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HOUSEHOLD FOOD INSECURITY AND MATERNAL AND CHILD NUTRITIONAL STATUS: EVIDENCE FROM MAHARASHTRA

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In this paper we rigorously examine the association of household food security status with maternal and child nutritional status exploring a rich micro-level database, the Comprehensive Nutrition Survey Maharashtra 2012. Using Household Food Insecurity Access Scale (HFIAS) as a metric to measure household food security, we apply simultaneous probit models to estimate the effect of food insecurity on maternal and child nutritional outcomes. The modelling framework addresses possible endogeneity in the above relationship. Findings indicate that household food insecurity increases the risk of maternal and child underweight with no effect on child stunting, wasting or maternal overweight. Women's decision-making power mediates these associations. Food security interventions should be effective in tackling the concerns with undernutrition, however, food alone is not the solution. A mix of nutrition-specific and nutrition-sensitive policies is warranted. Food security interventions should be integrated into policies for human development.

JEL Codes: I15, C31, D10, I30, O15

Keywords: experiential, endogeneity, food access, human development, nutritional status, women's bargaining power

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1. Introduction

The nature and extent of the association of food insecurity with nutritional status is of interest both from the perspective of economic theory and policy making. Research in the developed countries (primarily US) has evidence that lack of access to sufficient quantity of safe and nutritious food is associated with children's health, behavioral, academic and emotional problems beginning as early as infancy (Skalicky *et al.*, 2006; Cook and Frank, 2008; Gundersen *et al.*, 2011). The potential channel linking food insecurity to the above outcomes could be malnutrition which encompasses both overweight and undernutrition including micronutrient deficiencies; and has direct adverse consequences in terms of disability, disease, brain development, learning and earnings (Victora *et al.*, 2008; Black *et al.*, 2008). However, the association of food insecurity with nutritional outcomes is not yet well understood (FAO, 2018). Nutrition is a social determinant of health and development (WHO, 2000). Rich longitudinal evidence exists on the economic benefits of avoiding undernutrition (Victora *et al.*, 2008). Food insecurity might be a distant cause of malnutrition (Murray and Lopez, 1999). Therefore, understanding the exact nature of the relationship not only facilitates effective policy formulation but also contributes to the discourse in the development literature on the pathways to inclusive growth via poverty reduction and human development. Current research sheds some light on this question, however, further rigorous research is warranted (Maitra, 2018). The task is complex and is also getting increasingly challenging given the newly emerging complexities such as multiple burden of malnutrition (Haddad *et al.*, 2015; WHO, 2017) in the global nutrition scenario. Furthermore, the literature investigating food insecurity-malnutrition linkage suffers from methodological concerns relating to selection bias, measurement errors and unobserved heterogeneity which often render food insecurity endogenous with respect to nutritional outcomes. Limited availability of panel data further complicates empirical research. A recent review of 120 studies on the link between experiential food insecurity and nutritional status of adults and children across the globe (Maitra, 2018) identifies the failure to address these methodological issues as a crucial gap in the literature. The few studies that examine the above relationship in the Indian context (Mukhopadhya and Biswas, 2011; Gupta *et al.*, 2013; Chandrasekhar *et al.*, 2017) offer rich insight on the nexus between the two phenomena, albeit with similar limitations.

Given the above, in the present paper, we rigorously examine whether household food insecurity increases the risk of malnutrition in women and children. We aim to address the current research gap by modelling the above relationship with due consideration to the concerns relating to endogeneity. We undertake this exercise using a rich household level cross sectional dataset, Comprehensive Nutrition Survey Maharashtra (CNSM) 2012 (IIPS-UNICEF, 2013). The dataset is based on a representative sample of 2650 children aged 0–23 months and their mothers. The key indicator of household food insecurity (HFI) in our study is Household Food Insecurity Access Scale (HFIAS) - an experienced-based food security scale (EBFSS) which is a direct measure of access to food (Coates *et al.*, 2007). The nutritional outcomes are captured by anthropometric indicators—stunting (too short for one's age), wasting (too thin for one's height) and underweight in children; and BMI status for women (underweight/overweight) (WHO, 2010).

The intellectual motivation of our query stems from the fact that if food insecurity has any causal association with nutritional outcomes it can be theoretically modelled as an input in the production of human capital, given the robust microeconomic evidence on the intergenerational consequences of malnutrition on learning outcomes (Lewis, 2009; Grantham-Mcgregor *et al.*, 2007). A malnourished mother gives birth to a malnourished child and "severe early malnutrition, particularly during the period of rapid brain growth in the first two years of life, presents a permanent structural insult to brain function, leading to irreversible intellectual impairment" (Levitsky and Strupp, 1995, cited in Fishman *et al.*, 2004, p. 101). Such strong linkage between nutrition and human development suggests almost an immediate and direct link between food security and human development, provided we see a close alignment of food insecurity with nutritional outcomes. Such a possibility allows us to conceive of food security within the framework of Sen's (1985) capability approach (see Burchi and Muro, 2016), since "the human development discourse is conceptually underpinned by the capability approach" (Osmani, 2016, p. 2). The interaction between entitlement, capability and human development is also relevant in this context. Food insecurity can be both a cause and consequence of entitlement failure (Sen, 1981). It may result in entitlement failure (reduced command over commodities including food) by making an individual less capable in the labor market via the channels of poor nutrition, poor health and poor cognitive development. There exists a potential feed-back effect from malnutrition to the capacity of providing food, health, education and care (Burchi and Muro, 2016). This perspective also allows us to place food security within the broad realm of well-being, all the possible activities and social expressions a person would realize—his or her 'beings and doings' (Sen, 1985). The latter is also the idea of 'agency' as conceived by Sen (1999). Within this framework, we can extend the concept of food security in a manner that it ultimately strengthens human security–ensuring security by investment in human development, not in arms (UNDP, 1994). The usefulness of such a framework is, it has long term implications for food security policy formulation. It leads us away from the sole focus on entitlement, income or livelihood and allows us to think about food insecurity as a cause and consequence of lack of education, health and other basic capabilities that constitute people's wellbeing. This approach is people-centric and it also helps us to embrace the 'stability' aspect of food security (UNDP, 1994) which has the element of time embedded in it — "capability to be food secure", having a longer-term perspective (Burchi and Muro, 2016).

The above intellectual pursuit is further motivated by the fact that the food insecurity-malnutrition link reflects an underlying conceptual association between the *access* and *utilization* dimensions of food security. With the introduction of UNICEF's conceptual model (UNICEF, 1990) (Fig. B.1)[1] which provides a comprehensive framework to understand the causes of malnutrition, the definition of food security was broadened to include *utilization* as an additional element along with *availability* and *access* to food in the World Food Summit 1996 (WFS, 1996). Conceptually, food utilization relates to the capacity of an individual to absorb the nutrients in the food consumed and is determined by practices, beliefs, eating

[1]Figure B.1 presents an adapted version of UNICEF framework reported in Black *et al.* (2008).

habits, hygiene, sanitation and health (WFS, 1996). Ideally, proper utilization of food should be reflected in good nutritional status. The UNICEF framework identifies food insecurity as a necessary but not sufficient condition for nutrition security because malnutrition may be caused by other inter-related factors–inadequate maternal and child care, insufficient health services and unsanitary environment. This conceptual evolution of food security is parallel to the move from "entitlement" to basic human "capabilities" in the conversation on hunger –from command over food to capability to be free from hunger (Drèze and Sen, 1989) which argues, "a more reasoned goal would be to make it possible to have the capability to avoid undernourishment and escape deprivations associated with hunger" (Drèze and Sen, 1989, p. 13). This shift of focus to "nutritional capabilities" reflects the recognition that access to food is not adequate and utilization is critical (Burchi and Muro, 2016).

The implication of the above discussion for our purpose is, it generated confusion on the logical difference between food and nutrition security and subsequently shifted the unit of analysis from household to individual. One aspect of this development is, it further broadens the concept of food security by recognizing the possibilities of inequalities in intra-household distribution of food. When household is the unit of analysis in measuring access to food, the intra-household dynamics remains unexplored because adequate access to food at the household level does not automatically translate to access at the individual level (Maxwell and Smith, 1992). An indirect way of measuring individual food access would then be to look at anthropometric indicators which are often considered the gold standard measures of nutritional status (Jones *et al.*, 2013); and are outcomes of inadequate food access (Frankenberger, 1992) given the other conditions (care and health environment) remain stable. The other implication of the above development is purely policy-focused, related to targeting and monitoring. The more closely aligned are the access and utilization components of food security (adequate access-adequate food intake-better utilization-better nutritional status), stronger is our ability to detect intra-household disparities in access to food. In this scenario, policy can isolate and target those individuals who happen to be malnourished in an otherwise food secure environment. On a similar note, if changes in food security status are directly related to changes in nutritional status, then food security interventions should automatically improve nutritional outcomes. Nutritional relevance of food security indicators is also established (Headey and Ecker, 2013) ensuring that these indicators are able to identify nutritionally vulnerable individuals at minimal additional cost of data collection.

Given this policy relevance of our query it is not surprising that the volume of literature investigating the link between food security and nutrition security is growing. Our study is a contribution to this literature not just because it entails methodological improvement, but also because we take a novel perspective on the query by situating it within the framework of capability approach. This analytic framework offers a longer-term potential for analyzing food security as an underlying determinant of human development, a discourse which may have started with Sen's conversation on hunger (1981; 1985), however, barring some rare attempts (Burchi and Muro, 2016; UNDP, 2013) has not gained momentum since then.

