Why under five children are stunted in Pakistan? Multilevel analysis of Punjab Multiple Indicator Cluster Survey (MICS-2014)

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Abstract

Background: Pakistan is facing an acute problem of child under-nutrition as about 38 percent of children in Pakistan are stunted. Punjab, the largest province by population and GDP share having stunting prevalence of about 33.5 percent moderately and 13.3 percent severely stunted children of less than five years. Thus, this study aims at examining empirically the determinants of stunting (moderate and severe) at different level of hierarchy.

Methodology: Data for this study is coming from Punjab Multiple Indicators Cluster Survey (MICS-2014). MICS uses two-stage, stratified cluster sampling approach. MICS is sub national level (Punjab province) data covering urban and rural areas. The data consists of 25,067 children under five, for 9 administrative divisions and 36 districts of Punjab province of Pakistan. Descriptive statistics and multilevel hierarchical models were estimated. Multilevel data analyses has advantage because it provides robust standard error estimates and helps in finding variation in the data at various levels.

Results: Punjab has stunting prevalence of about 27 percent moderately and 10 percent severely stunted children of less than five years. The results depict that increasing age of child, increasing birth order, illiterate mothers and fathers, lack of sanitation facilities and being poor are associated significantly with the likelihood of moderate and severe stunting. Surprisingly, there is a gender bias in stunting in Punjab, Pakistan and being girl child is more likely associated with moderate and severe stunting which depicts the patriarchal nature of the society and a strong prevalence of gender bias in household resource allocations.

Conclusion: This outcome of our analysis points towards targeting not only households (focus on girls) but also their families and communities. Keywords: Undernutrition; Stunting; Child Health; Pakistan; Punjab; Multilevel Models; Multiple Indicators Cluster
Background

Globally, in 2016, about 155 million children (23 percent of worldwide children) of less than 5 years are stunted and 50 percent death of children less than five years is due to under-nutrition [1]. A stunted child is both physically short of their age and thus fails to grow cognitively. This condition of undernourishment of a child undermines their potential of life from its very manifestation and affects over the life cycle [2]. Under-nutrition leads to child morbidity and mortality, poor physical and cognitive development, poor school performance, reduced capacity to work later in life thus loss of productivity and wages [3–5]. Therefore, under-nutrition is one of the most pressing challenges of contemporary era due to its long-lasting and detrimental consequences [6].

Moreover, inadequate nutrition of mother during pregnancy and in the first two years of a child’s life is an important window of opportunity to realize a child’s full potential of life. If this window of opportunity is missed could cause irreversible and retarded growth, impaired learning and reduced work performance [2]. Stunting refers to poor child health status due to multiple factors like; physical development, cognitive abilities and the environment [7–11]. Stunting is a form of chronic under-nutrition and occurs when a child is short of their age relative to WHO child growth standards [12,13]. Globally, 87 million (56%) of the total stunted children are present in South Asia [2]. After India, Pakistan has the highest number of stunted children in South Asia [14–16]. Moreover, malnutrition is widespread in Pakistan among all age groups and the progress in not promising in the last decades [17,18].

In Punjab, stunting prevalence in the year 2011 was 36 percent and in 2014 it is reduced
to 33.5 percent (MICS 2016) and this prevalence rate of stunting is alarming for the largest and most developed province of the country. Punjab contributes more than 52 percent to the national income as well as more than 56 percent of the population of the country resides in this province. Given the severe prevalence of stunting in one of the biggest provinces of Pakistan, this study analyzes in detail the determinants and prevalence of stunting in Punjab as an important research question. Moreover, it is imperative to analyze the factors, i.e., immediate (Child level characteristics), underlying (mother, father, household and community level characteristics) and basic (i.e., areas of residence, region of residence and regional food security status) associated with stunting in Punjab, Pakistan.

The main factors associated with stunting such as multiple birth, low birth-weight, maternal education, household wealth, maternal body mass index and short birth interval [19]. Similarly, individual and community level factors are important determinants of childhood stunting. The result also confirms that 37 percent of stunting is due to community level factors in their study [20–21]. Apart from child specific characteristics and parental characteristics, the importance of water, sanitation and hygiene (WASH) has been recognized regarding health of infants and young children, particularly when the process of stunting is concentrated during the first two years of life [10].

Recent studies show that the poor diet of children in the first year of life, poor nutritional status of mother during and after pregnancy, poor sanitation practices, food insecurity and poverty, and social inequalities are significant drivers of childhood stunting [22–24]. In addition, child nutritional status is commonly influenced by factors such as adequate health services and/or lack thereof, nutritional and social services facilities at community/village level and access to these facilities [25–28]. Another study found that safe water access, education of women, gender equality, and food availability are the
main drivers in reducing the stunting [1].

Although, literature on Pakistan is rather scant [18]. There are attempts to investigate the determinants of under-nutrition not only at national level but also at micro-geographic level [29–34]. A study from Sindh province also pinpoints mother illiteracy, low income, and overcrowding as important risk factors of stunting [30]. Moreover, education among rural mothers could reduce stunting, as being female are more likely to be stunted and underweight compared to male in these areas [31]. Contrary to this assertion, for Punjab, a study using MICS 2011 data, explored that female headed household (a measure of female empowerment) had 26 percent lower odds of childhood stunting [34].

