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Abstract

This study uses the NFHS-3 data to estimate SUR model for HAZ, WAZ and WHZ to understand how the determinants of intergenerational transmission, feeding and care practices and ICDS vary in their impact when these commonly used measures of child nutritional status are considered together in a systems framework. As expected mother's height, BMI and anemia levels are all highly important in explaining the variations with large impact of height on HAZ, of BMI on WAZ and more widespread impact of anemia on WHZ. Initiation of breastfeeding within an hour of child's birth, exclusive breastfeeding in the first six months, and inclusion of protein rich diets for the older children has a large impact on HAZ and so does access of daily food supplements from ICDS by rural children. Other predictors such as wealth status, safe water access, sanitation and use of clean cooking fuel by the households, are found to be strongly associated with all the indicators. The results from this study strengthen the evidence that though multiple determinants play a role in child's growth the key factors are in the mother to child transmission and in quality of early child care of feeding habits and preventive and curative health care practices.

Keywords: *Child under-nutrition, stunting, underweight, wasting, Seemingly Unrelated Regression, India*

JEL Codes: C51, I12, I13, I14, J13, O15.

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INTRODUCTION

Once child health is considered as an end in itself then any health outcome variable based on child health automatically becomes a significant feature for policy makers to assess the triumph or malfunction of the various policy interventions. Infants and young children are more susceptible to infections and providing a disease free environment both from a preventive and curative sense is a major public health priority for any nation. Anthropometric indicators like the child's height and weight capturing their nutritional status can be viewed as an outcome of the health production function (Becker, 1965 and Grossman, 1972) where the inputs include intake of nutrients and diet patterns (Bhagowalia, 2010; Martorell and Young, 2012; Smith *et. al*., 2012), exposures to infections (Ramachandran and Gopalan, 2009), genetic dispositions (Currie and Moretti, 2007 and Ackerson *et. al*., 2009) and access to health care (Mosley and Chen, 1984). Socio-economic inequalities in health outcomes are becoming the emerging area of research in health literature which ultimately influences the overall development of the nation. In spite of tremendous progress the gains and deprivations are unevenly distributed between and within the countries. For instance, among developing countries child stunting in 2015 in South Asia is around 18 percent while that in Latin America it is around 6 percent. Some 6.6 million children under 5 years of age died in 2012, mostly from preventable causes (Von Grember *et. al.,* 2015).

Child undernutrition is a pressing concern and more so after several countries failing to meet the MDG targets by 2015. As nutrition is a powerful driving force of sustainable development the newer targets set by the Sustainable Development Goals seem to be taking a broader and integrated commitment from all sections of the society by elevating and scaling up nutrition specific targets and investments (Griggs *et. al.,* 2013). India continues to have high levels of malnutrition in some regions while in regions that have shown reductions in the past three to four

decades it has somewhat stagnated and slow improvements are being observed (Von Grebmer *et. al.*, 2014 and Malhotra, 2014). At an individual level, the child loses its educational attainment where they miss more school days due to illness after controlling for all background characteristics of the child in India (Save the children report, 2013). This report further quantifies the impact showing that children in India who are stunted at age 5 scored 7 percent worse on maths test and 19 percent less likely to be able to read a sentence and in future it affects the labor productivity where the children who are stunted would go on to earn 20 percent less in their adulthood compared to children who are well nourished which in turn affects economic growth.

The heartening news with the most recent data from the Rapid Survey of Children (RSOC) is that none of the States reported an increase in the proportion of the children who are underweight or stunted from 2004-05 to 2013-14, which is a significant reversal from the past trends (GOI, 2015). The recent fact sheets of NFHS-4 (2014-15) shows that the better performing states like Tamil Nadu has shown slower pace in reduction of stunting from 30.9 in 2005-06 to 27.1. In contrast a low ranking state Bihar decreased from 55.6 per cent to 43.9 during the same period. This trend is seen in case of other indicators of child undernutrition. This depicts that the prevalence of undernutrition based on different types of indicators are varying across states and that the rate at which the undernutrition has declined also varies across regions as well as the indicators. Differences in reduction rates of indicators between states may be due to various factors which call for further assessment.

Variations in social, economic, political, and environmental factors which have been usually associated (or its determinants) with child undernutrition leads to differences in the related indicators across states. Smith and Haddad (2015) show that sanitation, access to safe water, improvements in gender equality, dietary habits and care practices

are all relevant for reducing undernutrition especially stunting. Similarly in the Indian context these factors have been shown to be impacting undernutrition. However there are variations on the impact depending on how the care and feeding practices as well as relevant policies are captured by the studies. Further the impacts also vary between stunting, underweight and wasting. It is also observed that fewer studies in India focus on intergenerational transmission of undernutrition which also gives additional scope for intervening by targeting adolescent girls and boys, young mothers to improve child nutrition at a faster pace.

This study tries to compare the impact of the determinants of child growth using z scores of height for age (HAZ), weight for age (WAZ) and weight for height (WHZ) by particularly focusing on three determinants- intergenerational aspects, feeding practices including access to supplementary nutrition from ICDS and care practices. The SUR modelling framework used in this study enables us to arrive at separate estimates for each anthropometric indicator while also binding them to be part of a single system so that for each child all these indicators are taken together.

Our rationale of analyzing these indicators together in a single model is two-fold. *Stunting* (HAZ<-2) is a long term (chronic) measure of undernutrition and *underweight* (WAZ<-2) and *wasting* (WHZ<-2) are short term indicators of undernutrition. Measurement of health indicators by using appropriate data will help the countries' policy makers to achieve planning efficiency by identifying the problems with the right estimates. Quantitative estimates also help to plan specific interventions at local levels by identifying the geographical regions where the problems are heavily concentrated. It helps to compare and diagnose the outcomes where it lags and where it is ahead in the performances. The question of how to reduce or tackle the problem of undernutrition continues to be of great concern in the Indian context and gaps in earlier studies gives scope for probing further based on empirical evidence.

The next section (section 2) presents a brief review of literature on child nutritional indicators. Section 3 gives an overview of conceptual framework, data and model specification. Section 4 discusses the results and Section 5 concludes the chapter.

REVIEW OF LITERATURE

The focus of the review is largely on three specific determinants Intergenerational transmission, feeding and care practices, and access to ICDS and health care. Further, the discussion also tries to highlight that instead of assessing the impact of these determinants on a single indicator or as an index of nutritional deprivation, it may be more informative to consider several indicators jointly.

Height for age (HAZ), weight for age (WAZ) and weight for height (WHZ) are the commonly used indicators for assessing stunting, underweight and wasting rates as per WHO standards. These three variables are the z-scores adjusted for sex and age and measures as to how far or close the child's anthropometric measure is to the median value of the WHO (2006) reference standards as a proportion of the reference standard deviation[1].

Several earlier studies have focused on the determinants of child undernutrition indicators from different perspectives. With the prevailing measures and methodologies, various research studies have estimated the impact on stunting, underweight and wasting, of the child level variables, household characteristics, parental (mother and father) characteristics and policy related variables. These anthropometric

[1] Z-score is commonly used to define stunting, underweight and wasting rates as per WHO standards. A child is said to be moderately stunted or wasted or underweight if the respective z -score value is less than -2 or below and severely stunted if the height z- score value is less than -3 or below. The reference mean and the reference standard deviation is taken from the pooled sample of children living in Brazil, Ghana, India, USA, Oman and Norway through Box-Cox Power Transformation Method.

indicators are analyzed in the literature either separately (specific indicator) or as an index by combining any two of these indicators. However, there are very few studies in the empirical literature on child developmental outcomes that consider a unified approach which combines all the important indicators of child growth in particular or child health in general (Gaiha *et. al.*, 2010 and Bangura, 2014). It has been observed that different indicators of child health outcomes like mortality, morbidity or undernutrition as well as its different components like perinatal or neo-natal mortality; stunting or underweight respond to some common interventions but are also quite varied in its temporal changes across different geographical regions (Viswanathan, 2014). Such an uneven nature of progress has been rather pronounced for a country like India and evidence based policy making with a unified approach becomes an important tool of analysis for assessing the overall child growth pattern.

We consider child's health as a multidimensional feature with each of the growth indicator as its dimension. Instead of a combined indicator, we consider the HAZ, WAZ and WHZ as three separate dependent variables but combined into a system allowing for correlation between the errors across these equations. Combination of these three indicators in a system of equations tries to focus on answering the questions like what are the basic underlying determinants which causes the differential impact among the prevalence of the indicators. To the best of our knowledge, no study in the Indian context has used this method while a few studies for child nutrition in Africa and Latin America have used this approach for similar reasons as in this study (Morales, *et. al.* 2004; Burchi, 2010 and Bangura, 2014).