Maharashtra provides us a perfect setting to investigate the above queries because of the perplexing dissociation between indicators of growth, nutrition and food security the state experienced. Current statistics reports that Maharashtra is the leading Indian state in terms of per capita income, with the State economy forecasted to grow by 7.3 percent during 2017-18 over the previous year–much above the 6.5 percent expected growth rate for India in 2017 (Economic Survey Maharashtra, 2018). However, the nutritional indicators perform dismally. Maharashtra falls into the category of very high prevalence of wasting (≥15 percent) and underweight (≥30 percent) (Menon *et al.*, 2017). Simultaneously, the nutrition scenario is characterized by prevalence of high rates of maternal anemia (48 percent in 2016) which in fact escalated during 2006–2016 (NFHS, 2017). Prevalence of maternal underweight was also very high—above the national average of 36 per cent in 2006. While the proportion of underweight women has declined in 2016, that of overweight women has increased substantially (NFHS, 2017). The combination of these trends indicates the emergence of intra-household multiple burden of malnutrition such as stunting in child and obesity in mother in the same household; or intra-individual multiple burden such as stunting, obesity and anemia in the same individual (Meenakshi, 2016). The food security scenario has been equally grim with the state experiencing one of the highest rates of calorie deficiency among the Indian states in 2004–05 (NSSO, 2007). In 2008, Maharashtra ranked ten out of 17 Indian states following the Global Hunger Index (von Grebmer *et al.*, 2008), and was listed in the category of 'alarming hunger'. What seems to be puzzling is that since 2006 the nutritional status of children has improved due to sharp decline in the prevalence of child stunting; however, food insecurity continues to be a major concern (Haddad *et al.*, 2014). The paradox signals an apparent lack of correspondence between the two phenomena. These anomalies provide us the final motivation to undertake this research.

In modelling the food insecurity-malnutrition relationship we used the framework of simultaneous probit models, more specifically recursive bivariate probit/ordered probit models (Greene, 2012), to account for the endogeneity of experiential food insecurity, our key explanatory variable in the models. We also undertook a statistical exercise to test the reliability and validity of HFIAS before proceeding with any statistical analysis based on the indicator, which is also an improvement over the existing studies. Our findings indicate that HFI is a significant risk factor for child and maternal underweight, however, HFI has no effect on the risk of child stunting and maternal overweight. The impact of HFI on the risk of wasting disappears once the effect of women's decision-making power (a proxy for women's bargaining power in the household) is incorporated into the models. Women's bargaining power seems to be moderating the relationship between food insecurity and nutritional outcomes, highlighting the importance of addressing the concerns with intra-household distribution of food. Overall, the findings direct toward the need to alleviate household food access for the purpose of addressing nutritional deprivation of mothers and children residing in the household. However, long term nutritional deprivation of children (reflected in stunting) as well as the association with overweight requires further investigation, perhaps in the light of multiple burden of malnutrition. In general, a mix of nutrition-specific and nutrition-sensitive policies is suggested for tackling malnutrition.

The paper has been organized as follows: Section 2 discusses method which includes details of survey methodology, data, variables and statistical analysis; Section 3 describes the conceptual framework of the study, Section 4 reports results, Section 5 discusses the findings and Section 6 concludes with policy recommendations and direction for future research.

2. Method

2.1. *Data, Study Design and Participants*

The study is based on CNSM 2012 (IIPS-UNICEF 2013). The survey aimed at assessing the nutritional status of children aged 0–23 months through anthropometric measurements and infant and young child feeding practices in rural and urban areas of the state. The selection of sample was done separately in rural and urban areas using a multi-stage stratified sampling procedure. The rural sample was selected in two stages, with the selection of Primary Sampling Units (PSUs), villages, at the first stage. This stage was followed by a random selection of households within each PSU, in the second stage, among those households where at least one child under two years is residing. In urban areas, a three-stage sampling procedure was followed; selecting wards at the first stage, Census Enumeration Blocks at the second stage, and households with at least one child under two years at the third stage. The sample size was determined in terms of the number of under-two children as they were the focus of the survey. Remaining details on survey and sampling strategies are available in CNSM report (IIPS-UNICEF, 2013). Data collection was carried out during February–April 2012. The final sample comprises 2,630 households and 2650 children.

2.2. *Survey Instrument*

CNSM used three types of questionnaires: Household Questionnaire, the Mother's Questionnaire and Child's Questionnaire. The Household Questionnaire interviewed either the head of the household or any adult member of the household available at the time of the survey. The section on food security was administered to the household member primarily involved in food preparation. Information was collected on age, sex, relationship to the head of the household and marital status for each person listed. Additionally, information was gathered on the main source of drinking water, type of toilet facility, source of lighting, type of cooking fuel, religion and caste/tribe of the household head, ownership of a house, ownership of agricultural land, ownership of livestock and ownership of other selected items. Mother's Questionnaire was administered to all women in the household who have at least one (living) child born after January 1, 2010. Mother's profile including her age, marital status, age at marriage, literacy status, educational attainment and work status were collected. Information were also collected on mother's exposure to media, decision making and involvement in community organizations such as Self-Help Groups and; maternal health such as pregnancy, fertility history, antenatal care received, food intake, nutritional status and; lifestyle indicators such as tobacco use and alcohol consumption. For every child born after January 1, 2010, separate questionnaire was administered to the mother. The child's questionnaire collected information on child characteristics such as birth date, birth order and sex of the child. CNSM also included questions on infant and young child feeding practices including breastfeeding status, frequency of breastfeeding in 24 hours prior to survey, complementary foods given to the child in 24 hours prior to the survey and their frequency.

2.3. *Variables*

Dependent Variables: Anthropometric Indicators of Nutritional Status of Mothers and Children

Following WHO (2010) guidelines, three standard indices of physical growth that describe the nutritional status of children are constructed: 1) height-for-age z-scores; 2) weight-for-height z-scores; and 3) weight-for-age z-scores.[2] Since, in the present paper we are interested in examining the *risk* of malnutrition due to food insecurity, we express the scores as categorical variables. Children with height-for-age z-score <-2 standard devitations (SD) from the median of the reference population are considered short for their age or stunted. Stunting reflects longer term nutritional deprivation often aggravated by illness and is often intergenerational. Children with weight-for-height z-score <-2 SD from the median of the reference population are classified as thin for their height or wasted. Wasting captures short term nutritional deficiency which might be a result of inadequate nutrition and disease in the recent past. Weight-for-age is a composite index representing the sum of the information given by the other two indices, height-for-age and weight-for-height. Weight-for-age can be low because of stunting (short stature) and/or wasting (recent weight loss). Children with weight-for-age z-score <-2 SD from the median of the reference population are underweight.[3]

The ordered categorical variables *HAZ*, *WHZ* and *WAZ* are created to denote three categories of nutritional status–healthy ($-2 \leq$ z-score $\leq +2$), moderate ($-3 \leq$ z-score <-2) and severe (z-score <-3), respectively. Accordingly, we've the following representation of variables:

$$HAZ = \begin{cases} 0 & \text{if} \quad \text{healthy} \\ 1 & \text{if} \quad \text{modertaely stunted} \\ 2 & \text{if} \quad \text{severely stunted} \end{cases}$$

[2]It is important to note that anthropometric indicators are observable markers for the internal, physiological state of nutriture termed as malnutrition (Fishman *et al.*, 2004).

[3]Children over two standard deviations from the median weight-for-height of the WHO Child Growth standards are overweight. We do not model the association of household food insecurity with overweight status of children because proportion of overweight children in the sample is not large enough to allow a meaningful investigation. To be consitent, only children with z scores less than equal to +2 SD are included in the analysis. Children with height-for-age z-scores below -6 SD or above +6 SD, with weight-for-age z-scores below -6 SD or above +5 SD, or with weight for height z-scores below -5 SD or above +5 SD are marked as invalid data, following the guidelines of demographic and health surveys (DHS).

$$WHZ = \begin{cases} 0 & \text{if} \quad \text{healthy} \\ 1 & \text{if} \quad \text{moderately wasted} \\ 2 & \text{if} \quad \text{severely wasted} \end{cases}$$

$$WAZ = \begin{cases} 0 & \text{if} \quad \text{healthy} \\ 1 & \text{if} \quad \text{moderately underweight} \\ 2 & \text{if} \quad \text{severely underweight} \end{cases}$$

We also define children's nutritional status as binary variables: healthy if $-2 \leq$ z-score $\leq +2$ and malnourished if z-score <-2. Hence,

$$haz = \begin{cases} 1 & \text{if} \quad \text{stunted} \\ 0 & \text{if} \quad \text{healthy} \end{cases}$$

$$whz = \begin{cases} 1 & \text{if} \quad \text{wasted} \\ 0 & \text{if} \quad \text{healthy} \end{cases}$$

$$waz = \begin{cases} 1 & \text{if} \quad \text{underweight} \\ 0 & \text{if} \quad \text{healthy} \end{cases}$$

As indicator of maternal malnutrition, we use maternal BMI status with the following categorization: $18.5 \leq \text{BMI} < 25$ classified as healthy weight, $\text{BMI} < 18.5$ classified as underweight/thin (chronic energy-deficient); and $\text{BMI} \geq 25$ classified as overweight/obese.[4] The following binary indicators *m_under* and *m_over* define maternal underweight and overweight status, respectively, as:

$$m\_under = \begin{cases} 1 & \text{if} \quad \text{underweight} \\ 0 & \text{if} \quad \text{healthy} \end{cases}$$

$$m\_over = \begin{cases} 1 & \text{if} \quad \text{overweight} \\ 0 & \text{if} \quad \text{healthy} \end{cases}$$

[4]This category includes women who are obese (BMI ≥ 30). In the current sample, only a small fraction (2 percent) of women were obese. The BMI cut-offs are defined for non-pregnant, non-postpatrum women aged 15-49 years. Women whose calculated BMI is below 12.0 or above 60.0 are flagged as out of range and hence excluded from the analysis, following DHS guidelines.

Key Independent Variable: Household Food Security Status (HFS)

The key explanatory variable of interest in our analysis is HFS yielded by the 9-item HFIAS. HFIAS classifies households into four categories of food security status (by access): food secure, mildly food insecure, moderately food insecure and severely food insecure. The mothers were asked nine questions (see Appendix, Table A1) related to the households' experience of food insecurity in the last 30 days preceding the survey. These questions capture three key domains of household food security: 1) anxiety and uncertainty about access (Q1: *worried*); 2) insufficient quality (Q2-Q4: *preferred, variety, nochoice*); and 3) insufficient quantity (Q5-Q9: *smaller, fewer, nofood, hungry, daynight*). Each item starts with an occurrence question that identifies if the condition has been experienced in the household. An affirmative answer is then followed by a frequency-of-occurrence question to determine if the condition happened rarely (once or twice), sometimes (3–10 times), or often (>10 times) during the reference period. The responses are coded as 0 = never, 1 = rarely, 2 = sometimes, or 3 = often. Households that rarely experience some anxiety over sufficiency of food are categorized as food secure. Households that worry about not having enough food *frequently* as well as households that *sometimes* in last one month could not have their preferred food or had to eat limited variety of food or food that they really did not want to eat are categorized as mildly food insecure. Households that *frequently* ate food of limited choice and *sometimes* had to eat lesser quantity of food are categorized as moderately food insecure. Households that had no food to eat or had to starve day and night are categorized as severely food insecure.