All these research studies have focused on employing either ordinary least square (OLS) or binary logistic regression analyses. As standard OLS may over or under-estimate the coefficient of correlates at different points across the distribution of stunting prevalence, thus, bias the estimates. These hierarchies have important information to explore for better and targeted policies formulation. Therefore, this study uses multilevel hierarchical modeling approach to unravel the variation at household, community and at district level that is not explored in case of Pakistan at micro-geographic level. This analysis will set up the stage for policy level debate and provide the data driven information for public policy design. This study is first to analyze the determinants of stunting in Punjab Pakistan using Multiple Indicator Cluster survey (MICS–2014), which includes more than 31,000 children of less than five years.

Methods

The Multiple Indicator Cluster Survey (MICS) is an international household survey program developed by United Nations Children’s Fund (UNICEF) to collect comparable estimates of more than 125 key indicators that are used to assess the situation of children and women, in Punjab Pakistan. The MICS consists of all the households and their members in all urban
and rural areas of Punjab, which is divided administratively into 9 administrative divisions and 36 districts. A two-stage, stratified cluster sampling approach was used for the selection of the survey sample. The first-stage selection unit is enumeration and the village in urban and rural areas. From each of first-stage sample unit, a sample of 20 households selected both in rural and urban areas. Households were considered as secondary sampling units (SSUs) for urban and rural domains. The entire sample of households (SSUs) was drawn from 2050 Primary Sampling Units (PSUs), out of which 774 were urban and 1276 were rural adopting systematic sampling technique with a random start. The final recommended allocation is 2,050 clusters with 20 households in each, giving a total sample of 41,000 households and response rate is almost 98 percent across Punjab province. Detail on MICS Punjab 2014 is provided elsewhere (MICS Punjab Report 2016).

The current study investigates the determinants of stunting of under five years of children. For this purpose, after cleaning the data, we end up with 25066 children of under five year of age.

**Dependent variables**

Stunting (i.e., moderate and severe) is used as a binary variable in this analysis with not stunted being coded as zero while being stunted coded as one, similar is the case with severe stunted. Stunted is measured as moderate if the height for age z score of a child less than five year is less than minus 2 standard deviation from WHO reference growth standards and it is severe if z score is less than minus 3 standard deviation [35].

**Independent Variables**

Individual and household level characteristics include; age of child in months and is categorized into (0–5 months, 6–11 months, 12–23 months, 24–35 months, 36–47 months and 48–59 months). We divided first year of child into two categories because for the first
six months a child is exclusively breast-fed or having milk only as his (her) diet. Moreover, between 6 and 12 months he/she is starting solid food as well. Birth order of child, this variable is a rank number of children born to women of age 15–49 years and categorized into; first born, second born and third or after born having age less than five years. Gender of child is either boy or girl. Size of child at birth is divided into three categories i.e., large (combining very large and larger than average birth size category), average and small (combining smaller than average and very small category). Diarrhea, whether a child had diarrhea in the last two weeks (15 days) is a binary variable (Yes = 1; zero otherwise). Breastfeeding is a binary variable if a child is ever breastfed (Yes = 1) and (No = 0).

Parental education is categorized as; no education (less than 1 year), primary (1–5 years completed), middle (6–8 years of complete education), secondary (9–10 years of complete education) and higher (11+ years of complete education including professional or university degrees). Mother’s age is a categorical variable; less than 18 years, 18–24 years, 25–35 years and 35+ years. Postnatal care is proxies by whether a Lady Health Worker (LHW) visited the household in the past three months and is a binary variable. This variable captures the knowledge and information exchange that is positively associated with child health outcomes. Antenatal care visits (ANC visits) are number of times a woman received antenatal care during pregnancy and is coded as; less than 4 times as recommended by WHO and 4 times or greater times. Place of delivery where a woman gives birth to her child is coded as home delivery if birth occurred at her own home or at another home and institutional delivery if the delivery occurred at either public or private hospital or maternity care or basic/primary health care center. Household size includes number of household members in a household and is categorized into; 3–4 household members, 5–6 household members which is an average size of a family in Punjab, 7–8
household members and more than 8 household members to capture the effect of a very large family on child health outcomes.

Ethnicity is asking about the mother tongue of the head of household and is categorized into; Urdu, Punjabi, Saraiki and Others. Place of residence is a binary variable and coded as \textit{urban} = 1 and \textit{rural} = 0. Similarly, the sanitation facility is about the toilet facility a household possesses. It has been divided into two categories according to WHO definition. That is \textit{improved sanitation facility} of improved sanitation facility which include sewer connections, septic system connection, pour flush latrines, ventilated improved pit latrines and pit latrines with a slab or covered pit, \textit{unimproved sanitation facility}, which include pit latrines without slabs or platforms or open pit hanging latrines bucket latrines, open defecation in fields, forests and/or bushes. Water treatment (boiling water before drinking) is asking a household what household do to make water safer for drinking and is a binary variable coded as \textit{treated} = 1 and \textit{untreated} = 0.