We next review the literature in some detail focusing on the determinants of child nutrition that the study is specifically interested in. Usually, genetic traits in the literature are captured through father and mother characteristics such as their height, weight, sickness profile etc.

In this study mother's anthropometric status (Balhotra and Rawlings, 2011), her health status (Subramanian *et. al.*, 2009) and her own education, empowerment, attachment to the labor market (Nair, et. al., 2013; Devika and Thampi 2007) are analyzed. Using data from Vietnam, a recent study found that maternal height was strongly correlated with child height even after controlling for household and parent characteristics (Venkatramani, 2011). In Bolivia, it was shown that mother's height is more important for child height than for child weight but when covariates such as mother's skills (education, fluency in the language) were introduced, the significance of the maternal height reduced (Morales, *et. al.*, 2004). Among the South Asian women, the incidence of anemia are more prevalent and that too higher among pregnant women which leads to severe health and nutritional disadvantage for both mother and the future offspring (Osmani and Sen, 2003). Exposures to infections and adverse conditions in the early life of the mother results in the low birth weight of the babies and shortfall in their height (Deaton, 2013 and Balhotra, 2008). Most of the earlier studies for India have not considered these factors explicitly in assessing their role in influencing the child's anthropometric indicators. In this study, based on the availability of the data, mother's height and BMI are used to account for capturing the effect of intergenerational transmission as such features (genetic traits). Mother's current anemia levels are also included in the analysis assuming that most often women with low levels would also have had low levels during pregnancy and which in turn impacts the birth weight as the process of undernutrition starts at the fetal stage.

Apart from assessing the impact of parental characteristic on child's growth, we next consider the impact of feeding and care practices. Once the child is born, to a certain extent with proper care practices, the deprivations from intergenerational transmissions could be rectified with proper and timely interventions. For example, Crookston *et. al.* (2013) analyzed the relationship between cognitive achievement and growth

faltering with Young Lives data including India where those children who are able to recover from their early growth falters are able to perform well in their schooling. Many studies have shown the strong association of feeding and care practices with undernutrition and its long term impact. In Brazil, a cohort study found that children who were breastfed for more than 12 months were able to earn additional one third of income and education with those children who were not breastfed for longer time (Victora, *et. al.*, 2010). Feeding practices were found to be strongly associated with nutritional scores among children. This was followed by another study and found stronger impact on height for age (Ruel and Menon, 2002 and 2004). Pande and Jayachandran (2013) find that among Indians when compared to Africans, if the first child is a boy, then the chances of children born later being undernourished are high due to minimal investment of time and care by parents.

Apart from the care given to child at household level, it is also necessary to analyze the community level characteristics and other stakeholders' (government, women's agencies/NGOs) role in tackling the undernutrition. Large-scale highly nutrition-sensitive programs are needed to accelerate the reduction of malnutrition. One such program is the Integrated Child Development Scheme (ICDS) introduced in 1975 with the main objective to reduce malnourishment levels among 0-6 year children and also pregnant and lactating mothers. ICDS have several components like supplementary nutrition, immunization, health check-ups, growth monitoring, and preschool education to children, and nutrition education to mothers, where the services are provided through *anganwadi* centers. In spite of its early introduction and judicial interventions, studies have found limited coverage and impact (Mishra, 2010; PEO, 2011; CAG, 2012). However, a few recent studies through quantitative assessments have found some beneficial impact on one or the other child nutrition indicator.

One of the earliest studies to assess the impact of ICDS considered the performance and the potentials of the ICDS program with the help of NFHS first and second round of data where it highlighted the fact that the service delivery for most of the young children were neglected and the States which remained poor in the performance of nutrition levels still had low funding and coverage (Gragnolati, *et. al.*, 2006). Kandpal (2010) followed it up using NFHS-3 data for evaluating the impact using propensity score matching methods. Perhaps, this different method of approaching the impact of ICDS as well as a later year in terms of ICDS spread seems to have shown a positive impact on child growth. The results showed that treatment effects and placement effects reduced child stunting on the vulnerable children of 0-5 years - a child is said to be vulnerable when they are not able to function and grow normally because of deprivation of social and economic resources[2]. Using a similar approach of impact assessment, Jain (2015) focused on the utilization of ICDS program by taking into account the daily supplementary nutrition feeding component. Since the supplementary feeding for children below 2 years of age is intense they focused on this age group and found that girls of 0-2 years of age were at least 1.2 cm taller and boys 1cm taller than those who were not accessing it. However, no significant impact was observed either on the incidence of diarrhea, fever/cough or on underweight. Their result showed that there was only small evidence on the improvement of height in the villages with ICDS centers.

This study does not make any detailed analysis of ICDS. However it attempts to capture the rural/urban differences by considering the

[2] The placement effects are the presence or the State-wise distribution of ICDS centers where the government will make this placement decision on the basis of average population, income, sex ratios. This paper focused not only on the presence but also how well it is implemented with the goal to reduce undernutrition. While the treatment effect are the participation of child in ICDS centers where they will be compared with non participated or untreated children.

usage of daily supplementary nutrition[3] program on the one hand and to assess the differences if any on its impact for the different nutrition indicators, on the other hand.

We observe from several studies that the impact of the determinants varies across different anthropometric indicators. Taking this into account some studies have used combined measures to have an overall assessment of the factors affecting child undernutrition (Svedberg, 2002 and Gaiha, et.al, 2010). The combination of all the indicators sometimes may give inadequate assessment because we tend to lose out more information by converting into composite index. Since different factors are responsible for the performance of different indicators, it can be attempted and analyzed in a simultaneous equation framework for a household which will be useful to assess the varying degrees of undernutrition.

While trying to assess the importance of the above mentioned determinants it is also important to control for several other factors that influence child undernutrition. As much as inherited parental attributes, feeding and care practices are relevant so are the existing socio-economic features of the households and surrounding environmental conditions in influencing the nutritional status of the child. Unambiguously all studies show a strong association between wealth and health status through concentration indices (Arokiaswamy and Pradhan, 2011, Kanjilal, 2010, Mazumdar, 2010). Several studies show that because of lack of access to safe drinking water, open defecation rates, improper drainage facilities, risk of proneness to diseases increases and thereby influence the underweight and stunting rates. Spears (2013) by incorporating the people who are openly defecating per square kilometer explains 65 percent of variation in child height which could be one strong

[3] An earlier attempt was made by interacting the access of ICDS variable with the regions classified into North, South, Centre, West, North-East and East did not give satisfactory results as we expected.

reason for the differences in the international heights between children in Africa and India.

Exposure to indoor air pollution is another factor that poses high health risks among mothers and young children (Parikh, et.al., 1999, Duflo, *et. al.*, 2008). The susceptibility to illness reduces the capacity to absorb nutrition leading higher rate of undernutrition and controlling for this factor is essential to assess the net impact of other factors. Further, the differences in the quality of environment between rich and poor results in higher frequency of illness among the poorer children further exacerbating the gap between rich and poor (Ho and Martorell, 1984). Finally, poor access to quality healthcare during illness reduces the immunity for the child resulting in repeated morbidity further impacting undernutrition (Mazumdar, 2010).

Other determinants such as gender bias, mother's education, decision making power and economic independence plays a major role in influencing nutritional status of the child (Mehrotra, 2006; Kandpal and McNamara, 2009; Shukla 2011; Dasgupta, 2013; Nair et. al., 2013; Vepa *et. al.*, 2014).

OBJECTIVES

It is clear from the literature that there are gaps or further insights are needed for certain determinants because either they are ignored or much importance was not given to them.

The objective of this study is to assess the three nutritional outcomes of children- HAZ, WAZ and WHZ- in India using an empirical framework that not only gives scope for individual assessment but also considers child nutrition as a composite unit. By revisiting the determinants for the indicators this paper tries to give a few additional insight by restructuring the variables that were earlier used in the

literature and also incorporating a few relatively new determinants that were not given adequate attention in the Indian context. The aim is to focus specifically on the following three aspects as determinants of child's nutritional status:

(1) Inter-generational transmission especially from the mother to the child which includes genetic traits as well as deprivations that the mother could have experienced.