We create categorical variables capturing household food security status based on these scores. The findings from the extant literature indicate that the categorization is important. For example, there exists substantial evidence in the literature that mild or marginal food insecurity can be more detrimental to physical outcomes as opposed to severe food insecurity (Townsend *et al.*, 2001; Cook *et al.*, 2013). Research in the context of developing countries also find evidence of differential effects of various categories of food insecurity on anthropometric measures of nutritional outcomes (Velásquez-Melendez *et al.*, 2011).

Accordingly, variable *fsec3* is defined as an ordered categorical variable representing three categories of food security status– food secure, moderately food insecure and severely food insecure. We collapse mild and moderate food insecurity into one single category *moderately food insecure* to obtain more meaningful results since only 12 percent households are present in each of these categories. However, we retain *severely food insecure* as a separate category since these are the most venerable households and should be identified as such for policy purposes.

Hence *fsec3* is defined as:

$$fsec3 = \begin{cases} 0 & \text{if} \quad \text{highly food secure} \\ 1 & \text{if} \quad \text{moderately food insecure} \\ 2 & \text{if} \quad \text{severely food insecure} \end{cases}$$

We also define HFS as a binary variable by collapsing moderately food insecure and severely food insecure households into one single category *food insecure*:

$$fsec = \begin{cases} 1 & \text{if} \quad \text{food insecure} \\ 0 & \quad\quad \text{otherwise} \end{cases}$$

Table 1 reports the distribution of households by experience of food insecurity. We find, 58 percent of the households never worry about having insufficient food, a little over one-third of the households cannot eat preferred food, 31 percent of the households have to eat only limited variety of food and about a quarter of households have very limited choice of food. About 12 percent of households report that they had to eat smaller meals or had to cut meal size in the last one month though it happened rarely. The extreme situation of not having any food to eat was experienced by 12 percent of the households among which eight percent had this experience rarely. Eight percent of the households reported sleeping hungry without food and only five per cent reported having to go hungry without food day and night.

Control Variables

In modelling the relationship between child nutritional status and HFS, the control variables included in the equations for child nutritional status are: household characteristics such as household size and wealth status; age, gender, education and caste of household head; household environmental conditions captured by variables such as whether the house is pucca or not, whether the household has toilet facility, whether the household has access to piped water and whether the household is located in rural or urban setting; maternal characteristics including maternal educational status, age at marriage, nutritional status captured by BMI and stature (if height <145 cm.), whether mother received at least 3 antenatal care (ANC), maternal work status, mothers' exposure to media and; an empowerment index constructed by collapsing each of the eight survey questions on maternal decision making into binary format (=1 if the mother takes the decision jointly or alone; 0 otherwise) and adding the responses.[5] The total score on decision-making is a proxy for women's bargaining power in the household (Bloom *et al.*, 2001; Smith *et al.*, 2003; Doss, 2013; Antman, 2014). We also include selected child characteristics as control variables: age, gender, birth order, whether the child was low birth weight (LBW), whether the child was age appropriately breastfed, whether the child consumed at least 4 food groups and whether the child received full immunization. Regional dummies (Amaravati, Konkan, Nagpur, Nasik and Pune) are also included in all models.

Models on maternal nutritional status include the above household level variables and maternal characteristics. However, maternal BMI is now dropped from the models. In the models on maternal undernutrition (indicated by

[5]This methodology of constructing the unweighted index of empowerment is rather simplistic and ideally one should undertake a factor analysis (as in Smith *et al.*, 2003) to combine relevant items. It is also important to weight the decisions. However, the literature has some evidence on the use of similar methodology (see Bloom *et al.* 2001, for example). We examined internal validity of the score by estimating scale reliability coefficient Cronbach's alpha (Cronbach, 1951) which is 0.88 in our case, indicating good reliability (a value of Cronbach's alpha closer to 1 implies greater reliability).

TABLE 1
Percent Distribution of Households by Frequency of Experience of Food Insecurity (using HFIAS), Maharashtra, 2012

Food Insecurity Experience in One Month Prior to Survey	Frequency of Experience of Food Insecurity					Number of Households
	Never	Rarely	Sometimes	Often	Total	
Worry about insufficient food (worry)	57.9	24.2	14.5	3.4	100.0	2,624
Inability to eat preferred food (preferred)	63.4	21.0	14.0	1.6	100.0	2,617
Had to eat limited variety of food (variety)	68.6	17.6	11.8	2.1	100.0	2,624
Had to eat certain food items without choice (nochoice)	74.5	15.5	9.0	1.0	100.0	2,628
Had to eat smaller meals (smaller)	79.7	12.3	7.6	0.4	100.0	2,627
Had to eat fewer meals (fewer)	81.8	11.2	6.6	0.3	100.0	2,627
Had no food to eat (nofood)	87.8	7.6	4.3	0.3	100.0	2,626
Had to sleep without food (hungry)	92.3	5.2	2.4	0.0	100.0	2,626
Had to go day and night without eating any food (daynight)	95.5	3.0	1.5	0.0	100.0	2,627

underweight status) we include additional maternal characteristics such as number of times a mother was pregnant, status of iron and folic acid consumption and frequency of consumption of seasonal fruits and dark green leafy vegetables during the last 30 days.[6] Models on maternal overweight include frequency of consumption of oilseeds as an indicator of unhealthy food consumption.[7]

In addition to controlling for maternal empowerment and the household demographics included in the equations for nutritional status, the food security equation includes additional household level covariates such as the type of ration card possessed by the household (no card, yellow, white or orange)[8], household head's home ownership status and land ownership status and whether the household has some transport.

2.4. *Summary Statistics*

Table 2 reports summary statistics of variables. We find, 57 percent of households are food secure with higher fraction reported for urban areas. Twenty-three percent of children are stunted, while 16 percent are wasted and about 23 percent are underweight. Prevalence of LBW is similar in both rural and urban areas. One in every three non-pregnant mothers is underweight, as opposed to 11 percent non-pregnant mothers who are either overweight or obese. A higher proportion of underweight mothers is reported in rural areas, while a very high proportion of overweight mothers is noted in urban areas. Nearly 41 percent of the urban population belong to the highest wealth quintile as opposed to only two percent in the rural areas. Twenty percent of households are headed by persons who do not read or write. Only five percent of the households are female headed. Sixty-six percent of the households have access to piped drinking water, the proportion being much higher in urban areas. Fifty-five percent of households do not have access to any toilet facility. About one-fourth of the households may not have access to public distribution system (PDS) as they do not possess ration cards. In rural areas, the proportion of households having a yellow card is more than double of that in urban areas. Nearly one-third of the mothers were married before the legal age of 18 years which makes them vulnerable to early pregnancies. Twelve percent of mothers have received no formal education and majority of them (69 percent) are not engaged in any work besides household chores. Regarding the eight questions on maternal decision-making power, more than 60 percent of women take each decision jointly or alone; with majority (more than 75 percent) participating in decisions to spend their own money, decisions on food items given to the child and decisions on child immunization. Accordingly, the average empowerment score is quite high (5.61, SD 0.09) with a higher mean

[6]Fruits and dark green leafy vegetables are reliable indicators of diet quality (micronutrient intake), fruits being the one most promoted by the nutritionists (Binkley and Golub, 2011).

[7]A rapid increase in consumption of low-cost vegetable oil during the last few decades has been a major component of food system changes and consequent effects on body mass index in terms of obesity (Popkin, 2007).

[8]Three card categories are issued: Yellow: families having annual income up to Rs. 15,000/; Orange/Saffron: families having total annual income of more than Rs. 15,000 and less than 1 lakh; White: above poverty line - the families having annual income of Rs. 1 lakh or above (see details in: http://mahafood.gov.in/website/english/PDS.aspx.)

in urban areas. More than 50 percent of mothers in rural Maharashtra never or only occasionally consumed seasonal fruits in the last 30 months as opposed to 40 percent in urban areas. However, about 60 percent of mothers reported consuming oilseeds daily or on alternate days, with higher proportion reported for urban areas.

2.5. *Conceptual Framework*

In this section, we discuss some key conceptual issues related to our variables of interest before proceeding to building and estimating the empirical models.

The conceptual framework for our empirical models is based on the UNICEF model (UNICEF, 1990) (Figure B.1) as mentioned earlier in the introductory section. The theoretical perspective is provided by Sen (1985, 1999) who refers to the conversion factors and rates in explaining the relationship between food access, food intake and nutritional achievement–conversion of personal income, resources and commodities into well-being which will depend "crucially on a number of contingent circumstances, both personal and social" (Sen, 1999, p. 70): personal heterogeneities such as body size, nutrient requirements or intelligence; environmental conditions such as having access to proper sanitation and safe drinking water, access to transport; variations in social climate such as societal hierarchies; power relations related to class, gender, race, or caste; or differences in relational perspectives and distribution within the family (Burchi and De Muro, 2016). The choice of control variables in our empirical models follows the above conceptual and theoretical paradigms.

The food insecurity-malnutrition relationship has concerns with potential endogeneity of experiential food insecurity possibly arising from three sources. First, since health endowment and food insecurity are difficult to observe the variables may be simultaneously determined due to the presence of unobserved confounding factors affecting both outcomes. Examples of such unobserved variables might be "ability" which may affect both outcomes via the channel of educational attainment.[9] Additionally, individuals' nutritional *intake* and *needs* are very different, and it is often difficult to measure "needs" which could be related to several endogenous factors such as activity levels, body size and previous nutrient intakes (Strauss *et al.*, 2000). Furthermore, as mentioned previously, there may exist feedback effect from malnutrition to food insecurity (Burchi and De Muro 2016) via the channels of poor nutrition-low productivity-low earnings-poverty. A large body of growing literature also indicates that the health-hunger relationship may be bidirectional (Tarasuk *et al.*, 2013; Anderson *et al.*, 2016), while poor health in turn is often a consequence of malnutrition (Black *et al.*, 2008). A third source of endogeneity could be random measurement error in anthropometric as well as experiential food security indicators (Diskin, 1994). We exploit the sound empirical framework offered by recursive bivariate models[10] (Greene, 2012) (see the next section on Statistical Analysis) to address the above concerns.

