0.238	0.925	0.247	0.902	0.240
Order 2-4, IBI 2+ years	0.941	0.213	0.962	0.216	0.943	0.213
Order 5+, IBI <2 years	1.541	0.395	1.611	0.410	1.531	0.391
Order 5+, IBI 2+ years	1.247	0.264	1.297	0.273	1.251	0.265
Male (Female)	1.216	0.163	1.215	0.163	1.220	0.163
Maternal BF%	0.980*	0.010	0.981	0.010	0.982	0.010
Maternal Height (cm)	0.999	0.017	0.994	0.017	0.995	0.017
Maternal Grade Category (None)						
Some to 2	1.258	0.214	1.285	0.220	1.260	0.215
2 or More	1.068	0.221	1.115	0.232	1.079	0.224
Maternal Spanish Category (None)						
Some	0.974	0.157	0.936	0.150	0.977	0.157
Proficient or More	0.926	0.219	0.766	0.174	0.886	0.217
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	1.515	0.357				
3 (mean 46.00 km)	1.588	0.391				
4 (mean 91.19km)	2.048**	0.466				
5 (mean 149.51km)	1.820*	0.469				
Distance to San Borja (km)			1.003*	0.001	1.012*	0.005
Distance^2					1.000	0.000
Wet Season (Dry Season)	1.068	0.151	1.013	0.135	1.077	0.147
Time Period 2008-2012 (2002-2007)	1.351*	0.194	1.288	0.181	1.350*	0.192
AIC	1641.93		1643.71		1641.36	
Observations	2364		2364		2364	

Baseline categories included in parentheses

Table 2.11. Odds of Wasting 2-5, three forms of distance to San Borja (km)

Measure of Distance:	Quantiles		Linear		Squared	
	OR	SE	OR	SE	OR	SE
Age (months)	0.935***	0.010	0.936***	0.010	0.935***	0.010
Birth Order * Birth Interval (First Birth)						
Order 2-4, IBI <2 years	0.759	0.354	0.759	0.354	0.749	0.348
Order 2-4, IBI 2+ years	1.384	0.480	1.395	0.486	1.391	0.484
Order 5+, IBI <2 years	1.907	0.768	1.934	0.777	1.888	0.760
Order 5+, IBI 2+ years	0.978	0.340	0.986	0.342	0.965	0.334
Male (Female)	1.193	0.265	1.198	0.264	1.212	0.267
Maternal BF%	0.969	0.018	0.968	0.017	0.969	0.017
Maternal Height (cm)	1.003	0.029	1.003	0.029	1.004	0.029
Maternal Grade Category (None)						
Some to 2	0.711	0.208	0.743	0.220	0.722	0.213
2 or More	0.657	0.214	0.699	0.226	0.663	0.215
Maternal Spanish Category (None)						
Some	1.030	0.276	0.970	0.259	1.043	0.281
Proficient or More	0.819	0.361	0.728	0.315	0.894	0.397
Distance Quintile (1, mean 17.73km)						
2 (mean 29.90km)	0.747	0.289				
3 (mean 46.00 km)	1.150	0.457				
4 (mean 91.19km)	1.625	0.534				
5 (mean 149.51km)	1.191	0.488				
Distance to San Borja (km)			1.003	0.002	1.015	0.008
Distance ^2					1.000	0.000
Wet Season (Dry Season)	0.717	0.159	0.648*	0.140	0.699	0.155
Time Period 2008-2012 (2002-2007)	1.464	0.317	1.356	0.312	1.434	0.321
AIC	856.16		854.07		853.33	
Observations	3597		3597		3597	

Baseline categories included in parentheses

CHAPTER 3: GRANDPARENTAL CORESIDENCE AND CHILD NUTRITIONAL STATUS: EVIDENCE FROM THE YOUNG LIVES STUDY

ABSTRACT

Context: Declining fertility and increased longevity have shifted the age distribution of populations upward in high-income countries. This shift is also underway in low- and middle-income countries where social safety nets are less comprehensive, often resulting in multigenerational living arrangements. Multigenerational households are not new; many families rely on grandparental paid and unpaid work. However, increased longevity results in a longer period of grandparental coresidence with family members in earlier life course stages. This study uses a child-centered dataset to examine the relationship between grandparental coresidence and nutritional status for a cohort of children in Ethiopia, India, Peru, and Vietnam at approximate ages 1, 5, and 8 years of age. Grandparental age (over or under 65 years) is used to explore whether aging grandparents represent a net additional competition for limited resources within the household or supplement household resources provided by others.

Methods: Nutritional indicators including height-for-age (HAZ), weight-for-age (WAZ), and body mass index-for-age (BMIZ) z-scores are predicted using ordinary least squares (OLS) regression and child and household characteristics including grandparental coresidence and age. Exploratory analyses include country-level fixed effects and interactions to examine the association between grandparental coresidence and child anthropometric status at ages 1, 5, and 8 years of age. Final models stratified by country and controlling for child age include indicators for grandparental age (< 65, ≥65) and wealth as a moderator.

Results: Household wealth, caregiver education, and number of coresident children under the age of 5 are among the most consistent predictors of child nutritional status across the four countries in this study. Analyses suggest a positive association between coresidence and nutritional status for at least one coresident grandmother <65 and grandmothers of two different age groups residing in the same household in Peru and Vietnam. This relationship persists only in Peru after including wealth as a moderator. A non-statistically significant, negative main association with child nutritional status is mitigated by wealth among households with coresident grandparents in India and Vietnam. Including household wealth in the analyses suggests a negative, nonsignificant association between coresidence and child nutritional status is moderated by a positive, interaction with household wealth across countries and sex of grandparent.

Conclusion: Grandparents are not uniformly associated with childhood nutritional status by sex, age, or wealth across countries. There is evidence of a positive association between coresident grandmothers and nutritional status in Peru. Grandparental coresidence is negatively associated with nutritional status in several countries, though households with higher wealth indices appear to buffer children against any negative nutritional outcomes stemming from the burden of coresident elderly grandparents. Grandparental coresidence may affect other aspects of child development, but children in multigenerational households in the low- and middle-income countries in this sample have similar nutritional status to peers with non-coresident grandparents. Additional research measuring motivations for multigenerational living arrangements and how these impact child development is of especial interest as longevity increases in low and middle-income contexts.

INTRODUCTION

Population aging through increased longevity and declining fertility has far-reaching demographic and economic implications across countries, including shifting burdens of disability, work, household composition, and care for older adults (Anderson and Hussey 2000, Naidoo, Abdullah et al. 2010). Though individuals are living longer without severe disability, healthy life expectancy is likely to vary across economic contexts (Christensen, Doblhammer et al. 2009, Naidoo, Abdullah et al. 2010). Studies examining household composition and grandparental coresidence vary in focus; in low-fertility, aging countries the "sandwich generation" comprised of individuals caring for children and aging parents simultaneously are a central concern (Spillman and Pezzin 2000, Grundy and Henretta 2006). In high-fertility, high HIV settings, orphanhood and grandparents-turned-caretakers are the focus of intergenerational studies, concentrating on the welfare of caregivers and orphaned children (Joslin and Harrison 1998, Linsk and Mason 2004). The literature on the influence of grandparents and kin networks on child wellbeing ranges in scope of outcomes from mortality to birthweight and nutritional status (Sear, Mace et al. 2000, Beise and Voland 2002, Duflo 2003, Jingxiong, Rosenqvist et al. 2007, Cunningham, Elo et al. 2010). A common thread among all of these studies is both the cost and contribution of coresident grandparents, where "overlapping life lines" and the confluence of life course stages within the same household causes a complex exchange of resources.

In high-income countries such as the US and Italy with large elderly cohorts and large numbers of adult children who have not yet left the home, it is predicted that households will become increasingly multigenerational and the "sandwich generation" that cares for both for frail elderly parents and supports adult children will experience a double burden of paid and unpaid work (Spillman and Pezzin 2000, Grundy and Henretta 2006). In the US, caring for parents is increasingly becoming a "normative part of the life course" (Silverstein, Gans et al. 2006). Evidence thus far suggests complexity in direction of flows in kind and care, with contributions via income and unpaid work in both directions and across multiple generations rather than a unidirectional upward flow to the oldest generation (Grundy and Henretta 2006). Evidence of this phenomenon in low- and middle-income countries (LMICs) is lacking, though there is some qualitative evidence of the "sandwich generation" emerging in China, where it is proposed that the one-child policy has precipitated population aging and complicated care for the elderly with increased rural to urban migration of the second generation (Zhang and Goza 2006). Increased morbidity including depression and depressive symptoms have been documented in the elderly when care is provided by non-preferred caregivers; in China, middle-aged daughters and specifically daughters-in-law are preferred among the elderly (Cong and Silverstein 2008). Distinct preferences among the elderly for living and care arrangements together with their potential contributions to the household present a nexus of household conditions that require further exploration; understanding whether and how grandparents contribute to the household and subsequent generations is a critical component to understanding the implications of population aging.

While care of the elderly presents a question to be addressed at household and societal levels, grandparents also return care and resources over the life course of their children and grandchildren. The anthropological literature suggests that contributions from grandparents facilitated by increased post-reproductive lifespan increases the odds of survival for grandchildren (Sear, Mace et al. 2000, Lahdenperä, Lummaa et al. 2004, Gibson and Mace 2005). Grandmothers and their role in food sharing within the household are proposed to have played a key role in the evolution of post-menopausal lifespan; longer-lived women were hypothesized to have increased the odds of child survival, thereby increasing their own fitness and likelihood of genetic representation in future generations (Hawkes, O'Connell et al. 1998). There is mixed empirical evidence of grandparental presence predicting improved child survival, largely varying by gender of grandparent (Sear, Mace et al. 2000, Duflo 2003). A review of 45 studies of historical and contemporary high-fertility populations find a positive association between grandmother presence and child survival, however, the key finding among many of these studies was that the presence of at least one additional adult relative was associated with improved survival of children and that the helper's specific relationship to the child (father, sibling, grandparent) varies by ecological context. This was primarily measured by grandparental survival status rather than coresidence (Sear and Mace 2008). Comparative research assessing grandparental coresidence will go beyond including survival as a proxy for grandparental contact. In contexts where lifespan is increasing and coresidence of multiple generations is a common pattern, grandparents can possibly contribute in this "helper at the nest" capacity for a significant portion of a child's life.

The following analyses use data from the Young Lives cohort study sites in Ethiopia, Andhra Pradesh and Telangana (India), Vietnam, and Peru to consider whether grandparental coresidence is associated with child nutritional status across several low- and middle-income countries (Figure 3.1). Child height-for-age, weight-for-age, and BMI-for-age z-scores measured in the younger cohort at approximate ages 1, 5, and 8 years are included as measures of long- and short-term nutritional status (Figure 3.2). No direct measures of care are measured for non-primary caregivers for each round, and the majority of caregivers are mothers as opposed to grandparents (98% mothers, all countries at round 1). In place of direct measures of grandparental caregiving, grandparental coresidence and type (grandmothers vs. grandfathers) are included in the household roster. Nutritional status is predicted as a function of grandparent type (grandmothers vs. grandfathers) and coresidence in addition to other household factors including parental residence, caregiver education, and household wealth. To better understand how aging may contribute to this relationship, grandparental age (over or under 65 years) is added in addition to grandparental coresident status. The association between grandparental coresidence and age may be moderated by household wealth, and wealthier households may be better able to accommodate additional household members regardless of their ability to contribute to the household. This study seeks to describe the relationship between grandparental coresidence and child nutritional status across countries, and further unpack whether this relationship varies by grandparental age and household wealth.

BACKGROUND

Intergenerational Transfers and the Life Course Perspective

Intergenerational transfers are the focus of study across several disciplines, including anthropology, economics, and sociology. The two main forms of intergenerational support comprise emotional and instrumental support. Emotional support refers to non-material support relationships provide and can affect feelings of self-worth and family solidarity (Bengtson 2001, Reblin and Uchino 2008). Instrumental support, which can take the form of assistance with activities of daily living, help with childcare or housekeeping, or transfer of money or food, is a more commonly studied form of social support studied from an intergenerational perspective (Couch, Daly et al. 1999, Caldwell 2005, Cong and Silverstein 2008, Fingerman, Kim et al. 2015, Furstenberg, Hartnett et al. 2015). Within transfers, directionality either upward (from adult child to parents) or downward (from grandparent to grandchild or parent to adult child) are considered, however, the direction of transfers within a family is often need-based and varies temporally (Bengtson 2001). In addition to direction, intergenerational studies of wealth flows focus on public (pooled resources subsequently reallocated) or private transfers (transfers between individuals). Receipt of transfers is necessarily complicated; individuals may receive some combination of public and private transfers and in turn reallocate these resources within the family and across generations (Duflo 2003). For example, expansion of a social pension program in South Africa in the early 1990s offered an opportunity to see how children under five living with a pension recipient fared, finding that on average granddaughters benefitted when pensioner grandmothers reside in the same household (Duflo 2003).

Caldwell's 'wealth flows theory' of the 1970s was rooted in the high-fertility and fertility-decline context of the time, and proposed that more children reflected an economically rational choice in 'traditional' societies where costs of each additional child were low and children tend to produce most of what they consume. Longitudinal studies of hunter-gatherers and hunter-horticulturalists did not bear this out, however, but the concept of offspring as old-age insurance did not altogether disappear. Additionally, transfers become increasingly complex as both demographic and economic change are experienced within the course of one generation. One such example occurred in households in Ghana where work and schooling expectations vary between siblings, so that children of later birth orders face different work requirements than their older siblings and because of this different levels of investment are deemed necessary depending on birth order of the child (i.e., early birth orders may be expected to work to help put later birth orders through school) (Caldwell 1965). In a 2005 paper, Caldwell revisits many of the theories regarding transfers popular in this period and his initial theory (Caldwell 2005). Children's work and contributions to the household were assessed when in the 1990s and 2000s Kaplan and Lee analyzed wealth flows in a series of subsistence or 'traditional' populations and characterized patterns of production and consumption; children did not produce more than they consumed until considerably later than Caldwell predicted (≈20 years)(Caldwell 2005). However, downward transfers to children early in life may pay off over the life course as parents require care in old age. In the absence of institutionalized insurance, children represent an investment for old age in absence of alternative assets (Lee 2003). In economic contexts where access to pensions, credit, and insurance are sporadic (particularly farming and subsistence contexts), high fertility and dependence on adult children in old age may remain a key strategy (Caldwell 2005). In this case, fertility would remain high because a larger number of children surviving into adulthood ensures better coverage of old age care. As individuals age in 'traditional' societies, intergenerational household arrangements protect the elderly while the older generation can help by caring for children or working (Furstenberg, Hartnett et al. 2015). Though the oldest generation may not 'repay' the household in terms of consumption, child care or supplemental work represents continued downward transfer or exchange for support in old age.

Recent perspectives and revisions on multigenerational households and intergenerational transfers acknowledge rapidly aging societies that together with pressure to reduce the cost of supporting those in older ages might result in increased burden on family members (Furstenberg, Hartnett et al. 2015). The pattern of transfers in advanced economies is characterized as downward and prolonged, where older individuals are fairly well off due to social security and pensions, though this pattern varies by resources and ethnicity in high-income contexts. In light of rapid aging and a potentially overwhelmed social safety net, it is possible that while some families are able to accommodate the cost of additional household members, existing economic inequalities are amplified into older age (Furstenberg, Hartnett et al. 2015). The potential perpetuation of inequalities and the prospect of a 'sandwiched' caregiver generation are two potential drawbacks of a family-only model of support for the aging in high-income contexts.

Similar issues have been documented in low- and middle-income countries, and in-depth studies of population aging in these countries are increasingly available (Kowal, Chatterji et al. 2012, Zhao, Hu et al. 2012). Many aspects of aging in low- and middle-income countries necessitate a shift in focus to include aging and the care of the elderly as a research priority. More than 59% of the worlds' population aged 65 and older live in developing countries (Shrestha 2000). This proportion is only projected to increase, and according to UN estimates should reach 67% by 2020 (Shrestha 2000). India alone will be home to more than 93 million individuals aged sixty-five or older by 2020 (7.3 percent of its population compared to 5 percent in 2000) (Shrestha 2000). With a larger proportion of individuals surviving to older ages, an increased burden of disability, and limited expansion of services for the elderly, the question of whether and how coresidence affects other household members is a key aspect of understanding the consequences of population aging at the household level. Alternately, increased longevity and longer periods of grandparental coresidence may result in more years of contribution from the oldest generation to other members of the household, both in paid and unpaid work. This contribution may vary significantly by age and disability status of the grandparent, and lower household resources and existing inequalities may exacerbate the consequences of an additional household member.

Living Arrangements among the elderly in Ethiopia, India, Peru, and Vietnam

Social safety nets including social security, private pensions, and public health systems assist aging populations and supplement family resources allocated to the elderly in high-income countries (Bongaarts and Zimmer 2002). However, this extensive social safety net is often not available in many low-income contexts (Bongaarts and Zimmer 2002). A study of Demographic and Health Survey (DHS) data from 43 low- and middle-income countries ranging in date from 1990 to 1998, including 22 African countries, 11 Asian countries, and 9 Latin American countries described the living arrangements of adults aged 65 years and older, finding that this age group had the largest proportion of the population living alone (where older individuals are identified as household heads and live alone) (Bongaarts and Zimmer 2002). Across all countries in the sample, 11.1% of women aged 65+ live alone. In Africa, 12.3% of women 65+ live alone, 10.2% in Asia, and 8.9% in Latin America (Bongaarts and Zimmer 2002). These proportions still seem small relative to high-income countries. In the US, 28% of non-institutionalized older persons live alone, and 46% of women aged 75+ live alone (AoA 2014). In the 43 low- and middle-income countries included, co-residence with adult children was common and varied by region and sex. Coresidence with adult children was most common in Asia (68.3% of females and 66.3% for males) and least common in Africa (49.7% for females and 45.9% for males) (Bongaarts and Zimmer 2002). Coresidence was more common with sons than with daughters in Asia and Africa, but this was not the case in Latin America, where individuals aged 65+ were more likely to live with daughters. Though this particular study did not identify the relationship between those aged 65+ with children in the household, a large proportion of the sample were living with “any young child” (aged 0-17 years). This percentage ranged from 69.8% of elderly females and 70.3% of elderly males in Africa to 55.7% of elderly females and 55.1% of elderly males in Latin America (Bongaarts and Zimmer 2002). Though adults aged 65+ and their living arrangements (single, with spouse, with adult children, with children 0-17 years) were the focus of this study, coresidence of the elderly with adult children and much younger children is a common living arrangement in many low and middle-income countries.