(2) Age-specific feeding practices like breastfeeding, introduction of solid foods, dietary diversity and regular access to supplementary nutrition program of ICDS

(3) Care practices like access to health care separately for short term morbidity and diarrhea and mother's work status in the labor market.

This is attempted while also trying to understand (and control for) several other factors that are likely to influence child growth on these three dimensions. In this context, this study strengthens some of the existing results and also provides additional insights towards reduction in undernutrition among young children in India. This is possible by using the econometric technique of Seemingly Unrelated Regressions (SUR) by estimating a set of equations jointly, with each representing an anthropometric indicator. The SUR method allows us to assess the multiple indicators of child nutrition and the differential impact of the determinants on each of those indicators.

The next section discusses the conceptual framework underlying the proposed methodology to analyze the issues mentioned in the objectives.

CONCEPTUAL FRAMEWORK AND METHODOLOGY: SUR MODEL

Early part of research on child development focused largely on child's biological characteristics to describe the growth and development of the child. The attention then shifted towards exploring the processes that govern child's growth which included not just the physical growth but also cognitive development and this needed to be analysed in a multi-dimensional framework. The process or pathways incorporated the social, economic, technological, cultural factors and medical interventions along with the biological factors in explaining the overall physical growth of the child. Mosley and Chen (1984) noted a disparity between social science research and medical research, where the former focuses on the inclusion of all socio economic variables and cultural variables say, for child deaths and the latter focuses on specific disease processes and used morbidity as the most common outcome variable. Understanding the need to bridge the gap, they developed an analytical framework which integrates the two disciplinary approaches and introduced a single outcome variable. Our study partially follows this framework in terms of choosing the determinants but the outcome variables are the three anthropometric indicators of children (HAZ, WAZ and WHZ) unlike child survival.

They categorized the medical determinants as 'proximate' which includes maternal factors, environmental contamination, nutrition deficiency, injury and personal illnesses and the social determinants as 'distal' that includes income, traditions/norms, access to health services and sanitation. The core of their conceptual framework lay in the fact that all socio-economic and cultural variables are operating through a set of proximate determinants for the child growth or survival outcomes. Hence this framework facilitates possible interactions between proximate and socio-economic determinants while specifying the analytical model for our study.

In order to arrive at quantitative estimates that will help in understanding how the different determinants influence different outcomes of child health like morbidity, mortality and growth an economic model of household production gives us a useful framework. It also helps us in analyzing several indicators simultaneously. In this framework, the stock of health is valued in terms of both consumption and investment. In view of consumption, health enters the utility function directly so that there is disutility when household members fall sick. From the point of investment, it determines the time available for members to pursue market and non-market activities. Becker (1965) shows that the behavioral choices affect health status which is an input to production of health. With the assumption that household consist of adults and children the child's utility also depends on the choices that parents make. Rosenzweig and Schultz (1983) expand the inputs by classifying them into three categories: goods that affect both health and utility directly, goods that affect health only and goods that affect unobservable health endowments. We can thus obtain a set of reduced form equations after maximizing the household utility function, the child health production function including health inputs and budget constraints. These equations permit us to estimate an econometric model where some of the inputs are deterministic while others are unobservable. In this estimable framework based on the reduced form equations, we combine the Mosley and Chen framework which enables us to identify a set of determinants to arrive at quantitative estimates of determinants of child anthropometric indicators.

The child health production function could be characterized to have three outputs as the anthropometric indicators: HAZ, WAZ and WHZ, with the different determinants as inputs. These anthropometric indicators (Y) and by using the household production function framework we arrive at a system of three equations for the j^{th} child:

$$Y_{ij} = f(X_{ij}\beta) + \varepsilon_{ij} \quad \ldots\ldots\ldots\ldots\ldots i=1, 2,3 \text{ , } j=1,2\ldots.n$$

Where, i=1 for HAZ, i=2 for WAZ and i=3 for WHZ; f is a linear function; X is the set of proximate and distal determinants of child growth which will be identified based on the data used for empirical evidence for this study; β is the set of coefficient estimates obtained from estimating the econometric model using the sample of (n) children in the database and ε_{ij} is the random error term. The econometric model suitable to estimate the coefficients is Seemingly Unrelated Regressions (SUR) which is discussed in the next section.

The SUR model enables us to understand the relevance of the determinants for multiple indicators using a single framework. The assumptions of this modeling framework are such that it allows for correlations across the random error term so that for the j^{th} child, its unobserved growth characteristics are correlated.

This model proposed by Zellner (1962) is used for this study wherein a three-equation system with different dependant variables: HAZ, WAZ and WHZ for children aged 0-59 months, are considered. This method also allows for potentially different set of explanatory variables in each of the equations and hence enriches the analysis further. The model is represented as:

$$\boldsymbol{Y = X\beta + U}$$

With
$$\begin{bmatrix} \boldsymbol{Y}_1 \\ \boldsymbol{Y}_2 \\ \boldsymbol{Y}_3 \end{bmatrix}_{3Cx1} = \begin{bmatrix} \boldsymbol{X}_1 & \boldsymbol{0} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{X}_2 & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{X}_3 \end{bmatrix}_{3Cxk} \begin{bmatrix} \boldsymbol{\beta}_1 \\ \boldsymbol{\beta}_2 \\ \boldsymbol{\beta}_3 \end{bmatrix}_{kx1} + \begin{bmatrix} \boldsymbol{U}_1 \\ \boldsymbol{U}_2 \\ \boldsymbol{U}_3 \end{bmatrix}_{3Cx1}$$

$\mathbf{Y}_1$ is HAZ (height for age), $\mathbf{Y}_2$ is WAZ(weight for age), $\mathbf{Y}_3$ is WHZ(weight for height); $\mathbf{X_i}$ is the vector of child level, parental level and household level characteristics as well as policy relevant and regional variables for the i^{th} anthropometric indicator thus allowing for different set of

explanatory variables (k_i) for the different equations. The vector $\boldsymbol{\beta_i}$ are the different coefficients to be estimated with k_1, k_2 and k_3 coefficients for the respective equation such that the total number of coefficients is $k= k_1+k_2 +k_3$. $\boldsymbol{U}$ is the vector of residuals $E(\mathbf{U})=\mathbf{0}$; $E(\boldsymbol{UU'})=\boldsymbol{\Omega=\Sigma\otimes I}$ with $\boldsymbol{\Sigma=}\sigma_{ij}$, where $\sigma_{ij}=E(\boldsymbol{U_iU_{i'}})$, $i=1,2,3$. If c_j is the j^{th} child in the sample, then this correlation structure assumes that the errors are correlated across the indicators for each child but uncorrelated across different children where n is the total number of children in the sample. As mentioned in the beginning of this section this correlation structure is a valid a priori assumption (similar from the multiple output production function outcomes), however, this can also be statistically tested and such a model will be considered only after the test is empirically validated by the data.

X is a vector of the explanatory variables. The model is distinct from OLS as the explanatory variables need not be same for all the system of equations and the error terms will be correlated across equations and SUR model requires the number of sample observations to be same for each equation. The model was estimated with common set of child variables (child age, gender, birth size, birth order, and vaccination, incidence of fever, cough, diarrhea treatment practices and policy variables) in each of the indicators while parental and household variables varied across the indicator equations. Along with a brief discussion about the nature of these variables, the next section discusses the findings of the model estimation.

The next section discusses the data used in the analysis along with description of determinants in focus for this study.

DATA

The study uses the third wave of the National Family Health Survey for the year 2005-06 (IIPS, 2007). This is a nationally representative survey of households (104302) which has anthropometric data for the children (51,555) aged 0-59 months, with 19483 (38 percent) from urban and 32043 (67 percent) from rural. This is the most recent survey on child nutrition indicators that covers all the states of India with a wide of range information on socio-economic aspects. In spite of a vast literature on child nutrition using this database, there are several issues of relevance that are open to inquiry as mentioned in the objective of this paper.

The determinants are categorized into characteristics that pertain to the child, mother and household environment. Many of the child characteristics would ideally reflect the intergenerational transmission and care given by parents. However, each child may have its own specific features that finally impinge upon her growth and hence have been attributed to the child.