[9]Theoretically, better educational outcomes should expand people's basic capability which in turn should enable them to be well nourished and food secure in the long run.

[10]See Costa-Font and Jofre-Bonet (2008) for an application.

Next, we provide an understanding about the underlying theoretical framework of HFIAS. The construction of the EBFSS rests on non-linear factor analytic models such as the Rasch model (Bond and Fox, 2001). These models are located within the broad spectrum of Item Response Theory commonly employed in the education literature to conduct psychometric assessment of individuals' ability (latent variable) to answer progressively more difficult questions. In the food security literature, the latent variable is food insecurity and the items representing the underlying construct of interest are arranged along a continuum of severity. Under the above modelling framework food insecurity is viewed as a continuous, unidimensional and unobservable quantity that varies from household to household. Guided by the principles of Rasch model,[11] the selection of items in the scale is implemented by undertaking appropriate statistical tests on scale reliability and validity (see Hamilton *et al.*, 1997 for details). The scale items may broadly have universal applicability in diverse settings, however, for local adaptation the validity and reliability tests are recommended to ensure unbiased and reliable results.[12]

At this stage, we would like to highlight some concerns relating to the temporal dimensions of the food security and nutrition indicators. Inherently, food insecurity is a dynamic concept and embedded in it is the element of "time" (Maxwell and Smith, 1992). Issues relating to transient versus chronic food insecurity are likely to have differential impact on nutritional outcomes (Hernandez and Jacknowitz, 2009). Households transition in and out of food insecurity due to its cyclical/seasonal nature or due to appearance of sudden shocks such as price hike (Maxwell and Smith, 1992). Interestingly, a household identified as currently food insecure may also have reached that status by choice—going hungry now in order to prevent selling assets and going hungry later (De Waal, 1989). Therefore, when the EBFSS are used for analytical purposes in cross section framework, they may not be able to differentiate between transitory and chronic food insecurity (Devereux, 2006). While longitudinal data could be a potential solution, a major shortcoming of this literature is limited availability of such data, especially in the context of developing countries. However, even cross-sectional analysis is useful as different points in the life- course reveal a different picture of how food insecurity is related to nutritional outcomes (NRCIM, 2013). Additionally, the two time periods addressed by the survey items in the experiential food security scales (12 months and 30 days) and the follow-up items regarding frequency of occurrence are designed to capture some aspects of periodicity of food insecurity (Hamilton *et al.*, 1997). For example, hunger, the more severe form of food insecurity may occur at the end of the month when household resources are depleted but may disappear when payments or food assistance is received (Hamilton *et al.*, 1997). Similar ideas are reflected

[11]In general, the dichotomous Rasch model is used to analyze dichotomous items (e.g. yes/no) data, whereas the partial credit model developed by Masters (1982) is used as an extension of the dichotomous Rasch model for analyzing polytomous response pattern (never/rarely/sometimes/often) as in HFIAS.

[12]In our case, we undertook this exercise guided by Dr. Mark Nord from the Voices of the Hungry Project, FAO. Some concerns were detected with the use of two of the scale items (*smaller* and *fewer*). Accordingly, we re-estimated the models by dropping one of the items. However, none of the key conclusions changed substantially. Therefore, in this paper we have presented results based on the original nine-item scale. The details of the results on scale validity and reliability are not reported here but are available upon request.

in Devereux (2006) who argues, in the context of self-assessment indicators, that the recall component "would at least allow a crude categorization to be made of a household as either food secure, chronically food secure or transitorily food secure over a defined time period" (Devereux, 2006, p. 40).

A related issue is that often the anthropometric indicators (such as stunting) indicate long run nutritional deprivation. Therefore, statistical analysis based on indicators such as the EBFSS and stunting in cross sectional framework may seem apparently conflicting. We partially reconcile this contradiction by reiterating that some temporality is captured by the EBFSS via the recall component and the occurrence questions. Quantity reduction (for example, *nofood*) which occurs "often," reflects hunger and hence may be aligned with chronic nutritional deprivation since hunger and malnutrition are closely related concepts (see Hamilton *et al.*, 1997). Anthropometric indicators of malnutrition in fact represent differential temporal dimensions. Wasting, for example, is important for the description of current health status. Weight-for-age may not be able to discriminate between short and long-term forms of nutritional deprivation given that children classified on its basis are a composite group in terms of their nutritional status – stunted or wasted or both (Fishman *et al.*, 2004). Following Devereux (2006), "to some extent the anthropometric indicator of height-for-age can be used as a proxy for chronic food insecurity… The anthropometric indicator of weight-for-height which measures recent weight loss (wasting) and is caused by inadequate current food intake … can be used as a crude proxy for transitory food insecurity" (Devereux, 2006, p. 18). The interconnectedness of chronic and transitory food insecurity is also relevant in this context–recurring episodes of transient food insecurity create chronic food insecurity conditions (Maxwell and Smith, 1992). At this point, it may be worthwhile to point out that the literature has evidence that temporary food insecurity may have greater adverse nutritional consequences than persistent food insecurity (Hernandez and Jacknowitz, 2009).

3. Statistical Analysis

3.1. *HFS and Maternal and Child Nutritional Status*

We test our key hypothesis on the association of HFS with maternal and child nutritional status using the following empirical strategy: i) first we examine bivariate association of HFS and anthropometric indicators; ii) next we estimate multivariate association of nutritional outcomes and HFS using baseline models controlling for selected household, maternal and child characteristics: ordered probit (Oprobit) models for child nutritional status and probit models for maternal nutritional outcomes; and iii) at the final stage we modify our baseline models to address the issue of endogeneity of HFS with nutritional indicators. As mentioned previously, we use the framework of simultaneous equation models—recursive bivariate ordered probit (RBOprobit) & recursive bivariate probit (RBprobit) models (Greene, 2012)—to model the HFS-nutrition linkage. All models are estimated in stata accounting for survey design.

Two additional investigations are undertaken at this stage to ensure robustness. First, we add an interaction term on HFS and the empowerment score (*fsec*em_power*) in the RBprobit models.[13] This modification would allow us to examine whether the effect of HFS on anthropometric indicators changes with increase in women's decision-making power, hence shedding some light on the issue of intrahousehold distribution of food. Greater bargaining power (reflected in higher decision-making score) should allow women more control over household resources and hence ensure more equitable distribution of food within the household (Smith *et al.*, 2003). Accordingly, any adverse effect of food insecurity on women's and children's nutritional status should be smaller or may even be eliminated.

The second robustness check relates to examining the effect of each domain of food security captured by HFIAS (uncertainty, inadequate quality and inadequate quantity) on nutritional status.[14] In undertaking this exercise, we collapse each of the nine questions with polytomous response pattern (never, rarely, sometimes, often) to binary response variables: =1 if sometimes /often; =0 if never or rarely. We subsequently exploit the RBprobit framework to examine these effects by substituting the binary food insecurity variable (*fsec*) by each of the nine binary responses. We estimate the models without the interaction term but retaining all other original control variables.[15]

3.2. *HFS and Child Nutritional Status*

Ordered Probit Model

Baseline Oprobit models are estimated for three categories of child nutritional status—stunting (*HAZ*), wasting (*WHZ*) and underweight (*WAZ*). Three categories of HFS represented by the variable *fsec3* is the key explanatory variable of interest in each equation.

The Oprobit model for each indicator of child nutritional status is specified in the following manner. Let the latent nutritional status be denoted by HAZ^*, WHZ^* and WAZ^*; respectively for stunting, wasting and underweight. The underlying model for stunting consists of an equation relating the latent nutritional status HAZ^* and food security status $fsec3^*$ to background characteristics represented by vector x_1 (described in Table 2) in the following manner:

$$HAZ_i^* = \gamma fsec3_i^* + x_{1i}\beta_1 + \varepsilon_{1i} \tag{1}$$

[13]We could only examine this issue in the context of the RBprobit models because HFS is an ordered variable in the RBOprobit models which renders the use of interaction terms and calculation of marginal effects rather challenging.

[14]It must be noted that this exercise is somewhat rudimentary since by unidimensionality assumption of Rach model, the nine items should collectively identify the underlying latent trait of food insecurity.

[15]We restricted this exercise to RBprobit models assuming that the bivariate framework would be adequate to give us some insight into the nature of this association. The original RBprobit model specifications are retained on the assumption that they would not change substantially even if we substitute the composite food security indicator by an individual dimension of the scale. However, the interaction term is excluded from the model because this exercise is part of an independent robustness check.

TABLE 2
Summary Statistics Of Variables, Maharashtra, 2012

Variables	Description	Total	Rural	Urban
Child anthropometric indicators				
Ordered Categorical				
HAZ	=0 if healthy	0.772	0.752	0.797
	=1 if moderately stunted	0.153	0.166	0.130
	=2 if severely stunted	0.075	0.078	0.070
WHZ	=0 if healthy	0.836	0.829	0.845
	=1 if moderately wasted	0.118	0.123	0.112
	=2 if severely wasted	0.046	0.048	0.043
WAZ	=0 if healthy	0.774	0.750	0.803
	=1 if moderately underweight	0.160	0.182	0.134
	=2 if severely underweight	0.065	0.066	0.063
Binary				
haz_s	=1 if stunted, else 0	0.228	0.248	0.203
whz_w	=1 if wasted, else 0	0.163	0.171	0.155
waz_u	=1 if underweight, else 0	0.225	0.248	0.197
Maternal anthropometric indicators				
m_under	=1 if underweight, else 0	0.323	0.409	0.220
m_over	=1 if overweight/obese, else 0	0.110	0.039	0.193
Key Independent Variables				
fsec3 (categorical)	=0 if HH is food secure	0.572	0.502	0.659
	=1 if moderately food insecure	0.294	0.322	0.259
	=2 if severely food insecure	0.132	0.175	0.080
fsec (binary)	= 1 if HH is food insecure, else 0	0.427	0.498	0.340
HH socio-economic characteristics				
hhsize	household size	6.4 (0.08)	6.6 (0.12)	6.3 (0.12)
genderhead	=1 if female headed, else 0	0.048	0.028	0.074
headlit	=0, if HH head does not read/write	0.196	0.242	0.140
	=1 if HH head has below primary level education	0.144	0.165	0.117
	=2 if HH head has middle to senior level education	0.494	0.492	0.496
	=3 if HH head has college/university level education	0.165	0.100	0.245