Regional characteristics include districts wise food insecurity index and administrative divisions of province of Punjab. Food insecurity index is taken from SDPI report and this index is at district level. All the three composite indicators (availability, access and food absorption) were aggregated to determine the food insecurity level of the districts in Pakistan. The food insecurity indicator was not the simple sum of all composite indicators, but rather principal component analysis (PCA) was used\cite{22,24,36}. The food insecurity index is divided into three categories. (1) Food Insecure (0.53–0.71), (2) Vulnerable (0.72–0.80) and (3) Food Secure (0.81–0.93). The measure of food insecurity helps in better understanding the variation at sub national level (district) hence this variable is included at district level. Furthermore, Punjab province is divided into nine administrative divisions; Rawalpindi, Bahawalpur, D. G. Khan, Faisalabad, Gujranwala, Lahore, Multan, Sahiwal and Sargodha.
Data Analysis

The simultaneous analysis of two variables is captured through bivariate analysis. It explores whether there exists a significant difference between the variables or not. This study presents the prevalence of moderate and severe childhood stunting in percentages at various levels of covariates, the level of significance of each variable with that of response variable set at $P$-value $< 0.05$. In addition, the current study employs three-level random intercept multilevel hierarchical models. Many kinds of data including observational data have a hierarchical or clustered structure. For example, children with same parents tend to be more alike in their physical attributes, social attitudes, and mental characteristics than children chosen randomly. Multilevel models recognize the existence of data hierarchies by varying the residual components at each level in the hierarchy [37,38]. In a multilevel model, the groups in the sample are treated as a random sample, where it is not possible in the fixed effect model. For instance, if we use ordinary regression analysis in finding factors associated with stunting, we assume that for all children the outcomes (in this case, moderate and severe stunting) are independent. Nevertheless, in our analysis more than one child per family are included so that outcomes for siblings may be correlated, especially if nutritional status is dependent on characteristics common to a family such as the quality of parental care, the sanitary conditions within the household etc. Because of these household effects, we would expect stunting for children in the same household or community to be more alike than stunting for children from different households or communities [36–39]. A simple three level model without the explanatory variables, which is called unconditional model is written as:

$\text{Stunting}_{ijk} = b_0 + v_k + u_{jk} + e_{ijk}$

Where $\text{Stunting}_{ijk}$ is the observed value of being (Stuntingijk = 1) both moderately and severely stunted and being non-stunted (Stuntingijk
Several approaches are available to interpret variance components in multilevel models; we are considering here the; variance partition coefficients (VPCs) and intra class correlation coefficients (ICCs). The VPC statistics report the proportion of the response variance that lies at each level of the model hierarchy. Thus, the total variance is simply the sum of the three separate variance components. The ICC measures the expected degree of similarity between responses within specific level.

Results

Bivariate Analysis Results

Table 1 presents the prevalence of moderate and severe childhood stunting in percentages at various levels of covariates, the level of significance of each variable with that of response variable set at \( P\text{-value} < 0.05 \). A little more than a quarter (27.4\%) children are moderately stunted and one-tenth (10.4\%) is severely stunted in Punjab, Pakistan. Furthermore, 63 percent of children are moderately stunted between the age group of 36 months to 59 months whereas about 25 percent are severely stunted in the same age group. The figure for 0-11 months is 30 percent moderately stunted while 11 percent severely stunted children. Thus, child age is an important and significant predictor of the health outcomes. Childbirth order is an important risk factor for child stunting outcomes. For example, if a child birth order is 3 or above the child has more likelihood of being stunted (30\%) and severely stunted (11\%). Whereas a little more than one-fourth (27\%) of first-born are likely to be stunted and one-tenth (10\%) likely to be severely stunted. Of note, 27\% boys and 28 \% girls are moderately stunted whereas 10 \% boys and 11 girls are severely stunted. Girls are facing significantly higher burden of moderate and severe stunting. Child size at birth is also an important predictor, for
example, children born larger than average size are (21%) moderately stunted and (8%) severely stunted but those born with smaller than average birth size are 36% moderately and 15% severely stunted. Almost 24% children who breastfeed are moderately and about 9% severely stunted compared to 25% those who are not breast-feed are moderately stunted and 12% severely stunted. Children having diarrhea are more likely to be stunted (31%) compared to those who are not having diarrhea (27%).

Lower the mother’s education higher the chances that a child is facing stunting. For example, a woman with low education has higher likelihood of having stunted children (36% moderate and 15% severe) compared to highly educated (9% moderately stunted and 2% severely stunted). Children whose father is educated (13 % moderate and 4 % severe stunting) are less likely to be stunted compared to those children whose father is not educated (38 % moderate and 17 % severe stunting).

[Insert Table 1]

If a woman marries at age less than 18 years as compared to those marries after 36 years (29% of their children are moderately stunted and 11 % severely stunted) is more likely to borne stunted child. A significantly high number of children 30% living in rural areas are moderately stunted relative to 21% in urban areas where as about 12 percent severely stunted compared to 7 percent in urban areas. There are significant differences among the administrative divisions of the Punjab province. For example, Rawalpindi division has significantly lower prevalence of moderate and severe stunting (16% moderate and 5 % severe stunting) compared D. G. Khan, Bahawalpur and Multan (39%, 35% and 29% moderate stunting and 19%, 15% and 11% severe stunting) respectively. Every fourth child 25% (1.3–2.7) in Lahore, the provincial capital of Punjab, is moderately stunted and every tenth child 9% (1.3–2.7) is severely stunted. Those household having unimproved water and sanitation facilities are highly likely to have more stunted children (sanitation:
37% versus 23% and Water: unimproved 19% versus improved 28%) relative to those household having improved water and sanitation facilities. Almost 39 percent (18 percent) of those children living in food insecure districts are moderately (severely) stunted relative to 29 percent (11 percent) in vulnerable (borderline) districts and 24 percent (8 percent) in food secure districts.