Living arrangements vary within this study as well. Though the unit of analysis is the Young Lives Study focal child, coresidence of children with grandparents is assessed using the household roster. Prior studies of living arrangements in the Young Lives study site countries including Ethiopia, India, Peru, and Vietnam bear this out. Studies in rural Ethiopia among the Arsi Oromo pastoralists suggest that matrilocal post marital residence is associated with improved child survival, though children in these households were smaller on average (Gibson and Mace 2005). Even mothers who did not coreside with their daughters contributed to their daughters’ households by performing domestic tasks that relieve daughters of some housework (Gibson and Mace 2005). Among an urban adolescent sample of 1,934 children approximately 15 years old, those currently living in households with high old-age dependency ratios were on average 1.3kg lighter and had a BMI 0.59 units lower than their peers (Hadley, Belachew et al. 2011). It should be noted, however, that all siblings under 18 in addition to grandparents were included in this ratio and no controls on grandparental age or disability status were included. Though there is extensive literature on child nutrition in Ethiopia, there are relatively few studies linking grandparents to grandchildren, and even fewer examining the potential impact of grandparental coresidence and age on nutritional status.

Studies of living arrangements of the aging population in India suggest benefits to grandparents for living in multigenerational households. Using data from the 2004-2005 India Human Development Survey to predict short-term illness, Samanta and colleagues find that individuals aged 65+ fare best in terms of short-term illness when living with grandchildren, and that “health advantage diminishes when older adults live only with a spouse and adult children, and further diminishes when they live only with their spouse" (Samanta, Chen et al. 2014). Approximately 30% of this sample resides in multigenerational households with both adult children and young grandchildren, and another 25% reside in households with adult children only (Samanta, Chen et al. 2014). Residential patterns are primarily patriarchal, where the older generation resides with sons (Lamb 1999, Samanta, Chen et al. 2014). While there is some evidence of a benefit for the third generation, few studies have focused on the health and wellbeing of the youngest generation.

Living arrangements for the aging in Peru rely on a family-support model (Cruz-Saco 2010). Peru has undergone rapid demographic change; estimated fertility is 2.45 children per woman and outmigration of working aged persons has precipitated population aging (Cruz-Saco 2010, UNWPP 2015). Individuals aged 65+ years will comprise 7% of the population by 2015; this has increased from 3% in 1960 and is projected to reach 17.4% of the population by 2050 (UNWPP 2015). Though there is documentation of payments from remittances, public payments, and private pensions, these are not sufficient to support the growing income needs of the aging population (Cruz-Saco 2010). Extended families are a primary support network and "small children and older persons who need special care and income support are often assisted by family members" (Cruz-Saco 2010). Relatively few studies examine the impact grandparental coresidence and transfer patterns have on children in Peru.

The proportion of individuals over age 60 living in Vietnam is projected to increase from 7.5 percent of the population in 2005 to 26 percent of the population in 2050 (Knodel, Friedman et al. 2000, Giang and Pfau 2007). The UN medium variant estimates project fertility to have reached 2.1 by 2014 (UNWPP 2015). Household arrangements for the elderly in Vietnam are characterized by strong familial relations despite rapid social and economic changes between 1993 to 2004 (Giang and Pfau 2007). A high proportion of elderly coreside with their adult children, particularly married sons (Knodel, Friedman et al. 2000). Nearly 60% of the elderly in a 1997 regional sample of Ho Chi Minh City were documented as co-residing with married children, and 29.9% lived with at least one minor-aged relative in this sample. Though coresident children and grandchildren did not form the focus of this study, family support and coresidence is an important part of support for the elderly in this context (Knodel, Friedman et al. 2000). Ethiopia, India, Peru, and Vietnam represent four low- and middle-income countries with increasing proportions of the population entering older ages where multigenerational households and family support form a key source of security in old age in the absence of comprehensive social safety nets.

DATA AND METHODS

Data

The following analyses use cohort data from the Young Lives study which began data collection in 2002 in Ethiopia, India (Andhra Pradesh and Telangana), Vietnam, and Peru (Figure 3.1). The central aim of the Young Lives study is to collect data on the impact of childhood poverty in a diverse set of political, geographical, and cultural contexts (Barnett, Ariana et al. 2013). Data collection began with two cohorts, a "younger cohort" born from 2001-2002 recruited between 6 and 18 months (n≈ 2000 per site) and an "older cohort" born from 1994-1995 (n≈1000 per site) (Figure 3.2, Table 3.1). Household and community modules are collected at each round of the survey, with special site-specific surveys implemented to study impacts of local programs such as those promoting child schooling or cash transfers (Barnett, Ariana et al. 2013).

The Young Lives data have been used to describe overall growth patterns in these samples (Lundeen, Behrman et al. 2014) and examine growth as a correlate with cognitive outcomes both cross-sectionally and longitudinally (Fernald, Kariger et al. 2012, Crookston, Schott et al. 2013, Fink and Rockers 2014). Social network size and composition has also been considered as a predictor of child nutritional status in Andhra Pradesh and Telangana, though literacy of social networks formed the main focus and grandparental contributions were not explicitly examined (Moestue, Huttly et al. 2007). No research to date has used household rosters and grandparental coresidence to examine child nutritional status using these data, and few studies examine this association across low- and middle-income countries.

Child anthropometrics were collected at each round and World Health Organization (WHO) anthropometric z-scores were calculated for each of these measurements, including weight-for-age, height-for-age, and body mass index-for-age z-scores (Table 3.2) (Borghi, De Onis et al. 2006). The WHO Multicentre Growth Reference Study includes optimal growth trajectories for a subset of children in Brazil, Ghana, India, Norway, Oman, and the USA and provide a single international growth reference (Borghi, De Onis et al. 2006). Anthropometric z-scores represent the number of standard deviations a child's measurement is from the reference median value; a height-for-age z-score (HAZ) of -2 denotes a child's height is 2 standard deviations below the reference median of height for a given age. Each anthropometric indicator denotes different aspects of malnutrition; declining height-for-age often begins during the weaning period and indicates chronic undernutrition and infection (WHO and UNICEF 2009). This disadvantage accumulates over time. Weight-for-age and body mass index-for-age z-scores reflect more acute malnutrition, where children may lose and regain weight over shorter periods of time (WHO and UNICEF 2009). Rounds 1-3 are included in the current study, capturing measurements at approximate ages 1, 5 and 8 years of age; all anthropometrics included here should predate major pubertal growth spurts.

The following analyses use the household roster to determine whether grandparents co-reside in the focal child's household in any given round of data collection. Sex of each member of the household is recorded on the roster and is used to determine grandmothers from grandfathers. Age of each household member is also included in the roster, and this combined with the relationship to the focal child is used to construct a series of variables indicating whether a child coresides with no grandmothers, at least one grandmother under age 65, at least one grandmother over age 65, or two grandmothers of two different age groups. This coresidence-age classification is also made for grandfathers. The household roster was also used to generate a count of the number of siblings currently living in the household aged 5 years or younger at each round. Coresident siblings under age 5 are included in all analyses to control for possible resource competition from other young children in the household. Household wealth, caregiver education, and parental status are included as controls. The wealth index ranges from 0-1 and has been rescaled from 0-100. The household wealth index is made up of three equally weighted domains measured at each round and includes housing quality, durable goods, and quality of services to the household (e.g. electricity, water) and has been calculated by the Young Lives study (Dornan 2016). Household wealth indices and caregiver education are included to measure socioeconomic status of the household. Caregiver education, measured as highest grade completed (continuous) is included as a control in addition to parental living arrangements. Across countries, the most common living arrangement is for both parents to reside in the household, ranging from 82% in Ethiopia to 98% in India in round 1.

Methods and Analytic Strategy

Ordinary least squares (OLS) regressions stratified by round including country interactions were fit to explore the interaction between each outcome (WAZ, HAZ, BMIZ) and grandparental coresidence by country. Child ethnicity and caste were omitted; to include them in a model with country-level fixed effects would require some ranking of each ethnicity within country from most to least advantaged to create one consistent variable across country contexts. Relative disadvantage by race and caste within country contexts would be difficult to compare across social and economic contexts. Given the four descriptively different coresidence patterns by country, it is expected that grandparental roles may differ across sites. Economic and cultural differences between countries are expected to moderate the relationship between grandparental coresidence and child nutritional status. In the country-interaction models, a significant coefficient on any of the grandparental interactions would indicate some moderation of the association between grandparental coresidence and childhood nutritional status. These exploratory analyses motivated stratification by country in subsequent analyses (country interactions included in Appendix, Tables AB.3.1-AB.3.3).

To describe the association between grandparental coresidence and childhood nutritional status by country, OLS regressions including an indicator for grandparental coresidence by grandparent sex (e.g. grandmother coresides, 0/1) were estimated controlling for round of data collection where rounds 1, 2, and 3 correspond to approximate child ages 1, 5, and 8 years. To further understand whether this association varies by grandparental age, coresidence and age categories were combined in a single indicator of whether grandparents of different age categories reside in the same household as the focal child. Due to both the overarching question of how wealthier households fare with coresident older family members and descriptive differences in households with and without coresident grandparents, a final set of models includes an interaction between the combined grandparental coresidence-age variable and household wealth index.

RESULTS

Mean WAZ, HAZ, and BMIZ calculated by round indicate that on average, children in all four countries are shorter and lighter than the WHO standard (Table 3.2). Children in India have the lowest weight-for-age z-scores across all rounds, and children in Ethiopia have the lowest height-for-age z-scores (India round 1 WAZ = -1.55, Ethiopia round 1 HAZ = -1.54, Table 3.2). The only z-score consistently above zero is BMI in Peru, where after taking height into account children average at least 0.50 standard deviations above the standard median across all three rounds (BMIZ = 0.52 on average at age 8, Table 3.2).

Tables 3.3-3.6 provide sample characteristics for each of the study sites. Grandparental coresidence is least frequent in Ethiopia, where about 14% of children live with a grandparent of any sex (Table 3.3). Grandparental coresidence is most frequent in India; 53.06% live with any grandparent, 48.18% of the sample live with at least one grandmother (Table 3.4). Across all four countries, coresidence with at least one grandfather is less common than coresidence with grandmothers (Tables 3.3-3.6 and Appendix, Figure A.3.1).

Grandparental coresidence (at least one grandmother or at least one grandfather coresiding) is not significantly associated with child nutritional status after including round, child age and sex, siblings under 5, household wealth, parent configuration, and caregiver education as controls (Tables 3.7 and 3.8). With the exception of Ethiopia, coresidence with at least one grandmother is associated with higher HAZ, WAZ, and BMIZ, though this association is not statistically significant. Results are more heterogeneous with grandfathers, in some instances they are associated with higher WAZ and BMIZ but lower HAZ (Peru) or the exact opposite (India) (Tables 3.7 and 3.8). However, these results are not statistically significant and may mask heterogeneity of the association by age.

After adding grandparents categorized by age (<65, ≥65 years) to the model, grandparental coresidence is not strongly associated with child nutritional status in Ethiopia or India (Table 3.9). Coresidence of at least one grandmother under age 65 is positively associated with WAZ and BMIZ in Vietnam (Table 3.10). Coresidence of grandmothers of two different age groups (<65, ≥65) is associated with higher WAZ, HAZ, and BMIZ in Peru and WAZ and BMIZ in Vietnam (Table 3.10). Rather than reflecting a minimum of one coresident grandmother of a given age, this category reflects arrangements where there are grandmothers who belong to two different age groups and is likely capturing the association between having two coresident grandmothers and nutritional status. In the case of both Peru and Vietnam, this category is associated with a higher z-score (Table 3.10). For WAZ in Peru, presence of two grandmothers of differing age groups is associated with a 0.817 higher WAZ ($p<0.001$) and a 0.233 higher HAZ. Two coresident grandmothers are associated with improved short and long-term nutritional status. In Vietnam, coresidence of two grandmothers of differing age groups is associated with a 0.858 higher standard deviation in WAZ and 0.212 higher standard deviation in BMIZ ($p<0.001$, $p<0.05$, Table 3.10). This suggests that the presence of two grandmothers, though they may be of differing age groups, is associated with improved short-term nutritional measures.

Household wealth may moderate the association between coresident grandparents and child nutritional status, where households with increased wealth are in a better position to accommodate additional household older members. Across all rounds and countries in this sample, households with grandparents tend to have higher wealth indices and caregiver education compared to those who do not have coresident grandparents (Appendix, Tables AA3.1-AA3.4). Including wealth interactions shifts the previous findings; where no association between grandparental coresidence and child nutritional status was previously observed in Ethiopia, a negative and nonsignificant main association between grandmothers under age 65 is moderated by increased wealth index ($\beta^{grandma<65*wealth}= 0.010$, $p<0.05$, Table 3.11). The association between two coresident grandmothers of mixed age groups and BMIZ is positive and significant after including wealth as an interaction ($\beta^{grandmas<65,\ \geq 65}= 0.860$, $p<0.05$, Table 3.11). While the presence of at least one grandmother under age 65 is negatively associated with HAZ and moderated by household wealth, the presence of two grandmothers of mixed age groups is associated with higher body mass index-for-age z-scores.

Similar results are observed for India, where wealth moderates the association between coresidence and nutritional status. For both WAZ and HAZ, coresident grandmothers under age 65 are negatively associated with nutritional status with a small but statistically significant and positive wealth interaction (Table 3.12). A negative main association (though nonsignificant) and a positive, significant interaction indicates that households with higher wealth indices may experience some mitigation of any potential negative association between coresidence and nutritional status. This is also the case when two grandmothers of mixed age groups coreside; two coresident grandmothers of different age groups are associated with lower WAZ and HAZ in India (Table 3.12). For weight-for-age z-scores, coresidence of two grandmothers of mixed age groups is associated with a -1.292 lower standard deviation from the median (β= -1.292, $p<0.05$, Table 3.12). The opposite is observed for two coresident grandfathers, whose coresidence is associated with a 1.664 higher height-for-age z-score (Table 3.12). Overall in India, coresidence of at least one grandmother <65 and two grandmothers of mixed age groups is negatively and nonsignificantly associated with nutritional status (WAZ and HAZ), though this negative association is mitigated by wealth.

In Peru, many of the previously observed statistically significant relationships hold after including wealth interactions. Coresidence of at least one grandmother under age 65 is associated with higher WAZ and BMIZ (Table 3.13). However, in the case of both z-scores, this coefficient diminishes with increased wealth (WAZ: $\beta^{Grandmother<65*wealth}$ = -0.006, BMIZ: $\beta^{Grandmother<65*wealth}$ = -0.006, Table 3.13). The presence of two grandmothers of mixed age groups is also associated with increased WAZ, HAZ, and BMIZ, though there is no evidence of moderation by household wealth (Table 3.13). Peru is the only country where after estimating an interaction between grandparental coresidence and wealth, children in households with at least one grandmother under age 65 and two grandmothers of mixed age groups are consistently associated with higher nutritional outcomes, including WAZ, HAZ, and BMIZ (Table 3.13). The presence of at least one grandmother over age 65 is also positively associated with each nutritional outcome, however, the association is not statistically significant. Coresidence with at least one grandmother under age 65 and two grandmothers of differing age groups are consistently and positively associated with higher WAZ, HAZ, and BMIZ (Table 3.13).

Prior to inclusion of wealth as a moderator, the presence of at least one coresident grandmother was associated with higher weight-for-age and body mass index-for-age z-scores in Vietnam. After inclusion of wealth, coefficients are positive but no longer significant for grandmothers under age 65 (Table 3.14). Main associations for the presence of at least one coresident grandmother over 65 and grandmothers of two different age groups are nonsignificant and negative, with statistically significant evidence of mitigation of this negative main association with increased wealth (Table

3.14). Coresident grandmothers of two different ages are associated with a 2.622 lower BMI z-score, though this coefficient becomes less negative with increased wealth ($\beta^{grandmas<,>65*wealth}$ = 0.048, Table 3.14). Coresidence with at least one grandmother under age 65 or with two grandmothers of mixed age groups is negatively but nonsignificantly associated with WAZ and BMIZ, though increased wealth attenuates this negative association.

DISCUSSION AND CONCLUSION

Across the four countries included in this analysis, household wealth, caregiver education, and number of coresident children under the age of 5 years were among the most consistent predictors of child nutritional status. After including wealth interactions to examine the association between grandparental coresidence and child nutritional status, two general patterns emerged; in India and Vietnam, coresident grandmothers were associated with lower nutritional status, though few of these main associations were statistically significant. However, the interaction between grandmother coresidence and household wealth index was positive and significant, indicating some mitigation of a negative association between grandmother coresidence and child nutritional status as household wealth increased. The second pattern occurred only in Peru, where for WAZ, HAZ, and BMIZ, children with at least one grandmother under 65 and grandmothers of two different age groups had better nutritional status on average.