TABLE 2 *Continued*

Variables	Description	Total	Rural	Urban
headage	age of HH head	66.2 (0.02)	72.3 (0.35)	58.8(0.03)
caste	=0 if scheduled caste, omitted base group	0.153	0.124	0.184
	=1 if scheduled tribe	0.249	0.350	0.132
	=2 if other backward class	0.2493	0.213	0.290
	=3 if others	0.348	0.313	0.395
	=0 if, HH has white card	Total	Rural	Urban
RPDS[a]	=1 if HH has no ration card	0.048	0.028	0.072
	=2 if orange card	0.238	0.258	0.236
	=3 if yellow card	0.448	0.367	0.543
	=0 if HH belongs to poorest quintile	0.256	0.347	0.149
wealth	=1 if second wealth quintile	0.200	0.345	0.028
	=2 if middle wealth quintile	0.2048	0.321	0.056
	=3 if fourth wealth quintile	0.1964	0.231	0.158
	=4 if highest wealth quintile	0.2029	0.081	0.351
	=1 if household head owns home, else 0	0.1956	0.021	0.411
ownhome[a]	=1 if household head owns land, else 0	0.872	0.954	0.773
ownland[a]	=1 if at least some, else 0	0.450	0.679	0.169
transport[a]		0.509	0.515	0.501
HH environmental characteristics	=1 if kachha/semi-pucca , else 0 (pucca)			
hhtype:	=1 if HH does not have access to piped water, else 0	0.372	0.223	0.552
piped		0.666	0.486	0.887
t*oilet*	=0 if no school	0.554	0.335	0.823
Maternal characteristics	=1 if primary			
mschool	=2 if secondary to middle, else 0	0.116	0.143	0.082
	=3 if above secondary	0.058	0.076	0.035
	=1 if mother's age at marriage <18 ,else 0	0.614	0.663	0.553
	=1 if mother decides HH purchase of regular food items alone or jointly, else 0	0.211	0.117	0.328
agemarriage	=1 if mother decides food items to be given to the child jointly or alone, else 0	0.297	0.367	0.210
foodpurchase	=1 if mother decides HH purchase of regular food items alone or jointly, else 0	0.631	0.605	0.662
decisionfood	=1 if mother decides food items to be given to the child jointly or alone, else 0	0.778	0.783	0.772

TABLE 2 *Continued*

Variables	Description	Total	Rural	Urban
decisionmoney	=1 if mother decides how to spend her own earnings jointly or alone, else 0	0.773	0.772	0.779
decisionhealth	=1 if mother takes decision on her own health care jointly or alone, else 0	0.671	0.674	0.667
decisionvisit	=1 if mother decides visiting family or relatives jointly or alone, else 0	0.672	0.666	0.680
hhpurchase	=1 if mother decides major household purchase jointly or alone, else 0	0.657	0.655	0.661
decisionbaby	=1 if mother decides place of delivery of baby jointly or alone, else 0	0.649	0.625	0.679
decision_immune	=1 if mother decides child immunization jointly or alone, else 0	0.797	0.814	0.777
em_power[b]	empowerment index	5.61 (0.089)	5.59 (0.115)	5.64 (0.141)
lowheight	=1 if mother's height <145 cm, else 0	10.6	11.0	10.2
	=1 if mother received at least 3 ANC, else 0	Total	Rural	Urban
ANC	=1 if mother did not consume iron folic acid (IFA) more than 90 days, else 0	0.906	0.867	0.954
ironfolic[d]	=1 if mother does not have media, (print/electronic) exposure, else 0	0.567	53.2	60.9
media	= 1 if mother has not worked in last 12 months, else 0	0.253	0.363	0.117
work	Number of times a mother was pregnant	0.686	0.535	0.871
pregnancy[e]	=0 if consumption of dark green leafy vegetables is daily/alternate days	2.11(1.18)	2.15 (1.18)	2.08 (1.18)
darkgreen[d]	=1 if weekly	72.4	65.7	79.2
	=2 if never/occasionally	20.7	26.1	15.3
	=0 if fruit consumption is daily/alternate days	6.4	7.7	4.9
fruits[d]	=1 if weekly	22.2	13.9	32.4
	=2 if never/occasionally	26.5	26.3	26.7
	=0 if oilseed consumption is daily/alternate days	50.2	58.9	39.6
oil[f]	=1 if weekly	60.1	54.2	65.9
	=2 if never/occasionally	3.1	2.7	3.9
		36.5	43	30

TABLE 2 *Continued*

Variables	Description	Total	Rural	Urban
Child characteristics	age of child in completed months			
childage	=1 if girl, else 0	11.3 (0.17)	11.1(0.25)	11.5 (0.24)
childegender	=1 if LBW, else 0	0.447	0.439	0.458
LBW (low birth weight)[c]	=1 if first order, else 0 (higher order)	0.201	0.210	0.194
birthorder	=1 if first order, else 0 (higher order)	0.431	0.409	0.447
BF_age_appr	=1 if child age-appropriately breastfed, else 0	0.731	0.745	0.709
Seven_Fgr_recoded	=1 if child received food from >4 food groups	0.088	0.091	0.085
IM_nw	=1 if child received full immunization, else 0 (partial)	0.371	0.340	0.409
setting	=1 if urban, else 0 (rural)	0.55		
region	=0 if Amaravati, omitted base group	0.10		
	=1 if Aurangabad	0.17		
	= 2 if Konkan	0.25		
	=3 if Nagpur	0.08		
	=4 if Nasik	0.17		
	=5 if Pune	0.21		

[a]Included in food security equations alone.

[b]Empowerment score is constructed by adding the responses to the eight binary decision-making questions. Therefore, range of values for the score will be 0-8.

[c]Included in equations for stunting alone.

[d]Included in the equation for maternal undernutrition alone.

[e]Included in equations for maternal under- and overweight.

[f]Included in the equation for maternal overweight alone.

Source: CNSM 2012 (IIPS-UNICEF, 2013) & Author's compilation.

where $i = 1, 2\ldots\ldots n$, β_1 is a column vector of unknown parameters, γ is an unknown scalar which measures the effect of HFS on child nutritional status, ε_{1i} is the error term assumed to be distributed standard normal.

Hence, HAZ^* has an observable counterpart HAZ generated by the observability condition:

$$HAZ = \begin{cases} 0 & \text{if} \quad \mu_{-1} < HAZ^* \leq \mu_0 \\ 1 & \text{if} \quad \mu_0 < HAZ^* \leq \mu_1 \\ 2 & \text{if} \quad \mu_1 < HAZ^* \leq \mu_2 \end{cases}$$

where $\mu_i s$ are the threshold parameters. The variable *fsec3** is generated by the observability condition:

$$fsec3 = \begin{cases} 0 & \text{if} \quad \mu'_{-1} < fsec3^* \leq \mu'_0 \\ 1 & \text{if} \quad \mu'_0 < fsec3^* \leq \mu'_1 \\ 2 & \text{if} \quad \mu'_1 < fsec3^* \leq \mu'_2 \end{cases}$$

where $\mu'_i s$ indicate thresholds as above.

Similarly, the equations for wasting and underweight are:

$$WHZ_i^* = \delta\, fsec3_i^* + x_{2i}\beta_2 + \varepsilon_{2i} \tag{2}$$

$$WAZ_i^* = \theta\, fsec3_i^* + x_{3i}\beta_3 + \varepsilon_{3i} \tag{3}$$

Recursive Bivariate Ordered Probit Model

We estimate RBOprobit models with three categories of child nutritional status (indicated by *HAZ, WHZ* and *WAZ*) and HFS (*fsec3*) as joint dependent variables, with the latter appearing as an ordinary pre-determined variable on the right-hand side (RHS) of the nutrition equation. The model belongs to a general class of simultaneous equation models discussed by Heckman (1978), Maddala (1983) and Greene (2012). What makes it recursive is the fact that the potentially endogenous explanatory variable *fsec3* appears as pre-determined variable on the RHS of equations for the anthropometric indicators, however, *HAZ or WHZ or WAZ* do not appear on the RHS of the equation for *fsec3* (Greene, 2012).

We elaborate below the model specifications for stunting (*HAZ)*. Specifications for *WHZ* and *WAZ* would be similar. The underlying model for stunting consists of two separate equations relating *HAZ** and *fsec3** to background characteristics represented by vectors x_1 and x_0, respectively.

$$fsec3_i^* = \beta_0 x_{0i} + \varepsilon_{0i} \tag{4}$$

$$HAZ_i^* = \gamma' fsec3_i + \beta_1' x_{1i} + \varepsilon_{1i}' \tag{5}$$

where β_0 and β_1' are column vectors of unknown parameters, γ' is the unknown scalar which measures the effect of HFS on nutritional status,ε_{0i} and ε_{1i}' are the error terms assumed to be distributed standard normal. The background characteristics listed in x_{0i} and x_{1i} are detailed in Table 2. Full efficiency in estimation and an estimate of γ' are achieved by full information maximum likelihood estimation method (Greene, 2012).

If nutritional status and food security status are jointly determined, estimating the Oprobit equation (Equation 5) in isolation, will give a biased estimate of γ' (Greene, 2012). The possible joint determination of HAZ_i^* and *fsec3** are accounted for by allowing the errors ε_{0i} and ε_{1i}' to be distributed according to a standard bivariate normal distribution with correlation as shown below:

$$E(\varepsilon_{0i}) = E\left(\varepsilon_{1i}'\right) = 0$$
$$Var(\varepsilon_{0i}) = Var\left(\varepsilon_{1i}'\right) = 1$$
$$Cov(\varepsilon_{0i,}\, \varepsilon_{1i}') = \rho$$

The above model allows us to conduct an endogeneity test to check the potential endogeneity of *fsec3* by testing the significance of 'ρ'. The single equation Oprobit model outlined in Equation 1 is a special case of the RBOprobit with $\rho = 0$. If ρ is not significantly different from zero, one concludes that single equation Oprobit may be suitable for estimation purposes. Our coefficient of interest in Equation 5 is γ'. Similarly, our coefficients of interest for *WHZ*, WAZ** are δ' and θ' , respectively, in the following models:

$$WHZ_i^* = \delta' fsec3_i + \beta_2' x_{2i} + \varepsilon_{2i}'$$

$$WAZ_i^* = \theta' fsec3_i + \beta_3' x_{3i} + \varepsilon_{3i}'$$

where x_2 and x_3 are vectors of control variables detailed in Table 2.