**Multivariate Analysis Results**

Table 2 and 3 presents the results of the multilevel logistic regression analyses and the results are presented as Odds ratio (OR) with their 95% Confidence Interval (95% CI). The LR test favored the multilevel logistic regression instead of conventional logistic regression, shown by the statistically significant (LR $\chi^2 = 1005.94, P < 0.001$) for moderate stunting and (LR $\chi^2 = 628.88, P < 0.001$) for severe stunting (see Table 2–3).

Model 2 in Table 2 presents results of only child specific and parent’s level characters and their association with moderate stunting. For example, compared to reference category of zero to five months, children of 6 to 11 months are 2 and half times more likely to be stunted (OR = 2.58, CI = 1.9–3.5) whereas children of age 12–23 months are 7 times more prone to be stunted (OR = 7.25 (5.1,10.3). Girls are significantly more likely to be stunted than boys (OR = 1.14, 95% CI = 1.1–1.2). Children whose birth order is second is significantly likely to be stunted (OR = 1.57 95% CI = 1.4–1.8) whereas children whose birth order is 3 or more is 3 times more likely to be stunted (OR = 3.14 95% CI = 2.4–4.1). Children with no breastfeeding are not significantly likely to be moderately stunted (OR = 1.35 95% CI = 1–1.7) than those children who had breastfeeding. Children with no diarrhea are significantly less likely to be stunted compared to those having an episode of diarrhea (OR = 0.73 95% CI = 0.6–0.8). Children whose size at birth perceived smaller are more than 2.6 times likely to be moderately stunted than those who have large size at the time of birth (OR = 2.62 95% CI = 2.0–3.5). Mothers’ education is a significant covariate
of moderate stunting. Compared to no education, reference category, children of highly educated mothers are significantly less likely to be moderately stunted (OR = 0.25 95% CI = 0.2–0.3). Whereas children of Primary (OR = 0.67 95% CI = 0.6–0.8) and Middle school completed mothers (OR = 0.51 95% CI = 0.4–0.6) are significantly less likely than no educated mothers to be stunted. Children of father who has higher education are less likely to be stunted (OR = 0.40 95% CI = 0.3–0.5). Living in rural areas is a risk factor of moderate stunting. The results of severe stunting (less than minus 3 SD) are presented in table 3.

[Insert Table 2]

Table 4 presents the results of VPC and ICC for both moderate and severe stunting. The total variance (unconditional model 1) by combining the variation at three levels (district, community and household) is estimated to be 5.37 ( = 0.37 + 0.53 + 1.18 + 3.29) for moderate stunting. The district level explains 0.07% ( = 0.37/5.37) proportional change in variance (VPC), the community level variance shows 0.10% ( = 0.53/5.37) of variation and the household level variation implies that the risk of stunting varies significantly by 0.22% ( = 1.18/5.37). Similarly, looking at the ICC statistics of moderate stunting (unconditional model 1), we find that the district and community level ICC is 0.07 and 0.17 respectively. Thus, the correlation between two households from the same district, but different community is 0.07, while the correlation between two households from the same district and same community is higher at 0.17. This means that households in the same community have higher chance of correlation than the households of adjacent communities. This also shows that variance in the odds of child being stunted is explained 7% by district and 17% by community characteristics.

[Insert Table 3]

In summary, the VPC and ICC statistics show high degree of clustering in the Punjab
stunting data. However, majority of the variation in stunting both moderate and severe lies at the household level. The differences could be due to income inequality, access to health care facility, food insecurity of households. Hence, the findings imply that stark variation exist among household demographic and socio-economic characteristics. Therefore, for policy relevance, household level nutrition related policy should be prioritized, followed by community and districts level measures.

[Insert Table 4]

Discussion

We have analyzed the determinants of under nutrition (stunting) in Punjab Pakistan which include 25,066 children of less than five years using multilevel hierarchical models. Our results indicate that stunting and severe stunting is a daunting public health challenge of the province of Punjab, Pakistan because almost a little more than one fourth (27.4%) of children are moderately stunted and 10% are severely stunted in 2014. This number is alarming. The key individual and household level covariates significantly associated with stunting and severe stunting are; age of child, birth order of child, being female, being smaller in size at birth, episode of diarrhea, breast feeding, mother and father education, and wealth status of household. Number of studies done on Africa and south Asia found that risk of stunting and severe stunting increases with increase in age of a child [40,41,29,21,42]. It is because stunting can start during pregnancy (in utero) and is confirmed by a study using WHO child malnutrition and growth database as the average z score of infants drop rapidly until the age of 2 years [43,44]. Moreover, as child grow their needs for food and diverse diet increases as well as their requirements for calorie intake. Given the limited household resources it is certain that with the growing body needs unfulfilled, stunting will result.

