Age heterogeneities in child growth and its associated socio-demographic factors in India, 1992-2016

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Abstract

Objective: This study aims to assess age heterogeneities in child growth and its associated factors.

Data and Methods: We analyse anthropometric data, i.e., *height-for-age* z-scores (HAZ) and *weight-for-age* z-scores (WAZ), of 317,323 children aged <5 years, from four rounds of National Family and Health Survey (NFHS) conducted between 1992 and 2016. We plot anthropometric age profiles to reveal age heterogeneities in child growth and apply age-interactive regression models (OLS and mother fixed-effects) to assess underlying age heterogeneities in the correlates of child growth.

Results: Significant improvement in HAZ for all age groups was observed from 1992-93 to 2015-16, however, the shifts in HAZ scores were not uniform across all ages. The shifts were moderate among the younger children but, these appeared to be larger among the older children. Results from our fully age-interacted models suggest a wide range of determinants that have age dimensions, meaning that the effects of these determinants on child growth tend to vary with age.

Conclusion: Preliminary findings of this study highlight the existence of age heterogeneities in child growth correlates which is potentially a finding of some significance and may provide policy guidance through directing the timely nutrition interventions to achieve the maximum impact.

Keywords

Child growth patterns; Age heterogeneities; Age interaction; Structural break; Mother fixed-effect model

Introduction

In India, elimination of child undernutrition has been a key public health challenge. Despite several *nutrition-specific* and *nutrition-sensitive* interventions in place, there has been an unsatisfactory decline in the prevalence of undernutrition, particularly in the rate of stunting which has declined from 52% in 1992-93 to 38% in 2015-16. There are handful of studies[1–5] that have focussed on the determinants of child undernutrition. But surprisingly, very little has been explored regarding the age patterns of child growth indicators in children in India. To our knowledge, there is only one study by Mamidi et al.[6] in which authors have made an attempt to show the growth faltering pattern among children under aged five. Analysing the age patterns of child growth indicators is crucial in a country where prevalence of undernutrition is high, because it would facilitate understanding at what age policy actions should be taken to prevent undernutrition in children.

Further, it is also important to understand whether the association of child growth indicators with predictors vary as a function of child's age, and this is critical for understanding the fact that when interventions will have the maximum impact. Researchers have increasingly identified that the effects of various environmental, socioeconomic, and genetic determinants on child growth are not uniform across all ages, instead the effects of such determinants are shown to differ with the child's age. For example, a recent research by Bommer and colleagues[7] in low- and middle-income countries revealed that the impact of household socioeconomic status on stunting becomes more prominent as children grow older. The similar wealth-age gradients on child health was also evident from many developed countries like Canada[8], United States[9], and England[10]. In a multi-country study, Fernald et al.[11] documented a positive association between maternal education and child growth, where the slope of gradient was greater among younger children than the older ones. One common explanation for such age differences has been that the magnitude of response of nutrition to these protective measures (i.e., wealth and maternal education) are different at different level of child development. Another general agreement among the researchers has been that the responsiveness of children's height and weight to several risk factors and/or protective measures are in keeping with biological and behavioural mechanisms that are not age-independent. For example, pathogen exposure (e.g., diarrhoeal infection), the susceptibility to disease (e.g., immune response), and the importance of mother's care and nurturing (e.g., breastfeeding, preventive healthcare) are all issues that have age dimensions[12]. The impact of these circumstances are therefore likely to moderate the beneficial or harmful effects of the socioeconomic environment faced by the children and their mothers. Therefore, any meaningful analysis of child growth determinants should always account for the age heterogeneities associated with different level of child development.

In this study, we analyse growth indicators in Indian children and our objectives are twofold. First, we aim to assess the age patterns of child growth, this will allow us to understand the levels and trends of age heterogeneities in child growth. Second, we aim to identify the age-specific correlates of child growth that would reveal age heterogeneities in correlates of child growth.

Data and Methods

This paper uses children's anthropometric data—that is, *height-for-age* z-scores (HAZ) and *weight-for-age* z-scores (WAZ)—from four rounds of National Family and Health Survey (NFHS) conducted as part of the DHS in India during 1992-93 (NFHS-1), 1998-99 (NFHS-2), 2005-06 (NFHS-3), and 2015-16 (NFHS-4). In Table 1, we present a list of sample sizes for each round of NFHS. Our analysis was restricted to sample with valid anthropometric data. We exclude any sample with missing or inappropriate information on height and/or weight and with missing information on any covariates considered. Thus, our data contain information on 317,323 children below five years of age.

Table 1: Number of households, survey response rates, number of children, and time of field work by survey year

	Survey Year			
	1992-93	**1998-99**	**2005-06**	**2015-16**
Total children	50001	32393	56438	238448
Child age group	0-48 months	0-36 months	0-59 months	0-59 months
Anthropometric data available	26657	24215	46655	219796

To assess the age heterogeneities in child growth, we produced anthropometric age profiles (for HAZ and WAZ) by plotting mean Z-scores versus age. We calculate mean Z-scores for each month between birth and 59 months.