Child Variables: Individual Characteristics

A child's birth weight is an important indicator of child's general health status at the time of birth capturing health endowments and the future health trajectory. In India, institutional deliveries are still low in number and the records on birth weight are rather weak. Consequently, the survey enquired about a self-assessment of the birth size from the mothers as proxy indicator of birth weight. Birth size though self-reported by the mother reflects the starting condition and hence needs to be controlled for. Birth order of the child is controlled for as one expects later born to be less nourished due to lesser time for care and limited resources to feed (Venkatramani, 2011). Both these variables are categorical in nature as shown in Table 1. In developing countries, it is observed that undernutrition rates vary with age (in months) and also by

indicators. Though this could be largely attributed to care and feeding practices, the variables used in the model may not adequately explain the age related variations and hence this is included in the model. Also it is commonly observed that undernutrition first increases with age and then decreases and this non-linear effect are accounted for by including squared age. In general in South Asia it is observed that there are more undernourished girls than boys and more so in the context of India and to account for this gender difference, sex of the child is included in the model.

Child Variables: Feeding Practices

Since feeding and care practices are child centric we consider it as child characteristics. WHO has recommended the timely initiation of breastfeeding within 1 hour of birth of the child and exclusive breastfeeding for first 6 months. Further, it recommends introduction of solid foods from the age of 6 months along with breastfeeding (which would continue to supplement up to 24 months). So for children aged 6 months and above, we also study the impact of differences in dietary habits by considering consumption of dairy products, animal source foods and fruits and vegetables. Most of these food groups are sources of proteins and micro nutrients. We begin with breastfeeding which has been collected in the survey for two different qualitative aspects. First is the timely initiation and it is included in the analysis as within one hour of birth or not and second is whether exclusive breastfeeding was done for the first six months or not which relates to age-appropriateness and the duration.

The survey collects information on the type of food consumed based on a 24 hours recall period for the child which may not adequately capture food frequency. However to get a better sense of the feeding practice, another set of information based on broad types of food frequency of the mothers is combined with the child's previous 24 hours dietary diversity. The mother's intake towards a particular food type is

classified as plant based if they consumed pulses, milk, fruits and leafy vegetables and animal based with the consumption of eggs, fish and chicken or meat. But for the child the data has more diverse information on their diets like whether the mother gave child nuts, lentils, pulses, dairy products, smashed items, eggs, milk, meat etc. These variables are grouped again into plant and animal sources of consumption for the child. Both these information are combined so that mother's dietary habits are interacted with what the child consumed in the 24 hours previous to the survey. The categories as shown in Table 1 are: mother and child consume only plant source, mother consumes plant source and fed child animal source the previous day, mother consumes animal source and fed the child plant source, mother and child both consumes animal source. The first category wherein both mother and child consume plant based food is the reference category.

Child Variables: Care Practices

Along with quality diets preventive and curative health care also reduces the child's susceptibility to infections, thereby improves the absorption of nutrition and child's growth and in turn reduces absenteeism in the school. Through preventive care immunity to certain diseases is improved. Hence the information on vaccination for BCG, DPT, measles and polio are also used. For this the vaccination date on card, or reported by mother and vaccination marked on card are grouped together separately for each type of vaccination. These variables are then grouped to form three categories (as shown in Table 1): the best case if the child received all four vaccinations, or at least two vaccinations or no vaccination which could be the worst case.

Frequent instances of morbidity like fever/cough, diarrhea and other respiratory illness would affect the child's capacity to retain their intake of nutrients and hence affects child's growth and hence are its important determinants. Further, it is important to also differentiate between fever/cough and diarrhea because not only do the illnesses have

different impacts on child's growth. It has been shown that frequent occurrence of diarrhea amongst young children adversely affects child's linear growth and would also lead to weight loss. On the other hand severe fever/cough would have short term impact causing weight loss and it is very unlikely to affect linear growth. Given this the care required to cure or prevent varies between the two illnesses. Moreover, diarrhea is a public health issue and there are several options of treating it depending on its severity.

The data on the presence/absence for each of these morbidity variables are collected based on a two week reference period prior to the survey. Hence this morbidity information does not capture the intensity and the frequent recurrence of these illnesses. We expect that when the child is severely ill they would be taken for treatment. For instance if the child was ill and not treated then there is a possibility, that it was not very severe. However we do not rule out the possibility that the child may not have access to care and hence not taken for treatment. Hence using the care seeking behavior we hope to distinguish between the intensity of illness among children. In Table 1 we describe three variables with regard to types of care accessed for fever/cough like received treatment either from government, private hospitals or other category which includes all kinds of traditional methods. Thus we have the reference as 'not ill' with the other two categories as ill but have not sought treatment and ill but sought treatment. In case of diarrhea the treatment categories are providing ORS, or accessing the treatment from any form of private and government hospitals leaving the reference category as those not suffering from diarrhea in the last two weeks. Table 1 summarizes the details each of these dummy variables.

Table 1: Summary Statistics of the Variables

Variable	***Mean***	***Std. Dev***	***Variable Description***	***Variable***	***Mean***	***Std. Dev***	***Variable Description***
Dependant Variable				*Mother Height: Ref 3rd Quintile*	0.198	0.398	Quintiles
Length/height for age Z-score	-1.88	1.925	Continuous	First Quintile	0.196	0.397	
Weight for age Z score	-1.84	1.422	Continuous	Second Quintile	0.210	0.408	
Weight for length/height z score	-1.06	1.797	Continuous	Fourth Quintile	0.196	0.397	
				Fifith Quintile	0.199	0.400	
Independent Variable: Child Characteristics				*Mother BMI: Ref <18.5*	0.399	0.488	
Age (in months)	29.85	17.127	Continuous	18.5-24.9	0.540	0.498	
Age square	1184.07	1054.439	Continuous	25.0-29.9	0.056	0.229	
Gender : Ref Male	0.475	0.499	Dummy Male/Female	>30.0	0.012	0.110	Categorical
Birth Size: Ref Very Large	0.042	.201	Categorical	*Mother Anemia: Ref Severe*	0.018	0.132	
Larger than Average	0.192	0.394		Moderate	0.179	0.384	
Average	0.550	0.498		Mild	0.412	0.492	Categorical
Smaller than Average	0.149	0.356		Not Anemic	0.391	0.488	
Very Small	0.055	0.229		*Age of Mother at first birth: Ref 11-14 yrs*	0.045	0.208	Categorical
Birth Order: Ref 3 or more than 3rd Order	0.427	0.494	Categorical	15-19 Years	0.549	0.498	
One Child	0.292	0.455		19 and above	0.407	0.491	
2nd Order of the child	0.275	0.446		*Mother Lost Child: Ref Yes*	0.195	0.397	
Breast Feeding Initiation: Ref Within 1 Hour	0.345	0.476	Dummy	No	0.198	0.399	Dummy
Later 1 Hour	0.344	0.475		Women Autonomy			

Variable	***Mean***	***Std. Dev***	***Variable Description***	***Variable***	***Mean***	***Std. Dev***	***Variable Description***
Exclusive Breastfeeding : Ref No	0.911	0.284	Dummy	Health Care	0.174	0.379	Dummy
Yes	0.087	0.282		Money	0.236	0.425	Dummy
Interaction of Mother's Food With Child: Ref Plant Source for both	0.273	0.445		*Mother Education : Ref Illiterate*	0.499	0.500	Categorical
Mother consumes plant source * Child fed with animal source	0.001	0.030	Categorical-Interaction with Mother food habits with child	Primary	0.139	0.345	
Mother consumes animal source* Child fed with plant source	0.902	0.297		Secondary	0.309	0.462	
Mother consumes animal source* Child fed with animal source	0.080	0.271		Higher	0.048	0.214	
Vaccination: Ref No Vaccination	0.081	0.273		*Mother Working: Ref Not Working*	0.704	0.456	
Atleast Two Vaccination	0.773	0.419	Categorical	Working	0.301	0.459	Dummy
One Vaccination	0.148	0.355		Self-employed in agriculture	0.317	0.000	
Diarrhoea: Ref No Diarrhoea	0.906	0.291	Categorical-Interaction with Diarrhoea and treatment facilities	Self-employed in non-agriculture	0.036	0.187	
Govt, Pvt and Others	0.038	0.192		Wage labour in agriculture	0.152	0.359	Categorical
No treatment	0.032	0.175		wage labour in non agriculture	0.039	0.193	
Oral rehydration	0.025	0.155		Professional and Others	0.042	0.201	
Fever/Cough: Ref No Fever	0.770	0.420	Categorical-Interaction with Fever/Cough and treatment facilities	*Father Working : Ref Professional and Others*	0.256	0.436	
Government	0.025	0.155		Self-employed in agriculture	0.151	0.358	