Recursive Bivariate Probit Model

For robustness, instead of considering three categories of nutritional status and HFS, we use binary specifications of anthropometric indicators (*haz_s*, *waz_s*, *whz_s*) and HFS (*fsec*). RBprobit models are used to examine the effect of HFS on child nutritional status in this context. The essence of the model is similar to the RBOProbit model outlined in the previous section. In fact, the latter is an extension of the RBprobit model with more than two categories of the dependent variable.

3.3. *HFS and Maternal Nutritional Status*

We examine the impact of HFS (*fsec*) on maternal underweight (*m_under*) and overweight (*m_over*) separately since these indicators reflect different dimensions of nutritional imbalance – under- and overnutrition, respectively. The respective control variables are described in the section on variables (see also

Table 2). Following the baseline probit models, recursive bivariate probit models are estimated as above.

Identification

Both sets of models (RBOprobit and RBprobit) are estimated by imposing exclusion restrictions even though it is not strictly necessary. "Identification by functional form" is possible which only requires variations in the set of exogenous regressors (Wilde, 2000).[16] One of the identifying variables in the food security equation is *RPDS* denoting the type of ration card possessed by the household. This variable is not included in the nutritional status equation since having a ration card may have a direct impact on HFS (Gopichandran *et al.*, 2010) but not on anthropometric indicators.

4. Results

4.1. *HFS and Child Nutritional Status*

In Table 3, unadjusted models report that HFS is positively and significantly associated with stunting (rho 0.16, $p < 0.05$); while the association is weakly significant with respect to wasting (rho 0.18, $p < 0.08$) and statistically insignificant with respect to underweight. Driven by this mixed evidence, we now turn to the results of the fully adjusted models which control for potential predictors of child nutritional status.

Table 4 reports marginal effects of HFS on child nutritional status for various specification of the models.[17] In reporting the results we focus, primarily, on the RBOprobit/RBprobit models. The results of the baselines Oprobit models are reported for the purpose of comparison only.[18]

Results change noticeably in fully adjusted multivariate models. Stunting (*HAZ*) is no longer significant when potential predictors are adjusted for in the single equation Oprobit model. Moderate food insecurity increases the risk of moderate level of underweight ($WAZ = 1$), however, the effect is weakly significant ($p < 0.09$); while the effects of all categories of food security status on wasting (*WHZ*) are statistically insignificant.

Results change markedly again in the simultaneous ordered probit models. In the RBOprobit model, *severe* household food insecurity increases the risk of *moderate* level of child wasting ($WHZ = 1$) by 0.09 ($p < 0.045$). *Moderate* and *severe* food insecurity significantly increases the risk of *moderate* underweight ($WAZ = 1$) by 0.08 ($p < 0.03$) and 0.12 ($p < 0.04$), respectively; while *severe* level of underweight ($WAZ = 2$) is only weakly affected by moderate food insecurity ($p < 0.06$). The marginal effect of HFS on stunting remains statistically insignificant as before.

[16]Since identification by functional form relies heavily on the assumption of bivariate normality, it is common practice to impose exclusion restrictions to improve identification (Roodman, 2011).

[17]Estimating marginal effects in RBOprobit models is rather complicated and statistical softwares such as Stata do not routinely estimate them. To estimate the marginal effects in RBOprobit models we used David Roodman's "cmp" framework in Stata (Roodman, 2011).

[18]The complete results of the fully adjusted models are not reported but are available on request.

TABLE 3
ASSOCIATION OF HOUSEHOLD FOOD SECURITY STATUS WITH MATERNAL/CHILD NUTRITIONAL STATUS (UNADJUSTED), MAHARASHTRA, 2012

	Food Secure	Moderately Food Insecure	Severely Food Insecure	Rho[a]
Child nutritional status				
Stunting				
Healthy	0.803	0.739	0.712	0.16**
Moderately Stunted	0.146	0.170	0.145	
Severely stunted	0.051	0.090	0.142	
Underweight				
Healthy	0.810	0.737	0.698	0.18
Moderately Underweight	0.140	0.190	0.185	
Severely underweight	0.049	0.072	0.116	
Wasting				
Healthy	0.844	0.841	0.794	0.08*
Moderately Wasted	0.118	0.116	0.123	
Severely wasted	0.038	0.044	0.084	
Maternal nutritional status				
Underweight	0.338	0.405	0.375	0.07*
Overweight	0.196	0.123	0.078	−0.23

Note: [a]Polychoric correlations reported for children and tetrachoric correlations reported for mothers.

**,*Implies significance at 5% and 10% level of significance, respectively.

In all specifications, ρ is statistically significant hence justifying the importance of using simultaneous equation models rather than single equation ordered probit models for the purpose of modelling the food security-nutrition relationship.

Next, we report the results of RBprobit models for the two specifications: with and without the interaction term *fesec***em_power*. Results align closely except with respect to wasting. The marginal effects on stunting are statistically insignificant in all specifications. In the models without the interaction term, moderate food insecurity increases the risk of child wasting by 0.08 ($p < 0.04$) and the risk of underweight by 0.16 ($p < 0.000$). However, in models including the interaction term the effect of *fsec* on wasting is no longer significant. The effect on underweight remains statistically significant but is smaller in magnitude. In all models other than stunting, ρ is weakly significant.

Finally, we report the RBprobit results on the association of each component of the composite food security index with each of the three child nutrition indicators (Table 5). For stunting, marginal effect is positive and significant only for two items—the one capturing the dimension of inadequate quality (*preferred*) and the other capturing the dimension of inadequate quantity (*nofood*); while for wasting items capturing quality (*variety* and *nochoice*) and quantity (*fewer* and *nofood*) dimensions are statistically significant. Underweight is the only nutrition indicator which is positively and significantly related to all components of the composite index except for the most extreme condition *daynight* which reflects hunger.

4.2. *HFS and Maternal Nutritional Status*

Bivariate estimation of the association of HFS with maternal nutritional indicators in the unadjusted models (Table 3) reports that prevalence of maternal

TABLE 4

Association Of Household Food Security Status With Maternal/Child Nutritional Status, Maharashtra 2012: Marginal Effects In Adjusted Multivariate Models

Model	Moderately Food Insecure	Severely Food Insecure	Food Insecure (without interaction term: ***fsec*em_power***	Food Insecure (With Interaction Term: ***fsec*em_power***
Child nutritional status				
Ordered Probit [a]				
HAZ (=0)	−0.02 (0.018)	−0.017 (0.028)		
HAZ (=1)	0.0139 (0.01)	0.0009 (0.015)		
HAZ (=2)	0.0104 (0.008)	0.007 (0.012)		
WAZ (=0)	−0.036* (0.019)	−0.019 (0.026)		
WAZ (=1)	0.0230* (0.012)	0.0219 (0.022)		
WAZ (=2)	0.022 (0.012)	0.0114 (0.016)		
WHZ (=0)	0.013 (0.019)	0.004 (0.025)		
WHZ (=1)	−0.008 (0.012)	−0.003 (0.016)		
WHZ (=2)	−0.005 (0.006)	−0.0014 (0.008)		
Recursive Bivariate Ordered Probit[b]				
HAZ (=0)	−0.09 (0.06)	−0.13 (0.12)		
HAZ (=1)	0.05 (0.03)	0.07 (0.06)		
HAZ (=2)	0.04 (0.03)	0.06 (0.06)		
WHZ (=0)	−0.07 (0.05)	−0.17* (0.09)		
WHZ (=1)	0.05 (0.03)	0.09** (0.05)		
WHZ (=2)	0.03 (0.02)	0.07 (0.05)		
WAZ (=0)	−0.14** (0.065)	−0.21* (0.12)		
WAZ (=1)	0.08** (0.04)	0.12** (0.06)		
WAZ (=2)	0.06* (0.03)	0.09 (0.06)		
Recursive Bivariate Probit[c]				
haz			0.04 (0.07)	−0.02 (0.081)
whz			0.08**(0.03)	0.06 (0.049)
waz			0.16***.(0.03)	0.12** (0.055)
Maternal nutritional status				
Probit Model				
m_under (BMI < 18.5)				0.02 (0.074)

TABLE 4 *Continued*

Model (1)	Moderately Food Insecure (2)	Severely Food Insecure (3)	Food Insecure (without interaction term: ***fsec*em_power*** (4)	Food Insecure (With Interaction Term: ***fsec*em_power*** (5)
m_over (BMI ≥ 25)				−02 (0.02)
Recursive Bivariate Probit[d]				
m_under			0.17** (0.07)	0.24*** (0.07)
m_over			−0.14 (0.38)	−0.11 (0.39)

Note: ***,**,*Implies significance at 1%, 5% and 10% level, respectively. Standard errors in parenthesis. *HAZ (stunting), WAZ (underweight)* & *WHZ* (*wasting*) are ordered categorical variables: =0 if healthy, =1 if moderately malnourished & =2 if severely malnourished. *haz (stunting), waz (underweight), whz (wasting)* are binary variables: =0 if healthy & =1 if malnourished. *m_under* & *m_over* are binary variables: =0 if mother is healthy, =1 if mother is underweight/overweight, respectively.

[a]Models include child nutritional status as ordered categorical variables. Control variables in the equation for stunting include household characteristics: age, education, gender and caste of household head, household size, wealth status, whether the household is pucca, whether the household has access to piped water, whether the household has access to toilet facility; maternal characteristics: mother's age of marriage (if <18 yrs), education level, whether mother worked in last 12 months, whether mother received at least 3 ANC, if maternal height <145 cm, mothers' exposure to media, empowerment index; and child characteristics: child's age, gender, birth order, whether child is appropriately breastfed, whether child received at least 4 food groups, whether child had low birth weight (LBW) and finally setting (rural/urban) and region (Amaravati, Aurangabad, Konkan, Nasik and Pune). The equations for wasting and underweight do not include the variables LBW and maternal stature, but instead include maternal BMI status and whether the child received full immunization.

[b]Models include child nutritional status and HFS as ordered categorical variables. In addition to controlling for empowerment and the household demographics included in the equation for nutritional status as stated above, the food security equation includes additional household level factors such as the type of ration card possessed by the household (no card, yellow, white or orange), household home ownership and land ownership status & whether the household has some transport.