Though the impact of grandparental coresidence varies by country, the implications are clear; grandparents may sometimes be “helpers-in-the-nest,” and in other cases may rely on a family-support model for successful aging, wherein households with more resources are better able to offset the potential costs of an additional dependent household member. In the case of the former, more detailed information about the type of transfers from and to grandparents is required to better understand how they might contribute to improved child nutritional status, and why grandmothers in particular show a consistent pattern in the case of Peru. Coresident grandmothers may alter caregivers’ behavior, allow caregivers to work, or engage in other activities that indirectly benefit children. Where grandparental coresidence is negatively associated with child nutritional status, information on when and why grandparents move into the household would clarify whether this living arrangement is a normative part of the life course only after an individual becomes ill or widowed or if there is another motivation for joining the household and whether it would negatively affect other household members. Coresidence as a selective process where individuals choose to join a household requires further study from the perspective of those joining the household, and should form a more central focus of research in countries where a family support model is the primary form of social security.

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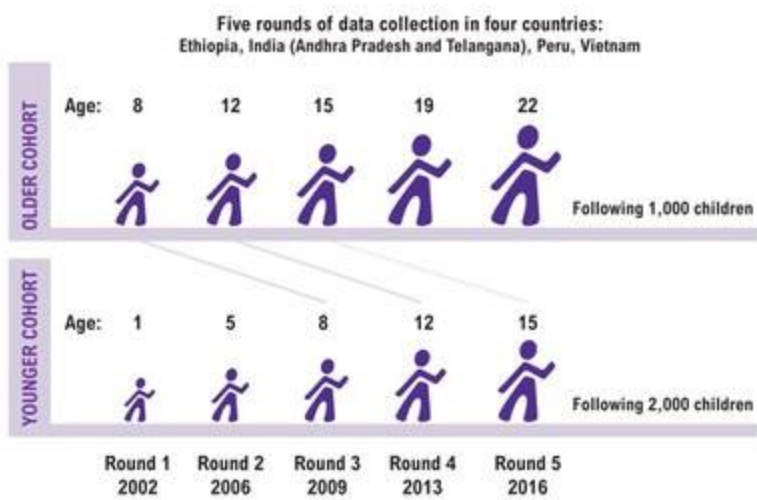
FIGURES AND TABLES

Figure 3.1. Young Lives Study Countries

Barnett, Petrou et al. 2013

Figure 3.2. Young Lives Study data collection: Rounds and Cohorts



From Young Lives Study (http://www.younglives.org.uk/what-we-do)

Table 3.1. Description of cohort by round

Round 1 Collected 2002	Round 2 Collected 2006-07	Round 3 Collected 2009-10	Round 4 Collected 2013
Young Cohort (Born 2001-2002) Age 1, n≈2000	Young Cohort (Born 2001-2002) Age 5, n≈2000	Young Cohort (Born 2001-2002) Age 8, n≈2000	Young Cohort (Born 2001-2002) Age 12, n≈2000

*Analyses exclude Round 4

Table 3.2. Mean WAZ, HAZ, and BMIZ by round: Young Lives Study, Rounds 1-3

	Round 1			Round 2			Round 3		
Outcome	N	Mean	SD	N	Mean	SD	N	Mean	SD
Ethiopia									
WAZ	1,847	-1.41	1.49	1,909	-1.36	0.93	1,881	-1.64	0.96
HAZ	1,917	-1.54	1.85	1,908	-1.45	1.13	1,878	-1.21	1.13
BMIZ	1,853	-0.68	1.53	1,909	-0.63	1.09	1,882	-1.30	1.08
India									
WAZ	1,993	-1.55	1.13	1,943	-1.87	0.93	1,929	-1.87	1.06
HAZ	1,970	-1.30	1.48	1,937	-1.65	0.99	1,924	-1.44	1.04
BMIZ	1,991	-1.04	1.17	1,943	-1.18	1.02	1,929	-1.41	1.19
Peru									
WAZ	2,039	-0.20	1.20	1,955	-0.54	1.03	1,936	-0.34	1.19
HAZ	2,035	-1.30	1.30	1,950	-1.54	1.11	1,937	-1.16	1.05
BMIZ	2,039	0.79	1.31	1,954	0.69	1.04	1,937	0.52	1.07
Vietnam									
WAZ	1,990	-0.96	1.08	1,963	-1.06	1.14	1,932	-1.14	1.28
HAZ	1,982	-1.11	1.25	1,956	-1.35	1.04	1,934	-1.10	1.07
BMIZ	1,992	-0.41	0.98	1,960	-0.30	1.13	1,925	-0.67	1.29

Table 3.3. Child and Household Characteristics by round: Ethiopia

	Ethiopia					
	Round 1		Round 2		Round 3	
Child Characteristics	**n**	**%**	**n**	**%**	**n**	**%**
Male	1,056	52.83	1010	52.82	993	52.71
Female	943	47.17	902	47.18	891	47.29
	mean	**SD**	**mean**	**SD**	**mean**	**SD**
Age (Years)	0.97	0.30	5.15	0.32	8.12	0.34
Household Characteristics	**n**	**%**	**n**	**%**	**n**	**%**
Coresident Siblings under 5 Years	0.60	0.63	0.65	0.66	0.92	0.84
Wealth Index (0-1)	0.21	0.18	0.28	0.18	0.33	0.18
Caregiver Education (Grade Attended)	5.95	7.41	6.15	7.53	6.15	7.55
Parent Living Arrangement	**n**	**%**	**n**	**%**	**n**	**%**
Both Parents Reside in Household	1,641	82.09	1,443	75.47	1,631	86.48
One Parent Resides, Other Away	285	14.26	315	16.47	133	7.05
One or Both Parents Deceased	40	2	121	6.33		
Other Living Arr or Parent Status	33	1.65	33	1.73	122	6.47
Grandparental Coresidence	**%**	**SD**	**%**	**SD**	**%**	**SD**
Any Coresident Grandmother (0/1)	12.51%	0.33	11.30%	0.32	17.07%	0.38
Any Coresident Grandfather (0/1)	5.25%	0.22	4.39%	0.20	7.69%	0.27
Any Coresident Grandparent (0/1)	13.91%	0.35	12.08%	0.33	19.03%	0.39
Coresident Grandparent Age (Years)	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Maternal Grandmother Age	53.66	11.22	56.32	10.62	60.21	11.29
Maternal Grandfather Age	62.81	12.28	64.71	10.84	69.16	13.42
Paternal Grandmother Age	56.90	13.56	62.49	10.72	65.07	11.40
Paternal Grandfather Age	63.06	12.11	65.28	9.67	69.20	11.33
Unclassified Grandmother (R1) Age	57.10	13.79	-	-	-	-
Unclassified Grandfather (R1) Age	57.27	9.40	-	-	-	-

Table 3.4. Child and Household Characteristics by round: India

	India					
	Round 1		Round 2		Round 3	
Child Characteristics	**n**	**%**	**n**	**%**	**n**	**%**
Male	1081	53.75	1039	53.28	1026	53.16
Female	930	46.25	911	46.72	904	46.84
	mean	**SD**	**mean**	**SD**	**mean**	**SD**
Age (Years)	0.99	0.29	5.36	0.32	7.95	0.32
Household Characteristics	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Coresident Siblings under 5 Years	0.28	0.54	0.54	0.64	0.41	0.62
Wealth Index (0-1)	0.41	0.20	0.46	0.20	0.51	0.18
Caregiver Education (Grade Attended)	5.28	5.37	5.39	5.41	5.37	5.37
Parent Living Arrangement	**n**	**%**	**n**	**%**	**n**	**%**
Both Parents Reside in Household	1,983	98.61	1,838	94.26	1,756	90.94
One Parent Resides, Other Away	15	0.75	59	3.03	60	3.11
One or Both Parents Deceased	9	0.45	48	2.46	71	3.68
Other Living Arr or Parent Status	4	0.2	5	0.26	44	2.28
Grandparental Coresidence	**%**	**SD**	**%**	**SD**	**%**	**SD**
Any Coresident Grandmother (0/1)	48.18%	0.50	35.74%	0.48	52.98%	0.50
Any Coresident Grandfather (0/1)	35.46%	0.48	21.38%	0.41	38.01%	0.49
Any Coresident Grandparent (0/1)	53.06%	0.50	39.69%	0.49	58.10%	0.49
Coresident Grandparent Age (Years)	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Maternal Grandmother Age	49.65	9.38	54.17	8.46	56.03	8.87
Maternal Grandfather Age	55.37	9.39	58.72	8.21	60.13	7.98
Paternal Grandmother Age	52.74	8.95	57.04	8.75	60.13	8.85
Paternal Grandfather Age	58.67	8.74	61.57	8.39	65.39	8.74
Unclassified Grandmother (R1) Age	60.34	13.77	-	-	-	-
Unclassified Grandfather (R1) Age	61.83	8.57	-	-	-	-

Table 3.5. Child and Household Characteristics by round: Peru

	Peru					
	Round 1		Round 2		Round 3	
Child Characteristics	**n**	**%**	**n**	**%**	**n**	**%**
Male	1,027	50.05	990	50.43	959	50.34
Female	1,025	49.95	973	49.57	946	49.66
	mean	**SD**	**mean**	**SD**	**mean**	**SD**
Age (Years)	0.96	0.30	5.29	0.39	7.91	0.30
Household Characteristics	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Coresident Siblings under 5 Years	0.46	0.63	0.49	0.63	0.63	0.77
Wealth Index (0-1)	0.42	0.24	0.47	0.23	0.54	0.21
Caregiver Education (Grade Attended)	7.74	4.61	7.74	4.61	7.74	4.61
Parent Living Arrangement	**n**	**%**	**n**	**%**	**n**	**%**
Both Parents Reside in Household	1,713	83.48	1,564	79.67	1,457	71
One Parent Resides, Other Away	309	15.06	360	18.34	368	17.93
One or Both Parents Deceased	13	0.63	20	1.02	26	1.27
Other Living Arr or Parent Status	17	0.83	19	0.97	201	9.8
Grandparental Coresidence	**%**	**SD**	**%**	**SD**	**%**	**SD**
Any Coresident Grandmother (0/1)	28.31%	0.45	20.73%	0.41	16.57%	0.37
Any Coresident Grandfather (0/1)	20.91%	0.41	14.01%	0.35	10.53%	0.31
Any Coresident Grandparent (0/1)	31.43%	0.46	23.08%	0.42	18.37%	0.39
Coresident Grandparent Age (Years)	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Maternal Grandmother Age	51.88	10.28	56.43	10.53	59.62	10.82
Maternal Grandfather Age	54.36	9.77	58.81	9.85	62.12	9.66
Paternal Grandmother Age	53.77	11.38	59.93	10.87	62.02	10.55
Paternal Grandfather Age	56.44	11.05	63.41	11.22	64.32	10.53
Unclassified Grandmother (R1) Age	53.04	9.87	-	-	-	-
Unclassified Grandfather (R1) Age	58.67	13.28	-	-	-	-

Table 3.6. Child and Household Characteristics by round: Vietnam

	Vietnam					
	Round 1		Round 2		Round 3	
Child Characteristics	**n**	**%**	**n**	**%**	**n**	**%**
Male	1,030	51.50	1,013	51.42	1,005	51.25
Female	970	48.50	957	48.58	956	48.75
	mean	**SD**	**mean**	**SD**	**mean**	**SD**
Age (Years)	0.97	0.26	5.25	0.31	8.05	0.31
Household Characteristics	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Coresident Siblings under 5 Years	0.30	0.51	0.32	0.51	0.41	0.58
Wealth Index (0-1)	0.44	0.22	0.49	0.18	0.61	0.19
Caregiver Education (Grade Attended)	6.95	3.70	7.03	3.66	7.00	3.64
Parent Living Arrangement	**n**	**%**	**n**	**%**	**n**	**%**
Both Parents Reside in Household	1,932	96.6	1,806	91.63	1,704	86.76
One Parent Resides, Other Away	60	3	114	5.78	123	6.26
One or Both Parents Deceased	4	0.2	30	1.52	41	2.09
Other Living Arr or Parent Status	4	0.2	21	1.07	96	4.89
Grandparental Coresidence	**%**	**SD**	**%**	**SD**	**%**	**SD**
Any Coresident Grandmother (0/1)	33.20%	0.47	24.66%	0.43	39.66%	0.49
Any Coresident Grandfather (0/1)	23.10%	0.42	14.81%	0.36	27.80%	0.45
Any Coresident Grandparent (0/1)	35.20%	0.48	26.18%	0.44	41.96%	0.49
Coresident Grandparent Age (Years)	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Maternal Grandmother Age	56.42	9.84	60.82	10.30	62.88	9.76
Maternal Grandfather Age	56.59	9.08	60.37	8.90	63.18	9.07
Paternal Grandmother Age	58.68	10.33	64.65	9.80	66.15	10.30
Paternal Grandfather Age	59.70	10.71	65.30	9.79	67.08	10.41
Unclassified Grandmother (R1) Age	62.71	12.40	-	-	-	-
Unclassified Grandfather (R1) Age	62.56	11.71	-	-	-	-

Table 3.7. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds– Ethiopia and India

	Ethiopia									India								
	WAZ			HAZ			BMIZ			WAZ			HAZ			BMIZ		
	β		SE	β		SE	β		SE	β		SE	β		SE	β		SE
Round 2 (Baseline 1)	1.008	***	0.287	2.265	***	0.321	-0.431		0.265	1.109	***	0.269	0.923	**	0.281	0.695	*	0.270
Round 3	1.440	**	0.490	4.094	***	0.549	-1.447	**	0.450	1.908	***	0.428	1.837	***	0.448	0.932	*	0.428
Male	-0.116	**	0.041	-0.244	***	0.049	0.059		0.040	-0.154	***	0.038	-0.138	***	0.042	-0.082	*	0.039
Age (Months)	-0.021	***	0.006	-0.046	***	0.006	0.009		0.005	-0.028	***	0.005	-0.025	***	0.005	-0.016	**	0.005
Total Sibs <5 Years	-0.102	***	0.025	-0.077	**	0.029	-0.072	**	0.027	-0.040		0.023	-0.041		0.025	-0.001		0.026
Wealth Index (0-100)	0.019	***	0.001	0.016	***	0.001	0.012	***	0.001	0.012	***	0.001	0.013	***	0.001	0.004	***	0.001
Parent Configuration																		
One Resides, Other Away	-0.100		0.052	-0.083		0.065	-0.046		0.056	-0.067		0.102	-0.053		0.096	0.024		0.125
One or Both Deceased	-0.132		0.077	-0.137		0.094	-0.067		0.078	-0.080		0.104	-0.068		0.112	0.036		0.091
Other Living Arrangement	-0.015		0.089	0.005		0.113	-0.109		0.098	-0.050		0.155	-0.035		0.217	0.003		0.229
Caregiver Education	0.008	**	0.003	0.009	*	0.003	0.004		0.003	0.021	***	0.004	0.023	***	0.004	0.010	**	0.004
At Least one Grandma Coresides	-0.002		0.058	0.037		0.071	-0.023		0.062	0.039		0.043	0.041		0.047	0.052		0.044
At least one Grandpa Coresides	-0.050		0.087	-0.008		0.106	-0.093		0.090	-0.014		0.046	0.005		0.051	-0.029		0.048
Constant	-1.470	***	0.084	-1.192	***	0.103	-1.046	***	0.080	-1.745	***	0.081	-1.615	***	0.087	-1.042	***	0.083
AIC	15842.45			18461.76			17234.45			16524.13			18054.56			17949.79		
Observations	5268			5336			5276			5843			5809			5841		

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.8. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds – Peru and Vietnam

	Peru									Vietnam								
	WAZ			HAZ			BMIZ			WAZ			HAZ			BMIZ		
	β		SE	β		SE	β		SE	β		SE	β		SE	β		SE
Round 2 (Baseline 1)	0.341		0.240	0.435		0.242	0.416		0.242	1.367	***	0.293	0.894	**	0.276	1.285	***	0.296
Round 3	0.901	*	0.385	1.187	**	0.386	0.536		0.388	2.138	***	0.484	1.777	***	0.456	1.616	***	0.488
Male	0.007		0.040	-0.093	*	0.039	0.148	***	0.039	0.012		0.042	-0.109	**	0.040	0.145	***	0.041
Age (Months)	-0.014	**	0.005	-0.014	**	0.005	-0.011	*	0.005	-0.030	***	0.006	-0.023	***	0.005	-0.023	***	0.006
Total Sibs <5 Years	-0.076	**	0.024	-0.060	**	0.023	-0.045		0.024	-0.072	*	0.030	-0.161	***	0.029	0.067	*	0.030
Wealth Index (0-100)	0.014	***	0.001	0.013	***	0.001	0.007	***	0.001	0.012	***	0.001	0.013	***	0.001	0.005	***	0.001
Parent Configuration																		
One Resides, Other Away	-0.061		0.050	-0.057		0.049	-0.039		0.051	-0.038		0.081	-0.067		0.080	0.012		0.078
One or Both Deceased	-0.258	*	0.130	-0.189		0.161	-0.171		0.138	0.034		0.178	-0.077		0.143	0.151		0.183
Other Living Arrangement	-0.231		0.120	-0.226		0.124	-0.007		0.140	-0.183		0.111	-0.297	**	0.103	0.051		0.121
Caregiver Education	0.049	***	0.005	0.064	***	0.005	0.009		0.005	0.063	***	0.008	0.052	***	0.007	0.040	***	0.007
At Least one Grandma Coresides	0.061		0.056	0.049		0.053	0.041		0.059	0.100		0.063	0.034		0.058	0.110		0.059
At least one Grandpa Coresides	0.023		0.066	-0.013		0.060	0.035		0.066	0.059		0.069	0.082		0.065	-0.002		0.067
Constant	-0.973	***	0.072	-2.103	***	0.072	0.479	***	0.076	-1.619	***	0.090	-1.716	***	0.087	-0.764	***	0.090
AIC	16575.65			16625.97			17767.91			17426.76			16866.44			17733.22		
Observations	5769			5762			5769			5799			5787			5792		