Variable	***Mean***	***Std. Dev***	***Variable Description***	***Variable***	***Mean***	***Std. Dev***	***Variable Description***
Private	0.122	0.327		Self-employed in non-agriculture	0.123	0.328	Categorical
Others	0.001	0.034		Wage labour in agriculture	0.165	0.372	
No treatment	0.081	0.273		wage labour in non agriculture	0.299	0.458	
Wealth: Ref Poorest	0.254	0.435	Categorical	*Quality of Water: Ref Untreated*	0.712	0.452	Dummy
Poorer	0.223	0.416		Treated	0.287	0.453	
Middle	0.199	0.399		*Sanitation: Ref Open Defecation*	0.636	0.481	Categorical
Rich	0.182	0.386		Flush	0.300	0.458	
Richer	0.138	0.345		Pit	0.039	0.194	
Caste: Ref SC	0.213	0.409		Others	0.011	0.104	
ST	0.098	0.298	Categorical	*Cooking Fuel: Ref Dirty Fuel*	0.813	0.389	Dummy
OBC	0.421	0.494		Clean Fuel	0.186	0.389	
Others	0.264	0.441		*Family Size: Ref Large Family*	0.462	0.499	Dummy
Religion: Ref Hindus	0.787	0.409	Categorical	Small Family	0.548	0.498	
Muslim	0.146	0.353		*Residence: Ref Rural*	0.756	0.429	Dummy
Christian	0.017	0.130		Urban	0.243	0.429	
Other religion	0.027	0.161		Rural Residents with daily access	0.083	0.276	Interaction with Icds and Rural areas

Mother Characteristics

These variables largely capture intergenerational transmission as well as awareness towards care and feeding practices. Mother's height is taken as a categorical variable after grouping into quintiles with those in median quintile as reference category. Mother's BMI is categorized on the basis of those below 18.5 (undernourished); with normal range of 18.5-24.9 as the reference category; 25-29.9 as the category representing

overweight women; and the last category of obese women with BMI above 29.9 are considered. Mother's anemic status as assessed during the time of survey is used with severe (<8g/dl), moderate (8-9.5g/dl) and mild (9.5-13g/dl) categories and those who are not anemic is the reference category. It is shown that mothers who are severely anemic during pregnancy are highly likely to produce children with low birth weight. Such children will be prone to deficits in growth at later stages. However since this data on mother's anemic status during pregnancy is not available it is perhaps likely that women who are currently anemic in a severe sense may also have been anemic at the time of pregnancy. Hence we consider current anemic status as a proxy of intergenerational transmission of undernutrition. Two other variables reflecting precondition of birth environment of the child are mother's age at first birth and if the mother lost at least one child. Early child birth affects the overall nutritional status of the mother (Viswanathan, 2014) thereby affecting the nutritional status of the children she gives birth to. In order to account for this, age of mother at first birth is grouped into three categories. All these variables are summarized in Table 1. Similar information on father's anthropometric indicators and anemia is not available for all the children in the sample as the anthropometric data for men has been collected for a smaller sample than that for women. If we include both the parent's information the reduced sample size could possibly lead to different results on indicators (Palmer-Jones, 2003). However, we do not find drastic differences in the main findings when we estimate with this smaller sample.

Mother's education reflecting her general awareness about care and feeding practices and her own health and hygiene is used as a categorical variable as shown in Table 1. Mother's engagement in the labor market has mixed results on child's growth in the literature. Participation of the mother in the labor market could possibly have an adverse impact on child's nutrition particularly for infants due to lesser time available for care (Smith, 2003). On the other hand if a woman is

engaged in the labor market to augment family's income then the additional income brought by them could have a positive influence on nutritional status. Alternatively, if the employed mother has access to child care in the workplace then it may be possible for the mother to take the young child to work and there is double benefit particularly for breastfeeding mothers. However, if the child is exposed to harsh environment while mother is at work, particularly agricultural work then it could be detrimental for the child. For the HAZ mother's working status is categorized into employed and not employed. For WAZ and WHZ, the working mother is categorized further into occupational groups as agricultural wage labor and non-agricultural wage labor and self-employed with the reference category as those not employed (Table 1). Mother's empowerment is captured through her decision making ability for making purchases at the grocery store or make bigger purchases without seeking permission from other family members. In our understanding, this simple feature reflects access to resources and mobility which would impact timely response to any adverse health condition of the child and hence indirectly her growth.

Household Variables

Economic status, socio-demographic variables like caste, religion and household size as well as access to basic amenities, like sanitation, safe drinking water and less polluting cooking fuels are all considered as household characteristics. These variables are summarized in Table 1.

Results

Preliminary Graphical Analysis

This is provided to get a preliminary assessment of the patterns and associations across variables that are the focus of this study.

Figure 1 shows the Cumulative Distribution Function (CDF) of the z-scores of height for age, weight for age and weight for height for children aged 0-5 years in India. As it is well known, if the z-score is below -2 (x-axis values) then the child is considered undernourished and

the CDF gives the proportion of children (y-axis values) who are below a certain z-score value. Since the WAZ and WHZ curves first order stochastic dominance (FOSD) the curves for HAZ so the percentage of children who are stunted is far higher than underweight rates and wasting rates are the lowest.

Figures 2a and 2b show the differences in HAZ and WAZ respectively across wealth groups for children of 0-5 years. The figures clearly show the dominance of the richest wealth group followed by the next richer group and so on so that the CDF for poorest wealth quintile lies above that for the other higher quintiles. This indicates that both stunting and underweight are more prevalent in poorest and poor households when compared with richer households. It is important to note that the wealth quintiles so formed are such that the bottom two quintiles show differing rates of undernutrition and that there is no crossing over. A second interesting fact is the differences in decline in undernutrition rates based on each of indicators as one moves up the wealth quintiles. In the richest category, stunting rate (12 percent) is higher than underweight rates (10.9 percent). But it is reverse in case of poorest category where the stunting rate is 23 percent and underweight rate is 26 percent.

Figure 3 depicts the diversity in the rates of indicators across states. The darker shade shows the higher prevalence of undernutrition. It is clear from the map that the performances of the indicators are not uniform across states. For instance Gujarat, MP, UP, Chhattisgarh, Bihar, Jharkhand have more prevalence of stunting and underweight, whereas in Rajasthan the percentage of underweight is more but stunting is less. States like Maharashtra, Bihar and Jharkhand have higher percentages of all three indicators. Thus, by looking at the variations in the spread of the three undernutrition variables, one can expect the impact of the different determinants (explanatory variables) to vary across different indicators of undernutrition.

Cumulative Distribution Function (CDF) Plots of z-scores for Height for Age, Weight for Age and Weight for Height (All- India)

Figure 1: CDF of Indicators

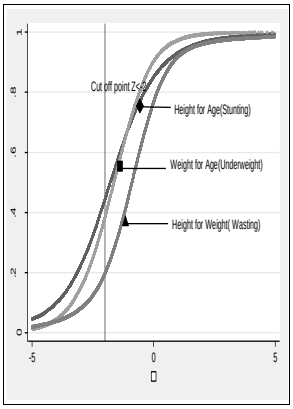


Figure 2: CDF by Wealth Groups

Figure 2a: Stunting

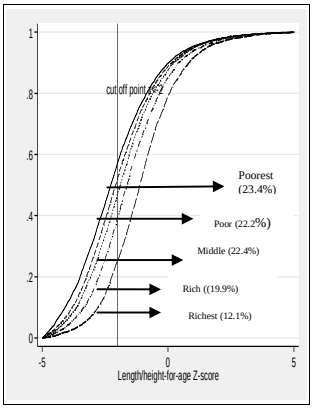


Figure 2b: Underweight

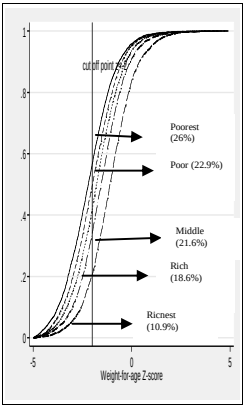
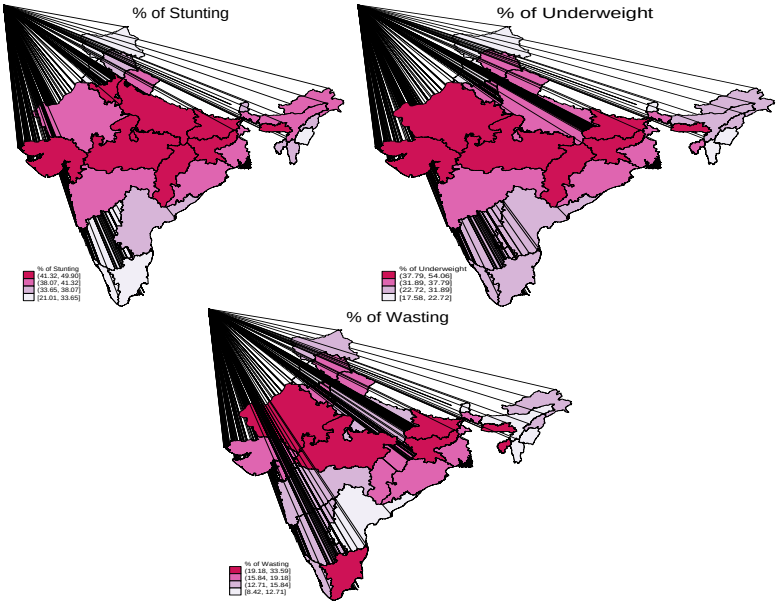