Child birth order is an important risk factor for child health outcomes. The higher the birth
order it is highly likely that the odds of a child being stunted increases 3 folds which is in line the studies from India and Africa [45-47]. For India, the study explains that it is due to son preference and other reasons that mother’s time allocation for child care is distributed among children in the household and competition for household food and non-food resources [47,48]. Gender of a child is an important factor in stunting outcome for example; Girls are facing relatively higher burden of stunting. Girls have 27% higher odds of being severely stunted and 14% moderately stunted relative to boys. This finding is in line with the study from Nepal and Pakistan [49,50] and from rural Thatta, Pakistan [31] but in contrast with findings from Bhutan and Bangladesh [51,52]. This gender bias depicts the patriarchal nature of social setup especially in Punjab, Pakistan. This is confirmed by a study of 61 countries ranking Pakistan second highest desired sex ratio for boys [53]. Furthermore, gender discrimination and patriarchy leave female sex behind and neglect their basic rights like food. The findings of our study showed that Children with diarrhea and less breast feeding at the earlier stages are more likely to be stunted. Similarly, rural residence (only in model 2 for moderate stunting) and smaller than average size at birth are more likely to be stunted. These results are also reported in other studies [54,55,48,56]. Mother and Fathers’ higher education status is associated significantly with the less likelihood of child of less than five years being stunted (moderate and severe) in Punjab, Pakistan. This result is in line with other studies from Asia and Africa [57,34,58,59,28]. Although the channels through which education of parents can affect child health outcomes are debated as it hypothesized that higher educated parents are relatively better endowed with (health care) knowledge and resources, relatively rich and better able to provide childcare [60,28,61]. There are significant differences among the administrative divisions of the Punjab province. For example, Rawalpindi division has significantly lower prevalence of moderate
and severe stunting and compared to Rawalpindi, a child living in Lahore is twice likely to be stunted (moderate and severe) which is a surprising result given the relative socio-economic development of Lahore division compared to other administrative divisions of the province. One possible explanation is due to its metropolitan nature. Lahore division is relatively expensive to bear household food and non-food expenditure especially for households with limited resources. Another possible reason can be that due to urbanization (82% population is urban in Lahore division) and expansion of Lahore it is highly congested (3500 person per square in Lahore district one of the highest in Punjab province and average household size 7.2 persons) and polluted city (poor living and unhygienic conditions) of the province which is detrimental for food absorption and health especially of children of younger ages [39,34]. This result also points towards nutritional inequalities that exist among the administrative divisions of the Punjab province. This area of research need further in depth empirical investigation. Mother’s age at marriage, household size, pre and postnatal care, drinking water facility and region of residence are not significant predictors of moderate and severe stunting in any of the models estimated. However, communities with improved sanitation facility have less likelihood of child being moderately or severely stunted. This finding is in line with the previous results reported by other studies [62,10,63]. While, analyzing the data from 172 Demographic and Health surveys, the results showed that likelihood of stunting in household with sanitation facilities were relatively lower [64].

Conclusion

The findings of this study confirm that the child specific, household, and district characteristics have strong predicting power in the explanation of stunting (moderate and severe). Furthermore, the results also reveal that stark differences exist among household level, while at the community and district level the variances decrease as we incorporate
the explanatory variables. The findings of this study have strong policy implication; indicating focus should be on the household while making public policy. Nevertheless, policy makers should not forget the role of community (village) and district level factors in policy priorities.

Abbreviations

MICS: Multiple Indicator Cluster Survey, OLS: ordinary least square, PCA: Principal Component Analysis, SSUs: Secondary Sampling Units, UNICEF: United Nations Children’s Fund, WASH: water, sanitation and hygiene, WHO: World Health Organization.

Declarations

Ethics approval and consent to participate: This study is based on an analysis of cross sectional data available freely and publicly with all identifier information removed, no ethics approvals were required.

Consent for publication: Not Applicable

Availability of data and material: MICS data set is publically available online on the following link: http://mics.unicef.org/surveys

Competing Interest: The authors declare no conflict of interest.

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Author’s contributions:

F.A and R.K performed the literature search and conceptualize this study. Data analysis was done by T.M with input from F. A. as well as interpretation of multilevel results. The manuscript was drafted by R.K and F. A. and reviewed by F.A, R.S and T. M. All the authors were involved in revision and editing of the draft. All authors critically reviewed the final manuscript and approve the draft for final submission.

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Tables

Table 1: Prevalence of moderate and severe childhood stunting at various levels of independent variables in Punjab, Pakistan (Punjab MICS-2014) (n=25,066)