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.9. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds with Grandparent Age – Ethiopia and India

	Ethiopia									India								
	WAZ			HAZ			BMIZ			WAZ			HAZ			BMIZ		
	β		SE	β		SE	β		SE	β		SE	β		SE	β		SE
Round 2 (Baseline 1)	1.015	***	0.287	2.275	***	0.320	-0.431		0.265	1.103	***	0.269	0.922**	**	0.282	0.683	*	0.270
Round 3	1.454	**	0.489	4.117	***	0.549	-1.448	**	0.450	1.902	***	0.429	1.840	***	0.448	0.918	*	0.428
Male	-0.116	**	0.041	-0.244	***	0.049	0.059		0.040	-0.154	***	0.038	-0.138	***	0.042	-0.082	*	0.039
Age (Months)	-0.022	***	0.006	-0.046	***	0.006	0.009		0.005	-0.028	***	0.005	-0.025	***	0.005	-0.016	**	0.005
Total Sibs <5 Years	-0.102	***	0.025	-0.076	**	0.029	-0.072	**	0.027	-0.040		0.023	-0.041		0.025	-0.001		0.026
Wealth Index (0-100)	0.019	***	0.001	0.016	***	0.001	0.012	***	0.001	0.012	***	0.001	0.013	***	0.001	0.004	***	0.001
Parent Configuration																		
One Resides, Other Away	-0.107	*	0.052	-0.100		0.064	-0.045		0.056	-0.068		0.102	-0.059		0.096	0.026		0.125
One or Both Deceased	-0.136		0.077	-0.146		0.094	-0.066		0.078	-0.081		0.104	-0.070		0.113	0.033		0.091
Other Living Arrangement	-0.015		0.090	-0.006		0.113	-0.104		0.099	-0.076		0.166	-0.091		0.229	0.011		0.242
Caregiver Education	0.008	**	0.003	0.009	**	0.003	0.004		0.003	0.021	***	0.004	0.023	***	0.004	0.010	*	0.004
Grandparent Residence and Age																		
Min One Grandma, <65	0.028		0.072	0.121		0.089	-0.035		0.076	0.061		0.047	0.050		0.051	0.076		0.047
Min One Grandma, ≥65	-0.050		0.078	-0.087		0.096	-0.014		0.086	-0.012		0.063	0.026		0.068	-0.026		0.068
Grandmas of Mixed Age Groups	-0.166		0.429	-0.573		0.658	0.472		0.273	0.111		0.277	0.223		0.202	0.108		0.230
Min One Grandpa, <65	0.045		0.119	0.040		0.143	-0.040		0.134	-0.048		0.055	0.010		0.061	-0.086		0.057
Min One Grandpa, ≥65	-0.151		0.105	-0.103		0.136	-0.137		0.101	-0.016		0.059	-0.029		0.067	0.004		0.060
Grandpas of Mixed Age Groups										0.120		0.237	0.206		0.194	-0.162		0.280
Constant	-1.470	***	0.084	-1.192	***	0.103	-1.046	***	0.080	-1.743	***	0.081	-1.616	***	0.087	-1.037	***	0.083
AIC	15844.68			18461.85			17239.2			16529.4			18059.63			17953.51		
Observations	5268			5336			5276			5843			5809			5841		

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.10. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds with Grandparent Age – Peru and Vietnam

	Peru									Vietnam								
	WAZ			HAZ			BMIZ			WAZ			HAZ			BMIZ		
	β		SE	β		SE	β		SE	β		SE	β		SE	β		SE
Round 2 (Baseline 1)	0.331		0.240	0.427		0.241	0.409		0.242	1.396	***	0.293	0.909	**	0.276	1.314	***	0.295
Round 3	0.885	*	0.385	1.174	**	0.386	0.525		0.388	2.183	***	0.483	1.798	***	0.456	1.661	***	0.487
Male	0.005		0.040	-0.093	*	0.039	0.147	***	0.039	0.007		0.042	-0.111	**	0.040	0.140	***	0.041
Age (Months)	-0.014	**	0.005	-0.014	**	0.005	-0.010	*	0.005	-0.030	***	0.006	-0.023	***	0.005	-0.024	***	0.006
Total Sibs <5 Years	-0.077	**	0.024	-0.061	**	0.023	-0.046		0.024	-0.073	*	0.030	-0.162	***	0.029	0.066	*	0.030
Wealth Index (0-100)	0.014	***	0.001	0.013	***	0.001	0.007	***	0.001	0.012	***	0.001	0.013	***	0.001	0.005	***	0.001
Parent Configuration																		
One Resides, Other Away	-0.062		0.051	-0.058		0.049	-0.041		0.052	-0.036		0.081	-0.066		0.080	0.015		0.077
One or Both Deceased	-0.249		0.132	-0.184		0.163	-0.163		0.137	0.042		0.177	-0.072		0.143	0.157		0.183
Other Living Arrangement	-0.236	*	0.119	-0.227		0.124	-0.015		0.142	-0.184		0.111	-0.304	**	0.103	0.056		0.121
Caregiver Education	0.049	***	0.005	0.064	***	0.005	0.009		0.005	0.063	***	0.008	0.052	***	0.007	0.040	***	0.007
Grandparent Residence and Age																		
Min One Grandma, <65	0.110		0.066	0.089		0.061	0.078		0.072	0.221	**	0.079	0.099		0.080	0.212	**	0.073
Min One Grandma, ≥65	-0.031		0.087	-0.001		0.085	-0.050		0.074	0.032		0.071	-0.003		0.063	0.056		0.069
Grandmas of Mixed Age Groups	0.817	***	0.084	0.233	**	0.079	0.900	***	0.087	0.858	***	0.227	0.404		0.243	0.688	*	0.294
Min One Grandpa, <65	-0.054		0.073	-0.085		0.069	-0.009		0.077	-0.122		0.088	-0.022		0.087	-0.164		0.086
Min One Grandpa, ≥65	0.125		0.104	0.085		0.092	0.083		0.103	0.142		0.081	0.127		0.076	0.082		0.081
Grandpas of Mixed Age Groups										-0.433		0.287	0.109		0.272	-0.613		0.318
Constant	-0.973	***	0.072	-2.103	***	0.071	0.480	***	0.076	-1.602	***	0.090	-1.707	***	0.087	-0.748	***	0.089
AIC	16572.99			16624.99			17768.94			17413.25			16866.77			17725.92		
Observations	5769			5762			5769			5799			5787			5792		

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.11. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds with Grandparent Age and Wealth Interactions – Ethiopia

	Ethiopia																	
	WAZ						HAZ						BMIZ					
	β		SE	Int β		SE	β		SE	Int β		SE	β		SE	Int β		SE
Round 2 (Baseline 1)	1.016	***	0.287				2.278	***	0.320				-0.434		0.265			
Round 3	1.456	**	0.490				4.122	***	0.548				-1.453	**	0.450			
Male	-0.116	**	0.041				-0.246	***	0.049				0.060		0.040			
Age (Months)	-0.022	***	0.006				-0.046	***	0.006				0.009		0.005			
Total Sibs <5 Years	-0.103	***	0.025				-0.079	**	0.029				-0.071	**	0.027			
Wealth Index (0-100)	0.018	***	0.001				0.015	***	0.001				0.012	***	0.001			
Parent Configuration																		
One Resides, Other Away	-0.108	*	0.052				-0.102		0.064				-0.044		0.056			
One or Both Deceased	-0.137		0.077				-0.147		0.094				-0.067		0.078			
Other Living Arrangement	-0.007		0.091				0.004		0.113				-0.099		0.099			
Caregiver Education	0.008	**	0.003				0.008	*	0.003				0.004		0.003			
Grandparent Residence and Age																		
Min One Grandma, <65	-0.121		0.144	0.005		0.004	-0.200		0.156	0.010	*	0.004	-0.015		0.154	-0.001		0.004
Min One Grandma, ≥65	-0.085		0.155	0.001		0.004	-0.180		0.174	0.003		0.004	0.051		0.167	-0.002		0.004
Grandmas of Mixed Age Groups	0.753		1.160	-0.020		0.023	0.434		1.645	-0.023		0.036	0.860	*	0.394	-0.008		0.014
Min One Grandpa, <65	0.044		0.251	-0.001		0.006	0.012		0.247	0.000		0.006	0.037		0.275	-0.002		0.006
Min One Grandpa, ≥65	-0.063		0.267	-0.003		0.006	-0.167		0.301	0.001		0.006	0.086		0.242	-0.006		0.005
Grandpas of Mixed Age Groups																		
Constant	-1.458	***	0.085				-1.156	***	0.105				-1.060	***	0.081			
AIC	15851.55						18462.4						17246.9					
Observations	5268						5336						5276					

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.12. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds with Grandparent Age and Wealth Interactions – India

	India																
	WAZ						HAZ						BMIZ				
	β		SE	Int β		SE	β		SE	Int β		SE	β		SE	Int β	SE
Round 2 (Baseline 1)	1.069	***	0.269				0.893	**	0.282				0.668	*	0.269		
Round 3	1.851	***	0.428				1.795	***	0.449				0.896	*	0.427		
Male	-0.156	***	0.038				-0.140	***	0.042				-0.083	*	0.039		
Age (Months)	-0.027	***	0.005				-0.025	***	0.005				-0.016	**	0.005		
Total Sibs <5 Years	-0.039		0.023				-0.039		0.025				-0.001		0.026		
Wealth Index (0-100)	0.010	***	0.001				0.011	***	0.001				0.003	**	0.001		
Parent Configuration																	
One Resides, Other Away	-0.053		0.102				-0.050		0.096				0.035		0.126		
One or Both Deceased	-0.081		0.104				-0.069		0.112				0.033		0.091		
Other Living Arrangement	-0.068		0.160				-0.082		0.229				0.016		0.242		
Caregiver Education	0.021	***	0.004				0.023	***	0.004				0.010	*	0.004		
Grandparent Residence and Age																	
Min One Grandma, <65	-0.176		0.107	0.005	*	0.002	-0.197		0.125	0.005	*	0.002	0.004		0.112	0.002	0.002
Min One Grandma, ≥65	-0.173		0.169	0.004		0.003	-0.248		0.168	0.006		0.003	0.042		0.186	-0.001	0.004
Grandmas of Mixed Age Groups	-1.292	*	0.583	0.027	**	0.010	-0.615		0.379	0.017	**	0.007	-0.745		0.561	0.016	0.010
Min One Grandpa, <65	0.007		0.123	-0.001		0.003	0.109		0.151	-0.002		0.003	-0.101		0.142	0.000	0.003
Min One Grandpa, ≥65	-0.153		0.155	0.002		0.003	-0.103		0.173	0.001		0.003	-0.147		0.163	0.003	0.003
Grandpas of Mixed Age Groups	1.174		0.655	-0.023		0.013	1.664	***	0.365	-0.030	***	0.008	-0.122		0.787	-0.002	0.016
Constant	-1.647	***	0.087				-1.524	***	0.094				-1.000	***	0.089		
AIC	16517.35						18056.07						17959.56				
Observations	5843						5809						5841				

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.13. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds with Grandparent Age and Wealth Interactions – Peru

	Peru																	
	WAZ						HAZ						BMIZ					
	β		SE	Int β		SE	β		SE	Int β		SE	β		SE	Int β		SE
Round 2 (Baseline 1)	0.329		0.239				0.427		0.242				0.405		0.242			
Round 3	0.881	*	0.384				1.174	**	0.386				0.518		0.387			
Male	0.008		0.040				-0.092	*	0.040				0.149	***	0.039			
Age (Months)	-0.014	**	0.005				-0.014	**	0.005				-0.010	*	0.005			
Total Sibs <5 Years	-0.075	**	0.024				-0.061	**	0.023				-0.046		0.024			
Wealth Index (0-100)	0.014	***	0.001				0.013	***	0.001				0.007	***	0.001			
Parent Configuration																		
One Resides, Other Away	-0.059		0.051				-0.059		0.049				-0.035		0.052			
One or Both Deceased	-0.236		0.132				-0.177		0.162				-0.149		0.136			
Other Living Arrangement	-0.228		0.118				-0.230		0.123				0.002		0.142			
Caregiver Education	0.049	***	0.005				0.064	***	0.005				0.009		0.005			
Grandparent Residence and Age																		
Min One Grandma, <65	0.416	**	0.135	-0.006	*	0.003	0.181		0.135	-0.002		0.003	0.384	**	0.144	-0.006	*	0.003
Min One Grandma, ≥65	0.065		0.176	-0.002		0.003	0.042		0.190	-0.001		0.003	0.001		0.162	-0.001		0.003
Grandmas of Mixed Age Groups	0.670	***	0.107	0.000		.	0.190	*	0.095	0.000		.	0.732	***	0.106	0.000		.
Min One Grandpa, <65	-0.460	**	0.158	0.008	**	0.003	-0.173		0.162	0.002		0.003	-0.516	**	0.161	0.010	***	0.003
Min One Grandpa, ≥65	-0.230		0.233	0.007		0.004	0.185		0.197	-0.002		0.004	-0.431		0.240	0.010	*	0.004
Grandpas of Mixed Age Groups																		
Constant	-0.973	***	0.075				-2.118	***	0.076				0.502	***	0.079			
AIC	16567.11						16630.64						17757.19					
Observations	5769						5762						5769					

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

Table 3.14. Weight-for-Age, Height-for-Age, and BMI for age z-scores, All Rounds with Grandparent Age and Wealth Interactions – Vietnam

Vietnam

	WAZ					
	β		SE	Int β		SE
Round 2 (Baseline 1)	1.392	***	0.292			
Round 3	2.165	***	0.482			
Male	0.004		0.042			
Age (Months)	-0.030	***	0.006			
Total Sibs <5 Years	-0.073	*	0.030			
Wealth Index (0-100)	0.011	***	0.001			
Parent Configuration						
One Resides, Other Away	-0.031		0.081			
One or Both Deceased	0.022		0.179			
Other Living Arrangement	-0.172		0.110			
Caregiver Education	0.062	***	0.008			
Grandparent Residence and Age						
Min One Grandma, <65	0.160		0.194	0.001		0.003
Min One Grandma, ≥65	-0.338		0.178	0.007	*	0.003
Grandmas of Mixed Age Groups	-0.898		0.865	0.025	*	0.012
Min One Grandpa, <65	0.055		0.212	-0.004		0.004
Min One Grandpa, ≥65	-0.241		0.209	0.006		0.004
Grandpas of Mixed Age Groups	-0.527		0.939	0.003		0.016
Constant	-1.540	***	0.095			
AIC	17394.03					
Observations	5799					

	HAZ				
	β		SE	Int β	SE
Round 2 (Baseline 1)	0.905	**	0.276		
Round 3	1.787	***	0.456		
Male	-0.115	**	0.040		
Age (Months)	-0.023	***	0.005		
Total Sibs <5 Years	-0.163	***	0.029		
Wealth Index (0-100)	0.012	***	0.001		
Parent Configuration					
One Resides, Other Away	-0.066		0.081		
One or Both Deceased	-0.083		0.144		
Other Living Arrangement	-0.302	**	0.102		
Caregiver Education	0.052	***	0.007		
Grandparent Residence and Age					
Min One Grandma, <65	0.165		0.226	-0.001	0.004
Min One Grandma, ≥65	-0.175		0.187	0.003	0.003
Grandmas of Mixed Age Groups	-0.065		1.257	0.007	0.017
Min One Grandpa, <65	-0.123		0.236	0.002	0.004
Min One Grandpa, ≥65	-0.219		0.231	0.006	0.004
Grandpas of Mixed Age Groups	-0.007		0.979	0.002	0.014
Constant	-1.659	***	0.092		
AIC	16865.92				
Observations	5787				

	BMIZ					
	β		SE	Int β		SE
Round 2 (Baseline 1)	1.307	***	0.294			
Round 3	1.639	***	0.485			
Male	0.139	***	0.041			
Age (Months)	-0.024	***	0.006			
Total Sibs <5 Years	0.066	*	0.030			
Wealth Index (0-100)	0.004	**	0.001			
Parent Configuration						
One Resides, Other Away	0.023		0.077			
One or Both Deceased	0.137		0.183			
Other Living Arrangement	0.072		0.120			
Caregiver Education	0.039	***	0.007			
Grandparent Residence and Age						
Min One Grandma, <65	0.002		0.175	0.004		0.003
Min One Grandma, ≥65	-0.352		0.181	0.007	*	0.003
Grandmas of Mixed Age Groups	-2.622	**	0.881	0.048	***	0.012
Min One Grandpa, <65	0.199		0.205	-0.007		0.004
Min One Grandpa, ≥65	-0.101		0.210	0.003		0.004
Grandpas of Mixed Age Groups	-0.170		0.957	-0.006		0.017
Constant	-0.691	***	0.093			
AIC	17706.53					
Observations	5792					

†All reported standard errors are clustered by child identification *** Denotes p≤0.001, ** Denotes p≤0.01 *Denotes p≤0.05

APPENDIX

Figure A1.1. Child Height and Weight by Age (1561 measurements, 638 children)

Height (cm) | Weight (kg)