To identify the age-specific correlates of child growth, we follow the methodology proposed by Rieger and Tremmlorva[13]. In which, to model the age-varying effects of underlying determinants on child growth (i.e., HAZ, WAZ), an interaction term between child's age and potential determinants is taken within the OLS regression model. Then in the next step, a *structural break*—which represents the threshold age of growth faltering, is introduced within the same model. The interaction terms between age and the independent variables allow us to understand the underlying determinants associated with the bending of anthropometric-age curve among younger children. While, on the other hand, the interaction terms between structural break and the independent variables allow us to understand how these factors are associated with upward and downward shifts of anthropometric-age curve in the older age groups.

Further, we use a mother fixed-effects model that compares children of different ages born to the same mother. The biggest advantage of this approach is that it enables us to control not only for observable variables, such as mother's education and household infrastructure, but also for mother- and household-level unobservable characteristics, such as maternal ability, socioeconomic status of the household. Furthermore, we introduce interactions between the age profile and characteristics of interest (individual, maternal, and household characteristics) in order to verify how maternal factors such as education and height correlate with height-for-age across different age groups. Similar to OLS model, we introduced a structural break within the mother fixed-effects model.

Results

We note a sharp decrease in HAZ up to the age of approximately 23 months, and that is common in all survey years, and thereafter relatively smaller decline was observed for the older age groups (Figure 1a). Although, HAZ-curve takes a marked upturn after approximately 24 months of age, it fluctuates substantially in the older age groups; however, these fluctuations appear to be much smoother in the recent surveys. This indicates that, over the time period, the rate of decline in HAZ has been slower with age.

Similar to HAZ, the decrease in WAZ was observed to be starting from the onset of child birth (0 months). However, compared to the HAZ-age curves, WAZ-age curves show relatively smooth patterns. Over the time period, the rate of decrease in WAZ has been slower with age (Figure 1b).

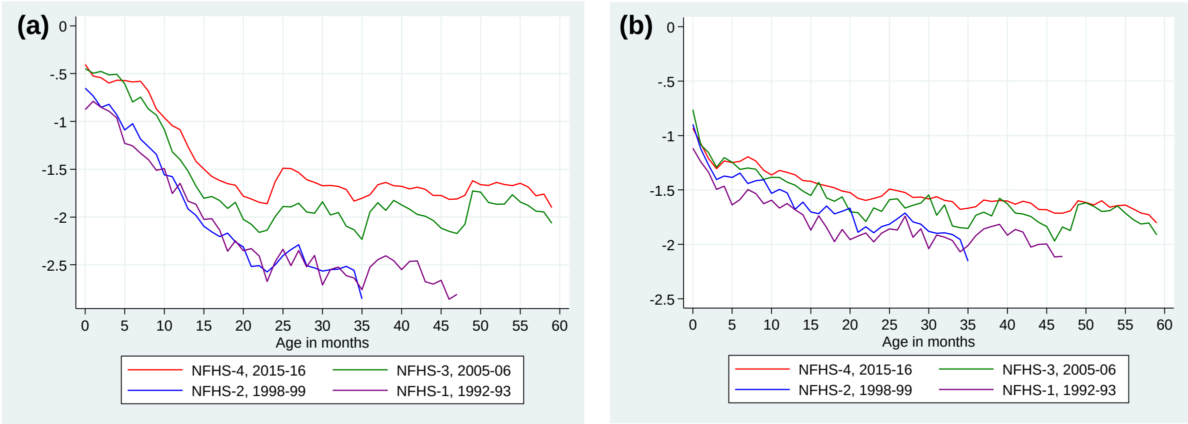

Figure 1: Age patterns of child growth indicators: (a) HAZ and (b) WAZ, India, 1992-93—2015-16.

The interactive effects of child's age, as presented in column 2 (Table 1A, Appendix), are significant for most of the independent variables, which implies that the correlations of these variables with HAZ are dependent to child's age. Note that negative interactive effects are associated with "pulling" children away from, while the positive interactive effects are associated with "pushing" children toward, the healthy or age-appropriate growth curve. Pull factors (or negative interactive effects) are noted for higher birth order, small birth size, and poorest household wealth. Push factors (or positive interactive effects) are observed for mother's higher education, improved toilet facility, and urban residence.

Coefficients presented in the column 3 (Table 1A, Appendix) show interaction between each variable and the structural break. Although, the signs of significant coefficients in column 3 go in the same direction as the age interaction in column 2, their magnitude shown to have varied substantially. The significant positive interactions or "push" factors are associated with a long-lasting upward shift of HAZ-age curve for the older age groups. On the other hand, the significant negative interactions or "pull" factors are associated with a long-lasting downward shift of HAZ-age curve for the older adults.