| Variables | Stunting (Moderate SD < -2) | Stunting (Severe SD < -3) |
|-----------|-----------------------------|---------------------------|
|           | Total Yes N (%) | No N (%) | Total Yes N (%) | No N (%) |
| Total (%) | 25066 | 6865 (27.4) | 18201 (72.6) | 25066 | 2602 (10.4) | 22464 |
| Age Group | <0.001 | | <0.001 | | <0.001 | | <0.001 |
|-----------|--------|--------|--------|--------|--------|--------|
| 0-5 months | 2,177  | 247(11)| 1,930(89)| 2,177| 99(5) | 2,078( |
| 6-11 | 2,767 | 531(19)| 2,236(81)| 2,767| 157(6)| 2,609( |
| 12-23 | 4,827 | 1,484(31)| 3,343(69)| 4,827| 569(12)| 4,258( |
| 24-35 | 4,838 | 1,266(26)| 3,572(74)| 4,838| 478(10)| 4,360( |
| 36-47 | 5,373 | 1,785(33)| 3,588(76)| 5,373| 657(12)| 4,716( |
| 48-59 | 5,082 | 1,549(30)| 3,533(70)| 5,082| 641(13)| 4,441( |
| Birth Order | 0.04 | 0.023 | 0.04 | 0.023 | 0.04 | 0.023 |
| 1st | 16,391 | 4,415(27)| 11,976(73)| 16,435| 1641(10)| 14794( |
| 2nd | 7,323 | 2,046(28)| 5,277(68)| 7323| 816(11)| 6507( |
| 3+ | 1,351 | 403(30)| 948(70)| 1351| 1371(11)| 10983( |
| Gender of Child | 0.024 | >0.001 | 0.024 | >0.001 | 0.024 | >0.001 |
| Boy | 12,712 | 3,384(27)| 9,328(73)| 12712| 1231(10)| 11481( |
| Girl | 12,354 | 3,481(28)| 8,873(68)| 12354| 1371(11)| 10983( |
| Size at Birth | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Large | 1,052 | 218(21)| 834(79)| 1052| 80(8)| 972(9) |
| Average | 8,862 | 2,281(26)| 6,581(74)| 8862| 846(10)| 8016( |
| Small | 2,633 | 938(36)| 1,695(64)| 2633| 406(15)| 2227( |
| Diarrhea | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Yes | 4391 | 1344(31)| 3047(69)| 4391| 556(13)| 3835( |
| No | 20676 | 5522(27)| 15154(73)| 20675| 2046(10)| 18629( |
| Breastfeeding | >0.001 | >0.001 | >0.001 | >0.001 | >0.001 | >0.001 |
| Yes | 13950 | 3365(24)| 10585(76)| 13949| 1226(9)| 12723( |
| No | 703 | 179(25)| 524(75)| 703| 81(12)| 622(8) |
| Mother Education | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| No Education | 12,270 | 4,428(36)| 7,842(64)| 12,270| 1,861(15)| 10,405( |
| Primary | 4,517 | 1,149(25)| 3,368(75)| 4,517| 367(8)| 4,150( |
| Middle | 2,481 | 508(20)| 1,973(80)| 2,481| 156(6)| 2,325( |
| Secondary | 3,101 | 529(17)| 2,572(83)| 3,101| 156(5)| 2,945( |
| Higher | 2,696 | 249(9)| 2,447(91)| 2,696| 63(2)| 2,633( |
| Mother Age | 0.042 | 0.305 | 0.042 | 0.305 | 0.042 | 0.305 |
| <18 | 1,696 | 499(29)| 1,197(71)| 1,696| 185(11)| 1,511( |
| 18-24 | 5,148 | 1,323(26)| 3,825(74)| 5,148| 495(10)| 4,653( |
| Antenatal Care                | >0.001 | >0.001 |
|------------------------------|--------|--------|
| 1-4 visits                   | 6169   | 1725(28)|
| 5+ visits                    | 3914   | 718(18) |
| Postnatal Care               | 0.723  | 0.431  |
| Yes                          | 4764   | 1315(28)|
| No                           | 7703   | 2100(27)|
| Child Delivery               | >0.001 | >0.001 |
| Home                         | 5452   | 1884(35)|
| Hospitals                    | 7150   | 1567(22)|
| Father Education             | <0.001 | <0.001 |
| Noeducation                  | 7,335  | 2,814(38)|
| Primary                      | 4,536  | 1,419(31)|
| Middle                       | 4,138  | 1,024(25)|
| Secondary                    | 5,507  | 1,144(21)|
| Higher                       | 3,548  | 463(13) |
| WealthIndex                  | <0.001 | <0.001 |
| Poor                         | 11,167 | 4,155(37)|
| Middle                       | 4,915  | 1,218(25)|
| Rich                         | 8,983  | 1,491(17)|
| Household Size               | >0.001 | >0.002 |
| 3-4 members                  | 2,873  | 705(25) |
| 5-6 members                  | 7,179  | 1,983(28)|
| 7-8 members                  | 6,177  | 1,838(30)|
| 8+ members                   | 8,836  | 2,339(26)|
| Community Level Characteristics |       |        |
| Ethnicity                    | >0.001 | >0.001 |
| Urdu                         | 1,267  | 243(19) |
| Punjabi                      | 16,141 | 3,967(25)|
| Saraikai                     | 6,040  | 2,139(35)|
| Others                       | 1,617  | 515(32) |
| Region                       | >0.001 | >0.001 |
| Urban                        | 7842   | 1620(21)|
| Rural                        | 17224  | 5245(30)|

Wealth Index:
- Poor: 11,167 (4,155), 7,012 (3,085)
- Middle: 4,915 (1,491), 3,697 (1,024)
- Rich: 8,983 (1,491), 7,492 (1,024)

Household Size:
- 3-4 members: 2,873 (705), 2,168 (705)
- 5-6 members: 7,179 (1,983), 5,196 (1,983)
- 7-8 members: 6,177 (1,838), 4,339 (1,838)
- 8+ members: 8,836 (2,339), 6,497 (2,339)

Community Level Characteristics:
- Ethnicity: Urdu: 1,267 (243), Punjabi: 16,141 (3,967), Saraikai: 6,040 (2,139)
- Region: Urban: 7842 (1620), Rural: 17224 (5245)
Table 2 Multivariable Regression results of Multilevel models Punjab for moderate stunting (n=25,066)

| Variables                          | Model 1 | Model 2 OR [95% CI] | Model 3 |
|------------------------------------|---------|---------------------|---------|
| Individual and Household Level Characteristics |
| Child age group (Reference Category 0-5 months) |         |                     |         |
| 6-11                               | 2.58*** [1.9,3.5]  | 2.61**              |
| 12-23                              | 7.25*** [5.1,10.3] | 7.37***             |
| 24-35            | 6.25*** [4.1,9.5] | 6.26*** |
| 36-47            | 15.36*** [7.3,32.5] | 15.23* |
| 48-59            | 13.28*** [6.5,27.2] | 13.09* |