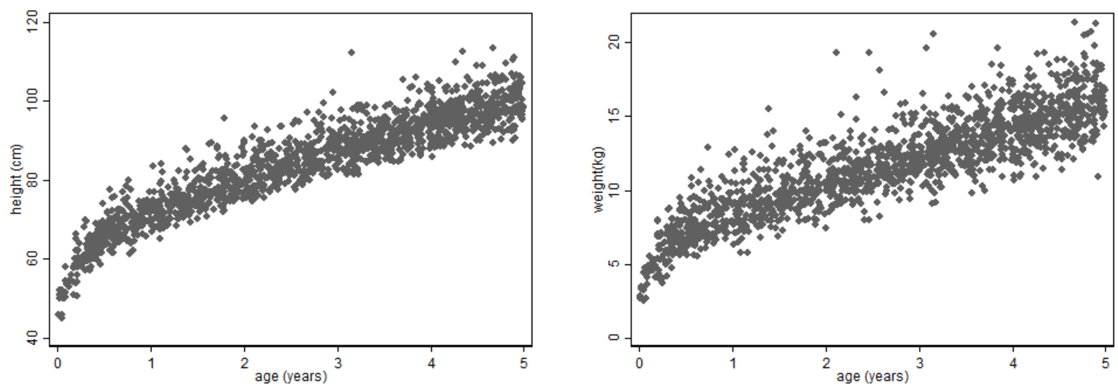


Figure A1.2. Distribution of Mother's and Father's IFS, Fraction (1561 measurements, 638 children aged 0-5)

Mothers | Fathers

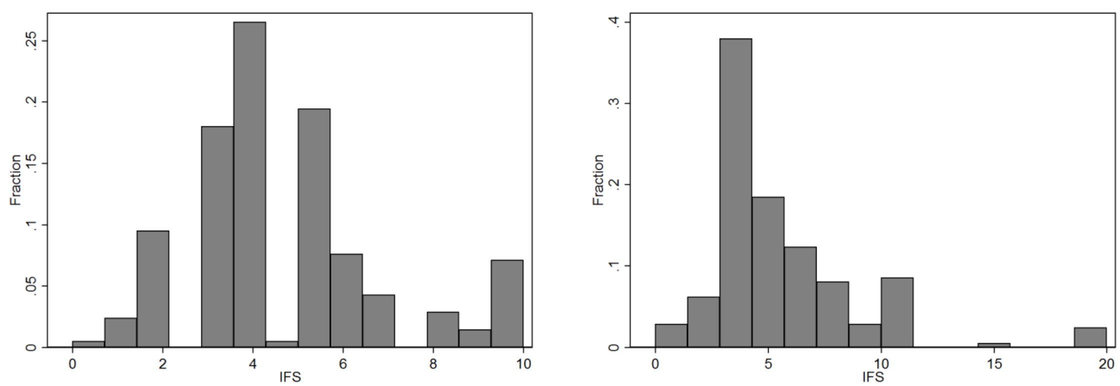


Table A2.1. Bivariate Regressions, HAZ ages 0-2 and 2-5

	Ages 0-2				Ages 2-5			
Height-for-age z-score	Coef.	Robust SE	P>t		Coef.	Robust SE	P>t	
Age in Months	-0.104	0.005	<0.001	***	0.004	0.002	0.013	*
Birth Order Category (Base 1)								
3-Feb	-0.019	0.143	0.892		0.059	0.078	0.451	
5-Apr	0.036	0.149	0.808		-0.059	0.087	0.499	
6+	0.043	0.136	0.753		0.026	0.075	0.730	
Birth Order * Birth Interval (Base 1, no previous)								
2-4, IBI <2	0.028	0.169	0.870		0.083	0.100	0.406	
2-4, IBI 2+	-0.005	0.144	0.972		0.001	0.078	0.993	
5+, IBI <2	-0.131	0.174	0.452		0.038	0.097	0.695	
5+, IBI 2+	0.087	0.136	0.523		-0.003	0.077	0.970	
Male	-0.386	0.086	<0.001	***	-0.073	0.052	0.160	
Maternal Body Fat %	0.014	0.006	0.022	*	0.014	0.003	<0.001	***
Maternal Height	0.009	0.010	0.378		0.051	0.005	<0.001	***
Maternal leg: height ratio	-1.974	2.324	0.396		1.805	0.855	0.035	*
Maternal Grade Category (Base None)								
Some to 2	0.123	0.109	0.258		-0.132	0.065	0.043	*
2 or More	0.226	0.109	0.037	*	-0.025	0.065	0.701	
Maternal Spanish Category (Base None)								
Some	0.064	0.096	0.507		-0.041	0.061	0.499	
Proficient or More	0.531	0.138	<0.001	***	0.296	0.08	<0.001	***
Distance to San Borja	-0.001	0.001	0.508		<0.001	0.001	0.798	
Distance to San Borja^2	<0.001	<0.001	0.381		<0.001	<0.001	0.224	
Distance Quintile (Base 1, mean 17.73km)								
2 (mean 29.90km)	-0.288	0.129	0.025	*	-0.331	0.075	<0.001	***
3 (mean 46.00 km)	-0.355	0.141	0.012	*	-0.112	0.079	0.154	
4 (mean 91.19km)	-0.165	0.125	0.186		-0.347	0.072	<0.001	***
5 (mean 149.51km)	-0.253	0.170	0.135		0.02	0.104	0.845	
Season of Measurement (Base dry)								
Wet	-0.119	0.082	0.146		-0.005	0.041	0.894	
Period of Measurement (Base 2002-2007)								
2008-2012	-0.228	0.093	0.015	*	0.106	0.052	0.043	*

Table A2.2. Bivariate Regressions, Odds of Stunting ages 0-2 and 2-5

	Ages 0-2				Ages 2-5			
Stunting	OR	Robust SE	P>z		OR	Robust SE	P>z	
Age in Months	1.105	0.007	<0.001	***	0.987	0.003	<0.001	***
Birth Order Category (Base 1)								
3-Feb	1.192	0.164	0.203		0.992	0.131	0.951	
5-Apr	1.024	0.152	0.872		1.137	0.162	0.368	
6+	1.044	0.138	0.747		0.993	0.125	0.957	
Birth Order * Birth Interval (Base 1, no previous)								
2-4, IBI <2	1.197	0.189	0.256		0.878	0.138	0.407	
2-4, IBI 2+	1.113	0.158	0.452		1.123	0.152	0.392	
5+, IBI <2	1.210	0.205	0.261		0.907	0.146	0.543	
5+, IBI 2+	0.987	0.132	0.921		1.057	0.135	0.662	
Male	1.495	0.13	<0.001	***	1.088	0.092	0.316	
Maternal Body Fat %	0.985	0.006	0.015	*	0.977	0.006	<0.001	***
Maternal Height	0.984	0.009	0.088		0.917	0.009	<0.001	***
Maternal leg: height ratio	0.722	1.45	0.871		0.021	0.045	0.071	
Maternal Grade Category (Base None)								
Some to 2	0.936	0.1	0.536		1.099	0.112	0.351	
2 or More	0.755	0.081	0.009	**	0.941	0.099	0.568	
Maternal Spanish Category (Base None)								
Some	0.845	0.082	0.082		0.995	0.095	0.959	
Proficient or More	0.573	0.077	<0.001	***	0.568	0.074	<0.001	***
Distance to San Borja	1.002	0.001	0.071		1.000	0.001	0.908	
Distance to San Borja^2	1.000	<0.001	0.028	*	1.000	<0.001	0.487	
Distance Quintile (Base 1, mean 17.73km)								
2 (mean 29.90km)	1.294	0.166	0.044	*	1.43	0.177	0.004	**
3 (mean 46.00 km)	1.413	0.195	0.012	*	1.134	0.149	0.337	
4 (mean 91.19km)	1.211	0.149	0.120		1.523	0.184	<0.001	***
5 (mean 149.51km)	1.489	0.240	0.013	*	0.972	0.149	0.853	
Season of Measurement (Base dry)								
Wet	1.136	0.094	0.123		1.055	0.072	0.434	
Period of Measurement (Base 2002-2007)								
2008-2012	1.139	0.105	0.159		0.877	0.074	0.118	

Table A2.3. Bivariate Regressions, WHZ ages 0-2 and 2-5

Weight-for-height z-score	Ages 0-2 Coef.	Robust SE	P>t		Ages 2-5 Coef.	Robust SE	P>t	
Age in Months	-0.005	0.005	0.288		0.013	0.002	<0.001	***
Birth Order Category (Base 1)								
3-Feb	0.096	0.110	0.385		-0.082	0.065	0.207	
5-Apr	0.054	0.118	0.650		0.001	0.07	0.989	
6+	-0.047	0.104	0.653		0.028	0.062	0.657	
Birth Order * Birth Interval (Base 1, no previous)								
2-4, IBI <2	0.027	0.130	0.834		-0.030	0.076	0.690	
2-4, IBI 2+	0.126	0.112	0.262		-0.051	0.066	0.443	
5+, IBI <2	-0.146	0.136	0.284		-0.022	0.089	0.804	
5+, IBI 2+	0.005	0.105	0.966		0.022	0.062	0.727	
Male	-0.121	0.070	0.082		0.040	0.042	0.341	
Maternal Body Fat %	0.017	0.005	0.001	**	0.022	0.003	<0.001	***
Maternal Height	0.018	0.007	0.015	*	0.005	0.005	0.278	
Maternal leg: height ratio	1.295	1.610	0.421		-0.210	0.811	0.796	
Maternal Grade Category (Base None)								
Some to 2	-0.101	0.084	0.231		0.113	0.051	0.027	*
2 or More	0.075	0.086	0.382		0.189	0.05	<0.001	***
Maternal Spanish Category (Base None)								
Some	0.058	0.079	0.464		0.095	0.047	0.043	
Proficient or More	0.252	0.104	0.015	*	0.412	0.061	<0.001	***
Distance to San Borja	-0.002	0.001	0.007	**	-0.002	<0.001	0.001	**
Distance to San Borja^2	<0.001	<0.001	0.335		<0.001	<0.001	0.056	
Distance Quintile (Base 1, mean 17.73km)								
2 (mean 29.90km)	-0.251	0.104	0.016	*	-0.120	0.060	0.047	*
3 (mean 46.00 km)	-0.256	0.107	0.016	*	-0.126	0.066	0.059	
4 (mean 91.19km)	-0.545	0.096	<0.001	***	-0.313	0.060	<0.001	***
5 (mean 149.51km)	-0.330	0.136	0.015	*	-0.165	0.077	0.033	*
Season of Measurement (Base dry)								
Wet	-0.119	0.067	0.078		-0.090	0.035	0.011	*
Period of Measurement (Base 2002-2007)								
2008-2012	0.165	0.068	0.016	*	0.019	0.041	0.649	

Table A2.4. Bivariate Regressions, Odds of Wasting ages 0-2 and 2-5

	Ages 0-2				Ages 2-5			
Wasting	OR	Robust SE	P>z		OR	Robust SE	P>z	
Age in Months	0.975	0.009	0.006	**	0.934	0.010	<0.001	***
Birth Order Category (Base 1)								
3-Feb	0.915	0.199	0.681		1.500	0.507	0.231	
5-Apr	1.034	0.236	0.883		0.999	0.395	0.999	
6+	1.226	0.239	0.296		1.281	0.414	0.443	
Birth Order * Birth Interval (Base 1, no previous)								
2-4, IBI <2	0.900	0.237	0.690		1.068	0.462	0.880	
2-4, IBI 2+	0.920	0.201	0.701		1.374	0.474	0.356	
5+, IBI <2	1.375	0.338	0.195		1.974	0.757	0.076	
5+, IBI 2+	1.169	0.232	0.431		1.085	0.362	0.807	
Male	1.257	0.166	0.083		1.158	0.242	0.482	
Maternal Body Fat %	0.985	0.009	0.117		0.973	0.016	0.100	
Maternal Height	0.983	0.014	0.228		0.982	0.025	0.462	
Maternal leg: height ratio	0.043	0.109	0.212		0.164	0.797	0.710	
Maternal Grade Category (Base None)								
Some to 2	1.200	0.189	0.247		0.732	0.183	0.211	
2 or More	0.969	0.167	0.855		0.727	0.187	0.214	
Maternal Spanish Category (Base None)								
Some	0.995	0.144	0.973		0.882	0.203	0.585	
Proficient or More	0.763	0.153	0.177		0.594	0.210	0.140	
Distance to San Borja	1.003	0.001	0.026	*	1.004	0.002	0.023	*
Distance to San Borja^2	1.000	<0.001	0.204		1.000	0.000	0.140	
Distance Quintile (Base 1, mean 17.73km)								
2 (mean 29.90km)	1.603	0.366	0.039	*	0.688	0.262	0.325	
3 (mean 46.00 km)	1.614	0.371	0.037	*	1.345	0.474	0.401	
4 (mean 91.19km)	1.986	0.411	0.001	**	1.690	0.500	0.076	
5 (mean 149.51km)	1.869	0.464	0.012	*	1.421	0.550	0.364	
Season of Measurement (Base dry)								
Wet	1.068	0.140	0.612		0.636	0.133	0.031	*
Period of Measurement (Base 2002-2007)								
2008-2012	1.195	0.165	0.198		1.420	0.320	0.120	

Table A2.5. HAZ 0-2, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	β	SE	β	SE
Age (months)	-0.103***	0.006	-0.103***	0.006
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.023	0.156	0.035	0.156
Order 2-4, IBI 2+ years	-0.036	0.132	-0.062	0.131
Order 5+, IBI <2 years	-0.122	0.169	-0.232	0.176
Order 5+, IBI 2+ years	0.013	0.129	-0.032	0.129
Male	-0.345***	0.081	-0.345***	0.081
Maternal BF%	0.004	0.006	0.005	0.006
Maternal Height (cm)	0.020*	0.009	0.016	0.010
Maternal Grade Category (Base None)				
Some to 2	0.168	0.112	0.253*	0.118
2 or More	0.081	0.126	0.086	0.143
Maternal Spanish Category (Base None)				
Some	-0.028	0.104	0.106	0.120
Proficient or More	0.365*	0.148	0.580**	0.176
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	-0.115	0.125	1.339*	0.612
3 (mean 46.00 km)	-0.190	0.136	-0.158	0.655
4 (mean 91.19km)	-0.057	0.124	1.273	0.712
5 (mean 149.51km)	-0.101	0.170	0.607	1.040
Season of measurement 0=dry 1=wet	-0.080	0.078	-0.004	0.089
Period of measurement 0=02-07, 1=08-12	-0.247**	0.090	-0.219*	0.098
Constant	-2.792*	1.413	-3.933*	1.544
AIC	9598		9589.69	
Observations	2364		2364	

Table A2.6. HAZ 2-5, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	β	SE	β	SE
Age (months)	0.004*	0.002	0.004*	0.002
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.067	0.098	0.021	0.098
Order 2-4, IBI 2+ years	-0.010	0.074	-0.029	0.073
Order 5+, IBI <2 years	-0.028	0.100	-0.082	0.102
Order 5+, IBI 2+ years	-0.003	0.077	-0.017	0.077
Male	-0.034	0.051	-0.034	0.050
Maternal BF%	0.003	0.004	0.004	0.004
Maternal Height (cm)	0.049***	0.005	0.043***	0.006
Maternal Grade Category (Base None)				
Some to 2	-0.162*	0.068	-0.086	0.071
2 or More	-0.151	0.078	-0.147	0.087
Maternal Spanish Category (Base None)				
Some	-0.010	0.068	0.038	0.070
Proficient or More	0.342***	0.090	0.411***	0.098
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	-0.147	0.076	0.046	0.200
3 (mean 46.00 km)	0.010	0.080	0.685	0.508
4 (mean 91.19km)	-0.167*	0.075	-0.018	0.251
5 (mean 149.51km)	0.113	0.107	-1.050**	0.329
Season of measurement 0=dry 1=wet	0.012	0.040	0.029	0.044
Period of measurement 0=02-07, 1=08-12	0.042	0.053	0.060	0.056
Constant	-9.528***	0.823	-9.091***	0.855
AIC	11302.67		11232.94	
Observations	3597		3597	

Table A2.7. Odds of Stunting 0-2, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	OR	SE	OR	SE
Age (months)	1.104***	0.007	1.114***	0.008
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	1.179	0.199	1.218	0.216
Order 2-4, IBI 2+ years	1.137	0.174	1.195	0.188
Order 5+, IBI <2 years	1.183	0.228	1.453	0.297
Order 5+, IBI 2+ years	1.025	0.153	1.133	0.177
Male	1.481***	0.140	1.491***	0.148
Maternal BF%	0.995	0.007	0.992	0.007
Maternal Height (cm)	0.974*	0.011	0.977*	0.011
Maternal Grade Category (Base None)				
Some to 2	0.937	0.119	0.897	0.129
2 or More	0.925	0.136	1.009	0.174
Maternal Spanish Category (Base None)				
Some	0.927	0.111	0.894	0.122
Proficient or More	0.667*	0.116	0.532**	0.111
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	1.060	0.152	0.360	0.243
3 (mean 46.00 km)	1.178	0.182	1.827	1.690
4 (mean 91.19km)	1.065	0.153	0.514	0.388
5 (mean 149.51km)	1.304	0.242	0.624	0.632
Season of measurement 0=dry 1=wet	1.094	0.103	1.102	0.126
Period of measurement 0=02-07, 1=08-12	1.163	0.119	1.072	0.126
AIC	2913.17		2893.9	