Result from the mother-level fixed effect model (on the right panel Table 1A, Appendix) reveals age heterogeneities that tend to occur among the children of different age from the same mother. Within this model, the estimations are based on deviations from maternal means, which implies that the coefficients are measured by comparing nutritional outcomes among the siblings. Since, the maternal factors do not vary among siblings, the main effects for such covariates cannot be measured within the mother-level fixed effect model. However, we derive coefficients for maternal factors after interacting these variables with age and the structural break.

Column 4 displays the coefficients explaining the main effects of child-level factors which are in line with the OLS estimates for child-level factors (column 1). We find significant negative age interaction for higher birth order, being a member of other religion, belonging to a caste/tribe group, poorest wealth group (column 5). Most of these variables bend the HAZ-curve so strongly that they lead to a significant long-lasting downward shift for the older age groups (column 6). On the other hand, significant positive age interactions are found for being a male child, mothers with higher education, and urban residence (column 5). These variables are associated with upward shifts of HAZ-curve in the older age groups.

Results from the OLS model suggest that weight-for-age is negatively correlated with being a male child, higher birth order, small birth size, non-institutional delivery, being a member of caste/tribe group, and poorest wealth groups (Table 2A, Appendix). Whereas, WAZ is positive associated with mother's age at child birth, educational attainment, being a member of Muslim and others religious group, and living in a household with improved toilet facility.

We find two negative age interactions (small birth size and poorest household wealth) and two positive age interactions (being a male child and households with improved toilet facility) that are significant and sizeable. Interactive effects of child's age appeared to be very small/negligible for non-institutional delivery, mother's educational attainment, caste/tribes, and urban residence. This indicates that, the correlation between these variables and WAZ are relatively less age dependent.

Discussion and Conclusion

Although, there was significant improvement in HAZ for all age groups from 1992-93 to 2015-16, the shifts in HAZ scores were not uniform across all ages. The shifts were moderate among the younger children but, the shifts were appeared to be larger among the older children. The observed upward shifts in HAZ scores at the youngest age (first 3-6 months of life) is an indicative of the improvements in birth size. Given that, low birth size has widely been recognized as one of the leading factors contributing to faltered growth, especially in children of younger age[14], this is potentially a finding of some significance. This finding may further corroborate to the fact that improvements in maternal nutrition and healthcare during the gestation might have been translated into the better nutritional outcomes in the younger children. However, despite better nutritional outcomes at birth, younger children continue to experience faltered growth as they grow older. This may imply that the protective effect of better nutritional outcomes at birth is altered by some other factors as children grow older and when they are directly exposed to the household conditions/environments.

Results from our fully age-interacted models suggest a wide range of determinants that have age dimensions, meaning that the effects of these determinants on child growth tend to vary with age. We find a larger effect of gender (being a male child) on growth deficit in the older age groups (> 24 months) than the younger age. Effect of higher order on poor child growth was stronger in younger children as compared to older children.

We observe that the effect of lowest household wealth much stronger in the older children. This could highlight the fact that, children from the poorest households suffer not just from the wide range of detrimental factors (e.g., poor living conditions, poor healthcare) that they experience at any point in time, but also they are exposed to a greater total number of these detrimental factors cumulatively across the course of their lives [11]. The cumulative effects of such detrimental factors are expected to magnify the associations of poorest household wealth and child health outcomes.

Our finding shows protective effect of improved toilet facility in the household, stronger in the older children. The positive association between improved toilet facility and nutrition outcomes in children is a well-documented finding in social science. However, our findings suggest that the children of all age groups are not equally benefitted from such a protective measure. This may be because of the fact that, for younger children the protective effect of toilet facility did not reflect since they are much dependent on others for care and nurture, and thus, younger children are hardly exposed to toilet facility of the household.

In conclusion, preliminary findings of this study highlight the existence of age heterogeneities in child growth correlates which is potentially a finding of some significance and may provide policy guidance through directing the timely nutrition interventions to achieve the maximum impact.