**Child Birth order (Reference Category First Born)**

| 2              | 1.57***[1.4,1.8] | 1.55** |
| 3+             | 3.14***[2.4,4.1] | 3.06** |

**Child Gender (Reference Category Boy)**

| Girl          | 1.14***[1.1,1.2] | 1.14** |

**Child size at birth (Reference Category Large Size)**

| Average       | 1.53*[1.1,2.0] | 1.52** |
| Small         | 2.62***[2.0,3.5] | 2.58** |

**Diarrhea (Reference Category No)**

| Yes          | 0.73***[0.6,0.8] | 0.74** |

**Breast Feeding (Reference Category Yes)**

| No          | 1.35*[1.0,1.7] | 1.36** |

**Mother Education (Reference Category No Education)**

| Primary     | 0.67***[0.6,0.8] | 0.77** |
| Middle      | 0.51***[0.4,0.6] | 0.63** |
| Secondary   | 0.47***[0.4,0.6] | 0.62** |
| Higher      | 0.25***[0.2,0.3] | 0.34** |

**Mother Age (Reference Category age of women<18 years of age)**

| 18-24       | 0.94[0.7,1.2] | 0.99[0. |
| 25-35       | 0.93[0.8,1.1] | 0.97[0. |
| 36-49       | 0.86[0.7,1.0] | 0.88[0. |

**Postnatal Care (Reference Category Yes)**

| No          | 0.97[0.9,1.1] | 0.98[0. |

**Prenatal Care (Reference category 1-4 visits)**

| More than 4 visit | 0.88[0.8,1.0] | 0.94[0. |

**Delivery Place (Reference category Home)**

| Hospital     | 0.93[0.8,1.1] | 0.98[0. |

**Father Education (Reference category No Education)**

| Primary     | 0.85*[0.7,1.0] | 0.90[0. |
| Middle      | 0.65***[0.6,0.7] | 0.71** |
| Secondary   | 0.56***[0.5,0.6] | 0.64** |
| Higher      | 0.40***[0.3,0.5] | 0.48** |

**Wealth index (Reference category Poor)**

| Middle  | 0.64** |
| Rich    | 0.47** |

**HH size (Reference category HH size 3-4 members)**
| Community Level Characteristics |  |
|---------------------------------|---|
| **Ethnicity** (Reference category Urdu) |  |
| Punjabi | 0.86 [0] |
| Saraikai | 0.95 [0] |
| Others | 1.08 [0] |
| **Region** (Reference category Urban) |  |
| Rural | 1.22*** [1.1,1.3] |
| **Sanitation facility** (Reference category Unimproved) |  |
| Improved | 0.86* [ ] |
| **Drinking water facility** (Reference category Unimproved) |  |
| Improved | 1.13 [0] |
| **Water treatment** (Reference category Treated) |  |
| Untreated | 1.26 [1] |
| **Regional Level Characteristics** |  |
| Food Insecurity index (Reference category Food Insecure) |  |
| Food Vulnerable | *  |
| Food Secure | **  |
| **Division** (Reference category Rawalpindi Division) |  |
| Bahawalpur |  |
| D.G Khan |  |
| Faisalabad |  |
| Gujranwala |  |
| Lahore |  |
| Multan |  |
| Sahiwal |  |
| Sargodha |  |
| Constant | -1.43 (0.13)*** |
| Level-1 (Household) | 1.18 (0.10)*** |
| Level-2 (Community) | 0.53 (0.03)*** |
| Level-3 (District) | 0.37 (0.03)*** |
| Chi2 | (1005.94)*** |

OR = Odds Ratio, CI = 95% Confidence Intervals in brackets. * p < 0.05, ** p < 0.01, *** p < 0.001.

a = base model (unconditional three level hierarchical model), b = hierarchical model with child and parental characteristics, c = hierarchical model with child, parental and household characteristics and d = hierarchical model with child, parental, household and
**Table 3 Multivariable Regression results of Multilevel models Punjab for severe stunting (n=25,066)**