Table A2.8. Odds of Stunting 2-5, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	OR	SE	OR	SE
Age (months)	0.986***	0.003	0.985***	0.003
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.845	0.139	0.908	0.156
Order 2-4, IBI 2+ years	1.155	0.160	1.204	0.174
Order 5+, IBI <2 years	0.963	0.168	1.102	0.199
Order 5+, IBI 2+ years	1.035	0.140	1.074	0.154
Male	1.019	0.089	1.012	0.092
Maternal BF%	0.995	0.006	0.994	0.007
Maternal Height (cm)	0.916***	0.010	0.921***	0.010
Maternal Grade Category (Base None)				
Some to 2	1.160	0.137	1.060	0.145
2 or More	1.159	0.161	1.226	0.204
Maternal Spanish Category (Base None)				
Some	0.954	0.108	0.880	0.111
Proficient or More	0.518***	0.084	0.440***	0.084
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	1.042	0.138	0.652	0.449
3 (mean 46.00 km)	0.912	0.131	0.361	0.376
4 (mean 91.19km)	1.154	0.153	0.800	0.609
5 (mean 149.51km)	0.818	0.133	5.303	6.541
Season of measurement 0=dry 1=wet	1.030	0.075	1.004	0.081
Period of measurement 0=02-07, 1=08-12	0.973	0.088	0.928	0.092
AIC	4772.04		4692.07	

Table A2.9. WHZ 0-2, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	β	SE	β	SE
Age (months)	-0.004	0.005	-0.005	0.005
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.044	0.129	-0.028	0.130
Order 2-4, IBI 2+ years	0.094	0.114	0.077	0.113
Order 5+, IBI <2 years	-0.209	0.142	-0.268	0.146
Order 5+, IBI 2+ years	-0.012	0.112	-0.073	0.114
Male	-0.082	0.070	-0.111	0.070
Maternal BF%	0.015**	0.005	0.017**	0.006
Maternal Height (cm)	0.005	0.008	0.001	0.009
Maternal Grade Category (Base None)				
Some to 2	-0.148	0.094	-0.088	0.106
2 or More	-0.041	0.111	-0.011	0.129
Maternal Spanish Category (Base None)				
Some	0.057	0.090	0.080	0.097
Proficient or More	0.075	0.128	0.058	0.141
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	-0.174	0.107	-0.815	0.517
3 (mean 46.00 km)	-0.266*	0.114	-1.270	0.694
4 (mean 91.19km)	-0.531***	0.106	-0.875	0.605
5 (mean 149.51km)	-0.314*	0.140	-1.446	1.145
Season of measurement 0=dry 1=wet	-0.147*	0.071	-0.250**	0.084
Period of measurement 0=02-07, 1=08-12	0.107	0.069	0.160*	0.077
Constant	-0.753	1.247	0.526	1.391
AIC	9098.99		9119.42	
Observations	2364		2364	

Table A2.10. WHZ 2-5, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	β	SE	β	SE
Age (months)	0.012***	0.002	0.012***	0.002
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.021	0.074	-0.007	0.077
Order 2-4, IBI 2+ years	-0.041	0.064	-0.050	0.066
Order 5+, IBI <2 years	-0.015	0.088	-0.019	0.086
Order 5+, IBI 2+ years	0.073	0.063	0.075	0.065
Male	0.026	0.041	0.021	0.041
Maternal BF%	0.022***	0.003	0.021***	0.003
Maternal Height (cm)	-0.007	0.005	-0.011*	0.005
Maternal Grade Category (Base None)				
Some to 2	0.119*	0.057	0.132*	0.059
2 or More	0.178**	0.063	0.166*	0.072
Maternal Spanish Category (Base None)				
Some	0.035	0.054	0.021	0.057
Proficient or More	0.227**	0.077	0.146	0.084
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	-0.083	0.062	0.197	0.172
3 (mean 46.00 km)	-0.043	0.070	-0.382	0.548
4 (mean 91.19km)	-0.264***	0.062	0.509*	0.223
5 (mean 149.51km)	-0.074	0.078	0.635	0.336
Season of measurement 0=dry 1=wet	-0.086*	0.037	-0.143***	0.040
Period of measurement 0=02-07, 1=08-12	-0.037	0.041	-0.069	0.044
Constant	0.328	0.735	0.438	0.792
AIC	10658.02		10629.2	
Observations	3597		3597	

Table A2.11. Odds of Wasting 0-2, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	OR	SE	OR	SE
Age (months)	0.975**	0.009	0.973**	0.009
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.892	0.238	0.986	0.282
Order 2-4, IBI 2+ years	0.941	0.213	0.914	0.217
Order 5+, IBI <2 years	1.541	0.395	1.738	0.502
Order 5+, IBI 2+ years	1.247	0.264	1.369	0.313
Male	1.216	0.163	1.315	0.189
Maternal BF%	0.980*	0.010	0.977*	0.011
Maternal Height (cm)	0.999	0.017	1.007	0.018
Maternal Grade Category (Base None)				
Some to 2	1.258	0.214	1.083	0.211
2 or More	1.068	0.221	0.955	0.228
Maternal Spanish Category (Base None)				
Some	0.974	0.157	1.009	0.184
Proficient or More	0.926	0.219	0.971	0.276
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	1.515	0.357	1.302	1.471
3 (mean 46.00 km)	1.588	0.391	1.809	2.794
4 (mean 91.19km)	2.048**	0.466	1.590	2.007
5 (mean 149.51km)	1.820*	0.469	2.188	3.402
Season of measurement 0=dry 1=wet	1.068	0.151	1.417*	0.248
Period of measurement 0=02-07, 1=08-12	1.351*	0.194	1.060	0.185
AIC	1641.93		1621.44	
Observations	2364		2260	

Table A2.12. Odds of Wasting 2-5, Distance Quintiles with and without village-level fixed effects

	No FE		Village FE	
	OR	SE	OR	SE
Age (months)	0.935***	0.010	0.932***	0.011
Birth Order * Birth Interval				
Order 2-4, IBI <2 years	0.759	0.354	0.683	0.348
Order 2-4, IBI 2+ years	1.384	0.480	1.223	0.436
Order 5+, IBI <2 years	1.907	0.768	1.771	0.732
Order 5+, IBI 2+ years	0.978	0.340	0.801	0.299
Male	1.193	0.265	1.225	0.289
Maternal BF%	0.969	0.018	0.970	0.019
Maternal Height (cm)	1.003	0.029	1.014	0.033
Maternal Grade Category (Base None)				
Some to 2	0.711	0.208	0.582	0.179
2 or More	0.657	0.214	0.463*	0.178
Maternal Spanish Category (Base None)				
Some	1.030	0.276	1.170	0.330
Proficient or More	0.819	0.361	0.858	0.407
Distance Quintile (Base 1, mean 17.73km)				
2 (mean 29.90km)	0.747	0.289	0.149	0.151
3 (mean 46.00 km)	1.150	0.457	3.851	4.723
4 (mean 91.19km)	1.625	0.534	0.516	0.592
5 (mean 149.51km)	1.191	0.488	0.699	0.901
Season of measurement 0=dry 1=wet	0.717	0.159	0.911	0.234
Period of measurement 0=02-07, 1=08-12	1.464	0.317	1.449	0.367
AIC	856.16		849.56	
Observations	3597		2866	

Figure AA.3.1. Prevalence of coresidence with grandparents by country and round

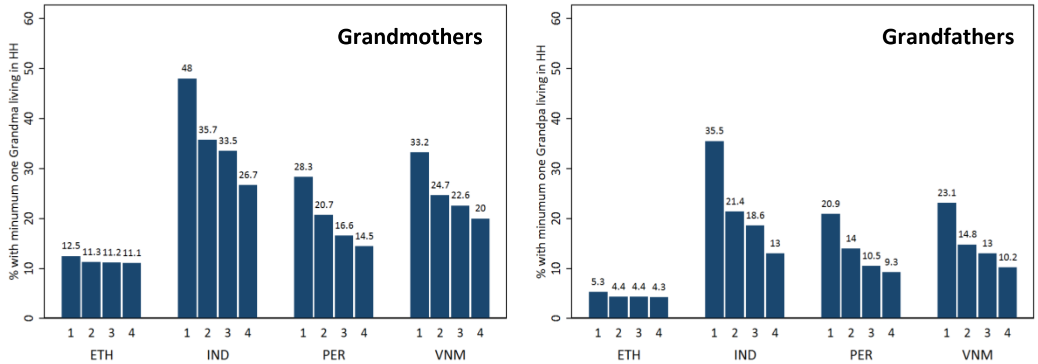


Table AA.3.1. Household Characteristics by Grandparental Coresidence, Ethiopia

Ethiopia	**No Grandparents**			**With Grandparents**		
				Round 1		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1721	0.53	0.50	278	0.52	0.50
Age (Months)	1721	11.67	3.57	278	11.69	3.58
Total Siblings <5 Years	**1721**	**0.64**	**0.64**	**278**	**0.34**	**0.53**
Wealth Index (0-1)	**1701**	**0.20**	**0.17**	**276**	**0.28**	**0.19**
Parent Configuration						
One Resides, Other Away	1721	0.08	0.27	278	0.52	0.50
One or Both Deceased	1721	0.02	0.12	278	0.05	0.21
Other Living Arrangement	1721	0.01	0.10	278	0.05	0.23
Caregiver Education	1614	5.86	7.39	269	6.51	7.51
				Round 2		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1681	0.53	0.50	231	0.50	0.50
Age (Months)	1681	61.86	3.86	231	61.84	3.76
Total Siblings <5 Years	**1681**	**0.69**	**0.66**	**231**	**0.30**	**0.52**
Wealth Index (0-1)	**1672**	**0.28**	**0.17**	**230**	**0.33**	**0.20**
Parent Configuration						
One Resides, Other Away	1681	0.12	0.32	231	0.50	0.50
One or Both Deceased	1681	0.06	0.23	231	0.12	0.32
Other Living Arrangement	1681	0.01	0.09	231	0.08	0.27
Caregiver Education	1574	5.93	7.27	223	7.70	9.05
				Round 3		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1525	0.53	0.50	359	0.52	0.50
Age (Months)	1526	97.45	4.09	358	97.64	3.87
Total Siblings <5 Years	**1527**	**0.98**	**0.84**	**359**	**0.66**	**0.80**
Wealth Index (0-1)	**1526**	**0.32**	**0.17**	**359**	**0.37**	**0.19**
Parent Configuration						
One Resides, Other Away	1527	0.12	0.32	359	0.27	0.44
One or Both Deceased	1527	0.06	0.24	359	0.11	0.31
Other Living Arrangement	1527	0.02	0.12	359	0.27	0.45
Caregiver Education	**1430**	**5.97**	**7.41**	**343**	**6.91**	**8.06**

***Bold denotes t-test, chi-squared test p<0.05**

Table AA.3.2. Household Characteristics by Grandparental Coresidence, India

India	No Grandparents			With Grandparents		
			Round 1			
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	944	0.53	0.50	1067	0.55	0.50
Age (Months)	**944**	**11.96**	**3.45**	**1067**	**11.70**	**3.53**
Total Siblings <5 Years	944	0.26	0.49	1067	0.29	0.58
Wealth Index (0-1)	943	0.40	0.20	1063	0.41	0.20
Parent Configuration						
One Resides, Other Away	944	0.01	0.08	1067	0.01	0.09
One or Both Deceased	944	0.00	0.06	1067	0.01	0.07
Other Living Arrangement	944	0.00	0.03	1067	0.00	0.05
Caregiver Education	**940**	**4.72**	**4.88**	**1067**	**5.76**	**5.72**
			Round 2			
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1176	0.52	0.50	774	0.55	0.50
Age (Months)	1176	64.35	3.89	774	64.15	3.89
Total Siblings <5 Years	**1176**	**0.50**	**0.62**	**774**	**0.60**	**0.66**
Wealth Index (0-1)	**1175**	**0.45**	**0.20**	**773**	**0.47**	**0.19**
Parent Configuration						
One Resides, Other Away	1176	0.02	0.14	774	0.05	0.21
One or Both Deceased	1176	0.02	0.13	774	0.04	0.19
Other Living Arrangement	1176	0.00	0.05	774	0.00	0.05
Caregiver Education	**1173**	**5.03**	**4.99**	**773**	**5.95**	**5.95**
			Round 3			
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	808	0.54	0.50	1122	0.53	0.50
Age (Months)	809	95.50	3.89	1122	95.35	3.79
Total Siblings <5 Years	**809**	**0.33**	**0.57**	**1122**	**0.47**	**0.65**
Wealth Index (0-1)	**809**	**0.50**	**0.18**	**1120**	**0.52**	**0.18**
Parent Configuration						
One Resides, Other Away	809	0.02	0.16	1122	0.04	0.19
One or Both Deceased	809	0.04	0.20	1122	0.03	0.18
Other Living Arrangement	809	0.00	0.07	1122	0.04	0.19
Caregiver Education	**806**	**4.91**	**5.03**	**1121**	**5.70**	**5.58**

***Bold denotes t-test, chi-squared test p<0.05**

Table AA.3.3. Household Characteristics by Grandparental Coresidence, Peru

Peru		No Grandparents			With Grandparents	
			Round 1			
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	**1407**	**0.50**	**0.50**	**645**	**0.49**	**0.50**
Age (Months)	1407	11.63	3.55	645	11.34	3.52
Total Siblings <5 Years	**1407**	**0.55**	**0.66**	**645**	**0.28**	**0.53**
Wealth Index (0-1)	**1403**	**0.41**	**0.23**	**644**	**0.46**	**0.25**
Parent Configuration						
One Resides, Other Away	1407	0.07	0.25	645	0.33	0.47
One or Both Deceased	1407	0.00	0.05	645	0.01	0.12
Other Living Arrangement	1407	0.00	0.05	645	0.02	0.14
Caregiver Education	**1349**	**7.31**	**4.62**	**614**	**8.69**	**4.44**
			Round 2			
Variable Obs	**Mean**	**Std. Dev.**	**Min**	**Obs**	**Mean**	**Std. Dev.**
Male	1510	0.51	0.50	453	0.48	0.50
Age (Months)	1510	63.43	4.72	453	63.64	4.66
Total Siblings <5 Years	**1510**	**0.52**	**0.63**	**453**	**0.39**	**0.59**
Wealth Index (0-1)	**1510**	**0.46**	**0.23**	**453**	**0.50**	**0.25**
Parent Configuration						
One Resides, Other Away	1510	0.10	0.30	453	0.45	0.50
One or Both Deceased	1510	0.01	0.09	453	0.02	0.12
Other Living Arrangement	1510	0.00	0.06	453	0.03	0.17
Caregiver Education	**1510**	**7.53**	**4.58**	**453**	**8.47**	**4.62**
			Round 3			
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1540	0.52	0.50	365	0.45	0.50
Age (Months)	1565	94.95	3.61	377	94.88	3.62
Total Siblings <5 Years	**1675**	**0.67**	**0.78**	**377**	**0.49**	**0.70**
Wealth Index (0-1)	**1559**	**0.54**	**0.21**	**376**	**0.57**	**0.22**
Parent Configuration						
One Resides, Other Away	1675	0.13	0.34	377	0.40	0.49
One or Both Deceased	1675	0.01	0.10	377	0.02	0.14
Other Living Arrangement	1675	0.08	0.28	377	0.17	0.37
Caregiver Education	**1587**	**7.49**	**4.58**	**376**	**8.83**	**4.58**

***Bold denotes t-test, chi-squared test p<0.05**

Table AA.3.4. Household Characteristics by Grandparental Coresidence, Vietnam

Vietnam	**No Grandparents**			**With Grandparents**		
				Round 1		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	**1296**	**0.51**	**0.50**	**704**	**0.52**	**0.50**
Age (Months)	1296	11.74	3.16	704	11.40	3.15
Total Siblings <5 Years	**1296**	**0.34**	**0.53**	**704**	**0.23**	**0.46**
Wealth Index (0-1)	**1296**	**0.42**	**0.21**	**703**	**0.47**	**0.22**
Parent Configuration						
One Resides, Other Away	1296	0.01	0.11	704	0.06	0.24
One or Both Deceased	1296	0.00	0.03	704	0.00	0.07
Other Living Arrangement	1296	0.00	0.03	704	0.00	0.07
Caregiver Education	1294	6.95	3.69	698	6.95	3.72
				Round 2		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1455	0.51	0.50	515	0.53	0.50
Age (Months)	**1455**	**63.17**	**3.76**	**515**	**62.72**	**3.68**
Total Siblings <5 Years	1455	0.32	0.51	516	0.32	0.51
Wealth Index (0-1)	**1443**	**0.48**	**0.18**	**509**	**0.51**	**0.18**
Parent Configuration						
One Resides, Other Away	1455	0.03	0.17	516	0.14	0.35
One or Both Deceased	1455	0.01	0.12	516	0.02	0.13
Other Living Arrangement	1455	0.00	0.07	516	0.03	0.16
Caregiver Education	1452	7.06	3.57	511	6.93	3.92
				Round 3		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Male	1137	0.50	0.50	824	0.52	0.50
Age (Months)	**1134**	**96.73**	**3.75**	**817**	**96.32**	**3.80**
Total Siblings <5 Years	**1140**	**0.38**	**0.57**	**824**	**0.45**	**0.58**
Wealth Index (0-1)	1102	0.60	0.19	805	0.61	0.19
Parent Configuration						
One Resides, Other Away	1140	0.04	0.20	824	0.09	0.29
One or Both Deceased	1140	0.02	0.13	824	0.03	0.16
Other Living Arrangement	1140	0.01	0.11	824	0.10	0.30
Caregiver Education	1135	6.99	3.56	818	7.01	3.75

***Bold denotes t-test, chi-squared test p<0.05**

Table AB.3.1. Round 1: Weight-for-Age, Height-for-Age, and BMI for age z-scores, including country controls and interactions