Figure 3: State - Level Comparisons of Indicators



SUR Estimates

The summary statistics reported in Table 1 gives a further assessment of the nature of variation in the explanatory variables. After excluding the missing observations and the extreme outliers in the sample, the analysis was done on 37667 children. 47 percent of the children in the sample are girls. The mean HAZ, WAZ and WHZ of the children in the sample are almost close to -2 (Table 1) and shows that many children in the sample are stunted, underweight and wasted when compared to the WHO reference standards. 39 percent mothers have BMI <18.5 and more than 35 percent of the mothers are aware of the early and timely initiation of breastfeeding and fed their children accordingly (Table 1).

Table 2 presents the results for the SURE estimates. A negative coefficient implies that the particular variable reduces the child's nutritional outcome and a positive coefficient suggests that the variable can improve a child's nutritional outcome since z-score is the deviation from the reference mean as a proportion of the reference standard deviation.

In the results section, first child related variables are explained and then mother related variables are discussed and finally the impact of household characteristics is explained.

Child Characteristics

The birth size variable are significant with negative coefficient implying that as birth size decreases that is if the baby is very small when compared with very large baby the undernutrition increases but the impact expectedly is more prominent on WAZ. In terms of gendered differences, compared to boys, girls fare better in the HAZ and WHZ indicated by positive significant coefficient which has similar results to Jain, (2015) while for WAZ, the coefficient is insignificant and hence girls and boys are not statistically different in this aspect. Recently, studies have also shown that cultural practices could determine later born girls to be more undernourished than older girls due to son preference in India (Jayachandran and Pande, 2013; Panigrahi and Das, 2014).

As age increases, the z-scores of height, weight and wasting are negative thereby indicating growth faltering with age as has been found in studies for India and other countries (Rehman, *et. al.*, 2009 and Sullivan and Goulet, 2010). In another study, the timing of the growth faltering was investigated in 39 countries on a global scale where the results confirm that WAZ and WHZ are not behaving in a similar manner and also faltering in length starts at 3 months of age (Shrimpton, *et. al.*, 2010). Squared age is positive and significant suggesting that undernutrition decreases again after a certain age when the child grows. This means that some catching up happens after a certain age. Based on the estimated coefficients for age and squared-age, this turning point for catching up can be estimated. This study finds that the turning point for HAZ is at 44 months, for WAZ is 14 months where the indicators

increases, decreases and then stabilize at these respective months[4] mostly for stunting.

Birth order is significant and positive indicating that households with few children would have more resources per capita (after controlling for everything else) to provide better care to their children. The study finds that children born later are more stunted and underweight as expected. Compared to the third or higher order of the child the results for all the indicators shows that the first child has a maximum advantage followed by the second child in lack of growth deficit. The results further show that for the first child the impact is more visible for WHZ (0.12) followed by WAZ (0.11) and less on HAZ (0.07). For the second child the effects are nearly similar across these indicators. It could mean that the children of different birth order face different levels of care and wealth effects which affect the outcomes of these indicators. Thus in regions where fertility rates are still high with households having more than two children the undernutrition rates are likely to be high contributed largely by the younger siblings and more intensive interventions may have to be put in place rather than neglecting them because such children do not belong to families that have not followed the two children norm[5]. The results in Table 2 show that the children for whom breastfeeding was initiated within 1 hour of birth has a strong impact only on HAZ which has been recommended by WHO that initiating the breastfeeding within 1 hour of birth is the perfect food for newborn. For those children who were exclusively breastfed in the first six months the impact is significant mainly for HAZ and WAZ where exclusive breastfeeding for the first six months has a large impact on HAZ (0.55) and only 8 percent of the mothers in the sample are exclusively breastfeeding their child and relatively lower but significant impact on WAZ. Thus the emphasis and

[4] These values are derived after differentiating the squared age with respect to age (Wooldridge).

[5] To strengthen this, interaction between gender and birth order were tried as in Pande and Jayachandran(2000) but we do not find significant impact of gender on birth order. However, if this is further confounded with states that are known have low sex ratio we may also get similar results as in the above mentioned study which compares India with Africa.

policy interventions to strengthen the breastfeeding practices would go a long way in improving HAZ.

After controlling for variations in breastfeeding practices and other covariates, the results overall show that in households where there is a preference for consuming animal source food frequently (after controlling for wealth effects) as reflected by mothers food frequency variable, HAZ and WAZ are on an average higher. Once again the feeding practice has a larger impact on HAZ than WAZ. In the instance where mother's food frequency reflects mainly plant source food even though the child is reported to consume animal source food there is no differential impact compared to a household where there is a preference mainly for plant source food. This could be because in such households (second category) we find that animal source food is largely from egg consumption and lacks diversity in animal source food consisting of egg, fish, chicken and meat. We find that diversity in consumption of animal source food seems to have a large impact (Neumann *et. al.*, 2003; Dror and Allen, 2011).

These results only indicate that when plant sourced food may not be adequate in quantity and quality, animal based foods are good supplements and child growth would not be affected. This should not lead us to conclude that children who consume plant source food are more prone to undernourishment. With adequate diversity in such diets as well as regular consumption of recommended quantities would also have beneficial effects on child growth. It must however be noted that these variables do not capture the dietary diversity among households which consume only plant based food. Further modifications may be possible to some extent if a food count measure is used but this still does not allow us to take into account the shortfall or adequacy of the recommended quantities of consumption. The food frequency information of the mother is rather limited and forbids us from constructing such a diversity measure while it may be possible to construct this measure

based on the 24 hour recall of the child's diets but has not been attempted here[6].

The results for vaccination capturing prevention of certain childhood diseases causing poor health do not seem to give the expected results. We find that children who receive at least two vaccinations have lower HAZ and WAZ than those who have one or none. Children who reported fever/cough have lower WAZ and WHZ on average and do not affect HAZ. This is an expected result given that short-term morbidity if severe would affect weight and hence those related indicators. The results also do not show large differences in fever/cough with the type of care for WAZ and WHZ. It appears that those children who are more ill/sick with the symptoms are accessing the professional treatment from private hospitals. This perhaps results in significant negative coefficient for WAZ and WHZ. It is quite likely that when the child is more severely ill it is more likely to lose weight and the parents see the signs and take them to perhaps a more reliable place for treatment.

In contrast to this, for diarrhea, the coefficients of HAZ and WAZ are on an average lower but has no significant impact on WHZ. Further, the impacts are larger on HAZ than on WAZ even though the data pertains to one-point assessment of diarrhea rather than its severity or frequency. The strongest adverse impact is noted for children reported to seek either traditional or professional treatment (others) while those treated with Oral Rehydration Salt (ORS) have the coefficient with lower magnitude. The results show that children who are not treated have the least impact on child nutrition. When information on the severity of diarrhea is not known from this database it perhaps gets mixed up with type of treatment sought and should not be interpreted as reported

[6] It is also important to note that we have not accounted for age specific needs of recommended diets in the sense that young children say up to 36 months perhaps may not be in position to consume several food items. In spite of the fact that the sample may consist more of younger age group in a data set of up to 59 months we find an impact of animal sourced food on child growth.

access to care has adverse impact on child nutrition. One could infer that a child may be treated only if she is somewhat severely affected, though one does not rule out the possibility of lack of awareness and opportunities to provide medical care. Consequently the nutrition indicators in this instance have a somewhat lower adverse impact compared to the other two instances. More importantly, irrespective of the severity (as inferred by the care sought) diarrhea has a strong adverse impact on child growth.