[c]Model includes nutritional status and food security status as binary variables. Additionally, column five reports result of Rbprobit models including the interaction term on empowerment score and HFS.

[d]Models include maternal nutritional status and food security status as binary variables. These models do not include child characteristics. All household level variables mentioned above are included. Maternal characteristics include additional covariates such as frequency of consumption of fruits and dark green leafy vegetables (in underweight equation)/consumption of oilseeds (in overweight equation), number of times mother was pregnant (in both underweight & overweight equations), and whether mother consumed iron and folic acid for more than 90 days (in underweight equation).

underweight increases from food secure (34 percent) to severely food insecure households (38 percent), however the relationship is weakly significant (rho 0.07, $p < 0.07$). Prevalence of overweight decreases with increasing food insecurity, however the relationship is statistically insignificant.

In the fully adjusted probit models (Table 4), HFS has no effect on maternal underweight or overweight. As before, results change distinctly in the RBprobit models which address potential endogeneity of *fsec* (Table 4). We report results for two specifications of the models again, with and without the interaction term, and find that the results are robust. In the model without the interaction term, increase in the probability of food insecurity significantly increases the risk of maternal underweight by 0.17 ($p < 0.02$); while the inclusion of the interaction term increases the magnitude of the effect to 0.24 ($p < 0.001$). The marginal effects on overweight status remains statistically insignificant in both specifications. Rho (ρ) is statistically insignificant for various specification of the models.

With regard to the marginal effects of individual dimensions of food insecurity on the risk of maternal underweight and overweight, all effects are statistically insignificant for overweight status while maternal underweight is significantly affected by the quantity dimensions of food insecurity (*fewer*, *nofood, hungry*).

5. Discussion

Evidence on the association of food insecurity with nutritional outcomes is mixed. Certain key issues emerge. First, in examining this relationship it is important to address the concerns with potential endogeneity of HFS with respect to anthropometric indicators. Results of the baseline models change markedly when we account for endogeneity within the framework of simultaneous ordered probit/probit models. Rho is insignificant only in the RBprobit models on child stunting and maternal underweight /overweight which imply that in these cases the relationship may be examined using single equation probit / ordered probit models.[19]

Second, household food insecurity is not able to explain child stunting in any of the models. Using this same dataset for Maharashtra, Chandrasekhar *et al.* (2017) do not report any association of HFS with child stunting, wasting or underweight. Similar results have been reported in other populations such as: for children aged 6 to 36 months in Ghana (Saaka and Osman, 2013) and for children aged 6–23 months in Nepal (Osei *et al.*, 2010). However, several studies from low-, lower middle- and upper middle-income countries report strong association of HFS with stunting for under-five children — Motbainor *et al.* (2015) and Reis (2012) to cite a few—which apparently contradicts our conclusion. In such cases, our results may not be comparable primarily due to two reasons. First, the empirical strategy used in our paper attempts to address endogeneity which none of the other studies addressed. Second, our study has a younger age-group specification of 0–23 months. The only study which reports significant association between HFS

[19]However, this outcome does not remove the endogeneity of HFS with respect to nutritional outcomes (Greene, 2010).

TABLE 5

Association of Each Item in HFIAS with Maternal and Child Nutritional Status, Maharashtra, 2012: Marginal Effects in Recursive Bivariate Probit Models

	Child Stunting	Child Wasting	Child Underweight	Maternal Underweight	Maternal Overweight
Worried	0.048 (0.086)	0.040 (0.049)	0.110*** (0.021)	−0.005 (0.115)	−0.207 (0.296)
Preferred	0.074*** (0.017)	0.015 (0.074)	0.087*** (0.028)	0.059 (.095)	−0.155 (0.278)
Variety	0.066 (0.107)	0.059** (0.020)	0.117*** (0.022)	−0.013 (0.138)	−0.149 (0.271)
Nochoice	0.050 (0.156)	0.065** (0.027)	0.089*** (0.019)	0.069 (0.153)	−0.275* (0.150)
Smaller	0.009 (0.195)	0.017 (0.111)	0.102*** (0.035)	0.040 (0.196)	0.046 (0.198)
Fewer	−0.051 (0.486)	0.053** (0.022)	0.060** (0.023)	0.140** (0.057)	0.001 (0.397)
Nofood	0.042*** (0.012)	0.038** (0.015)	0.036* (0.020)	0.163** (0.039)	−0.175 (0.095)
Hungry[a]	0.029 (0.076)	0.040 (0.046)	0.035** (0.012)	0.028*** (0.005)	−0.136 (0.118)
Daynight[b]	0.055 (0.090)	0.158	0.132 (0.088)	0.047 (0.094)	−0.113 (0.140)

Note: Each item is a binary variable with the following response pattern: =1 if no or rarely; =0 if sometime or often. All variables in the models are as described in Table 4 for the RBprobit models.

and stunting for children aged 0–24 months (Saha *et al.*, 2009) uses longitudinal data as opposed to cross sectional data used in our study. Importantly, age related differences are crucial in understanding contradictory evidence from various studies. Biologically, linear growth is a slower process than growth in body mass which implies that a significant degree of stunting takes longer to be visible and may not be evident for some years (WHO, 1986); albeit prevalence of stunting increases over time up to the age of 24–36 months after which it may level off (WHO, 1986). Apart from these biological variances there may also prevail geographical and gender related differences in the process of stunting and wasting (WHO, 1986) which help to reconcile conflicting findings from various studies. Furthermore, stunting reflects longer term deprivation driven more by factors such as maternal nutritional deficiency and consequent low birth weight of the child (Black *et al.*, 2008). Lack of access to improved sanitation and drinking water could be the other major contributors. Incidentally, in 2016, only 52 percent households in Maharashtra used improved sanitation facility which is only marginally higher than the national average (48 percent) and far below the average in Kerala (98 percent); while drinking water coverage has not improved in the state over the last decade 2006–16 (NFHS, 2017). It is also possible that food insecurity observed in Maharashtra is more cyclical or temporary rather than being chronic and hence not associated with stunting (Devereux, 2006). Even with chronic food insecurity, households may develop some coping strategies to deal with food insecurity (Hernandez and Jacknowitz, 2009). In either of the above cases we would not expect any association of HFS with stunting. Among the various components of the composite food security index, the only component which reports any association with child stunting is 'no food to eat of any kind' reflecting severe food insecurity.

Evidence on the impact of HFS on child wasting from various models is mixed. The recursive bivariate specification of the model without the interaction term reports significant increase in the risk of wasting due to HFI. Further disaggregating results, from the recursive ordered specifications we find that it is severe food insecurity which influences wasting. However, the effect of food insecurity on wasting disappears when we incorporate the additional effect of women's bargaining power by including the interaction term in the model. We attempt to reconcile the above findings by positing three sets of arguments. First, the fact that severe food insecurity has an effect on the risk of wasting (moderate) is consistent with the biological process of wasting and its possible link to food insecurity. As discussed previously, wasting captures recent episodes of growth deficit caused by inadequate current food intake and infection possibly due to a sudden a shock (e.g. food price hike) which is typically more acute (Devereux, 2006). Second, as opposed to stunting, wasting is a quicker process (both onset and recovery can be rapid) (WHO, 1986). Additionally, contrary to stunting, prevalence of wasting is greatest between 12 and 24 months of age and tend to decrease later on. These differences help explain why we observe significant association of HFS with wasting but not with stunting for children aged 0–23 months. Regarding why household food insecurity no longer affects child wasting once we incorporate the effect of women's bargaining power (proxied by decision-making), one immediate explanation might be that in times of sudden shocks or acute shortage of food women with higher bargaining power are better able to protect their children from adverse effects of food insecurity (Quisumbing *et al.*, 1996). The pathways through which improvement in women's status improve child nutritional status may be higher quality care for themselves and their children - better complementary feeding practices, better information about healthy food choices, ability to increase budget share of food and better treatment of illness and immunization of children (Smith *et al.*, 2003). Concerning the alignment of our results with the broader literature, the evidence on food insecurity-wasting link is limited. Only three out of 15 studies reported in Maitra (2018) find positive and significant association of experiential food insecurity with child wasting–for under-five children in Ethiopia (Motbainor *et al.*, 2015), Bangladesh (Hasan *et al.*, 2013) and Nigeria (Ajao *et al.*, 2010). Ali *et al.* (2013) report significant association for under-five children in Bangladesh but not in Ethiopia and Vietnam. The age-related biological factors or geographical factors discussed in the context of stunting may explain the contradictory findings in this context too.

Household food insecurity is a significant driver of underweight in children. Additionally, this finding is robust to various specifications of the models. All individual components of food insecurity captured by the items relating to anxiety, inadequate quality and inadequate quantity also report strong association with child underweight. Interestingly, even when we account for women's decision-making power, the effect of food insecurity on the risk of child underweight remains strong. However, the magnitude of the effect is smaller implying, as before, that greater bargaining power of women promote higher child well-being by dampening the adverse nutritional consequences of food insecurity. Our finding is consistent with such claims from the wider literature that equal status of men and women is likely to reduce prevalence of underweight in children aged under three years in South Asia (Smith *et al.*, 2003). The pathway from food insecurity to child underweight is most likely nutritional, driven by the fact that children from food-insecure households are more likely to consume diet low in energy and micronutrients (Oh and Hong, 2003; Cook *et al.*, 2004; Skalicky *et al.*, 2006). Similar results have been reported for children aged 0–24 months in Bangladesh (Saha *et al.*, 2009); and for pre-school children in Columbia (Hackett *et al.*, 2009).

We find household food insecurity to be a risk factor for maternal underweight as well. As with the case of child underweight, this finding may be explained by low total energy intake and poor nutrient intake caused by inadequate access to food (Tarasuk and Beaton, 1999). Additionally, in the face of household food insecurity mothers often resort to coping strategies by which they compromise their own energy intake to meet their children's need (Isanaka *et al.*, 2007). Particularly, low income mothers may allocate resources or sacrifice their own food consumption to protect children from hunger (Devine *et al.*, 2006). Perhaps this behaviour explains why only the questions related to the 'quantity' dimensions of HFIAS are significantly associated with maternal underweight. Similar findings are reported in Cambodia (McDonald *et al.*, 2015), Nepal (Singh *et al.*, 2014) and Columbia (Isanaka *et al.*, 2007). Interestingly, when we incorporate the effect of women's bargaining power in HFS, the magnitude of the effect of food insecurity on the risk of underweight increases. It is possible that the decision-making variable itself is problematic as a proxy indicator of bargaining power–women may be making decisions within the constraints imposed by their husbands (Doss, 2013). For example, they may be given a budget for food and household expenses which they decide how to spend. Such decisions drive better outcomes for the children but may leave themselves deprived once they have taken care of the children. Therefore, the cultural context is also important in interpreting results based on decision- making as proxy to women's bargaining power (Doss, 2013).