	WAZ			HAZ			BMIZ		
	β	Sig	SE	β	Sig	SE	β	Sig	SE
Country (Base Ethiopia)									
India	-0.449	***	0.049	-0.110		0.059	-0.527	***	0.053
Peru	0.805	***	0.044	-0.189	***	0.053	1.270	***	0.048
Vietnam	0.038		0.046	0.007		0.055	0.061		0.050
Male	-0.211	***	0.026	-0.274	***	0.032	-0.080	**	0.029
Age (months)	-0.053	***	0.004	-0.087	***	0.005	0.005		0.004
Coresident Siblings < 5	-0.154	***	0.023	-0.130	***	0.028	-0.093	***	0.025
Wealth Index	1.401	***	0.068	1.367	***	0.083	0.789	***	0.075
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.129	*	0.056	-0.175	**	0.067	-0.040		0.061
One or Both Parents Deceased	-0.324	*	0.148	-0.331		0.179	-0.139		0.162
Other Living Arrangement	-0.053		0.173	-0.213		0.201	0.051		0.184
Caregiver Education	0.019	***	0.003	0.027	***	0.003	0.003		0.003
Maternal Grandma Coresides	0.145		0.109	0.085		0.133	0.143		0.118
Maternal Grandpa Coresides	-0.194		0.196	-0.366		0.238	-0.133		0.213
Paternal Grandma Coresides	0.196		0.229	0.244		0.274	0.065		0.249
Paternal Grandpa Coresides	-0.272		0.189	-0.005		0.228	-0.332		0.206
Grandparent - Country Interactions (Base Ethiopia)									
Maternal Grandma Coresides - India	0.019		0.175	0.096		0.214	-0.014		0.191
Maternal Grandma Coresides - Peru	-0.016		0.138	0.042		0.168	-0.026		0.150
Maternal Grandma Coresides - Vietnam	-0.177		0.178	0.081		0.218	-0.248		0.194
Maternal Grandpa Coresides - India	0.235		0.263	0.474		0.320	0.049		0.287
Maternal Grandpa Coresides - Peru	0.273		0.220	0.404		0.268	0.168		0.240
Maternal Grandpa Coresides - Vietnam	0.468		0.262	0.427		0.319	0.380		0.285
Paternal Grandma Coresides - India	-0.212		0.238	-0.271		0.285	-0.002		0.259
Paternal Grandma Coresides - Peru	0.021		0.262	-0.169		0.315	0.162		0.286
Paternal Grandma Coresides - Vietnam	-0.194		0.243	-0.298		0.292	-0.009		0.265
Paternal Grandpa Coresides - India	0.253		0.202	0.047		0.243	0.243		0.220
Paternal Grandpa Coresides - Peru	0.157		0.236	-0.047		0.286	0.206		0.258
Paternal Grandpa Coresides - Vietnam	0.300		0.211	-0.015		0.255	0.357		0.230
Constant	-0.983	***	0.060	-0.705		0.073	-0.843		0.066
AIC	23689			26789			25025		
Observations	7628			7666			7635		

Table AB.3.2. Round 2: Weight-for-Age, Height-for-Age, and BMI for age z-scores, including country controls and interactions

	WAZ			HAZ			BMIZ		
	β	Sig	SE	β	Sig	SE	β	Sig	SE
Country (Base Ethiopia)									
India	-0.753	***	0.039	-0.485	***	0.040	-0.622	***	0.043
Peru	0.514	***	0.036	-0.420	***	0.038	1.208	***	0.040
Vietnam	-0.061		0.037	-0.277	***	0.039	0.204	***	0.042
Male	0.071	**	0.022	-0.066	**	0.023	0.183	***	0.024
Age (months)	-0.009	***	0.003	0.003		0.003	-0.016	***	0.003
Coresident Siblings < 5	-0.025		0.019	-0.080	***	0.019	0.058	**	0.021
Wealth Index	1.440	***	0.061	1.551	***	0.064	0.503	***	0.068
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.079	*	0.040	-0.040		0.042	-0.060		0.044
One or Both Parents Deceased	-0.056		0.068	-0.097		0.071	0.041		0.076
Other Living Arrangement	-0.182		0.113	-0.188		0.118	-0.064		0.127
Caregiver Education	0.022	***	0.002	0.023	***	0.002	0.009	***	0.002
Maternal Grandma Coresides	-0.067		0.090	0.037		0.095	-0.092		0.101
Maternal Grandpa Coresides	0.006		0.173	0.091		0.181	-0.132		0.194
Paternal Grandma Coresides	0.124		0.150	0.242		0.157	-0.020		0.167
Paternal Grandpa Coresides	-0.060		0.163	-0.107		0.171	-0.003		0.183
Grandparent - Country Interactions (Base Ethiopia)									
Maternal Grandma Coresides - India	0.367	*	0.149	0.233		0.155	0.251		0.166
Maternal Grandma Coresides - Peru	0.149		0.118	0.042		0.124	0.108		0.132
Maternal Grandma Coresides - Vietnam	0.389	*	0.157	0.061		0.165	0.316		0.176
Maternal Grandpa Coresides - India	-0.169		0.234	-0.298		0.245	0.122		0.262
Maternal Grandpa Coresides - Peru	-0.037		0.196	-0.223		0.205	0.213		0.219
Maternal Grandpa Coresides - Vietnam	-0.118		0.239	0.027		0.251	-0.018		0.268
Paternal Grandma Coresides - India	-0.153		0.160	-0.250		0.167	0.020		0.178
Paternal Grandma Coresides - Peru	-0.045		0.193	-0.291		0.202	0.170		0.216
Paternal Grandma Coresides - Vietnam	-0.058		0.167	-0.230		0.174	0.125		0.186
Paternal Grandpa Coresides - India	0.128		0.176	0.204		0.184	-0.017		0.196
Paternal Grandpa Coresides - Peru	0.075		0.218	0.221		0.228	-0.123		0.243
Paternal Grandpa Coresides - Vietnam	0.082		0.186	0.176		0.194	-0.039		0.208
Constant	-1.328	***	0.169	-2.132	***	0.177	0.046		0.188
AIC	20875			21486			22547		
Observations	7616			7598			7613		

Table AB.3.3. Round 3: Weight-for-Age, Height-for-Age, and BMI for age z-scores, including country controls and interactions

	WAZ			HAZ			BMIZ		
	β	Sig	SE	β	Sig	SE	β	Sig	SE
Country (Base Ethiopia)									
India	-0.647	***	0.048	-0.617	***	0.046	-0.346	***	0.052
Peru	0.800	***	0.041	-0.402	***	0.040	1.549	***	0.045
Vietnam	-0.187	***	0.046	-0.495	***	0.044	0.253	***	0.050
Male	-0.054	*	0.024	-0.101	***	0.023	0.094	***	0.026
Age (months)	-0.012	***	0.003	-0.008	**	0.003	-0.015	***	0.003
Coresident Siblings < 5	-0.065	***	0.018	-0.065	***	0.017	-0.026		0.020
Wealth Index	1.929	***	0.070	1.781	***	0.067	0.988	***	0.077
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.021		0.042	-0.050		0.040	0.052		0.046
One or Both Parents Deceased	-0.094		0.067	-0.142	*	0.064	0.037		0.073
Other Living Arrangement	-0.154	*	0.065	-0.206	***	0.062	0.008		0.071
Caregiver Education	0.027	***	0.002	0.022	***	0.002	0.018	***	0.003
Maternal Grandma Coresides	0.049		0.082	0.060		0.079	0.003		0.090
Maternal Grandpa Coresides	0.174		0.147	0.072		0.141	0.204		0.162
Paternal Grandma Coresides	0.086		0.129	-0.060		0.123	0.194		0.141
Paternal Grandpa Coresides	-0.121		0.132	0.129		0.127	-0.323	*	0.145
Grandparent - Country Interactions (Base Ethiopia)									
Maternal Grandma Coresides - India	0.117		0.133	0.143		0.127	0.047		0.146
Maternal Grandma Coresides - Peru	-0.166		0.121	-0.057		0.116	-0.189		0.133
Maternal Grandma Coresides - Vietnam	0.344	*	0.139	-0.033		0.134	0.526	***	0.153
Maternal Grandpa Coresides - India	-0.269		0.197	-0.122		0.189	-0.282		0.217
Maternal Grandpa Coresides - Peru	-0.058		0.185	0.001		0.178	-0.113		0.203
Maternal Grandpa Coresides - Vietnam	-0.156		0.200	0.167		0.192	-0.460	*	0.220
Paternal Grandma Coresides - India	-0.028		0.141	0.122		0.135	-0.144		0.155
Paternal Grandma Coresides - Peru	-0.068		0.197	0.215		0.190	-0.308		0.217
Paternal Grandma Coresides - Vietnam	0.039		0.147	0.140		0.141	-0.116		0.161
Paternal Grandpa Coresides - India	0.088		0.145	-0.170		0.139	0.331	*	0.160
Paternal Grandpa Coresides - Peru	0.233		0.218	-0.185		0.209	0.495	*	0.239
Paternal Grandpa Coresides - Vietnam	0.191		0.154	-0.023		0.148	0.349	*	0.169
Constant	-1.183	***	0.310	-1.027	***	0.300	-0.286		0.341
AIC	21637			21015			23018		
Observations	7435			7430			7430		

Table AB.3.4. Ethiopia: Child Round (age)- level interactions by outcome

	WAZ			HAZ			BMIZ		
	β	Sig	SE	β	Sig	SE	β	Sig	SE
Round 2 (Base 1)	1.024	***	0.288	2.242	***	0.322	-0.395		0.265
Round 3 (Base 1)	1.441	**	0.490	4.069	***	0.550	-1.436	**	0.450
Male	-0.116	**	0.041	-0.244	***	0.049	0.060		0.040
Age (months)	-0.022	***	0.006	-0.046	***	0.006	0.008		0.005
Coresident Siblings <5	-0.102	***	0.025	-0.076	*	0.029	-0.073	**	0.027
Wealth Index	1.861	***	0.110	1.596	***	0.132	1.150	***	0.112
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.097		0.053	-0.073		0.065	-0.049		0.057
One or Both Parents Deceased	-0.136		0.077	-0.136		0.094	-0.072		0.078
Other Living Arrangement	-0.031		0.093	-0.014		0.119	-0.129		0.103
Caregiver Education	0.008	**	0.003	0.009	*	0.003	0.004		0.003
Maternal Grandma Coresides	0.103		0.119	0.029		0.154	0.127		0.139
Maternal Grandpa Coresides	-0.235		0.218	-0.410		0.247	-0.162		0.281
Paternal Grandma Coresides	0.202		0.193	0.262		0.267	0.049		0.245
Paternal Grandpa Coresides	-0.275		0.216	-0.007		0.311	-0.341		0.191
Grandparent - Round Interactions (Base Coresides, Round 1)									
Maternal Grandma Coresides - Round 2	-0.218		0.125	-0.008		0.164	-0.282		0.172
Maternal Grandma Coresides - Round 3	-0.058		0.122	0.008		0.153	-0.082		0.153
Maternal Grandpa Coresides - Round 2	0.241		0.223	0.560		0.295	-0.020		0.352
Maternal Grandpa Coresides - Round 3	0.375		0.205	0.454		0.240	0.366		0.299
Paternal Grandma Coresides - Round 2	-0.091		0.243	-0.020		0.323	-0.097		0.306
Paternal Grandma Coresides - Round 3	-0.101		0.214	-0.312		0.282	0.168		0.272
Paternal Grandpa Coresides - Round 2	0.214		0.236	-0.006		0.335	0.246		0.243
Paternal Grandpa Coresides - Round 3	0.136		0.209	0.118		0.310	0.047		0.227
Constant	-1.473	***	0.085	-1.190	***	0.104	-1.051	***	0.080
AIC	15854			18475			17242		
Observations	5268			5336			5276		

Table AB.3.5. India: Child Round (age)- level interactions by outcome

	WAZ			HAZ			BMIZ		
	β	Sig	SE	β	Sig	SE	β	Sig	SE
Round 2 (Base 1)	1.063	***	0.271	0.894	**	0.284	0.672	*	0.273
Round 3 (Base 1)	1.837	***	0.430	1.794	***	0.450	0.882	*	0.429
Male	-0.153	***	0.038	-0.137	**	0.042	-0.082	*	0.039
Age (months)	-0.028	***	0.005	-0.025	***	0.005	-0.016	**	0.005
Coresident Siblings <5	-0.040		0.023	-0.040		0.026	-0.003		0.026
Wealth Index	1.224	***	0.096	1.341	***	0.104	0.430	***	0.101
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.086		0.103	-0.073		0.097	0.019		0.101
One or Both Parents Deceased	-0.103		0.105	-0.093		0.113	0.034		0.102
Other Living Arrangement	-0.092		0.161	-0.090		0.215	0.003		0.163
Caregiver Education	0.021	***	0.004	0.023	***	0.004	0.010	**	0.003
Maternal Grandma Coresides	0.194		0.133	0.253		0.150	0.102		0.136
Maternal Grandpa Coresides	0.014		0.155	0.060		0.209	-0.076		0.173
Paternal Grandma Coresides	-0.015		0.061	-0.007		0.078	0.053		0.065
Paternal Grandpa Coresides	-0.018		0.065	0.040		0.085	-0.088		0.069
Grandparent - Round Interactions (Base Coresides, Round 1)									
Maternal Grandma Coresides - Round 2	0.097		0.114	-0.019		0.157	0.075		0.195
Maternal Grandma Coresides - Round 3	-0.028		0.108	-0.069		0.141	-0.036		0.178
Maternal Grandpa Coresides - Round 2	-0.175		0.171	-0.213		0.213	0.001		0.255
Maternal Grandpa Coresides - Round 3	-0.105		0.14	-0.108		0.2	-0.018		0.225
Paternal Grandma Coresides - Round 2	-0.001		0.064	0.005		0.081	-0.039		0.092
Paternal Grandma Coresides - Round 3	0.079		0.057	0.069		0.075	0.005		0.090
Paternal Grandpa Coresides - Round 2	0.084		0.074	0.041		0.09	0.075		0.103
Paternal Grandpa Coresides - Round 3	-0.003		0.06	-0.08		0.079	0.11		0.095
Constant	-1.737	***	0.083	-1.626	***	0.091	-1.027	***	0.068
AIC	16530.12			18062.34			17965.53		
Observations	5843			5809			5841		

Table AB.3.6. Peru: Child Round (age)- level interactions by outcome

	WAZ			HAZ			BMIZ		
	β	Sig	SE	β	Sig	SE	β	Sig	SE
Round 2 (Base 1)	0.366		0.239	0.458		0.242	0.437		0.241
Round 3 (Base 1)	0.926	*	0.384	1.199	**	0.387	0.565		0.385
Male	0.006		0.040	-0.092	*	0.039	0.146	***	0.039
Age (months)	-0.014	**	0.005	-0.014	**	0.005	-0.010	*	0.005
Coresident Siblings <5	-0.073	**	0.024	-0.059	*	0.023	-0.042		0.024
Wealth Index	1.360	***	0.107	1.267	***	0.105	0.719	***	0.106
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.053		0.051	-0.054		0.049	-0.033		0.053
One or Both Parents Deceased	-0.257	*	0.131	-0.191		0.161	-0.169		0.139
Other Living Arrangement	-0.211		0.124	-0.221		0.128	0.024		0.145
Caregiver Education	0.049	***	0.005	0.065	***	0.005	0.009		0.005
Maternal Grandma Coresides	0.101		0.082	0.081		0.081	0.121		0.106
Maternal Grandpa Coresides	0.086		0.094	0.041		0.097	0.047		0.112
Paternal Grandma Coresides	0.229	*	0.115	0.093		0.118	0.223		0.131
Paternal Grandpa Coresides	-0.134		0.149	-0.076		0.123	-0.118		0.166
Grandparent - Round Interactions (Base Coresides, Round 1)									
Maternal Grandma Coresides - Round 2	-0.056		0.096	-0.015		0.100	-0.139		0.127
Maternal Grandma Coresides - Round 3	-0.207		0.110	-0.105		0.099	-0.266	*	0.127
Maternal Grandpa Coresides - Round 2	-0.136		0.112	-0.190		0.117	0.022		0.142
Maternal Grandpa Coresides - Round 3	0.030		0.132	-0.002		0.119	0.073		0.147
Paternal Grandma Coresides - Round 2	-0.141		0.137	-0.143		0.145	-0.062		0.168
Paternal Grandma Coresides - Round 3	-0.232		0.170	0.033		0.160	-0.342		0.177
Paternal Grandpa Coresides - Round 2	0.140		0.173	0.214		0.158	-0.040		0.207
Paternal Grandpa Coresides - Round 3	0.303		0.218	0.049		0.181	0.322		0.229
Constant	-0.998	***	0.073	-2.119	***	0.073	0.451	***	0.078
AIC	16585			16639			17778		
Observations	5769			5762			5769		