Table 2: Estimation Results from Seemingly Unrelated Regression Model

Variables	Height For Age	Weight For Age	Weight for Height
Birth size (Very Large: ref)			
Larger than average	-0.154***(0.002)	-0.207***(0.000)	-0.194***(0.000)
Average	-0.179***(0.000)	-0.214***(0.000)	-0.181***(0.000)
Smaller than average	-0.388***(0.000)	-0.495***(0.000)	-0.408***(0.000)
Very small	-0.473***(0.000)	-0.595***(0.000)	-0.471***(0.000)
Gender of the child (Male: ref)			
Female Child	0.033* (0.066)	-0.004 (0.76)	0.068*** (0.000)
Birth Order (>=3rd or more: ref)			
1st Child	0.070***(0.006)	0.118***(0.000)	0.112***(0.000)
2nd Child	0.042*(0.092)	0.059***(0.001)	0.044*(0.074)
Age	-0.088*** (0.000)	-0.028***(0.000)	-0.160***(0.000)
Age square	0.001*** (0.000)	0.001*** (0.000)	-0.001*** (0.000)
Initiation of breastfeeding (Later 1 hr: ref)			
Within 1 hour	0.042**(0.048)	-0.022(0.157)	0.013(0.529)
Exclusive breastfeed (No: ref)			
Yes	0.555***(0.000)	0.228***(0.000)	0.041(0.372)
Mother *Child Food (Plant Source: ref)			
MPs * CAs	0.107(0.733)	0.097(0.678)	-0.002(0.994)
MAs*CPs	0.161**(0.023)	0.084*(0.011)	-0.023(0.734)
MAs*CAs	0.220***(0.005)	0.162***(0.005)	0.018(0.809)
Vaccination (Zero: ref)			
One Vaccination	-0.053(0.150)	-0.030(0.264)	0.055(0.119)
At least Two	-0.102*(0.013)	-0.055*(0.074)	0.040(0.331)
Fever/Cough (No: ref)			
Govt. Hospitals	0.072(0.230)	-0.011(0.809)	-0.078(0.187)
Private Hospitals	-0.025 (0.390)	-0.067***(0.002)	-0.084*** (0.003)
Others	0.122(0.655)	-0.071*(0.076)	-0.248(0.361)
No treatment	-0.023(0.492)	-0.028(0.261)	-0.043(0.203)
Diarrhoea (No: ref)			
Other Modes of Treatment	-0.093**(0.053)	-0.097***(0.006)	-0.068(0.154)
Oral Rehydration	-0.205***(0.001)	-0.071**(0.068)	-0.051(0.324)
No treatment	-0.111***(0.035)	-0.095***(0.031)	0.017(0.761)
Mother Height (Q3: ref)			
Q1	-0.384***(0.000)	-0.300***(0.000)	-0.104***(0.000)

Q2	-0.147***(0.000)	-0.116***(0.000)	-0.033***(0.000)
Q4	0.109***(0.000)	0.075***(0.000)	0.022***(0.000)
Q5	0.330***(0.000)	0.243***(0.000)	0.089***(0.000)
Mother BMI (18.5-24.9: ref)			
<18.5	-0.140***(0.000)	-0.289***(0.000)	-0.307***(0.000)
25-29.9	0.114***(0.007)	0.227***(0.000)	0.242***(0.000)
>30	0.203**(0.016)	0.307***(0.000)	0.268***(0.001)
Mother Anaemic(Severe: ref)			
Moderate	-0.021(0.766)	0.042(0.428)	0.085(0.228)
Mild	0.052(0.452)	0.131*(0.01)	0.166**(0.015)
Not Anaemic	0.160***(0.002)	0.174***(0.001)	0.132**(0.054)
Age of mother at first child (11-14yrs: ref)			
15-19	0.080* (0.079)	0.049(0.144)	0.006(0.894)
19 and Above	0.133***(0.005)	0.055(0.118)	0.132**(0.054)
Mother Lost Child (Yes: ref)			
No	-0.036(0.154)	-0.024(0.209)	0.003(0.911)
Mother Education (illiterate: ref)			
Primary	0.122***(0.000)	0.081***(0.000)	0.023***(0.000)
Secondary	0.148***(0.000)	0.159***(0.000)	0.103***(0.000)
Higher	0.343***(0.000)	0.343***(0.000)	0.222***(0.000)
Women Autonomy			
Healthcare	-0.003(0.907)	-0.036**(0.031)	-0.052*(0.018)
money	-0.010(0.801)	0.024(0.444)	0.041(0.322)
Mother Occupation (not working: ref)			
Working	0.122***(0.000)		
Mother Occupation(not working: ref)			
Self employed in agriculture		0.074**(0.041)	0.129*(0.017)
self employed in non agriculture		0.010(0.818)	0.051(0.429)
wage labour in agriculture		0.059*(0.084)	0.104**(0.042)
wage labour in non agriculture		0.026(0.539)	0.040(0.524)
Professional and Others		0.071**(0.025)	0.092**(0.051)
Father Occupation (Professional and Others: ref)			
Self employed in agriculture	-0.081*(0.015)	-0.058**(0.024)	-0.015(0.66)
Self employed in non agriculture	-0.094***(0.004)	-0.058*(0.018)	-0.033(0.322)
Wage labour in	-0.116***(0.000)	-0.086***(0.000)	-0.027(0.407)

agriculture			
Wage labour in non agriculture	-0.098***(0.000)	-0.085***(0.000)	-0.046*(0.079)
Wealth (Poorest: ref)			
Poor	0.177*** (0.000)	0.088*** (0.000)	-0.032(0.231)
Middle	0.251*** (0.000)	0.171*** (0.000)	0.028(0.365)
Richer	0356***(0.000)	0.254*** (0.000)	0.042(0.274)
Richest	0.601***(0.000)	0.419*** (0.000)	0.066(0.222)
Caste (SC: ref)			
ST	0.002(0.96)	-0.116***(0.000)	-0.157***(0.000)
OBC	0.046*(0.072)	0.056***(0.003)	0.045*(0.072)
Others	0.137***(0.000)	0.109***(0.000)	0.037(0.207)
Religion (Hindus: ref)			
Muslim	-0.014(0.831)	-0.028(0.548)	-0.041(0.521)
Christian	-0.163*(0.019)	-0.090*(0.081)	-0.007(0.918)
Others	-0.047(0.639)	-0.010(0.892)	0.015(0.875)
Quality of water (untreated: ref)			
Treated Water	0.036 (0.228)	0.031*(0.096)	0.017(0.483)
Sanitation (Open Def: ref)			
Flush	0.097***(0.002)	0.078***(0.001)	0.041(0.193)
Pit	-0.013(0.803)	0.015(0.705)	0.029(0.568)
Others	-0.025(0.779)	0.064(0.34)	0.092(0.302)
Cooking fuel (Dirty fuel: ref)			
Clean Fuel	0.040(0.296)	-0.022(0.432)	-0.085**(0.023)
Family Size (Large family: ref)			
Small Family	0.004(0.837)	0.015(0.309)	0.006(0.752)
Residence (Rural: ref)			
Urban	0.060**(0.036)	-0.050*(0.019)	0.004(0.878)
Rural residents with daily access to ICDS	0.099*** (0.000)	0.032(0.254)	-0.037(0.132)
Constant	-0.77***(0.003)	-1.62***(0.000)	-1.5***(0.000)
R- Square	0.1679	0.1581	0.0589
No. of Parameters	93	97	97
Chi-square	7610.17 (0.0000)	7071.19 (0.0000)	2361.70 (0.0000)

Note: *p < 0:10, ** p < 0:05, *** p < 0:001, figures in the parentheses are p-values.

Mother Characteristics

Compared to a child whose mother is in the 3rd quintile of height, the improvement in z-score is of the order of 0.3 for a mother in top most quintile. There is a significant increase in the HAZ coefficient once the mother's height crosses 160 cm (cut off point for top quintile). The large difference between the coefficients from 4th quintile to the 5th quintile suggests a substantial improvement in the HAZ of the children. Alternatively, the negative signs for first and second height quintiles reflect that shorter mother has a shorter offspring and is an expected result. On the one hand this captures the genetic traits for mother and child but it is also observed that South Asian women are far shorter than other country women (Deaton, 2007) so there are also deprivations of mother not being able to attain the potential and this could be a matter of larger concern. For instance, though the quintiles are equally spaced, we observe that the child with mother in the bottom height quintile stands to lose more in height than what observes as the gain for a child with a mother in the topmost quintile. The fact that mother's height also has an impact on WAZ and WHZ further highlights the mother's poor nutritional status affect the child's nutrition in multiple dimensions.