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APPENDIX

Table 1A: HAZ

HAZ	OLS			FE		
	Variable	**Variable × Age**	**Variable × Break**	**Variable**	**Variable × Age**	**Variable × Break**
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Male	-0.287*** (0.012)	0.007*** (0.001)	-0.036 (0.021)	-0.190*** (0.020)	0.005*** (0.001)	-0.102** (0.037)
≥4 Birth Order	-0.190*** (0.018)	-0.003** (0.001)	-0.001 (0.032)	-0.030 (0.028)	-0.007*** (0.001)	0.137** (0.049)
Small Birth Size	-0.446*** (0.016)	0.006*** (0.001)	-0.058 (0.031)	-0.304*** (0.029)	0.002 (0.001)	-0.015 (0.052)
Child Delivered at Home	-0.259*** (0.014)	0.004*** (0.001)	-0.145*** (0.024)	0.142*** (0.025)	0.001 (0.001)	-0.267*** (0.038)
Mother's age at Child Birth	0.023*** (0.001)	0.000 (0.000)	-0.005*** (0.001)	-	-0.000* (0.000)	-0.033*** (0.002)
Mother's Primary Edu.	0.145*** (0.019)	0.001 (0.001)	-0.046 (0.033)	-	-0.003* (0.001)	0.003 (0.049)
Mother's Secondary Edu.	0.397*** (0.016)	-0.001 (0.001)	0.059* (0.028)	-	-0.002* (0.001)	0.044 (0.041)
Mother's Higher Edu.	0.690*** (0.024)	-0.003* (0.001)	0.180*** (0.046)	-	-0.003 (0.002)	0.234** (0.085)
Muslim	0.094*** (0.017)	-0.001 (0.001)	-0.045 (0.032)	-	0.001 (0.001)	-0.143** (0.048)
Other Religion	0.377*** (0.019)	-0.007*** (0.001)	0.069 (0.036)	-	-0.007*** (0.002)	0.228*** (0.056)
Caste/Tribe	-0.067*** (0.013)	-0.000 (0.001)	0.047 (0.025)	-	0.002* (0.001)	-0.103** (0.038)
Poorest Wealth Group	-0.164*** (0.015)	0.002* (0.001)	0.011 (0.030)	-	0.003* (0.001)	-0.126** (0.043)
Improved Toilet	0.002*** (0.000)	-0.008*** (0.001)	0.056* (0.026)	-	0.001 (0.001)	0.046 (0.041)

Facility						
Urban Residence	-0.023	0.002*	-0.055*	-	-0.000	0.015
	(0.014)	(0.001)	(0.027)		(0.001)	(0.043)
_cons	-1.598***			-0.938***		
	(0.036)			(0.019)		
N	317867			133397		
R^2	0.101			0.656		

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2A: WAZ

	OLS			**FE**		
WAZ	**Variable**	**Variable × Age**	**Variable × Break**	**Variable**	**Variable × Age**	**Variable × Break**
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Male	-0.178***	0.005***	0.012	-0.134***	0.006***	-0.106***
	(0.008)	(0.000)	(0.015)	(0.014)	(0.001)	(0.025)
≥4 Birth Order	-0.179***	-0.001	0.051*	-0.078***	-0.001	0.023
	(0.013)	(0.001)	(0.023)	(0.019)	(0.001)	(0.033)
Small Birth Size	-0.468***	0.005***	0.009	-0.390***	0.003**	0.027
	(0.012)	(0.001)	(0.022)	(0.019)	(0.001)	(0.035)
Child Delivered at Home	-0.113***	-0.000	0.018	0.010	0.000	-0.087***
	(0.009)	(0.001)	(0.018)	(0.017)	(0.001)	(0.026)
Mother’s age at Child Birth	0.015***	0.000	-0.002*	-	-0.000***	-0.009***
	(0.001)	(0.000)	(0.001)		(0.000)	(0.001)
Mother’s Primary Edu.	0.134***	0.000	-0.030	-	-0.003***	0.028
	(0.013)	(0.001)	(0.024)		(0.001)	(0.033)
Mother’s Secondary Edu.	0.325***	-0.001*	0.013	-	-0.003***	0.059*
	(0.011)	(0.001)	(0.020)		(0.001)	(0.028)
Mother’s Higher Edu.	0.571***	0.000	0.036	-	-0.005**	0.266***
	(0.018)	(0.001)	(0.034)		(0.002)	(0.058)
Muslim	0.139***	-0.002*	-0.013	-	0.000	-0.090**
	(0.012)	(0.001)	(0.023)		(0.001)	(0.033)

Other	0.597***	-0.007***	-0.008	-	-0.004***	-0.003
Religion	(0.014)	(0.001)	(0.026)		(0.001)	(0.038)
Caste/Tribe	-0.065***	-0.001	0.017	-	0.001	-0.087***
	(0.009)	(0.001)	(0.018)		(0.001)	(0.026)
Poorest	-0.288***	0.003***	0.016	-	0.002**	-0.042
Wealth Group	(0.011)	(0.001)	(0.021)		(0.001)	(0.029)
Improved	0.001***	0.008***	-0.114***	-	0.000	0.011
Toilet Facility	(0.000)	(0.000)	(0.019)		(0.001)	(0.028)
Urban	0.013	-0.000	-0.006	-	0.001	-0.009
Residence	(0.010)	(0.001)	(0.002)		(0.001)	(0.029)
_cons	-1.704***			-1.259***		
	(0.026)			(0.013)		
N	317867			133397		
R^2	0.112			0.690		

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$