Table AB.3.7. Vietnam: Child Round (age)- level interactions by outcome

	WAZ			HAZ			BMIZ		
	β	Sig	SE†	β	Sig	SE†	β	Sig	SE†
Round 2 (Base 1)	1.340	***	0.293	0.864	**	0.277	1.277	***	0.295
Round 3 (Base 1)	2.068	***	0.482	1.710	***	0.456	1.579	**	0.487
Male	0.011		0.042	-0.110	**	0.040	0.145	***	0.041
Age (months)	-0.030	***	0.006	-0.023	***	0.005	-0.023	***	0.006
Coresident Siblings <5	-0.076	*	0.030	-0.167	***	0.029	0.066	*	0.030
Wealth Index	1.233	***	0.129	1.344	***	0.127	0.510	***	0.121
Parent Configuration (Baseline Both Reside)									
One Parent Resides in HH, Other Away	-0.072		0.082	-0.108		0.081	0.002		0.080
One or Both Parents Deceased	0.010		0.182	-0.092		0.143	0.135		0.188
Other Living Arrangement	-0.265	*	0.115	-0.353	***	0.106	0.001		0.124
Caregiver Education	0.062	***	0.008	0.052	***	0.007	0.040	***	0.007
Maternal Grandma Coresides	-0.037		0.170	0.161		0.167	-0.111		0.129
Maternal Grandpa Coresides	0.257		0.190	0.028		0.195	0.260		0.157
Paternal Grandma Coresides	0.018		0.081	-0.034		0.092	0.066		0.071
Paternal Grandpa Coresides	0.041		0.091	-0.006		0.106	0.029		0.082
Grandparent - Round Interactions (Base Coresides, Round 1)									
Maternal Grandma Coresides - Round 2	0.372		0.220	-0.043		0.166	0.334		0.193
Maternal Grandma Coresides - Round 3	0.460	**	0.164	-0.109		0.147	0.659	***	0.167
Maternal Grandpa Coresides - Round 2	-0.413		0.255	0.079		0.203	-0.460		0.236
Maternal Grandpa Coresides - Round 3	-0.266		0.182	0.204		0.172	-0.543	**	0.194
Paternal Grandma Coresides - Round 2	0.054		0.092	0.051		0.095	0.039		0.087
Paternal Grandma Coresides - Round 3	0.104		0.090	0.121		0.095	0.002		0.097
Paternal Grandpa Coresides - Round 2	-0.019		0.110	0.073		0.119	-0.073		0.107
Paternal Grandpa Coresides - Round 3	0.036		0.102	0.124		0.110	-0.003		0.112
Constant	-1.590	***	0.090	-1.685	***	0.087	-0.753	***	0.090
AIC	17426			16872			17733		
Observations	5799			5787			5792		

Table AB.3.8. Weight-for-height and height-for-age z-scores stratified by country and round: Ethiopia

	WAZ						HAZ					
	Round 1		Round 2		Round 3		Round 1		Round 2		Round 3	
	β	p	β	p	β	p	β	p	β	p	β	p
Male	-0.296	<0.001	0.054	0.203	-0.107	0.014	-0.447	<0.001	-0.126	0.014	-0.158	0.003
Age of child in months	-0.069	<0.001	-0.014	0.013	0.006	0.228	-0.122	<0.001	-0.023	0.001	-0.004	0.521
Total # of Sibs in HHH <5	-0.157	0.004	-0.051	0.151	-0.111	<0.001	-0.049	0.478	-0.102	0.017	-0.088	0.012
Wealth Index	2.683	<0.001	1.370	<0.001	1.552	<0.001	1.747	<0.001	1.471	0.000	1.545	<0.001
Parent Living Arrangement (b Both)												
One parent home, other away	-0.197	0.073	-0.060	0.350	-0.031	0.639	-0.240	0.085	0.012	0.880	-0.007	0.930
One or both parents deceased	-0.407	0.086	-0.091	0.311	-0.118	0.179	-0.601	0.043	-0.102	0.348	-0.065	0.544
Status unknown	-0.004	0.988	0.229	0.178	-0.131	0.216	-0.116	0.734	0.158	0.442	-0.024	0.854
Caregiver Education	0.009	0.051	0.007	0.013	0.007	0.016	0.012	0.040	0.008	0.021	0.006	0.117
M Grandma	0.081	0.552	-0.092	0.300	0.065	0.391	0.135	0.441	-0.012	0.908	0.026	0.780
M Grandpa	-0.276	0.242	0.002	0.992	0.151	0.244	-0.326	0.282	0.108	0.587	0.027	0.863
P Grandma	0.145	0.598	0.144	0.309	0.103	0.363	0.239	0.491	0.250	0.143	-0.066	0.634
P Grandpa	-0.317	0.164	-0.052	0.739	-0.097	0.415	-0.013	0.964	-0.069	0.715	0.104	0.470
Unclassified grandma	**-0.543**	**0.017**					-0.024	0.934				
Unclassified grandpa	0.687	0.156					-0.180	0.750				
Constant	-0.956	<0.001	-0.923	0.007	-2.662	0.000	-0.236	0.163	-0.391	0.345	-1.179	0.073
AIC	5957.33		4671.49		4674.75		7097.38		5357.3		5350.38	
Observations	1717		1785		1766		1789		1784		1763	

Table AB.3.9. Body mass index-for-age z-scores stratified by country and round: Ethiopia

	BMI					
	Round 1		Round 2		Round 3	
	β	p	β	p	β	p
Male	-0.098	0.167	0.219	<0.001	0.062	0.231
Age of child in months	0.019	0.058	0.006	0.351	0.002	0.714
Total # of Sibs in HHH <5	-0.163	0.006	0.026	0.546	-0.085	0.012
Wealth Index	2.340	<0.001	0.501	0.001	0.692	<0.001
Parent Living Arrangement (b Both)						
One parent home, other away	-0.049	0.676	-0.089	0.264	0.011	0.887
One or both parents deceased	-0.138	0.589	-0.030	0.788	-0.076	0.470
Status unknown	-0.348	0.241	0.154	0.458	-0.163	0.195
Caregiver Education	0.005	0.291	0.003	0.399	0.006	0.085
M Grandma	-0.010	0.944	-0.081	0.458	0.057	0.525
M Grandpa	-0.277	0.277	-0.156	0.436	0.215	0.166
P Grandma	0.000	0.999	-0.001	0.997	0.230	0.088
P Grandpa	-0.360	0.142	-0.036	0.849	-0.262	0.064
Unclassified grandma	**-0.647**	**0.007**				
Unclassified grandpa	0.872	0.094				
Constant	-1.276	<0.001	-1.271	0.002	-1.744	0.005
AIC	6240.45		5396.1		5290.81	
Observations	1724		1785		1767	

Table AB.3.10. Weight-for-height and height-for-age z-scores stratified by country and round: India

	WAZ						HAZ					
	Round 1		Round 2		Round 3		Round 1		Round 2		Round 3	
	β	p	β	p	β	p	β	p	β	p	β	p
Male	-0.200	<0.001	-0.050	0.229	-0.213	<0.001	-0.199	0.002	-0.105	0.016	-0.112	0.013
Age of child in months	-0.046	<0.001	-0.027	<0.001	-0.015	0.012	-0.076	<0.001	-0.001	0.795	-0.007	0.245
Total # of Sibs in HHH <5	-0.057	0.206	-0.003	0.920	-0.049	0.182	-0.074	0.215	-0.023	0.498	-0.034	0.357
Wealth Index	1.106	<0.001	1.039	<0.001	1.652	<0.001	1.118	0.000	1.300	<0.001	1.691	<0.001
Parent Living Arrangement (b Both)												
One parent home, other away	-0.156	0.583	-0.130	0.293	-0.011	0.932	-0.387	0.299	-0.044	0.735	-0.016	0.902
One or both parents deceased	-0.163	0.653	-0.044	0.740	-0.091	0.449	0.407	0.419	0.029	0.839	-0.215	0.072
Status unknown	0.600	0.268	-0.347	0.390	-0.126	0.426	-0.054	0.940	0.002	0.997	-0.118	0.451
Caregiver Education	0.020	<0.001	0.014	<0.001	0.030	<0.001	0.034	<0.001	0.013	0.002	0.022	<0.001
M Grandma	0.171	0.196	**0.277**	**0.014**	0.164	0.106	0.202	0.249	**0.253**	**0.033**	**0.198**	**0.049**
M Grandpa	0.030	0.860	-0.113	0.453	-0.119	0.344	0.083	0.707	-0.181	0.258	-0.062	0.623
P Grandma	-0.021	0.743	-0.012	0.825	0.058	0.296	-0.032	0.700	0.005	0.934	0.059	0.283
P Grandpa	-0.017	0.801	0.065	0.288	-0.030	0.609	0.036	0.683	0.091	0.161	-0.047	0.416
Unclassified grandma	-0.155	0.445					-0.041	0.879				
Unclassified grandpa	-0.002	0.994					-0.081	0.797				
Constant	-1.430	<0.001	-0.693	0.044	-1.344	0.018	-0.927	<0.001	-2.190	<0.001	-1.724	0.002
AIC	5951.81		5088.52		5403.34		6948.62		5279.25		5360.05	
Observations	1984		1937		1922		1961		1931		1917	

Table AB.3.11: Body mass index-for-age z-scores stratified by country and round: India

	BMIZ					
	Round 1		Round 2		Round 3	
	β	p	β	p	β	p
Male	-0.114	0.031	-0.003	0.944	-0.129	0.018
Age of child in months	0.012	0.102	-0.033	<0.001	-0.025	<0.001
Total # of Sibs in HHH <5	0.011	0.824	0.032	0.381	-0.030	0.503
Wealth Index	0.525	<0.001	0.160	0.198	0.684	<0.001
Parent Living Arrangement (b Both)						
One parent home, other away	0.079	0.797	-0.144	0.300	0.181	0.245
One or both parents deceased	0.038	0.923	-0.073	0.625	0.146	0.311
Status unknown	0.814	0.165	-0.557	0.221	0.019	0.920
Caregiver Education	-0.002	0.707	0.008	0.081	0.023	<0.001
M Grandma	0.134	0.349	0.151	0.233	0.037	0.762
M Grandpa	-0.089	0.622	0.023	0.891	-0.110	0.468
P Grandma	0.068	0.314	0.016	0.792	0.050	0.445
P Grandpa	-0.081	0.259	-0.017	0.804	0.015	0.826
Unclassified grandma	-0.139	0.526				
Unclassified grandpa	0.164	0.522				
Constant	-1.338	<0.001	0.813	0.036	0.495	0.464
AIC	6251.17		5548.07		6087.46	
Observations	1982		1937		1922	

Table AB.3.12. Weight-for-height and height-for-age z-scores stratified by country and round: Peru

	WAZ						HAZ					
	Round 1		Round 2		Round 3		Round 1		Round 2		Round 3	
	β	p	β	p	β	p	β	p	β	p	β	p
Male	-0.195	<0.001	0.140	0.001	0.068	0.158	-0.217	<0.001	-0.014	0.751	-0.056	0.191
Age of child in months	-0.053	<0.001	0.010	0.043	-0.010	0.118	-0.086	<0.001	0.022	<0.001	-0.007	0.231
Total # of Sibs in HHH <5	-0.179	<0.001	-0.014	0.685	-0.048	0.150	-0.160	<0.001	-0.022	0.550	-0.034	0.257
Wealth Index	1.209	<0.001	1.174	<0.001	1.629	<0.001	0.901	<0.001	1.254	<0.001	1.394	<0.001
Parent Living Arrangement (b Both)												
One parent home, other away	-0.130	0.094	-0.046	0.441	-0.010	0.884	-0.085	0.308	-0.040	0.526	-0.046	0.437
One or both parents deceased	-0.655	0.029	-0.080	0.697	-0.160	0.440	-0.118	0.713	-0.107	0.625	-0.249	0.172
Status unknown	-0.543	0.083	-0.416	0.053	-0.038	0.770	-0.505	0.116	-0.297	0.184	-0.150	0.185
Caregiver Education	0.033	<0.001	0.049	<0.001	0.061	<0.001	0.062	<0.001	0.066	<0.001	0.061	<0.001
M Grandma	0.120	0.173	0.062	0.433	-0.141	0.135	0.061	0.514	0.063	0.444	-0.023	0.784
M Grandpa	0.085	0.374	-0.041	0.645	0.071	0.536	0.026	0.803	-0.149	0.111	0.035	0.727
P Grandma	**0.260**	**0.032**	0.085	0.467	-0.023	0.880	0.070	0.593	-0.034	0.779	0.126	0.345
P Grandpa	-0.173	0.196	0.008	0.954	0.124	0.482	-0.053	0.711	0.105	0.468	-0.042	0.784
Unclassified grandma	**2.666**	**0.013**					0.775	0.501				
Unclassified grandpa	**-2.162**	**0.004**					-0.500	0.663				
Constant	-0.189	0.078	-2.153	<0.001	-0.695	0.278	-0.991	<0.001	-4.022	<0.001	-1.661	0.003
AIC	5783.01		5188.19		5450.81		6039.06		5340.15		4974.08	
Observations	1946		1955		1868		1943		1950		1869	

Table AB.3.13: Body mass index-for-age z-scores stratified by country and round: Peru

	BMIZ					
	Round 1		Round 2		Round 3	
	β	p	β	p	β	p
Male	-0.091	0.121	0.279	<0.001	0.258	<0.001
Age of child in months	0.006	0.446	-0.014	0.014	-0.010	0.142
Total # of Sibs in HHH <5	-0.129	0.010	0.027	0.499	-0.025	0.448
Wealth Index	0.897	<0.001	0.466	0.001	0.955	<0.001
Parent Living Arrangement (b Both)						
One parent home, other away	-0.146	0.119	-0.016	0.819	0.034	0.605
One or both parents deceased	-0.805	0.027	0.070	0.770	-0.016	0.938
Status unknown	0.427	0.241	-0.298	0.220	0.119	0.340
Caregiver Education	-0.010	0.236	0.005	0.490	0.027	<0.001
M Grandma	0.165	0.122	0.009	0.917	**-0.180**	**0.050**
M Grandpa	0.039	0.737	0.083	0.413	0.070	0.533
P Grandma	0.256	0.081	0.138	0.295	-0.140	0.344
P Grandpa	-0.186	0.252	-0.120	0.442	0.177	0.301
Unclassified grandma	**3.021**	**0.021**				
Unclassified grandpa	-0.964	0.294				
Constant	0.498	<0.001	1.124	0.001	0.588	0.346
AIC	6533.72		5670.64		5358.23	
Observations	1946		1954		1869	

Table AB.3.14. Weight-for-height and height-for-age z-scores stratified by country and round: Vietnam

	WAZ						HAZ					
	Round 1		Round 2		Round 3		Round 1		Round 2		Round 3	
	β	p	β	p	β	p	β	p	β	p	β	p
Male	-0.151	0.001	0.140	0.004	0.058	0.277	-0.238	<0.001	-0.017	0.703	-0.071	0.113
Age of child in months	-0.043	<0.001	-0.025	<0.001	-0.030	<0.001	-0.059	<0.001	-0.008	0.175	-0.013	0.034
Total # of Sibs in HHH <5	-0.153	0.001	-0.010	0.842	-0.059	0.216	-0.229	<0.001	-0.176	<0.001	-0.122	0.002
Wealth Index	0.763	<0.001	1.205	<0.001	1.995	<0.001	1.289	<0.001	1.051	<0.001	1.700	<0.001
Parent Living Arrangement (b Both)												
One parent home, other away	-0.066	0.654	-0.130	0.242	-0.004	0.975	-0.127	0.444	-0.095	0.348	-0.116	0.219
One or both parents deceased	0.146	0.777	0.139	0.475	-0.023	0.901	0.114	0.846	-0.110	0.532	-0.082	0.605
Status unknown	-0.077	0.883	-0.362	0.131	-0.212	0.120	0.465	0.433	-0.376	0.084	-0.375	0.001
Caregiver Education	0.040	<0.001	0.075	<0.001	0.068	<0.001	0.038	<0.001	0.068	<0.001	0.048	<0.001
M Grandma	-0.005	0.970	**0.369**	**0.011**	**0.374**	**0.003**	0.150	0.321	0.132	0.321	0.044	0.679
M Grandpa	0.281	0.074	-0.169	0.362	0.015	0.924	0.052	0.771	0.083	0.624	**0.251**	**0.048**
P Grandma	0.022	0.771	0.081	0.317	0.119	0.134	-0.049	0.569	0.036	0.619	0.088	0.184
P Grandpa	0.037	0.658	0.022	0.823	0.068	0.443	-0.023	0.815	0.070	0.435	0.118	0.109
Unclassified grandma	-0.088	0.822					-0.141	0.752				
Unclassified grandpa	0.182	0.719					-0.057	0.921				
Constant	-0.971	<0.001	-0.704	0.082	0.017	0.981	-1.053	<0.001	-1.784	<0.001	-1.202	0.036
AIC	5728.62		5707.65		5881.95		6215.94		5311.53		5209.39	
Observations	1981		1939		1879		1973		1933		1881	

Table AB.3.15: Body mass index-for-age z-scores stratified by country and round: Vietnam

	BMIZ					
	Round 1		Round 2		Round 3	
	β	p	β	p	β	p
Male	0.0009	0.984	0.238	<0.001	0.208	<0.001
Age of child in months	-0.018	0.010	-0.025	<0.001	-0.032	<0.001
Total # of Sibs in HHH <5	0.004	0.931	0.182	<0.001	0.038	0.461
Wealth Index	0.029	0.814	0.653	<0.001	1.142	<0.001
Parent Living Arrangement (b Both)						
One parent home, other away	0.005	0.972	-0.070	0.544	0.092	0.450
One or both parents deceased	0.094	0.849	0.336	0.098	0.056	0.786
Status unknown	-0.509	0.308	-0.093	0.709	0.083	0.570
Caregiver Education	0.021	0.004	0.044	<0.001	0.052	<0.001
M Grandma	-0.063	0.614	0.254	0.097	**0.496**	**<0.001**
M Grandpa	0.270	0.073	-0.199	0.307	-0.270	0.100
P Grandma	0.076	0.287	0.102	0.226	0.065	0.451
P Grandpa	0.036	0.659	-0.044	0.673	0.016	0.864
Unclassified grandma	0.028	0.940				
Unclassified grandpa	0.220	0.649				
Constant	-0.392	<0.001	0.474	0.262	1.138	0.125
AIC	5564.86		5865.07		6136.12	
Observations	1983		1937		1872	