For the BMI categories also we observe that the impact is seen on all the indicators but with a larger magnitude for WHZ and WAZ than for HAZ so that weight related characteristics have similar impacts. We observe that for mothers who are currently CED (BMI<18.5), the negative impact is larger on WHZ than on WAZ and HAZ. Though the results for mothers who are currently overweight or obese may have to be interpreted with caution for the child's nutritional status but it is also noted that this aspect of malnutrition among women increases with age. There is a possibility that this most likely applies to older women and that many of these women may have been well nourished at the time of pregnancy and child birth resulting in the possibility of having better nourished child.

If the mother is currently anemic (severe, mild or moderate) their children's nutritional status is lower when compared with the mothers who are not anemic after controlling for other factors. If the mother had her first child during her teens then this affects HAZ alone indicating that longer-term nutrition of the child is more affected than other indicators. If the mother bears a child after the age of 18 years, it has a substantial impact in improving HAZ as indicated by a significant and large (0.13) positive coefficient. If the mother lost a child (focusing on prenatal, neonatal or infant mortality) this could also affect the nutritional status of the future offspring because of mother's own health condition, lack of proper medical care and hence was also included to capture intergenerational transmission. However, this did not seem to affect any of the growth indicators for the child, perhaps because other maternal health factors and health care variables have already been controlled for, which also influence infant/child mortality.

Thus, a well-nourished mother who is taller, is not chronically energy deficient, not anemic, gave birth to the child at an appropriate age with an offspring who is also good in nutritional status have an advantage compared to their counterparts who may not possesses one or some of these characteristics. More importantly most of these factors have a larger impact on HAZ indicating that for a faster reduction in stunting or improvements in HAZ, large emphasis on adolescent and maternal nutrition is very important.

Another aspect highlighted in the literature with regard to mother characteristics is mother's education. The results show a strong effect that when compared with an illiterate mother, better educated mothers have better nourished children emphasizing the impact of awareness on child growth.

By and large it is observed that the coefficients for autonomy of women are not significant. In a few instances where it is significant, the

estimates are negative. For instance, if a mother is able to visit the health care facility without needing to take permission from other family members shows a negative impact indicating more of a selection problem that undernourished children is perhaps needing more assistance.

The results from this study shows that after controlling for economic status of the household, the income effect of participation in the labour market rather than the lack of care effect seems to be substantiated. That is, compared to a woman who is not in the labour market other women have better nourished children. Since HAZ reflects long term nutritional status of child, a simpler classification of working and non-working mothers reflects the overall positive impact and there was no significant difference across occupational classifications. In this study we find that the mother's work status for WAZ and WHZ has a positive impact on nutritional status with higher effects seen among those women who are salaried/professional. The additional income brought by mother adds to the flow of regular income to the household and having a strong impact on these two indicators as they are short term nutritional phenomenon.

Father's occupation has a different connotation in the sense that male participation rates are usually above 95 percent though there may be spells of unemployment and underemployment within a year for some of them. Those children with fathers who works as professional have the best nutritional status for all the three indicators resulting in a negative coefficient for all other occupational groups. We also note that the impacts are visible both on HAZ and WAZ while in some instances the magnitude is larger for HAZ and in some for WAZ, once again highlighting the differential impact and allowing for a meaningful comparison.

Household Characteristics

Compared to children in the lowest economic strata, all the others have better HAZ and WAZ values while WHZ is not affected at all by economic status after controlling for other variables. These coefficients have the largest magnitude compared to any other variable for the 'richer' and 'richest' households corresponding to the 4th and 5th wealth quintiles. So clearly economic status matters a lot and the coefficient for the 2nd and 3rd quintiles are also large and similar to the magnitudes that we see for birth size, maternal anthropometric characteristics and mother's education.

Among the social status variables caste has a significant impact as socially disadvantaged groups have been marginalized and discriminated historically. In our study we find that scheduled tribe children are the most disadvantaged with high mean z scores of -2.15, -2.22 and -1.41 in HAZ, WAZ and WHZ respectively (Table 1). Basic amenities in the form of sanitation (open defecation or not), use of untreated drinking water by the household, use of fuels like wood, charcoal and cow-dung for cooking adversely affect the health of children. These variables influence the environmental conditions making the child more susceptible to diseases - the former two for illnesses like diarrhea and fever while the latter for respiratory illness. In most cases one observes the impact to be more on HAZ and WAZ than on WHZ (Deaton et. al., 2013) and our results also are similar. Those children who are in households using flush toilet and drinking treated safe water and less exposed to dirty fuel have improved nutritional status. It is important to note that we find such impact even after controlling for morbidity.

With respect to demographic variables such as family size, the results show that the children who reside in a small family are well nourished. Though birth order partly controls for this, it also means that the first child in a larger family may not be as better off as in a smaller

family where the child would get more attention and care when compared with the big family with many children. Also, usually larger family sizes and hence larger number of children are among the poorer regions and sections of the population (given that infant and child mortality rates are likely to be high). Therefore, we find that in spite of controlling for economic status there is still a significant impact of family size and birth order on the nutritional status of the child.

Similarly, after controlling for basic amenities, occupation and economics status which are usually better in urban areas we still find that they are not adequate in explaining the variations in child nutrition and the coefficient for urban residence is positive and significant compared to rural residence.

The variations in the access to ICDS gave us an idea to interact the variables with the urban and rural areas. As mentioned in the data section, rural dummy is interacted with regular access to supplementary nutrition of ICDS and a significant positive coefficient is reported for HAZ alone. This shows that though rural children on an average have lower nutritional status, access to ICDS regularly does improve at least one of the nutritional indicators, HAZ[7]. This means that for improving HAZ (and hence to reduce stunting) ICDS has an impact in rural areas though for other two nutrition indicators perhaps after controlling for other factors like economic status, rural residence and state dummies, the estimated coefficients are not statistically significant.

[7] We had attempted two other variants to this. First, we tried interacting ICDS access with economic status to see that among children from poorer households if those who accessed it regularly were better off than those who did not. However, not only did the results not turn out satisfactory but it also disturbed the coefficients for wealth status as well and hence this is not reported here. Second, we also attempted interaction between geographic regions with regular ICDS access, as some regions particularly southern states are far better in placement and treatment, followed by western regions, with far weaker presence in the eastern, northern and central Indian states. However, this also did not have any impact as we have controlled for state dummies which perhaps has a stronger influence on how the scheme is placed and also its performance.

CONCLUSION

This study examined the determinants of nutritional indicators with the help of SUR technique for children aged 5 and under in India. We find support for the fact that the joint estimation of these three indicators show that the factors affecting anthropometric status of children do vary across these indicators. The underlying objectives with respect to inter generational transmission, mother's height and weight are significant factors for the improved nutritional status of child. By restructuring the usage of feeding and dietary variables, this study finds that both exclusive breastfeeding with proper initiation and the timely introduction of the complementary food to the child witness better nourishment of the child which is substantiated in recent surveys (RSOC, NFHS-4) where exclusive breastfeeding increased from 46 percent to 64 percent alongwith a reduction in stunting. Over the decade there is a reduction in number of child marriages and hence early childbirth with improvements in maternal and neonatal care which may have contributed to reduction in undernutrition rates. These factors have also been shown as associated with nutritional status of the child in our study. The fact that older children lose out more than younger ones, mothers who are undernourished and less educated and less empowered, low economic status, poor access to amenities like clean water, sanitation and polluting cooking fuels are all associated with poor nutritional status shows that there is a lot of scope for public policy intervention. This has to come both in terms of investment in improving the quality of facilities provided as well as improving the access and usage of these facilities by creating awareness.

A major limitation of this study is in the use of a decade old data in the absence of a recent and representative national level data on nutrition and child growth. In the last decade India has shown tremendous improvements in its economic growth and this should have

had a trickle-down effect. However, this growth has mainly come in the non-agricultural sector and how this uneven growth would have impacted inequality in access to resources and amenities and hence child growth remains to be assessed once the recent data for 2014-15 is made available. If ICDS services are complemented with better water, sanitation and other environment policies, more lives of children can be saved and the impact of ICDS could have a long term effect. However, the decline in funds allocated to this scheme in the most recent budget as well as the allocations to social sectors would further delay India's catching up of children's nutritional status with other well performing nations.

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