Severe Stunting SD > -3

| Variables                              | Model 1<sup>a</sup> | Model 2<sup>b</sup> OR [95% CI] | Mo  |
|----------------------------------------|---------------------|---------------------------------|-----|
| Individual and Household Level Characteristics |                       |                                 |     |
| Child age group (months)               | (Reference Category 0-5 months) |                                 |     |
| 06-11                                  | 1.56[1.9,3.5]        | 1.57[1.0,2.6]                   | 1.5 |
| 12-23                                  | 4.85***[5.1,10.3]    | 4.92***[2.9,8.2]                | 4.9 |
| 24-35                                  | 4.62***[4.1,9.5]     | 4.61***[2.5,8.7]                | 4.6 |
| 36-47                                  | 6.36***[7.3,32.5]    | 6.31***[2.9,17.9]               | 6.3 |
| 48-59                                  | 6.98***[6.5,27.2]    | 6.97***[2.4,17.9]               | 6.9 |
| Child order (Reference Category First Born) |                     |                                 |     |
| Second                                 | 1.76***[1.4,1.8]     | 1.73***[1.4,2.1]                | 1.7 |
| More than 2                            | 2.71***[2.4,4.1]     | 2.62***[1.7,4.0]                | 2.6 |
| Gender of child (Reference Category Boy) |                     |                                 |     |
| Girl                                   | 1.27***[1.1,1.2]     | 1.27***[1.2,1.4]                | 1.2 |
| Child size at birth (Reference Category Large Size) |   |                                 |     |
| Average                                | 1.29[1.1,2.0]        | 1.28[0.9,1.9]                   | 1.2 |
| Small                                  | 2.20***[2.0,3.5]     | 2.16***[1.6,3.0]                | 2.1 |
| Diarrhea (Reference Category No)       |                      |                                 |     |
| Yes                                    | 0.64***[0.6,0.8]     | 0.65***[0.6,0.8]                | 0.6 |
| Breast Feeding (Reference Category yes) |                      |                                 |     |
| No                                     | 1.87**[1.0,1.7]      | 1.89**[1.3,2.8]                 | 1.8 |
| Mother Education (Reference Category No Education) | | | |
| Variable                          | Reference Category Age of Women <18 Years of Age | Age 18 &<=24 | Age >24 &<=35 | Age >36 |
|----------------------------------|--------------------------------------------------|--------------|--------------|---------|
| Mother Age (years)               |                                                  | 0.99[0.7,1.2] | 0.89[0.8,1.1] | 0.92[0.7,1.0] |
| Primary Education                |                                                  | 0.80*[0.7,1.0] | 0.56***[0.6,0.7] | 0.56***[0.5,0.6] |
| Middle Education                 |                                                  | 0.56***[0.6,0.7] | 0.56***[0.5,0.6] | 0.41***[0.3,0.5] |
| Higher Education                 |                                                  | 0.40***[0.4,0.6] | 0.22***[0.2,0.3] | 0.56***[0.5,0.6] |
| Wealth Index                     | Poor                                             | 0.61***[0.5,0.7] | 0.46***[0.4,0.6] |        |
| HH size                          | 3-4 members                                      | 1.1:         | 1.2:         | 1.2:    |
| Community Level Characteristics  |                                                  |              |              |         |
| Ethnicity                        | Urdu                                             |              |              |         |
| Language        |       |       | 0.8 | 1.1 | 1.1 |
|-----------------|-------|-------|-----|-----|-----|
| Punjabi         |       |       |     |     |     |
| Saraikai        |       |       |     |     |     |
| Others          |       |       |     |     |     |

Region *(Reference category Urban)*

| Region |       |       | 1.18 [1.0, 1.4] | 0.8 |
|--------|-------|-------|-----------------|-----|
| Rural  |       |       |                 |     |

Sanitation facility *(Reference category Unimproved)*

| Status       |       |       | 0.7 |     |
|--------------|-------|-------|-----|-----|
| Improved     |       |       |     |     |

Drinking water facility *(Reference category Unimproved)*

| Status       |       |       | 1.1 |     |
|--------------|-------|-------|-----|-----|
| Improved     |       |       |     |     |

Water treatment *(Reference category Treated)*

| Status |       |       | 1.1 |     |
|--------|-------|-------|-----|-----|
| Untreated |       |       |     |     |

*Regional Level Characteristics*

*Food Insecurity index *(Reference category Food Insecure)**

| Status         |       |       |     |     |
|----------------|-------|-------|-----|-----|
| Food Vulnerable |       |       |     |     |
| Food Secure     |       |       |     |     |

Division *(Reference category Rawalpindi Division)*

| Division       |       |       |     |     |
|----------------|-------|-------|-----|-----|
| Bahawalpur     |       |       |     |     |
| D.G Khan       |       |       |     |     |
| Faisalabad     |       |       |     |     |
| Gujranwala     |       |       |     |     |
| Lahore         |       |       |     |     |
| Multan         |       |       |     |     |
| Sahiwal        |       |       |     |     |
| Sargodha       |       |       |     |     |

| Constant  | -3.14 (0.25) *** | 0.011 (0.005) *** | 0.0 |
|-----------|------------------|-------------------|-----|


OR = Odds Ratio, CI=95% Confidence Intervals in brackets. * p< 0.05, ** p < 0.01, *** p < 0.001.

a = base model (unconditional three level hierarchical model), b = hierarchical model with child and parental characteristics, c = hierarchical model with child, parental and household characteristics and d = hierarchical model with child, parental, household and districts food insecurity index and division.

Table 4: Results from random intercept model: Measure of variation VPC and ICC
| Models | Model 1 | Model 2 | Model 3 | Mc |
|--------|---------|---------|---------|----|
| Standard Deviation | -2 SD | -3 SD | -2 SD | -3 SD | -2 SD | -3 SD | Mc |
| Variance Partition Coefficient (VPC) | = | 0.22 | 0.21 | 0.37 | 0.41 | 0.38 | 0.40 | 0.3 |
| = | 0.10 | 0.10 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.0 |
| = | 0.07 | 0.08 | 0.007 | 0.02 | 0.006 & 0.02 | 0.0 |
| Intra Class Correlation (ICC) | = | 0.17 | 0.19 | 0.03 | 0.05 | 0.03 & 0.05 | 0.0 |
| = | 0.07 | 0.08 | 0.007 & 0.02 | 0.006 = 0.02 |

Note: total variance = +