We do not find any association of HFS with maternal overweight. This finding is robust across all models, and is also consistent with the broader literature which concludes that any relationship between experiential food insecurity and overweight is limited or absent in developing country settings. Several literature reviews (Nettle *et al.*, 2017; Dinour *et al.*, 2007; Maitra, 2018) conclude that the food insecurity-overweight link in adults is the most pronounced among women in high income countries; and "limited evidence from developing countries may not show the same pattern as the developed countries (especially the USA) from which most of the evidence comes" (Nettle *et al.*, 2017, p. 7). Despite methodological concerns which pervade this literature, the consensus among researchers on this issue is overwhelming. This finding may reflect the fact that in a developing country context household food insecurity might be associated with lack of availability of even the least expensive energy dense food that might lead to overweight. Similar results are reported by Isanaka *et al.* (2007) for Columbia where adults and children from resource poor households resort to fewer purchase of commercial energy dense food like fried snacks/chips, as opposed to similar population from the US. In the latter case, the individuals from food insecure households facing limited resources consume less expensive and more calorie-dense food to maintain caloric intake at less cost, exposing themselves to greater risk of overweight (Drewnowski and Specter, 2004). In our context, accounting for women's empowerment does not change the conclusion, indicating that the pathways from food insecurity to overweight are likely to be very different from those linking undernutrition and food insecurity (FAO, 2018). Recent discourse on multiple burden of malnutrition and nutrition transition indicate that these pathways may be associated with the particular stage of nutrition transition the country is situated in (see Kac *et al.*, 2012; Doak *et al.*, 2005; Smith, 2015). In the Indian context, labor market inactivity could also be a driver of obesity (Dang *et al.*, 2019). Moreover, overweight and associated dual burden of undernutrition is more prevalent in affluent households in India (Helble and Sato, 2018).

A key message emerging from the above results is, we do have some indirect evidence that food insecurity might be a potential determinant of human development. The strong and robust association of HFS with child and maternal underweight indicates that effects of food insecurity may persist throughout the life cycle. Maternal underweight is a risk factor for low birth weight (Black *et al.*, 2008) with dire consequences such as increased risk of neo-natal mortality and poor child growth both of which are detrimental to formation of human capital (Victora *et al.*, 2008). Low weight-for-age in child has been associated with delayed motor development, poor performance on conservation tasks (Fishman *et al.*, 2004) and lower scores on aggregate measures such as IQ (Aboud and Alemu, 1995) to cite a few. These adverse outcomes affect productivity in the long run, perpetuating the cycle of poverty-food insecurity-poor nutrition-poor learning outcomes-low earnings. Future research should examine the direct effects of food insecurity on cognitive outcomes of children and their late life earnings to generate more concrete evidence on the above hypothesis.

6. Conclusion

We report mixed evidence with respect to the association of household food insecurity with maternal and child nutritional status. Household food insecurity predicts child wasting and underweight but not child stunting. However, women's bargaining power seems to be dampening the adverse effects of food insecurity on child malnutrition. Furthermore, household food insecurity is a risk factor for maternal underweight but not for overweight. Overall, these findings indicate that policies aimed at improving household food access should improve nutritional outcomes of women and children, however, food alone may not be the solution.

Providing adequate access to food may not address the concerns with child stunting (Rah *et al.*, 2015). Potential solutions may lie elsewhere, such as in the direction of addressing maternal nutritional deficiencies within the notion of first "1000 days" of life (Victora *et al.*, 2008) or in ensuring access to improved drinking water and sanitation (Ngure *et al.*, 2014). Growing evidence suggests a link between child linear growth and household water, sanitation and hygiene (WASH) practices. Thus, a multisectoral approach is warranted for prevention of stunting.[20] Dietary diversity is also important in this context highlighting the importance of *quality* (micro-nutrients) of food rather than *quantity* (calories primarily).

Wasting, on the other hand requires actions at the community and household level such as child feeding practices (breastfeeding and complementary feeding), and improved disease environment aimed to reduce infection (for example, promoting intervention on zinc with management of diarrhea). At the community level, programs such as Integrated Child Development Services (ICDS) should be more active in providing adequately nutritious food to the vulnerable population. Quality and timing of school meals must improve which is a concern in the Indian context (Afridi *et al.*, 2016). For example, recently egg has been introduced in ICDS meals which could have higher benefits in terms of improving child nutritional status (Mittal and Meenakshi, 2018). Also, typically cited as a classic example of policy failure (Haddad *et al.*, 1997), often with public food assistance programs such as "school meals" children's food allocation at home is reduced when they receive meals from school. Mittal and Meenakshi (2018) cite evidence of such partial meal substitution at home in the Indian context. Considering wasting is seen as a short-term response to inadequate dietary intake and is reversible (WHO, 1986), concerted efforts should be made in the above directions. In this context, similar policy recommendations follow for child underweight which is also a likely outcome of inadequate access to food. For example, for children with moderate malnutrition, family food can help recovery as long as the diet is diverse providing adequate

[20]Accordingly, the UNICEF (1990) conceptual framework has been extended to include WASH interventions (see Haddad *et al.*, 2015).

protein, energy and micronutrients (for example, diet based on legumes, animal protein and dark green leafy vegetables) (Briend *et al.*, 2009).

The strong link between maternal underweight and household food insecurity is concerning because maternal undernutrition has life-long consequences (Victora *et al.*, 2008). The high rates of child undernutrition in south Asia, the so-called "Asian Enigma," has been traced back to higher rates of maternal undernutrition (Ramalingaswami *et al.*, 1996). If thinness is caused by household food insecurity, utmost effort should be directed at providing nutrition-specific interventions such as maternal dietary supplementation or multiple micronutrient fortification (Bryce *et al.*, 2008). The issue of women's status is also important in this context which we discuss below. Interestingly, even if food security interventions may be effective in confronting maternal underweight, different sets of policies may be necessary for dealing with overweight or obesity. In terms of policy, interesting options such as the question of geographical targeting have become relevant—for example, if programs such as maternal spot feeding should offer so many calories to mothers residing in states (such as Karnataka) where geographically overweight prevalence is already high (Sethi, 2018).[21]

A crucial policy implication of the findings of the paper relates to women's empowerment. Even though we have not dealt explicitly with intra-household resource allocation issues in the present paper, our findings indicate that women's bargaining power may have a critical role in mediating the association between household food insecurity and nutritional outcomes of women and children living in the household. Part of the puzzle of 'Asian enigma' is explained by intrahousehold inequity in access to food by women and girls. One straightforward policy implication of this finding is, a greater focus on programs which promote women's empowerment—the well-established nutrition-sensitive programs (Ruel and Alderman, 2013). Examples of such programs are: girls' schooling, conditional cash transfer programs, provision of basic health services or social support schemes to address maternal mental health and concerns with low self-esteem which are risk factors common to both nutrition and child development (Tripathy *et al.*, 2010).

Finally, in the context of policy implications, we refer to the challenges posed by multiple burden of malnutrition (WHO, 2017; Haddad *et al.*, 2015). The Maharashtrian sample does provide some evidence of intra-household dual burden of malnutrition since we observe the presence of both overweight mothers and undernourished (stunted, wasted or underweight) children in our sample. However, since we have not explicitly dealt with such mother-child pairs in the present study, we would not be able to draw any inference on its link to household food insecurity. For our purposes what seems to be important is that the complexities of multiple burden of malnutrition further complicate food and nutrition related policy interventions. For example, if food based polices target households with high overweight prevalence then the underweight individuals residing in dual burden households may become "target of obesity-prevention policies" (Doak *et al.*, 2005). Such possibilities caution us on potential policy failure. These contradictions also take us back to a focus on households rather than individuals at a time when what we

[21]Approximately 23 percent of women in Karnataka were overweight in 2015–16 and the prevalence rate increased from 15 percent in 2006 (NFHS, 2017).

urgently need is a set of holistic policies promoting wellbeing of every individual residing in the household (Doak *et al.*, 2005). Referring to our previous discussion on stunting, policies with an overwhelming focus on *quantity* of food rather than *quality*—"Calorie fundamentalism" (Headey *et al.*, 2012)—are not holistic and are likely to result in persistence of undernutrition and overweight.

Overall, the policy implications of our findings suggest that a combination of nutrition specific and nutrition sensitive policies is required to address the concerns with malnutrition. At this stage we mention some limitations of our research. A major shortcoming of our study is its cross-sectional design. For better understanding of the food insecurity-malnutrition link longitudinal data is essential. The dynamic nature of this relationship would not be fully understood unless we are able to analyze the mechanism of households/individuals moving in and out of food insecurity. Such data also allows us to examine the problem using a life course framework. Second, we could not explicitly model intra-household allocation of resources in the present paper. The proxy indicator capturing women's bargaining power can be improved and information on women's time allocation is crucial (Senauer *et al.*, 1986). At this stage, we recommend further research in this context. Future research should also focus on the rising complexities of multiple burden of malnutrition and related policy issues. The experiential food security indicator also has its limitations (Jones *et al.*, 2013). In general, research should be directed toward exploring better ways of incorporating the time dimension in the experiential scale measures. Furthermore, it is important to be able to measure maternal and child food insecurity at the individual level in order to get reliable and precise estimates of the effect of food insecurity on individual nutritional status. Inferring on child food security status based on parental reporting may be misleading (NRCIM, 2013). Future research should also direct its attention to understanding the various channels from food insecurity to nutritional outcomes for effective policy formulation (FAO, 2018). Such efforts might go a long way in formulating development polices which are "people" centric. Integrating food and nutrition security in policies for human development may be a pathway to inclusive growth, or perhaps more appropriately "nutrition sensitive growth" (Headey, 2011). After all, nutrition may be the bridge between economic and human development (Haddad, 2014).

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Table A1: Household Food Insecurity Access Scale: Measurement Tool (HFIAS)

Figure B1: Conceptual framework to understand the relationshp between maternal/child nutritional status and household food security status.